Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1977

Volume IV. Receptors — Birds

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

U.S. DEPARTMENT OF INTERIOR
Bureau of Land Management

VOLUME I	RECEPTORS -- MAMMALS
VOLUME II	RECEPTORS -- BIRDS
VOLUME III	RECEPTORS -- BIRDS
VOLUME IV	RECEPTORS -- BIRDS
VOLUME V	RECEPTORS -- BIRDS
VOLUME VI	RECEPTORS -- FISH
VOLUME VII	RECEPTORS -- FISH
VOLUME VIII	RECEPTORS -- FISH
VOLUME IX	RECEPTORS -- FISH
VOLUME X	RECEPTORS -- FISH
VOLUME XI	RECEPTORS -- MICROBIOLOGY
VOLUME XII	EFFECTS
VOLUME XIII	CONTAMINANT BASELINES
VOLUME XIV	TRANSPORT
VOLUME XV	TRANSPORT
VOLUME XVI	HAZARDS
VOLUME XVII	HAZARDS
VOLUME XVIII	HAZARDS DATA MANAGEMENT

Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1977

Volume IV. Receptors — Birds

Outer Continental Shelf Environmental Assessment Program

Boulder, Colorado

March 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratory

U.S. DEPARTMENT OF INTERIOR
Bureau of Land Management

DISCLAIMER

VOLUME IV

RECEPTORS - BIRDS

CONTENTS

ANNUAL REPORT - 1976

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF ALASKAN MARINE BIRDS IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

Office of Biological Services - Coastal Ecosystems
U. S. Fish and Wildlife Service
U. S. Department of the Interior
800 A Street
Anchorage, Alaska 99510

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to
March 31, 1977

GENERAL INTRODUCTION

PART I

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. J. Gould
R. E. Gill and G. A. Sanger
Co-principal Investigators

U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

March 1977

Table of Contents

ABSTRACT

Site-specific studies of marine birds were conducted at 13 locations in the Gulf of Alaska and southern Bering Sea during the 1976 field season. Although the studies did not adequately consider all species or habitats in the regions concerned, the locations contained diverse habitats and species assemblages which were believed to be at least representative of other colony locations in the northern Gulf and southern Bering Sea. Studies at 10 locations focused on traditional "seabirds" while those at three locations focused primarily on shorebirds or both shorebirds and waterfowl. Species best represented on the study areas included murres, Tufted and Horned Puffins, Black-legged Kittiwakes, Glaucous-winged Gulls, and Pelagic Cormorants. Other species such as the Northern Fulmar and some small alcids were represented on only one study area. The high seasonal and local variability in populations and production indicates that continuing studies will be required to adequately evaluate average long term productivity on population levels over a broad geographic region.

INTRODUCTION

This study of the population dynamics and trophic relationships of marine birds is part of a comprehensive program for evaluation of the status and ecology of marine birds in the Gulf of Alaska and the southern Bering Sea. While this study concentrates effort on the detailed evaluation of populations, productivity, and trophic dynamics of birds at a few key locations, other studies include the cataloging of all seabird colonies (Research Unit 338/343) and the evaluation of the seasonal distribution and abundance of birds at sea (RU 337). Thus the collective effort of all projects should permit a comprehensive evaluation of the status of major species.

The overall objective of the OCSEAP bird studies program is to gather, analyze, and present information that will effectively aid decision makers in the identification and resolution of problems associated with development of Outer Continental Shelf petroleum resources thus provide information necessary to identify and evaluate potential resource impacts and develop means for preventing, minimizing and/or mitigating adverse impacts. In addition, bird information gathered through the OCSEAP program will prove exceedingly useful for evaluating areas proposed by the Secretary of the Interior for inclusion in the National Park and National Wildlife Refuge Systems, and for management of marine birds in areas already within these systems.

The BLM/NOAA Outer Continental Shelf Environmental Assessment Program (OCSEAP) provided the primary source of funding; however, the U. S. Fish and Wildlife Service has also contributed substantially to the overall bird program in Alaska.

Objectives of the site specific studies of individual colonies were:

1. To determine the number and distribution of each species relative to other species, to periods of the breeding season, and to characteristics of available habitat within the colony or study area.

2. To provide estimates of production or nesting success of principal species.

3. To establish and describe sampling areas or units which may be utilized in subsequent years or by other persons for monitoring the status of populations.

4. To determine the amount and kinds of foods utilized by principal species, when possible to determine the relationship of food selected to that available, and to describe daily foraging patterns.

5. To describe the chronology and phenology of events in the biology of breeding birds including changes in population from the onset of site occupancy in the spring through departure in fall.

6. To provide a comparison of current data with recent historical data.

Studies of trophic dynamics considered under objective No. 6 included the collection of birds at sea and the analysis of seasonal food requirements and foraging behavior of birds in relation to their patterns of distribution and to other physical or biological features of the marine ecosystem.

This report, in Parts II through XIV summarizes the results of studies at individual colonies or of specific study elements. Only those sites and elements funded by OCSEAP are included, but data from other areas which may be of interest to the OCSEAP program will be included in subsequent reports.

STUDY AREAS

The selection of study areas was based on several factors including the juxtaposition of the colony to an OCS lease area and consequent probable vulnerability of the site to pollution or onshore activities associated with petroleum development, the size and diversity of avian populations, the presence of key species, the status of information already available, and the supplementary benefits that might be derived from evaluation of the particular site. The characteristics or importance of individual sites is briefly summarized below; detailed descriptions of the individual study areas are provided in Parts II through XIV of this report.

Copper River Delta

The Copper River Delta provides habitat of critical importance to migrant populations of shorebirds and to both migrant and nesting populations of waterfowl, in particular the Trumpeter Swan and the Dusky Canada Goose. However, the study focused entirely on habitat use and trophic relationships of shorebirds of which Dunlins and Western Sandpipers were the primary species. Waterfowl were not considered because their habitat is not as vulnerable as that of shorebirds, and because substantial effort has already been devoted to this group of species by the U. S. Fish and Wildlife Service, the Alaska Department of Fish and Game and the U. S. Forest Service.

Hinchenbrook Entrance

Hinchenbrook Entrance was selected as a study area because of the diversity of habitats, presence of several species of marine birds representative of the Northeast Gulf of Alaska, and because of its high vulnerability to impacts from offshore developments in both the Northeast and Northwest Gulf regions and from Prince William Sound, ie., pollution that may result from tanker traffic from the Port of Valdez.

Wooded Islands

Colonies of marine birds in the Wooded Islands off the seaward side of Montague Island are vulnerable to impacts associated with offshore development in both the Northeast and Northwest Gulf of Alaska regions. The island contains a diverse assemblage of species which are representative of other colonies in the region except for the presence of Fork-tailed Storm Petrels which were selected as a "key species" for study.

Barren Islands

The Barren Islands contain one of the largest and most diverse populations of seabirds within the northern Gulf of Alaska; the total number of birds dependent on the area probably exceeding one million. The population would be vulnerable to development in the Kodiak Basin, Lower Cook Inlet, or Northeast Gulf of Alaska.

Kodiak Archipelago

The Kodiak Archipelago contains more than 175 colonies of marine birds of diverse species assemblages and habitat requirements. Those colonies, which vary in size from as few as 10 to more than 200,000 birds, would be most vulnerable to offshore and onshore developments in the Kodiak lease region. The area is of particular interest because of all study areas it provides the most opportunity to evaluate productivity and trophic relationships of birds from numerous colonies within a single region, and because of the existence of a road system and other logistic aids, which make year round studies more feasible in this area than in any other.

Ugaiushak Island

Studies on Ugaiushak Island were initiated by the U. S. Fish and Wildlife Service in 1974 and were continued with OCSEAP funding in 1976 and 1977. The island has a diverse species assemblage which is readily accessible to observers based on the island, thus increasing the likelihood for substantive results with minimal effort.

Semidi Islands

The Semidi Islands contain the only large accessible colony of Northern Fulmars in the Gulf of Alaska, and except for incidental information obtained in the Pribilofs, is the only area in which information on this species is being obtained. Colonies of Ancient Murrelets, Cassin's, Crested, and Least Auklets are similiarly the only large colonies of these species under study in the Gulf of Alaska. The Semidi Islands were selected as a study area primarily on the basis of the large size and importance of colonies there, and the presence of species not found on other study areas. Colonies on the Semidis will be most vulnerable to developments in the Kodiak and Alaska Peninsula regions.

Koniuji Group, Shumagin Islands

The Koniuji Group contains numerous colonies of seabirds which are representative of other colonies in the Shumagin Islands. The study in this area emphasizes work on Crested Auklets which winter in large numbers around Kodiak Island, and were considered elsewhere only incidentally as part of studies on the Semidi Islands and on St. Lawrence Island in the northern Bering Sea.

Unimak Pass

Unimak Pass is the primary route traveled by birds moving between the Bering Sea and the Gulf of Alaska, and observations there are of particular interest for evaluating the time and pattern of movements of individual species between these two oceanic regions. The Pass is also a major route for marine mammals including the gray whale and observations in the study area are of particular value for determining the size of the population and characteristics of migration for this endangered species.

Nelson Lagoon

Nelson Lagoon forms a part of Port Moller which is the largest estuarine area on the north side of the Alaska Peninsula. It is of primary importance for migrant shorebirds and waterfowl although lesser numbers of other groups of marine birds also utilize the area. The study in Nelson Lagoon represents the only substantive effort directed toward habitat use and trophic relationships of shorebirds within that region, and data from the study area may be at least partially representative of other similar estuarine areas of the Peninsula. Coastal habitats along the north side of the Peninsula will be vulnerable to offshore and onshore developments in Bristol Bay and St. George Basin lease areas.

Cape Peirce

This study area is considered of major interest because of the diversity of habitats (lagoon, seacliffs, and islands) and the large number of birds (approximately 750,000) which are perhaps representative of the still larger colonies at Cape Newenham. Birds utilizing Cape Peirce and Cape Newenham will be particularly vulnerable to development in Bristol Bay, and may also be affected by offshore development in St. George Basin.

Yukon Delta

More than half of the total populations of several species of waterfowl and shorebirds depend on habitats of the coastal fringe of the Yukon Delta. This critical habitat is either intertidal or scarcely above mean high tide; thus, all of it is potentially vulnerable to development in Norton Basin. Studies on the Yukon Delta are presented in the Annual Report for RU 488.

METHODS

Methods of study invariably depended primarily on the direct observation of adult birds and their nests or young. Beyond this basic common factor, methods of study varied within and between species and study areas depending on the nature and accessibility of habitats being used. A detailed description of methods and/or sampling techniques is provided for each study area in Parts II through XIV of this report.

RESULTS AND DISCUSSION

More than 90 species of birds are associated with estuarine and marine habitats which may be affected by the development of petroleum resources of the OCS. Of these species, 28 are traditionally included in the non-taxonomic category of "seabirds", e.g., the gulls, alcids, cormorants, etc. Most other species are waterfowl or shorebirds associated with estuarine habitats, although some waterfowl including particularly eiders and Old Squaw ducks range throughout the Bering Sea in winter. Because of their greater vulnerability to OCS development, and because less information was available on them, selection of study areas stressed species in the seabird group. Thus, in 10 of 13 areas seabirds were of primary interest, and shorebirds or waterfowl were or primary interest in only three. Among the seabirds, murres, Black-legged Kittiwakes, Tufted and Horned Puffins, Glaucous-winged Gulls and Pelagic Cormorants were widely represented in the study areas, while the Northern Fulmar and many of the smaller alcids were represented in only one or two areas. Overall, our study areas probably sampled substantially less than 5% of the colony areas or estuarine habitats within a given region.

The results to be discussed in following parts of this report generally indicate low productivity or reproductive success of most species, but being highly variable for individual species both within and between study areas and regions. This variability results partly from the variability in available habitat, accessibility of colonies to predators, and perhaps most importantly, to factors we are unable to evaluate with data presently available.

The overall low productivity of seabirds has obvious implications in respect to long range impacts which may be anticipated from development of the OCS, as low productivity will greatly extend and perhaps preclude recovery from losses which may occur. The high variability in reproductive success similarly increases the difficulty in determining "normal" reproductive rates and population levels - thus the difficulty in predicting long range effects of development or monitoring of changes which may occur. Long term studies will be required to assess annual variation in populations and productivity. The number of study areas we are able to evaluate on a continuing basis is inadequate for most species.

SCHEDULE OF WORK FOR THIRD AND FOURTH QUARTERS

Primary effort during the third and fourth quarters will be directed toward continuation of field studies initiated in 1976. Effort devoted to each areas is summarized below. Except for minor effort extended to additional estuarine habitats on the Alaska Peninsula and the Yukon Delta, no additional study areas will be examined under the OCSEAP program. Work in several study areas conducted in 1976 will be terminated or much reduced.

Field studies will be initiated on individual study areas between 7 April and 31 May depending on logistical constraints and phenology of key species at a given site. Field work will be continued until late August, or late September, the time period primarily reflecting the phenology of the breeding season at different locations.

Site-Specific Studies

Copper Delta

Work in this study area will be discontinued as part of the OCSEAP program as major objectives of the study have been obtained.

Hinchenbrook Entrance

Work on this study area will be terminated as part of the OCSEAP program, but will be continued with U. S. Fish and Wildlife Service funding at a slightly reduced level.

Middleton Island

Although of significant importance, funding will not permit continuation of a Major Study effort on Middleton Island. Except perhaps for short visitations to document production, studies at Middleton Island will be terminated.

Wooded Islands

Studies on the Wooded Islands will continue at the 1976 level of effort. The study area contains one of the two colonies of Fork-tailed Storm Petrels which will be evaluated during the 1977 field season.

Barren Islands

Work on the Barren Islands study area will continue at approximately the 1976 level of effort.

Kodiak Archipelago

Work in the Kodiak Archipelago will be substantially expanded during 1977, reflecting priorities of the revised OCS lease schedule, the high vulnerability of birds to onshore and offshore impacts in the Kodiak lease area, and the feasibility of integrating our study efforts with fisheries and oceanographic study efforts.

Ugaiushak Island

Studies on Ugaiushak will continue at approximately the 1976 level.

Semidi Islands

Study effort on the Semidi Islands will be reduced substantially, although work on the Northern Fulmar will continue at the 1976 level. This species will not be considered on any other study area within the Gulf of Alaska.

Koniuji Group, Shumagin Islands

Work in the Shumagin Islands will be terminated as part of the OCSEAP program. A low level effort may be continued with USFWS funding.

Unimak Pass

Studies of migration through Unimak Pass will continue at an increased level of effort during critical periods, but with reduced effort at other times. Timing of studies will coincide with the anticipated movement of gray whales through the Pass, thus extending the overall value of the work.

Nelson Lagoon

Studies in Nelson Lagoon will continue at a slightly increased level in order to permit more adequate evaluation of trophic relationships and to extend work on a reconnaissance level to adjacent estuarine systems along the northside of the Peninsula. The reconnaissance effort is essential for determining the degree that our effort at Nelson Lagoon is representative of other lagoons systems on the Alaska Peninsula.

Cape Peirce

Studies at Cape Peirce will be discontinued or reduced to the minimal effort necessary to evaluate annual production.

Site-specific Studies Funded by U. S. Fish and Wildlife Service

Although not a part of the OCSEAP Program, the U. S. Fish and Wildlife Service will be funding and conducting studies at a modest level of effort at several additional locations of interest to the OCSEAP program. As evidenced on Figure 1, these include studies on Forrester Island in Southeastern Alaska which will continue a study initiated in 1976; and reconnaissance study of colonies on the Hazy Islands and St. Lazaria also in Southeastern Alaska, on St. Matthew Island in the central Bering Sea and on Chamisso Island in Kotzebue Sound. In addition, seabird and/or coastal waterfowl studies will be conducted on the Arctic, Izembek, Aleutian, Kodiak, and Kenai National Wildlife Refuge areas. All of these refuge areas are adjacent to OCS lease regions and data obtained will complement the OCSEAP program. The OCSEAP program will also benefit from these studies since the data will be archived in OCSEAP data formats and appropriate reports will be provided to the OCSEAP program offices.

Non-Site-specific Studies

While studies of trophic dynamics are an integral part of each site specific study, the major thrust of this part of the study is to obtain comprehensive region-wide evaluation of seasonal food dependencies and their relationship to other biotic elements and to physical characteristics of the marine ecosystem. This part of our study will be substantially increased during the third and fourth quarters, partly by increased effort, but also by increased integration of studies of trophic dynamics with other phases of this study, with studies on the distribution and abundance of birds at sea, and other study disciplines in the OCSEAP program.

ANNUAL REPORT

NOAA OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Reporting Period: October 1, 1976 to
March 31, 1977

POPULATIONS AND ECOLOGY OF MARINE BIRDS ON THE SEMIDI ISLANDS

by

Lora L. Leschner and Galen Burrell

Part II

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS

IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

J.C. Bartonek, C.J. Lensink, P.J. Gould,
R.E. Gill, and G.A. Sanger
Co-principal Investigators

U.S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

March 1977

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (continued)

TABLE OF MAPS

TABLE OF MAPS

(cont.)

INTRODUCTION

Seabirds have been considered Alaska's most neglected resource (Sowls and Bartonek, 1974). Management of seabirds has been mainly passive and limited to the acquisition of lands for the protection of breeding colonies, and even this protection has been generally directed towards the spectacularly conspicuous colonies of cliff-nesting species. Acquisition of key habitat remains important, but information on populations and ecology has become crucial to proper management or to evaluation of the effects of increasing human activity in coastal regions.

This report presents observations on the breeding biology and populations of seabirds on the Semidi Islands, Alaska. The primary objectives of this study were to:

1. Determine the status of individual species.
2. Determine the breeding phenology of all nesting species.
3. Determine the food habits of the principal species.
4. Determine the size of the nesting population for each species.
5. Determine the nesting success of the principal species.

The first report containing important information on birds of the Semidis was provided by Brooks (1915) who participated in the Harvard University expedition to Alaska in 1913. Gabrielson (from Troyer, 1972) made a cursory survey of the bird life in the Semidis during three short visits: June 18, 1940; August 5, 1945; and August 21, 1946. Troyer (1972) visited the Semidis in May 1972 and estimated the size of the largest seabird colonies and noted their distribution. These few surveys conducted over a period of 60 years provided information on species occurrence, and crude estimates of population size, by such data was inadequate for current needs of management or for predicting or monitoring the effects of increased human activity associated with marine fisheries, or more particularly, the exploration for and development of petroleum resources of the Outer Continental Shelf.

Our study of the breeding biology of seabirds in the Semidis was conducted from 24 May to 4 September in 1976, and included work on all species. During the same period, Scott and Martha Hatch conducted an intensive study of the Pacific Fulmar (*Fulmarus glacialis*) which is included as Part III of this report.

STUDY AREA

The Semidi Islands are all within the Semidi Islands National Wildlife Refuge established by Executive Order 5858 in 1932. The refuge includes all islands, rocks, and underwater lands lying between parallels 55 degrees 57 minutes and 56 degrees 15 minutes north latitude and meridians 156 degrees 30 minutes and 157 degrees longitude west (Troyer, 1972). The remote refuge lies roughly 50 miles from the nearest Alaskan mainland on the Alaska Peninsula and 100 miles southwest of Kodiak. There are nine major islands in the Semidis (Map 1).

The Semidis are the erosional remnant of a broad shoal of the Kodiak - Shumigan Shelf (Cobb, et. al, 1968). The islands rise to elevations of from 105 meters to more than 305 meters (U.S. Coast and Geodetic Survey, 1964). The shorelines are extremely precipitous. Water depths around the islands drop rapidly to 10 and 30 fathoms and then to 40 and 50 fathoms offshore (U.S. Coast and Geodetic Chart #8851).

The vegetation of the Semidi Islands is much like that of the lowland arctic tundra. Generally, grass-sedge communities dominate lower elevations. Crowberry (*Empetrum nigrum*) associations prevail at higher elevations and lichens and mosses occur at the highest elevations. Although Growth is restricted to low growing or prostrate form, vegetation is generally lush and varied, and a total of 68 species, exclusive of sedges, were collected in Chowiet Island (Appendix I).

Fifty-four species of birds have been observed of which all but 16 species depend primarily on marine or other aquatic habitat (Table 2). Some terrestrial birds have ubiquitous distributions, but most are restricted to particular habitats. Gray-crowned Rosy Finches frequented all habitats on Chowiet Island, while Lapland Longspurs, Snow Buntings, and Parasitic Jaegars were always seen at the higher elevations. Song Sparrows, Fox Sparrows, and Hermit Thrushes were usually seen in lowland areas along the stream beds.

Avian predators include Peregrine Falcons, Bald Eagles, and Northern Ravens. There were five Peregrine Falcon nests and four Bald Eagle nests on Chowiet Island (Map 2). These raptors are the primary predators on adult and juvenile seabirds, while ravens are active predators on the eggs and chicks of open and cliff nesting species.

A total of 18 species of seabirds nested in the Semidi Islands.

Arctic ground squirrels (Spermophilus undulatus) are the only land mammals. They were seen on Choweit, Kateekuk, and Aghiyuk Islands, where they had ubiquitous distributions. It is not known whether the arctic ground squirrels are endemic to the Semidiis or were introduced by fox farmers.

Steller sea lions (Eumetopias jubatus) harbor seals (Phoca vitulina), and sea otters (Enhydra lutris), are resident along the shores. A sea lion rookery of approximately 5,230 adults is located on the southern tip of Chowiet Island. Gabrielson (from Troyer, 1972) in June 1940 and Troyer (1972) in May 1972 counted only 500 sea lions on Chowiet Island.

Harbor seals were seen on all islands we visited. Major hauling out places included coves on the northwest side of Chowiet, a sandy beach on the southeast side of Kateekuk, and a large gravel beach on the east side of Aghiyuk. On June 9, 16 adults with nine pups were seen on Chowiet Island.

Sea otters were present in low numbers. Only single adults were seen until 10 August when two adults and one pup were seen near Suklik Island.

Whales were occasionally seen feeding around the islands. Species included were Pacific killer whale (Orcinus orca), finback whale (Balaenoptera physalus), sei whale (Balaenoptera borealis), minke whale (Balaenoptera acutorostrata), and humpback whale (Megaptera novaeangliae).

METHODS

All data on breeding biology and populations of species nesting in open, crevice, and burrow habitats were made on Chowiet and Kateekuk Islands. These islands as well as five of the other islands, Aghiyuk, Aghik, Anowik, Kiliktagik, and Suklik, were surveyed for distribution and numbers of cliff-nesting species.

Habitat Preference and Population Estimates

Habitat preferences and populations were estimated by the census techniques recommended by Nettleship (1976) and the Pacific Seabird Group (1975). The techniques varied for cliff, open, crevice, and burrow-nesting species. Because of difficulties in sampling, a combination or modification of methods was often necessary.

Cliff-nesting species

Population estimates for cliff nesting species were obtained by direct counts from land or a pneumatic boat. Population sizes of all colonies of Black-legged Kittiwakes and Red-faced and Pelagic Cormorants were based on actual nest counts. Estimates of the number of birds in colonies of Common and Thick-billed Murres were made by rough counting by 10's or 100's of the entire colony. Census points on Chowiet Island were marked on a map and photographed for future surveys of cliff-nesting species (Table 3, Map 4).

Open-nesting species

Open nesting species were censused by direct counts of nests, pairs, or nesting territories. Glaucous-winged Gull population estimates were obtained by counting all nests containing eggs in each colony. Common Eiders were censused before egg-laying by direct count of pairs around Chowiet Island. The Black Oystercatcher breeding population was estimated from two direct count of birds on territories.

Crevice-nesting species

There is no satisfactory method to census crevice-nesting species. We could not establish control plots where the number of adults to chick ratio was known because many nests were inaccessible. The line transect census method was the most appropriate method, but there were still sampling problems.

Nettleship (1976) suggested that signs of excavation or defecation stains be used to locate nests. However, we found that some of the nests were not marked by stains and that one entrance may lead to several nests or that one nest may have several entrances. Furthermore, it was often difficult or impossible to distinguish between nests of Horned Puffins, Tufted Puffins, and Parakeet Auklets.

Thus two methods were necessary to census crevice-nesting species. We censused Horned Puffins, Tufted Puffins, and Parakeet Auklets on Chowiet Island by a combination of the line transect method and direct counts of birds on colony or in the water around the island. Transects were randomly placed and all combinations of nesting habitats were censused. Transects stretched from the intertidal zone to the top of the slope. Quadrats of $3m^2$ were alternately placed at 3m intervals along the transect line.

The maximum area of nesting habitat available to all three species was 380, 282 m^2. The average burrow density obtained for each species from the transects was then multiplied by the available nesting area to obtain the maximum population estimates.

Direct counts of Horned Puffins, Tufted Puffins, and Parakeet Auklets on colonies and in the waters around the island were made prior to egg-laying. The entire coast of Chowiet Island was surveyed in this manner. The direct counts were then compared to the population estimates obtained from the line transects.

Numbers of Pigeon Guillemot were estimated from direct counts of individuals in the waters around Chowiet early in the breeding season.

Burrow-nesting species

Burrow-nesting species were censused by direct count of all burrows or by counts on sample quadrats of $5m^2$ placed randomly throughout the colony. The total breeding population obtained was then multiplied by the percent burrow occupancy to obtain the true breeding population.

Numbers of Rhinoceros Auklets were determined from a direct count of burrows in all colonies. The number of breeding pairs was then estimated by excavating a sample of burrows in each colony and determining the ratio of occupied to unoccupied burrows.

On Kateekuk Island, Horned and Tufted Puffins using burrows were censused by counting burrows in 5x5 meter quadrats and extrapolating average density on quadrats to the available nesting area. The total number of burrows was then multiplied by the percent occupancy.

Nesting Phenology and Breeding Success

Study plots were set up to monitor nesting phenology and breeding success of seabirds nesting on Chowiet and Kateekuk Islands (Maps 5 and 6). Nests within these plots were visited regularly or observed through a 20-45 power spotting scope.

Accessible nestlings within these plots were banded with metal U.S. Fish and Wildlife Service bands when two to three weeks old.

Food Habits and Endoparasites

Birds were collected throughout the breeding season for study of food habits and endoparasites. Collecting trips were made in a pneumatic boat between 0900 and 1300 hours local Daylight Time.

All stomach samples were sent to Gerry Sanger, U.S. Fish and Wildlife Service, Anchorage, Alaska, for analysis and endoparasites were sent to Eric Hoberg at the University of Saskatchewan for identification.

Direct observations of feeding behavior, food remnants on nesting areas, or of food items brought to nestlings, supplemented the collections and are discussed under individual species accounts.

Weights and Measurements

All birds were weighed with Pesola scales. Wing lengths and diagonal of the tarsus were measured with a metric ruler, and culmen lengths were measured with a metric caliper.

RESULTS AND DISCUSSION

Alcidae

Common and Thick-billed Murres

We censused the Common and Thick-billed Murre population in mid-August and estimated that there were 141,150 individuals nesting in five colonies on Chowiet Island (Map 7). Nettleship (1976) suggested that the number of breeding pairs be determined by calculating the ratio of adults to eggs or chicks. However, this was not feasible on Chowiet because all nesting ledges were inaccessible. Thus, we could only estimate the number of individuals on colony. The location and number of murres counted at each sample point and a map and photographic record are summarized in Table 3 and Map 7.

Troyer (1972) estimated 435,000 murres on Choweit in early May, 1972. The difference in the estimates may be due to differences in the technique and date of census. Troyer apparently included both birds on the cliffs and in the water around Chowiet, while we counted only the birds on the cliffs. Troyer censused from a large boat while we censused primarily from land and only used a small boat to count concealed ledges.

Although four sample plots were monitored for egg-laying and hatching, neither eggs or chicks could be counted on the crowded ledges. The first egg was found in a gull colony on June 6 by Martha Hatch (Pers. Comm.). We did not see any eggs on the ledges until June 18. The first fledgling was seen north of Chowiet on August 10.

Measurements of culmen length, diagonal tarsus length, wing length, and weight were taken on nine murres collected for food habits analysis. Measurements are given for both species in Table 4. Although the sample is small, there appears to be some difference in the measurements of Common and Thick-billed Murres. Swartz (1966) found significant differences in all measurements when the two species were compared and suggested that this may be related to differences in feeding niche.

Murres were nesting on all the islands in the Semidis that we surveyed, varying from as few as 400 birds to more than 230,000 (Table 5, Maps 8 to 12).

Pigeon Guillemot

Approximately 60 pair of Pigeon Guillemots nested at irregular intervals around Chowiet Island (Map 12). Nest sites were found in boulder piles, crevices in cliffs, and under large boulders on beaches.

Two Pigeon Guillemot nests were monitored for breeding phenology. Egg-laying calculated from known hatching dates and a 32-day incubation period (Drent, 1965) occurred on June 10 and 14. Gabrielson and Lincoln (1959) state that Pigeon Guillemots usually lay their eggs after June 1 in Alaska and that eggs were found in the Shumagins on June 24, 1892.

Chicks hatched on July 12 and 14 and fledged after 39-46 and 37-44 days respectively. On Mandarte Island, British Columbia, the fledging period was 35 days (n=15) with a range of 29 to 39 days (Drent, 1965).

Adults were observed foraging from ten meters to one kilometer from shore. The preferred feeding area appeared to be at the edge of the kelp beds, roughly ten to twenty meters from shore. Fish carried by adults on four trips to the nest included two sculpins (Cottidae), one sandlance (Ammodytes hexapterus), and one large greenling (Hexagrammidae).

Although a few Pigeon Guillemots were seen near all the islands we visited, their nesting status was determined only for Chowiet.

Horned Puffin

Horned Puffins first arrived in the waters around Chowiet Island on May 29 and first landed at colony on May 30.

We estimated that 54,000 pair of Horned Puffins nested ubiquitously around Chowiet Island (Map 14). Regular counts at 0930 hours showed that Horned Puffin numbers fluctuated tremendously (Fig. 1). This fluctuation may be related to feeding patterns, weather conditions, breeding phenology, or variation in numbers of non-breeding birds.

Horned Puffins nested in four habitat types: rock-pile, cliff, grass-rock and grass (Figs. 2 and 3). The highest burrow density was found in the rockpile habitat (.195 burrows/meter^2), followed by grass-rock (.05 lm^2), cliff (.02 lm^2), and grass (.006 lm^2). Within these habitat types five different nest sites were utilized (Fig. 2).

Egg-laying spanned a period of 25 days, from 14 June through 9 July with a mean egg-laying date of June 22 (Fig. 4).

Sixteen nests were monitored to determine the incubation period of Horned Puffins. Seven of the sixteen monitored nests contained eggs and four of these hatched. The average incubation period was 39 days with a range of 38 to 40 days. This differs from the 41.4 day incubation period (n=5) found by Sealy (1973) on St. Lawrence Island, Alaska. The small sample size or a difference in the time of initiation of incubation may account for the difference in incubation period.

A sample plot of 56 nests was established to gather information on hatching and the nestling period. Hatching spanned a period of 23 days, from 23 July to 17 August, with a mean hatching date of 31 July. Although none of the chicks fledged prior to our departure from Chowiet, two chicks were 37 days old and one was 39 days old when we left on 4 September. One Horned Puffin chick fledged at 38 days on St. Lawrence Island (Sealy, 1973).

Of the total of 48 eggs laid, 16 were lost during the incubation period giving a 66.6 percent hatching success. Of the 16 losses, 6 eggs were deserted due to human disturbance, 2 rolled out of the nest, 1 chick died during hatching and 7 disappeared.

Of the thirty-two chicks hatched, nineteen probably fledged giving a 59.49 fledging success. Three chicks died from starvation,, two were killed by rodents, one was killed by an adult, and seven disappeared. The overall breeding success was 39.6 percent.

A control study plot was established to monitor hatching success on Kateekuk Island. These nests were disturbed only twice during the breeding season: once during the incubation period and once during the nestling period. Hatching success was 100 percent (n=10). Fledging success was not determined because our last visit to Kateekuk was early in the nestling period.

Horned Puffins were frequently seen feeding around Chowiet Island after hatching began. Small sandlance and capelin (Mallotus villosus) were the predominate fish species in 20 fish loads delivered to nestlings.

Measurements of culmen length, diagonal tarsus length, wing length, and weight were taken on both the eight birds collected and the live adults captured (Table 6). Although mean lengths and weights of males were greater than females the differences were not significant (P.05).

Sealy (1974) states that the average weight of Horned Puffins on St. Lawrence Island was 599 grams (n=22). Birds collected from the

Semidis averaged only 518.5 grams (n=11). The reason for the difference in weight may be related to a higher productivity in northern waters (Raymont, 1963).

Horned Puffins nested on all the islands we visited in the Semidis. However, the only other island other than Chowiet that we were able to census was Kateekuk. We estimated that 28,000 pairs of Horned Puffins nested on this island. Nests were very accessible on Kateekuk and future studies of Horned Puffins in the Semidi Islands should be conducted there.

Tufted Puffin

Approximately 2000 pairs of Tufted Puffins nested in relatively isolated colonies on Chowiet Island (Map 15). The distribution of nests in two colonies is illustrated in Figures 5 and 6.

Tufted Puffins are mainly burrow nesters throughout most of their range (Sealy, 1973). This species burrowed extensively on Suklik, Kateekuk, Anowik, and Kiliktagik Islands. On Chowiet though, Tufted Puffins nested under large boulders on bedrock, in burrows under single boulders, and in crevices in rockpiles, while only a few pairs nested in burrows (Fig. 7).

The first eggs were found on 31 May. However, egg-laying calculated from known hatching dates extended from 25 May through 30 June (Fig. 8).

We monitored a sample plot containing seventeen nests to determine the incubation period of Tufted Puffins. Eggs were laid in nine of the nests and three of these eggs hatched. The incubation periods were 45 days, 41-44 days, and 56 days. Wehle (Pers. Comm.) found that the average incubation period of Tufted Puffins was 45 days (n=18) on Ugaiushak Island. The variation in the incubation period might be explained by individual differences in the actual beginning of brooding, replacement of a damaged egg, or laying of another egg by a different pair in the same nest site.

A sample plot containing fortyeight nests was established to gather information on the hatching and nestling period. Hatching of Tufted Puffins in 1976 spanned a period of 37 days, from 9 July to 14 August, with a mean hatching date of 19 July.

Only one Tufted Puffin chick had fledged by 4 September. This chick was 55 days old. The nestlings that remained in burrows ranged from 54 to 59 days old and still had remnants of down on their bodies. On Destruction Island, Washington, Tufted Puffin chicks fledged at 50.4 days of age (Burrell, unpubl. data). The long nestling period and slow development of chicks on Chowiet Island corresponded to their slow growth rates (Burrell and Leschner, unpubl. data).

Of the sample of 38 eggs from Chowiet Island, 22 were lost during the incubation period giving a 42 percent hatching success. Of the 22 losses, 19 eggs were deserted due to human disturbance, one died on hatching, one nest was taken over by a Horned Puffin, and one egg was cracked.

Of the 16 chicks hatched, nine probably fledged giving a 56 percent fledging success. Two chicks starved, one was killed by adults, and four disappeared. The overall breeding success was 23.7 percent.

A control study plot was established on Kateekuk to monitor hatching success. Twenty-four of the 28 eggs laid hatched (85.7%). Fledging success was not determined because our last visit to Kateekuk was prior to fledging.

The difference in hatching success between the two islands was due to different levels of human disturbance. Nests on Chowiet were disturbed during egg-laying and then regularly checked late in the incubation period, while nests on Kateekuk were disrupted only once during incubation. Fifty percent of the eggs on Chowiet were deserted because of human disturbance, while only 14 percent were deserted on Kateekuk.

Tufted Puffins were rarely seen feeding around Chowiet Island early in the breeding season. In August when feeding assemblages were more frequent around Chowiet, Tufted Puffins were often participants (Hoffman, Pers. Comm.). Sandlance and Walleye Pollock (Theragra Chalcogramma) were the predominate fish in 12 loads delivered to nestlings.

Measurements of culmen, diagonal tarsus, wing, and weight were taken on the six Tufted Puffins collected for food habits analysis (Table 7).

Tufted Puffins nested on all other islands we visited in the Semidis. An estimated 30,600 pairs of Tufted Puffins nested on Kateekuk Island. Suklik Island had an especially high density of burrows, and although we did not land to census the population in 1976, Troyer (1972) estimated a population of 65,000 Tufted Puffins. Future studies of Tufted Puffins in the Semidis should be conducted on Kateekuk or Suklik Islands.

Rhinoceros Auklet

We discovered three Rhinoceros Auklet colonies on Chowiet Island (Map 16). This extends the known breeding distribution 275 kilometers to the west. Formerly, the only colony reported outside of southeastern Alaska was that on Sud Island in the Barren Islands (Bailey, 1976).

Colony 1 was the largest colony with a total of 342 burrows (Fig. 9). The average percent occupancy was 64 percent. Thus, there were approximately 219 breeding pairs in this colony.

The other two colonies differed in size and occupancy (Figs. 10 and 11). Eighty percent of the 179 burrows in Colony 2 were occupied, for a total of 143 breeding pairs. Colony 3 was the smallest colony. Only 53.3 percent of the 45 burrows were occupied, so there were only 24 breeding pairs.

The patchy distribution of the Rhinoceros Auklet colies may be attributed to the absence of suitable habitat. Rhinoceros Auklets burrow only in areas of sufficient soil accumulation (Leschner, 1976). Most of the available nesting area on Chowiet was primarily bedrock or weathered boulder slides covered by a shallow sod. The three areas where Rhinoceros Auklets burrowed were characterized by relatively gradual slopes and a well-developed soil.

Mixed grasses (*Hordeum brachyantherum*, *Festuca altaica*, and *Phleum cummutatum*), Cow Parsnip (*Heraculum lanatum*), and Crowberry (*Empetrum nigrum*) were the most common plants in the three colonies. Although Rhinoceros Auklets nested in rye grass and crowberry associations, the majority of nests were in the mixed grass association.

Egg-laying dates can be calculated from hatching if the incubation period is known. Rhinoceros Auklets have a 45- to 46-day incubation period (Leschner, 1976). We calculated that egg-laying began the last week of May and extended through 17 June (Fig. 12).

Three sample plots were established to study the Rhinoceros Auklet nestling period. Hatching spanned a period of 28 days, with a mean hatching date of 16 July. The first chicks fledged on 19 August. Four chicks fledged at 45 - 54 days of age.

Adult Rhinoceros Auklets were never observed while feeding. Nestlings were fed only fish. The five fish loads recovered from adults were primarily composed of large sandlance.

Of the 45 eggs laid, 13 were lost during the incubation period, giving a 71.1 percent hatching success. Eleven of the 13 eggs lost were deserted due to human disturbance and two eggs disappeared.

Of the 32 eggs hatched, 23 probably fledged, giving a 72 percent fledging success. Five chicks were killed by ground squirrels, one died from a peck wound, and three disappeared. The overall breeding success was 51.1 percent.

Rhinoceros Auklets were not found on the other islands we visited. Aghiyuk Island does not appear to have suitable nesting habitat. There appears to be available habitat on Kateekuk Island, but no Rhinoceros Auklets were found. The species could be nesting on Anowik Island, but no Rhinoceros Auklet burrows were found during our cursory search of the east side of the island.

Parakeet Auklet

We estimated that there were 29,000 pairs of Parakeet Auklets nesting around Chowiet Island (Map 17). Regular counts of birds at 0930 hours showed that auklet numbers fluctuated considerably throughout the breeding season (Fig. 13). The variation in numbers may be related to weather conditions, feeding patterns, nesting phenology, or changes in the numbers of non-breeding birds. Parakeet Auklet numbers decreased drastically by mid-August when most of the nestlings had fledged.

Parakeet Auklets generally occupied the smallest crevices in any habitat (Fig. 14). The most common nest site was small crevices in boulder piles, but auklets also nested in small talus, crevices in cliffs, and occasionally under boulders on top of parent rock.

We found seven eggs of Parakeet Auklet on Chowiet Island between 28 May and 14 June in 1976. Eggs were collected from Kodiak Island on 19 June, 1884 (A. Fisher from Gabrielson and Lincoln, 1959). Preeble and McAtee (in Gabrielson and Lincoln, 1959) found Parakeet Auklets laying eggs between 8 June and 16 June in the Pribilofs. Sealy and Bedard (1973) found that egg-laying occurred between 12 June and 7 July on St. Lawrence Island.

Five eggs hatched between 25 June and 19 July. The mean hatching date was 10 July.

Information on nesting success was difficult to obtain because most of the nests were inaccessible. Of seven eggs monitored during the breeding season, two eggs were deserted and five eggs hatched. Two of these chicks died of starvation or exposure caused by human disturbance.

Eight of nine Parakeet Auklets collected contained plastic particles in their digestive systems. The maximum number found was 48 in the gizzard of one bird. Three plastic particles found in the gular pouch of one adult suggests the particles may be picked up during the breeding season. The effect of these plastic particles on Parakeet Auklets is unknown, but there is a definite need for further study.

Parakeet Auklets were occasionally seen feeding in tide rips around the islands, but most of the birds collected with food in their gular pouches were flying in from further offshore. Similarly, Bedard (1967) rarely observed Parakeet Auklets feeding less than one kilometer from St. Lawrence Island.

Measurements of the nine birds collected during the summer are given in Table 8. Three birds with brown wings, light bill color, and white with gray iris color were thought to be juveniles. These birds weighed less than the other birds collected. However, the sample is too small to determine if this difference is significant.

We observed Parakeet Auklets congregating in the waters near all the islands we surveyed, but no population estimates were obtained.

Least Auklet

Least Auklets were found breeding in one small colony on Chowiet Island (Fig. 15). According to Gabrielson and Lincoln (1959), the eastern limit of the Least Auklet's breeding distribution was the Shumagin Islands. Thus, the discovery of a colony on Chowiet Island extends the known breeding distribution 145 kilometers to the east.

Least Auklets arrived on colony on 10 June and left by 6 August. The maximum number of birds observed on daily counts was 15. The breeding population was estimated to be three to five pairs.

One nest was found in a small crevice in a rockpile. Locations of three to four other nests were discovered in small crevices under boulders, but access was impossible.

The egg in the single accessible nest hatched on 20 July. The nestling died one day after hatching because of human disturbance.

No Least Auklets were seen on any of the other islands.

Ancient Murrelets

The first Ancient Murrelets were seen between Anowik and Chowiet Islands on 11 June. Hatch (Pers. Comm.) estimated their numbers at 100 to 200 pairs.

Ancient Murrelets were only found nesting on Kateekuk Island (Map 18). We estimated that they numbered approximately 400 to 600 pairs. An accurate estimate was not possible because we were unable to distinguish burrows of murrelets from those of puffins and arctic ground squirrels.

Burrows were found in areas of both sandy and loamy soils. Average burrow length was approximately one meter and did not vary with substrate. All burrows of murrelet that we found were within one to two meters of burrows belonging to Tufted or Horned Puffin. In one case, murrelet egg shells were found within the engtance of a Horned Puffin burrow.

On 26 July, the chicks had left three of the four nests occupied on 15 July. The fourth nest contained two deserted eggs.

An Ancient Murrelet fledgling was seen north of Chowiet Island on 10 August. This was the last murrelet seen during the summer.

Crested Auklet

Crested Auklets were occasionally seen north of Chowiet Island, but no colonies were found. One adult Crested Auklet in breeding plumage was collected on 11 June by Scott Hatch. We saw one group of five Crested Auklets in breeding plumage on 19 June. On 27 June, two were seen between Kateekuk and Aghiyuk Islands. Gabrielson (1959) saw Crested Auklets in the Semidis on 5 August.

Bedard (1969) describes the nesting habitat of Crested Auklets as talus slopes. Aghiyuk is the only island in the Semidis with extensive areas of talus, but we did not have the opportunity to search any talus slides on Aghiyuk and no Crested Auklets were seen on our brief survey of the island.

Cassin's Auklet

Cassin's Auklets were seen occasionally in the waters around the Semidis. Adults in breeding plumage landed on a boat anchored at night off Chowiet on 2 May (Moe, Pers. Comm.). We saw five Cassin's Auklets approximately one kilometer northwest of Chowiet Island on 27 June.

Cassin's Auklets were not found nesting on Chowiet or on the other islands we visited. On one overnight visit to Kateekuk, we did not hear or see any Cassin's Auklets, and all of the burrows excavated were occupied by other burrowing species. However, our exploration of other islands in the Semidi group was limited. There appears to be suitable nesting habitat for this nocturnal species on Suklik, Aliksemit, and Kiliktagik Islands.

Laridae

Black-legged Kittiwake

We estimated that 7,804 pairs of Black-legged Kittiwakes nested on Chowiet Island. (Map 8). The population was censused in mid-August and only active nests were included in the count. The location of sample points, the number of kittiwakes counted at each location, and a photographic record are given in Table 3.

Troyer (1972) estimated that 55,000 kittiwakes were present around Chowiet in early May, 1972. The large discrepancy between estimates may be due to the date of census and the technique. Our estimates were made when many pairs had failed and had left the nesting ledges. Troyer censused the population from a boat and included all birds seen while we censused from land and from a boat and counted only active nests.

On Chowiet, kittiwakes nested on inaccessible cliffs. Five sample plots containing a total of 65 nests were monitored by spotting scope for breeding phenology. Egg-laying spanned a period of 23 days, from 15 June to 8 July, with 83 percent of the eggs laid between 15 and 26 June (Fig. 16). Bent (1922) reported that eggs were collected in the Semidis on 1 July, 1911.

The clutch size of Black-legged Kittiwakes on Chowiet Island in 1976 averaged 1.81 eggs (n=27 nests). This is similar to that reported by other workers, e.g., 1.85 (Maunder and Threlfall, 1972), 1.84 (Swartz, 1966), and 2.05 (Coulson and White, 1958a). Clutch size may be related to food supply (Lack, 1968) or age and previous breeding experience of the bird (Coulson and White 1958a, 1958b).

Hatching occurred from 7 July to 4 August, and the first fledgling was seen on 20 August.

Only nine chicks survived to fledging of 49 eggs that were laid in our sample of nests (Table 9). The reason for the poor success is not known. Bad weather or predation by gulls and ravins may have contributed to the poor reproductive success. This is one aspect that should be monitored and compared to other colonies in the future.

Nine Kittiwakes were collected during the breeding season for analysis of food habits and examination for endoparasite. Measurements of culmen, diagonal tarsus, wing and weight were taken on the collected birds (Table 10). Average weights and measurements of wings were greater in males than in females, but this difference was not statistically significant (P .05). Swartz (1966) also found a slight sexual dimorphism in body size in Black-legged Kittiwakes. However, he was not able to use these differences for sexing live birds because of the high degree of overlap.

Black-legged Kittiwakes were observed foraging primarily in tide rips until the last week of July. Thereafter, they formed large feeding assemblages. This activity is associated with feeding on schools of small fish (Hoffman, Pers. Comm.).

Black-legged Kittiwakes were nesting on five of the seven of the islands that we surveyed, with largest colonies occurring on Aghiyuk Island (Table 11, Maps 7 to 10).

Glaucous-winged Gull

A total breeding population of 354 pairs of Glaucous-winged Gulls were counted in 15 colonies on Chowiet Island (Map 19). Colony size ranged from 3 to 130 pairs. Figures 17 and 18 illustrate the distribution of nests in the two intensively studied colonies.

Colonies were located among boulders and on exposed bedrock. Gulls nested primarily in beach rye grass and cow parsnip. Nests were constructed of dried moss, lichens, and beach rye grass (Fig. 19).

All nesting phenology data was gathered from 90 nests in Colony M. Egg-laying began the last week of May and ended on 28 June (Fig. 20). The peak of laying was 9 through 17 June. Average clutch size from three colonies varied from 2.44 to 2.55 eggs (Table 12). Hatching occurred from 17 June to 17 July, with a peak between 3 and 12 July. The first fledgling was seen on 28 July.

Eleven percent of the occupied nests in the sample plot lost eggs. Five single egg clutches, one complete 2-egg clutch and two complete 3-egg clutches were lost and the eggs were not replaced. The reason for the high proportion of single egg clutches lost is not known.

We were unable to quantify hatching success because we could not determine if chicks were actually gone or only well-hidden in the tall grass. We did find 13 dead chicks on one visit, but it is unknown what percent of the total number lost this represents.

Glaucous-winged Gulls are primarily scavengers. On Chowiet Island gulls ate limpets (Collisella sp.), chitons (Katharina tunicata), mussels (Mytilus sp.) Fulmar eggs, murre eggs, Black-legged Kittiwake eggs, fish, and dead sea lion pups. Gulls were most often seen foraging in the murre, kittiwake and Fulmar colonies, in tide rips, along the intertidal and in feeding frenzies late in the summer.

Glaucous-winged Gulls nested on all the islands we visited in the Semidis. Gulls were censused on only one other island, Kateekuk. Approximately 75 to 100 pairs of Glaucous-winged Gulls were found nesting there.

Phalacrocoracidae

Red-faced and Pelagic Cormorants

There were two cormorant colonies on Chowiet Island in 1976 (Map 19). The colony on the northwest side of the island was the most accessible and all information was collected there. Sixty-three pairs of cormorants occupied nests in the colony. The occupants of 50 nests identified to species included 37 (74%) nests of Red-faced Cormorants and 13 (26%) of Pelagic Cormorants.

Colony attendance decreased during the breeding season. On 1 May, 52 nests in one sample plot were occupied. On 7 July, only five nests were occupied.

Cormorant nests were built on ledges on the side of a sheer cliff. There was no apparent nest site segregation between the two species.

Fifty-seven nests were monitored for egg-laying. Eggs were laid in only nine of the nests. The first eggs were laid by Pelagic Cormorants between 1 and 9 June and the first Red-faced Cormorant eggs were laid between 9 and 16 June. Only 3 eggs hatched of 16 eggs in the 6 nests monitored through incubation (Table 13). It was difficult to determine the cause of the extremely poor nesting success on Chowiet Island. However, there are three possible explanations: Raven predation, Glaucous-winged Gull predation, or inclement weather during the incubation period.

Although both species of cormorants were seen on other islands in the Semidis, no breeding colonies were found.

Procellariidae

Northern Fulmar

Fulmars were the subject of an intensive study by Scott Hatch and information on this species is summarized in Part III of this report.

Hydrobatidae

Fork-tailed and Leach's Petrels

Both Fork-tailed and Leach's Petrels nested in the Semidis. Petrels landed at night on boats anchored off Chowiet on 2 May (Hatch, Pers. Comm.) and on 28 July (Hoffman, Pers. Comm.) in 1976. However, we did not find any nests on Chowiet. We did find one Fork-tailed Petrel nest and one Leach's Petrel nest on Kateekuk Island. Other burrows were excavated on Kateekuk, but only puffins were found. Petrels may nest on other islands in the Semidis, but we were unable to conduct a thorough search of islands other than Chowiet and Kateekuk.

The Fork-tailed Petrel nest found on 15 July on Kateekuk was in a beach rye-grass hummock less than two meters from Tufted Puffin burrows. The burrow was less than .5 meters long and the entrance was small. There was no nesting material in the nest chamber.

The Leach's Petrel nest found on 26 July was in matted beach rye-grass roots less than .2 meters from Horned Puffin burrows. This burrow was also short and there was no nesting material. Although this was the only Leach's Petrel nest found, we heard five to fifteen Leach's Petrels calling at 2330 hours on 25 July.

Both the Fork-tailed and Leach's Petrels were incubating eggs when we excavated the burrows on 15 July and 26 July, respectively. The Fork-tailed Petrel was still present on 26 July but had deserted the egg on 4 August. The Leach's Petrel was still incubating on our last visit, 16 August.

Anatidae

Common Eider

We censused the nearshore waters around Chowiet Island in late May and counted 30 pairs of Common Eiders. Brooks (1915) reported Common

Eiders in the Semidis as early as 18 April. Allen Moe (Pers. Comm.) saw 22 male and 17 female Common Eiders around Chowiet on 5 May, 1976. Juvenile eiders were seen in small numbers throughout the summer.

Seven Common Eider nests were found (Map 20). All of the nests were in beach rye-grass and five of the seven nests were located in Glaucous-winged Gull colonies.

Five completed clutches were found. Clutch size ranged from three to five eggs with a mean clutch size of 4.0 eggs.

In one nest monitored from onset through incubation, the clutch was completed on 18 June and the three eggs hatched on 16 July after an incubation period of 28 days. The first ducklings were seen on 29 June. None of the ducklings fledged prior to our departure on 4 September.

Common Eiders fed close inshore near the kelp beds. Sea urchins (<u>Strongylocentrotus sp.</u>) appeared to be an important food item.

Adult Common Eiders were seen in the waters around Aghiyuk, Anowik, and Kiliktagik Islands.

Haematopodidae

Black Oystercatcher

Black Oystercatchers were the only shorebird nesting on Chowiet Island. Nesting was also observed on Aghiyuk and Kateekuk Islands but their status on other islands was not determined. Twenty pairs of oystercatchers were counted on Chowiet (Map 21). The absence of Black Oystercatchers from the south end of the island may be caused by presence of sea lions which occupied all suitable habitat.

All nests were either on rocky beaches or on bedrock outcrops near the water. Three of the nests were located in gull colonies. Nests consisted of shell fragments, limpet shells, and small pebbles.

Egg-laying of Black Oystercatchers in three nests spanned a period of 25 days. Since the average incubation period is 27 to 28 days (Nysewander, Pers. Comm.), eggs piped in one nest on 9 June were probably laid about 13 May. In the two other nests, eggs were laid on 6 and 8 June.

The incubation period of one pair of Oystercatchers was 28-29 days. The two chicks hatched from this nest on 5 July. Both chicks fledged by 19 August at the age of 45 days.

Adults fed primarily at low tide in the intertidal zone. We found numerous chiton, small mussel, and limpet shells in the areas where chicks were fed.

Three nests were monitored for nesting success (Table 14). Five other nests were found late in the breeding season and thus success could not be calculated. One pair apparently made two attempts at nesting for a single egg was found in different nests in the same territory on two different dates. Three other nests contained two chicks and one nest contained three chicks. The fate of these chicks is unknown.

Conclusions

Seventeen species of seabirds nested in the Semidi Islands during the summer of 1976. Two other species, Cassin's Auklets and Crested Auklets, were occasionally seen, but no breeding populations were found. Cliff-nesting species were surveyed on all the major islands, but the number and distribution of crevice, burrow, and open nesting species was obtained only on Chowiet and Kateekuk Islands. A summary of our estimates for the size populations is provided in Table 15. There is a definite need for extensive exploration of the other seven islands.

The number and distribution of species on Chowiet Island usually appeared to be independent of interspecific activities. However, on some occasions murres influenced the local distribution of Black-legged Kittiwake nests by roosting on kittiwake ledges and destroying their nests. Also, Tufted Puffin and Parakeet Auklet nests were sometimes occupied by Horned Puffins and the egg or chick evicted. The frequency of this loss of nests to other species and its effect on the overall distribution is unknown.

Seabird populations fluctuated daily and with the period of the breeding season. Numbers of Horned Puffins were greatest when they first arrived, while Parakeet Auklets were most abundant during incubation and hatching. Both species also had daily population fluctuations. Other seabirds also showed fluctuations in their populations, but these changes were not quantified. Reasons for population fluctuations may be related to breeding phenology, weather conditions, availability of food, and variation in numbers of non-breeding birds.

Nesting habitat had an important effect on the number and distribution of species. Murres, cormorants and kittiwakes occupied only steep cliffs with areas of numerous ledges. Rhinoceros Auklets nested only in areas with well developed soils. All seabirds nested only around the perimeter of Chowiet Island, although there appeared to be suitable nesting habitat further inland. The reason for the limited distribution is unknown.

Dates of reproductive events were determined for most species on Chowiet Island. The phenologies of representative species are summarized in Figure 21. Horned Puffins and Least Auklets were the only nesting species that were not present when we arrived on 26 May. Only Least and Parakeet Auklets had left the Semidis prior to our departure on 4 September.

Breeding seasons of seabirds have presumably evolved so that the timing of egg-laying maximizes the chance of successfully producing young (Lack, 1968). Seasonal variations in food supply have been shown to be a proximate selective force determining the breeding season (Salmonsen, 1955; Bedard, 1969; and Sealy, 1975). Sealy (1975) showed that predominately plankton feeding species began egg-laying earlier than fish feeding species and completed the breeding season while the fish feeding species were still feeding their young.

Although there was no major difference in the initiation of egg-laying between plankton and fish feeding species on Chowiet, there was a difference in fledging and adult departure times. This is due to a greater synchrony of egg-laying and a shorter incubation and nestling period in Parakeet and Least Auklets. Thus, Parakeet Auklets left Chowiet by 20 August and Least Auklets by 6 August, while Horned Puffins, Tufted Puffins, and Rhinoceros Auklets were still feeding their young.

The seemingly low nesting success of seabirds on the Semidi Islands may be attributed to several factors. Inclement weather, egg and chick predation by gulls and ravens, and poor feeding conditions, all probably lowered production of cliff nesting species. Nesting success was lowered in crevice and burrow nesting species by egg desertion due to human disturbance even though interference was minimized, nestling predation by ground squirrels, and starvation of nestlings presumably due to poor feeding conditions.

We feel that the primary reason for the low nesting success of all species was related to the food supply. The importance of the food supply to seabirds has been established by many authors (Belopol'skii, 1957; Salmonsen, 1955; Ashmole, 1963; Lack, 1968; Bedard, 1969; and Sealy, 1975). However, more information about the availability and abundance of food resources in the Semidis is necessary, for, as Bedard (1969) has pointed out, only indirect evidence such as an observed decrease in growth rate or an increase in the deaths of nestlings is available to classifiy this year as a "poor" food year.

The major foraging areas for seabirds in the Semidis were impossible to determine without numerous ship transects. However, tide rips, particularly those north and west of Chowiet and Kateekuk, appeared to be important feeding areas. After the first of August, numerous feeding frenzies were seen close to Chowiet Island. More information is needed to determine the important feeding areas for the seabirds of the Semidi Islands.

Only preliminary conslusions are possible from this initial study as nearly all our data suggest that there must be much seasonal variation in population and in production of young. For example, productivity of some species was so low, i.e., cormorants, that it could not sustain the population. We consider long-term studies essential for evaluation of these annual fluctuations and to establish realistic values for monitoring.

More information is needed in the following areas:

1. A comparison of 1976 with other years to determine what is a Normal year.

2. An analysis of prey availability and abundance.

3. A definition of the major feeding areas near the Semidis and a determination of how far away principal species are foraging.

4. Quantification of the effect of ground squirrels on seabirds.

5. A thorough survey of the seven other Semidi Islands to determine what other species could be present.

Bibliography

Ashmoel, N. P. 1963. The regulation of numbers of tropical oceanic birds. Ibid 103b:458-473.

Bailey, E. P. 1976. Breeding bird distribution and abundance in the Barren Islands, Alaska. The Murrelet 57(1):2-12.

Bedard, J. 1967. Ecological segregation among plankton-feeding Alcidae. Unpubl. Ph.D. thesis, University of British Columbia.

Bedard, J. 1969. Feeding of the Least, Crested, and Parakeet Auklets around St. Lawrence Island, Alaska. Can. J. Zool. 47:1025-1050.

Belopol'skii, L. O. 1957. Ecology of sea colony birds of the Barents Sea. Israel Program for Scientific Translations, Jerusalem, 1961.

Brooks, W. S. 1915. Notes on birds from East Siberia and Arctic Alaska. Bull. Mus. Comp. Zool., 59, pp. 361-413.

Cobb, E. H., A. A. Wanek, A. Grantz and C. Carter. 1968. Summary report on the geology and mineral resources of the Bering Sea, Bogoslof, Simeonof, Semidi, Tuxedni, St. Lazaria, Hazy Islands and Forrester Island National Wildlife Refuges. Geological Survey Bull. 1260-K. U.S. Govt., Wash. D. C.

Coulson, J. C. and E. White. 1958a. The effect of age on the breeding biology of the kittiwake (Rissa tridactyla). Ibid 100:40-51.

Coulson, J. C. and E. White. 1958a. Observations on the breeding of the kittiwake. Bird Study 5:74-83.

Drent, R. H. 1965. Breeding biology of the Pigeon Guillemot, Cephus columba. Ardea 53:99-160.

Gabrielson, I. N. and F. C. Lincoln. 1959. Birds of Alaska. The Stackpole Co., Harrisburg, Pa.

Lack, D. 1968. Population studies of birds. Clarendon Press, Oxford.

Leschner, L. L. 1976. The breeding biology of the Rhinoceros Auklet on Destruction Island. M. Sci. Thesis. University of Washington.

Maunder, J. E. and W. Threlfall. 1972. The breeding biology of the Black-legged Kittiwake in Newfoundland. The Auk 89(4):789-816.

Raymont, J. E. G. 1963. Plankton and productivity in the oceans. Pergamon Press, Oxford.

Salmonsen, F. 1955. The food production in the sea and the annual cycle of Faerose marine birds. Oikos 6:92-100.

Sealy, S. G. 1973. Breeding biology of the Horned Puffin on St. Lawrence Island, Bering Sea, with zoogeographical notes on the North Pacific puffins. Pacif. Sci. 27:99-119.

Sealy, S. G. 1975. Feeding ecology of the Ancient and Marbled Murrelets near Langara Island, British Columbia. Can. J. Zool. 53:418-433.

Sowls, L. W. and Bartonek J. C. 1974. Seabirds - Alaska's most neglected resource. N. Am. Wildl. and Nat. Res. Conf. 39:117-126.

Swartz, L. G. 1966. Sea-cliff birds, pp.611-678. In N. J. Wilimovsky and J. N. Wolf (ed.) Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tenn.

The Pacific Seabird Group. 1975. Seabird Colony census techniques. 18 pp.

Troyer, W. A. 1972. Semidi wilderness proposal. U.S. Fish and Wild. Serv. 22 pp.

U.S. Coast and Geodetic Survey. 1964. U.S. Coast Pilot, Pacific and Arctic Coasts. U.S. Dept. of Commerce, Wash. D.C.

TABLES

Table 1. A list of plant species collected on Chowiet Island.

Achillea borealis
Acontium delphinum
Agrostis scabra
Androsace chamaejasme
Angelica lucida
Antennaria monocephala
Arctostaphylos alpina
Arnica lessingii
Artemisia arctica
Artemisia tilesii
Athyrium filix-femina
Botrychium lanceolatum
Calamagrostis canadensis
Caltha palustris
Campanula lasiocarpa
Carex spp.
Castilleja unalaschcensis
Chrysanthemum arcticum
Claytonia siberica
Cornus sueica
Dodecatheon pulchellum
Draba borealis
Elymus arenarius
Empetrum nigrum
Epilobium angustifolium
Epilobium behringianum
Epilobium latifolum
Eriophorum russeolum
Equisetum arvense
Festuca altaica
Fritillaria camschatcensis
Galium triflorum
Gentiana algida
Gentiana amarella
Gentiana prostrata
Geranium erianthum
Geum rossii
Heracleum lanatum
Hordem brachyantherum
Iris setosa
Juncus spp.
Ledum palustre
Ligusticum scoticum
Lupinus nootkatensis
Orobanche fasciculata
Pedicularis verticillata
Petasites frigidus
Phleum commutatum
Plantago maritima
Plantanthera convallariaefolia
Polemonium acutiflorum
Polygonum viviparum
Potentilla villosa
Pyrola asarifolia
Ranunculus occidentalis
Rhododendron camtschaticum
Rubus arcticus
Rubus chamaemorus
Salix spp.
Sanguisorba stipulata
Saxifraga bracteata
Sedum rosea
Senecio pseudo-arnica
Solidago multiradiata
Swertia perennis
Vaccinium uliginosum
Vaccinium vitis idaea
Viola langsdorffii

Table 2. Breeding and migrant bird species seen in the Semidi Islands during the summer of 1976.

Species	Breeding	Migrant
Fulmar (*Fulmarus glacialis*)	X	
Fork-tailed Petrel (*Oceanodroma furcata*)	X	
Leach's Petrel (*O. leucorhoa*)	X	
Pelagic Cormorant (*Phalacrocorax pelagicus*)	X	
Red-faced Cormorant (*P. urile*)	X	
Brant (*Branta bernicla*)		X
Pintail (*Anas acuta*)		X
Green-winged Teal (*A. carolinensis*)		X
Greater Scaup (*Aythya marila*)		X
Harlequin (*Histrionicus histronicus*)		X
Common Eider (*Somateria mollissima*)	X	
White-winged Scoter (*Melanitta deglandi*)		X
Bald Eagle (*Haliaeetus leucocephalus*)	X	
Peregrine (*Falco peregrinus*)	X	
Black Oystercatcher (*Haematopus bachmani*)	X	
Semi-palmated Sandpiper (*Charadrius semipalmatus*)		X
Surfbird (*Aphriza virgata*)		X
Ruddy Turnstone (*Arenaria interpres*)		X
Black Turnstone (*A. melanocephala*)		X
Wandering Tattler (*Heteroscelus incanum*)		X
Rock Sandpiper (*Eurolia ptilocnemis*)		X
Pectoral Sandpiper (*E. melanotos*)		X
Least Sandpiper (*E. minutilla*)		X
Western Sandpiper (*Ereunetes mauri*)		X
Parasitic Jaegar (*Stercorarius parasiticus*)	X	
Glaucous-winged Gull (*Larus glaucescens*)	X	
Mew Gull (*L. canus*)		X
Black-legged Kittiwake (*Rissa tridactyla*)	X	
Common Murre (*Uria aalge*)	X	
Thick-billed Murre (*U. lomvia*)	X	
Pigeon Guillemot (*Cephus columba*)	X	
Ancient Murrelet (*Synthliboramphus antiquum*)	X	
Cassin's Auklet (*Ptychoramphus aleutica*)	?	
Parakeet Auklet (*Cyclorrhynchus psittacula*)	X	
Crested Auklet (*Aethia cristatella*)	?	
Least Auklet (*Aethia pusilla*)	X	
Rhinoceros Auklet (*Cerorhinca monocerata*)	X	
Horned Puffin (*Fratercula corniculata*)	X	
Tufted Puffin (*Lunda cirrhata*)	X	
Common Raven (*Corus corax*)	X	
Tree Swallow (*Iridoprocne bicolor*)		X
Winter Wren (*Troglodytes troglodytes*)	X	
Hermit Thrush (*Hylocichla guttata*)	X	
Water Pipit (*Anthus spinoletta*)	X	

Table 2. Continued

Species	Breeding	Migrant
Yellow Warbler (*Dendroica petechia*)	X	
Wilson's Warbler (*Wilsonia pusilla*)	X	
Gray-crowned Rosy Finch (*Leucosticte tephrocotis*)	X	
Pine Siskin (*Spinus pinus*)		X
Savanna Sparrow (*Passerculus sandwichensis*)	X	
Golden-crowned Sparrow (*Zonotrichia atricapilla*)	X	
Fox Sparrow (*Passerela iliaca*)	X	
Song Sparrow (*Melospiza melodia*)	X	
Lapland Longspur (*Calcarius lapponicus*)	X	
Snow Bunting (*Plectrophenax nivalis*)	X	

Table 3.

The location of sample points, the number of Murres and Black-legged Kittiwakes estimated at each location, and a list of photographs taken. Estimates made on 12 August, 1976.

Time	Location	Murres	Black-legged Kittiwakes	Picture (No.)	Description
1000	1). Northwest point	1,750	40	2-3	Flat rock and cliff
1100	2). Point between #1 and cliff	1,370	101	4	Murres and kittiwakes on flat ledge
				5	Ledge just before cliff
				6	Cliff face
	3).	800	30	7	Rock could only see small portion of at #2
				8	Location of first 3 counts & eagle nest, #1 before eagle nest
				9	Cliff face on pinnacle below #2
	4).	410	36		
1130	5). Study plots on offshore rocks	4,700	520	10-14	Rock - left to right count (South to North)
	6). North side of pinnacle bordering gull colony	1,950	51	15	Rock directly below point
		600		16-17	Offshore rocks through cleft
1300	7). Main gull colony "O"	1,280	102	18	Gull colony - Kittiwake and Murre plots
		5,200	76	19	Cliff south of gull colony
	8).	500	101	20	Part of cut southeast of Gull colony "O"

Table 3. Continued

Time	Location	Murres	Black-legged Kittiwakes	Picture (No.)	Description
1600	9). Gull colony "N"-walked down to point	52,120	784	21-30	Overlapping pictures from point below main gull colony "O" to bottom of colony "N"
1700	10). Rocks southwest and below gull colony "N"	19,700	549	31-37	Rocks southwest of gull colony "N". From north to south, could not count two major crevices

Table 4. External measurements (in millimeters) and weight (in grams) of adult Common and Thick-billed Murres collected in the Semidi Islands.

	Common Murre				Thick-billed Murre			
Sex	Weight	Wing	Diagonal Tarsus	Culmen	Weight	Wing	Diagonal Tarsus	Culmen
M	1175	210	50.5	48.0	1130	230	43.0	45.5
M	1050	214	53.5	50.0	1035	222	44.5	45.0
M					1160	232	47.0	42.5
F	1140	207	48.0	46.0				
F	1030	222	47.0	43.5				
F	1185	220	48.0	41.4				
F	930	205	47.0	45.0				
Mean	1085	213	49.0	45.6	1108	228	44.8	44.3

Table 5. Population estimates of Common and Thick-billed Murres on the islands censused in 1976.

Island	Date of Census	Population Estimate/1
Aghiyuk	27 June	231,000
Aghik	27 June	36,000
Anowik	16 August	13,315
Chowiet	12 August	141,150
Kiliktagik	10 August	400
Kateekuk	16 August	26,300
Suklik	10 August	10,000

/1 Figures include on birds present on cliffs. Bird on the water adjacent to islands were not counted.

Table 6. External measurements (in millimeters) and weights (in grams) of adult Horned Puffins measured in the Semidi Islands

Measurement	Sex	Number Measured	Mean	Range
Wing Length	M	3	183.6	177 - 188
	F	5	178.4	170 - 184
	M + F	11	179.7	170 - 188
Diagonal Tarsus	M	3	36.5	35.0 - 37.5
	F	5	36.3	35.0 - 39.5
	M + F	10	36.4	35.0 - 39.5
Culmen	M	3	49.1	47.0 - 51.2
	F	5	45.6	43.5 - 50.0
	M + F	8	46.9	43.5 - 51.2
Weight	M	3	553.7	520 - 581
	F	5	524.4	487 - 585
	M + F	11	518.5	435 - 585

Table 7. External measurements (in millimeters) and weights (in grams) of adult Tufted Puffins collected in the Semidi Islands.

Sex	Wing	Culmen	Diagonal Tarsus	Weight
M	201	61.0	42.0	770
M	194	58.0	46.0	750
M	198	58.0	39.0	790
M	193	59.0	43.5	805
M	205	57.0	45.5	770
M	201	62.0	45.0	798
Mean	198.7	59.2	43.5	780.5

Table 8. External measurements (in millimeters) and weights (in grams) of adult Parakeet Auklets.

Sex	Eye Color	Wing Color	Wing	Diagonal Tarsus	Culmen	Weight
M	White	Black	152	37.0	14.0	281
M	White	Black	151	35.5	15.5	271
M	White	Black	150	35.5	15.0	278
M	White	-----	149	36.5	16.5	270
M	White	Black	145	35.0	15.0	269
F	White	Black	146	34.5	15.8	263
Mean			148.8	35.6	15.3	272
M	White & Gray	Brown	142	34.0	15.2	240
M	White & Gray	Brown	147	35.0	15.9	222
F	White & Gray	Brown	145	37.0	14.4	228
Mean			144.7	35.3	15.2	230

Table 9. Nesting success of Black-legged Kittiwakes on Chowiet Island.

Category	1976
Total active nests	27
Total eggs laid	49
Average clutch size	1.81
Total fledged	9
Breeding success (%)	18.3

Table 10. External measurements (in millimeters) and weight (in grams) of Black-legged Kittiwakes collected in the Semidi Islands.

Measurement	Sex	Number Measured	Mean	Range
Wing Length	M	3	318.3	315 - 320
	F	6	300.1	296 - 310
	M + F	9	306.2	296 - 320
Culmen	M	3	37.7	36.5 - 38.5
	F	6	37.6	35.2 - 39.5
	M + F	9	37.7	35.2 - 39.5
Diagonal Tarsus	M	3	42.2	41.0 - 43.0
	F	6	41.3	40.5 - 43.0
	M + F	9	41.6	40.5 - 43.0
Weight	M	3	408.3	372 - 438
	F	6	390.1	358 - 431
	M + F	9	396.2	358 - 438

Table 11. Population estimates of Black-legged Kittiwakes on the islands censused in 1976.

Island	Date Censused	Population Estimate (number of pairs)
Aghiyuk	27 June	77,000
Aghik	27 June	-------
Anowik	16 August	2,600
Chowiet	12 August	7,804
Kiliktagik	10 August	0
Kateekuk	16 August	7,342
Suklik	10 August	2,240

Table 12. Clutch size of Glaucous - winged Gulls nesting on Chowiet and Aghiyuk Islands.

Location	Number of one-egg nests	Number of two-egg nests	Number of three-egg nests	Total Number of nests	Average clutch size
Colony 'M'	6	30	54	90	2.53
Colony 'C'	1	8	9	18	2.44
Aghiyuk	1	2	6	9	2.55

Table 13. Combined nesting success of Pelagic and Red-faced Cormorants on Chowiet Island.

Category	1976
Total active nests	6
Total number of eggs	16
Number of eggs per nest	2.67
Total number of chicks hatched	3
Hatching success (%)	18.8
Number of chicks probably fledged	3
Breeding success (%)	18.8

Table 14. Nesting success of Black Oystercatchers on Chowiet Island.

Category	1976
Total number of nests	3
Total number of eggs	8
Number of eggs per nest	2.67
Total number of chicks hatched	7
Hatching Success (%)	87.5
Total number of chicks fledged	6
Breeding Success (%)	75.0

Table 15. Estimated number of seabirds nesting in the Semidi Islands 1976.

Species	Aghiyuk	Aghik	Anowik	Chowiet	Kaliktagik	Kateekuk	Suklik
Common and Thick-Billed Murres /1	231,000	36,000	13,315	141,150	400	26,300	10,000
Pigeon Guillemot	X		X	60	X	X	X
Horned Puffin	X	X	X	54,000	X	28,000	X
Tufted Puffin	X	X	X	2,000	X	30,600	X
Rhinoceros Auklet				386			
Parakeet Auklet	X	X	X	29,000	X	X	X
Least Auklet				3-5			
Ancient Murrelet						400-600	
Black-legged Kittiwake	77,000	X	26,000	7,804	0	7,342	2,240
Glaucous-winged Gull	X	X	X	354	X	75-100	X
Red-faced Cormorant				47			
Pelagic Cormorant				16			
Fork-tailed Petrel						X	
Leach's Petrel						X	
Common Eider	X		X	30	X		
Black Oystercatcher	X			20		X	

/1 Estimates for murres represent the number of individuals, while estimates for the other species are given as number of pairs. X denotes presence.

FIGURES

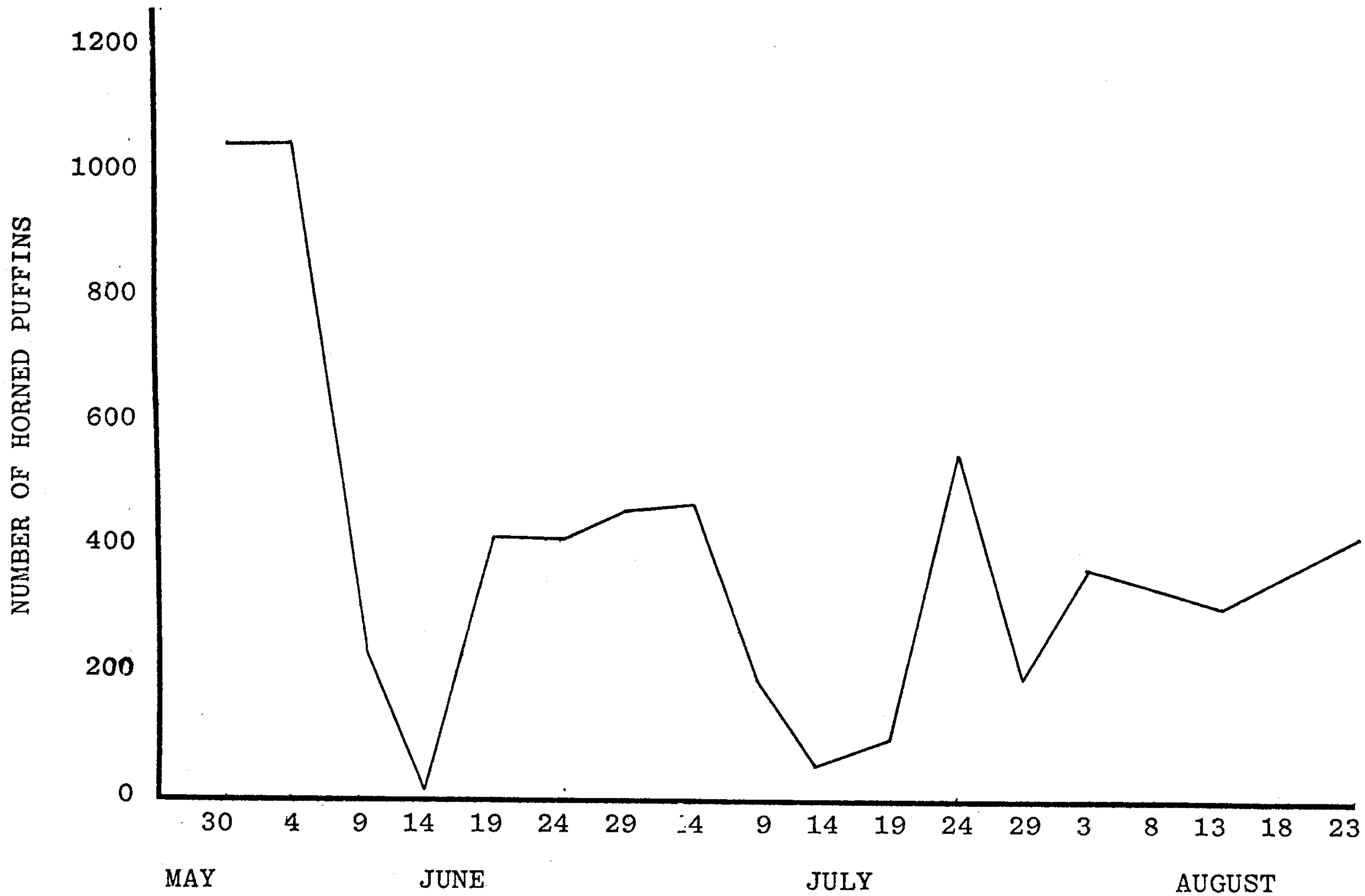


Figure 1. Regular counts of Horned Puffins made at 0930 hours from the same location.

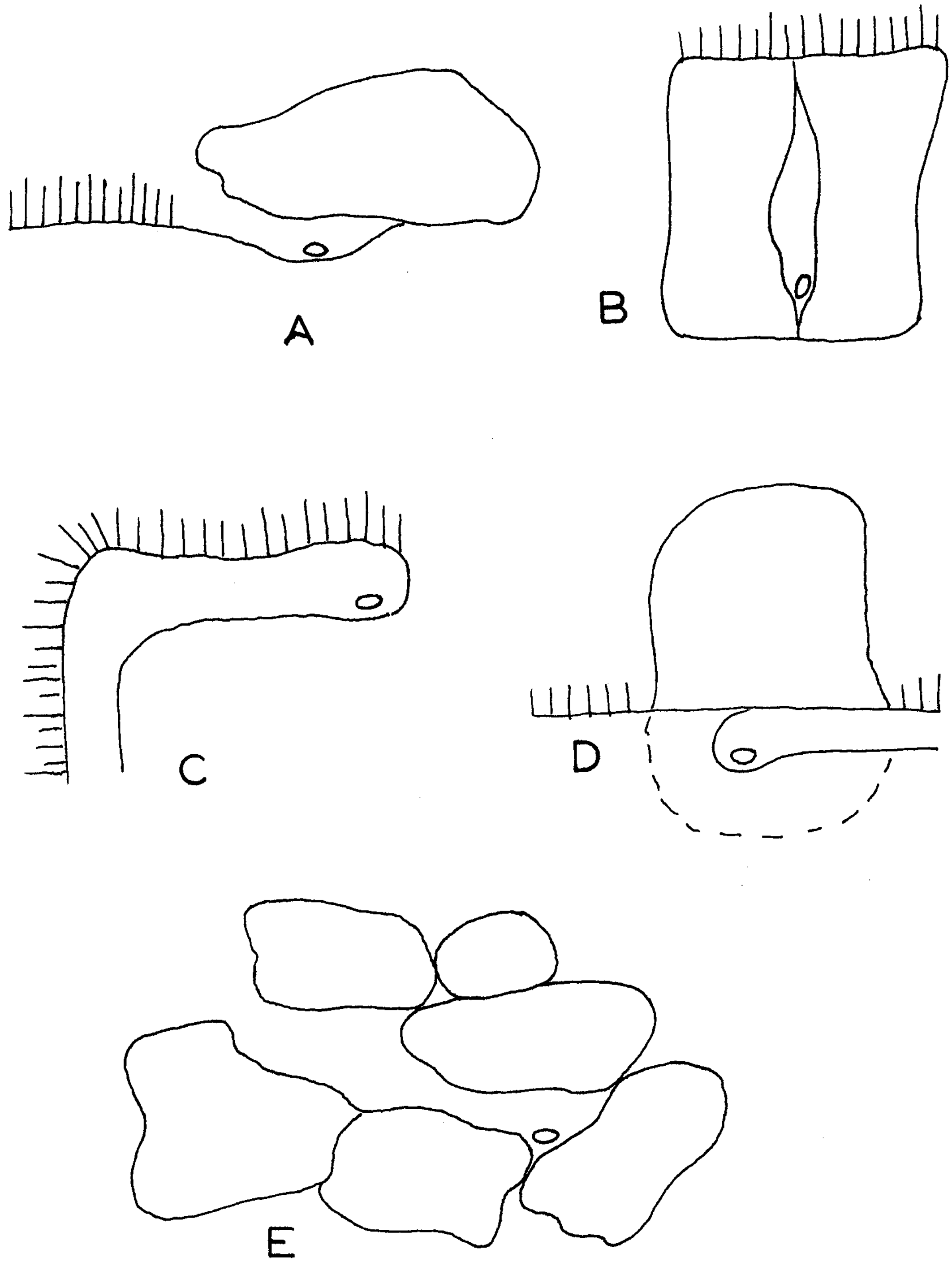


Figure 2. Diagram of the main nest types of Horned Puffins on Chowiet Island. A: burrow under boulder, B: crevice in cliff, C: burrow, D: burrow beside boulder, E: crevice in rockpile.

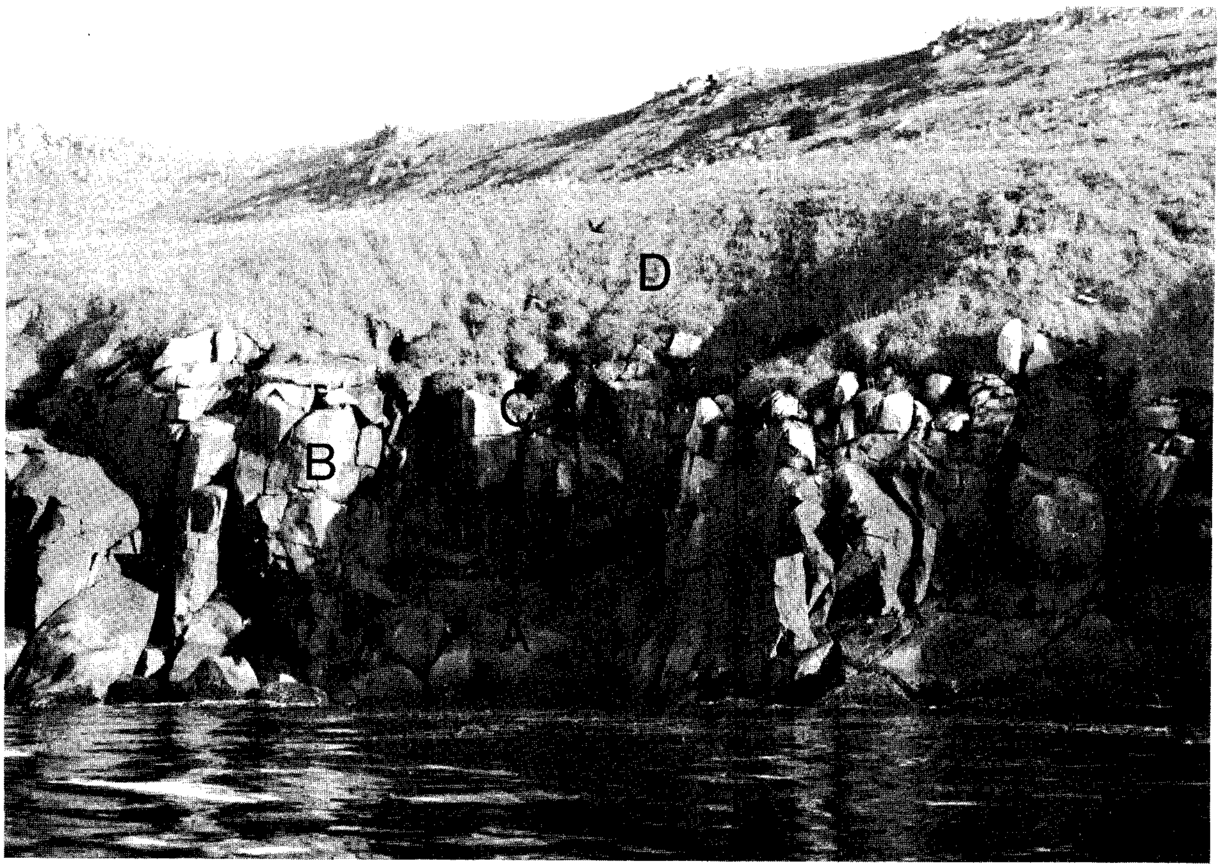


Figure 3. The four habitat types where Horned Puffin nests were found. A: Rockpile, B: Cliff, C: Grass-rock, D: Grass.

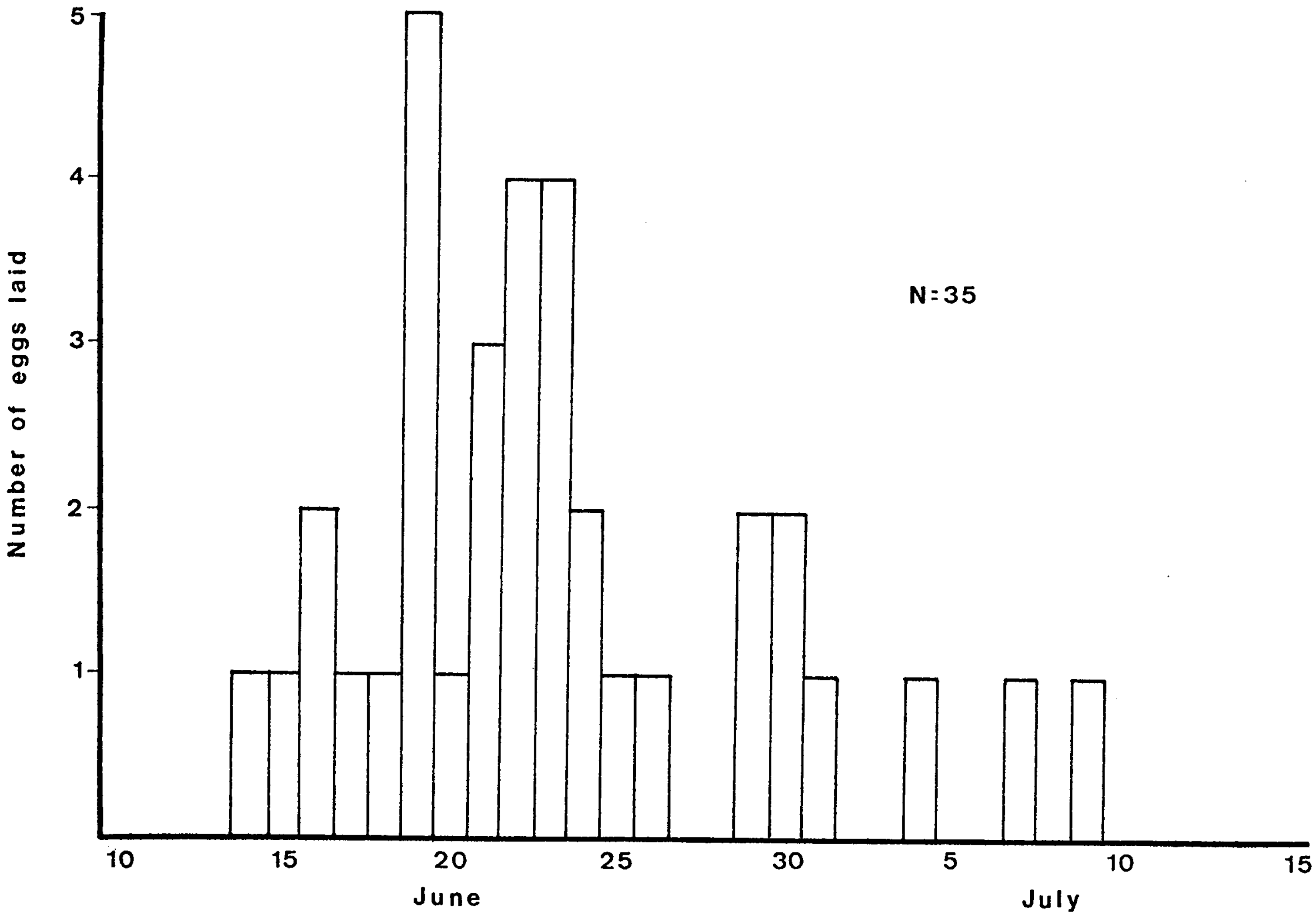


Figure 4. Egg-laying of Horned Puffins on Chowiet Island.

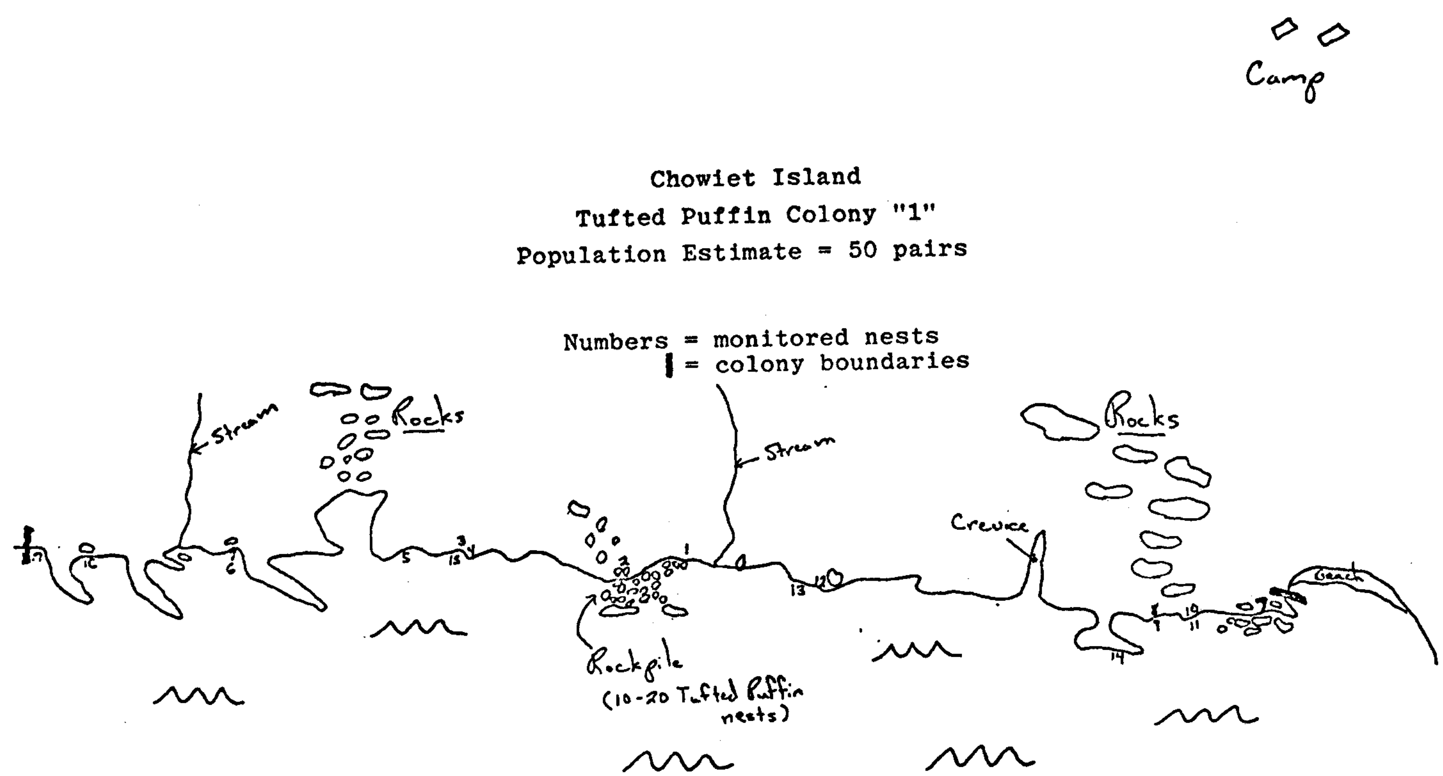


Figure 5. Sketch map of Tufted Puffin Colony 1.

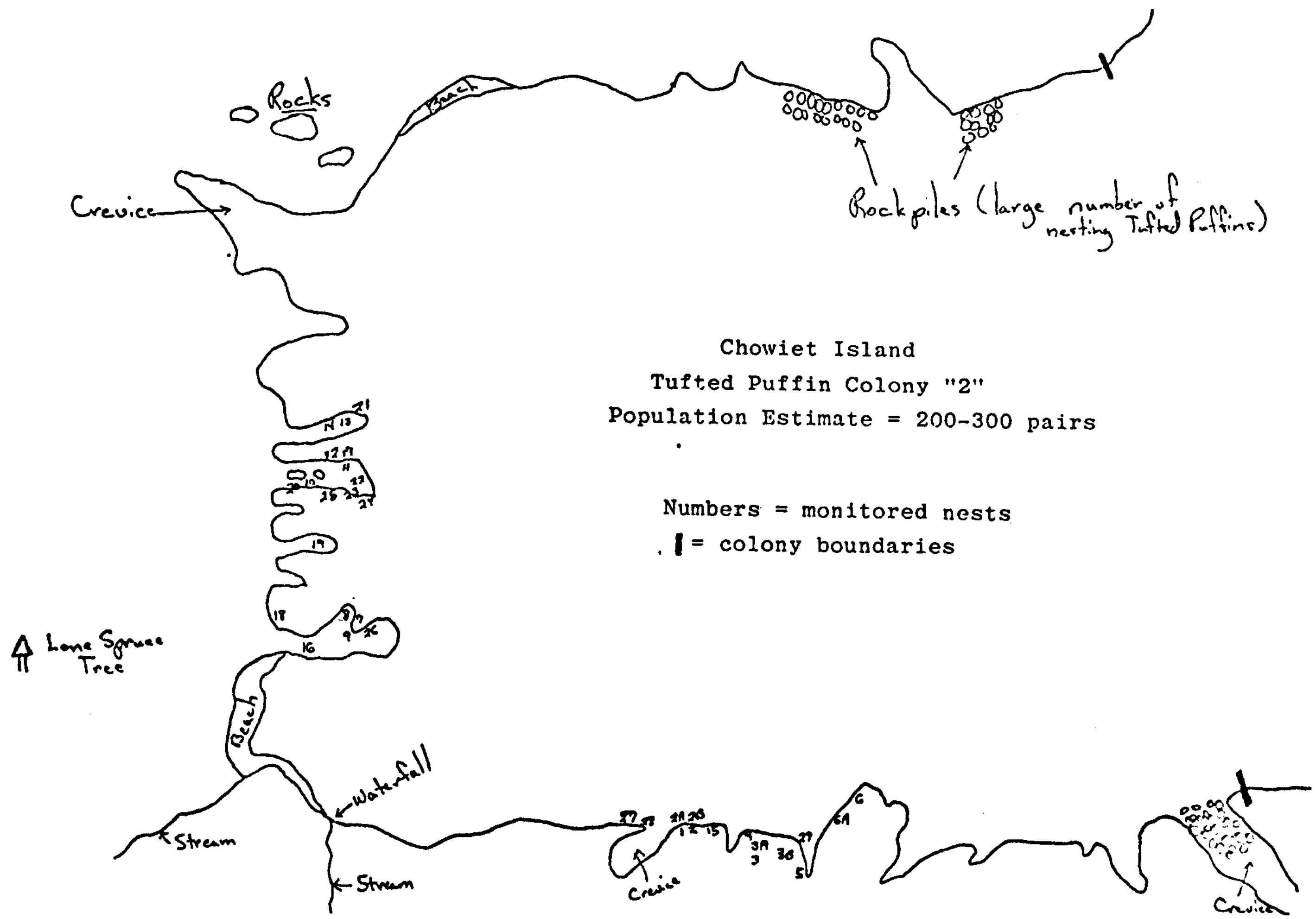


Figure 6. Sketch map of Tufted Puffin Colony 2.

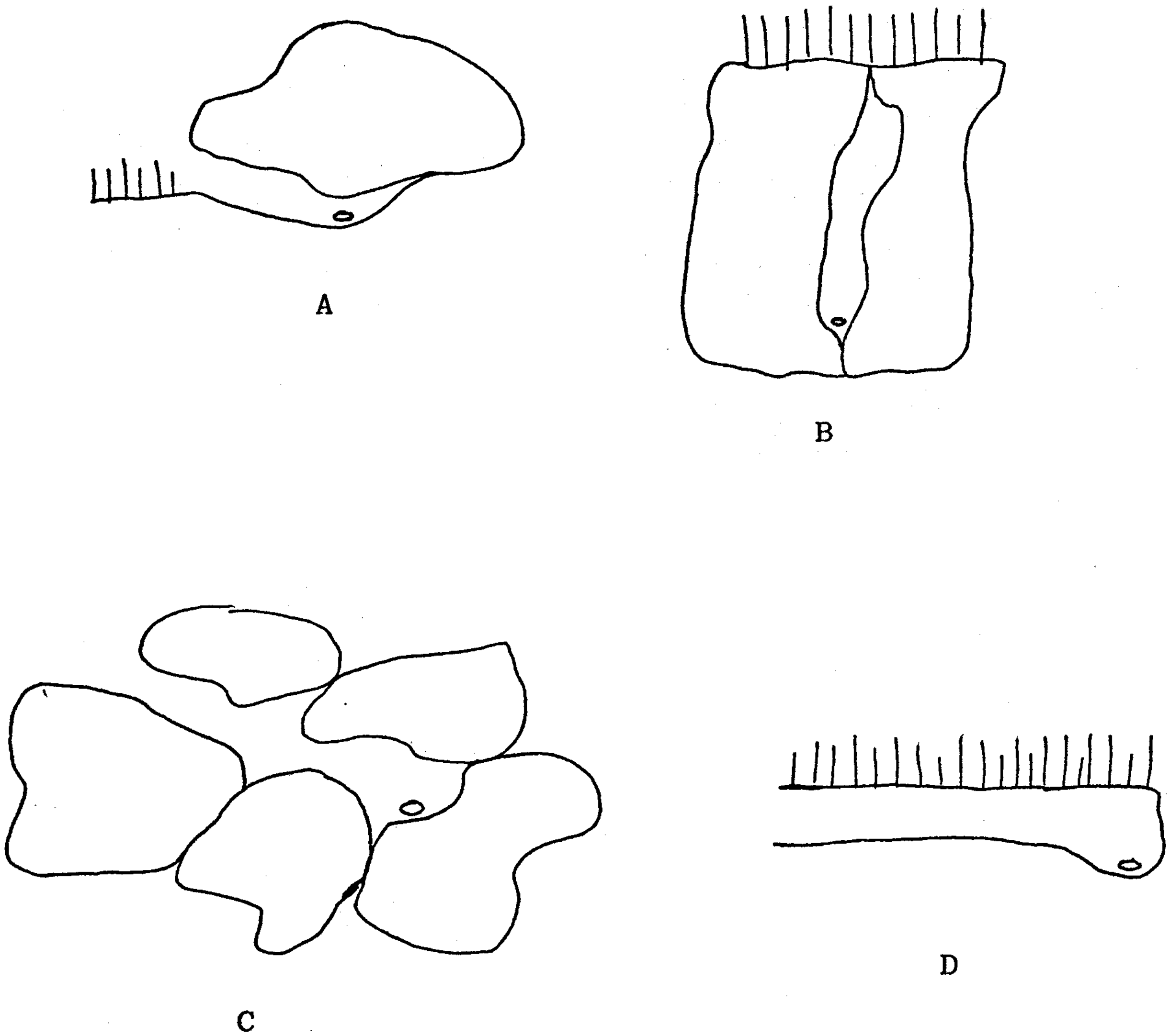


Figure 7. Cross-sections of the main nest sites used by Tufted Puffins on Chowiet Island. A: burrow under boulder, B: crevice in cliff, C: crevice in rockpile, D: burrow.

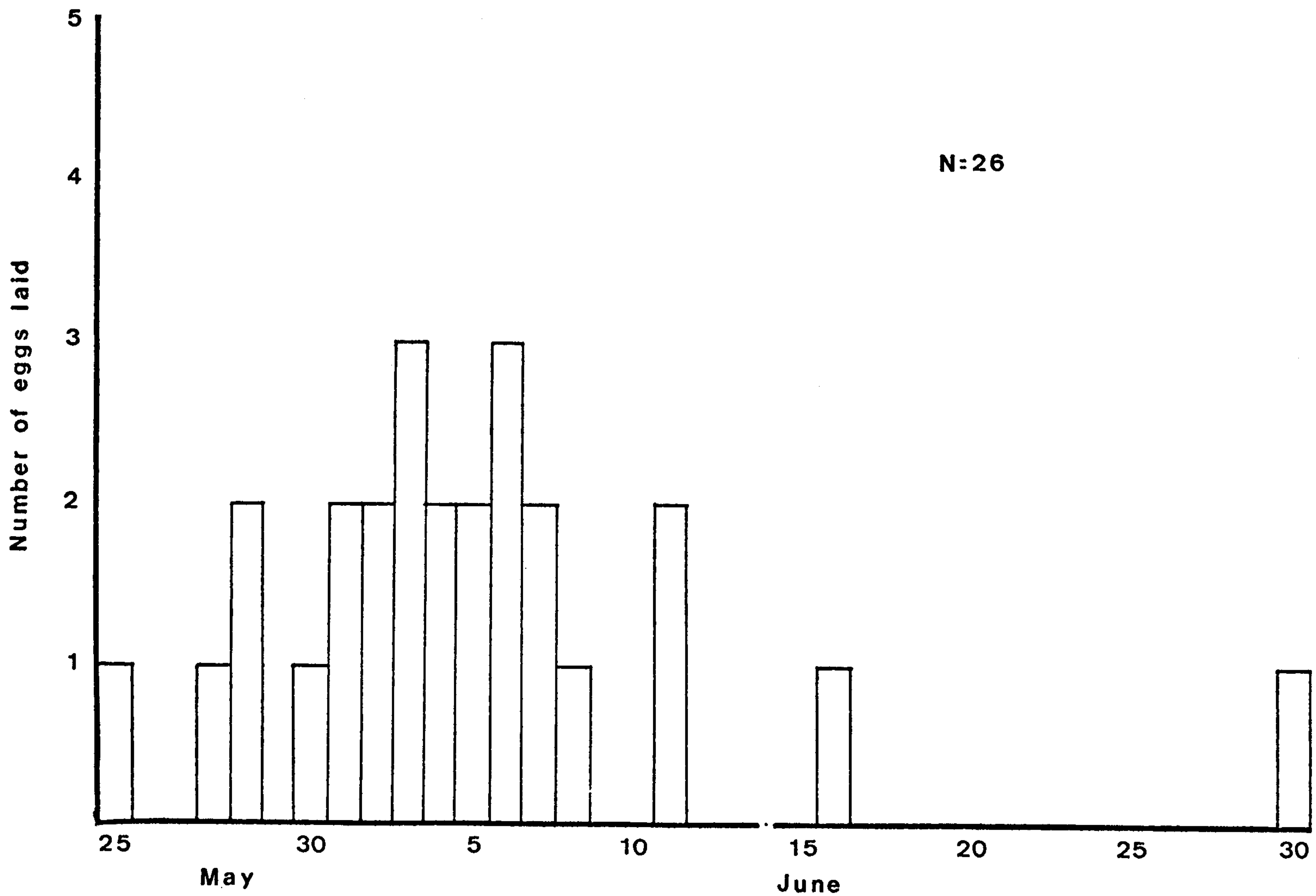


Figure 8. Egg-laying of Tufted Puffins on Chowiet Island.

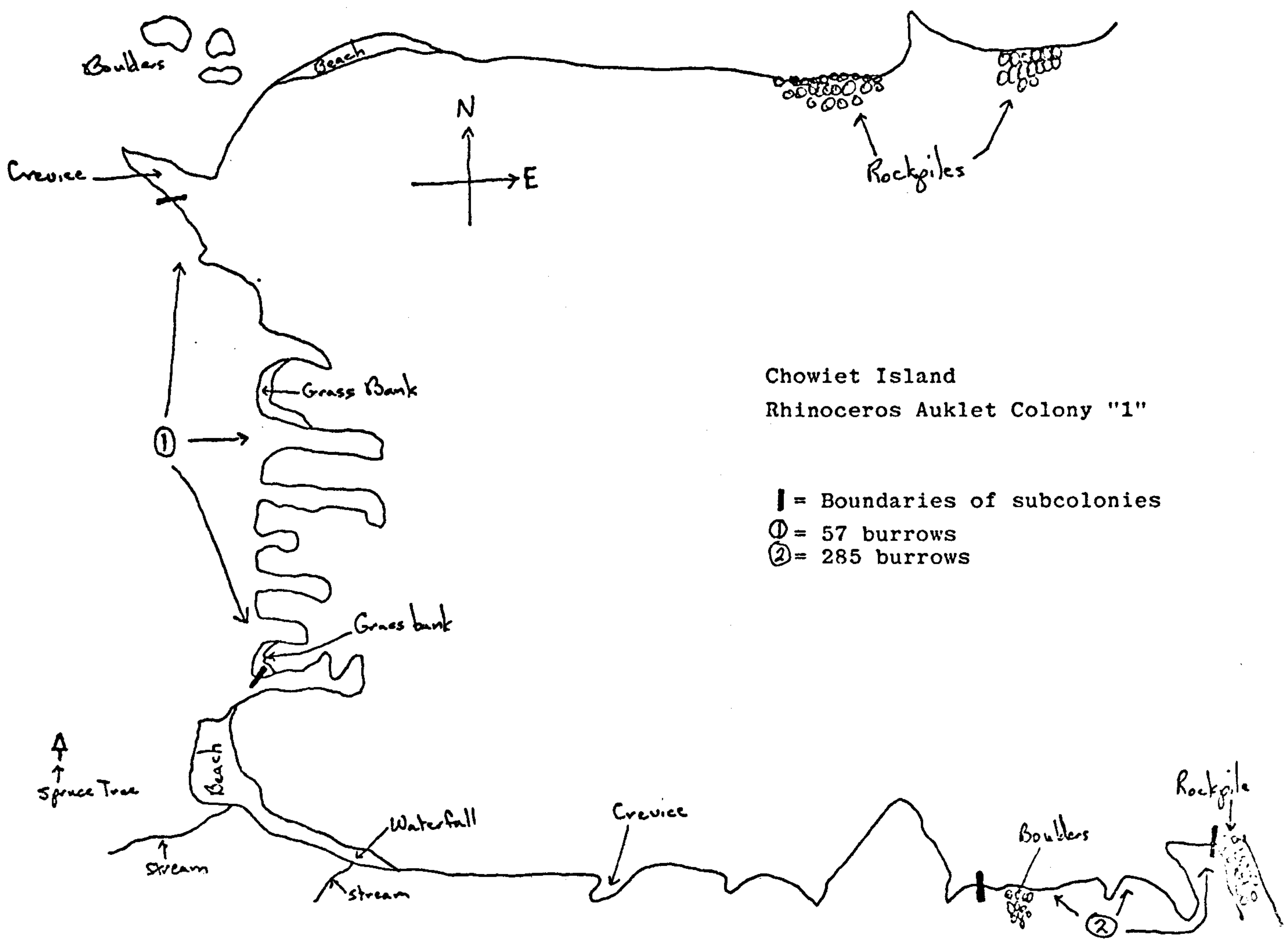


Figure 9. Sketch map of Rhinoceros Auklet Colony 1.

Chowiet Island

Rhinoceros Auklet Colony "2"

▌ = Boundaries of subcolonies
① = 38 burrows
② = 65 burrows
③ = 19 burrows
④ = 24 burrows
⑤ = 33 burrows

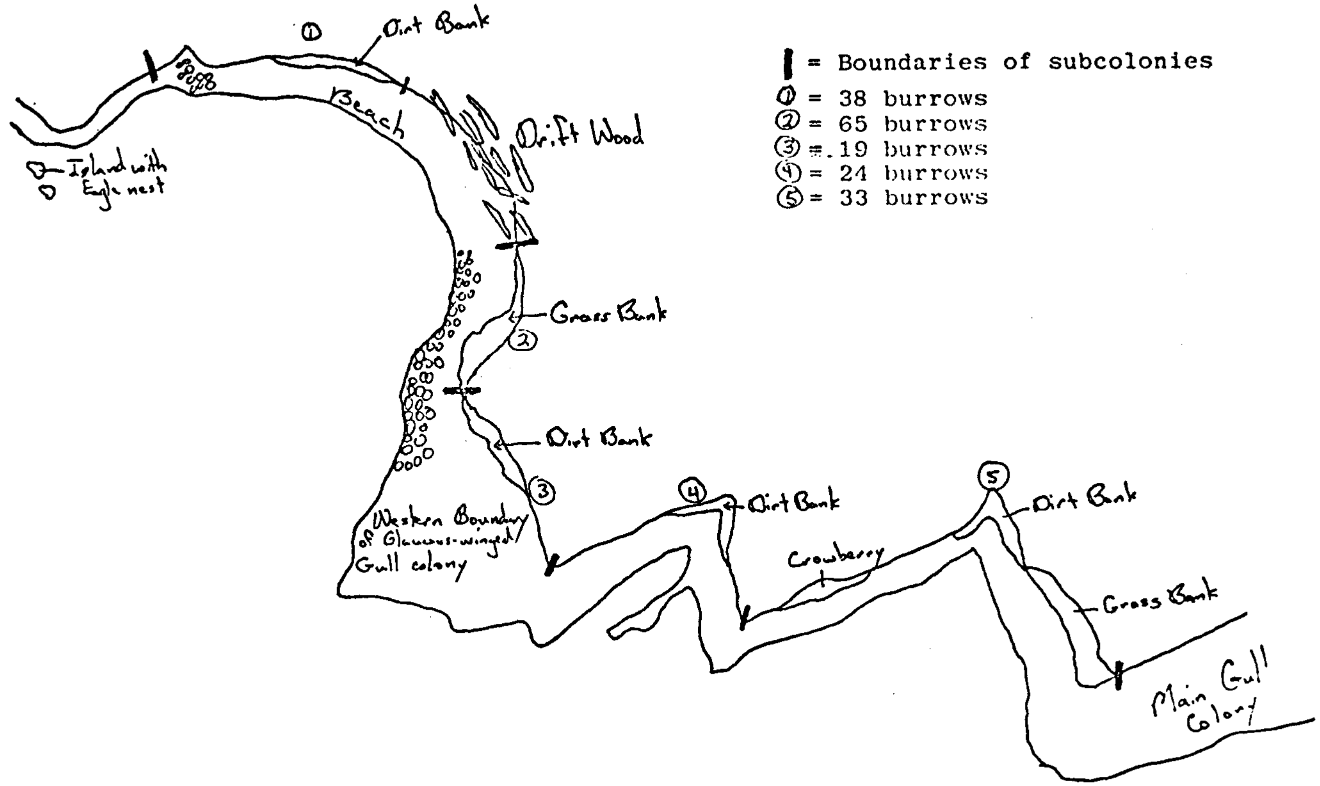


Figure 10. Sketch map of Rhinoceros Auklet Colony 2.

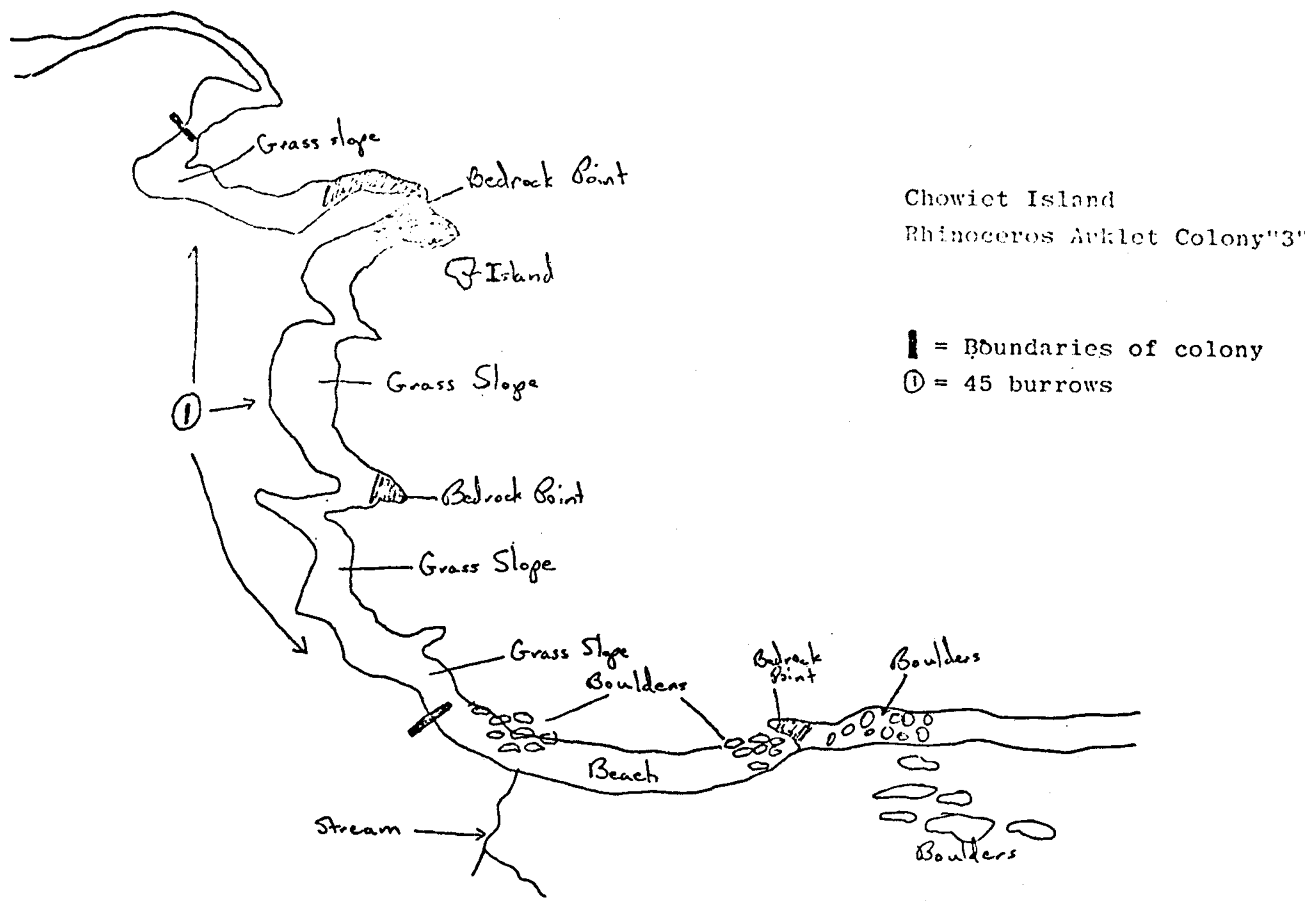


Figure 11. Sketch map of Rhinoceros Auklet Colony 3.

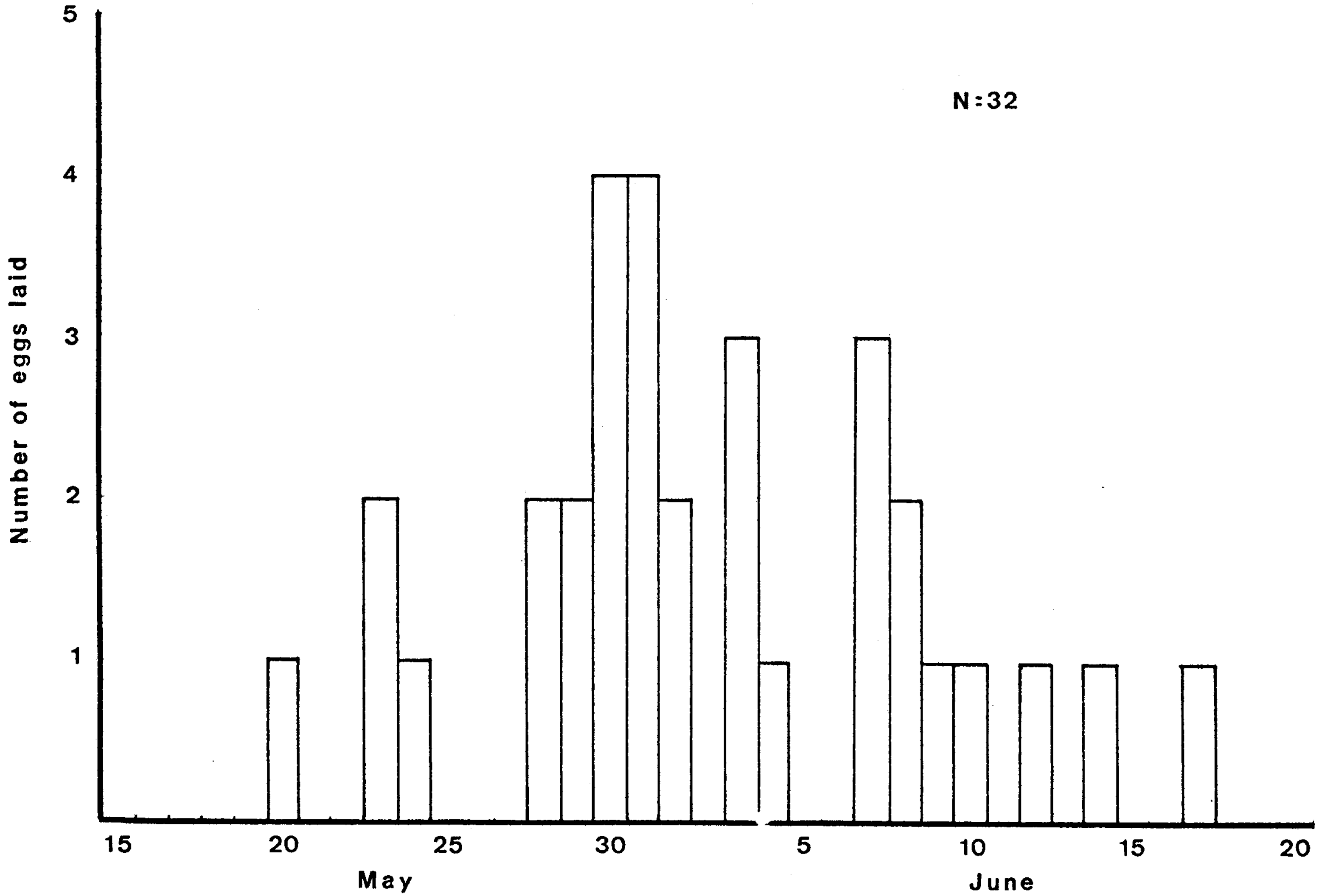


Figure 12. Egg-laying of Rhinoceros Auklets on Chowiet Island.

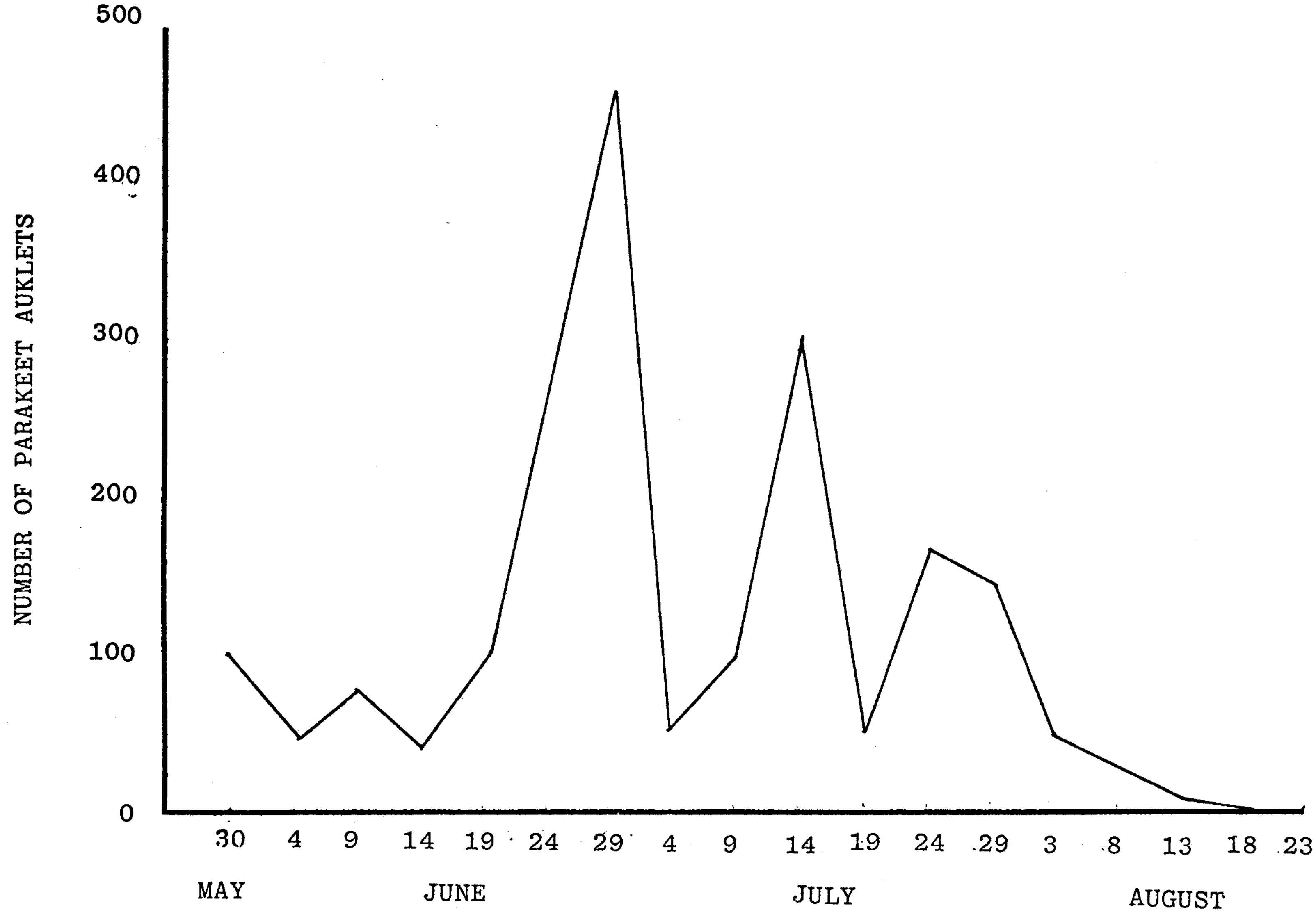


Figure 13. Regular counts of Parakeet Auklets made at 0930 hours from the same location.

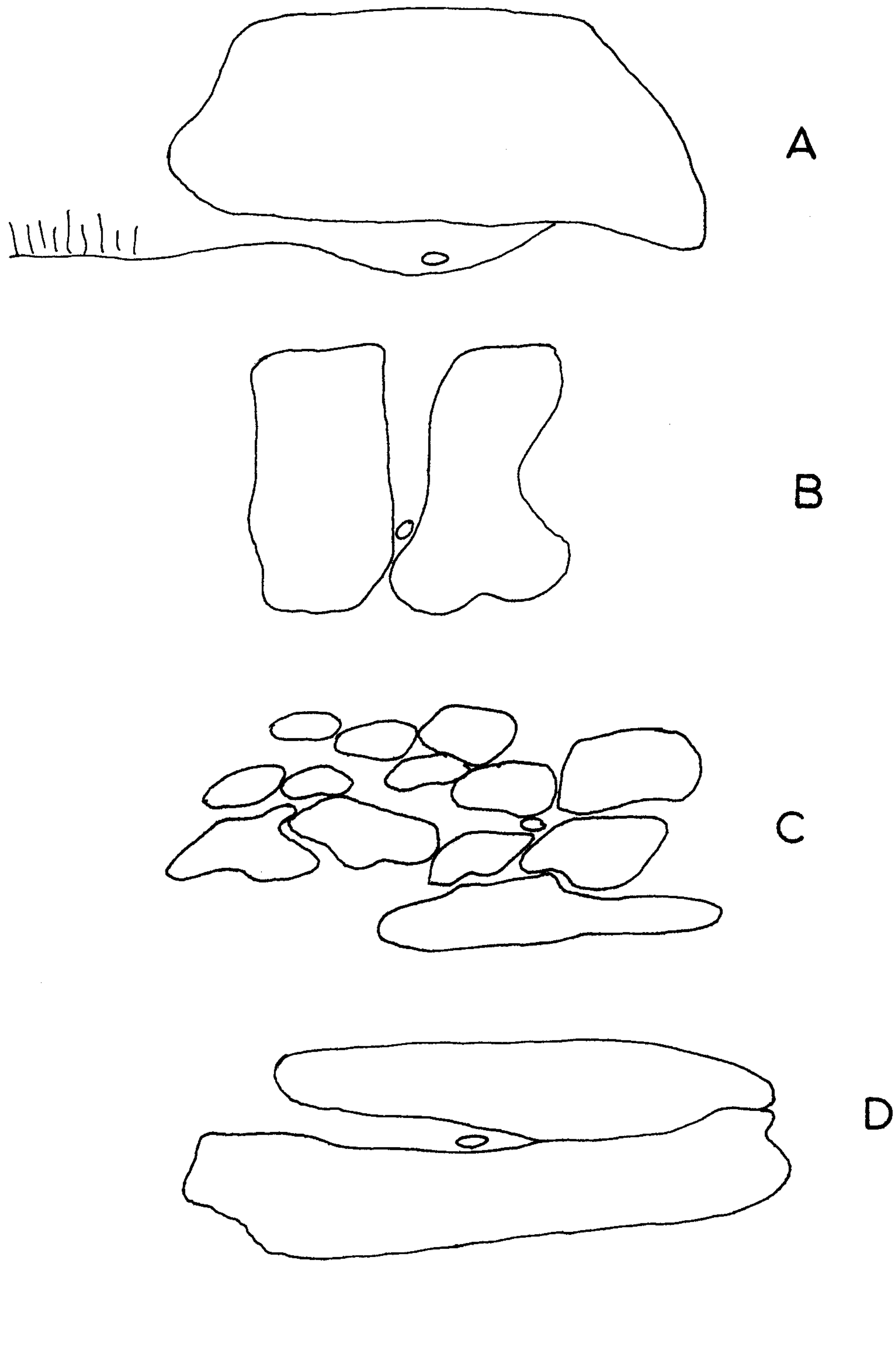


Figure 14. Cross-sections of nest types utilized by Parakeet Auklets on Chowiet Island. A: burrow under boulder, B: crevice in cliff, C: crevice in rockpile, D: crevice in bed-rock.

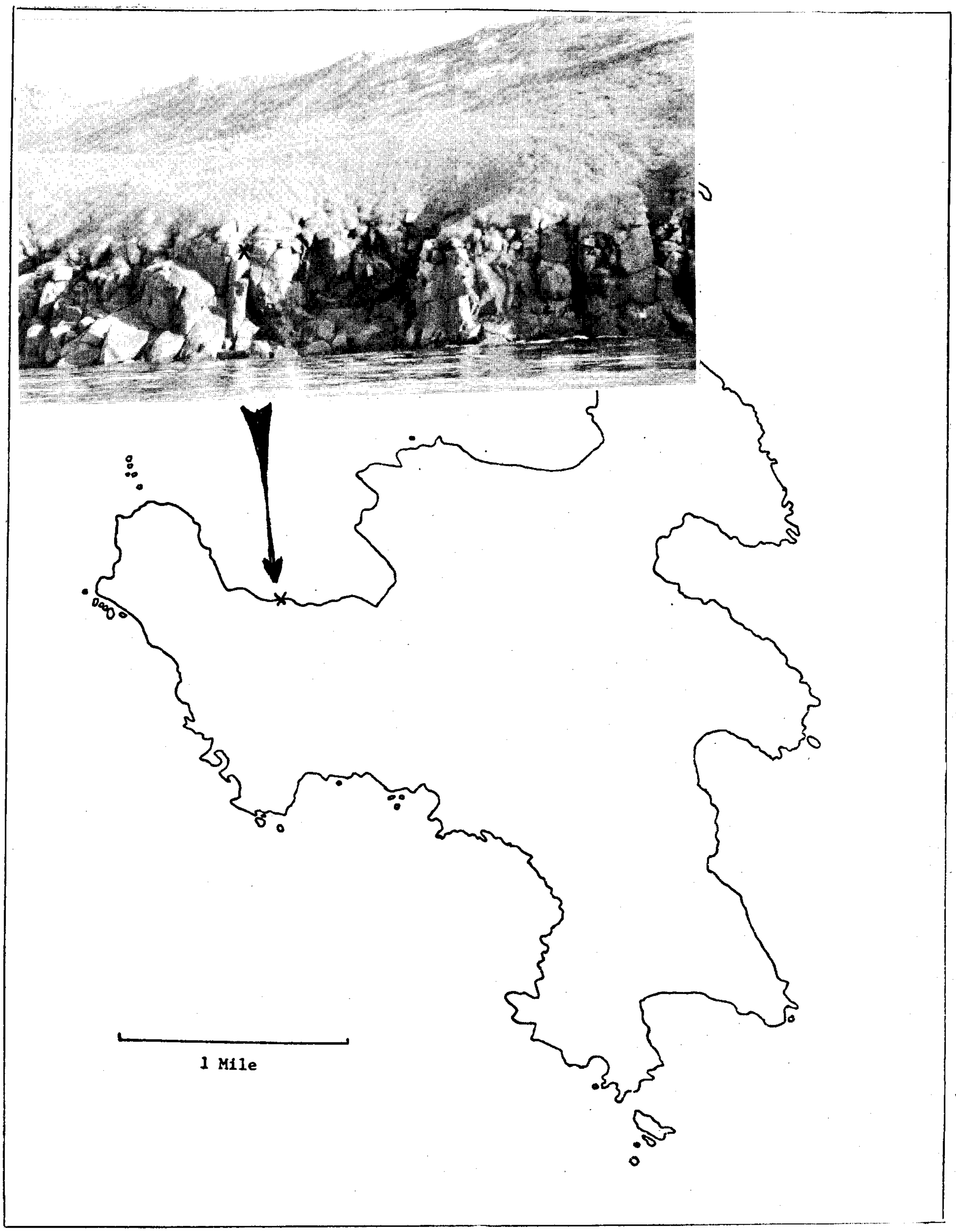


Figure 15. Location and photograph of the Least Auklet colony on Chowiet Island.

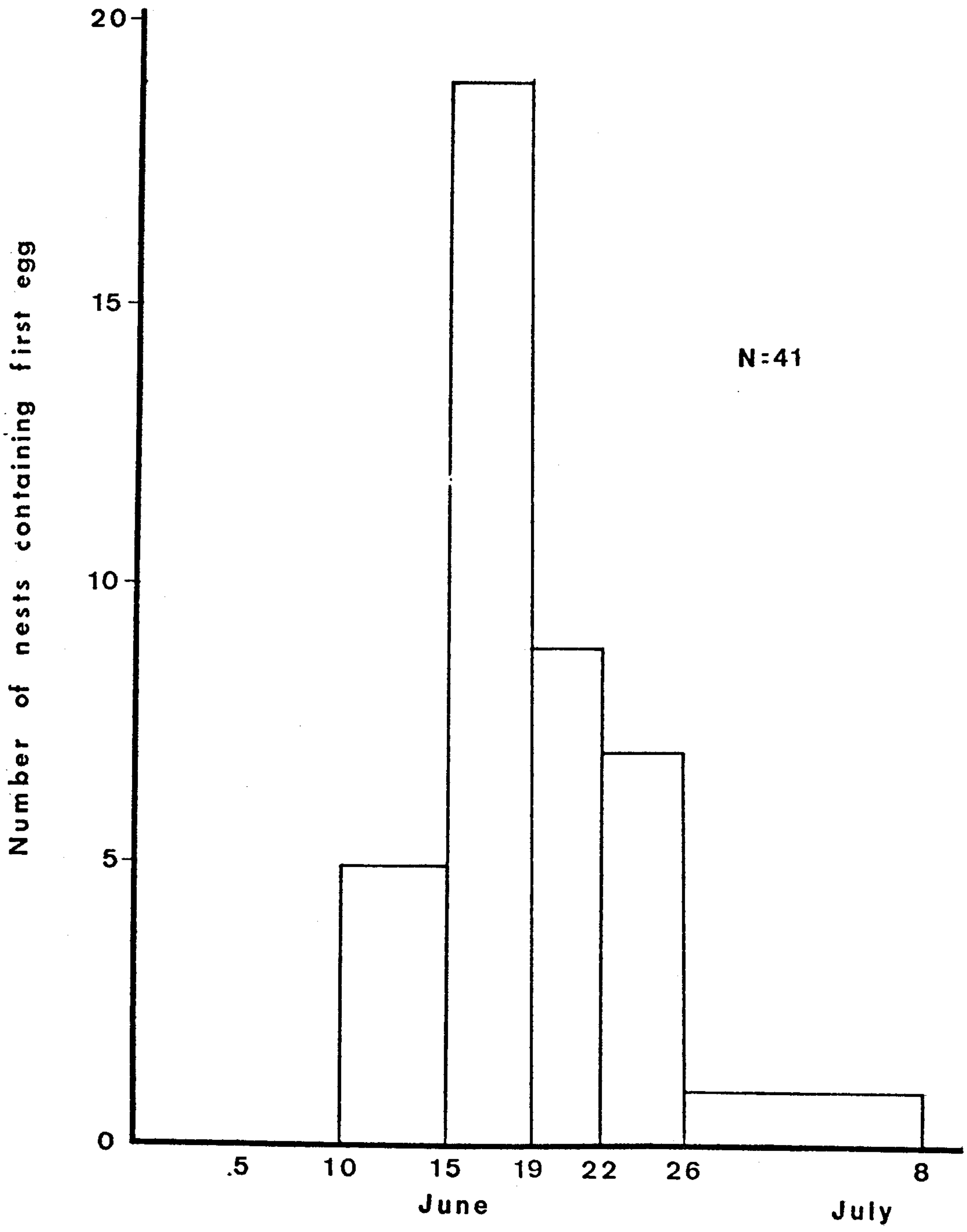


Figure 16. Egg-laying of Black-legged Kittiwakes on Chowiet Island.

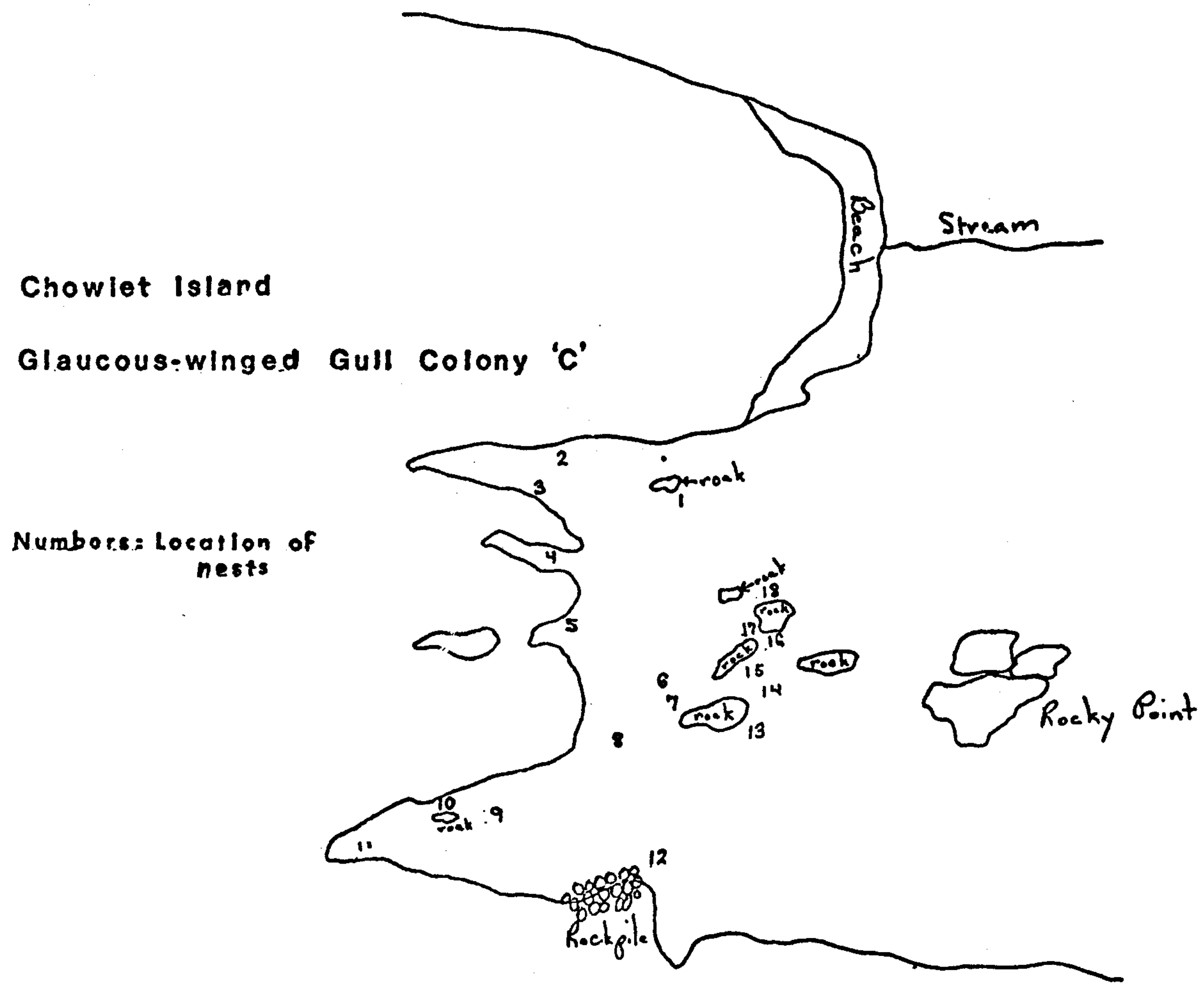


Figure 17. Sketch map of Glaucous-winged Gull Colony C.

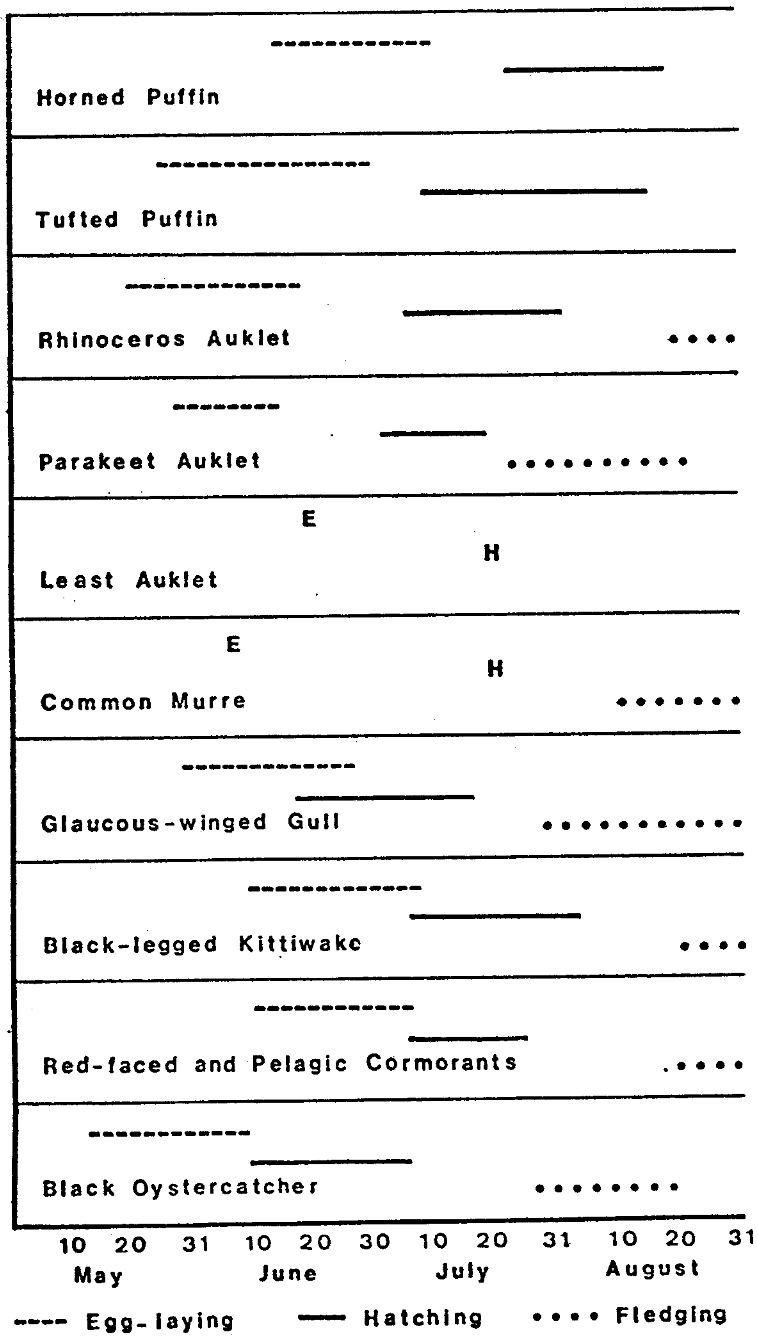


Figure 21. Breeding phenology of seabirds, Chowiet Island, Alaska.

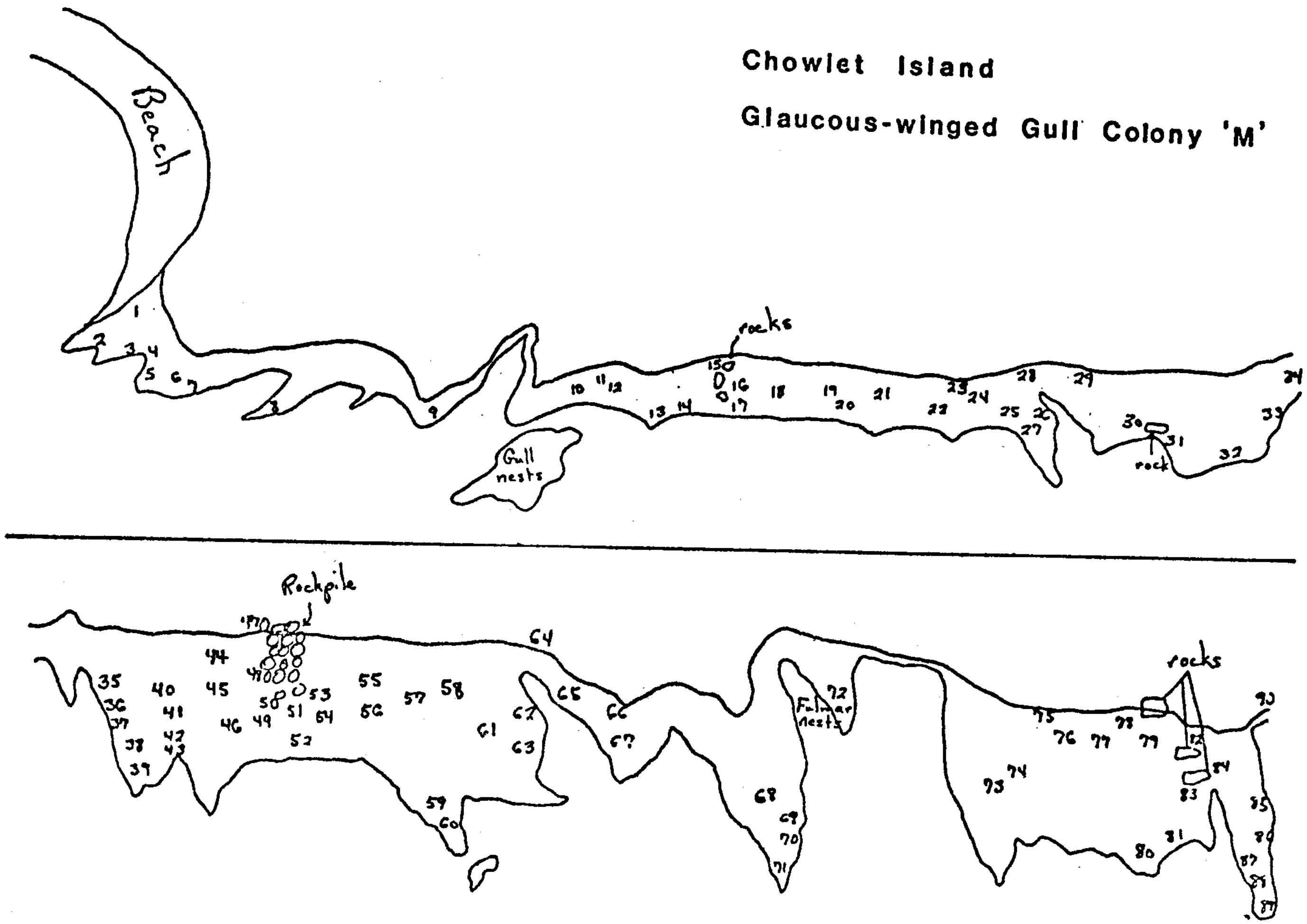
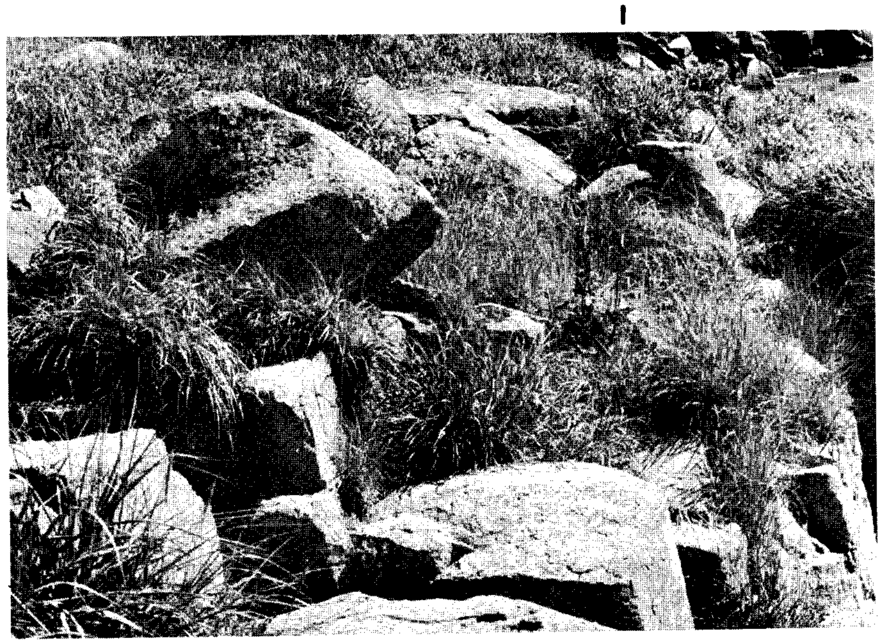


Figure 18. Sketch map of the distribution of monitored nests in Glaucous-winged Gull Colony M.

A



B

Figure 19. Photograph A shows Glaucous-winged Gull Colony "M" depicting typical boulder and exposed bedrock nesting habitat. Photograph B is a close-up of boulder-beach rye-grass habitat where most gull nests were found.

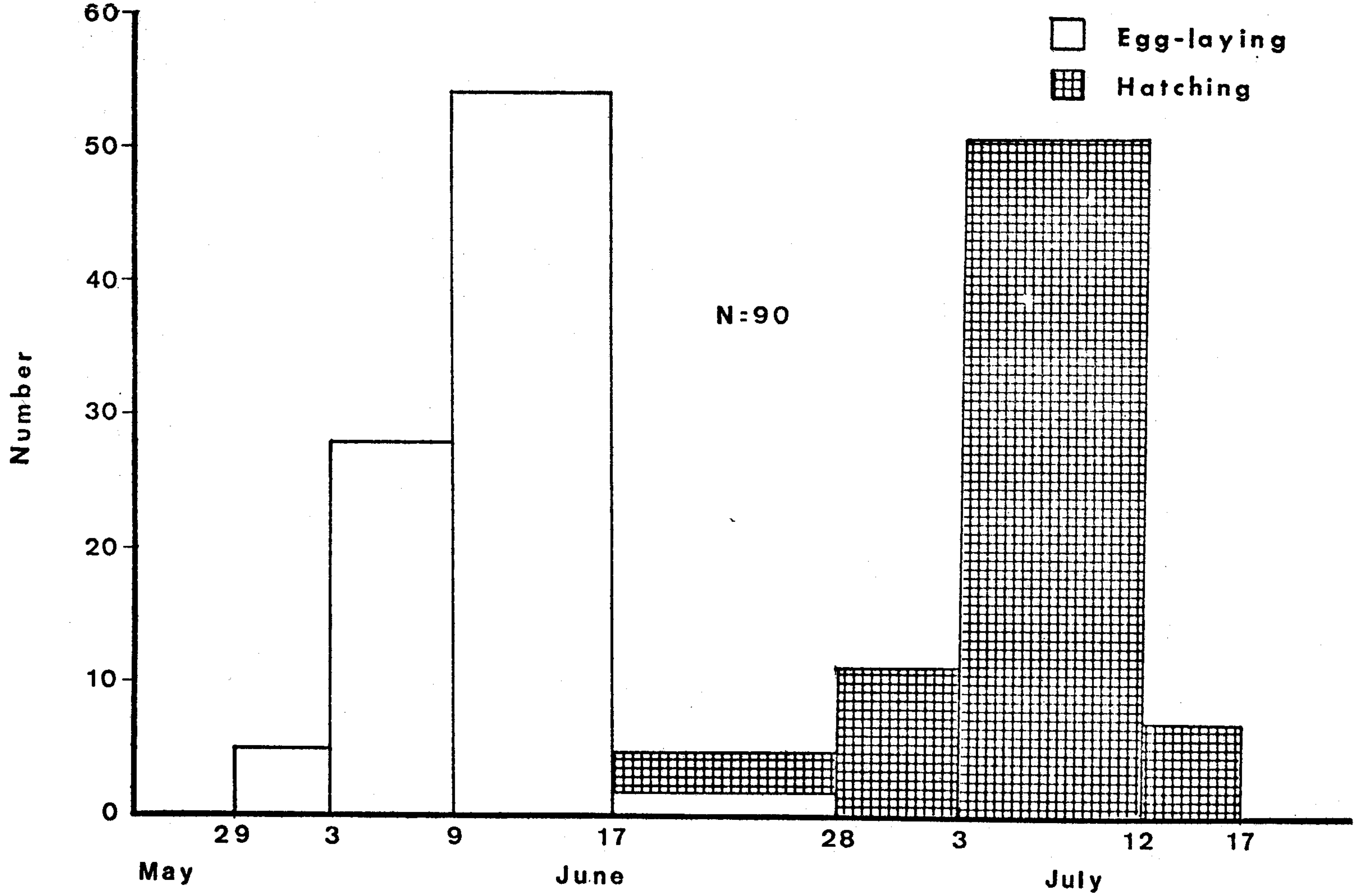
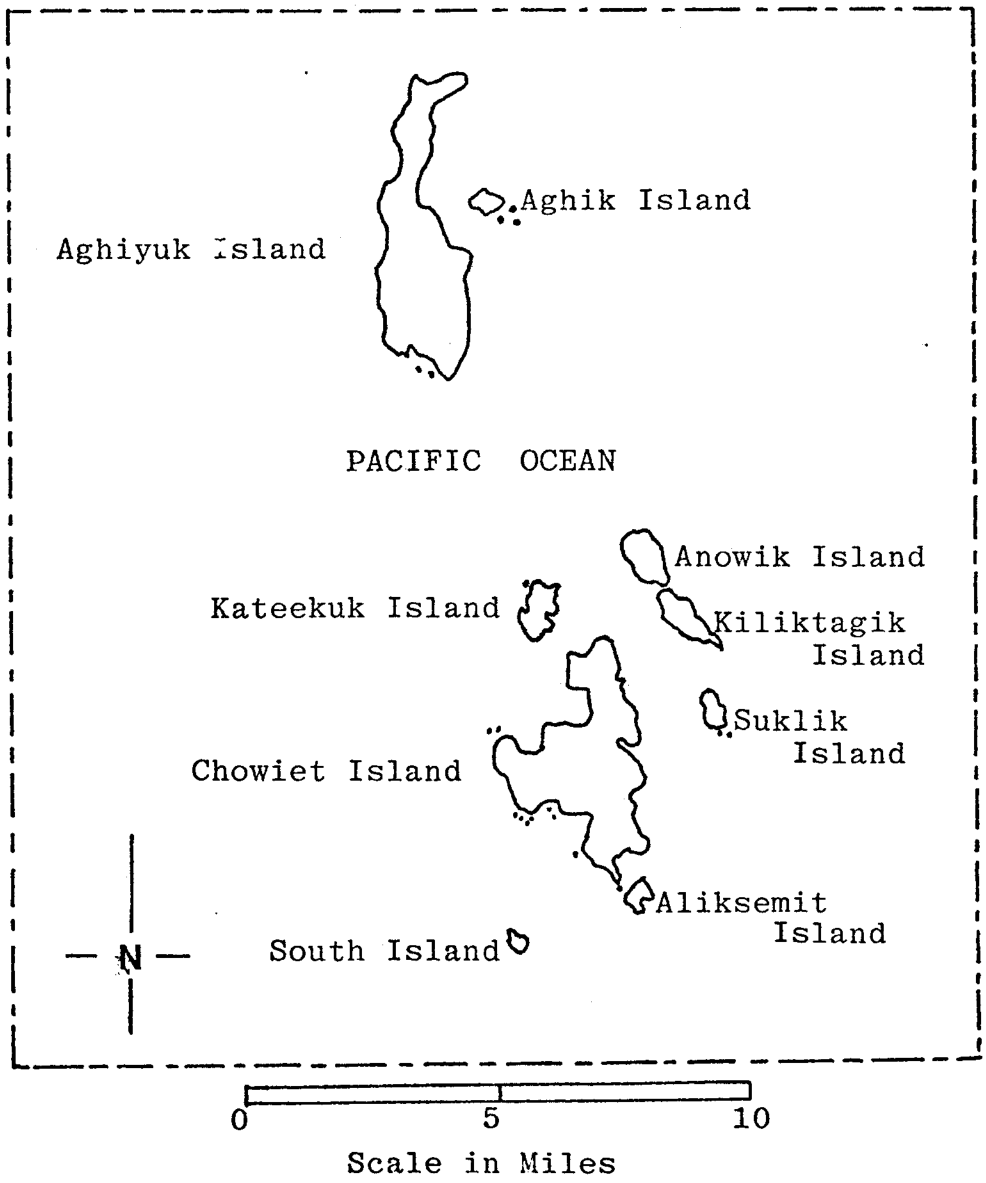
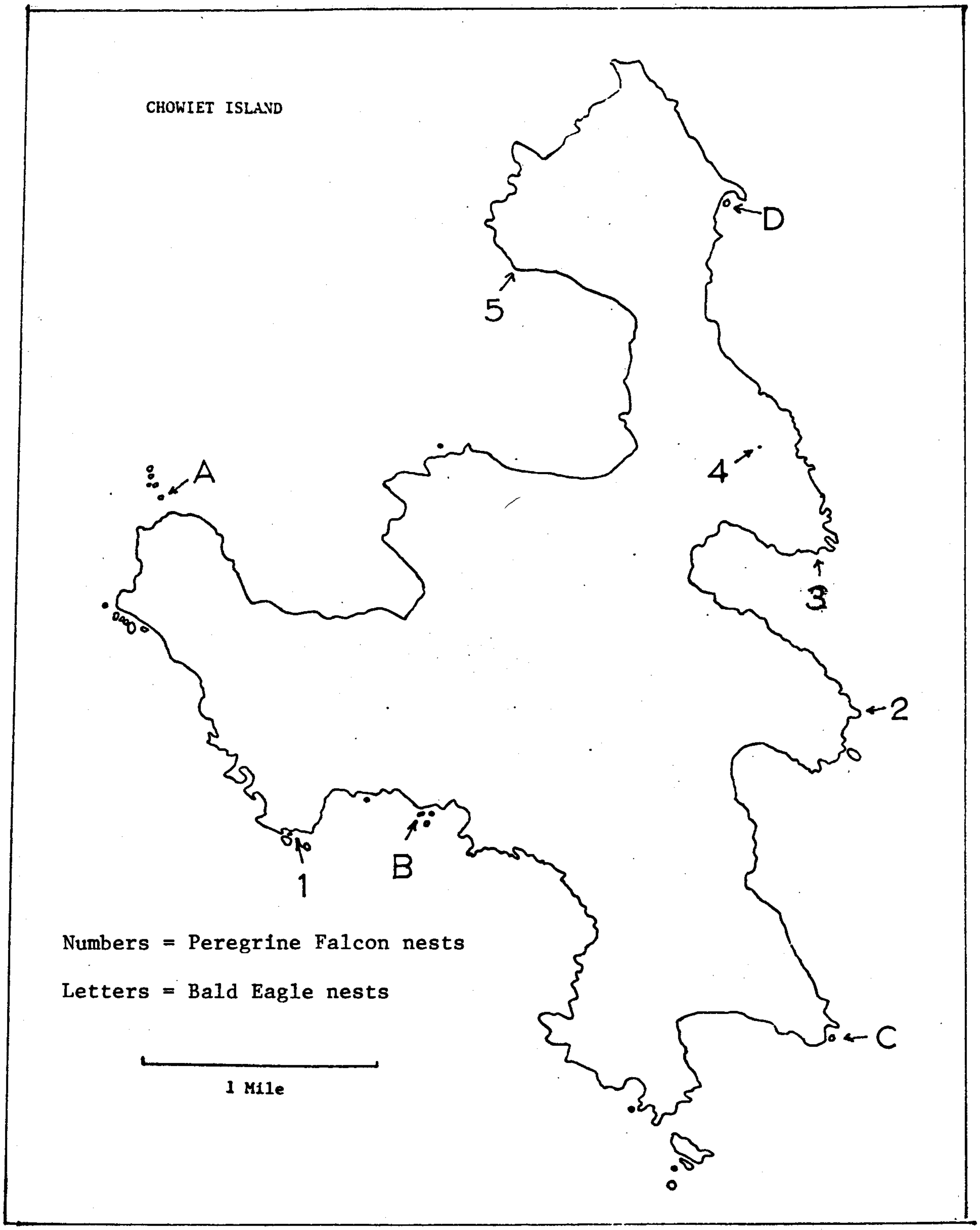


Figure 20. Egg-laying and hatching of Glaucous-winged Gulls in Colony "M".

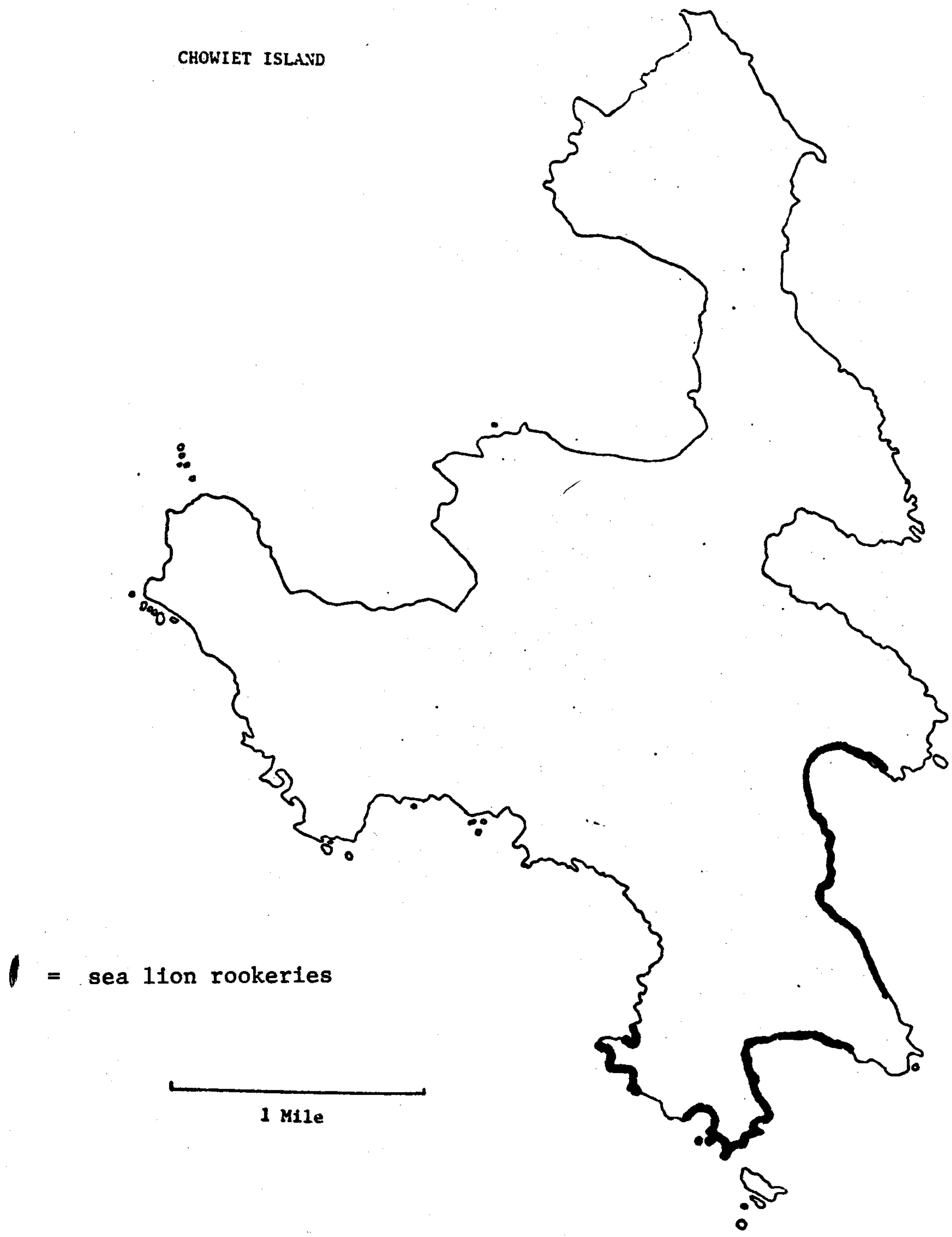
MAPS



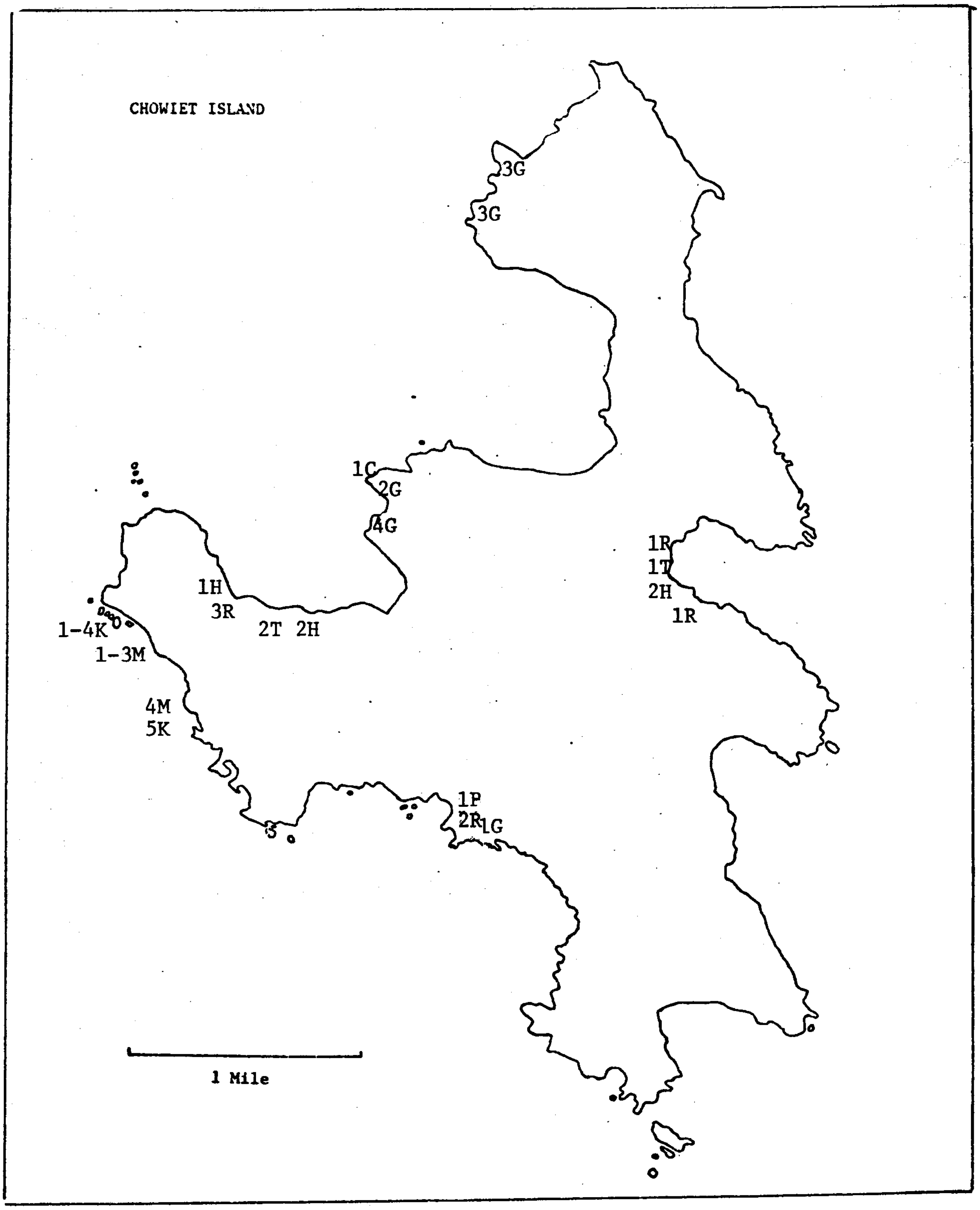
Map 1. Map of the Semidi Islands National Wildlife Refuge.



Map 2. Location of active Bald Eagle and Peregrine Falcon nests on Chowiet Island in 1976.

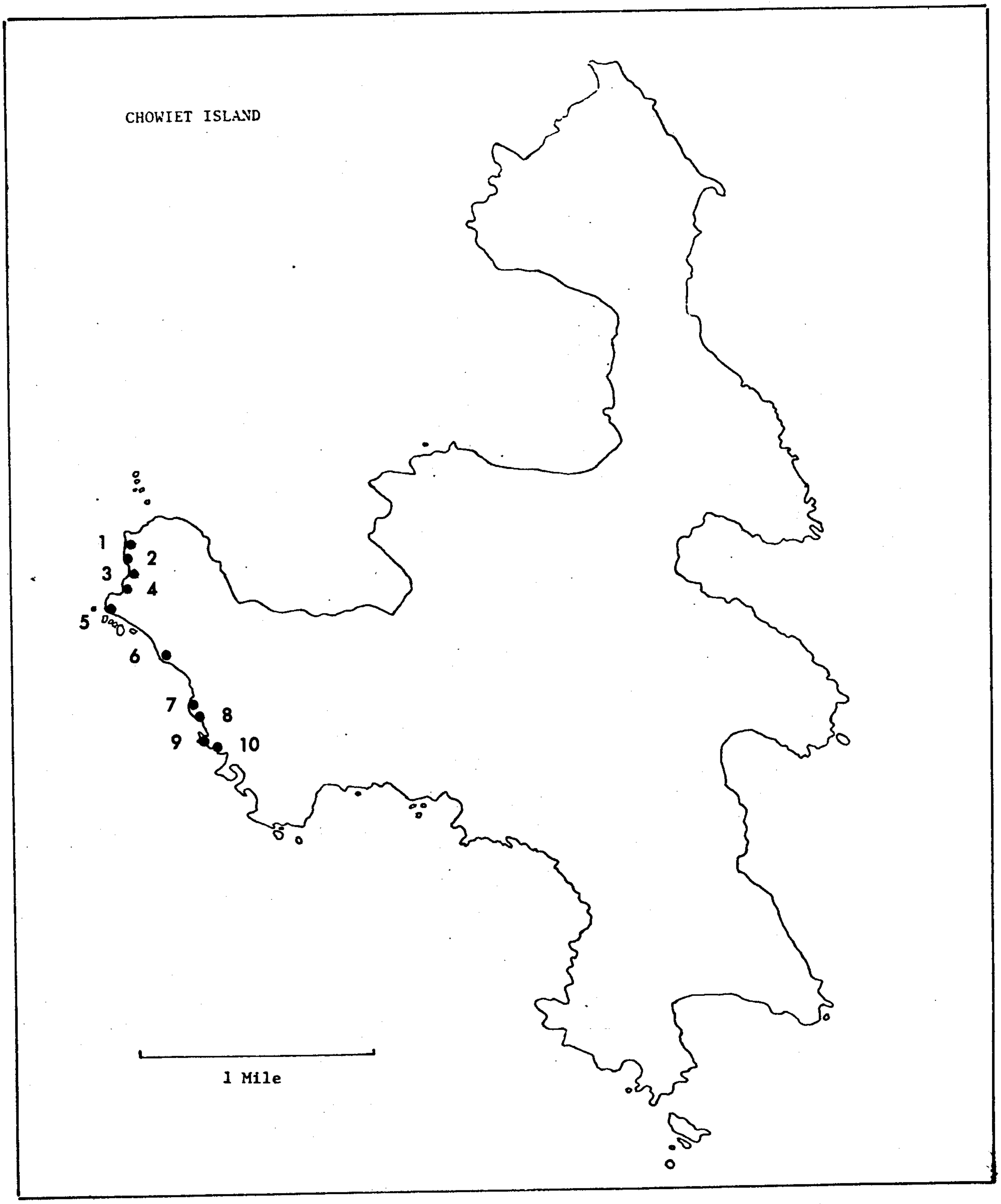


Map 3. Distribution of sea lion rookeries on Chowiet Island.

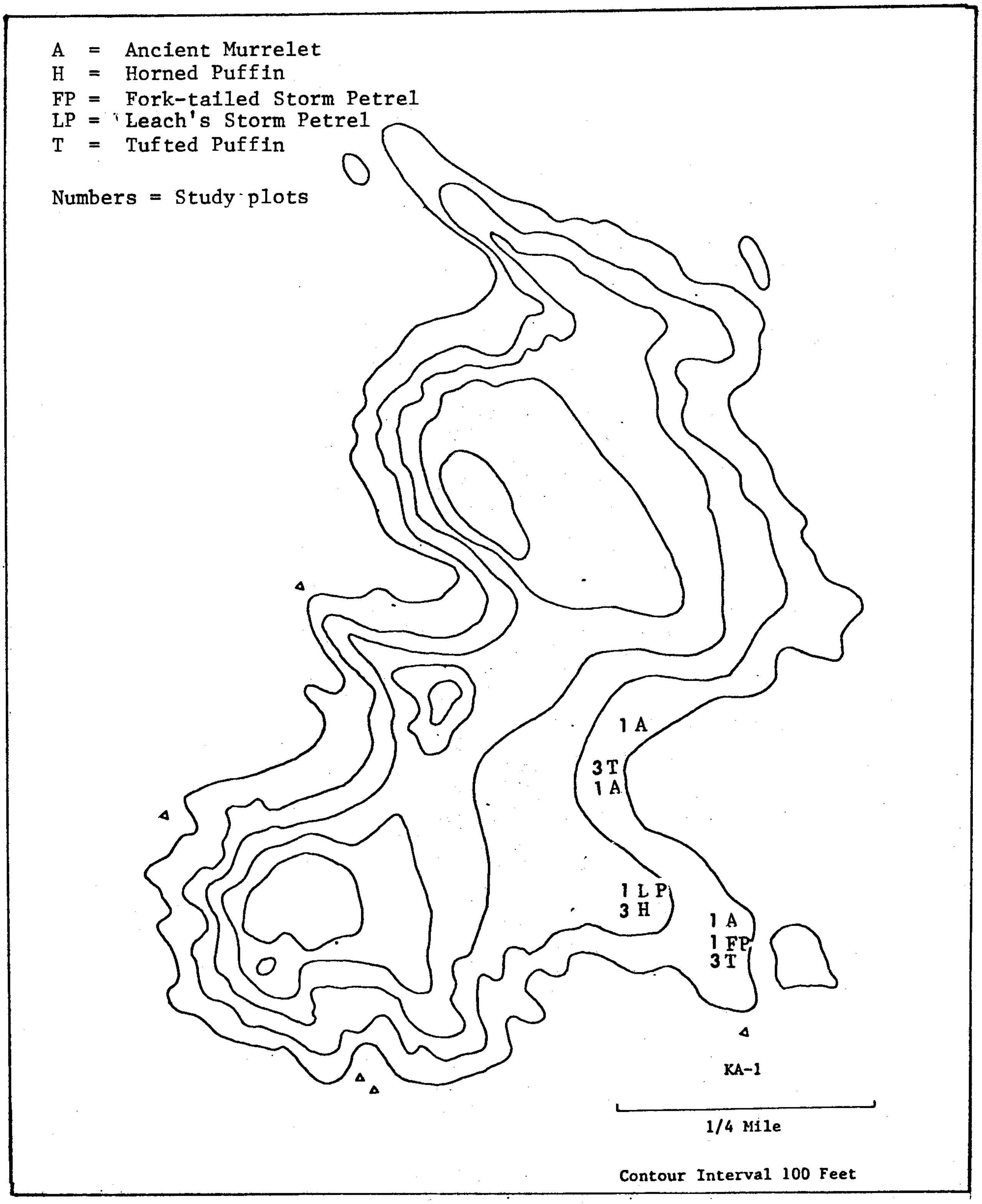


Map 4. Location of study plots on Chowiet Island.

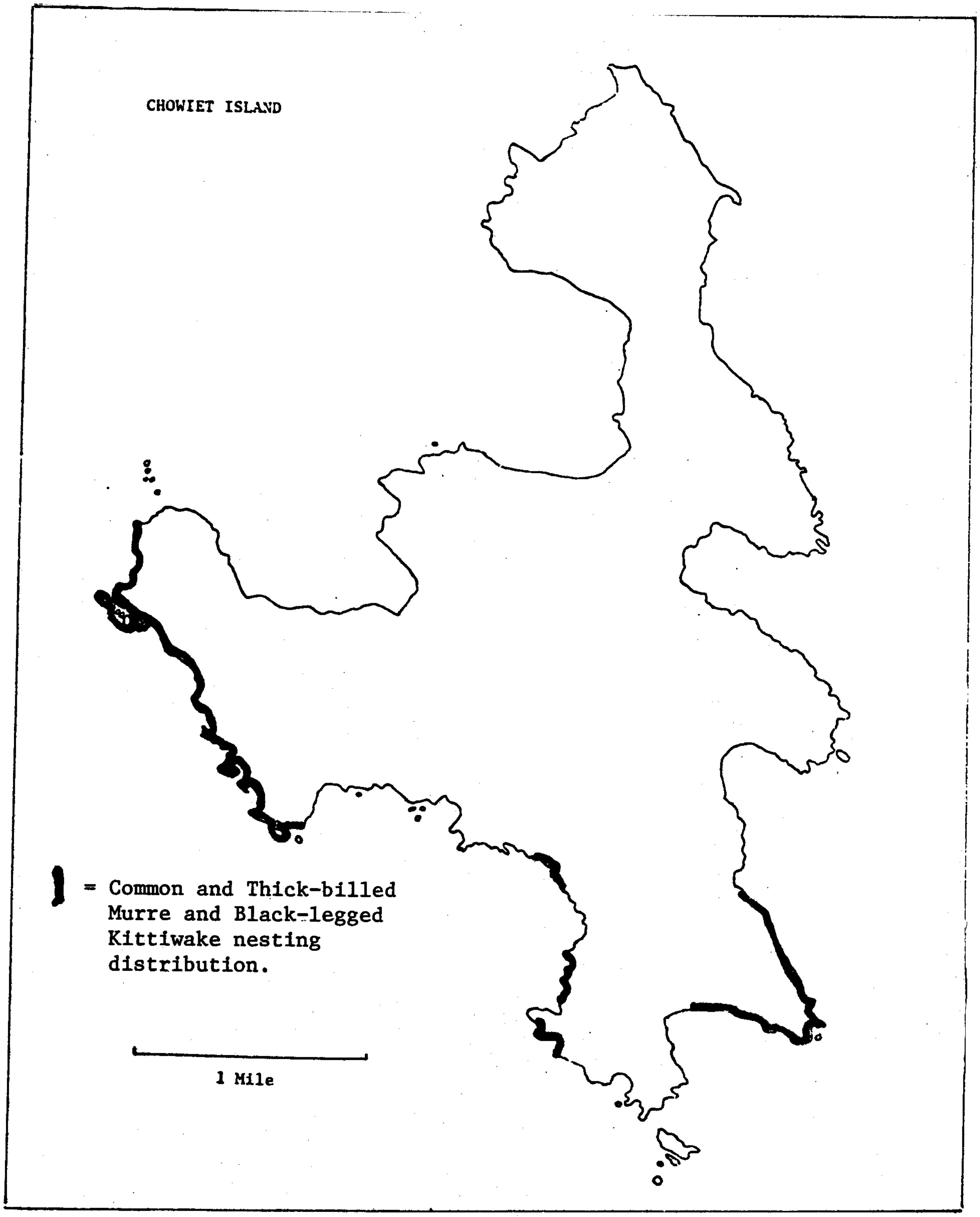
C = Cormorant; G = Glaucous-winged Gull; H = Horned Puffin; K = Black-legged Kittiwake; M = Murre; P = Pigeon Guillemot; R = Rhinoceros Auklet; T = Tufted Puffin; Numbers = Study plots



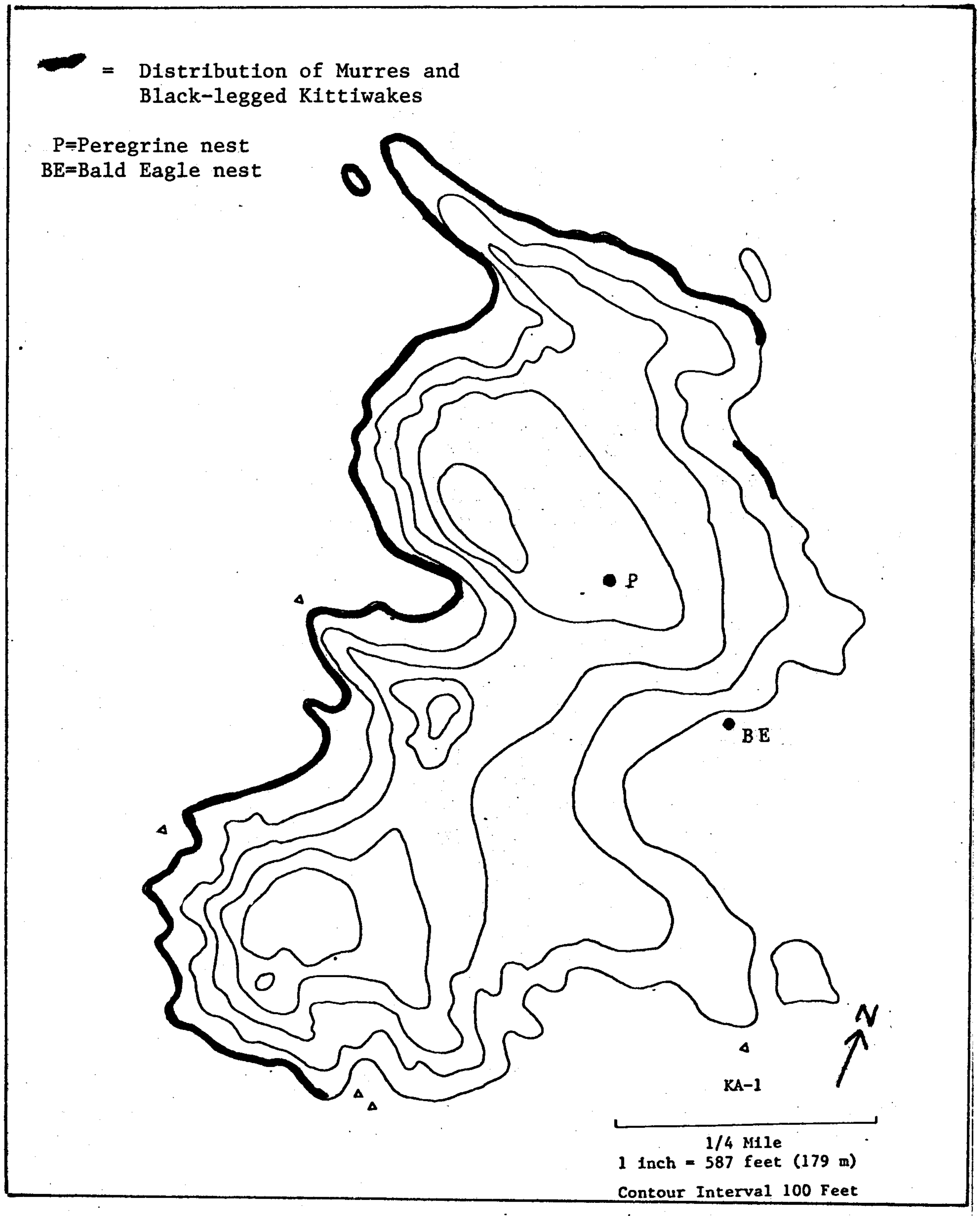
Map 5. Location of sample points from which Murres and Black-legged Kittiwakes were counted.



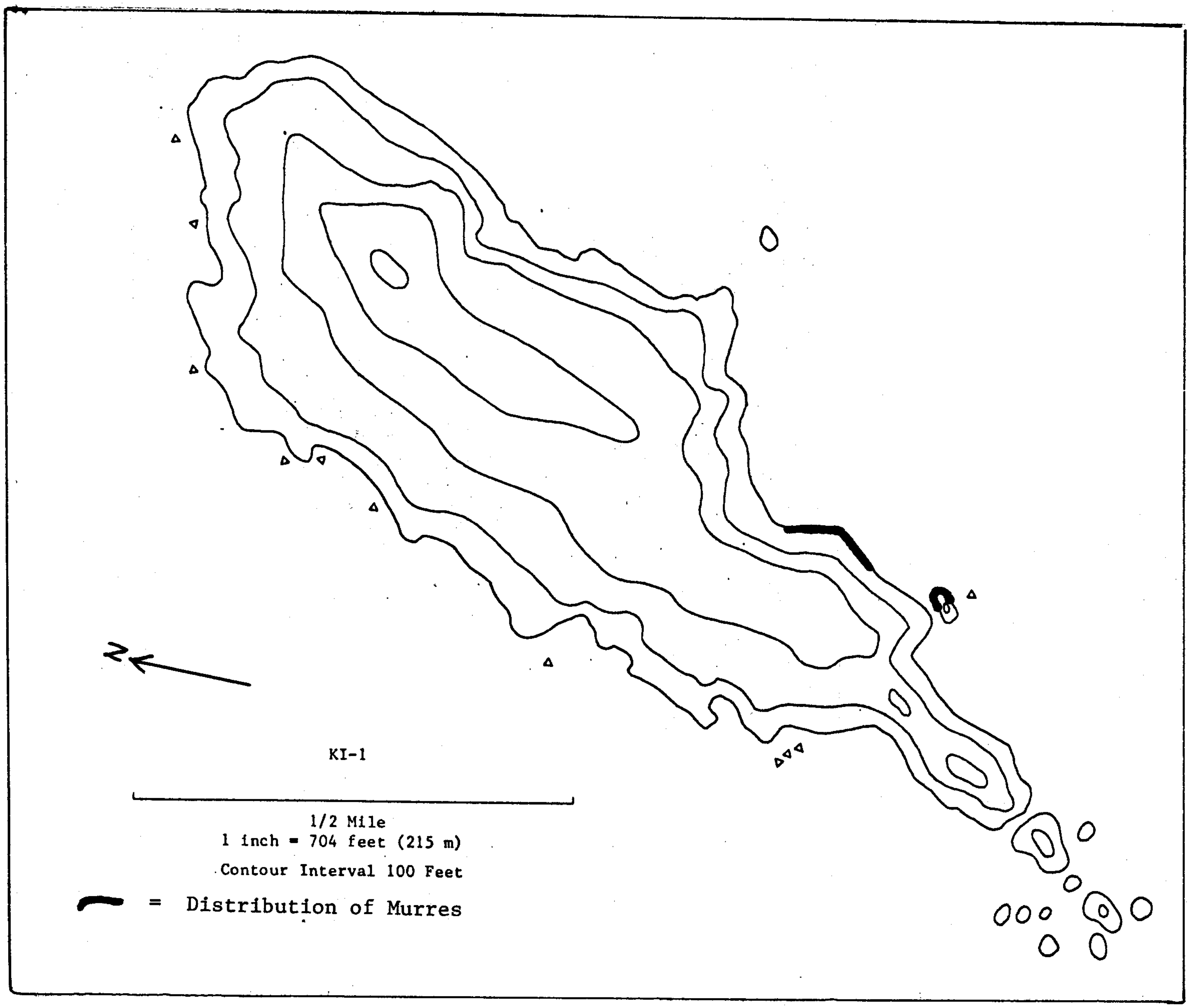
Map 6 Location of study plots on Kateekuk Island.



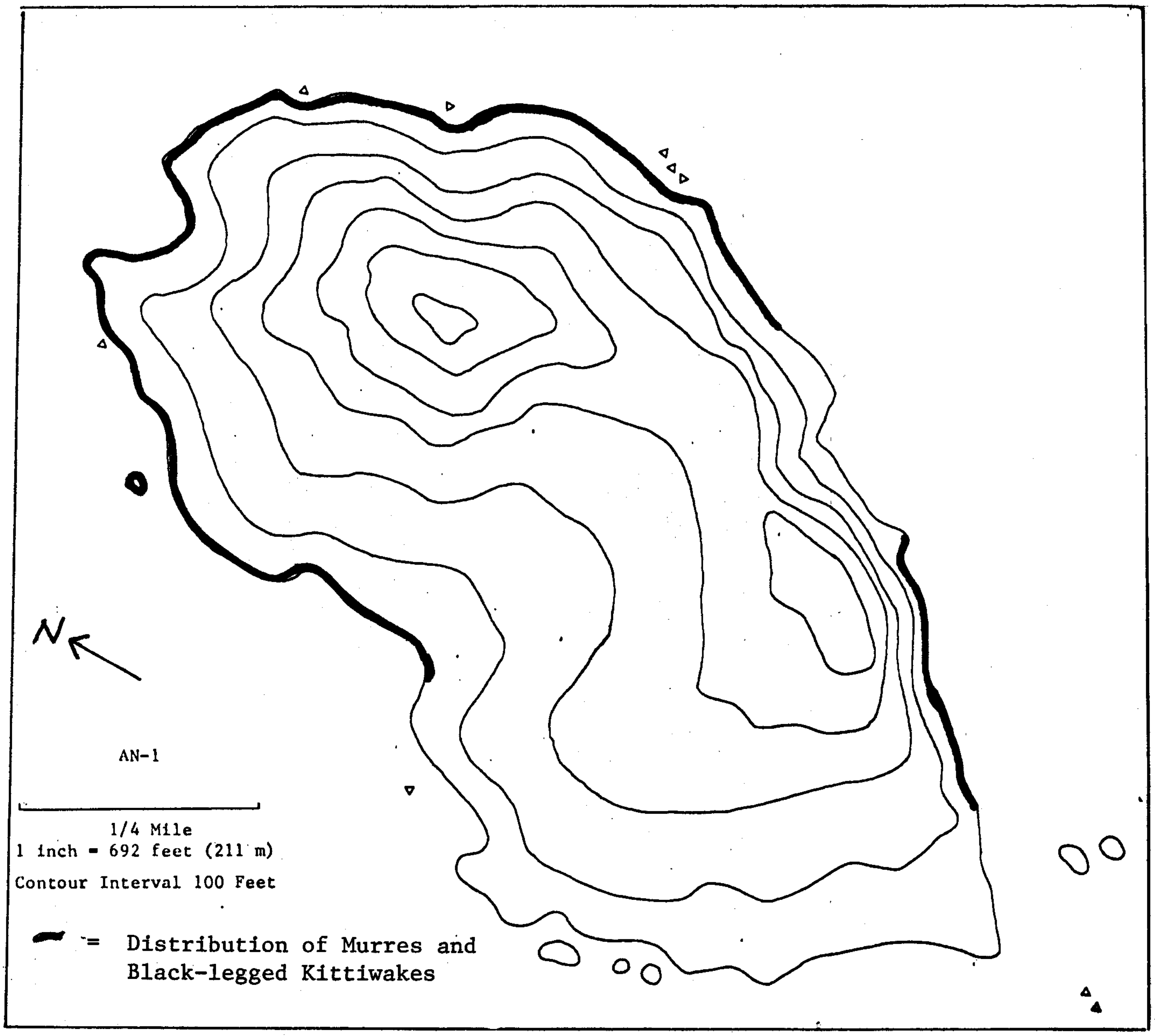
Map 7. Common and Thick-billed Murre and Black-legged Kittiwake nesting distribution on Chowiet Island.



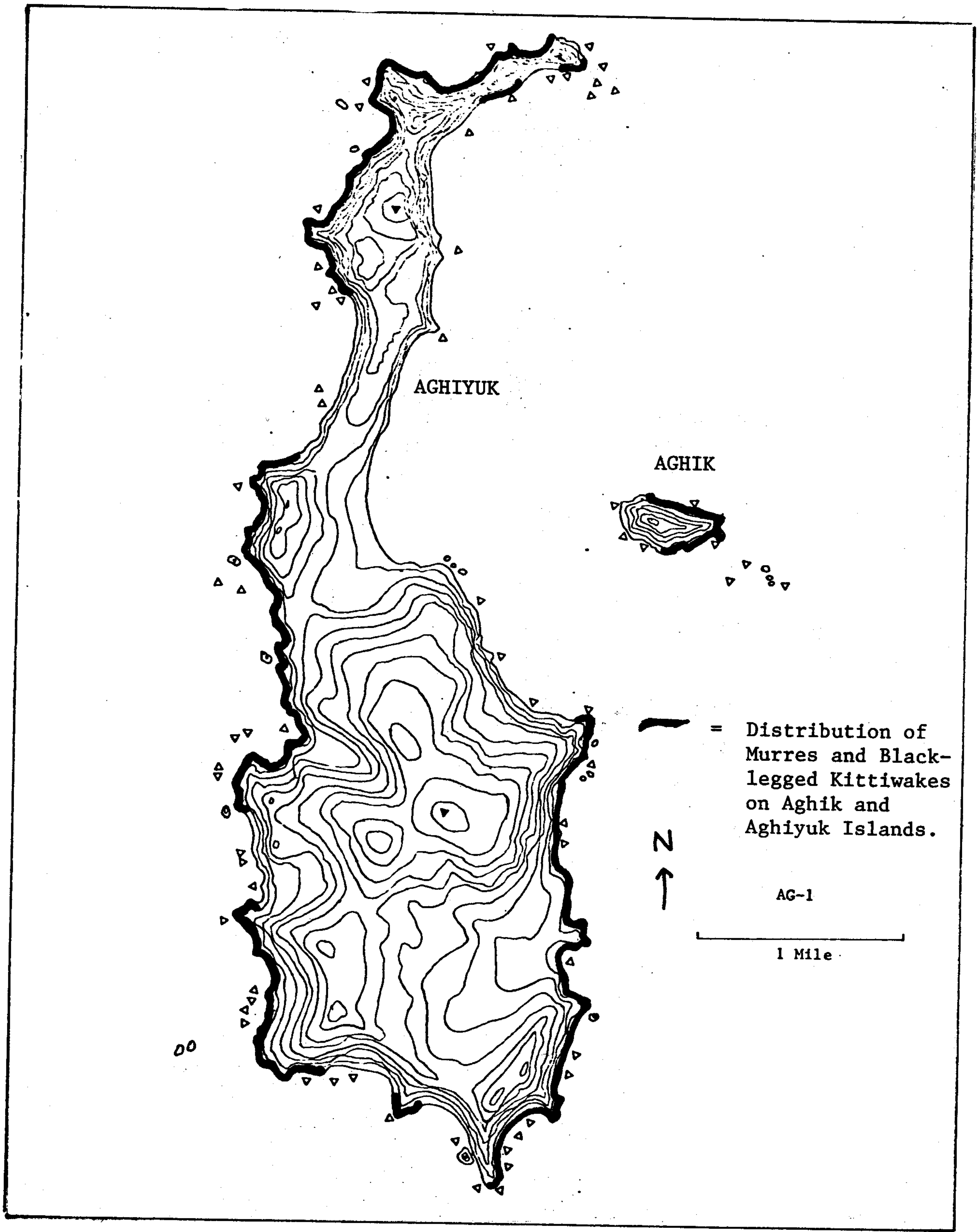
Map 8. Distribution of Murres and Black-legged Kittiwakes on Kateekuk Island.



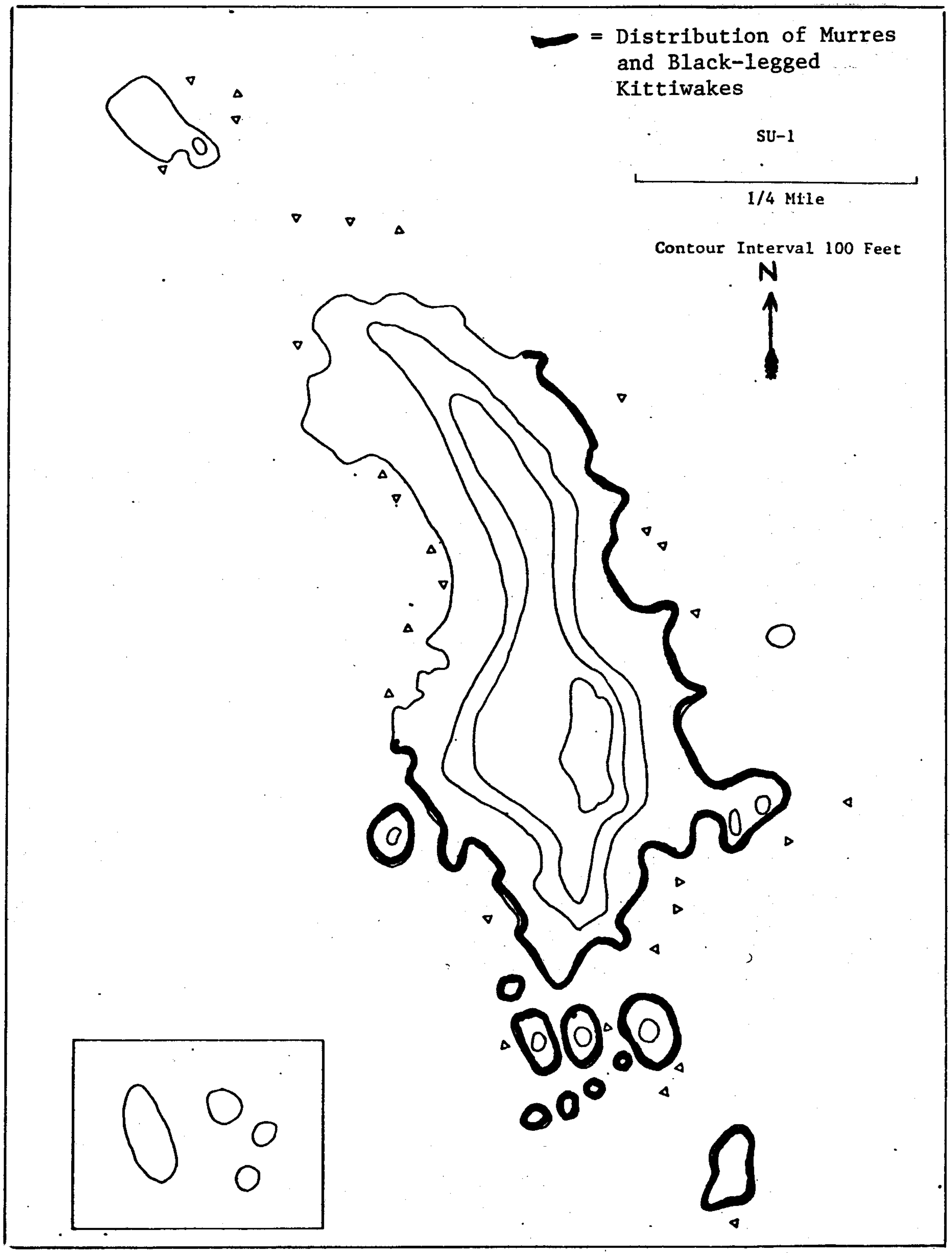
Map 9. Distribution of Murres on Kiliktagik Island.



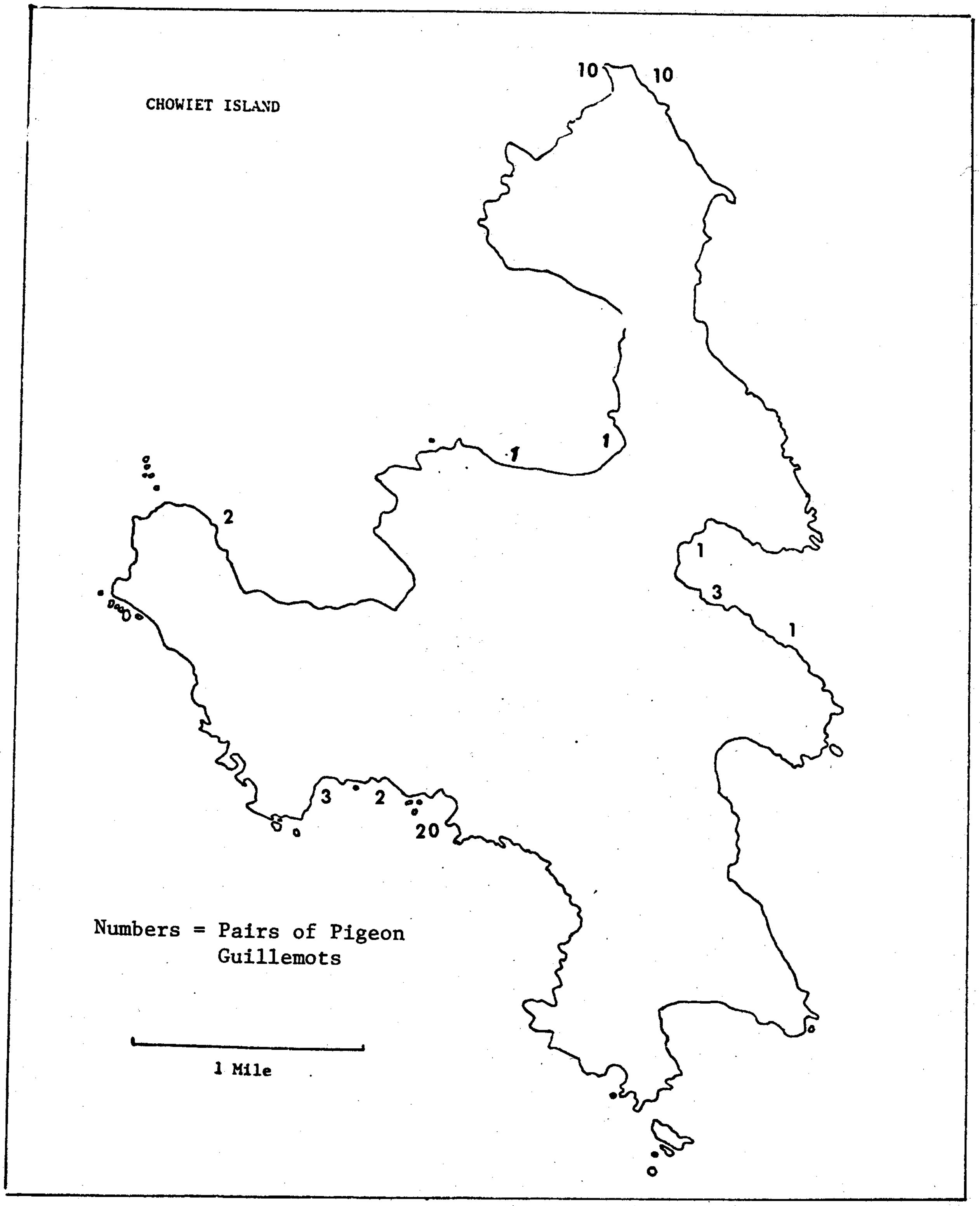
Map 10. Distribution of Murres and Black-legged Kittiwakes on Anowik Island.



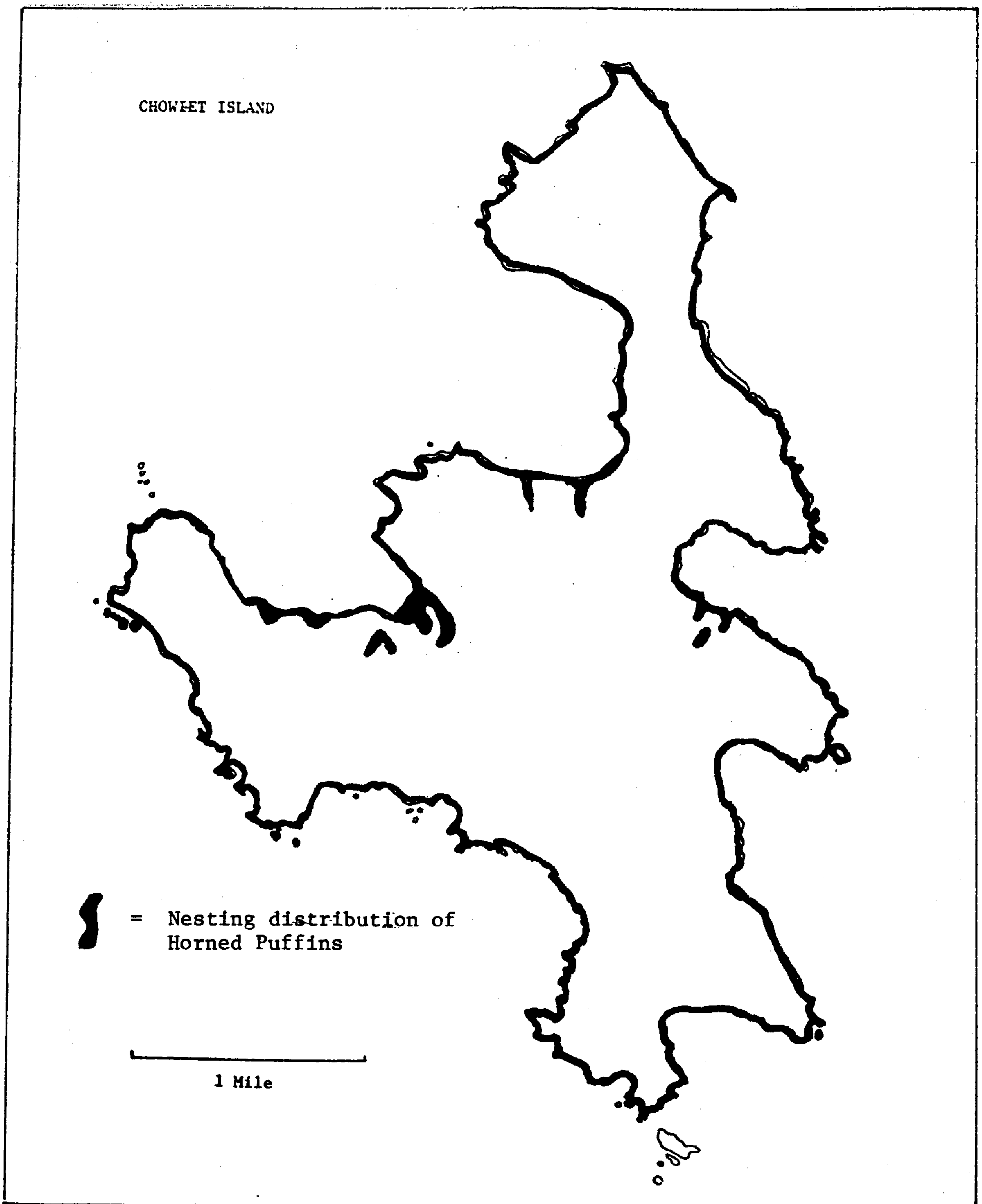
Map 11. Distribution of Murres and Black-legged Kittiwakes on Aghik and Aghiyuk Islands.



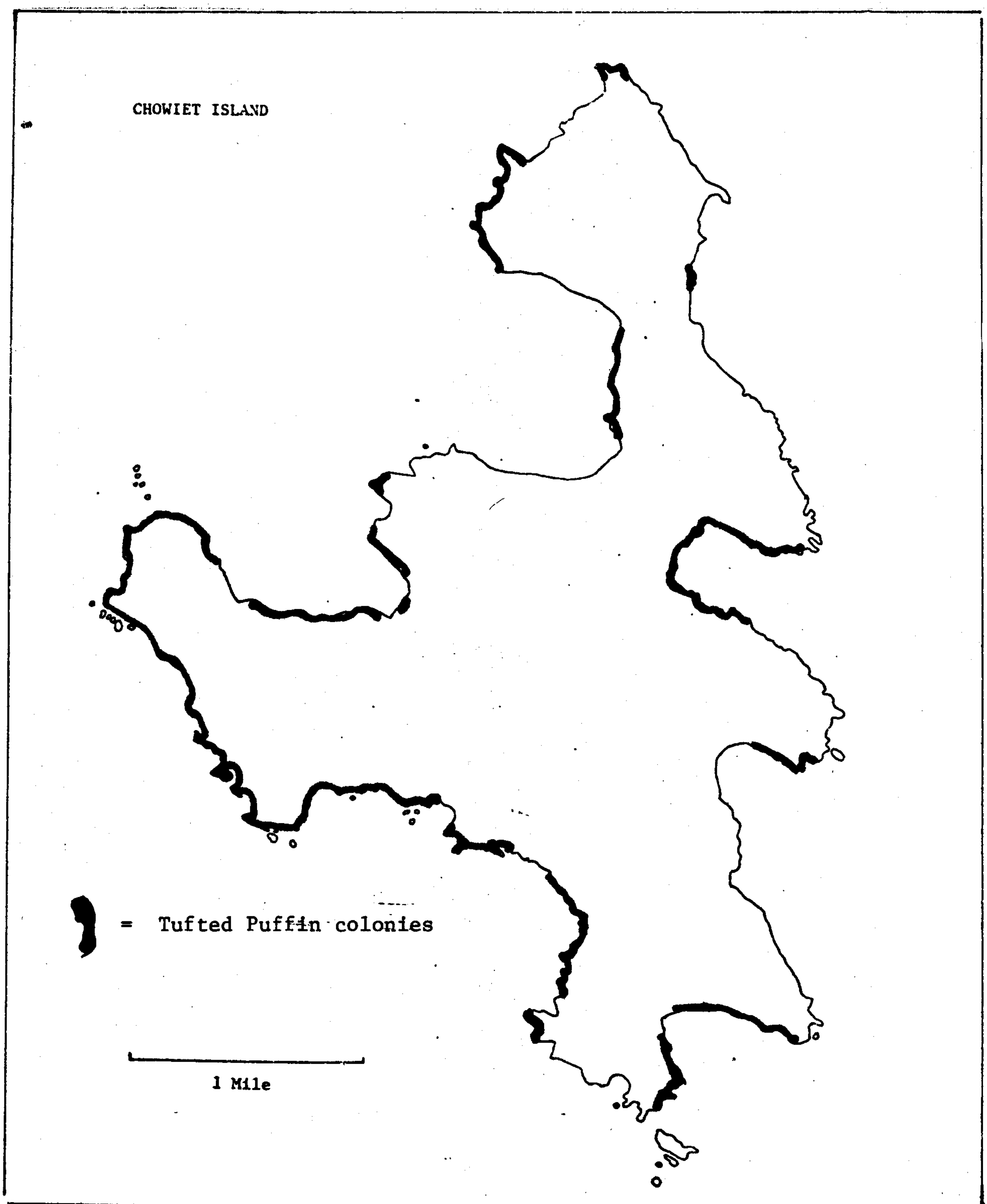
Map 12. Distribution of Murres and Black-legged Kittiwakes on Suklik Island



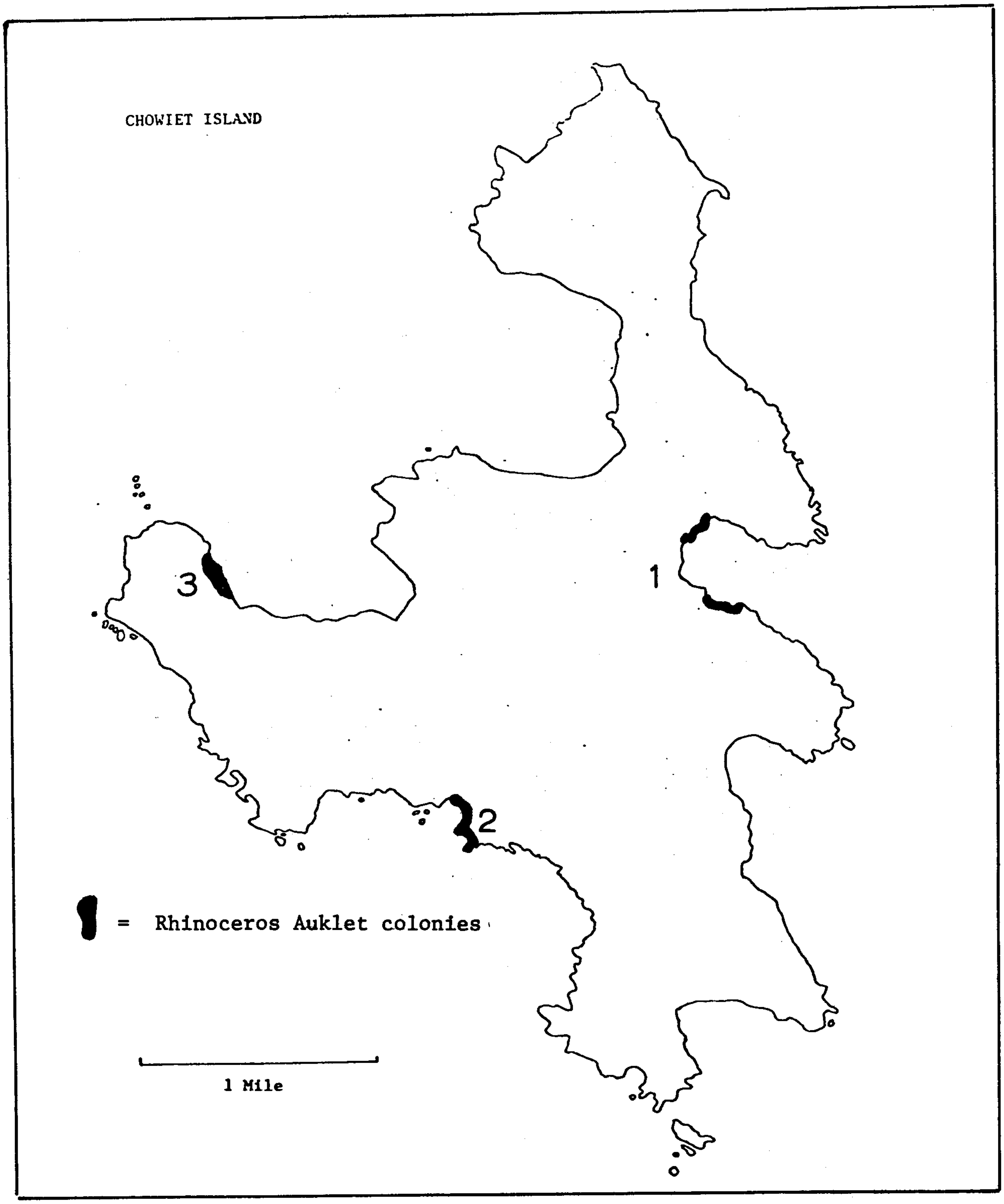
Map 13. Nesting distribution of Pigeon Guillemots around Chowiet Island.



Map 14. Nesting distribution of Horned Puffins on Chowiet Island.



Map 15. Location of Tufted Puffin colonies on Chowiet Island.



Map 16. Location of the three Rhinoceros Auklet colonies on Chowiet Island.

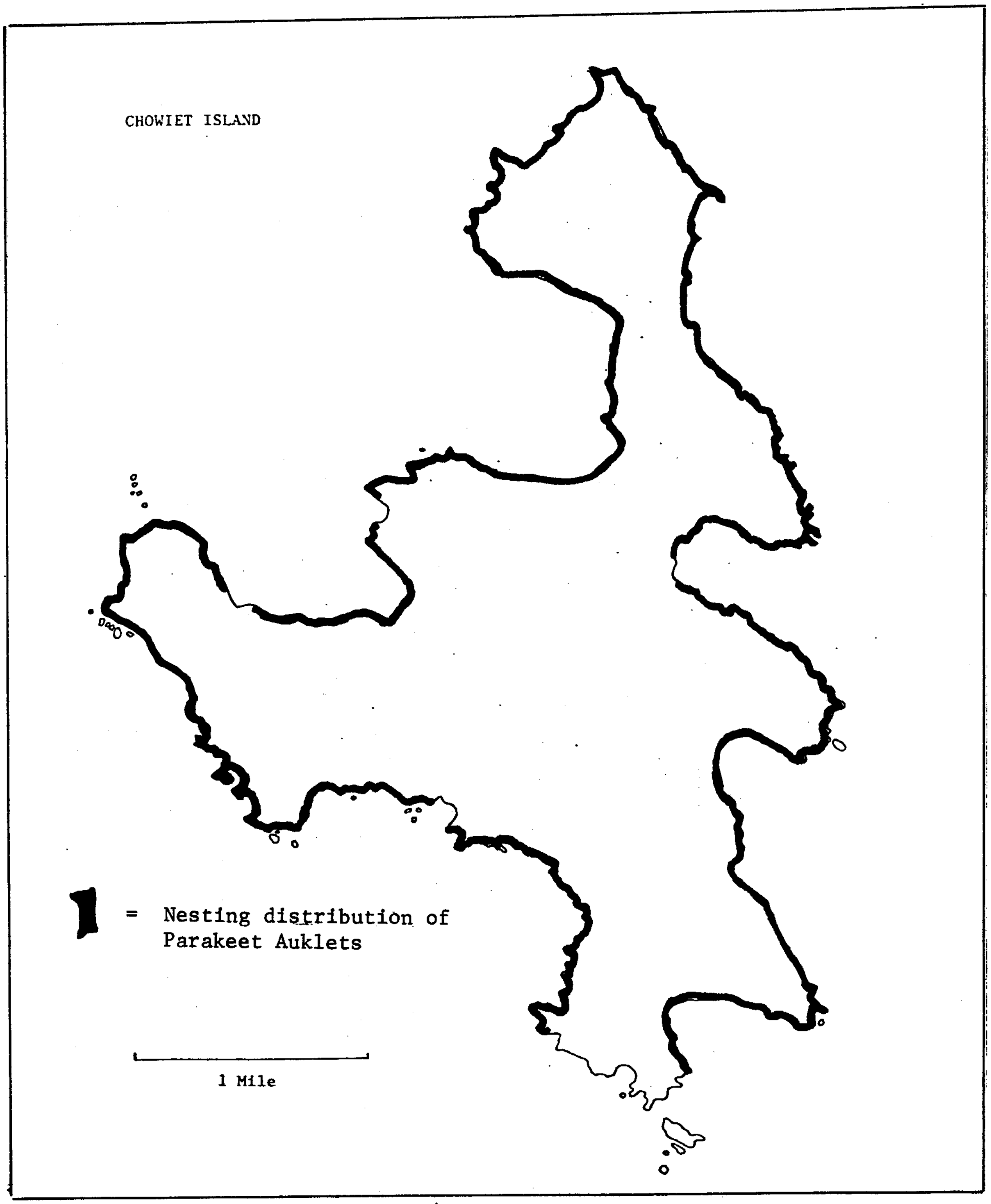
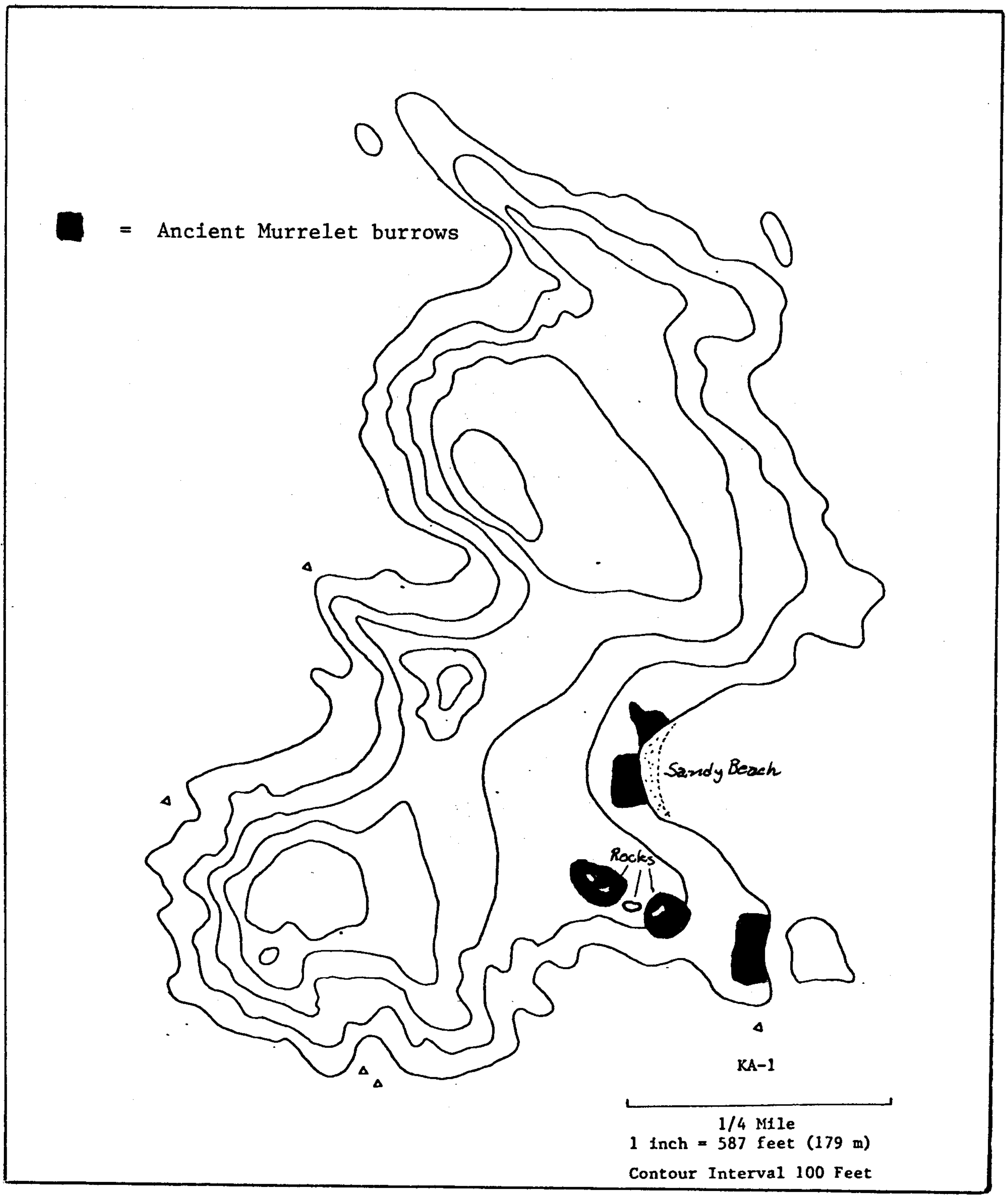
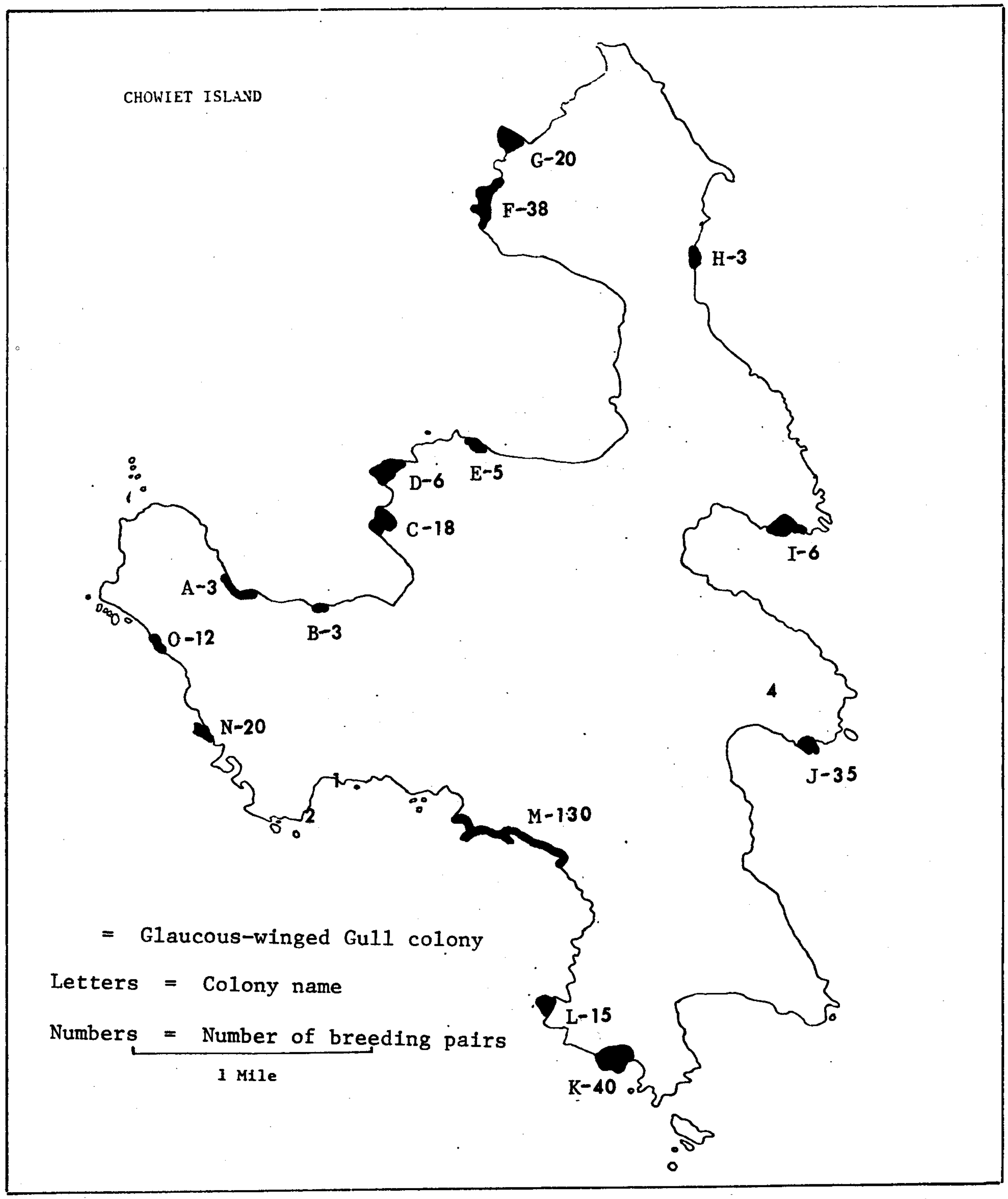


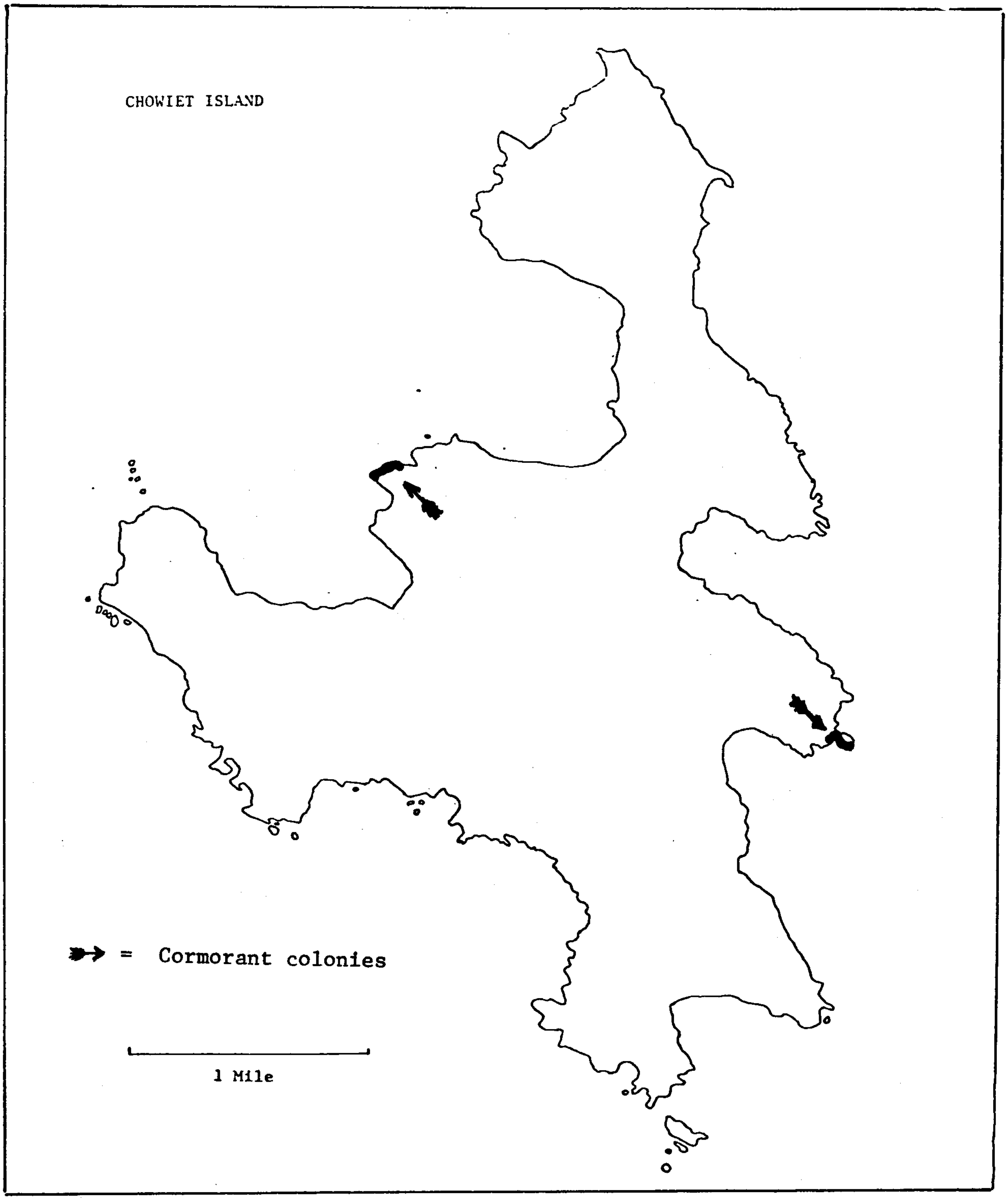
Figure 17. Nesting distribution of Parakeet Auklets on Chowiet Island.



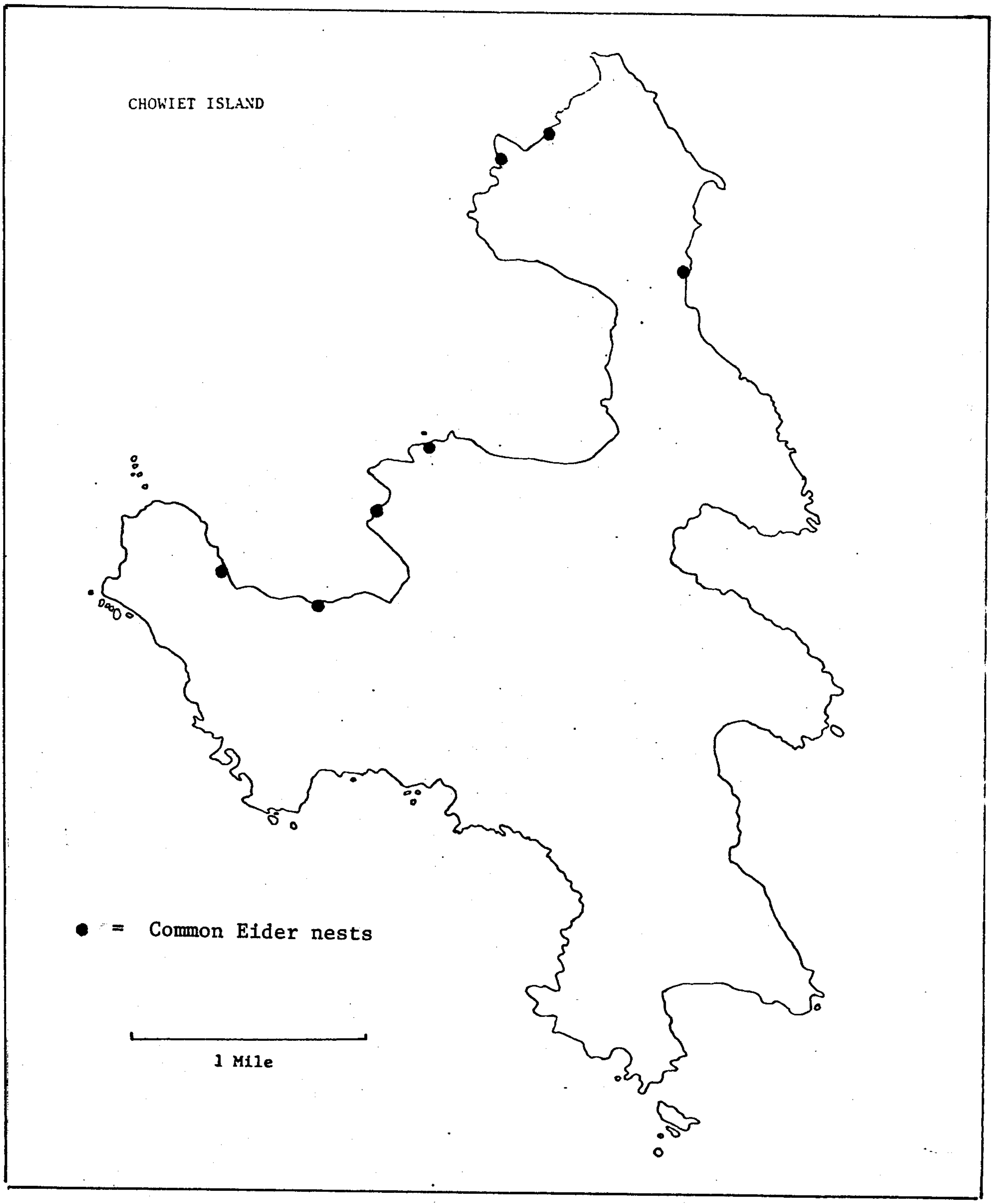
Map 18. Locations of Ancient Murrelet colonies on Kateekuk Island.



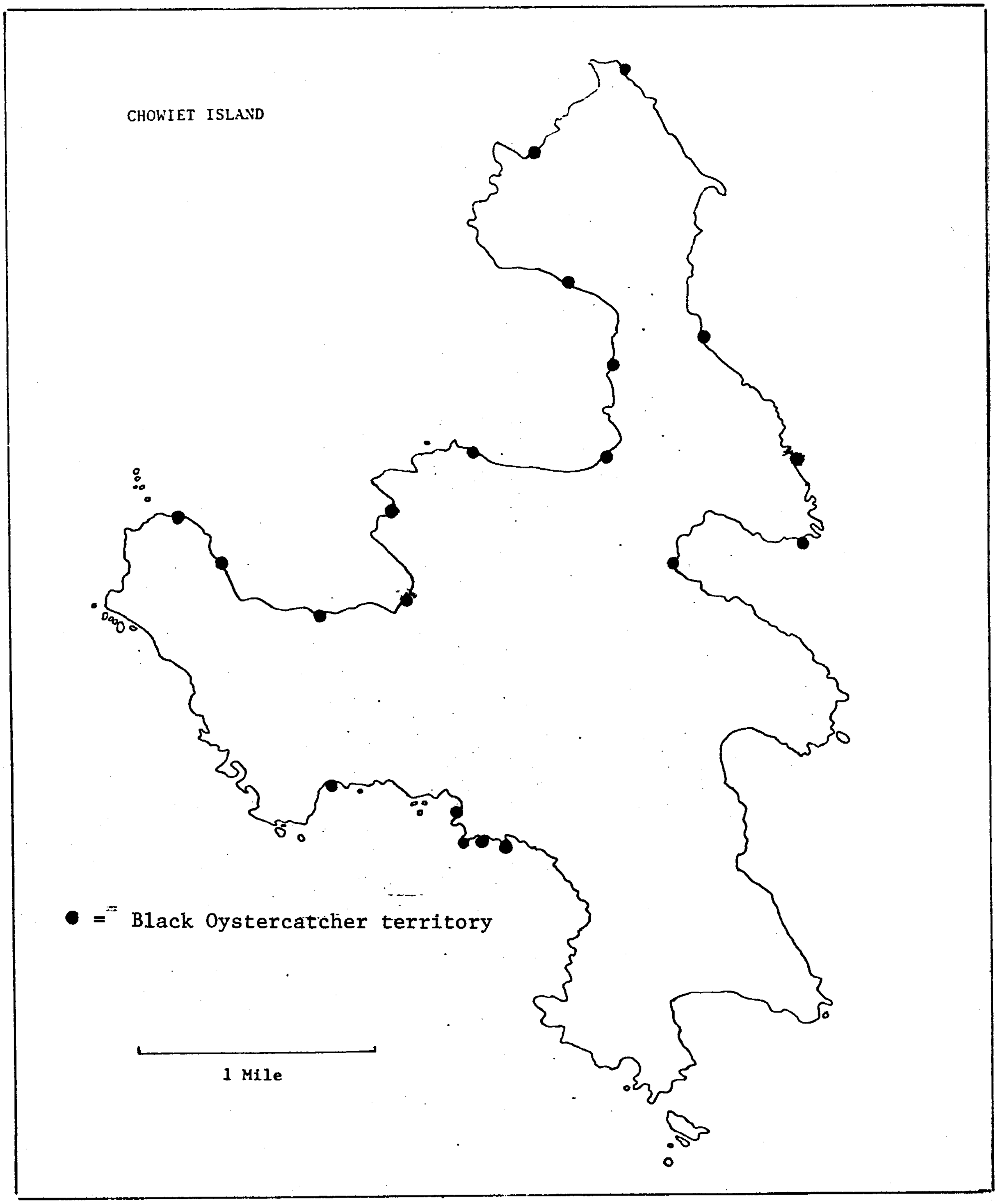
Map 19. Location of Glaucous-winged Gull colonies on Chowiet Island.



Map 20. Location of the Red-faced and Pelagic Cormorant colonies on Chowiet Island.



Map 21. Location of the seven Common Eider nests found on Chowiet Island.



Map 22. Distribution of Black Oystercatcher territories on Chowiet Island.

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Reporting Period: October 1, 1976 to March 31, 1977
Number of pages: v + 39

BREEDING BIOLOGY OF FULMARS AT SEMIDI ISLANDS, ALASKA

by

Scott Hatch

Part III

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS

IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

Calvin J. Lensink and James C. Bartonek
Co-principal Investigators

U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

February, 1977

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

A population of at least 500,000 fulmars utilize cliff nesting habitat at Semidi Islands. Fulmars prefer the higher, vegetated portions of cliffs, therefore little or no overlap occurs in habitat use between fulmars and other cliff-nesting species. Most suitable habitat is now occupied, however nesting space does not appear to be limiting.

Attendance at the colony throughout the season was characterized by synchronized arrivals and departures occurring in cycles of several days and largely predictable in terms of changing weather conditions. Maximum numbers of birds at anytime during the breeding season occurred during May, prior to egg-laying. Total evacuations of the colony lasting up to nine days also took place in this month. Later on fluctuations in attendance were attributable in large part to the movements of unemployed birds.

Egg-laying commenced on 29 May and ended on 22 June. Hatching began around 15 July and was completed by 8 August. No chicks had fledged by 3 September. A few chicks were probably still on land in early October.

Reproductive success was 14.9 percent for 208 breeding pairs. Hatching success varied from total failure to over 44 percent and overall breeding success from 0 to 33 percent in fairly discrete nesting areas within the colony. Rate of egg loss was 50 percent during the first 14 days after laying and 78 percent overall. Survival of chicks from hatching to near fledging was 67 percent.

Glaucous-winged gulls and ravens were the only known egg predators, gulls being by far the more serious. Lack of assiduousness on the part of incubating fulmars accounted for most egg losses and was particularly evident around the time of incubation changeovers. The rate of egg infertility was estimated at six percent.

Incubation spells of up to 13 days duration were observed. The mean duration was around six days.

Nestling weight gain was sporadic with a tendency toward synchronized feeding schedules among chicks of all ages.

The percentage of birds at the colony in wing molt (failed and nonbreeders) reached a peak of 78 percent near the end of July after which most of these birds went to sea. However, a partial reoccupation of breeding sites in these same groups occurred during the latter part of August and early September.

Some 6,000 fulmars were censused along 2 km of cliffs in late June and early July. It was shown that this figure represents no more than 18 percent of the total population occupying the area at some time during the year. The proportion of nest-sites occupied by breeding birds was around 65 percent. About 17 percent of the Semidi Islands population are of the "light phase."

Reproductive success in 1976 was believed to be below the average necessary for population replacement. Several characteristics of breeding biology of fulmars at Sedimi Islands would facilitate a long-term study of population dynamics and could be equally valuable in monitoring the effects of environmental changes on reproductive ecology.

INTRODUCTION

The fulmar (Fulmarus glacialis) is one of the dominant pelagic birds of Alaskan OCS areas. The Semidi Islands may comprise the largest of four major breeding grounds of the species in the North Pacific, the other three being Chagulak Island in the eastern Aleutians, the Pribilof Islands and St. Mathew Island in Bering Sea. Unlike many other Alaskan seabirds with a more homogeneous distribution of breeding populations, production in the fulmar apparently hinges on the success of these few very large colonies.

Current knowledge of population and reproductive ecology of the Pacific fulmar (F.g. rodgersii) is scant. The present study has been undertaken to provide baseline information on distribution and abundance, habitat, breeding chronology, productivity and other aspects of breeding biology needed to evaluate potential impacts on the Semidi Islands fulmar population of oil exploration and development in the Kodiak Basin and adjacent OCS areas. Field work in 1976 began on 2 May and terminated on 3 September.

STUDY AREA

The Semidi Islands are located near latitude 56°N and longitude 157°W in the western Gulf of Alaska. There are nine islands in the group, Aghiyuk, Aghik, Chowiet, Kateekuk, Anowik, Kiliktagik, Suklik, Aliksemit and South, ranging in size from 8 to 3,000 acres. At elevations below about 500 ft (150 m) the islands support lush subarctic plant communities of grasses, forbs and prostrate shrubs. At higher elevations mosses and lichens become predominant. The climate is polar maritime, with a mean annual temperature of 40°F (4.4°C) and average annual precipitation of about 60 in (Troyer 1972). Weather data for May-August, 1976 are summarized in Table 1.

Precipitous shorelines on all the islands harbor vast colonies of cliff-nesting seabirds while rocky shores and upland areas receive variable use by crevice and burrow nesters. Intensive observations of fulmars were confined to a 2 km stretch of cliffs on the west side of Chowiet Island (Figure 1).

METHODS

Attendance at the colony was monitored through daily observations of five study plots in May and later on twelve separate plots comprising about 800 nest-sites altogether. Numbers of pairs, singles, light phase individuals and active nests, i.e., those containing an egg or chick, were recorded along with appropriate weather data.

Altogether, over 550 individual nest-sites were monitored for all or part of the season. These were located either photographically or marked on the ground in such a manner that they can be relocated in subsequent years. Observations made on these sites were as follows:

245 sites--located photographically prior to egg-laying and checked daily from mid-May to 3 September to determine the distribution of egg-laying dates, incubation period and survival rates of eggs and young.

150 sites--numbered and marked on the ground prior to egg-laying and not revisited until after all young were hatched in late August.

61 sites--added as eggs were laid and checked daily thereafter.

34 sites--active nests of light phase-dark phase pairs added just prior to the onset of hatching and checked daily thereafter.

26 sites--selected during the hatching stage for growth studies. Growth data were obtained every other day from hatching.

50 sites--"successful" sites recorded photographically in late August.

Continued observations on nest-sites in which eggs were never laid and on failed sites after failure were maintained along with active sites.

Egg losses to glaucous-winged gulls (Larus glaucescens) were monitored in a 1,000 m^2 plot established within a gull nesting area. From 3 June to 9 July fulmar eggshells were collected from the plot at two-day intervals, washed, dried and weighed.

The percentage of birds present at the colony undergoing primary molt was determined daily from 30 June to 3 September. This involved a simple tabulation of 100 birds selected at random from those in the air.

Fulmars were censused along approximately 2 km of cliffs on the western side of Chowiet Island from 23 June to 8 July. Numbers of pairs, singles, light phase individuals and incubating birds were counted. Extensive photographic coverage of cliff habitat in color and black and white film was obtained from the water during July and August for the purpose of delineating nesting areas and documenting the current usage of the islands by fulmars and associated cliff-nesting birds. The shorelines of Kateekuk, Anowik, Kaliktagik, Suklik, and Aliksemit Islands were covered in their entirety, along with all cliffs occupied by fulmars on Chowiet Island. These photographs are currently being catalogued and will be available from the U.S. Fish and Wildlife Service, Office of Biological Services-Coastal Ecosystems, Anchorage, Alaska.

Habitat characteristics assessed for all study plots and individual nest-sites included identification and percentage cover of dominant vegetation types, slope, exposure, elevation, substrate and distance to the nearest neighboring nest-site.

Weather data were collected using a Taylor maximum-minimum thermometer, Dwyer wind gauge and Tru-Chek rain gauge.

Twelve adult fulmars were collected, four in each of the three months June, July and August. Stomach contents were preserved and study skins were prepared from all specimens. An effort was made to obtain a series representative of the color phases of fulmars found at Semidi Islands.

RESULTS AND DISCUSSION

Nesting Habitat

Overlap in nesting habitat between fulmars and other open cliff-nesting species is essentially nil at Semidi Islands. Murres (*Uria aalge* and *U. lomvia*) and black-legged kittiwakes (*Rissa tridactyla*) are largely confined to bedrock cliff ledges while fulmars dominate the higher, vegetated portions of cliffs.

Nesting areas occupy slopes inclined to about 40 degrees exceptionally, but cliffs from 60 degrees to nearly vertical are more typical. A slope of at least 50 degrees in the immediate vicinity of a vegetated nest-site seems to be necessary for unhampered access and egress by the birds. Suitable habitat of any exposure and elevation is utilized. On Chowiet Island the latter ranged from about 30 ft (10 m) to 500 ft (150 m) above sea level. Nesting areas situated in the numerous canyons indenting the shoreline occupy very irregular terrain often capable of access by both humans and arctic ground squirrels (*Citellus undulatus*). The latter, being the only known land mammal inhabiting the islands, is apparently innocuous.

Nest-sites are usually established on a soil substrate but occasionally on bedrock outcrops or unconsolidated sand and rubble with no vegetative cover. A few nests were discovered amongst boulders at the bases of cliffs. By far the most important cover plant was *Elymus arenarius* although others which contributed significantly at individual nest-sites included *Conioselinum chinense*, *Angelica lucida*, *Heracleum lanatum* and *Ligusticum scoticum*.

Nest-sites tend to be aggregated in irregular terrain. Typical densities are one nest-site per 1 to 4 m^2 although occasionally pairs will nest 10 to 15 m from the nearest neighboring fulmar pair.

In surveying the islands there appeared to be a minor amount of suitable habitat which is not utilized by fulmars.

Phenology

Figure 2 presents the distribution of egg-laying dates in 205 nests. There can be little doubt that the first eggs were laid on 29 May as a total evacuation of the colony of several days duration occurred prior to egg-laying (see below), and the only fulmar observed on land on the rounds of 29 May happened to be incubating in a study nest.

The spread of hatching can be extrapolated from the egg dates and incubation period. The latter, determined to within one day in sixteen cases, averaged 49 days with a range from 47 to 50 days. This is in agreement with certain other accounts (Eggeling 1952, Lack 1967) but not with the 55-57 period given by Palmer (1962). It is rather less variable than five cases given by Fisher (1952) ranging from 41 to 57 days.

Hatching, then, can be presumed to have commenced on about 15 July and to have been all but completed by 8 August. The first chick hatched at a study nest-site on 19 July and the last on 8 August.

Age at departure was 50, 54 and 56 days in three chicks studied by Williamson (1952) but averages 46 days with a range from 41 to 57 days according to Fisher (1952). As of 3 September fledging had not been observed anywhere in the colony, nor did it appear imminent for any of 20 chicks aged 41 to 46 days. In this year at Semidi Islands it is unlikely that any chicks fledged before 5 September, possibly none before 10 September, and some were probably still on land in early October.

Production

Data on reproductive success in 208 individually monitored breeding pairs on five separate study plots are summarized in Table 2. Hatching success varied from total failure to over 44 percent in fairly discrete nesting areas within the colony. Overall reproductive success averaged 14.9 percent but varied from 0 to 33 percent. Plots A through E comprise individually monitored nest-sites checked daily, but usually from considerable distance using binoculars or spotting scope, therefore disturbance by the observer was believed to have been minimal. Nevertheless, there were instances in which incubating birds were apparently induced by the presence of the observer to leave their eggs unattended, resulting in egg loss. Of an original 219 nests, 11 which failed under these circumstances have been deleted from the analysis.

As a further check on the reliability of the data in Table 2 production on plots A through E is compared to that on nine additional plots in Table 3. Study plots F through N were observed from a sufficiently great distance that human interference was never a factor. Daily counts of adults and approximate numbers of eggs or chicks were made, and although the total number of eggs laid on these plots is unknown, the number of nest-sites and maximum number of eggs observed during the egg-laying period can be used as a basis for comparison with individually monitored nests. The number of chicks produced per nest-site and the ratio of chicks produced to the maximum number of eggs observed were somewhat higher on plots F through N. If the differences are not simply a result of inaccurate counts of nest-sites and eggs (counts of apparent nest-sites on these plots are necessarily conservative), they provide an overall estimate of breeding success of 17.5 percent. In view of the spatial variation in production noted above and evident also in the data for plots F through N, the accuracy of either estimate of breeding success ultimately depends on the degree to which the areas selected for study represent a realistic cross section of the entire colony, whether the differences are due to habitat effects or age and experience of breeders. Also revealed in Table 3 is considerable variation in the proportions of nest-sites occupied by breeding and non-breeding pairs on various plots.

Production in 150 nest-sites marked on the groung during the birds' pre-laying absence and visited again only after all chicks were well along in late August amounted to 21 chicks or 0.14 chicks per nest-site. While this approach yields no information on the number of eggs laid, the plot is designed to provide a reliable index to production in subsequent years.

A survivorship curve for eggs and nestlings has been constructed in Figure 3 which is based on an initial population of 208 eggs. Egg losses amounted to 50 percent during the first fourteen days after laying. Likewise, chick mortality was highest during the first two weeks after hatching. Most losses occurring after 62 days were of eggs which had escaped predation but failed to hatch. Thus, barring any calamity after 3 September, the probability of fledging in chicks attaining the age of 14 days was on the order of 0.97.

Factors Affecting Production

Glaucous-winged gulls are the principal predators on eggs of fulmars at Semidi Islands. Pressure on fulmars was particularly great during the first two weeks of June, after which it may have been relieved partially by increased availability of murre eggs (Table 4). Dense plant growth made regular collection of shells impractical after 9 July.

The total of 78 eggs represents some minor fraction of the eggs taken by eight gulls (four pairs) with established territories on the plot. Casual observations indicated that the majority of eggs are broken and devoured on the spot rather than carried off to the predator's nesting territory. A few are swallowed whole.

Gulls took eggs when they were left unattended for short periods, something the fulmars were prone to do with surprising regularity. Rate of egg loss was highest during the first day or two after laying (Figure 3) then tended to coincide with incubation changeovers later on, as revealed in the data for unsuccessful light phase-dark phase pairs. Considering only those cases where at least one successful changeover was made, 22 out of 32 egg losses (69 percent) occurred within 1 day after an incubation changeover (14 cases) or 9 to 13 days after the last changeover (8 cases). Records of the latter type may reflect restlessness on the part of birds having just resumed incubation duties or on the part of birds having already sat for an exceptionally long spell. Some of the losses occurring after 5 days (3 cases), 6 days (3 cases) and 7 days (1 case) may also have coincided with incubation changeovers (see below).

Ravens (*Corvus corax*) took a few eggs of fulmars but were seen doing so on only three occasions compared to dozens of observations of gull predation.

Of 50 eggs which survived the full term of incubation, 4 failed to hatch. One was improperly incubated--left unattended for periods of one to four days during the latter half of the incubation period--and contained a dead embryo when it was later collected and examined. The remaining 3, incubated assiduously for 62, 67 and 74 days respectively, were probably infertile. Thus, infertile eggs are estimated to have comprised around 6 percent of the total.

Fresh remains of adult fulmars were noted on several occasions in one of three eyries of bald eagles (Haliaeetus leucocephalus) on Chowiet Island, but on the whole this source of mortality must be rather insignificant.

Duration of Incubation Spells

Observation of mated light phase and dark phase birds provided data on the duration of incubation spells. Sittings of 10 to 13 days, often truncated by egg loss, were not uncommon, but only completed spells are considered here. In Table 5 the present findings are summarized and compared to those of Dunnet et.al. (1963) who obtained data for the first three incubation spells in several years at a small Atlantic fulmar (F.g. glacialis) colony. Average second and third incubation spells were significantly longer in the Semidi Islands birds, the differences being 1.63 days (P less than 0.05) and 2.71 days (P less than 0.01) respectively. On daily visits the first bird seen with a newly laid egg is often the male since males generally begin a lengthy incubation spell within the first 24 hours. This pattern was revealed in the sexed birds of Dunnet et.al. (1963) and clearly evident in this study also. For the purpose of this comparison initial spells of three or four days were attributed to the female only if followed by a spell of seven or more days by the presumed male.

Williamson (1952) monitored the incubation stints in three Atlantic fulmar pairs from two or three days after laying until hatching. The longest sitting he recorded was about nine days while the majority lasted from two to five days. Moreover, he noted an abrupt shift in the incubation rhythm a week or ten days before hatching, with the majority of spells reduced to two days or less. In this study most spells during this period were of five or six days duration. The average duration of incubation spells in 11 pairs whose eggs survived the full term ranged from 3.46 to 7.50 days, excluding the first brief spell by females. The mean of these values was 5.88 days which is significantly greater (P less than 0.01) than the comparable value of 3.37 days calculated from Williamson's (1952) data. Here the comparison is based on samples of three and eleven pairs rather than the total number of incubation spells recorded, thereby allowing for the likelihood that spells are not independently variable, i.e., there are consistent individual differences.

Growth

Figure 4 and Table 6 summarize the data on nestling weight gain and growth in wing, tarsus and culmen. Measurements of seven adult females and five adult males have been added at the end of the table for reference.

The instantaneous relative growth rate was calculated over each two-day interval according to the formula given in Brody (1945).

Individual chicks experienced very erratic progress in weight gain, alternating periods of steady gain with losses of up to 26 percent of body weght occurring over a 2 to 6 day interval. Moreover, gains and losses tended to occur simultaneously in chicks of all ages as is illustrated in Figure 5. The figure was constructed in the following manner. First, the changes in weight between every two visits were determined for each chick. These values were arrayed according to age, and the mean change in weight and its variance were calculated for chicks at each age. The expected total weight gain of all chicks measured on each visit and the variance and 95 percent confidence limits of this sum could then be computed, based on the hypothesis that chicks gained or lost weight independently of one another. These parameters are graphed in Figure 5. When the observed total weght gain is superimposed it is seen that the values oscillate between extremes, being significantly less or greater than expected on seven occasions. Thus, it is concluded that intermittent feeding of chicks took place in synchronous cycles.

The only published data on growth of fulmar chicks are for two individuals during the first two weeks of life (obtained by E. Duffey but reported in Fisher 1952: 370). The final weights were 595g and 665g which is well above the range observed in 14 day old chicks at Semidi Islands (Figure 4). The difference may not be quite so dramatic. The previous measurements were begun when the chicks were estimated to be two days and four days of age. Duffey (1951) describes the means by which he assigned these ages but the data as presented in Fisher (1952) suggest that initial ages may have been underestimated by as much as several days.

Molt

The proportion of birds at a fulmar colony undergoing primary molt in relation to the chronology of breeding may provide at least a rough measure of the level of production in a given year. The pattern seems to involve failed breeders which initiate molt of innermost primaries soon after failure and linger at the colony before going away to sea where the outermost primaries are replaced (Duffey 1950, Fisher 1952, Carrick and Dunnet 1954). When growth of new primaries is nearly complete these birds may again visit the colony. Nonbreeders may also begin molt in mid-season while successful breeders apparently initiate molt after the young are fledged or during the latter part of the nestling period as was observed in this study.

The first observation of a bird undergoing primary molt was made on 19 June. By 30 June, when daily counts were begun, the proportion had increased to 20 percent (Figure 6). The percentage rose to nearly 80 percent during the latter part of July, after which an equally sharp decline probably reflects the departure of failed and nonbreeding birds from the colony.

At a large Atlantic fulmar colony Bourne (1966) found 33 percent of fulmars in the air in wing molt on 10 July, 1960, which is comparable to the situation this year at Semidi Islands. None of the birds at a series of small colonies visited by him just ten days later were in primary molt.

Nest-site Attendance

The pattern of attendance over the course of the breeding season is illustrated in Figure 7. The figure is based on counts of most of the same plots as in Table 3 and therefore includes the full range of production areas. On a few foggy days it was not possible to obtain counts for all plots. The totals for these days were prorated according to the average relative contribution of each plot or combination of plots missed so that all daily counts would be comparable.

Note that maximum attendance at any time during our stay occurred in May, prior to egg-laying. On 7 May, before regular counts were begun, there was a peak in attendance as great or greater than that observed on 18 May. Thus there were at least two cycles of high attendance and complete evacuation during the pre-laying period. Fisher (1952: 343) compiled information on large colonies of the Atlantic fulmar and concluded that maximum numbers of birds on land may actually occur during January with another peak in late April. Coulson and Horobin (1972) made daily counts at a small British colony from 1 January to 9 May. The maximum number of occupied sites occurred during January followed by a general decline in numbers from February to May. This period was marked, however, by cycles of attendance and total or nearly total desertion of the colony for periods of one to several days. At Semidi Islands this pattern was still evident in May but terminated with the so-called "pre-laying exodus" or "May dip" (Fisher 1952). Except for a small number of birds on land on 23 May, this lasted fully 9 days from 20 to 28 May. Recall that the first eggs were laid on 29 May. The pre-laying exodus, which has been described for various procellariiform birds, is probably an important preliminary to egg production in the female and the first long incubation stint in the male. In the fulmar total desertion of the breeding grounds at this time has not previously been described. Fisher (1952) generalized that attendance in early to mid-May drops to about 60 percent of the peak population in April, then recovers to 100 percent again in June. More in accordance with the present data are those of Dunnet et.al. (1963) for a British colony of around 100 breeding pairs. The minimum number of breeders present during May was estimated at 10, 6 and 3 percent of the total in three years. Subsequent recovery was around 65-80 percent of the peak pre-laying population. Working with banded birds these authors determined the average duration of absence in individuals was about two weeks but due to the spread of egg-laying (16-20 days) evacuation of the colony was never total.

The period from 1 June to 20 July, corresponding approximately to the incubation phase of the nesting cycle, is marked by numerous peaks and declines in attendance. That these fluctuations involve primarily the movements of failed and nonbreeding birds is apparent in Figure 8 which is based on data for 260 individually monitored nest-sites. Figure 9 compares the patterns of nest-site attendance in failed and nonbreeders. Note the persistently fuller attendance by failed breeders than nonbreeders and also the semi-permanent departure of many birds in both categories during the latter part of July, i.e., at the onset of hatching.

Williamson (1952) noted a marked tendency during the latter week to ten days of the incubation period for the unoccupied partner to remain at the nest-site with its incubating mate. This was true only to a very limited degree at Semidi Islands (Figure 10). Nettleship (1976) has recommended the latter half of the incubation period as the best time to census fulmar colonies because it is the time when many pairs are together on the ledges. It is important to realize, however, that these paired birds are not necessarily incubating eggs. If the present data are at all typical, it may practically be assumed that they are not.

During the nestling period the proportion of total observed pairs which were actively raising young increased steadily (Figure 10). This was also a time when the number of chicks unattended by either parent fluctuated in a cyclic manner (Figure 11). Maxima in the percentage of unattended chicks occurred on August 5, 9, 16, 21, 24, 28 and 31, i.e., generally two or three days before the peaks in total weight gain of chicks in Figure 5.

The number of birds on the breeding grounds rose significantly during late August and early September (Figure 7). This involved both fuller attendance by active parents (Figures 8 and 10) and the synchronized return of many failed and nonbreeding birds (Figures 8, 9 and 10). It is unknown to what extent this trend continued or when the adult population finally deserted the colony altogether. Actually, at some of the larger Atlantic fulmar colonies some birds remain on land throughout the year (Dott 1973). At smaller colonies a complete absence of fulmars generally lasts only six to eight weeks in September and October with birds returning in early November (Fisher 1952). The meager information on hand concerning possible winter activity at Alaskan fulmar colonies is negative. In conjunction with Fish and Wildlife Service aerial marine bird surveys three of the four largest Alaskan fulmar colonies were surveyed during February and March, 1976. No fulmars were observed on land at St. George Island on 29 February, at Chagulak Island on 4 March or at Chowiet Island on 7 March, nor did generally low densities of fulmars over the water noticeably increase in the vicinity of these islands. Thus, while Pacific fulmars probably spend more time on land each year than sympatric seabird species it seems unlikely that they are as closely associated with the breeding grounds during winter months as are their Atlantic counterparts.

The diurnal pattern of nest-site attendance was not studied in detail this year. Series of counts were made on two days early in the season at two plots comprising about 140 nest-sites (Figure 12). Coulson and Horobin (1972) found that fulmars deserted the cliffs after sunset throughout the winter pre-laying stage. Birds began reoccupying cliff ledges before dawn and the number present between 0900 and sunset remained fairly stable. Dott (1973) reviewed the information on diurnal activity patterns in and out of the breeding season and concluded attendance showed no regular diurnal pattern from March to July. His own counts made on 23 July suggested a return to a diurnal rhythm in attendance with a peak in the forenoon.

The counts upon which Figure 7 is based were generally made between the hours 0900 and 1600. However, there was no assurance that the maximum attendance on any given day would occur during this period. For example, 128 birds were counted on seven plots between 1130 and 1230 on 21 July. Between 1615 and 1700 the same day 177 birds were counted while 90 were present the following day between 1300 and 1600. Throughout this study weather, rather than time of day, seemed to be the overriding determinant of fulmar activity cycles.

Periods of "fair" and "stormy" weather are indicated in Figure 7. With few exceptions the peaks in attendance occurred under stormy conditions and the lows under fair conditions. Moreover, the extremes tend to occur near the middle of each period, i.e., the movements of fulmars between land and sea seem to anticipate changes in weather conditions. The intervals are defined primarily on the basis of cloud cover and rain or fog. Thus calm, rainy days were designated as stormy while clear days with strong winds are considered fair. Coulson and Horobin (1972) concluded that increasing wind speed was associated with decreasing numbers of fulmars on land but found no correlation between attendance and wind direction. Dott (1975) also expressed doubt as to the possible effect of wind direction on numbers of fulmars at the colonies. In this study, on the contrary, the movements of birds between land and sea were decidedly influenced by wind direction. This may explain the birds' ability to "anticipate" the weather since a change from clear to stormy conditions, or the reverse, is normally initiated by a change in wind direction. On days with northwesterly winds (usually associated with clear weather) the number of birds on land usually decreased (Table 7). A change to a southwesterly wind (and the likelihood of cloudy, rainy weather) usually meant increasing numbers of birds at the colony. In contrast to previous observations (Coulson and Horobin 1972), calm days, rainy or otherwise, generally saw a movement of birds out to sea. It may reasonably be postulated that wind direction primarily affects the ease with which fulmars travel to and from distant feeding grounds while wind speed may have a greater influence on the availability of food organisms at the surface.

Population Census

In assessing seabird populations it is desirable to know both the total number of birds utilizing a given area and the proportion of that total which comprises the breeding stock. For the fulmar, Nettleship (1976) has outlined a procedure for censusing colonies which entails a series of repetitive counts made over three to seven days during the latter half of the incubation period. This provides a figure for the average occupancy of nest-sites but does not distinguish between nonbreeding nest-site holders and true breeders. The result must be regarded only as an index of population size since average occupancy during this period may represent only a small part of the total population visiting the colony at some time during the pre-egg stage.

The technique employed in this study enables a breakdown of the population into its breeding and nonbreeding fractions but requires that several kinds of data be collected over a number of weeks. The actual census data (Table 8) are nonreplicated counts made on several of the days with lowest attendance during the incubation period (cf. Table 8 and Figure 7). This was desirable because it afforded a more accurate count of the number of incubating birds. With some experience an observer can generally distinguish these from single nest-site occupants which do not have eggs. As previously discussed, pairs may safely be assumed to be without eggs, especially on days with low attendance. The quick determination of presence or absence of an egg in a nest-site remains somewhat subjective, however, and for this reason the ratio of eggs to single birds counted on each day of the census is compared to the same datum for study plots A, B and C in Table 8. On the average, agreement was very close.

An estimate of the proportion of eggs laid surviving on each day of the census was derived from individually monitored nest-sites. Using these values the numbers of eggs counted are extrapolated to numbers of eggs originally laid and numbers of breeding birds (Table 9). Based on 14.9 percent breeding success, an estimated 1,657 young were fledged in the census area.

Finally, the ratio of breeders to nonbreeders is estimated from the number of eggs laid in 245 nest-sites selected for study prior to egg-laying (Table 10) and the total population of the census area reckoned accordingly. The figure 34,228 is considered to be minimum estimate for two reasons. First, terrain and vegetation conceal some fraction of nest-sites from view. This varies with habitat and the vantage point available but is subjectively estimated to average 15 to 20 percent. Second, in addition to nonbreeding nest-site holders, there are undoubtedly nonbreeders which frequent the colony but do not have established nest-sites.

The boundaries of the census area are indicated in Figure 1. The area constitutes about one half of a colony to which Troyer (1972) attributed 10,000 birds, his overall estimate for the Semidi Islands population being 386,000. The present results do not imply that the latter figure underestimates the actual population by 600 to 700 percent since other of the previous observer's component estimates are believed to be considerably more accurate. Surveys of the rest of the islands disclosed that fulmars nest along most (ca. 80 percent) of the coastline of Aghiyuk Island and virtually the entire coastlines of the seven smaller islands in the group. To adequately census the entire breeding grounds would be an immense task. The number of fulmars per linear mile varies roughly according to cliff-height. The census area included some of the higher, more densely populated cliffs. The writer is confident in placing the minimum estimate for the total Semidi Islands population at 500,000. It may prove to be considerably in excess of this figure.

Of 6,088 birds counted on the census, 1,057, or 17.4 percent, were of the "light" color phase (Table 8). Actually, the color morphology of this population is exceedingly complex with one extreme grading imperceptibly into the other. As a rule, those birds were designated as light phase which appeared to have some measure of clear white plumage in the head and breast region. There is some promise that correlation of color phase ratios observed at colonies and at sea might aid in the determination of the foraging range of fulmars during the breeding season.

The results of the census point to the problems encountered in trying to assess seabird populations during brief visits to colonies. It has been shown that even a relatively thorough count of fulmars on the breeding grounds during the incubation phase may correspond to a population nearly six times as great. The discrepancy between numbers of birds observed on short visits to a colony and actual total population is probably particularly great in the fulmar, but the results should be considered in terms of the type of data generally available for other seabirds as well.

FURTHER DISCUSSION AND CONCLUSIONS

The fulmar is a long-lived bird with a low reproductive rate. From banding studies conducted over a twelve year period, Dunnet et.al. (1963) calculated a mean annual adult survival rate of 0.938, corresponding to a mean duration of adult (reproductive) life of 15.58 years. The age at first breeding has been determined in three cases, being seven years in one and eight years in two individuals (Dunnet and Anderson 1965, Dott 1973). The Atlantic population of the fulmar, for which these data were obtained, has been rapidly expanding for over two-hundred years (Fisher 1952,1966). Recognizing, then, that population dynamics in the Pacific and Atlantic fulmars might differ substantially, it is nevertheless useful to consider the reproductive performance of the Semidi Islands fulmars in light of the above information.

If the average annual rate of reproductive success were 0.149, a pair of fulmars would be expected to fledge 2.32 young over the course of their reproductive lives. Two of these, or about six out of every seven young fledged, would have to attain breeding age in order to effect replacement. This corresponds to a mean annual survival rate from fledging to age 7 of 0.979, which is considerably higher than the adult survival rate and probably not to be expected. If the annual survival rate during the prebreeding years were the same as adult survival, annual reproductive success in a stable population would average 20.0 percent. It seems likely, however, that survival of immature birds, especially during their first winter, would be considerably lowered when, for example, severe storms coincide with first attempts at self-feeding. Thus, it is concluded that reproductive success at Semidi Islands in 1976 was below average.

Fulmars are highly vulnerable to egg predation by gulls. An estimated population of 700 to 1,000 glaucous-winged gulls took over 70 percent of the eggs of perhaps 60,000 breeding fulmars at Chowiet Island this year. It seems apparent that any environmental change permitting a significant expansion of the present low population of gulls at Semidi Islands could have serious consequences for the fulmars. Such changes in the populations of the larger *Larus* gulls in reponse to human activities have been documented by Brown (1967) and Kadlec and Drury (1968) among others.

In the preceding discussions a number of comparisons have been drawn between aspects of fulmar breeding biology observed in this study and published accounts for the Atlantic fulmar. Ways in which the Semidi Islands population differed from the latter included a more dramatic pre-laying exodus, longer incubation spells, a tendency for unoccupied partners in breeding pairs to spend more time at sea and slower growth in chicks. These several lines of evidence suggest, among other possibilities, that fulmars were contending with poor feeding conditions, the result being a lowered reproductive drive. Thus, while predation pressure from gulls was seen to be the most important proximate cause of reproductive failure, it is possible that a paucity of food in this particular year was the ultimate cause.

While the study of population dynamics in long-lived animals with low reproductive rates is inherently problematical, several aspects of fulmar breeding biology render this species particularly well suited to this purpose. The birds mate for life and establish discrete, identifiable nest-sites to which they return year after year under normal circumstances (Carrick and Dunnet 1954). At Semidi Islands these features are combined with a mixture of (apparently) randomly mated color phases making possible the recognition of selected individual pairs from year to year and of individuals within pairs. This facilitates the collection of certain kinds of data not commonly available for cliff-nesting seabirds since banding or otherwise marking individuals is obviated. Just as growth rates provide information on conditions prevailing during the nestling period, the average length of incubation spells might serve as a useful indicator of feeding conditions earlier in the season. In a continuing study, events such as changes of mate or of nest-site, variations in nesting chronology of individual pairs, annual turnover of individuals on study plots or failure to breed could be detected and quantified. By working with large samples to offset what errors in recognition might occur, it would eventually be possible to relate reproductive performance to relative age. Many of these studies would not require that observers be in the field for the duration of each breeding season. The essential data could be gathered in a two to three weed period near the beginning and end of the nesting cycle.

As exploration and development of mineral resources in Alaskan outer continental shelf areas proceeds, means of monitoring the effects of environmental changes on wildlife populations are needed. In this regard study of the Semidi Islands population of the fulmar holds rather unique potential.

SUMMARY

A population of at least 500,000 fulmars utilize cliff nesting habitat at Semidi Islands. Fulmars prefer the higher, vegetated portions of cliffs, therefore little or no overlap occurs in habitat use between fulmars and other cliff-nesting species. Most suitable habitat is now occupied, however nesting space does not appear to be limiting.

Attendance at the colony throughout the season was characterized by synchronized arrivals and departures occurring in cycles of several days and largely predictable in terms of changing weather conditions. Maximum numbers of birds at anytime during the breeding season occurred during May, prior to egg-laying. Total evacuations of the colony lasting up to nine days also took place in this month. Later on fluctuations in attendance were attributable in large part to the movements of unemployed birds.

Egg-laying commenced on 29 May and ended on 22 June. Hatching began around 15 July and was completed by 8 August. No chicks had fledged by 3 September. A few chicks were probably still on land in early October.

Reproductive success was 14.9 percent for 208 breeding pairs. Hatching success varied from total failure to over 44 percent and overall breeding success from 0 to 33 percent in fairly discrete nesting areas within the colony. Rate of egg loss was 50 percent during the first 14 days after laying and 78 percent overall. Survival of chicks from hatching to near fledging was 67 percent.

Glaucous-winged gulls and ravens were the only known egg predators, gulls being by far the more serious. Lack of assiduousness on the part of incubating fulmars accounted for most egg losses and was particularly evident around the time of incubation changeovers. The rate of egg infertility was estimated at six percent.

Incubation spells of up to 13 days duration were observed. The mean duration was around six days.

Nestling weight gain was sporadic with a tendency toward synchronized feeding schedules among chicks of all ages.

The percentage of birds at the colony in wing molt (failed and nonbreeders) reached a peak of 78 percent near the end of July after which most of these birds went to sea. However, a partial reoccupation of breeding sites in these same groups occurred during the latter part of August and early September.

Some 6,000 fulmars were censused along 2 km of cliffs in late June and early July. It was shown that this figure represents no more than 18 percent of the total population occupying the area at some time during the year. The proportion of nest-sites occupied by breeding birds was around 65 percent. About 17 percent of the Semidi Islands population are of the "light phase".

Reproductive success in 1976 was believed to be below the average necessary for population replacement. Several characteristics of breeding biology of fulmars at Semidi Islands would facilitate a long-term study of population dynamics and could be equally valuable in monitoring the effects of environmental changes on reproductive ecology.

LITERATURE CITED

Bourne, W.R.P. 1966. The plumage of the fulmars of St. Kilda in July. Bird Study 13(2): 209-213.

Brody, S. 1945. Bioenergetics and growth. Reinhold Pub. Corp., New York.

Brown, R.G.B. 1967. Breeding success and population growth in a colony of herring and lesser black-backed gulls _Larus argentatus_ and _L. fuscus_. Ibis 109: 502-512.

Carrick, R. and G.M. Dunnet. 1954. Breeding of the fulmar _Fulmarus glacialis_. Ibis 96: 356-370.

Coulson, J.C. and J.M. Horobin. 1972. The annual reoccupation of breeding sites by the fulmar. Ibis 114: 30-42.

Duffey, E. 1950. Nonbreeding in the fulmar, _Fulmarus glacialis_. Scottish Naturalist 62: 111-121.

-----. 1951. Field studies on the fulmar _Fulmarus glacialis_. Ibis 93: 237-245.

Dunnet, G.M., A. Anderson and R.M. Cormack. 1963. A study of survival of adult fulmars with observations on the pre-laying exodus. Brit. Birds 56: 2-18.

Dunnet, G.M. and A. Anderson. 1965. A study of fulmars on Eynhallow, Orkney. Scottish Birds 3(5): 233-235.

Dott, H.E.M. 1973. Fulmars at land in summer and autumn. Bird Study 20: 221-225.

-----. 1975. Fulmars at colonies: Time of day and weather. Bird Study 22(4): 255-259.

Eggeling, W.J. 1952. Notes on the breeding of the fulmar. Scottish Naturalist 64: 148-150.

Fisher, J. 1952. The Fulmar. Collins, London. 486 p.

-----. 1966. The fulmar population of Britain and Ireland, 1959. Bird Study 13: 5-56.

Kadlec, J.A. and D.H. Drury. 1968. Structure of the New England herring gull population. Ecology 49: 644-676.

Lack, D. 1967. Interrelationships in breeding adaptations as shown by marine birds. Proc. 14th Int. Ornithol. Congr., 1966: 3-42.

Nettleship, D.N. 1976. Census techniques for seabirds of arctic and eastern Canada. Canadian Wildlife Service, Occasional Paper No. 25. 33 p.

Palmer, R.S. ed. 1962. Handbook of North American Birds. Vol. 1. Yale Univ. Press, New Haven, Conneticut. 567 p.

Troyer, W. 1972. Wilderness Record: Semidi Wilderness Proposal. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Williamson, K. 1952. The incubation rhythm of the fulmar. Scottish Naturalist 64: 138-147.

Table 1. Semidi Islands weather summary, 9 May - 31 August, 1976.

Month	Temperature (°C) Extremes Max.	Temperature (°C) Extremes Min.	Temperature (°C) Ave. Daily Max.	Temperature (°C) Ave. Daily Min.	Temperature (°C) Mean	Precipitation % Days	Precipitation Total (mm)	Wind Vel. (kts) Max.	Wind Vel. (kts) Ave.	Wind Direction (% Days) NE	Wind Direction (% Days) SE	Wind Direction (% Days) SW	Wind Direction (% Days) NW	Wind Direction (% Days) Calm
May	13.3	-3.9	8.2	0.8	4.5	45	16	40	20	4	9	35	52	0
June	17.8	1.1	12.0	4.3	8.2	43	45	30	11	17	13	17	36	17
July	24.4	1.7	16.2	6.8	11.9	61	70	40	15	26	16	26	13	19
August	25.0	2.8	17.0	7.7	12.4	58	88	30	16	16	13	26	32	13

Table 2. Breeding success of fulmars at Semidi Islands, 1976.

Study Plot	Eggs Laid	Eggs Hatched		Chicks Fledged		Chicks Fledged Per Egg Laid
		Number	Percent	Number	Percent	
A	111	23	20.7	13	56.5	0.117
B	25	4	16.0	4	100.0	0.160
C	33	7	21.2	5	71.4	0.152
D	27	12	44.4	9	75.0	0.333
E	12	0	0	0	0	0
Totals	208	46	22.1	31	67.4	0.149

Table 3. Comparison of estimated breeding success of fulmars on two types of study plots, Semidi Islands, 1976.

Study Plot	Number of Nest-sites	Maximum No. Eggs Observed	Chicks Fledged	Max. No. Eggs/ No. Nest-sites	Chicks Fledged Per Nest-site	Chicks Fledged/ Max. No. Eggs
A	165	71	13	0.430	0.079	0.183
B	40	17	4	0.425	0.100	0.235
C	49	24	5	0.490	0.102	0.208
D	43	22	9	0.512	0.209	0.409
E	30	11	0	0.367	0	0
Totals	327	145	31	0.443	0.095	0.214
F	32	20	2	0.625	0.063	0.100
G	24	18*	4	0.750	0.167	0.222
H	75	29	7	0.387	0.093	0.241
I	65	9*	0	0.138	0	0
J	35	4	0	0.114	0	0
K	150	61	16	0.407	0.107	0.262
L	24	11	2	0.458	0.083	0.182
M	125	73	30	0.584	0.240	0.411
N	100	57	10	0.570	0.100	0.175
Totals	630	282	71	0.448	0.113	0.252

* Plots added late. Numbers of eggs estimated by back-calculation.

Table 4. Fulmar eggshells collected from a 1000 m^2 plot within a glaucous-winged gull colony, Semidi Islands, 1976.

Date	Weight of Shells (g)	Approx. Equiv. No. of Eggs	Other Materials
June 3	146	17	3 fresh regurgitated adult fulmar skulls; 2 weathered adult murre skulls; 1 weathered kittiwake skull
5	78	9	
7	80	9	
9	110	13	
11	73	9	
13	53	6	
15	70	8	
17	4	1	1 murre egg
19	8	1	1 murre egg
21	0	0	6-8 murre eggs
23	0	0	3 murre eggs
25	21	3	3 murre eggs
27	0	0	
29	0	0	1 murre egg
July 1	0	0	
3	0	0	
5	0	0	
7	0	0	2 murre eggs
9	0	0	
15	--	1	
17	--	1	
Total		78	17-19 murre eggs

Table 5. Duration of incubation spells of fulmars, Semidi Islands, 1976.

	Percentage Frequency											
	1st Spell (Female)		2nd Spell (Male)		3rd Spell (Female)							
Duration of Spells (days)	Dunnet et.al. (1963)	This Study	Dunnet et.al. (1963)	This Study	Dunnet et.al. (1963)	This Study	4th (M)	5th (F)	6th (M)	7th (F)	8th (M)	9th (F)
Under 1	69	51	2		17							
1	16	20	8		17		4	10				
2	8	8			8	6	4	5			10	14
3	3	14	5	3	17	10			13			
4	3	8	12	5	8	16	12	5	6	15	10	
5	1		10	14	25	16	15	29	13	38	60	43
6			20	22	8	13	8	10	19	8	20	43
7			22	8		13	12	19	31	15		
8			12	3		19	19	10		15		
9			2	24		3	15	10	13	8		
10			3	16		3	12	5	6			
11			5	3			4					
12				3								
13							4					
Sample Size	100	51	60	37	12	31	26	21	16	13	10	7
Mean	0.93	1.33	5.86	7.49	3.00	5.71	7.00	5.81	6.31	6.00	4.80	5.00
Standard Error	0.09	0.16	0.32	0.37	0.57	0.38	0.56	0.54	0.51	0.45	0.36	0.53

Table 6. Growth of fulmar chicks at Semidi Islands, 1976.

Age (days)	N	Weight (g) Mean	Weight (g) Range	Weight (g) Instantaneous Relative Growth Rate	Wing (mm) Mean	Wing (mm) Range	Tarsus (mm) Mean	Tarsus (mm) Range	Culmen (mm) Mean	Culmen (mm) Range
0	6	65	60-68	---	23	19-25	24	20-26	20.3	19.8-20.8
1-2	17	82	59-91	0.117	24	21-28	26	24-27	19.9	19.2-21.4
3-4	16	105	87-125	0.123	26	23-32	28	24-30	20.6	19.4-22.7
5-6	16	139	90-189	0.141	29	25-33	30	27-33	21.5	20.2-24.1
7-8	14	167	83-217	0.092	33	28-40	33	28-37	22.6	20.5-25.6
9-10	14	192	112-258	0.070	37	29-45	35	28-39	23.8	21.5-26.4
11-12	13	242	168-320	0.116	41	32-50	37	31-42	25.0	23.0-27.0
13-14	14	290	198-440	0.091	46	35-56	40	31-45	25.9	23.7-28.6
15-16	13	361	248-495	0.110	51	41-61	42	34-47	26.9	24.8-29.6
17-18	13	386	272-500	0.034	58	43-68	45	36-51	28.2	25.4-31.0
19-20	13	455	340-670	0.082	67	49-88	47	39-53	29.3	26.7-32.6
21-22	13	540	410-735	0.086	78	56-94	50	43-55	30.6	28.0-33.7
23-24	13	600	425-800	0.053	89	62-112	52	45-57	31.4	28.8-34.5
25-26	13	671	470-865	0.056	101	71-124	54	47-59	32.6	29.5-35.3

(continued)

Table 6 (continued). Growth of fulmar chicks at Semidi Islands, 1976.

		Weight (g)			Wing (mm)		Tarsus (mm)		Culmen (mm)	
Age (days)	N	Mean	Range	Instantaneous Relative Growth Rate	Mean	Range	Mean	Range	Mean	Range
27-28	13	699	480-920	0.026	114	79-135	55	49-59	33.2	30.0-36.4
29-30	13	733	570-935	0.024	127	87-150	56	51-61	34.0	30.9-36.9
31-32	13	772	620-880	0.026	140	100-165	57	53-62	34.4	30.7-37.8
33-34	13	797	575-955	0.016	152	115-178	57	53-62	35.2	31.3-38.5
35-36	12	819	685-1035	0.014	162	128-187	58	54-61	35.6	32.5-38.5
37-38	11	800	680-1000	-0.012	172	142-194	58	54-61	35.7	33.1-38.9
39-40	6	808	755-860	0.005	188	171-203	58	54-61	36.5	33.9-39.0
41-42	5	887	795-935	0.047	199	178-209	58	55-61	36.8	34.1-39.3
43-44	2	965	845-1085	0.042	221	219-223	60	59-61	38.1	36.9-39.3
45-46	1	875	---	-0.049	232	---	61	---	39.3	---
Adult Males	5	668	600-710	---	322	320-325*	63	62-65*	39.2	38.3-41.2
Adult Females	7	581	550-650	---	308	300-320*	58	57-59*	36.6	35.0-37.9

* Sample sizes are 3 males and 5 females.

Table 7. Effect of wind direction on attendance of fulmars at nest-sites, Semidi Islands, 1 June - 3 September, 1976.

	Wind Direction				
	NW	NE	SE	SW	Calm
No. of Days	25	18	12	24	15
No. of Days Attendance Decreased	19	11	5	8	12
No. of Days Attendance Increased	6	7	7	16	3
Mean Percentage Change From Previous Day	-11.4 *	-1.5	+21.5	+29.4 *	-11.6 *
Standard Error	4.24	6.49	15.80	8.73	4.83

* Mean is significantly different from zero (P less than 0.05).

Table 8. Census data for fulmars on 2 km of cliffs on the west side of Chowiet Island, Semidi Islands, 1976.

Date	Time	Singles	Pairs	Total	Light Phase	Eggs	Eggs/Singles	
							Census	Control Plots
June 23	1400-1730	298	41	380	57	241	0.81	0.79
24	1000-1810	1,261	207	1,675	258	934	0.74	0.73
25	0900-2000	1,383	168	1,719	317	1,075	0.78	0.88
July 7	1000-1800	1,247	56	1,359	247	1,167	0.94	0.90
8	1030-1905	875	40	955	178	718	0.82	0.87
Totals		5,064	512	6,088	1,057	4,135		
Means							0.817	0.824

Table 9. Calculation of total and breeding populations of fulmars along a 2 km stretch of cliffs, Semidi Islands, 1976.

Date	I No. Eggs Counted	II Eggs Surviving/ Eggs Laid (Control Plots)	III Column I/ Column II (Total Eggs Laid)	IV Column III x 2 (Total Breeders)	V Column IV/0.65 (Total Population)
June 23	241	0.46	524	1,048	1,612
24	934	0.45	2,076	4,152	6,388
25	1,075	0.44	2,443	4,886	7,517
July 7	1,167	0.31	3,765	7,530	11,585
8	718	0.31	2,316	4,632	7,126
Totals			11,124	22,248	34,228

Table 10. Estimation of the proportion of breeding nest-site holders in the Semidi Islands fulmar population, 1976.

Study Plot	Number of Nest-sites	Number of Eggs Laid	Eggs Per Nest-site
A	172	116	0.67
B	40	25	0.63
C	33	19	0.58
Totals	245	160	0.65

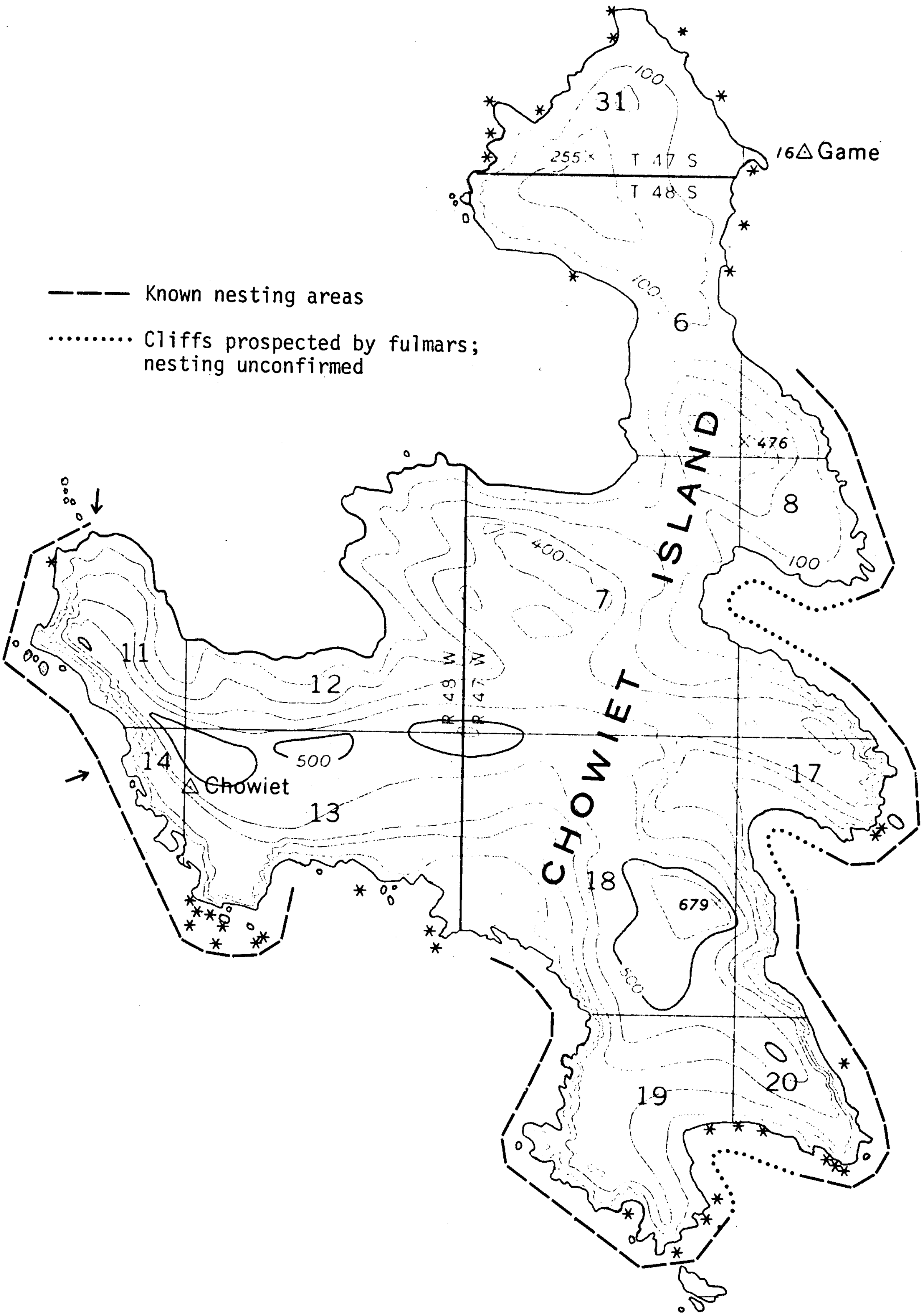


Figure 1. Map of Chowiet Island showing the extent of fulmar nesting areas in 1976. Arrows indicate the boundaries of the main study area (census area).

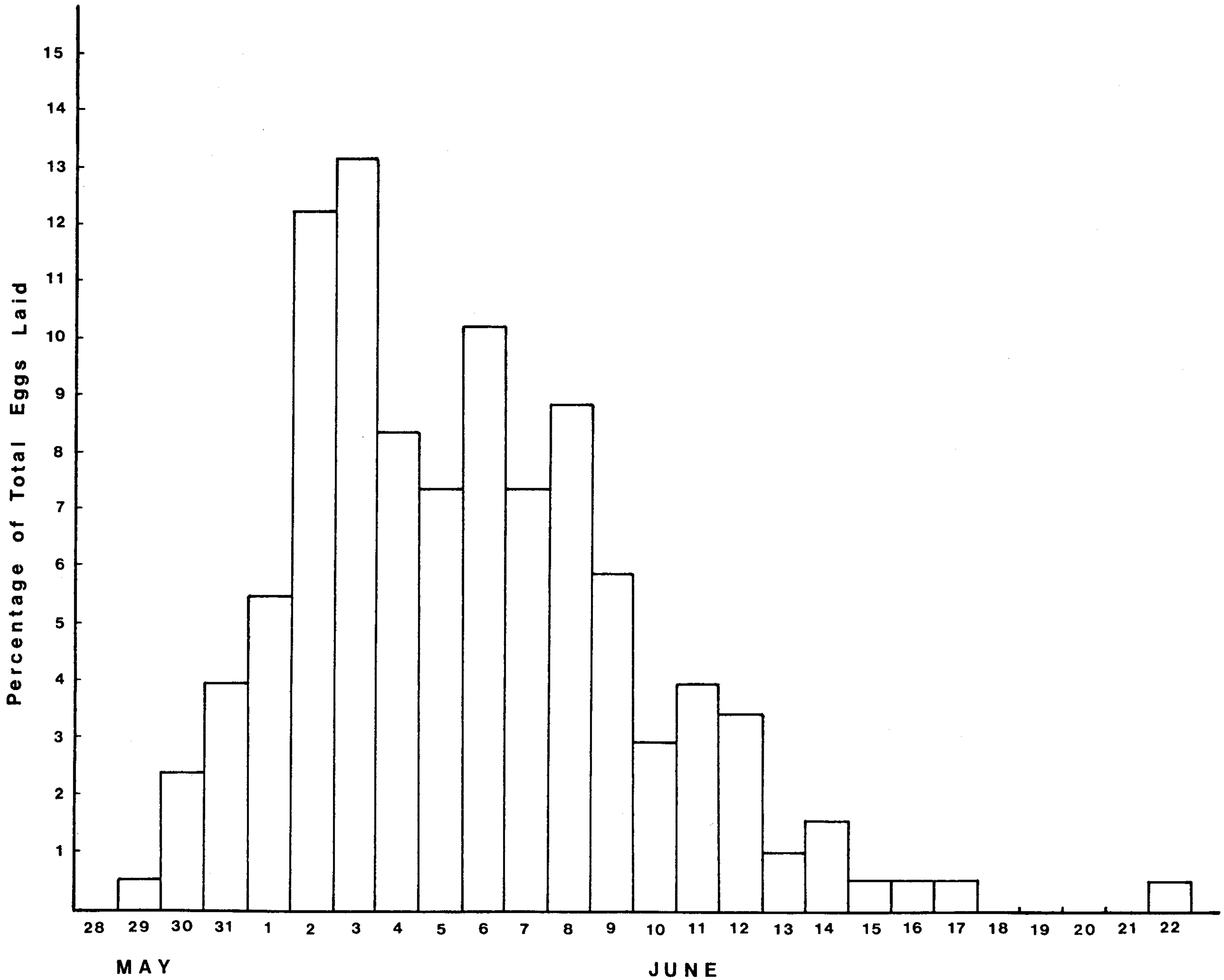


Figure 2. Egg-laying dates of fulmars, Semidi Islands, 1976.

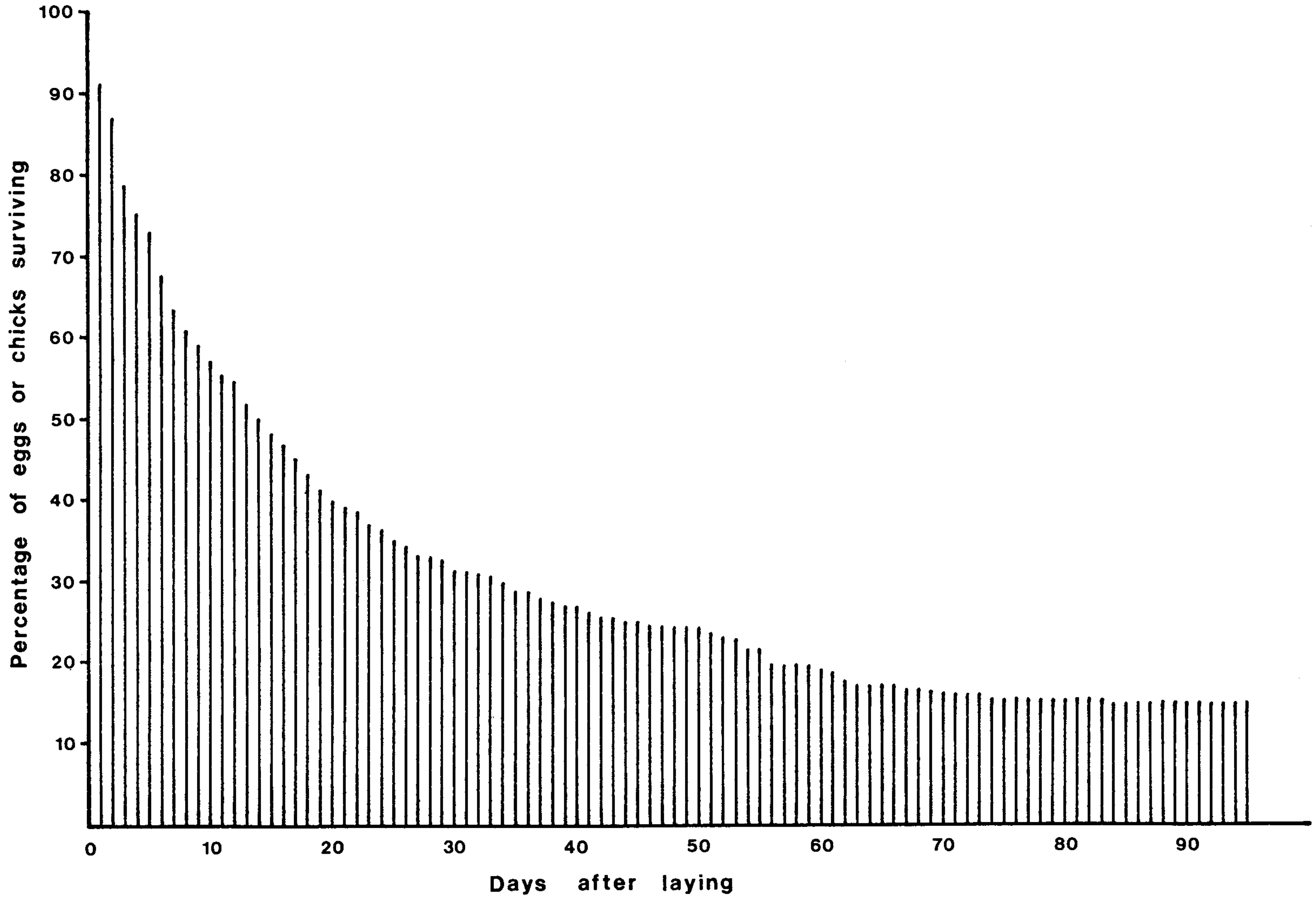


Figure 3. Survivorship of fulmar eggs and nestlings, Semidi Islands, 1976.

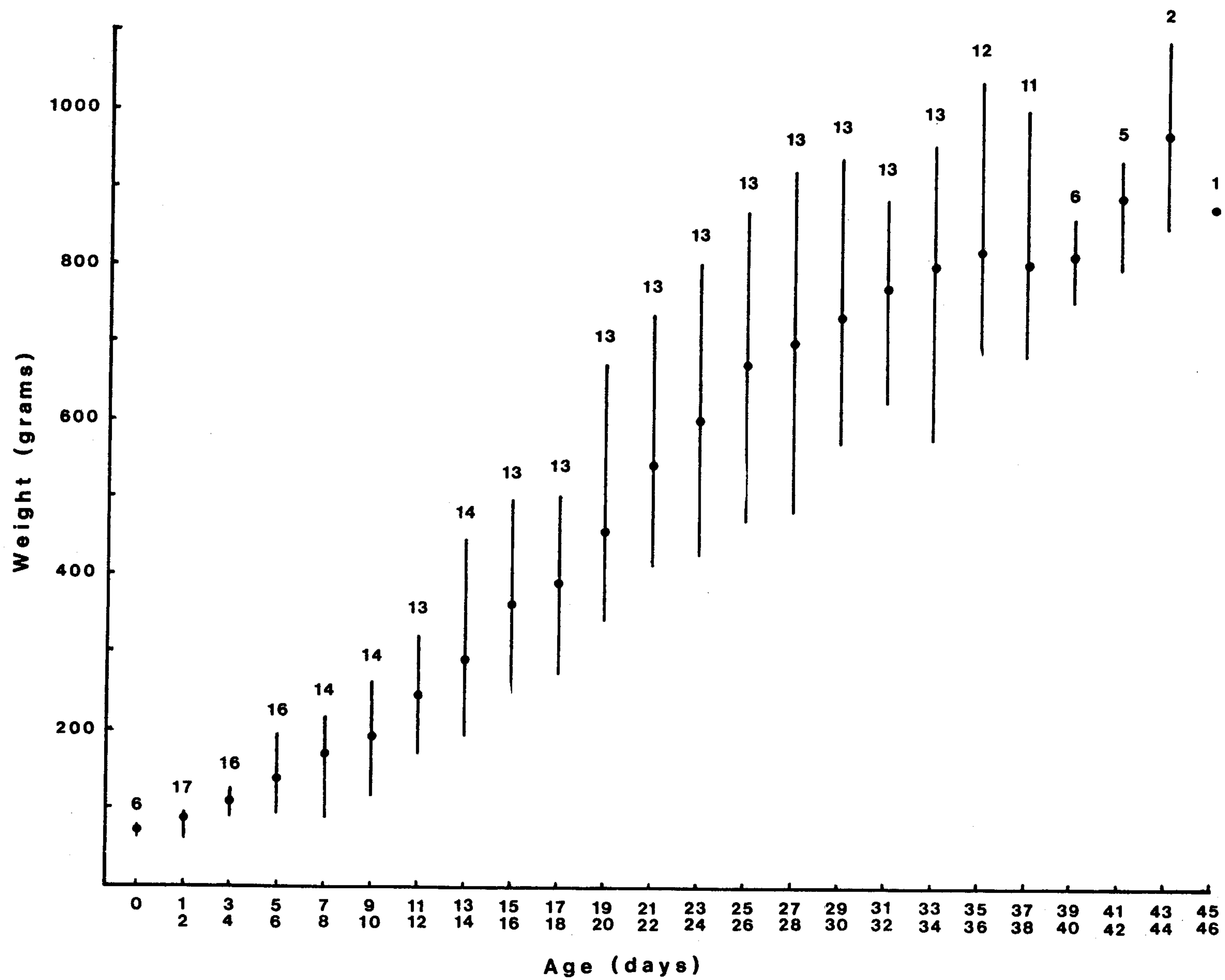


Figure 4. Weight gain of fulmar chicks, Semidi Islands, 1976. Means, sample sizes and sample range are indicated.

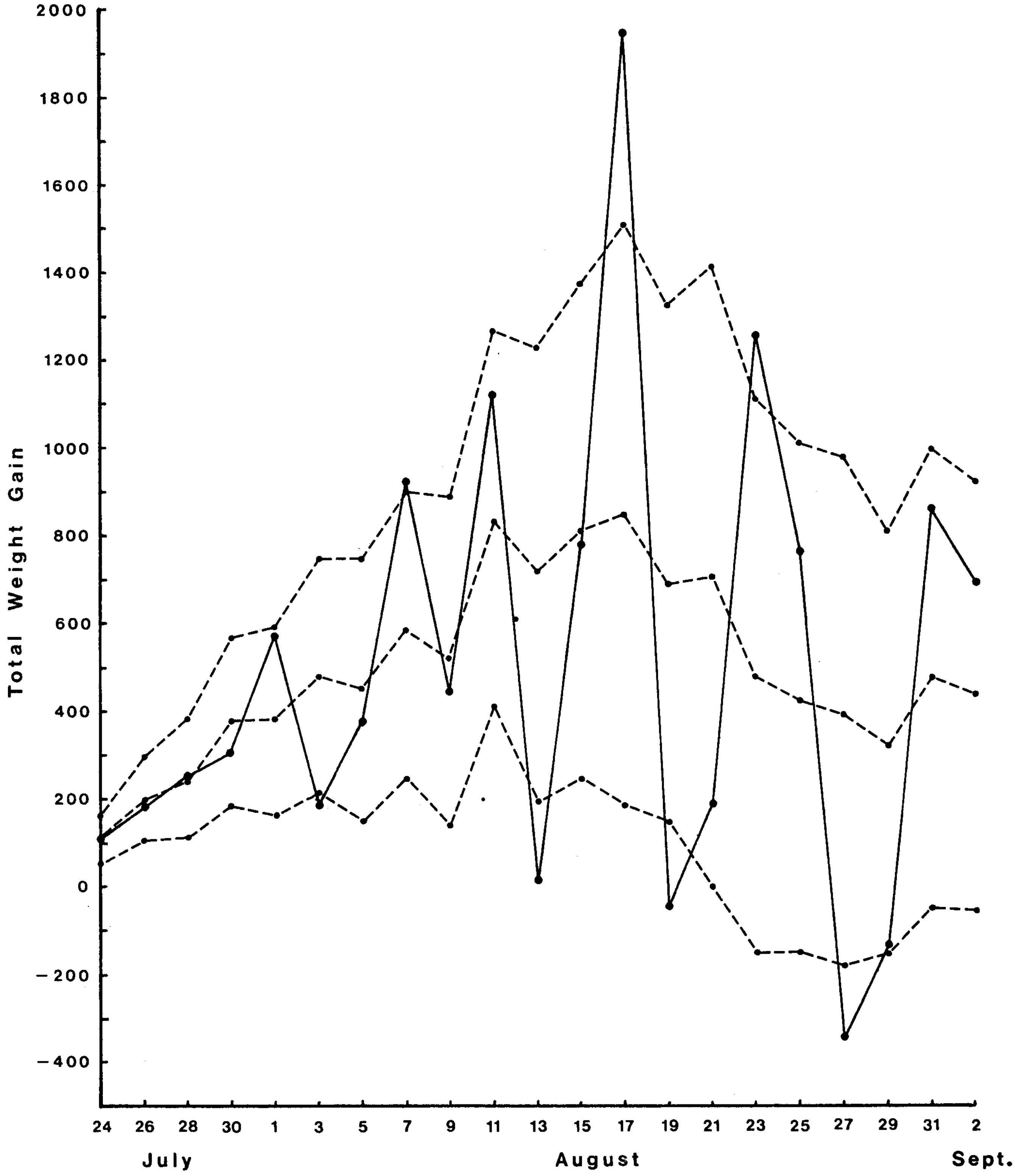


Figure 5. Collective gain or loss in weight of fulmar chicks between measurements, Semidi Islands, 1976 (solid line). Broken lines indicate the expected total weight gain (see text) and 95 percent confidence limits of same.

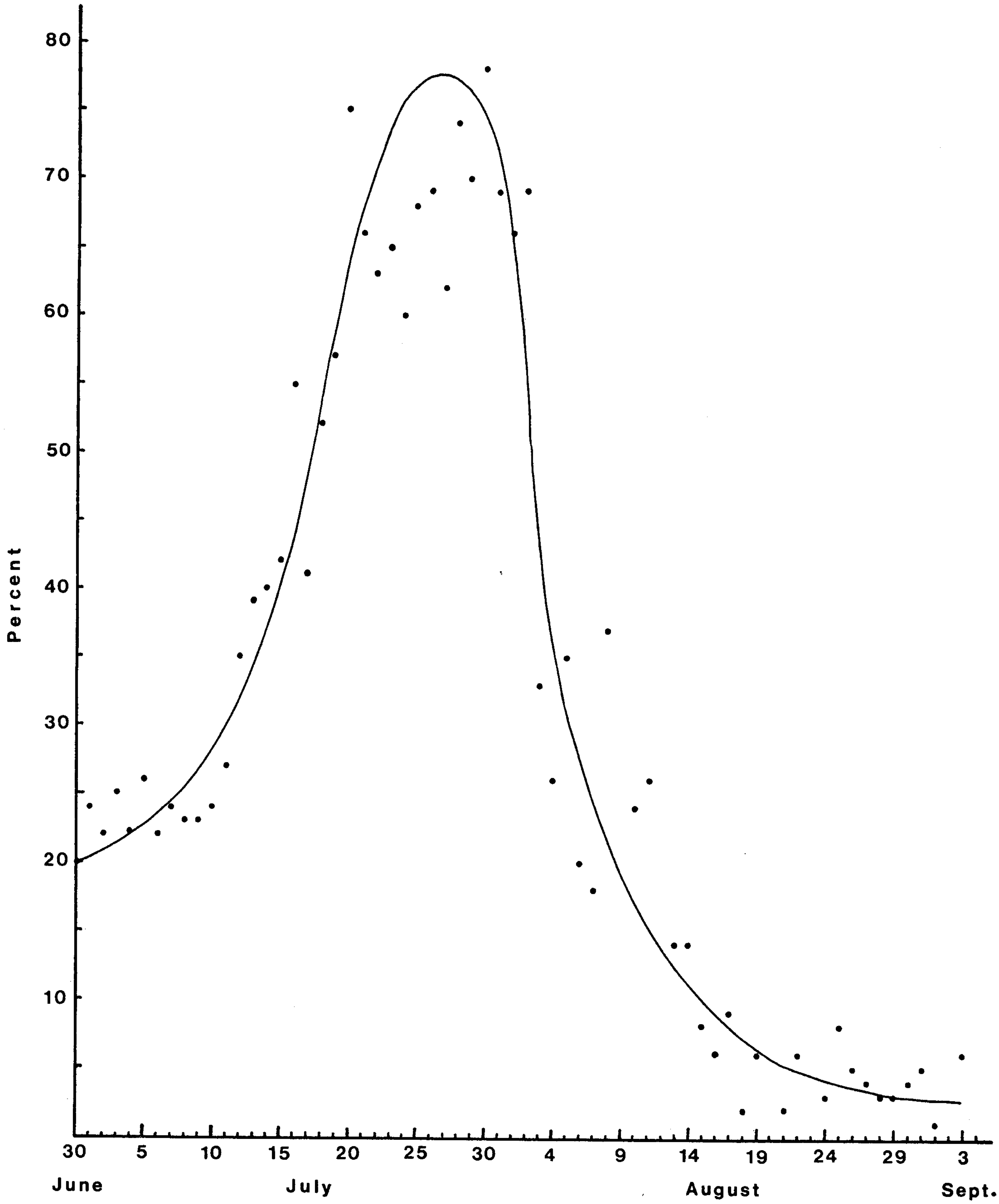


Figure 6. Percentage of fulmars in the air undergoing primary molt from 30 June to 3 September, Semidi Islands, 1976.

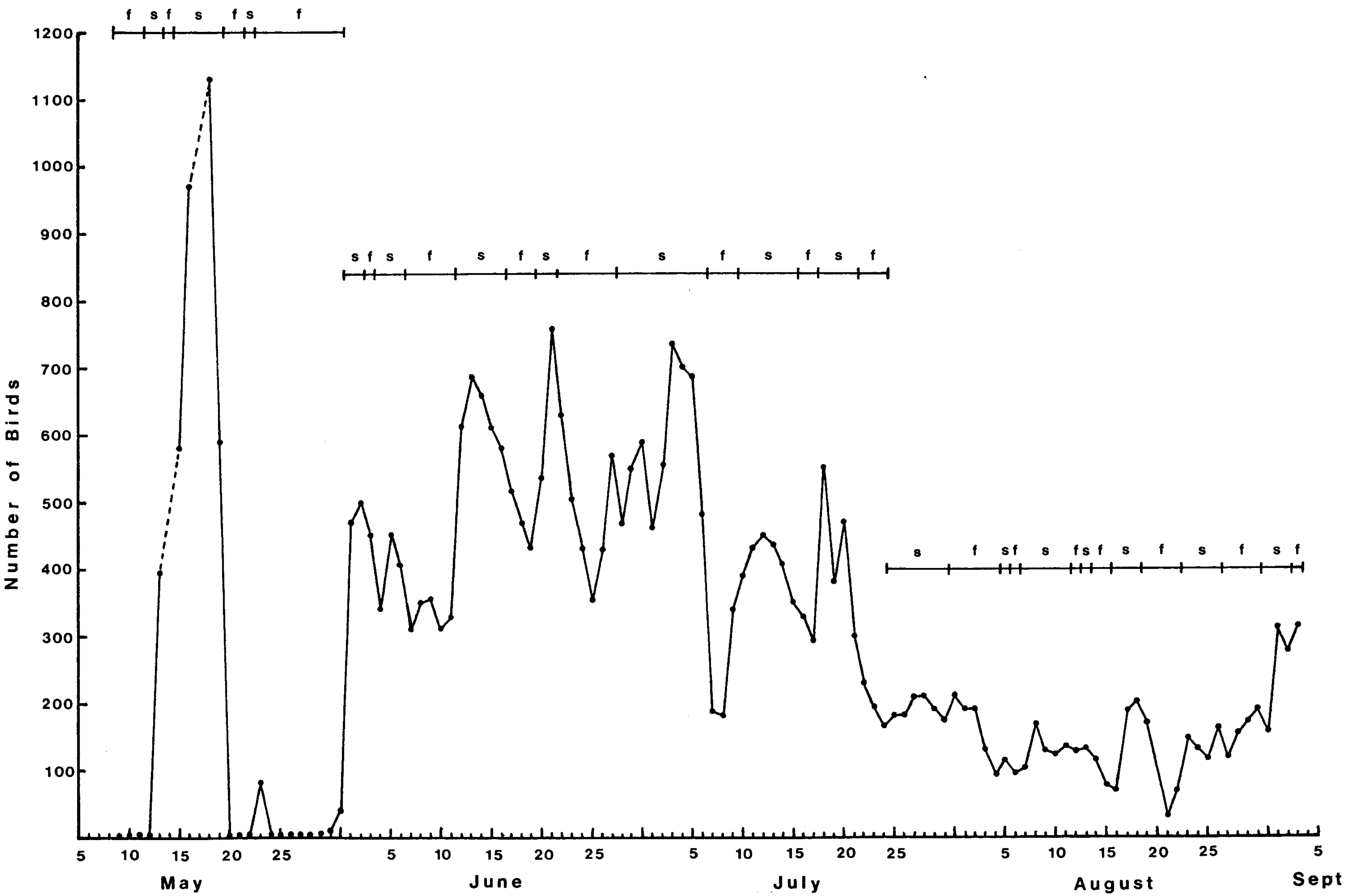


Figure 7. Attendance of fulmars at nest-sites during the breeding season, Semidi Islands, 1976. Periods of fair (f) and stormy (s) weather are indicated.

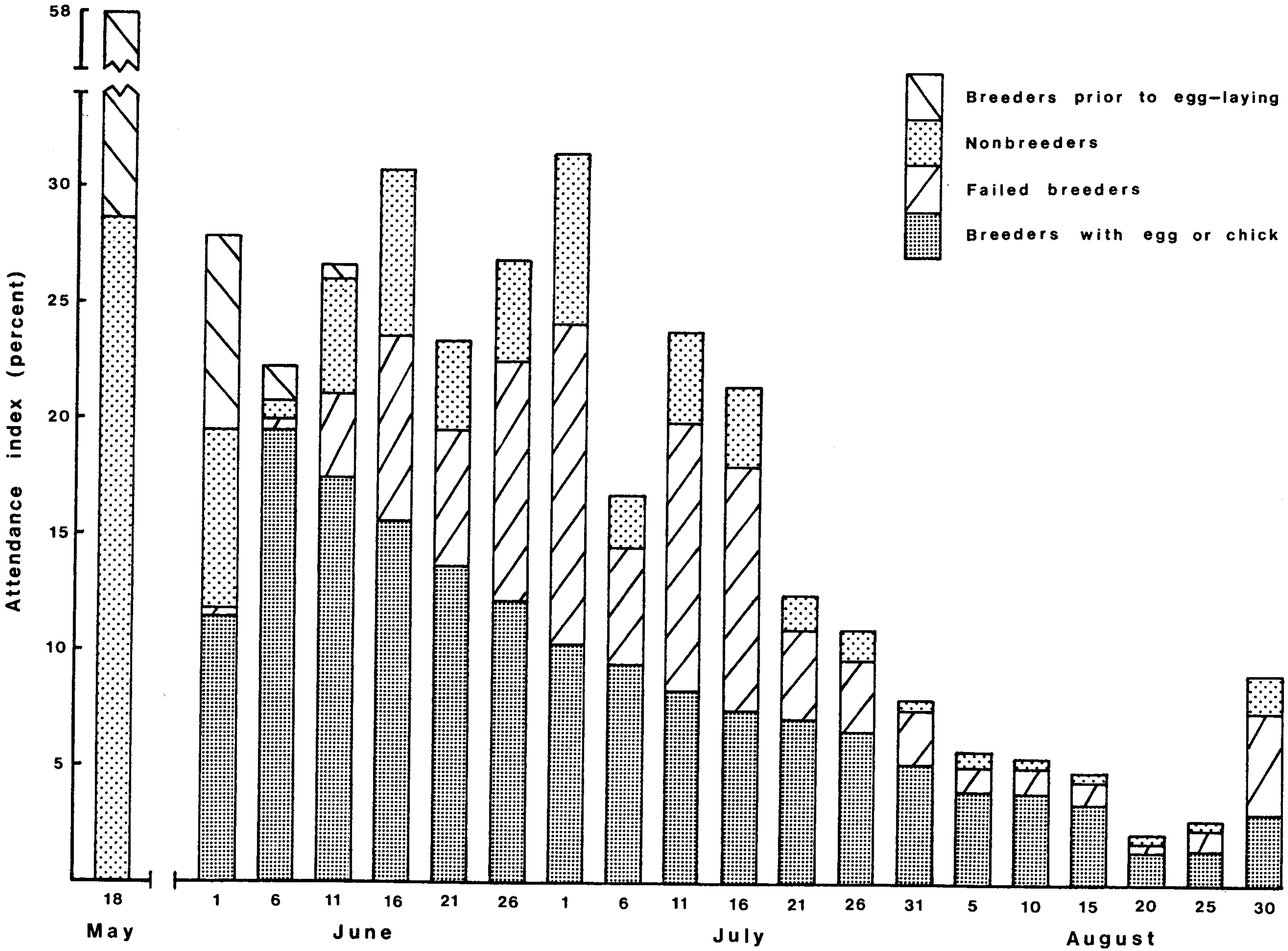


Figure 8. Breeding status of fulmars at nest-sites summarized by five-day periods beginning on the dates indicated, Semidi Islands, 1976. Note: Two birds occupying all sites under observation would constitute 100 percent attendance.

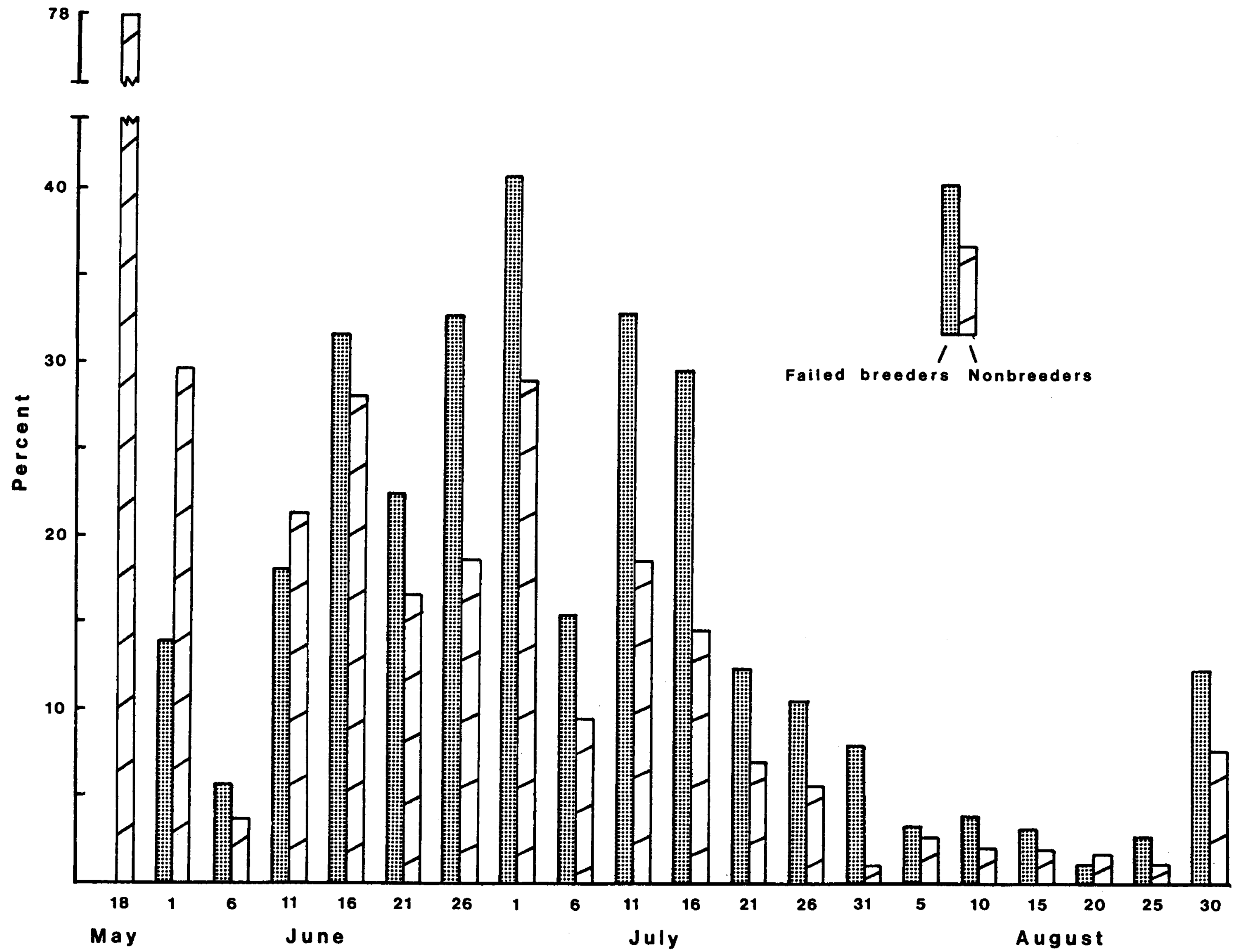


Figure 9. Percentages of failed and nonbreeding fulmar nest-sites occupied by single birds or pairs, summarized by five-day periods beginning on the dates indicated, Semidi Islands, 1976.

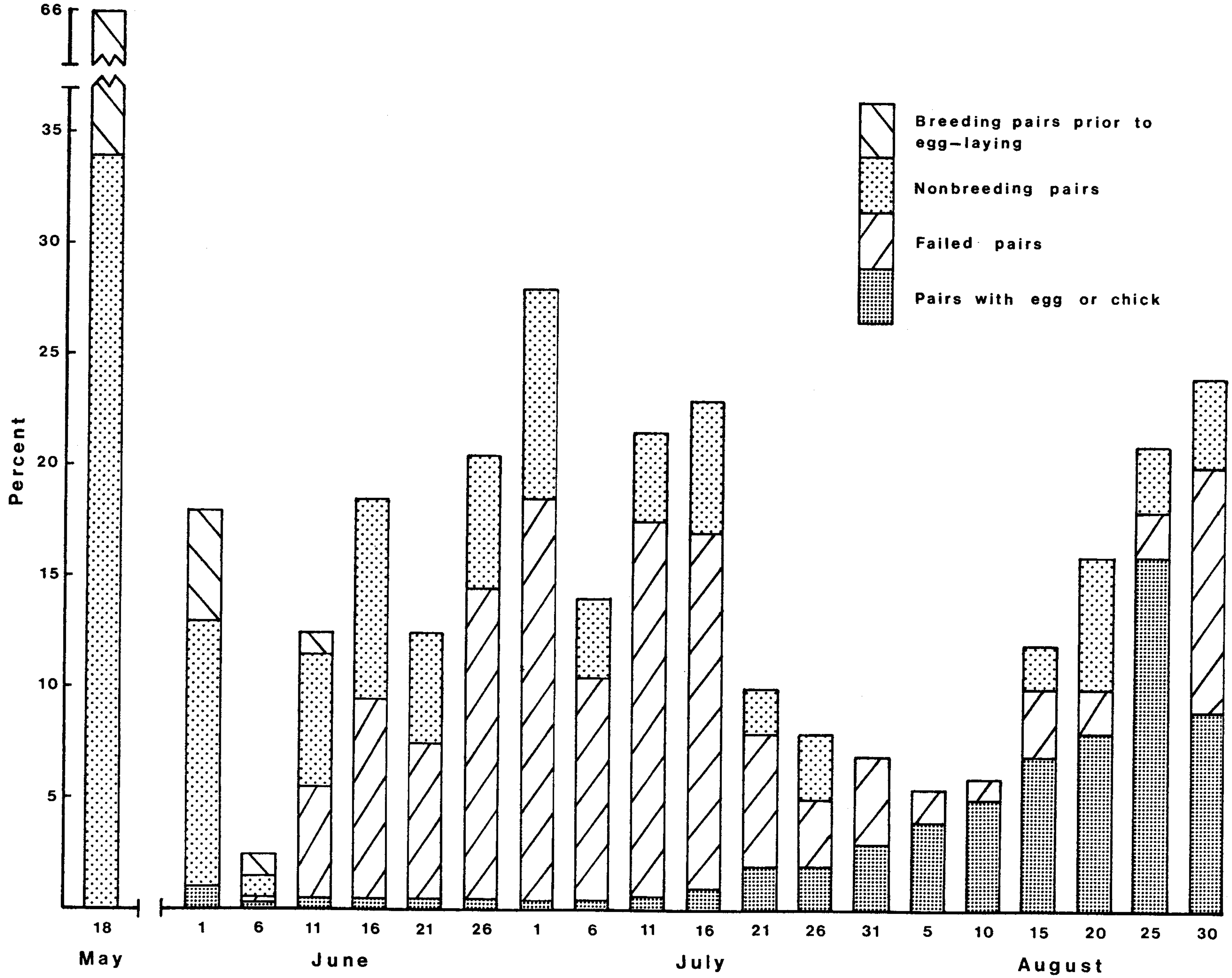


Figure 10. Percentage of occupied fulmar nest-sites containing pairs, summarized by five-day periods beginning on the dates indicated, Semidi Islands, 1976.

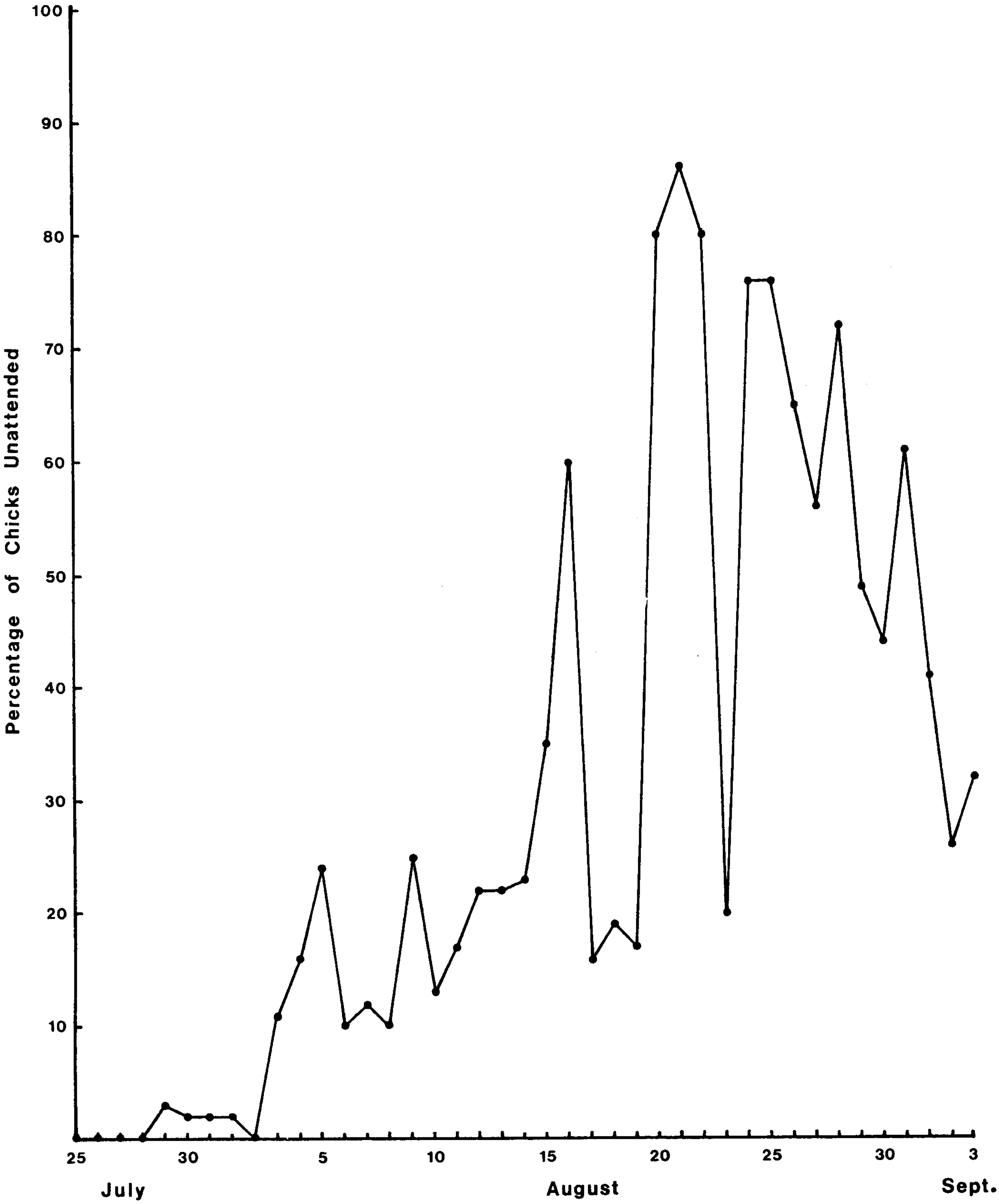
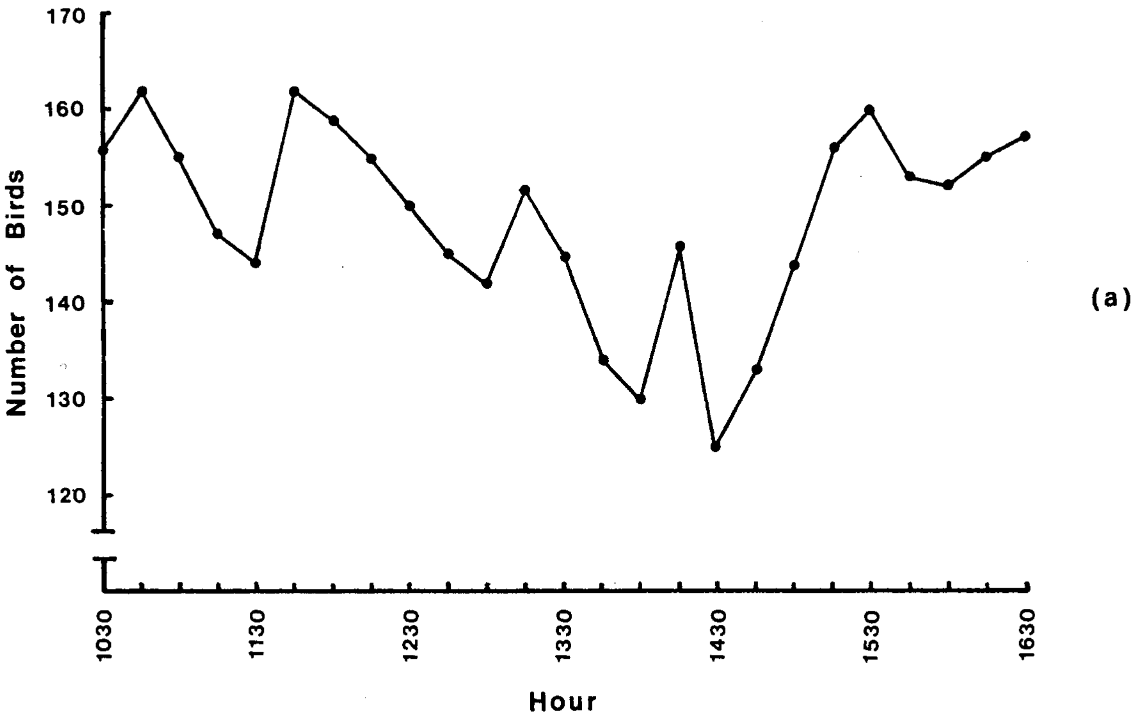


Figure 11. Daily percentage of fulmar chicks unattended by either parent, Semidi Islands, 1976.



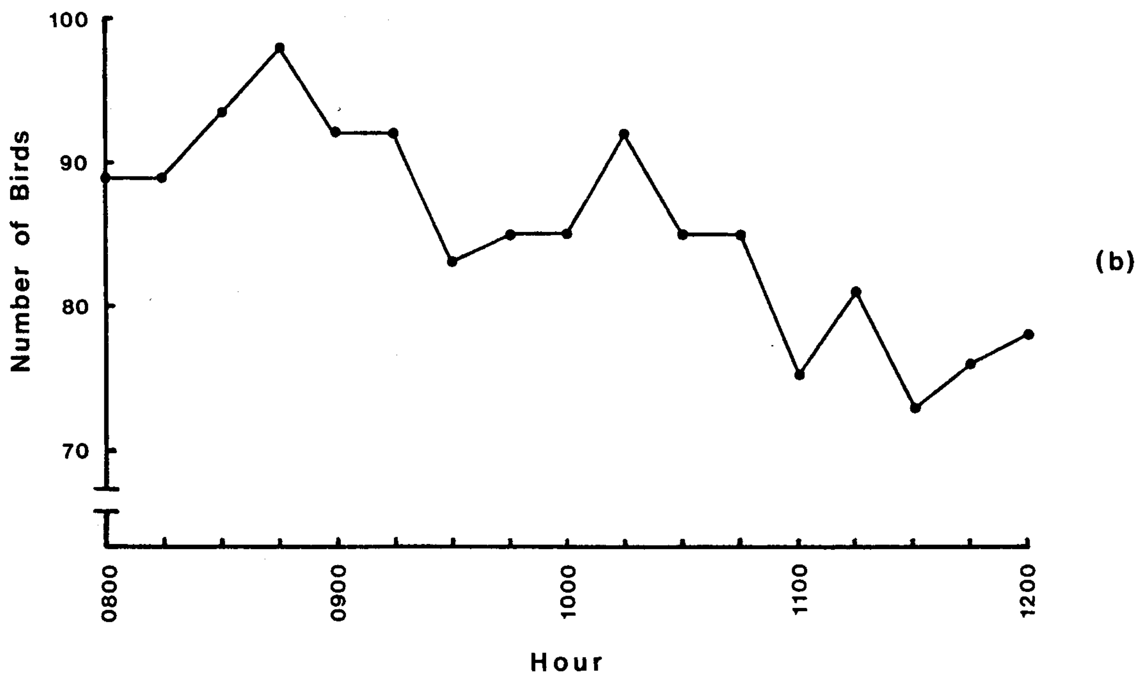


Figure 12. Counts of fulmars at approximately 140 nest-sites on 18 May (a) and 15 June (b), Semidi Islands, 1976.

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to March 31, 1977

STUDIES OF MARINE BIRDS ON UGAIUSHAK ISLAND

By

Henry S. Wehle, Eric P. Hoberg and Kevin Powers

Part IV

OF

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS
OF MARINE BIRDS IN THE GULF OF ALASKA
AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. J. Gould
R. E. Gill and S. A. Sanger
Co-principal Investigators

U. S. Fish & Wildlife Service
Office of Biological Services/Coastal Ecosystems
Anchorage, Alaska

March 1977

TABLE OF CONTENTS

List of Tables

Page

List of Figures

List of Figures Continued

INTRODUCTION

This study of populations and ecology of the marine avifauna of Ugaishak Island continues a preliminary study initiated by George Divoky, U.S. Fish and Wildlife Service, in 1974. The objectives of this study were to: 1) determine the numbers of seabirds breeding on the island, 2) evaluate spacial distribution and to map all seabird nesting areas, 3) determine breeding chronology and productivity for as many species as possible, 4) evaluate feeding habits and foraging areas, 5) initiate long-term studies of survival by banding of known age birds, and 6) evaluate current mortality through surveys of beaches for presence of dead birds.

Three investigators were present on the island during the field season. Duff H.S. Wehle was on the island from 24 May through 2 September, Eric P. Hoberg from 24 May through 11 July, and Kevin Powers from 28 July through 2 September. In addition to the major objectives stated above, Wehle conducted an intensive study of the feeding ecology and breeding biology of the Tufted Puffin (Lunda cirrhata), Hoberg conducted an intensive study of endoparasites in nine species, and Powers conducted a detailed survey of the flora.

Location and Physical Characteristics of the Study Area

Ugaiushak Island (56° 47' N, 156° 41' W) is approximately 13 km south of the Alaska Peninsula and 126 km northeast of Chignik (Figure 1). The island consists of two major parts connected by a narrow isthmus (Figure 2). The total area is approximately 170 hectares. Vertical cliffs, rising up to 100 m, composed much of the coastline especially along the southwestern half of West Island and virtually all of the southwestern side of East Island. The coastline from Murre Point north to Eagle Point is primarily rock or boulder beach backed by steep slopes or vertical cliffs. The eastern coastlines of West Island and East Island are mostly rock backed by low cliffs or steep slopes. The interior of West Island contained a high ridge running along the west side from just north of Gull Point to just north of Kittiwake Lake. North of Kittiwake Lake was a valley extending from Log Beach to Secluded Bay. Northwest of this valley were the highest elevations of the Island, extending from Murre Point to Eagle Peak. Ugaiushak Summit, the highest point on the island, was estimated to be about 170 m above sea level. The eastern side of West Island and all of East Island are relatively flat. Two holes were present on East Island, Hole-in-the-wall and Devil's Hole, which were open from the surface of the ground down to the sea about 50 m below.

Camp was located at the western end of Isthmus Island, at the site of an old fox farmer's cabin which was still standing, although much deteriorated. Ground water flowed over the rock face just south of camp and provided suitable drinking water throughout most of the summer.

Kittiwake Lake was also fresh, but due to its use by Black-legged Kittiwakes for bathing, it was not potable. Guillemot Cove was closed off from Peninsula Bay during low tide by a shoal (dashed line in Figure 2), but provided a protected area where the Zodiac could be anchored. Although the island was treeless, driftwood was abundant on Isthmus and Log Beach and was used as the major fuel source for heating. Fishing around the island' was excellent throughout the summer with sculpin, greeling, rockfish, and halibut being most frequently caught.

The only prior work on Ugaiushak was that by George Divoky and Gus VanFleet (1974), but only a brief summary of their work is available.

CENSUSES

Oceanodrama furcata. Fork-tailed Petrel.

Date: June, July, August

Time: Night

Method: Counts of individual nests were not possible because nesting was predominantly among rock crevices in inaccesible areas. The dates above represent those on which the limits of the colony were defined by walking around this island at night observing the presence of birds by sight or sound. The census figure represents no more than an educated guess of actual numbers based on night observations made during June and July.

Census: 2,000 - 4,000 estimated total birds

Oceanodrama leucorhoa. Leach's Petrel.

Date: June, July, August

Time: Night

Method: As in the case of the previous species, counts of individual nests were not possible because nesting was confined to rock crevices in inaccesible areas and the limits of the colony were defined in a similiar manner.

Comments: Leach's Petrels were heard on only two occassions throughout the summer. One dead Petrel of this species was found. These observations were the only indications that Leach's Petrels might have been breeding on the island. Divoky (1974) estimated Leach's Petrels to be one-tenth as abundant as Fork-tailed Petrels.

Census: Less than 200 birds estimated.

Phalacrocorax auritus. Double-crested Cormorant.

Date: 25 June, 1976

Time: 11:30 - 13:00

Weather: Overcast with partly sunny skies. Wind 10 m.p.h. Seas with 2 to 3 foot swell.

Method: A direct count of all active nests was made from the Zodiac and from vantage points along the cliff top between Hole-in-Wall and Oystercatcher Beach. This was the only area on the island where Double-crested Cormorants were found nesting.

Comments: Most nests contained hatching eggs. Divoky (1974), found 26 nests.

Census: 34 active nests, 68 estimated total birds.

Phalacrocorax urile. Red-faced Cormorant.

Date: 25 June, 1976

Time: 11:30 - 13:00

Weather: Overcast with partly sunny skies. Wind 10 m.p.h. Seas with 2 to 3 foot swell.

Method: A direct count of all active nests was made from the Zodiac and from vantage points along the cliff top between Hole-in-the-Wall and Oystercatcher Beach. This was the only area on the island where Red-faced Cormorants were found nesting although rocks at the end of Gull Point and Widow's Rock were occupied by non-breeding birds. A direct count of individual birds in these two areas was made from the Zodiac.

Comments: About 75% of the nests contained eggs. The remaining nests were active with birds in attendance but no eggs present.

Census: 173 active nests, 346 estimated birds
12 birds on rocks at Gull Point
6 birds on Widow's Rock
364 estimated total birds

Phalacrocorax pelagius. Pelagic Cormorant.

Date: 25 June, 1976

Time: 11:30 - 13:00

Weather: Overcast with partly sunny skies. Wind 10 m.p.h. Seas with 2 to 3 foot swell.

Method: A direct count of all active nests was made from the Zodiac and from vantage points along the cliff top between Hole-in-the-Wall and Oystercatcher Beach. This was the only area on the island where Pelagic Cormorants were found nesting.

Comments: About 75% of the nests contained eggs. The remaining nests were active with birds in attendance but no eggs present.

Census: 57 active nests, 114 estimated total birds.

Histrionichus histrionicus. Harlequin Duck.

Date: 1 July, 1976

Time: 15:00 - 17:00

Weather: Foggy with ceiling about 200 feet. Wind 5 m.p.h. Seas 3 to 4 foot swell.

Method: The island was circumnavigated by Zodiac, as close to shore as possible to permit count of individual birds.

Comments: The rocky and irregular shoreline made birds roosting among the rocks difficult to locate, however, the census figure given corresponds closely with the numbers of birds observed during the course of daily operations around the island.

Census: 62 (48 males, 14 females) individual birds counted
65 - 80 estimated total birds

Somateria mollissima. Common Eider.

Date: 27 June, 1976

Time: 13:30 - 15:30

Weather: Sunny skies clear. Wind 5 m.p.h. Seas with 2 to 3 foot swell.

Method: Eiders were censused from a Zodiac craft in the same manner as described for Harlequins. Similar problems were encountered.

Comments: At the time of this census, Common Eiders were engaged in egg-laying or were in the early stages of incubation. At the time of the census, Many drakes had apparently already abandoned their mates and the island.

Census: 24 (7 males, 17 females) individual birds counted
25 - 30 estimated total birds

Haliaeetus leucocephalus. Bald Eagle.

Date: late May, June, early July

Method: Observations made during the course of daily operations around the island

Census: 2 pair adults
3 - 8 subadults
7 - 12 birds total

Falco peregrinus. Peregrine Falcon.

Date: late May, June and July

Method: Observations made during the course of daily operations around the island.

Census: 1 pair, 2 birds total

Haematopus bachmani. Black Oystercatcher.

Date: The census figure was not based on a specific date, but rather represents the total number of pairs with nests or which occupied territories along the coast during late May, June and July.

Method: The location of pairs on nests or territories was determined by observations from land and from the Zodiac during the course of daily operations around the island.

Census: 26 pairs on nests or territories, 52 birds total.

Stercorarius parasiticus. Parasitic Jaeger.

Date: The census figure was not based on a specific date, but rather represents the numbers of birds observed daily during late May, June and July before young of the year fledged.

Method: Observations made during the course of daily operations around the island.

Census: 3 pairs, 6 birds total

<u>Larus</u> <u>glaucescens</u>. Glaucos-winged Gull.

Date: 26 June, 1976
Time: 10:00 - 18:00

Method: Glacous-winged Gulls nested in four major colonies on the island. The method of census is described below for each of the colonies.

East Island Colony: The East Island Colony was visually divided by topographic features into six sub-colonies. A direct count of all nests in each sub-colony was made.

Gull Point Colony: A direct count of all nests in the colony was made. Also, a direct count of all gulls on and about the colony was made. Both methods revealed nearly identical results.

Kittiwake Bluffs Colony: Because of the high vegetation in this area a direct nest count was not deemed a reliable census method. Instead, the colony was viewed from the vantage point of the southeastern slope of Ugaiushak Summit. Using binoculars, gulls incubating eggs could be counted and the limits of the colony defined.

Main Talus Colony: Because of the rugged terrain of this area a direct nest count was not deemed a reliable census method, nor was there a suitable vantage point on land from which to count incubating birds. A direct count of all birds on or about the colony was made from the Zodiac at 25 - 50 m offshore

Comments: Glaucous-winged gulls were in the mid-stages of incubation at the time of census.

Census: (Figure 3) East Island Colony

Subcolony 1	105 nests
2	105 nests
3	37 nests
4	15 nests

5	88 nests
6	26 nests
Gull Point Colony	110 nests
Kittiwake Bluffs Colony	54 nests
Main Talus Colony	600 birds

1,500 - 1,800 estimated total birds

Rissa tridactyla. Black-legged Kittiwake.

Date: 15 August, 1976

Time: 15:30

Weather: Sunny clear skies. Wind 5 m.p.h. Seas calm.

Method: A direct count of individual birds on land, water, and in the air was made by circumnavigating the island in the Zodiac. Separate counts were obtained for individual breeding colonies and loafing sites. Chicks of the year were not included in the censsus. One year old birds were included, however, their total number at this time was probably less than 50 individuals.

Comments: Counts of nests were not used as a census technique because of the asynchrony in nesting phenology and the dissertion and consequent distruction of many nests. Census figures do not include those Kittiwakes in feeding flocks away from the island. These foraging birds may have numbered 10 to 20 percent of the birds actually censused.

Census	Location	Map Location Number (Figure 4)	Number of Birds Contacted
	Murre Point Colony (including Main Talus beach rocks)	1	705
	Widow's Rock	2	450
	Secluded bay Beach & Southeast Murre Point	3	497
	Kittiwake Lake	4	130
	Secluded Bay Colony	5	960
	Kittiwake Cove Colony	6	225
	Kittiwake Bluffs Colony	7	2,017
	Sqaure Bay Colony	8	1,615
	Murre Cove Colony	9	639
	Hole-in-the-Wall Colony	10	265
		Total	7,503

Estimated total birds: 8,000 - 10,000

Uria aalge and U. lomvia. Common Murre and Thick-billed Murre.

Date: 15 August, 1976

Time: 15:30

Weather: Sunny skies. Wind 5 m.p.h. Seas calm.

Method: The number of birds on most colonies was determined from a direct count of individual breeding colonies and loafing sites were censused seperately as seen from the Zodiac. Murres nesting in Murre Cove also were counted from vantage points along the cliff top above the cove. However, the geomorphology of the area made it impossible to count all birds in this colony and an estimated $\pm$ 200 birds could not be observed directly from any position. In addition to nesting on cliff edges, murres also nested in puffin burrows along the cliff tops from Secluded Bay to midway between Square Bay and Gull Point and also within rock crevices and amidst heavily vegetated talus areas in the Main Talus. Because few birds occupying these inaccesible habitats were visible, only an "educated guess" as to their numbers could be made.

Comments: Both species of murres were in the last half of their incubation period at the time of censusing. Judging on the basis of daily observations with respect to the relative numbers of murres on or near the breeding areas at different times of the day, probably greater than 90% of the murre population was represented in the census data. The relative abundance of two species was not determined.

Census	Location	Map Location Number (Figure 5)	Number of Birds counted
	Main Talus (exposed)	1	586
	Murre Point	2	1,737
	Secluded Bay	3	856
	Kittiwake Cove	4	298
	Kittiwake Bluffs	5	939
	Square Bay	6	585
	Murre Cove	7	3,000 + 200
	Hole-in-the-Wall	8	139
	Main Talus (inaccesible) and burrow nesters	89	350
		Total	8,490 + 200

Estimated total birds: 8,500 - 10,000

Cepphus columba. Pigeon Guillemot.

Date: 27 June, 1976

Time: 13:30 - 15:30

Weather: Sunny, Clear skies. Wind 5 m.p.h. Seas with 2 to 3 foot swell

Method: The island was circumnavigated by Zodiac, as close to shore as possible. A direct count of individual birds on both the water and on the land was obtained . Solitary birds and those associated with other Guillemots were recorded separately.

Comments: Most birds were probably in the initial stages of incubation at the time of the census and incubating birds as well as those offshore could not be counted.

Census: 176 individuals counted
250 - 300 estimated total birds.

Fratercula corniculata. Horned Puffin.

Horned Puffins nested in rock crevices and talus areas around the periphery of most of the island and it was impossible to derive a reliable censusing method. However, members of pairs tended to exchange incubation duties sycronously with other pairs, and at these times, many birds would be visible. The percent of the birds visible as apposed to those within the crevices and talus or remaining at sea could not be determined, but those visible provided a means of establishing a minimum estimate of population size. Counts were made during one of those periodic occupations of nesting areas in mid-August. The number of birds observed in sample areas were counted and used to estimate birds in the larger area of the colony.

Location	Map Location Number (Figure 6)	Estimated Number of Birds
Main Talus (Murre Pt. to Saddle Peak	2	2,400
Saddle Peak to Eagle Point	3	2,500
Eagle Point to Log Beach	4	1,100
Remainder of West Island	5	2,100
East Island	6	900
	Total	18,200

Lunda cirrhata. Tufted Puffin.

Tufted Puffin nested in rock crevices, vegatated talus areas, and in burrows around the periphery of much of the island. On West Island, Tufted Puffins nested in all three habitat types. While on East Island, nesting appeared to take place almost exclusively in burrows. Hence, it was possible to estimate the number of breeding pairs on East Island by counting the number and determining the status of (active or inactive) burrows on East Island, as described below:

East Island Census:

Date: 30 July 1976

Time: 10:00 - 16:00

Method: Tufted Puffins nested along the cliff-edge of the island with all burrows located within 5 m of the cliff-edge. The island was divided into sub-areas on the basis of a preliminary examination of burrow density. In areas of low burrow density, such as the north side of the island where burrows were found, only a few discrete areas where cliffs occur, a direct count of all burrows was made. In areas of high burrow density, direct counts of burrows were made in 5 x 5 m quadrats in each sub-area. The quadrats sampled within each sub-area were chosen randomly with the number of quadrats sampled being proportional to the size to the sub-area. The linear length of each sub-area was measured by pacing off the distance along the contours of the cliff-edge within the sub-area. A mean burrow density for each sub-area was determined and the total number of burrows within each sub-area was then obtained by extrapolation of sample densities. Summed totals of the sub-areas gave the total number of burrows on the island. Burrow occupancy was determined by randomly sampling burrows within each sub-area and assigning occupancy on the basis of signs of escavation, defecation stains, or other signs of nesting activity. As percent burrow occupancy was about equal within each sub-area, this value was multiplied times the estimated number of burrows to get the estimated total number of active burrows, and hence, breeding pairs.

Sub-Area (Figure 7)	Length of Coastline	Number Quadrats	Mean Number Burrows	Total Number Burrows
A	156	31.2	24.3	758
B	44	8.8	10.0	88
C				25
D	182	36.4	11.0	400
E	154	30.8	9.0	277
F	141	28.2	13.0	367
G				50
H	100	20.0	13.5	270
I	46	9.2	14.0	128
J				25
K	615	123.0	9.0	1,107
L	83	16.6	3.0	50
M				25
N				25
O				50
P	182	36.4	1.0	36
Q				30
R	455	91.0	1.0	91
S				100
T				50
U	91	18.2	1.0	18
V				75
W	1,820	364.0	1.0	364
				4,404 Total

Burrow occupancy = 90%

3,963 total active burrows

West Island Census

Because Tufted Puffins nested in rock crevices, vegetated talus, and burrows on West Island, there was no way to reliably census these birds. Although Tufted Puffins, like Horned Puffins, would periodically occupy the nesting areas as a population, the nature of the substrate did not make Tufted Puffins as visible and hence, more difficult to count. Therefore, only a rough guess as to the number of Tufted Puffins on the West Island could be made.

Estimated total numbers: 8,000 - 12,000

Estimated total birds on West and East Islands combined: 12,000 - 16,000

Cerorhinca monocerta. Rhinoceros Auklet.

Date: late June, July, August

Method: Nesting Burrows of Rhinoceros Auklets were not located. The census figure is based on observations made 2 or 3 days a week of birds rafting offshore at sunset. The largest single Raft observed was of 10 birds on 8 August.

Census: 20 - 40 estimated total birds.

Cyclorrhynchus psittacula. Parakeet Auklet.

Date: June and July

Method: Accurate censuses were not possible because birds nested among rock crevices. Population estimates are based on observations of Parakeet Auklets on the water and on land during the course of daily operations around the island in the Zodiac.

Comments: Parakeet Auklets were frequently observed in small rafts of usually less than 25 birds off of Eagle Point. No large colonies of Parakeet Auklets were observed on Ugaiushak Island, although a colony of perhaps several hundred birds was observed on the Northeastern end of Central Island.

Census: 80 - 120 estimated total birds.

Synthliboramphus antiquus. Ancient Murrelet.

The only evidence of Ancient Murrelets on Ugaiushak Island was the finding of one egg and one carcass of an adult bird. On 30 June, 30 + birds were seen in Peninsula Straight and three birds again 1 July, however, it was not known whether these birds were residents of Ugaiushak. Divoky (1974, see Appendix I), observed six young going to sea and heard others. He also netted two adults in petrel nets.

BREEDING BIOLOGY

Oceanodrama furcata. (Fork-tailed Petrel.

Fork-tailed Petrels were first heard at night on 23 June, though they were undoubtedly present on the island prior to this date. The limits of the breeding area used by this species was determined by listening for birds during night walks around the island in June, July, and August. The Petrel colony appeared to be concentrated in elevations above 50 m from Murre Point to Eagle Point (Figure 8). Petrels may also have nested in the vegetated talus area extending from Main Talus to Saddle Peak at 20 - 50 m elevation. However, due to the difficulty and danger of traversing this area at night, it was not surveyed. Petrels did not appear to escavate burrows in the soil but rather used rock crevices in talus areas for nesting.

One nest was found on 23 June and a second nest on 24 June in the vegetated talus area of Saddle Peak, about 100 m above sea level..Both nests contained one egg and one incubating adult. Divoky (1974) found no nests.

On 24 July, a dead day old chick was found outside a rock crevice above Main Talus at an elevation of about 95 m.

Fleding probably did not occur until at least mid-September.

Oceanodrama leucorhoa. (Leach's Petrel)

Leach's Petrels were heard on only two occassions during the summer, both times in areas occupied by Fork-tailed Petrels. No nests were located. (Divoky 1974) reported Leach's Petrels being about one-tenth as common as Fork-tailed Petrels.

Phalacrocorax auritus. (Double-crested Cormorant)

Double-Crested Cormorants were present on Ugaiushak Island when the field party arrived on 24 May, in numbers approximately equal to the later estimated breeding population (See Censuses section of this report). Nesting was confined to the cliff face along Cormorant Cove and from there south about 150 m (Figure 9). Between 5 and 10 June, four study plots were established in this area to collect data as the breeding biology of all three species of Cormorants breeding on the island. Study plots were selected so as to allow observations from a vantage point on the island rather than from the sea (Figure 10).

As most cormorant nests were inaccesible for marking, a schematic map depicting the location of each nest was made for each study plot. Each nest on the map was given a number, and by referring to this map during daily visits to the colony, it was possible to observe and record data for individual nests. General observations were made with the naked eye, while 10x50 binoculars were used to determine presence and number of eggs and chicks. Because of the position of the observer and distances at which observations were made, disturbance to the birds was minimal; however, this procedure made it difficult to obtain daily counts of eggs or newly hatched chicks which were concealed by incubating or breeding adults.Observations were made every 2 to 3 days at each study plot.

When monitoring of cormorant study plot CSP #01 began on 5 June, twelve nests contained eggs, ranging from one to five in number. Three other nests of Double-crested Cormorants were monitored in CSP #02 and all contained sitting adults on 6 June. On 8 June, two of these nests had four eggs, and the other still contained a tightly sitting adult. Hence, some Double-crested Cormorants began laying at least by 1 June and probably up to several days earlier.

Six of the 15 monitored nests were abandoned between 5 and 18 June, probably as a result predation of the eggs by ravens. A pair of Ravens nested in Cormorant Cove and fledged two chicks on 15 June. The adult Ravens were frequently seen around the nesting ledges of the Cormorants and interaction between Ravens and incubating cormorants were observed on several occassions. The Ravens would usually fly about the cormorant colony or stand on the cliff tops, apparently searching for unattended eggs. When such eggs were located, the Ravens quickly seized them and carried them off. Remnants of these eggs were found on the cliff tops along Cormorant Cove. Any factor which caused the cormorants to leave their nests unattended, even briefly, probably led to the predation of some or all of the eggs by Ravens. Glaucous-winged Gulls also nested in close proximity to Cormorant Cove and were seen also flying about the nesting ledges, but were never observed actually taking cormorant eggs, though this may have occurred.

Because the cormorants tended to sit tightly on newly hatched chicks. the exact dates of hatching were usually not known. However, the range of hatching appeared to have been from 22 June to 15 July, with peak hatching occurring about 25 June. Relative inaccesibility of nests and the potential of disturbance to other birds nesting nearby, precluded collection of growth rate data on this species.

All nine nests which hatched chicks fledged young. The first chicks fledged on 17 August and all Double-crested Cormorants chicks had fledged by 30 August.

Phalacrocorax urile. (Red-faced Cormorant)

Red-faced Cormorants were present on the island when the field party arrived on 24 May. This species nested on the cliff faces within Hole-in-the-Wall and south to and within Cormorant Cove and from there south along East Island about 150 m (Figure 11).

A total of 32 nests were monitored in CP #1 and #2 (see Double-crested Cormorants above for discussion of study plots and methods). Of these, two nests contained eggs on 5 June, 10 on 10 June, 22 on 16 June, and 31 on 27 June. Of these 31 nests with eggs, 25 nests or 81% failed to retain their eggs until hatching. Whether disertion by adults occurred before or after loss of the eggs was not known; however, it was likely the cormorants left the eggs unattended and hence, subject to predation by ravens and gulls. Some nests which had eggs predated, had eggs laid in them again, presumably by the same adults, however, these eggs also disappeared in all cases. Desertion of most nests occurred in early July. Thus, only six nests or 19% of those which had eggs laid in them, hatched chicks.

The range of hatching was from 3 July to 31 July with peak hatching occurring between 21 and 28 July. Relative inaccessibility of nests and the potential disturbance to other birds nesting nearby, precluded the collection of data on growth rates.

By 30 August, approximately two-thirds of all the Red-faced Cormorants chicks in the colony fledged.

Phalacrocorax pelagicus. (Pelagic Cormorant)

Pelagic Cormorants were present on the island when the field party arrived on 24 May. This species nested in the same areas used by the Red-faced Cormorants (Figure 12). Where the three species of cormorants nested on the same cliff face, Double-crested Cormorants always nested on the top ledges, Red-faced Cormorants usually nested in the middle areas, and Pelagic Cormorants usually nested on the lower ledges. Some overlap did occur between Red-faced and Pelagic Cormorants.

Nests of 36 Pelagic Cormorants were monitored in CSP #1, #2, #3, and #4 (see discussion of Double-crested Cormorants above for discussion of study plots and methods.) Of those, one nest had eggs laid in it by 6 June, 11 by 10 June, 22 by 16 June, and 36 by 29 June. Of those 36 nests, eight nests or 22% failed to retain their eggs until hatching, presumabley as a result of predation by ravens or gulls. In seven of these nests, egg loss and nest desertion occurred in mid to late July. Pelagic Cormorants seemed more reluctant to leave their nests unattended then were Red-faced Cormorants which may account for the lesser desgree of egg loss and desertion in this species. Also, the tendency for Pelagic Cormorants to nest on the lower levels of the cliff face probably made their eggs more difficult to be seen by ravens standing on cliff tops overhead.

Eggs in 78% of the Pelagic Cormorants nests hatched. The range of hatching was from 15 July to 15 August which peak hatching occurring between 23 and 31 July.

By 30 August, approximately two-thirds of all the Pelagic Cormorant chicks in the colony had fledged.

Somateria mollissima. (Common Eider)

Common Eiders were present around the island when the field party first arrived 24 May. A total of eight nests were located; two on the west side of East Island, one on Gull Point, and five along the Gulf Bay coastline of West Island (Figure 13). In general, nests were located in small patches of Elymus along rocky outcroppings of the coastline.

The first five nests were located on 28 June, having clutches of 2,2,3,3, and 6 eggs. On 3 July, two of those nests had one new egg, one nest was abandoned, one was unchanged, and one had a tightly sitting adult which was not disturbed to check the nest.

Ducklings were first observed on 15 July and females with broods were present in nearshore waters around Ugiaushak Island, especially in Peninsula Bay, throughout August (Appendix II).

Haliaeetus leucociphalus. (Bald Eagle)

Two adult pairs and two subadult were present on the island when the field party arrivedon 24 May. One aerie was located on 29 May atop Eagle Peak. The nest contained two eaglets less than a week old and one unhatched egg. A second aerie found on 30 May at the southwestern end of East Island contained a single unhatched egg (Figure 14). The unhatched egg from the aerie on Eagle Peak was collected on 13 June and sent to Patuxent Wildlife Research Center for pesticide analysis. By 23 June, the egg in the aerie on East Island had disappeared. Adults from this aerie remained on Ugaiushak Island for about a week afterward and then were not seen again.

One of the eaglets from the Eagle Peak had fledged by 29 July and the other left the aerie and occupied a ledge underneath on 6 August. This bird finally fledged on 10 August.

As noted above, only two subadult birds were present on the island when the field party arrived. By 13 June, seven subadults were present, but by 24 June, only five were present and only two or three subadults remained on the island by early July. The apparent immigration and emigration of subadult Bald Eagles coincided with pupping by the Harbor Seal (see Mammals section of this report).

One aerie was located on the east side of Central Island and at least one subadult was present on the island. No information on this aerie was obtained.

Falco peregrinus. Peregrine Falcon.

One adult pair of Peregrine Falcons was present on the island when the field arrived on 24 May. Although the aeries was never seen, it was believed to have been on the cliff face above Main Talus (Figure 15). The two adults were seen in the company of a fledging on 24 July. All three birds were present on the island until 21 August, after which only one or two birds were observed.

<u>Haemotopus bachmani</u>. (Black Oystercatcher.)

Black Oystercatchers were present on the island when the field party arrived on 24 May. The first nest was located on 26 May and the first egg was laid in this nest on 27 May. Seven other nests were subsequently located on the beaches around the island, though more were probably present (Figure 16).

A nest with two pipped eggs was located on 15 June. Allowing 27-28 days for incubation, these eggs were probably laid around 20 May. By 16 June, two nests had been washed away by high seas, probably during the storm of the preceding two or three days. One of the pairs from these nests had relaid in nearly the same spot by 30 June, when the nest was found to contain three eggs. As a result of such renesting, the breeding phenology of Black Oystercatchers on Ugaiushak Island was staggered throughout the summer.

Beginning on 28 July and continuing through August, flocks of 11 to 34 birds were seen congregated on the beaches of Guillemot Cove. These flocks were probably composed of post-breeding adult fledgings and possible migrants.

<u>Stercorarius parasiticus</u>. (Parasitic Jaeger.)

Parasitic Jaegers were first observed on 26 May, although they were undoubtedly present prior to this date. Three pairs probably nested on the plateau just west of camp (Figure 17). One nest containing a single egg was located on 13 June. This nest was neither relocated nor were other nests found despite extensive searching of the area.

No more than six birds were observed daily during June and July, although up to 11 birds were observed after 5 August. The increase in number probably reflected the addition of fleding young. On 28 August, 16 Parasetic Jaegers were observed. It was not known whether this further increase in numbers represented more fledged birds from Ugaiushak Island or the stopping off of migrating birds.

<u>Larus glancescens</u>. (Glaucous-winged Gulls.)

Glaucous-Winged Gulls were present in numbers approximately equal to those of the breeding population when we arrived on 24 May. Four major colonies were established at Gull Point, Kittiwake Bluffs, Main Talus, and East Island, with the later colony being divided into several sub-colonies (Figure 18). Divoky (1974) also reported the presence of these four major colonies.

Gull colonies at Kittiwake Bluffs and Main Talus were chosen for intensive study. The Gull Point and East Island colonies were not as intensively monitored in order to minimize interference with studies of Tufted Puffins in nearby areas.

The first nests with eggs found in each colony, occurred as follows:

Colony	Date	Clutch size/nest
Gull Point	14 June	1
Kittiwake Bluffs	6 June	1,2
Main Talus	15 June	1,2,3,3
East Island	9 June	1,1

Peak egg-laying was estimated to have occurred in all four colonies between 15 and 20 June. Nests in all four colonies were randomly sampled to determine clutch size (Table 1).

Table 1. Clutch size of Glaucous-Winged Gulls at four colonies.

	Gull Point		Kittiwake Bluffs		Main Talus		East Island		Totals	
Clutch Size	n	%	n	%	n	%	n	%	n	%
1 egg	10	32.3	10	31.3	8	21.6	10	35.3	38	29.7
2 egg	10	32.3	15	46.9	16	43.2	13	46.4	54	42.2
3 egg	11	35.4	7	21.9	13	35.1	5	17.8	36	28.1
Totals	31		32		37		28		128	

Ravens were observed preying on eggs of Glaucous-winged Gulls on several occassions. The impact of Raven predation on gull eggs was highest at Kittiwake Bluffs and East Island where the two Raven nests were located.

Monitored nests in Kittiwake Bluffs and Main Talus were marked with brightly colored flags attached to meter-long metal rods and also with numbered tongue depressors. These two colonies were not visited during the mid and late incubation stages to minimize disturbance. At the time of anticipated hatching, the colonies were revisited, however, winds had torn the flags off most of the markers and the vegetation had overgrown the rods, making relocation of marked nests extremely difficult. Hence, the estimated peak period of hatching from 8 to 15 July, was based on general observation from the four colonies rather than specific nest data.

Because Glaucous-winged Gull chicks leave the nest shortly after hatching, enclosures were built around 3 nests on East Island to restrain chicks and permit repeated measurements for evaluation of growth. Measurements have not been analysed and the results of the activity will be discussed in a later report.

Rissa tridactyla. Black-Legged Kittiwake.

Black-Legged Kittiwakes were present in high numbers when the field party arrived 24 May. Although some Kittiwakes were on the cliffs at this time, birds were observed in new areas of the cliffs up to 14 June. It was not known whether this continual occupation of new nesting areas was due to new birds arriving at the island or was the result of birds moving from "loafing areas" to the breeding cliffs. The major nesting areas of kittiwakes on Ugaiushak Island are shown in Figure 19.

Two study plots were monitored (Figure 20) and all data on reproduction were collected from them. Study Plot #04 was monitored directly by checking individual nests marked with numbered tongue depressors inserted under each nest. Access to this study area was possible only at low tide from Square Bay. Hence, this study area was subject to considerable disturbance. Study Plot #05 was monitored from a vantage point on the cliff top opposite the plot, and hence, was subject to minimal disturbance.

A total of 60 active nests were monitored in Study Plot #04. Egg-laying began between 20 and 23 June and peak egg-laying occurred between 25 June and 2 July. Of those 60 nests, 28 had clutches of one egg, 17 had clutches of two eggs, and 15 never contained eggs. Thus, on 75% of the nests held eggs. Of the 45 nests with eggs, only 10 hatched eggs, 6 with one chick and 4 with two chicks, and 35 nests did not hatch chicks. Seventeen percent of the original 60 nests were successful to hatching. Of those 10 nests with chicks, only two nests still contained chicks on 28 August when the last observations were made. Thus, only 3% of the original 60 nests could have fledged young during the breeding season.

A total of 35 active nests were monitored on Study Plot #05. The first egg was laid on 27 June. On 3 July, three of the 35 nests contained eggs, two with two egg clutches and one with a single egg clutch. On 6 July, 10 of the original 35 nests were abandoned or destroyed and none of the others contained eggs. No further breeding activity was observed for the study plot.

The two study plots indicated a breeding failure at two different phenological periods: Study Plot #04 at the end of the egg-laying and early incubation periods, and Study Plot #05 at the initial stages of egg-laying. It was thought that human disturbance to Study Plot #04 was probably a major factor in causing the low production value. Observer presence on the colony caused most of the birds to flush from the ledge, ocassionally breaking eggs as they departed, and always subjecting the remaining eggs to predation by ravens and Glaucous-winged Gulls. For this reason, visits to the colony were made as short as possible. During the nesting period, subadult Bald Eagles preyed on nestlings after the observer had left the colony and prior to the return of adult Kittiwakes. However, Eagles also flushed adults and preyed on nestlings in the absence of an observer. Study Plot #05 was located in close proximity to a raven nest, from which two young fledged by 14 June. Although this was nearly two weeks prior to egg-laying by the Kittiwakes, the raven family remained in that area and could have preyed heavily on the kittiwake eggs as they did on the murre eggs. Some of the nests in this study plot were relatively low on the cliff face and could have been washed off of the cliff by high seas in early July.

Our general impression of the breeding success of the kittiwake population as a whole was that it was similar to that of two study plots.

In 1975, Divoky (per. com.,) found egg-laying to have began on 21 June. Of the 75 nests he examined on 2 July, 57 had two eggs, 16 had one egg, and 2 had no eggs. Although he had no specific data on fledging success, he believed it have been high.

Uria aalge and *U. lomvia*. Common Murre and Thick-billed Murre.

The following discussion refers to both species collectively unless otherwise stated due to the difficulty of separating the two species at a distance.

No murres were observed when the field party arrived on 24 May. The first observation of murres was on 29 May when a flock of 2,500 to 3,000 birds was rafted off Kittiwake Bluffs. On 30 May, about 6,000 birds were observed off of Murre Point and about 10,000 birds were seen in the same location on 1 June. Murres began to visit the nesting ledges during the first week of June.

Major nesting areas of murres on cliff faces are shown in Figure 21. In addition to these cliff nesting areas, Common Murres also nested within rock crevices and in areas of vegetated talus in Main Talus. Thick-billed Murres were also observed to nest in abandoned Tufted Puffin burrows along the cliff top from Main Talus to midway between Square Bay and Gull Point. A small number of murres nested on the ledges within Hole-in-the-Wall.

The first evidence of egg-laying was on 17 June, when the remains of two fresh murre eggs were found in the gull colony at Kittiwake Bluffs. Kittiwake Bluffs also served as a nest site for a pair of Ravens which fledged young between 6 and 8 June. Freshly predated murre eggs were located regularly on the cliff tops above the murre colonies up through early July. Ravens were seen with murre eggs on several occassions and in one instance, a Glaucous-winged Gull was observed chasing a Raven carrying what was presumed to be a murre egg. Though gulls were never seen with an egg in their bills, they were frequently observed flying about the murre ledges. On 15 July, a sample of 100 regurgitation pellets of Glaucous-winged Gulls from the Kittiwake Bluffs Colony and 100 pellets from the Main Talus Colony revealed 60 and 26, respectively, with remnants of murre eggs (one egg was considered the equivalent of one pellet). None of these eggs were fresh, but had probably been eaten two or three weeks earlier. Hence , there was little doubt that Glaucous-winged Gulls as well as Ravens were preying heavily on murre eggs.

The murre colonies were observed from the Zodiac around 23:00 on 24 June and no murres were observed on the ledges. At about 22:30 on 25 June, a flock of several thousand murres was observed flying from the colonies west around the island and then northeast up Peninsula Straight until they were out of sight. A survey of the colonies at 23:00 revealed very few murres on the nesting ledges. Although some birds had laid eggs by this time, the population appeared to desert the colonies at night.

Nesting ledges were only acessible from sea level either by Zodiac or by walking along the intertidal zone from access areas such as Square Bay beach or the southernmost draw in Kittiwake Bluffs. Human presence on the colonies usually caused mass emigration from the nesting ledges causing eggs to be broken and subjecting the remaining unattended eggs to predation by gulls and ravens. Vantage points along the cliff tops above the murre nesting ledges allowed the observer an excellent view of the ledges. However, human presence at such vantage points still created disturbance, especially on the higher nesting ledges. For these reasons, we did not attempt to obtain information on the breeding phenology of murres. The use of blinds along the cliff tops in the future should help to correct the difficulties.

The generall impression was that most of the murres probably began incubation between 10 and 20 July. One murre egg was found pipped on 12 August, and on 17 August, two chicks were found in a puffin burrow in Kittiwake Bluffs, one about two days old and the other about 5 to 7 days old. On 30 August, several chicks were found among the crevices of Main Talus, all between one and two weeks old. Most chicks probably did not fledge until after the departure of the field party on 2 September.

Cepphus columba. Pigeon Guillemot.

Pigeon Guillemots were present around the island when the field party arrived on 24 May. Birds were mostly observed on the water, as opposed to standing on beach rocks, prior to 12 June. Guillemots were regularly observed going into and out of rock crevices along the beaches after 14 June. The first nest with an adult attending an egg, was located on 22 June on Main Talus beach. This nest was subsequently deserted.

Areas where guillemots were frequently observed entering and leaving rock crevices were intensively searched for nests during June; however, no accessible nests were located at this time. Two nests marked by Divoky in 1974 were located but neither were active. The major nesting areas of Pigeon Guillemots on Ugaiushak Island were delineated and mapped from observations of birds entering and leaving crevices and by listening for birds calling from within crevices or log piles (Figure 22). The two areas of highest concentration were Log Beach, where the birds nested among the large pile of driftwood, and along Saddle Beach, where they nested among boulders.

Fratercula corniculata. Horned Puffin.

Horned Puffins were not observed around Ugiaushak Island until 31 May. Thereafter , they were seen regularly through 2 September when the field party departed. Horned Puffins nested in rock crevices and talus areas around the periphery of most of the island, though the major concentrations were at Main Talus, Saddle Peak, and Eagle Point (Figure 23).

An instensive study of the breeding biology of this species was planned, however, inaccessibility of individual nests precluded such a study. The birds usually nested deep within the rock crevices of the talus areas. Such areas were searched intensively for nests with the aid of a flashlight, but only a few nests were seen and most of those were not accessible. Several large crevices at Main Talus and Saddle Peak allowed Wehle to climb up to 15 m into the talus but nests were still in inaccesible smaller passageways branching off from the larger crevice. Horned Puffins could be heard vocalizing deep within the recesses of the honeycombed talus. The higher elevations of Saddle Peak afforded the greatest number of accessible nests which were located in a vegetated talus area. This area was designated by Puffin Study Plot #04. The loose rock comprising the talus in PSP #04 made working there extremely dangerous.

A total of 29 nests with eggs were eventually located. Most of these were in PSP #04, the others being found in Main Talus, Eagle Point, and in small rock crevices among beach boulders. Because it was very difficult to identify nests prior to the presence of an egg, PSP #04 was searched in its entirety on 15, 19, 21, 24, and 27 June for presence of eggs. On 15 June, only one egg was present, on 27 June, 22 eggs were present. No further increase in the number of eggs was noted on subsequent visits. Nests containing eggs were marked with flags and numbered tongue depressors. Egg weight and measurements were recorded.

Throughout July, Horned Puffins were observed in locations around the island where they had not been previously observed, especially along the east side of East Island, the east side of West Island along Gulf Bay, and on the cliff face of Murre Point. A freshly laid egg with an adult in attendance was found on 23 July along the east side of West Island on Gulf Bay. This egg was later deserted. Another Horned Puffin was observed in mid-August still uncubating an egg. It was believed that egg-laying in the major colonies probably peaked during mid to late June, but birds nesting in more solitary conditions, as was the case of most of the birds observed in these new areas, laid eggs during July and perhaps into August. Reasons for such asynchrony in egg-laying was not known.

Horned Puffins were first observed carrying fish to young on 23 June near Eagle Point. On 24 July, survey of Main Talus revealed two starred eggs and two discarded eggshells near crevice entrances.

On 29 July, nests in PSP #04 were checked for presence of chicks. Two chicks had hatched by this date, but both were able to retreat back into the crevices rendering them inaccessible for obtaining growth rate measurements. While checking nests on this data, a small rockslide occurred in the study plot nearly taking Wehle with it. It was subsequently decided that the area was too dangerous for further work.

No information on fledging dates was obtained; however, based on the earliest observations of adults carrying fish and allowing 40 days for the nestling period, Horned Puffins probably began fledging about 1 September.

Lunda cirrhata. Tufted Puffin.

Less than a dozen Tufted Puffins were seen daily from 24 May to 30 May when a flock of about 300 birds was seen. Thereafter, most of the breeding population remained around the island through 2 September when the field party left the island. Tufted Puffins nested primarily in burrows but also nested in rock crevices and in talus areas around the periphery of most of the island (Figure 24).

An intensive study of the breeding biology of this species was conducted. Three major study plots were established (Figure 25). Puffin Study Plot (PSP) #01 was used for collection of data pertaining to egg-laying dates, egg measurements, hatching dates, growth rates of chicks, and fledging dates. PSP #02 was used to collect data on incubation rhythms, hatching dates, twinning experiments, growth rates of chicks and fleding data. PSP #03 was used to collect data on behavior and food brought back to the young. The three study plots were used to collect essentially different kinds of data in an attempt to minimize potential desertion by adults as a result of prolonged human disturbance during data collection.

Ninety-four burrows were monitored in PSP #01 and marked with flags attached to meter-long metal rods and also with numbered tongue depressors. Ten burrows were first marked on 31 May, and additional 40 burrows on 1 June, and the remaining 44 burrows on 2 June. Burrows whose nest chambers were not accessible through the burrow entrance, were fixed with an observation hold into the nest chamber. The hole was plugged with plywood, rocks, or vegetation between visits by the observer. Burrows were examined on 1,2,3,5,7,9, and 11 June for signs of escavation, nest building, and/or presence of an egg. Once an egg was discovered, the burrow was not checked again for at least 42 days. Checking of all burrows was ceased on 11 June in order to minimize disturbance to the colony as Tufted Puffins are extremely proned to desertion, especially during the incubation period.

One egg was found in each of two burrows checked on 31 May and 1 June. Both eggs were heavily soiled and were cold. It was thought that these eggs were last year eggs on the basis of their soiled appearance and by the fact that very few Tufted Puffins had been seen during the previous week. However, both of these eggs were subsequently incubated and both hatched chicks. This indicated that at least some of the Tufted Puffins laid their eggs and then went back out to sea for an unknown length of time before returning to incubate the egg. Most Tufted Puffins monitored, however, began incubation within a day of laying the egg.

Fifty-two of the original 94 burrows had eggs by the end of the breeding as revealed by a recheck of all burrows in late July. Of these 52 burrows, 41 had eggs on or prior to 11 June when initial checking of the nests was stopped. On the basis of the data collected from PSP #01, peak laying occurred between 2 and 7 June and peak hatching occurred between 17 and 20 July. The incubation period ranged from 44-45 to at least 52 days with mean of 46.8 days.

Fifteen incubating adults were banded and color marked with picric acid (see Banding section of this teport) in PSP #02. Only one bird per burrow was marked. It was hoped that such marked birds could be used to obtain information on the incubation rythms of these pairs. However, 14 of the 15 marked birds deserted the nest shortly after being marked. The burrow containing the remaining marked bird was checked at least twice daily, with one check being made at about the same time each day. The burrow was checked by observing the bird through the burrow entrance with the aid of a flashlight. Although identification of the marked bird was not always possible, there appeared to be about a 24 hour shift for each bird. It was hoped that the remaining marked birds would return to the same nest in the future, thereby allowing such a study to be conducted at that time.

Data on growth rates was obtained on 48 chicks from PSP #01 and #02. Chicks were weighed usually every two or three days and measurements of tarsus length, culmen length, and wing length were made weekly. Analysis of growth rate was not available at the time of this writing.

Twinning experiments were conducted on four chick pairs. On 22 July, 4 chicks weighing 130, 120, 98, and 59g were placed in burrows with chicks weighing 139, 117, 97, and 66g, respectively. When the burrows were checked again on 24 August, two of the introduced chicks were missing and their two "host" chicks were doing well, one introduced chick and one host chick were dead (in different burrows), and one chick pair was doing well. The latter chick pair were the two chicks weighing 59 and 66g which were twinned when both chicks were less than a day old. Both of these chicks were still alive when last checked on 2 September, though one chick weighed 189 and the other 380g. Growth rates for both of these chicks was much slower than for those chicks raised alone. The purpose of this experiment was to determine if food resources were limiting the Tufted Puffins to only raising one chick. The deaths and disappearances within the other chick pair probably did not result from insufficient food, but rather from agression between the chicks or possible between the introduced chick and the adults. The chick pair which was twinned at a day of age became more aggresive toward each other as time went on. However, a higher degree of tolerance, not promoting death or desertion of the burrow by the chicks, was probably the result of the chicks being twinned at such a young age. Further studies similar to this experiment may be effective for evaluating the abundance of food resources available to Tufted Puffins in different areas.

Five of the 48 chicks originally monitored died during the nestling period. Of the remaining 43 chicks, seven had fledged by 30 August and 12 fledged between 30 August and 2 September. The remaining 24 chicks were still in their burrows when the field party departed on 2 September. These birds would probably have fledged during the next two weeks.

Cerorhinca monocerata. Rhinoceros Auklet.

Rhinoceros Auklets were first observed on 1 June in Peninsula Bay. though they were probably present prior to that date. This species was observed regularly at dusk, but only in this area throughout the rest of the summer.

Although no nests were located, birds were seen flying ashore in the evening and doing typical puffin "fly-bys" around Log Beach. It was suspected that Rhinoceros Auklets probably nested on the vegetated slope extending from Eagle Peak to Log Beach (Figure 26).

Nightly returns of Rhinoceros Auklets to the island strongly suggested that they were breeding on the island, however, even during August when they would have had young, no birds were observed carrying fish to young.

Synthliboramphus antiques. Ancient Murrelet

Although birds were seen in Peninsula Straight on 30 June and 1 July, Ancient Murrelets were not observed on Ugaiushak Island during the summer. One adult Murrelet, apparently killed by a Peregrine Falcon, was found near the peregrine aerie above Main Talus on 19 June. One abandoned egg was found on 24 July in the vegetated talus area of Main Talus at an elevation of about 90 m. Divoky (1974) did not locate any nests but saw six young heading to sea, heard other young, and netted two adults in petrel nets.

Cyclorrhynchus psittacula. Parakeet Auklet.

Parakeet Auklets were first observed on 3 June about 0.5 m offshore in Peninsula Bay and were seen regularly thereafter in the vicinity of Eagle Point (Figure 27). On 15 June, birds were heard within the rock crevices of the boulder beach on the west side of Eagle Point. A search for nests in this area was made several times in June but none were located. It was suspected that the birds were nesting deep within the crevices and hence were inaccessible for observation.

During visits to Central Island, Parakeet Auklets were observed flying into and out of small talus areas and vertical cracks in the cliff face along the north side of the island.

No information on the breeding biology of Parakeets was obtained from either colony.

Corvus corax. Common Raven.

Two pair of Ravens were present on the island when the field party arrived on 24 May. Two nests were located: one on the cliff at Kittiwake Bluffs contained four chicks and the other on the south cliff at Cormorant Cove contained two chicks (Figure 28).

On 6 June, the four chicks at Kittiwake Bluffs left the nest and occupied ledges nearby. All chicks had fledged by 14 June. The two chicks at Cormorant Cove fledged a day later. The adult ravens and their fledglings remained on the island throughout the summer. On 16 August, 11 Ravens were observed. It was assumed that 10 of these were the two family groups and the additional bird was probably a stray from a nearby island or from the Alaska Peninsula.

Feeding Ecology

Studies feeding ecology were of three general categories: 1) collection of seabirds for analysis of esophagus and stomach contents. 2) identification of foraging areas, and 3) collection of food brought back to the young.

Table 2. Seabirds collected for analysis of esophagus and stomach contents.

Species	# Collected	Activity [1a]	Location [1b]
F. glacialis	1	A	3
L. glaucescens	20	D	2
R. tridactyla	30	D	4
U. aalge	34	ABC	3
U. lomvia	13	ABC	3
C. columba	1	A	1
B. marmoratum	2	A	1,3
S. antiquis	2	A	3
C. psittacula	2	A	3
C. monocerata	4	B	5
F. corrculta	15	ABC	3
L. cirrhata	30	ABC	3

a/ Activities:

A - Feeding

B - Rafting

C - Flying from foraging area (presumed)

D - Loafing

b/ Location:

1 - Coastal Ugaiushak Island

2 - Central Island

3 - Peninsula Straight

4 - Kittiwake Lake

5 - Peninsula Bay

One-hundred and thirty-four birds comprising 11 species were collected at or in the vicinity of Ugaiushak Island during the summer of 1976. In addition, 20 Glaucous-winged Gulls were collected during the summer on Central Island, making a total of 154 birds of 12 species collected by Wehle, Hoberg and Powers, (Table 3 and 4). The primary objectives for collecting specimens were: 1) internal and external parasite analysis and 2) food-studies analysis. Secondary objectives included collection of data with respect to stage of breeding, plumage, aging, sexing, population structure, and general morphology.

All birds were collected at sea except the Black-Legged Kittiwakes which were shot on the island as they flew between Kittiwake Lake and Secluded Bay.

Collecting trips were usually less than one hour in length so that birds could be returned to the field camp and contents place in formalin before deterioration of contents occurred. Formalin was not injected down the esophagus immeidately after a bird was collected because of interference with parasite collection procedures. Once the birds were brought to the field camp, the esophagus and stomach was extracted, opened up, and placed in whirl-pals bags containing a 10% buffered formulin solution. All samples were submitted and stored for laboratory analysis which are discussed in another report. The esophagus and stomach of each bird collected were opened up and placed in a whirl-pak bag with 10% formalin, and all samples stored for later analysis. Internal parasites were removed from selected specimens for analysis by E.P. Hoberg at the University of Saskatchewan (see Appendix III). External parasites were collected, placed in vials containing 70% ethyl alcohol, and stored for identification.

Sketeton speciments were made from; Tufted Puffins, Horned Puffins, Rhinoceros Auklets, Northern Fulmars, Common Murre, Thick-billed Murres, Ancient Murrelets, Gloucous-winged Gulls, Black-legged Kittiwakes, Marbled Murrelets, Parakeet Auklets, and Pigeon Guillemots. Skeletons were made by placing individual skinned carcasses in a small-mesh wire basket suspended from a buoy in Guillemot Cove, amphipods would clean off all tissue down to the bones in the bones in six to twenty-four hours, depending on the size of the carcass. Care had to be taken to recover the skeleton before the bones were disarticulated. All skeletons were deposited in the vertibrate terrestrial collections, University of Alaska museum.

Table 3. Seabirds collected at Ugaiushak Island, 1976.

Species	Wehle	Hoberg	Powers	Total
Fulmarus glacialis	1	0	0	1
Larus glaucescens	20	0	0	20
Rissa tridactyla	0	30	0	30
Uria aalge	0	29	5	34
U. lomvia	0	8	5	13
Cepphus columba	0	1	0	1
Fratercula corniculata	15	0	0	15
Lunda cirrhata	10	20	0	30
Cerorhinca monocerata	4	0	0	4
Brachyramphus marmoratus	1	0	1	2
Sythliboramphus antiquus	2	0	0	2
Cyclorrhynchus psittacula	2	0	0	2
				154 Total

Table 4. Seabirds Collected by D.H.S. Wehle at Ugaiushak Island, 1976

Species	A.O.U. #	Date	OBS Collection Numbers	Sex	Age	Weight (gm)
L. Cirrnata	012	7 Jun 76	06-35-001	F	AD	770
			002	F		718
			003	M		799
			004	M		740
			005	F		862
		18 Jun 76	011	F		749
			012	M		771
			013	F		711
			014	M		788
			015	F		708
F. Corniculata	014	7 Jun 76	006	M	AD	506
			007	F		559
			008	F		502
			009	F		584
			010	F		501
		10 Jul 76	022	M		594
			023	F		523
			024	F		481
			025	F		570
			026	F		512
		22 Aug 76	031	F		468
			032	F		445
			033	F		542
			034	M		558
			035	M		578
C. Monocerata	015	30 Jun 76	017	M	AD	459
		2 Jul 76	020	M		518
		17 Aug 76	029	-		448
		17 Aug 76	030	M		528
S. antiquus	021	1 Jul 76	018	M	AD	233
			019	F		231
C. psittacula	017	25 Jun 76	016	M	AD	220
		5 Jul 76	021	F		203
B. marmoratum	023	4 Aug 76	028	F	AD	228
F. glacialis	086	10 Jul 76	027	M	AD	628

A total of 43 samples plus numerous partial samples of food items brought back to young by Tufted Puffins were collected. Food samples were collected in puffin Study Plot #03 from 3 to 30 August. Analysis of food samples was not completed at the time of this writing.

Identification of Foraging Areas

Fulmarus glacialis. Northern Fulmar.

On both 9 and 10 July, a flock of 20+ fulmars were observed feeding in Peninsula Straight (Figure 29). On 9 July the fulmars were foraging in the absence of other species while on 10 July they were observed feeding with 15 Northern Phalaropes.

Phalacrocorax auritus, *P. urile*, and *P. pelagicus*. Double-crested, Red-faced, and Pelagic Cormorants.

No distinction of foraging areas between the three species of cormorants was noted. All three species appeared to feed primarily within about 2 km of shore on the eastern side of the island (Figure 30).

Rissa tridactyla. Black-legged Kittiwake.

Black-legged Kittiwakes were frequently observed in foraging flocks of 25-100 birds at several specific locations around the island (Figure 31). The number of birds observed and the frequency in which these flocks were seen indicated that kittiwakes also fed further at sea beyond our vision. Kittiwakes visited Kittiwake Lake daily for bathing. The lake was seined in mid-August and revealed an abundance of Threespine Stickleback (Gasterosteus aculeatus), however, kittiwakes were never observed feeding on these fish. Fish collected were given to Aquatic Collections, University of Alaska Museum.

Uria aalge and *U. lmovia*. Common and Thick-Billed Murres.

During the incubation and nestling periods, murres were commonly observed in dense rafts within 0.5 km of the cliffs between Main Talus and Kittiwake Bluffs. Birds rafted in this area were seldom observed feeding. Beyond 0.5 km from shore, from Kittiwake Bluffs, around the west side of the island to Peninsula Straight, murres were frequently seen foraging in loose rafts or individually. Birds were observed almost daily in flocks of 5-30 individuals flying to and from the northeast in Peninsula Straight and also to and from the south (Figure 32). Hence, murres probably concentrated their feeding efforts at unknown distances to the northeast and south of Ugaiushak Island.

Cepphus columba. Pigeon Guillemot.

Pigeon Guillemots concentrated their feeding efforts to within several hundred meters of shore throughout the breeding season. Major foraging appeared to be directly seaward from the nesting areas (Figure 33).

Fratercula corniculata. Horned Puffin.

Horned Puffins appeared to concentrate their feeding effort to within about 3 km of shore along the west, north, and east sides of the island (Figure 34). Lower densities of birds were regularly seen at greater distance from the island, especially in Peninsula Straight. Horned Puffins were also particularly common in mixed foraging flocks feeding over a shoal extending several hundred meters south from Middle Finger.

During the pre-egg and incubation periods, both Horned and Tufted Puffins showed irregular periods of attendance around Ugaiushak Island. Where the birds were during such absences was not known, but this behavior appears to be common in puffins (Wehle, unpublished data, Burrel and Lechner pers. comm.) and should be taken into account in delineating foraging areas used by these two species during the breeding season.

Cerorhinca monocerata. Rhinoceros Auklet.

Parakeet Auklets were frequently seen in the vicinity of Eagle Point, where they nested, but were not observed foraging in that area. On a few ocassions, they were seen in flocks of less than five birds several kilometers from Ugaiushak Island in Peninsula Straight and were presumed to be feeding (Figure 38). Parakeet Auklets were observed twice in Gulf Bay, but feeding was not observed.

Synthliboramphus antiquus. Ancient Murrelet.

Although Ancient Murrelets bred on Ugaiushak Island in very low numbers, they were observed at sea on only two ocassions during the summer. In both instances, the birds flew from the water before foraging could be observed. On 30 June a group of about 30 and 1 July a group of three were seen in Peninsula Straight (Figure 37).

Cyclorrhynchus psittacula. Parakeet Auklet.

Parakeet Auklets were seen frequently in the vicinity of Eagle Point, where they nested, but were not observed foraging in this area. On a few ocassions, they were seen in flocks of less than five birds several kilometers from Ugaiushak Island in Peninsula Straight and were presumed to be feeding (Figure 38). Parakeet Auklets were observed twice in Gulf Bay, but feeding was not observed.

BANDING

Black-Legged Kittiwake

Nine Black-legged Kittiwake nestlings were banded with USFWS bands (Size 4A) and with red plastic bands between 13 and 22 August in the Kittiwake study plot #04 at Kittiwake Bluffs. Tarsus length, clumen length, right wing length, and total weight measurements were recorded (Appendix III).

Glaucous-winged Gull

Fourte n Glaucous-winged Gull chicks were banded with USFWS bands (Size 7A, aluminum) and with red plastic bands between 24 July and 8 August. Tarsus length, culmen length, right wing length, and total weight measurements were recorded.

Horned Puffin

Three Horned Puffin adults were banded with USFWS bands (Size 5, monel) on 22 August. The birds were caught in nets, which were laid over the rocks of mini-talus, in an attempt to obtain food samples that the adults were carrying to chicks. No measurements were taken.

Pelagic Cormorant

Thirty-eight Pelagic Cormorant nestlings were banded with USFWS bnds (Size 7B, monel) and with red plastic bands on 9 August. As Pelagic Cormorants tended to nest on the lower portions of the sea-cliffs, the Zodiac was used to drop the banders off on the rocks below the nests. From there the bander could climb to accessible nests. No measurements were taken.

Fork-tailed Petrel

Forty-nine Fork-tailed Petrel adults banded with USFWS bands (Size 1B, aluminum during four nights of banding on 15, 17, and 29 July and 22 August. Birds were mist-netted at night at Saddle Peak.

Tufted Puffin

Fifteen Tufted Puffin adults and 55 nestlings were banded on 9 and 10 June and from 20 to 28 August respectively. The adults were banded with USFWS bands (Size 6, aluminum) and the nestlings with USFWS bands (Size 6, monel) and with red plastic bands. The adults were flushed from their burrows into a small landing net by escavating the burrow into the nest chamber or by pounding the earth over the burrow with one's hand. All fifteen of the adults were also "painted" with picric acid on their white face masks. Three of the adults were also affixed with an orange, .10 cm long plastic leg streamer which was attached around the tarsus with a steel pin and washers. (see diagram). No measurements were taken on the adults. Tarsus length, culmen length, right wing length and total weight measurements were recorded for the chicks.

Song and Savannah Sparrows

Ten Song Sparrows and four Savannah Sparrows were banded with USFWS bands, (Size 1B, aluminum and Size 1, aluminum, respectively) at the field camp between 20 July and 9 August. Tarsus length, culmen length, right wing length, and total weight measurements were recorded.

Beached Bird Census

Beached bird censuses were conducted ancillary to other projects on the island. Ugaiushak Island was small enough so that all beaches on the island were surveyed at least monthly during the summer (Table 4).

Table 5. Location and Frequency of Beached Bird Censuses

Beach	# Times Surveyed
Guillemot Cove Beach	daily
Guillemot Cove to Eagle Point Beach	bi-weekly
Saddle Beach	bi-weekly
Main Talus Beach	bi-weekly
Secluded Bay Beach	monthly
Kittiwake Bluffs Beach	monthly
Square Bay Beach	weekly
Gulf Bay Beach at Isthmus	daily
Cormorant Cove Beach	weekly
Oystercatcher Beach	bi-weekly
South Wash-Out Beach	bi-weekly
North Wash-Out Beach	bi-weekly

Although all beaches contained flotsam and jetsam, especially Guillmot Cove Beach, no beached birds were found on any beach at any time during the summer from 24 May to 2 September. Though Glaucous-winged Gulls and Ravens were present on the island throughout this period, these birds were not observed removing or eating any beached bird carcasses. This "negative" information on the presence of beached birds on Ugaiushak Island may prove useful for comparison with future beached bird surveys of the island.

Mammals

Phoca vitulina. Harbor Seal.

Harbor Seals were seen daily from 24 May to 2 September. Although no specific census was made, the estimated pre-pupping population was 150-200 seals. Harbor Seals were most frequently observed hauled-out on offshore rocks in Peninsula Bay and on the gently sloping northern coastline of East Island. (Figure 39).

Subadult Bald Eagles were observed preying on seal pups on several ocassions in early and mid-June. Wehle estimated that about one-third of the Harbor Seals population had pupped by 28 May and that peak pupping occurred around 6 June. From 24 May to 29 May only two subadult Bald Eagles were on the island. On 29 May a third subadult was observed, a fourth on 9 June and by 13 June, seven subadult Bald Eagles were present. The subadult Eagles were frequently observed perched on intertidal rocks among Harbor Seal cows which were hauled-out with their pups. Eagles were also perched on cliff edges above the seals.

Although Eagles had been seen in close proximity to Harbor Seals for about a week, the first observation of predation was recorded on 10 June. A Harbor Seal pup had been on the beach of Guillemot Cove since 31 May, apparently abandoned. As many as three subadult Eagles were observed perched on the clifftop above the pup on several occassions. Wehle checked the pup at 13:00 on 31 May and found it alive but weak. At 18:00 Wehle found a subadult Eagle standing about 1 m from the pup. Upon examination, the pup had one eye missing and a hole in the skull, in back of the eye, measuring about 5 cm in diameter. The brain was still present and no other marks were observed.

On 11 June, subadult Eagles were observed standing less than 2 m from cows hauled-out with pups. Ocassionally, an Eagle approached one of the cows with pups. The cow reacted by jerking her head back and forth from "looking at" the pup to the eagle and occassionally opened its mouth in the direction of the approaching Eagle. The eagle then stopped. Also on this date, two pups, were found high up the intertidal zone near East Island Ascent, apparently deserted. High wind and seas the previous two days, may have stranded them at this location.

On 18 June, Wehle found a subadult Bald Eagle eating one of the pups. Upon examination, this pup had one eye missing, a hole in the skull in back of the eye measuring 6 to 7 cm, and the brain missing. The other pup was found with its skin completely everted over the skeleton, the bones free of meat, and the skull seperated from the body with a hole in back of the orbit. A third pup was found alive nearby, but weak, apparently deserted, and with one wounded eye.

An observation of attempted predation was made on about 18 June. Thirty to fourty Harbor Seal cows and pups were hauled-out on the intertidal rocks near East Island Ascent. Two subadult eagles were perched about 30 m apart on rocks above the seals. One of the eagles was about 2 m above a cow and pup which slowly began to make their way into the water, the cow ahead. As the seals moved down the rocks, the more distant eagles flew with talons outstretched to the location of the moving cow and pup, but was intercepted in flight by the other eagle which had been perched above the seals. As the eagles "fought" in mid-air, the cow and pup made it safely into the water.

On 24 June, only five subadult eagles were present on the island and by early June only two or three subadult eagles remained on the island, perhaps the same birds that were there in late May.

In summary, it appeared that subadult Bald Eagles immigrated to Ugaiushak Island at the time of pupping by the Harbor Seals and emigrated from Ugaiushak Island after the seal pups had grown enough sufficiently to avoid attack. Eagles tended to prey on pups which had been abandoned by adults or stranded during storms, though they also attacked pups accompanied by cows.

Eumetopas jubata. Steller Sea Lion.

Sea Lions did not breed on Ugaiushak Island. Periodically during late July and August, individual adult bulls were observed swimming along the northern coast of the island, but were not observed hauled out. Two adult bulls were found dead on the shore, just north of Guillemot Cove on West Island and one on Saddle Beach, however, it was not known whether these animals hauled themselves out on the rocks and then died, or whether they were washed ashore dead. Ravens were seen in the vicinity of the sea lion near Guillemot Cove, and presumably fed on the carcasses.

Unidentified Shrew

One unidentified shrew was seen in the vegetated talus area of East Island above Isthmus on 11 July. This was the only observations of a land mammal on the island with the exception of one sighting of an Alaskan Brown Bear.

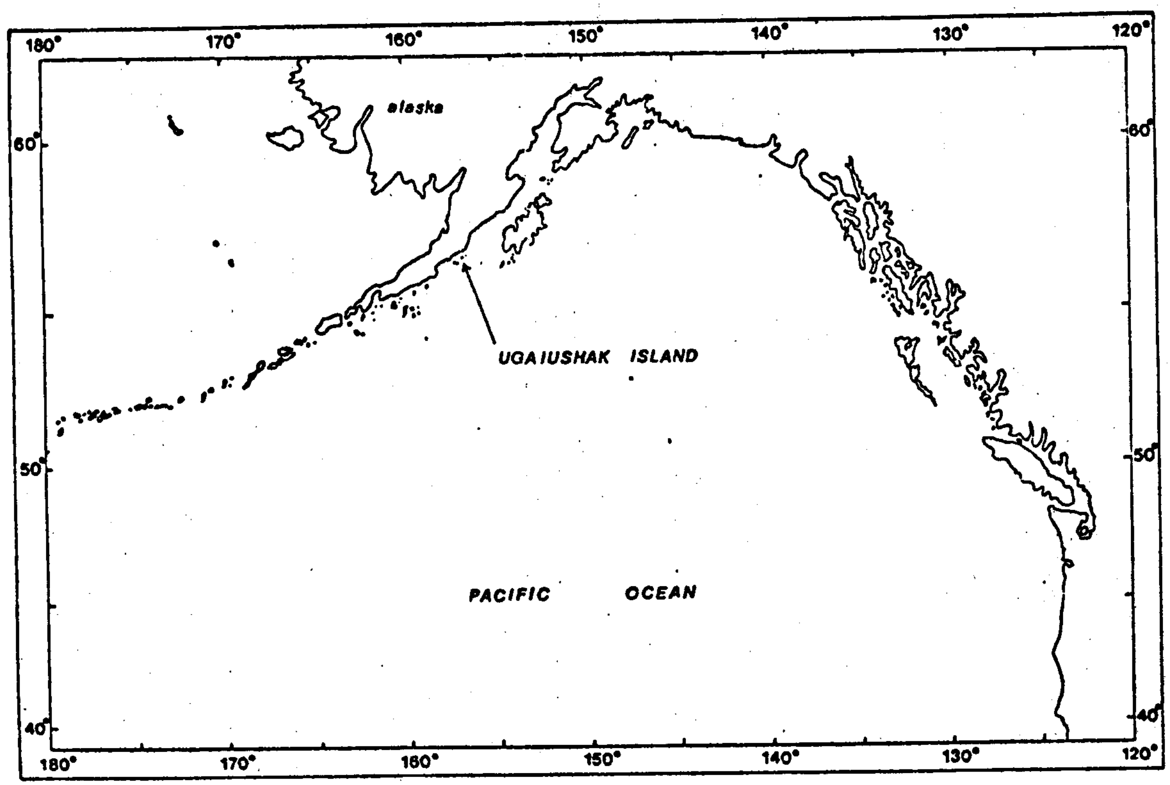
Ursus arctos. Brown Bear.

On 24 July, Powers saw an Alaskan Brown Bear on the southeastern end of East Island (Figure 40). Powers returned to camp to alert Wehle and together they returned to East Island to observe the bear. The bear was not observed again, even after a thorough search of East Island. A large hole in the ground measuring about 2 m in diameter and 0.5 m deep was found on the southeastern end of the island just above the rocky shoreline. Bear tracks were observed around the hole and other smaller scrapes around the area were noted.

Wave height between the Alaska Peninsula and Ugaiushak Island was about 3 to 4 feet, and it seemed very unlikely that the bear would have been able to swim away from the island that day. However, no further sighting of the bear were obtained. The bear could only have come from the Alaska Peninsula, perhaps by way of Central Island, a total distance of about 13 km. Divoky (per. comm) also reported one sighting of an Alaskan Brown Bear on Ugaiushak Island during late summer in 1974.

Enhydra lutris. Sea Otter.

Sea otters were observed around Ugaiushak Island regularly from 24 May to 2 September. A census was made on 27 June between 13:30 and 15:30 by circumnavigating the island near the kelp beds. Four otters were observed (Figure 41), on the Kittiwake Bluffs but were not observed during the census. Estimated total number of sea otters was six.



Fiqure 1. Location of Ugaiushak Island.

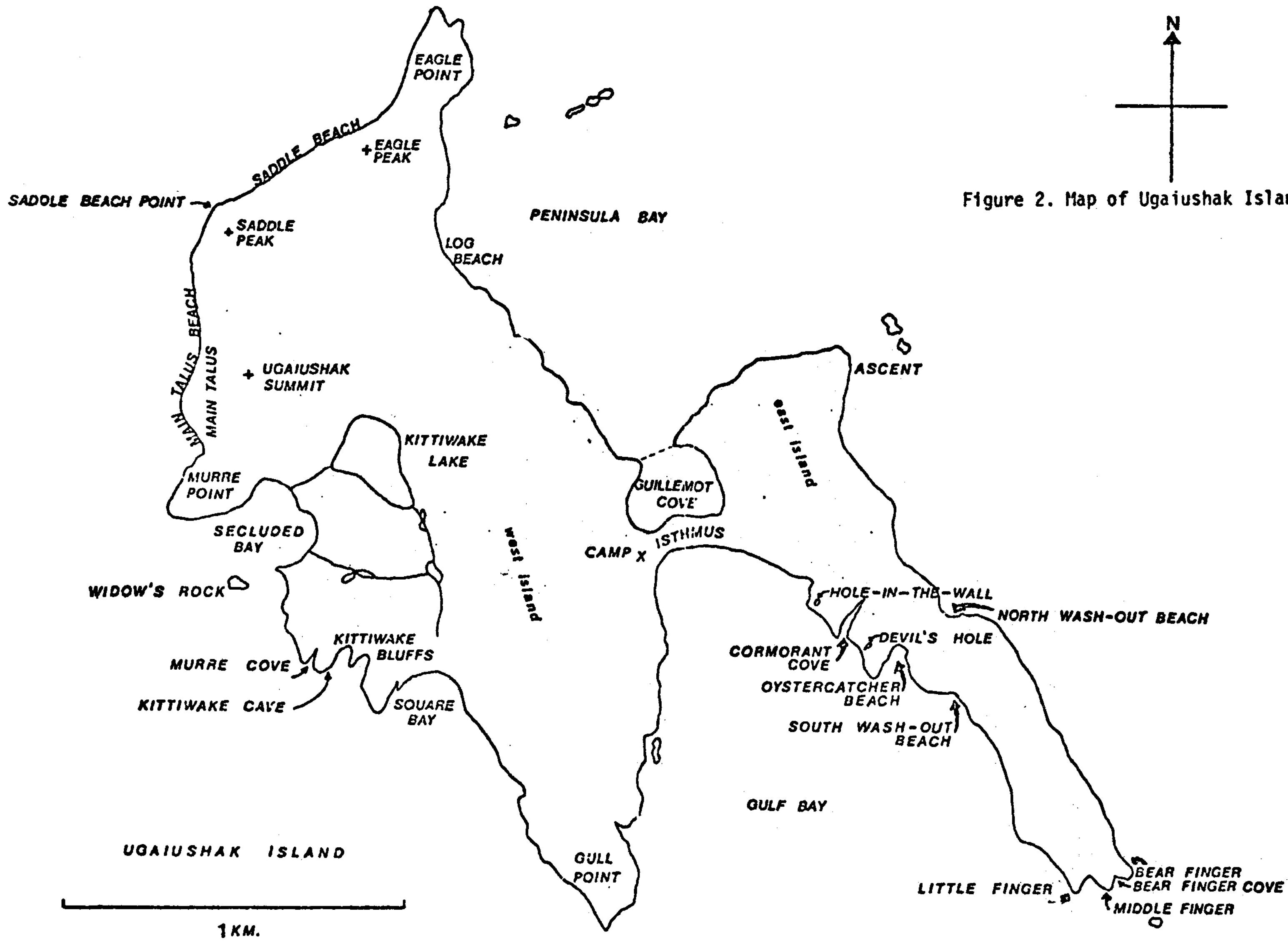


Figure 2. Map of Ugaiushak Island.

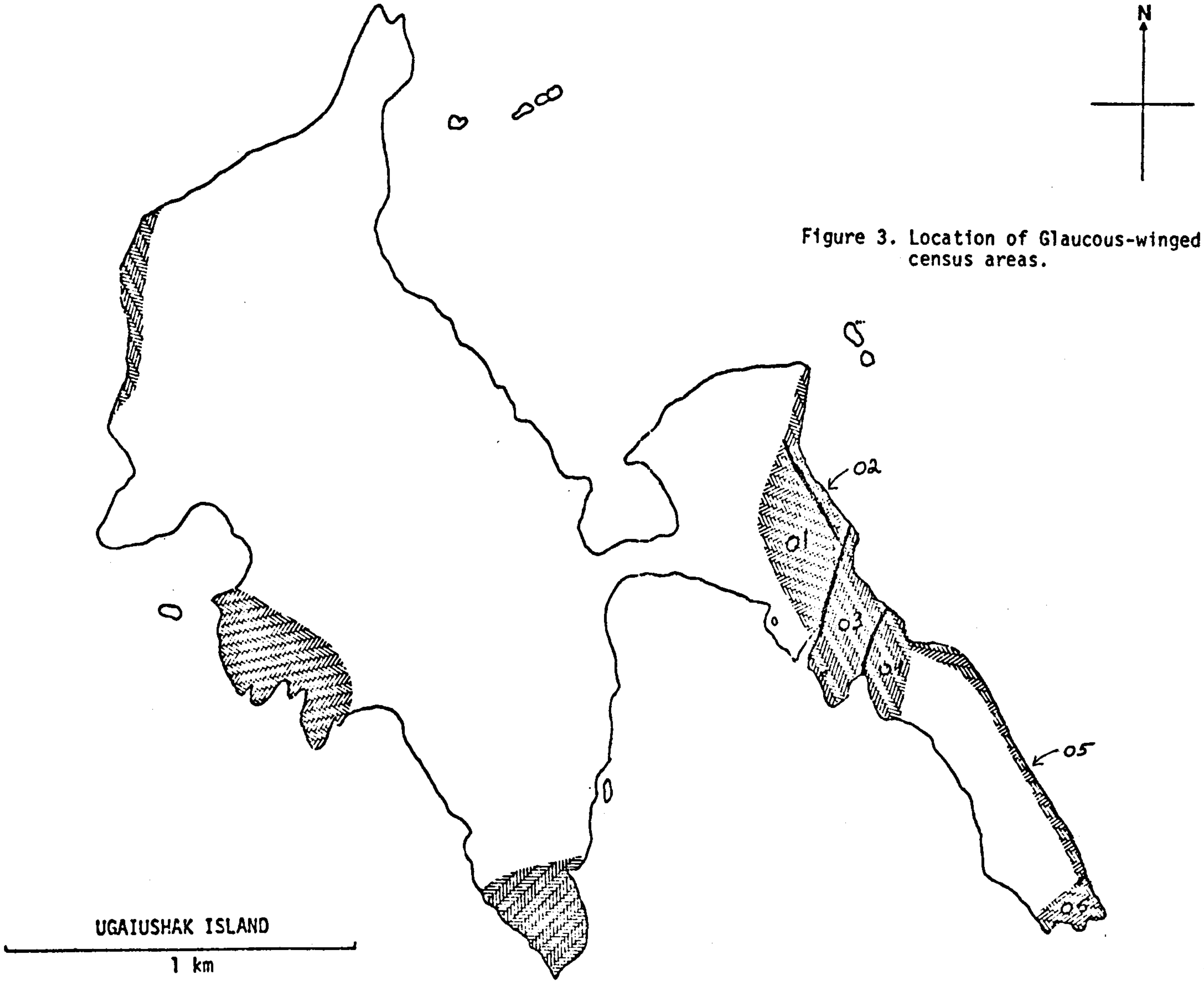


Figure 3. Location of Glaucous-winged Gull census areas.

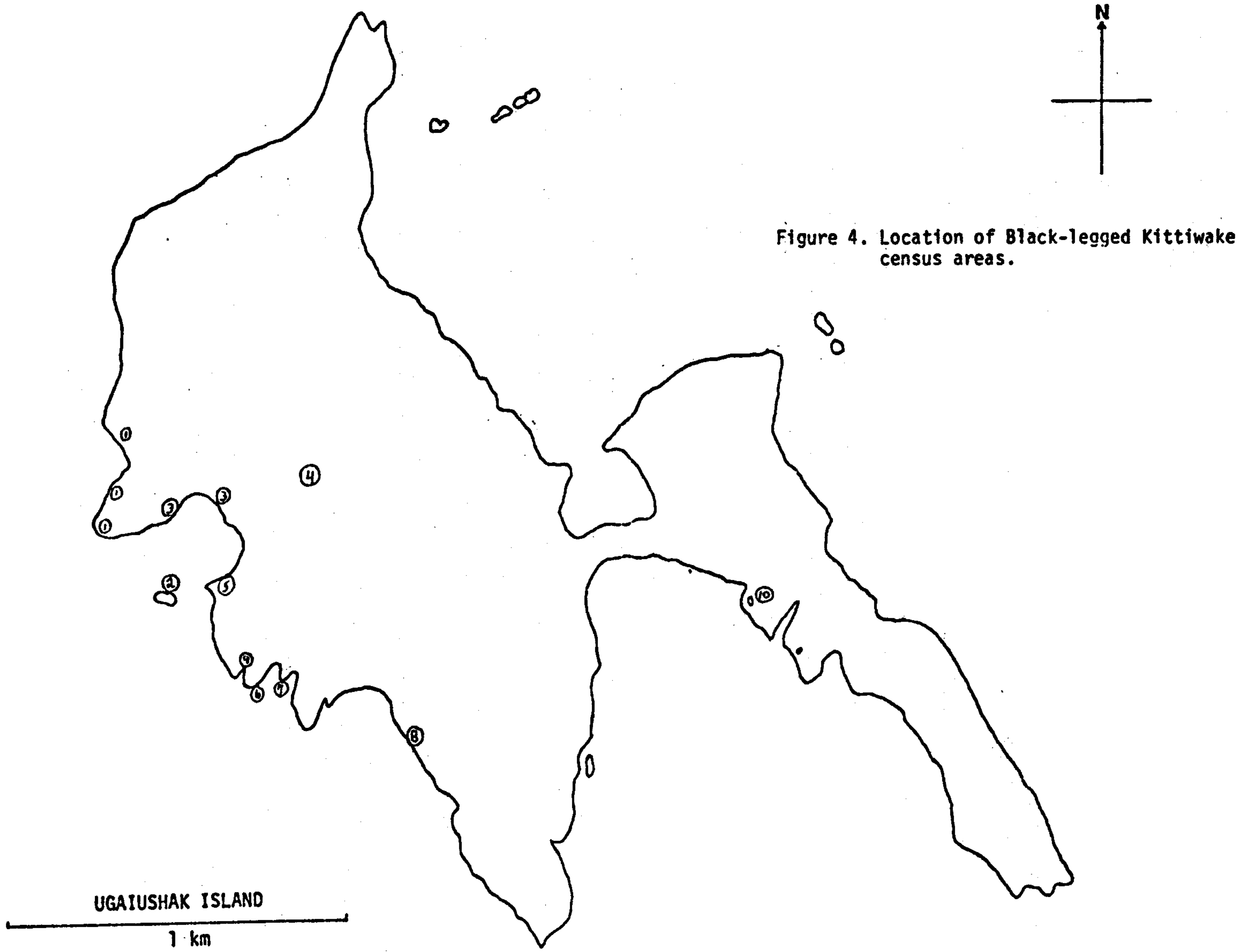


Figure 4. Location of Black-legged Kittiwake census areas.

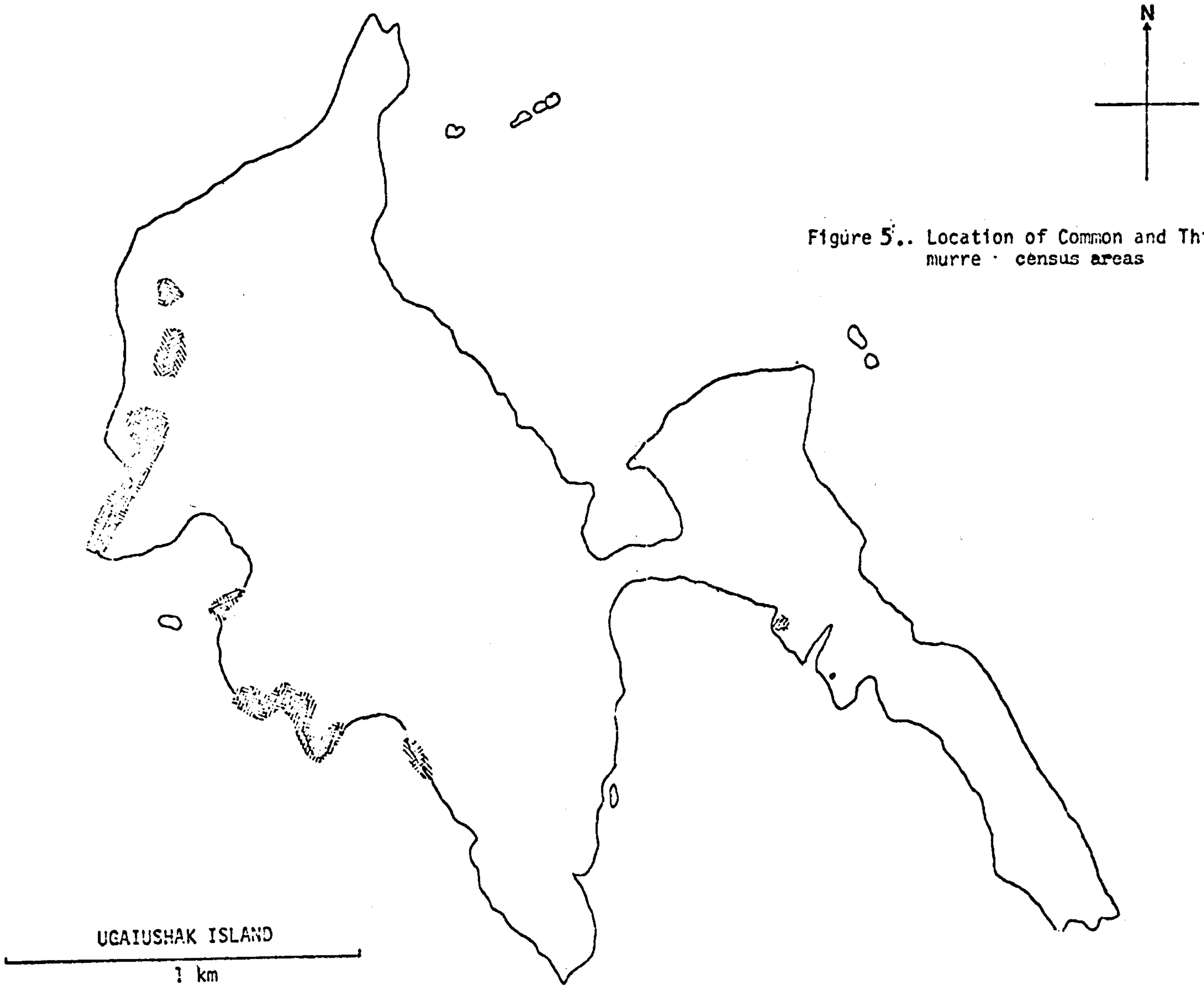


Figure 5.. Location of Common and Thick-billed murre census areas

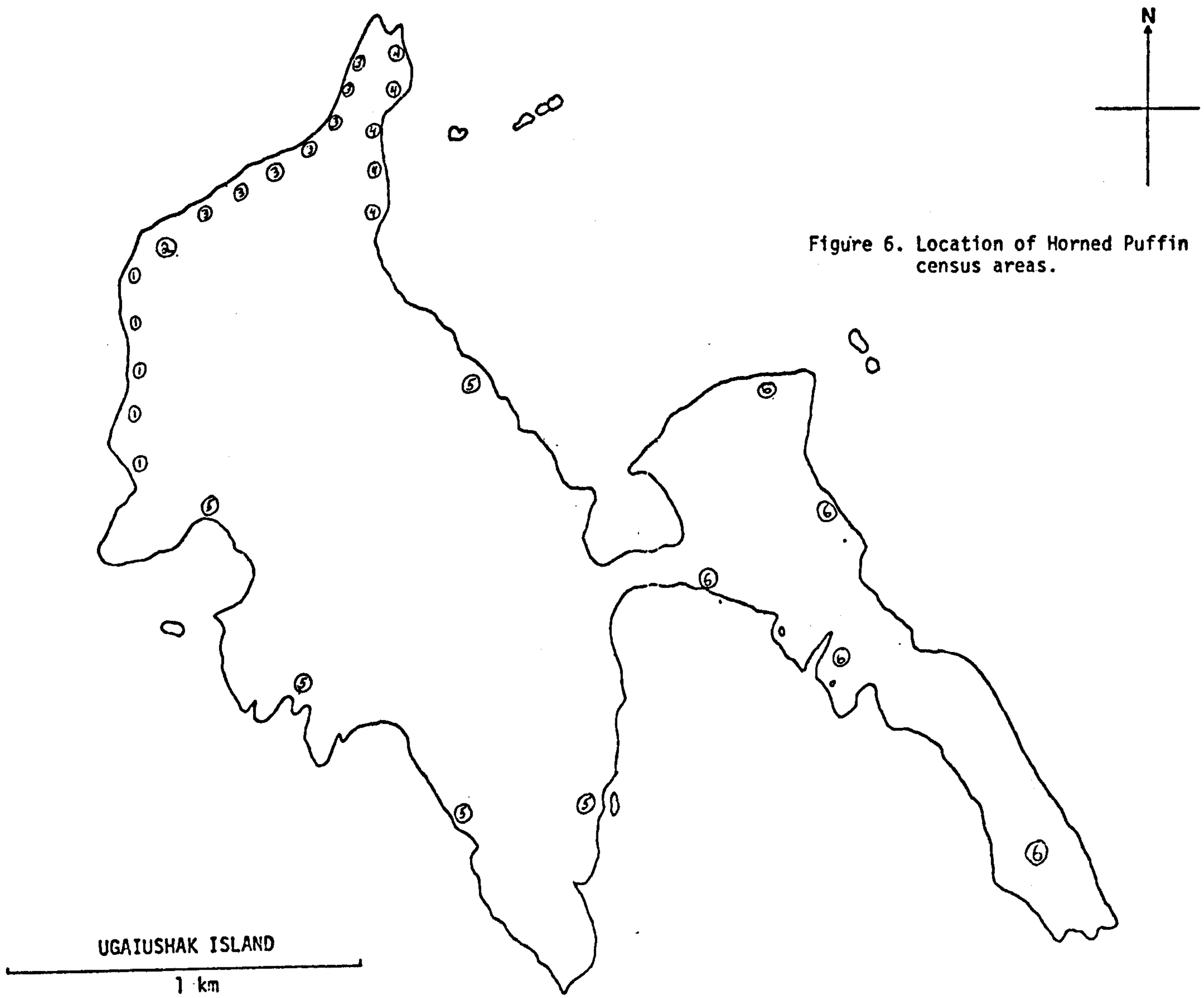


Figure 6. Location of Horned Puffin census areas.

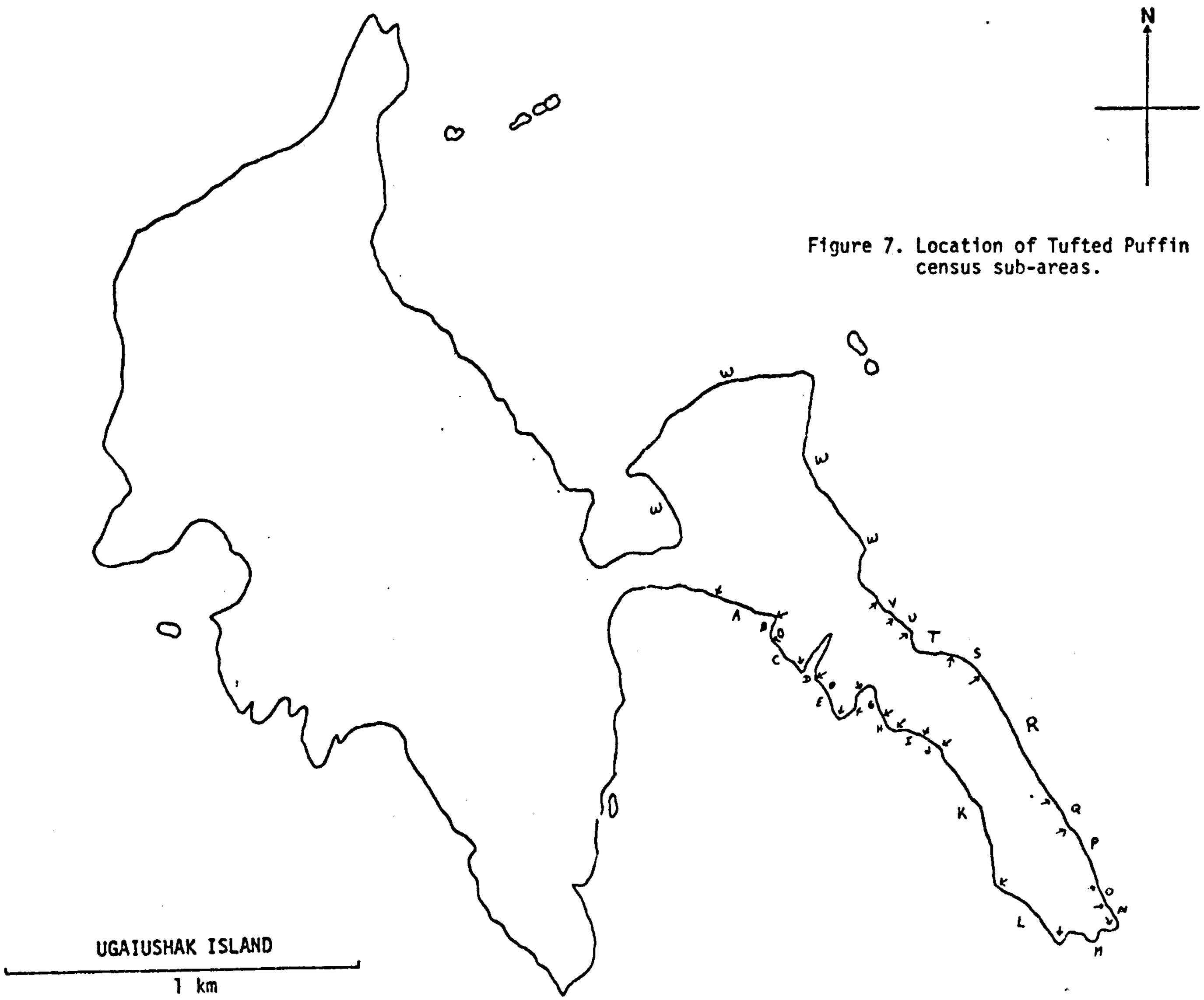


Figure 7. Location of Tufted Puffin census sub-areas.

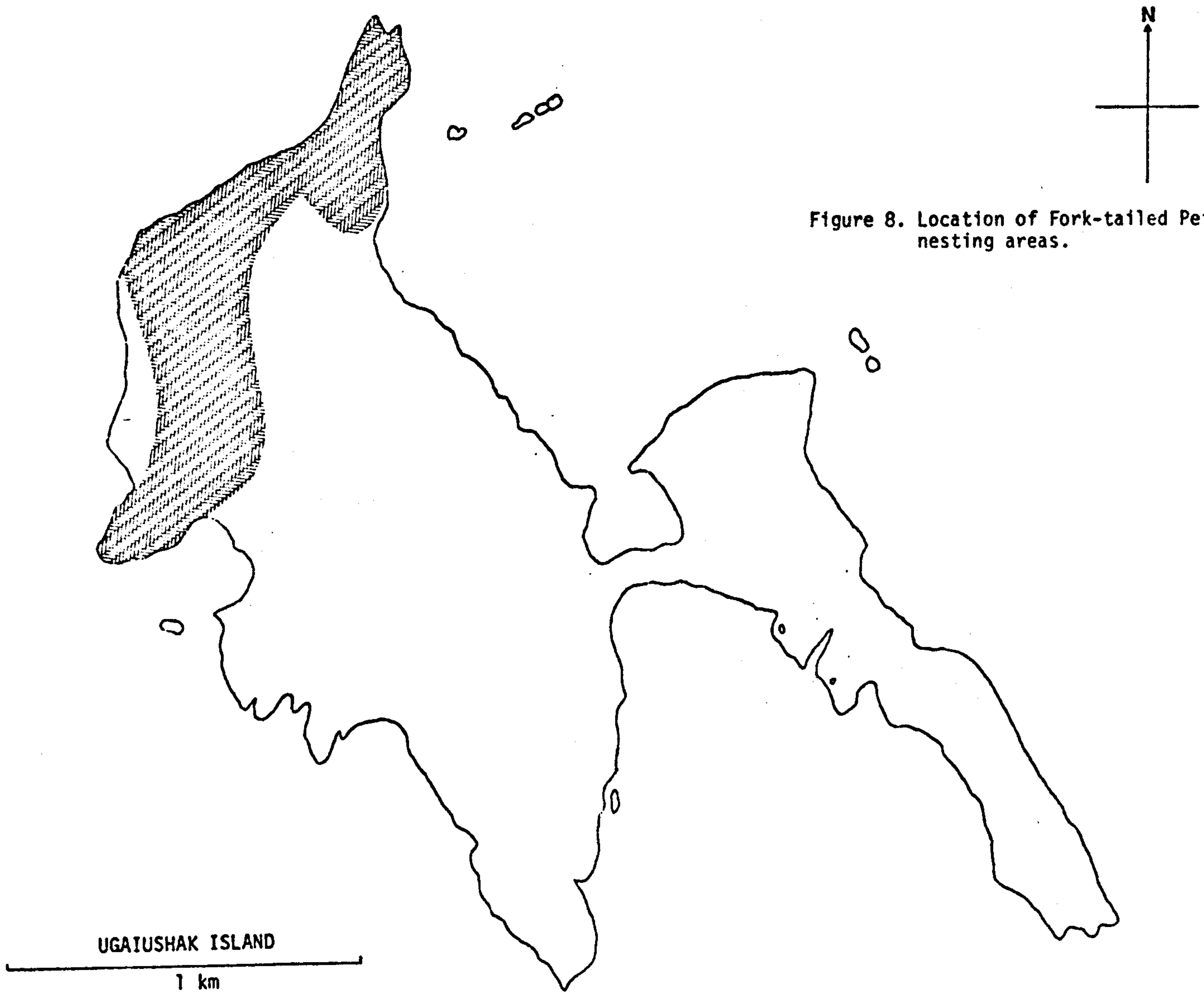


Figure 8. Location of Fork-tailed Petrel nesting areas.

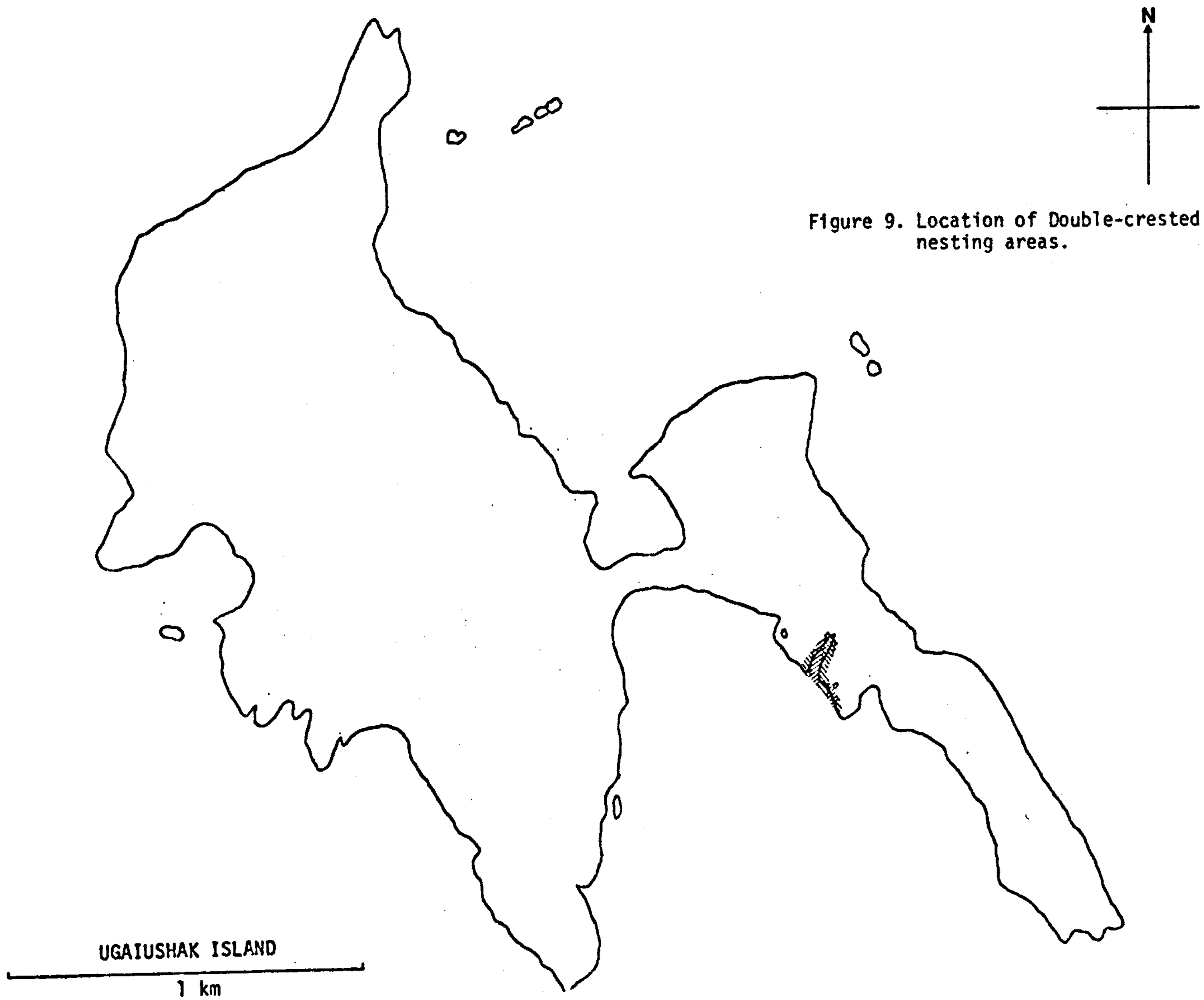


Figure 9. Location of Double-crested Cormorant nesting areas.

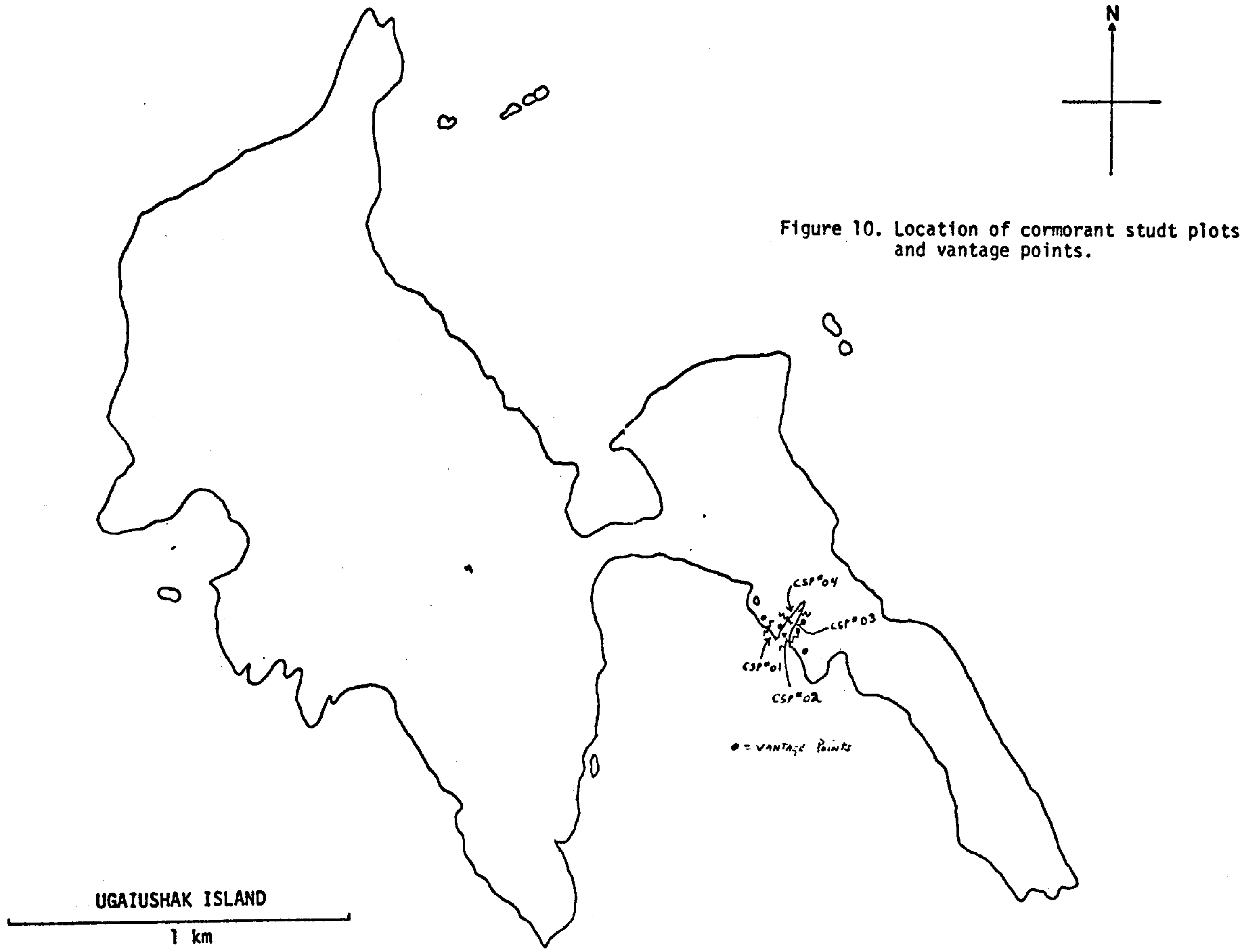


Figure 10. Location of cormorant studt plots and vantage points.

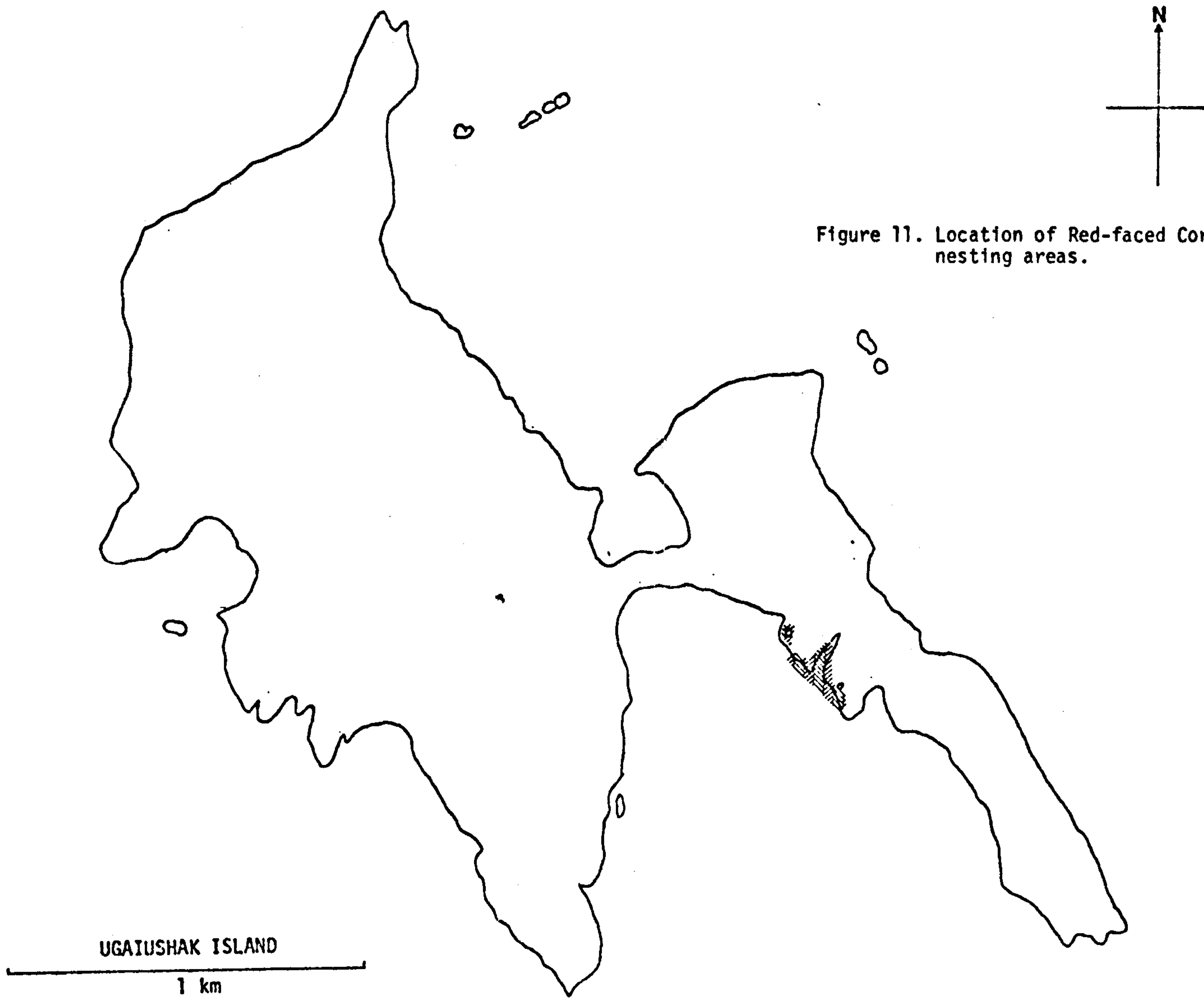


Figure 11. Location of Red-faced Cormorant nesting areas.

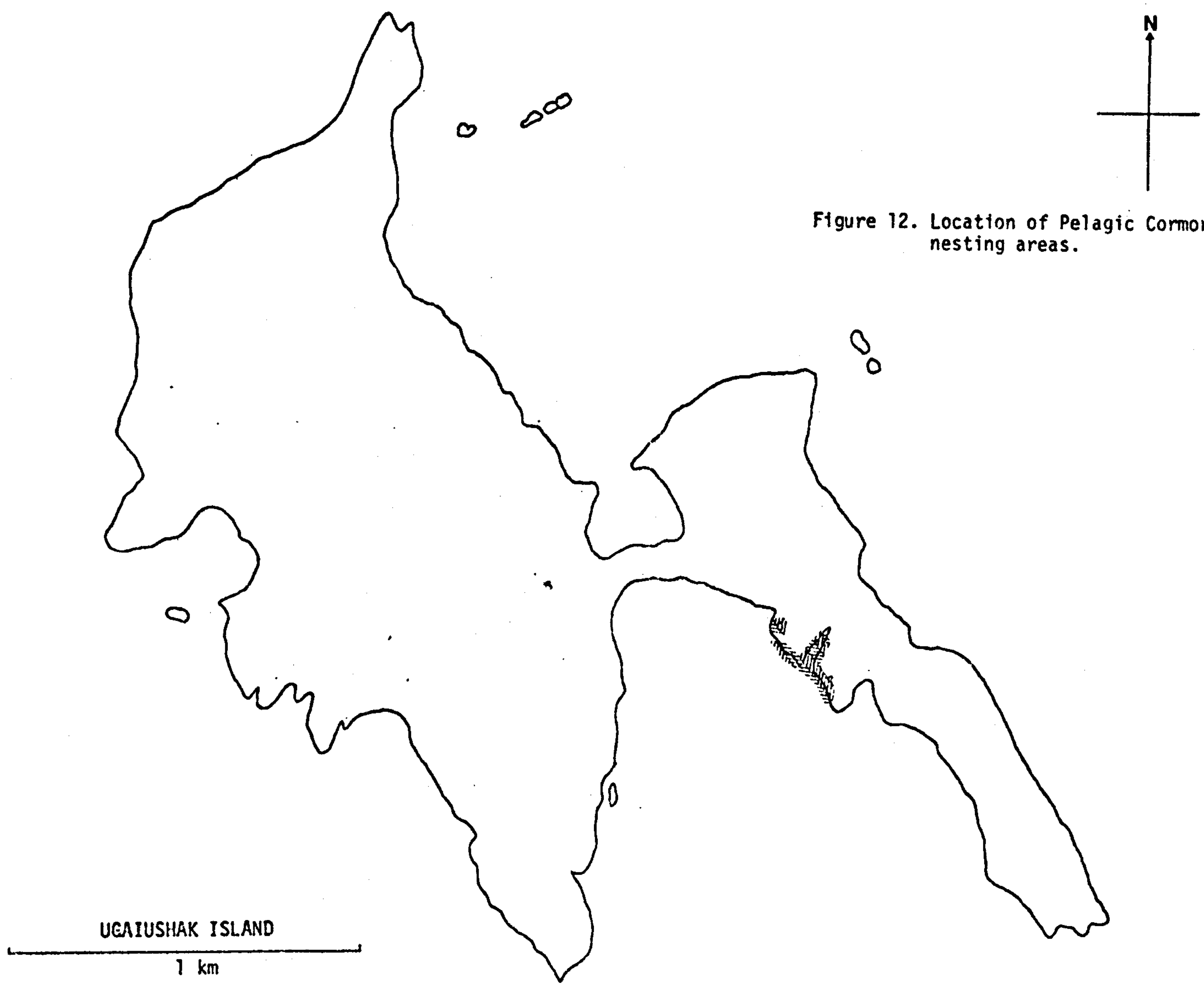


Figure 12. Location of Pelagic Cormorant nesting areas.

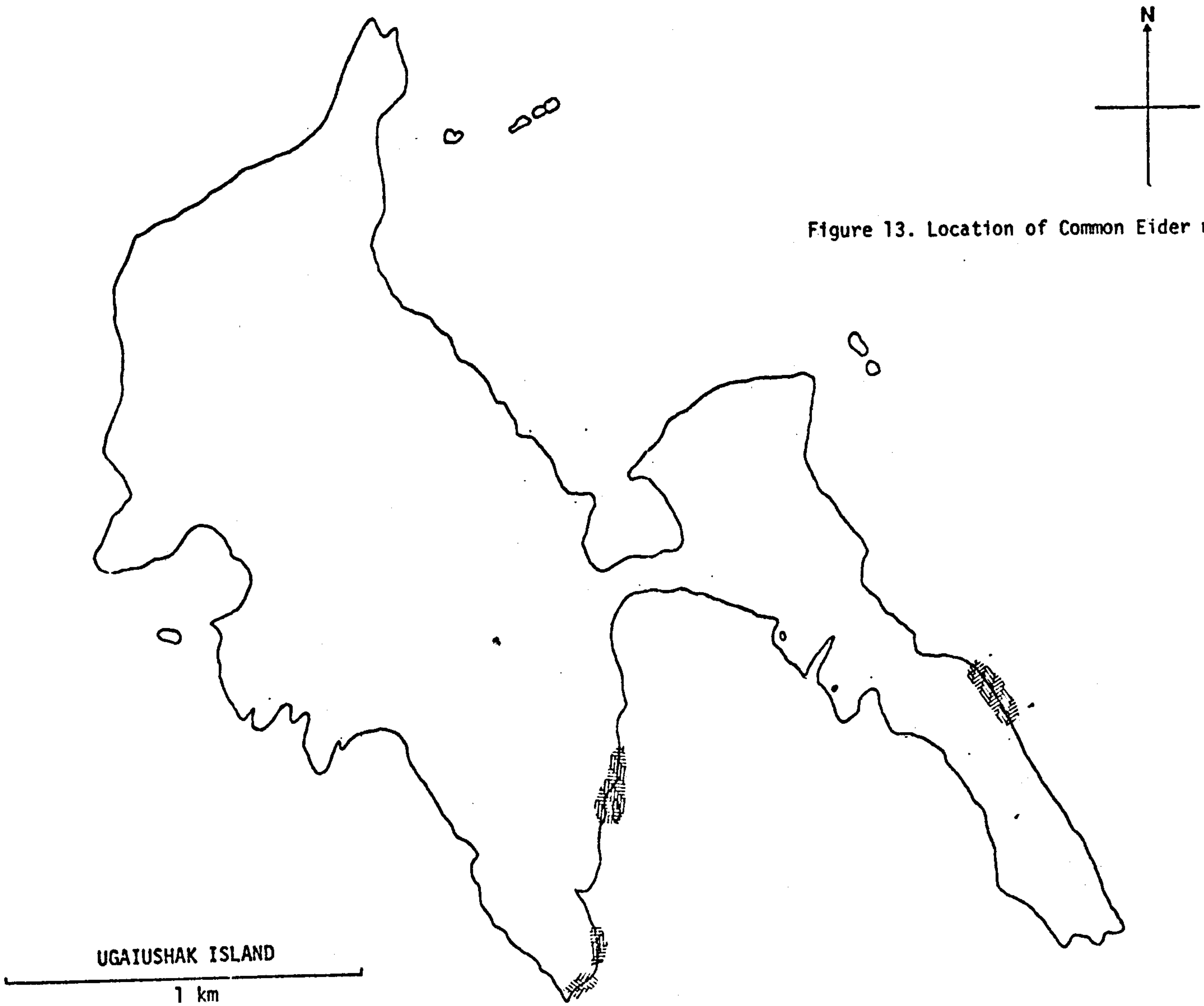


Figure 13. Location of Common Eider nesting areas.

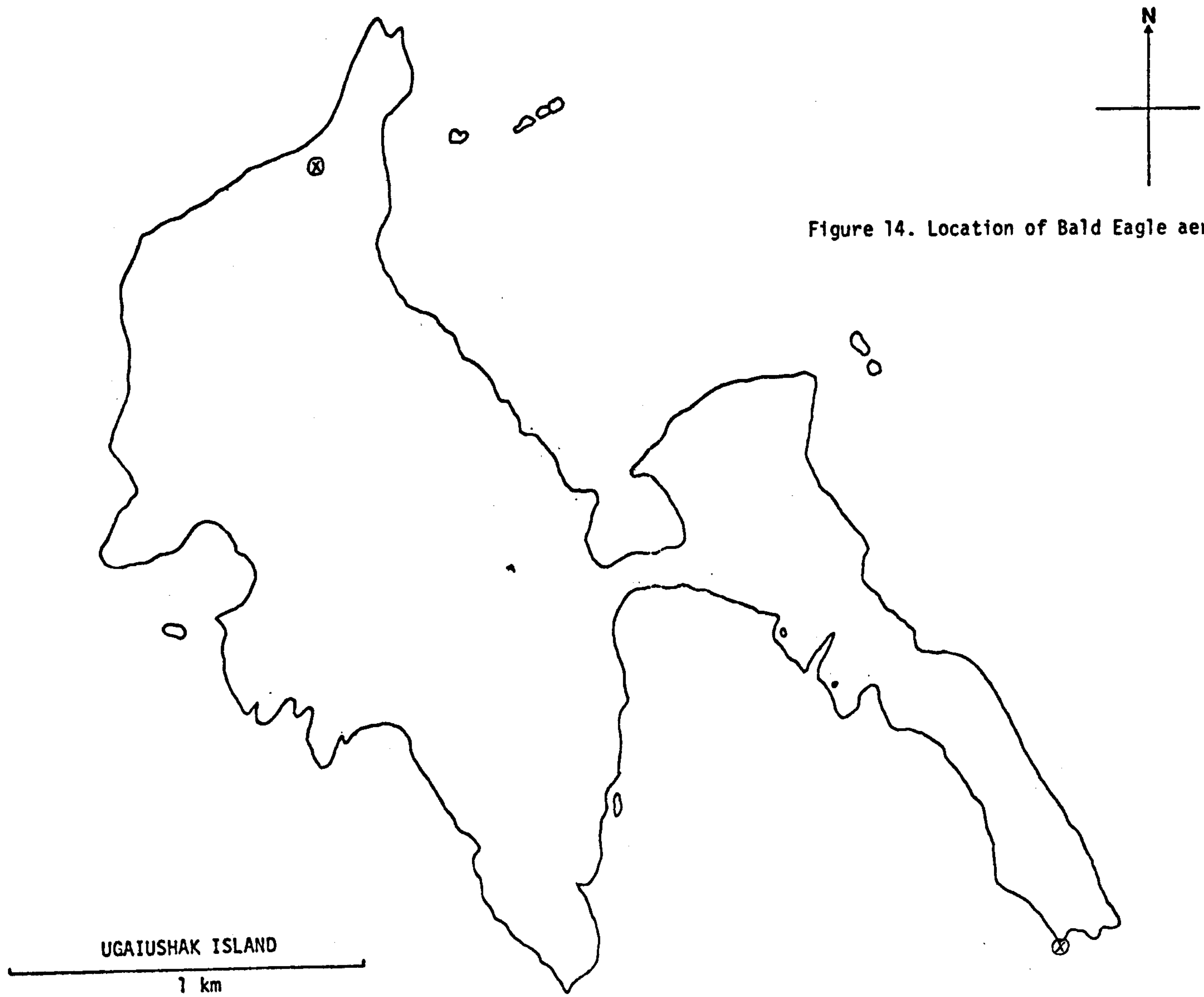


Figure 14. Location of Bald Eagle aeries.

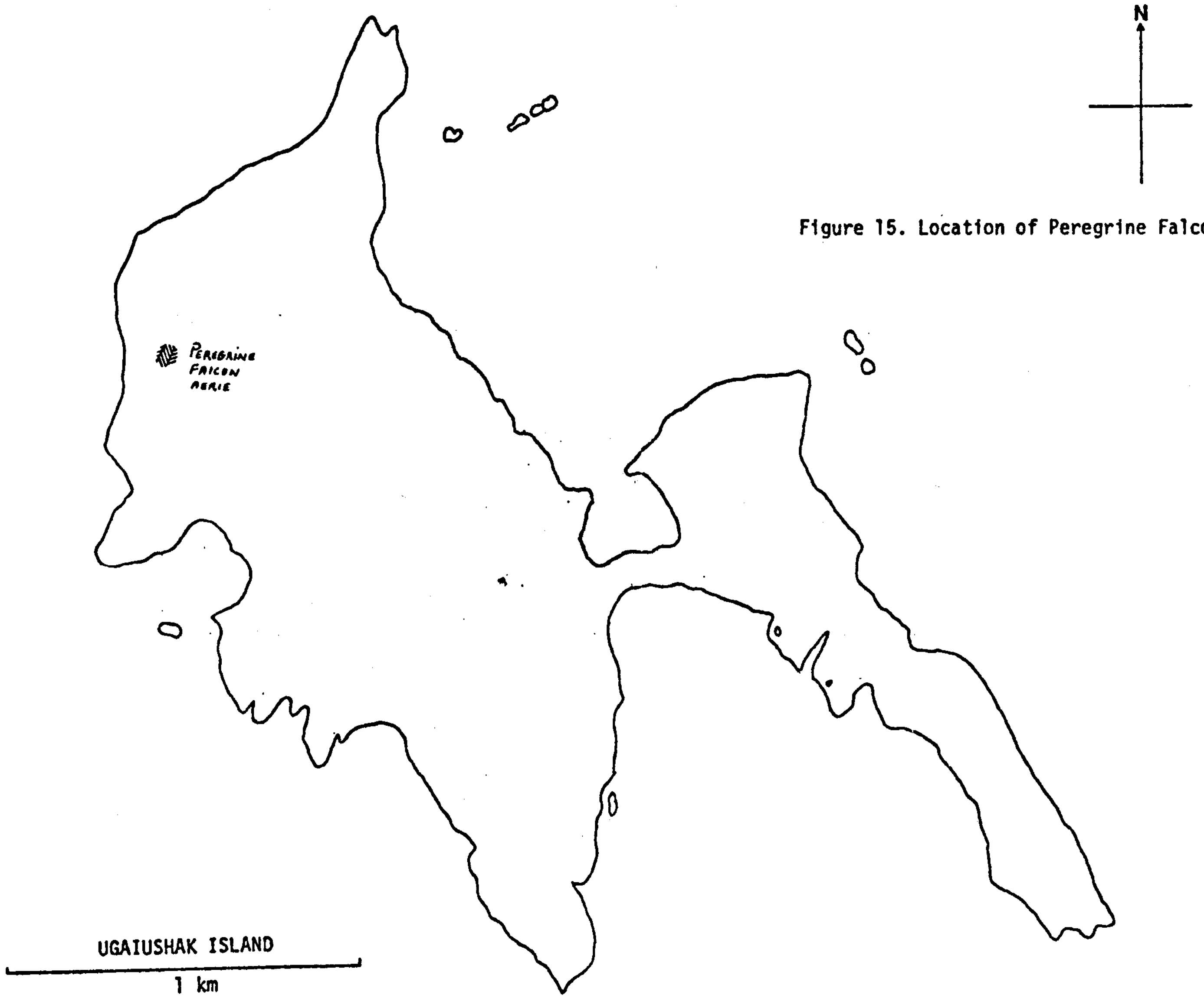


Figure 15. Location of Peregrine Falcon aerie.

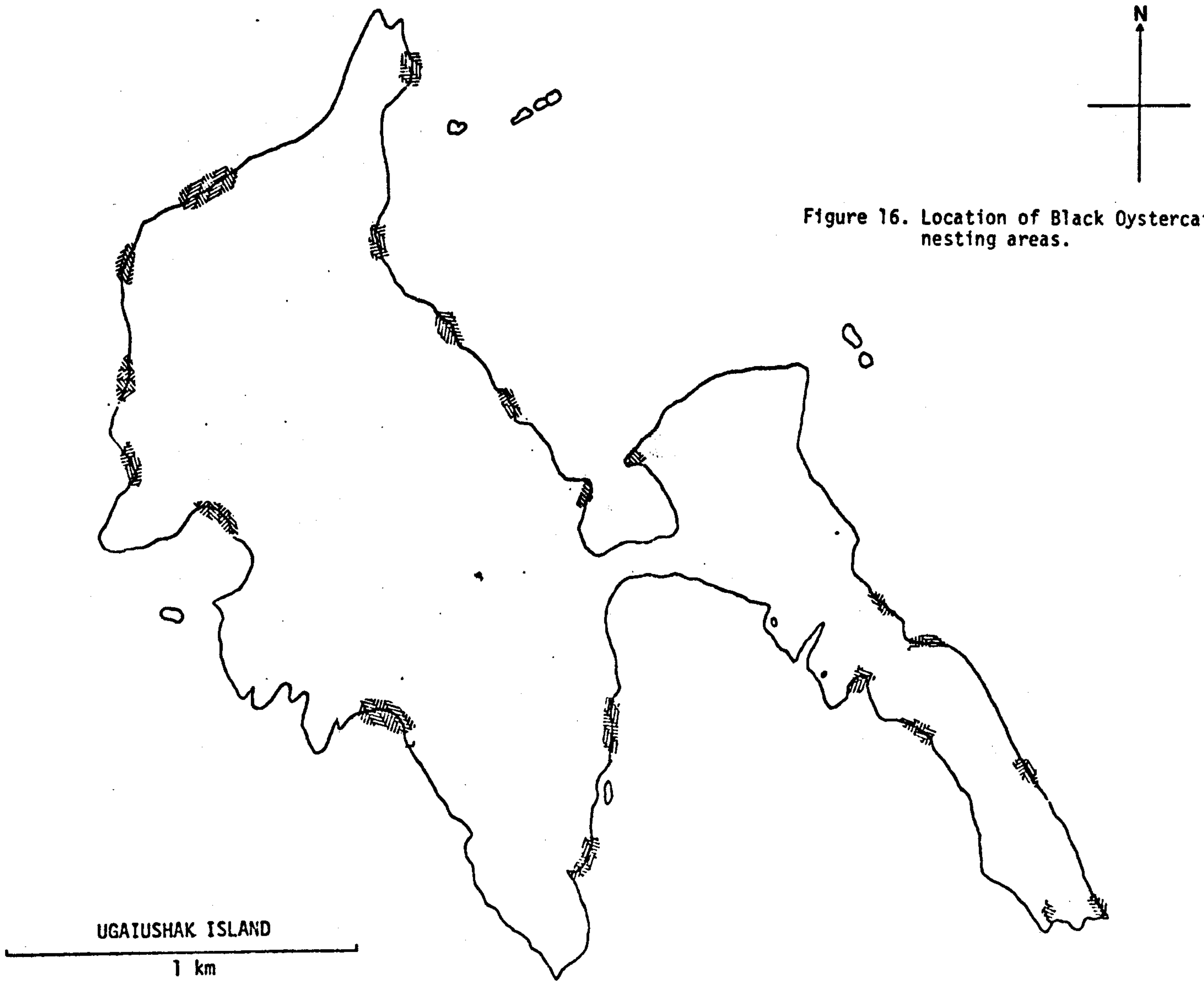


Figure 16. Location of Black Oystercatcher nesting areas.

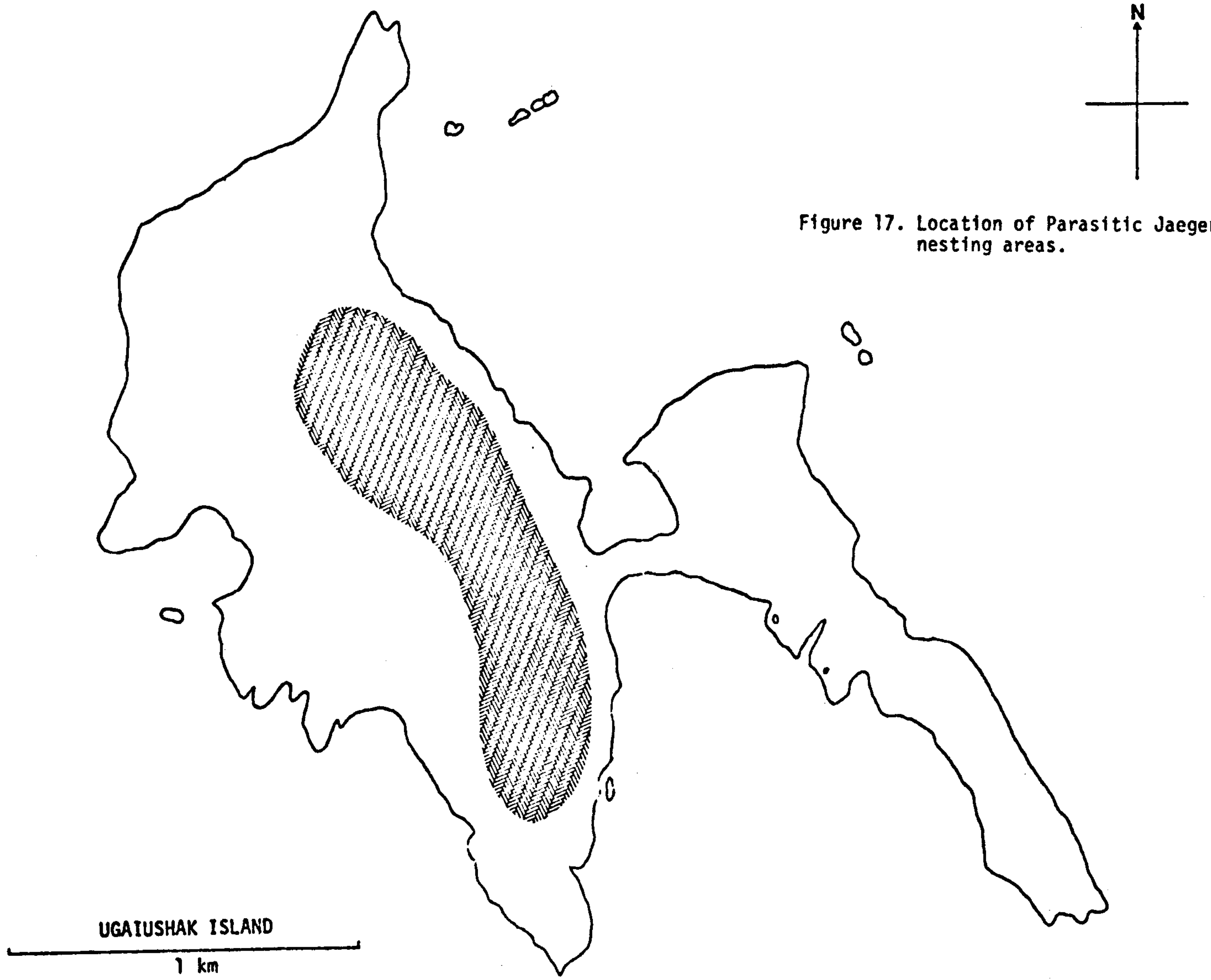


Figure 17. Location of Parasitic Jaeger nesting areas.

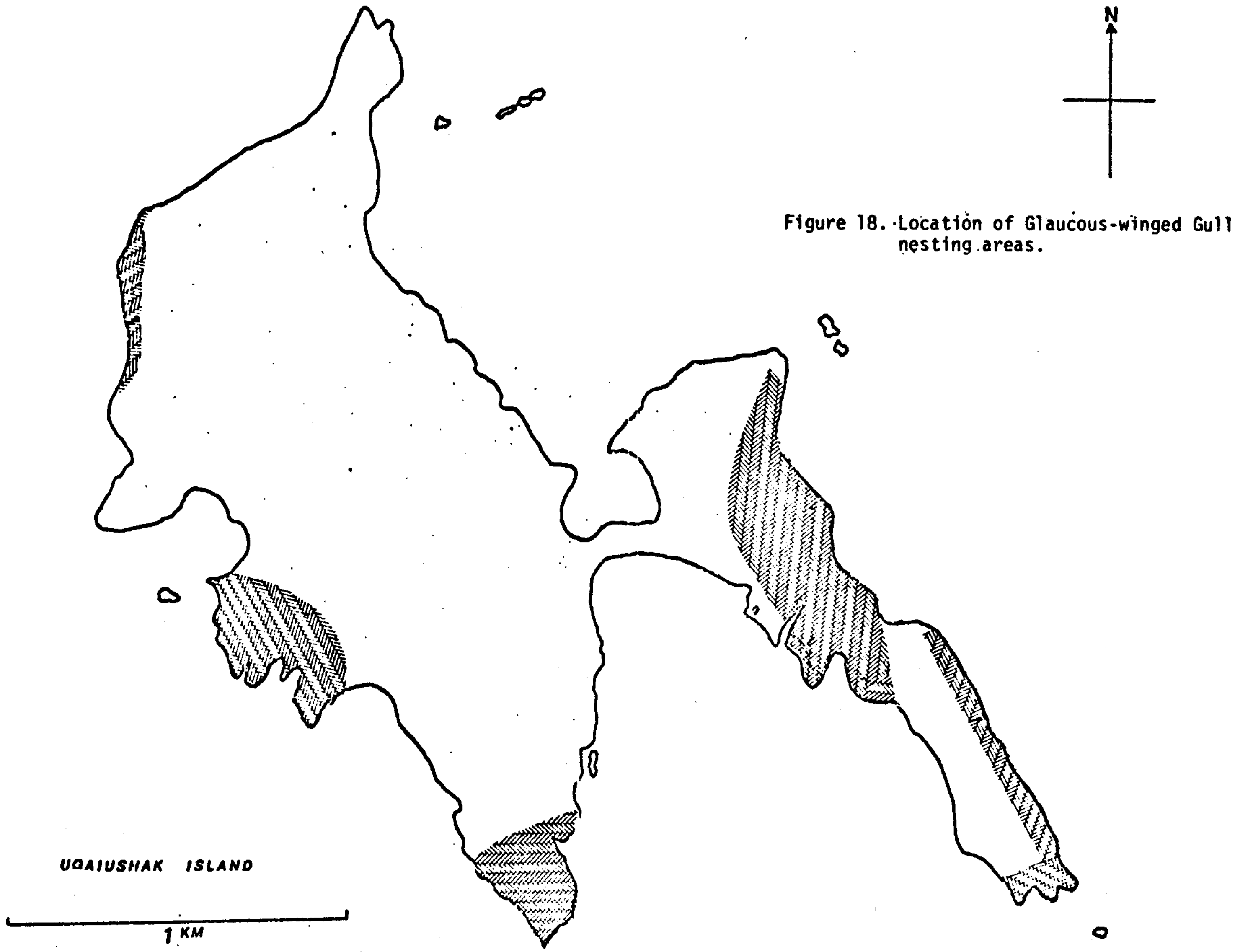


Figure 18. Location of Glaucous-winged Gull nesting areas.

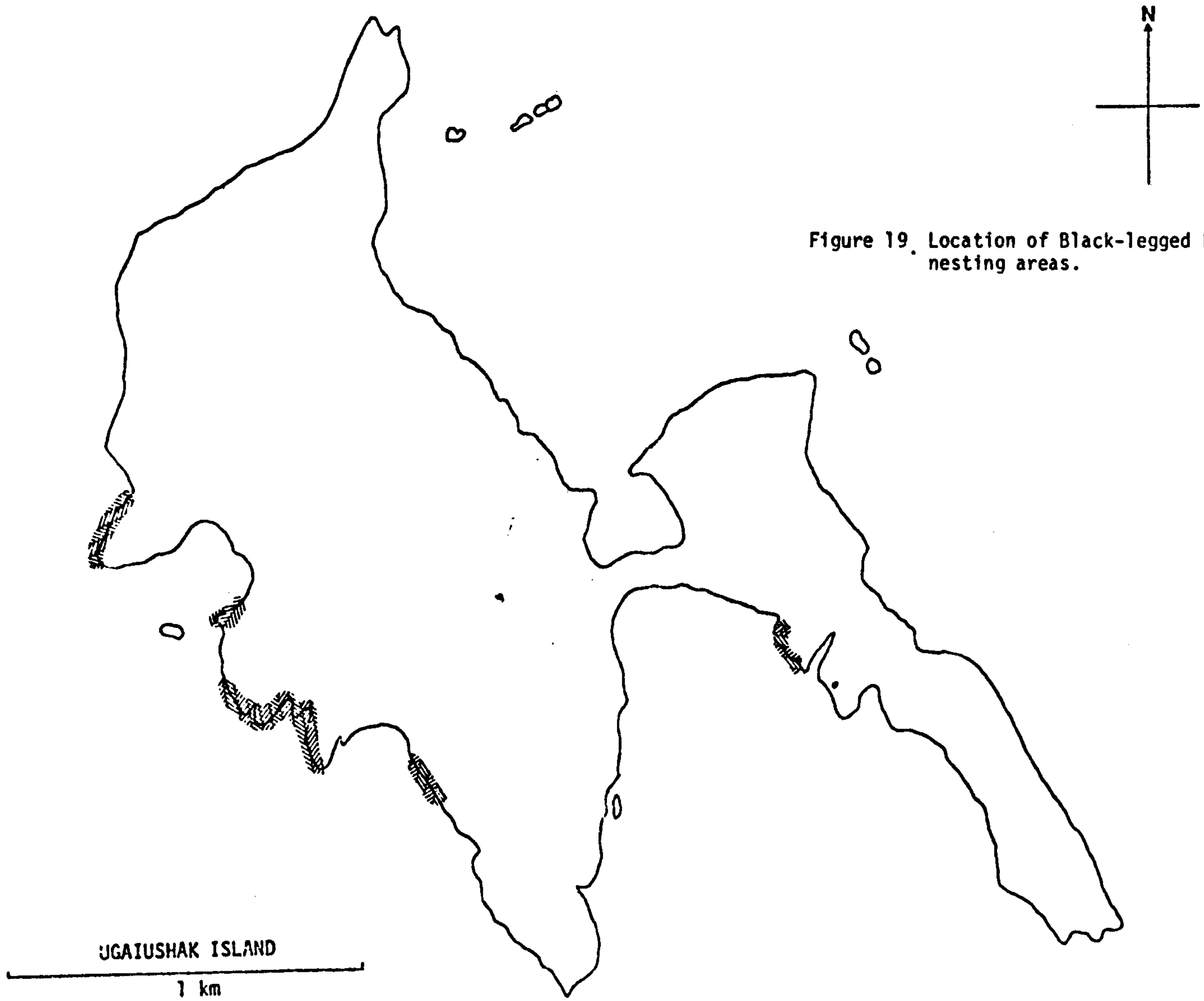


Figure 19. Location of Black-legged Kittiwake nesting areas.

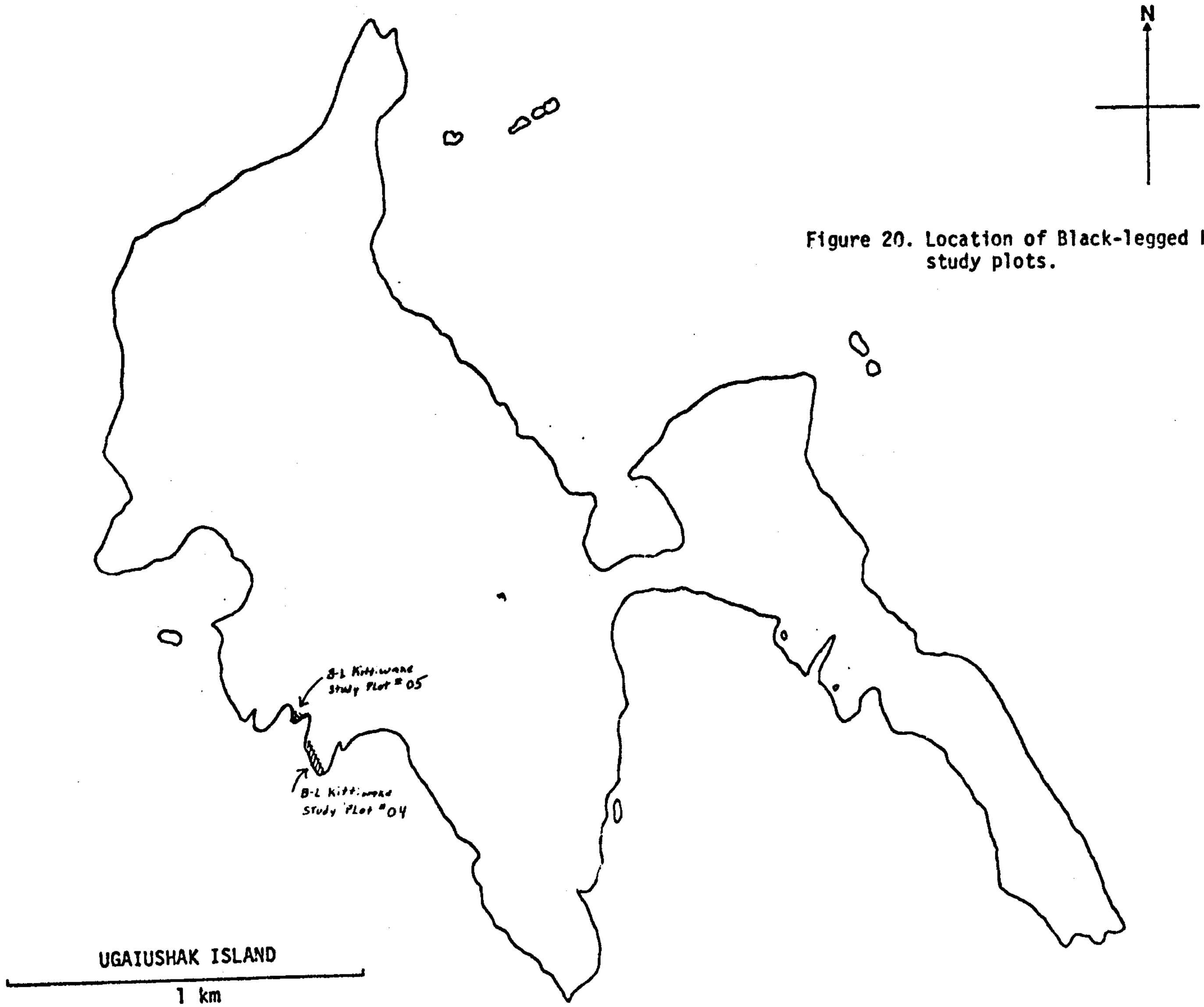
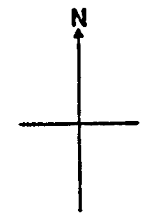


Figure 20. Location of Black-legged Kittiwake study plots.



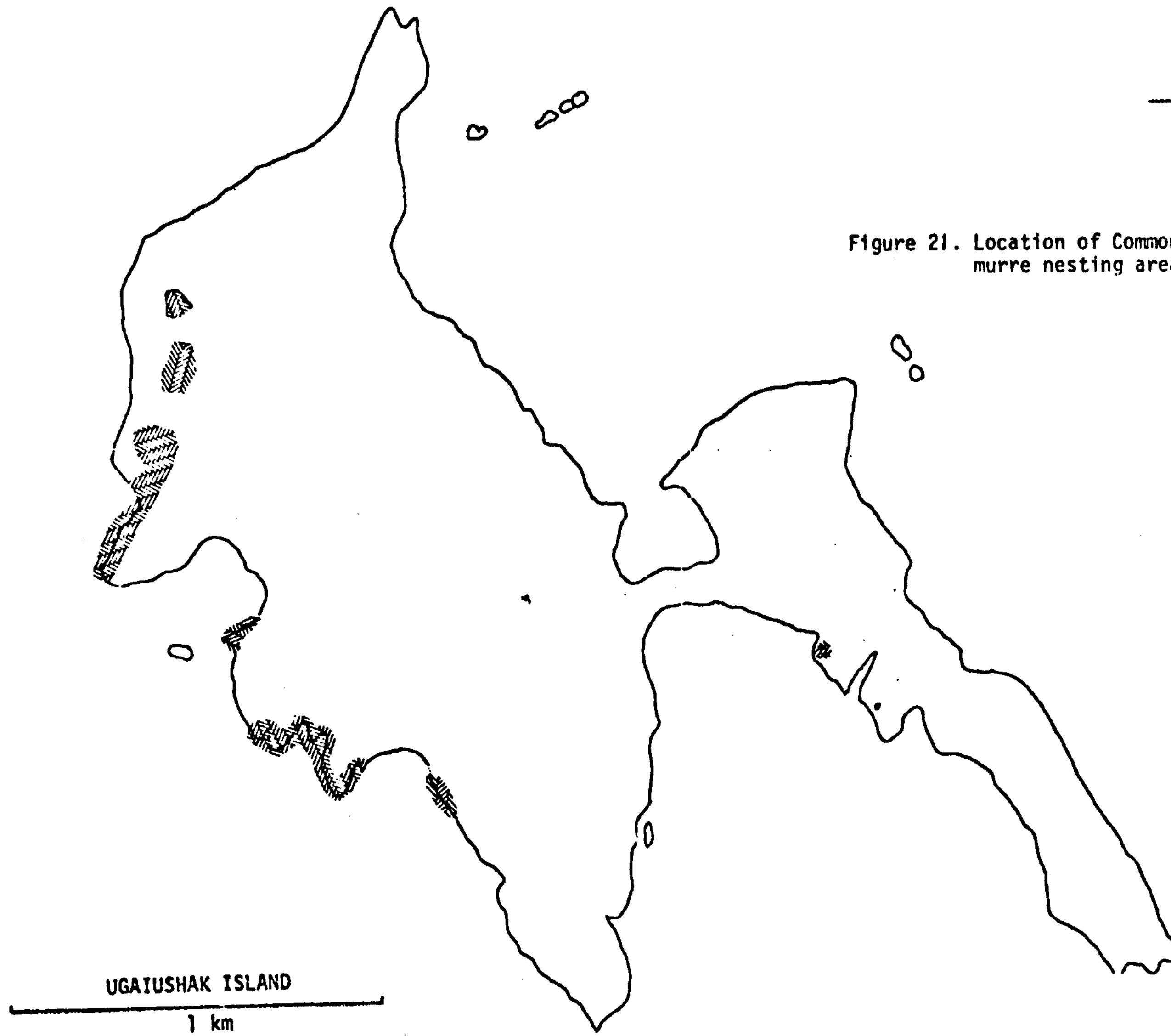


Figure 21. Location of Common and Thick-billed murre nesting areas (cliffs only).

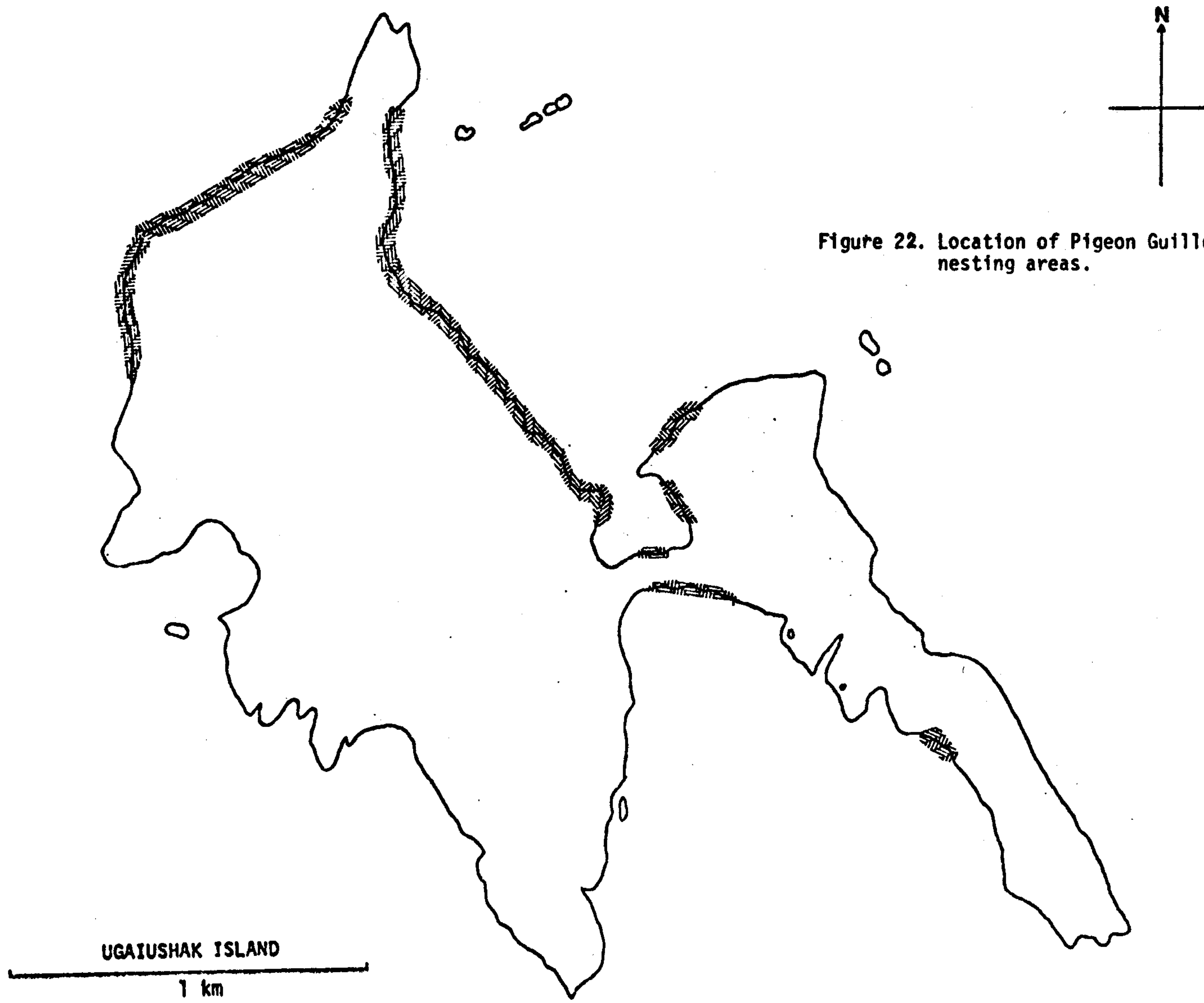


Figure 22. Location of Pigeon Guillemot nesting areas.

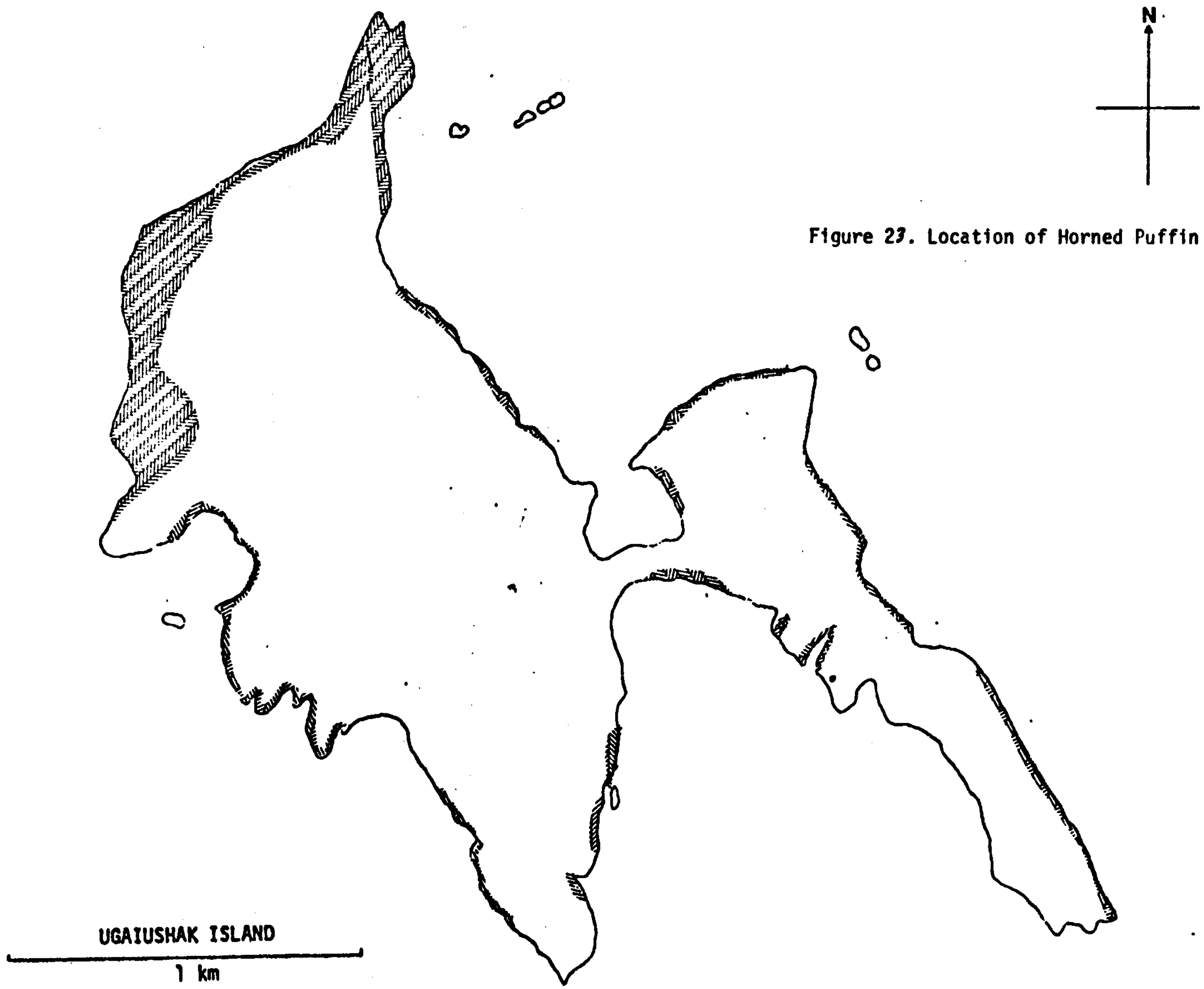


Figure 23. Location of Horned Puffin nesting areas.

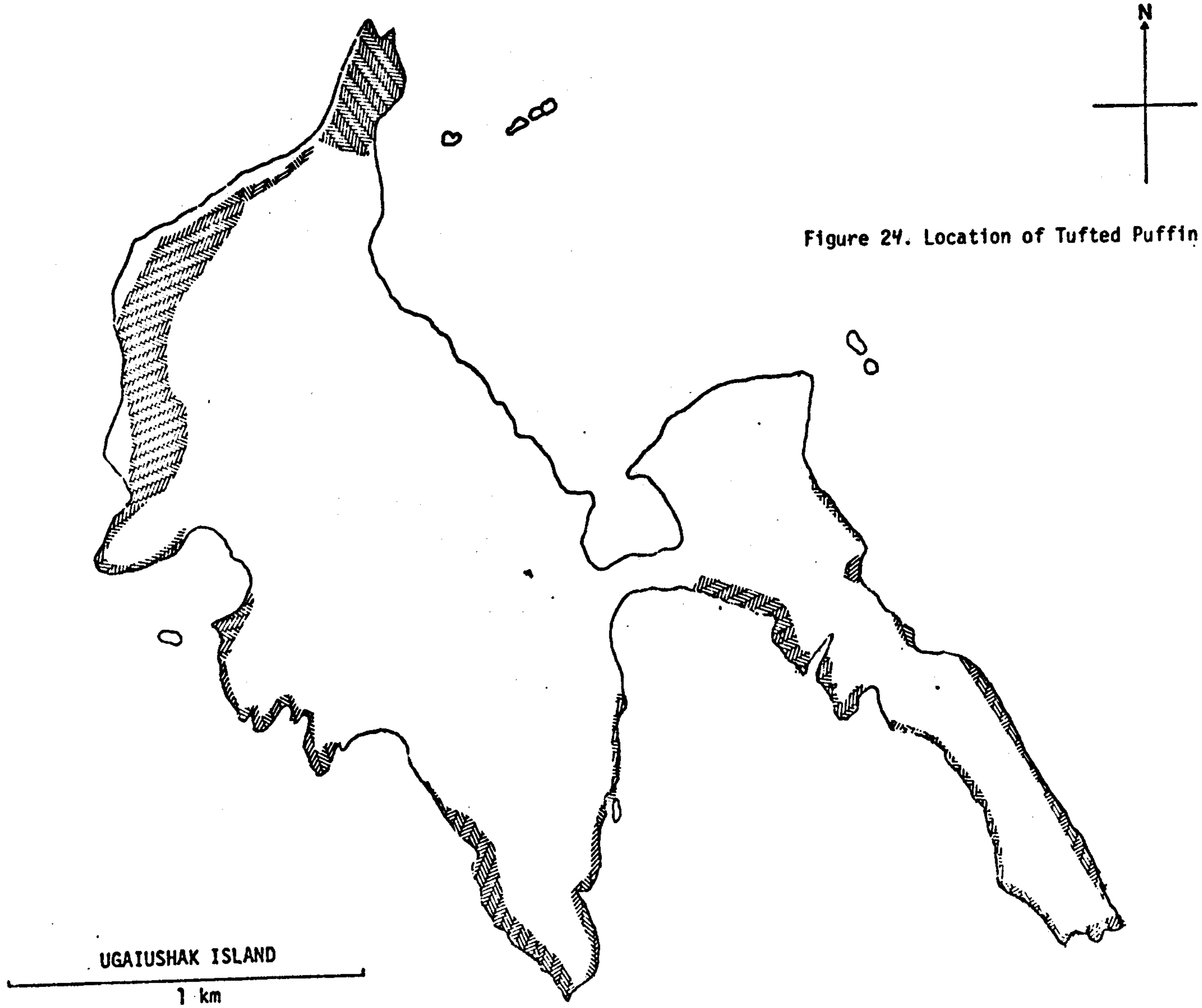


Figure 24. Location of Tufted Puffin nesting areas.

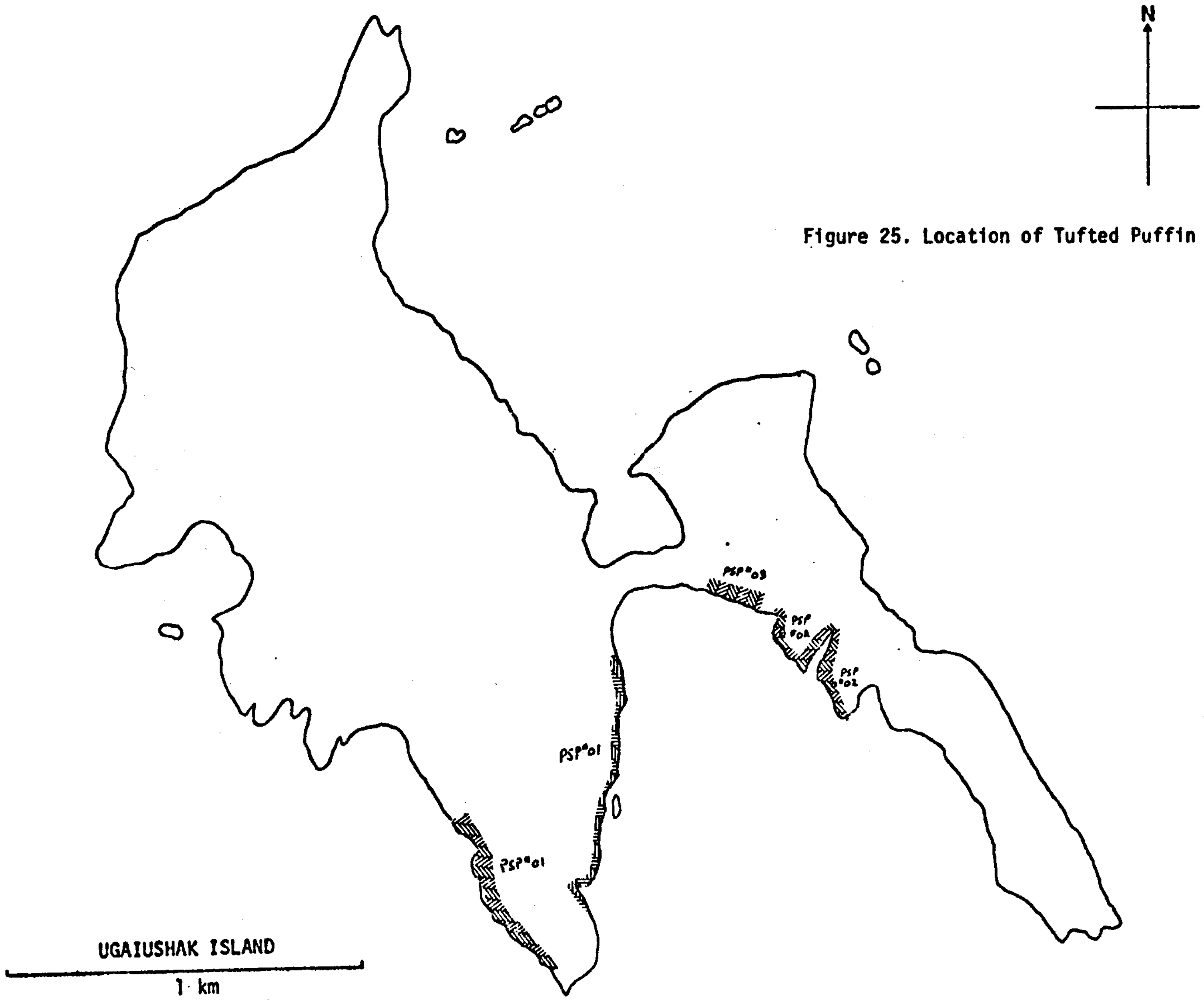


Figure 25. Location of Tufted Puffin study plots.

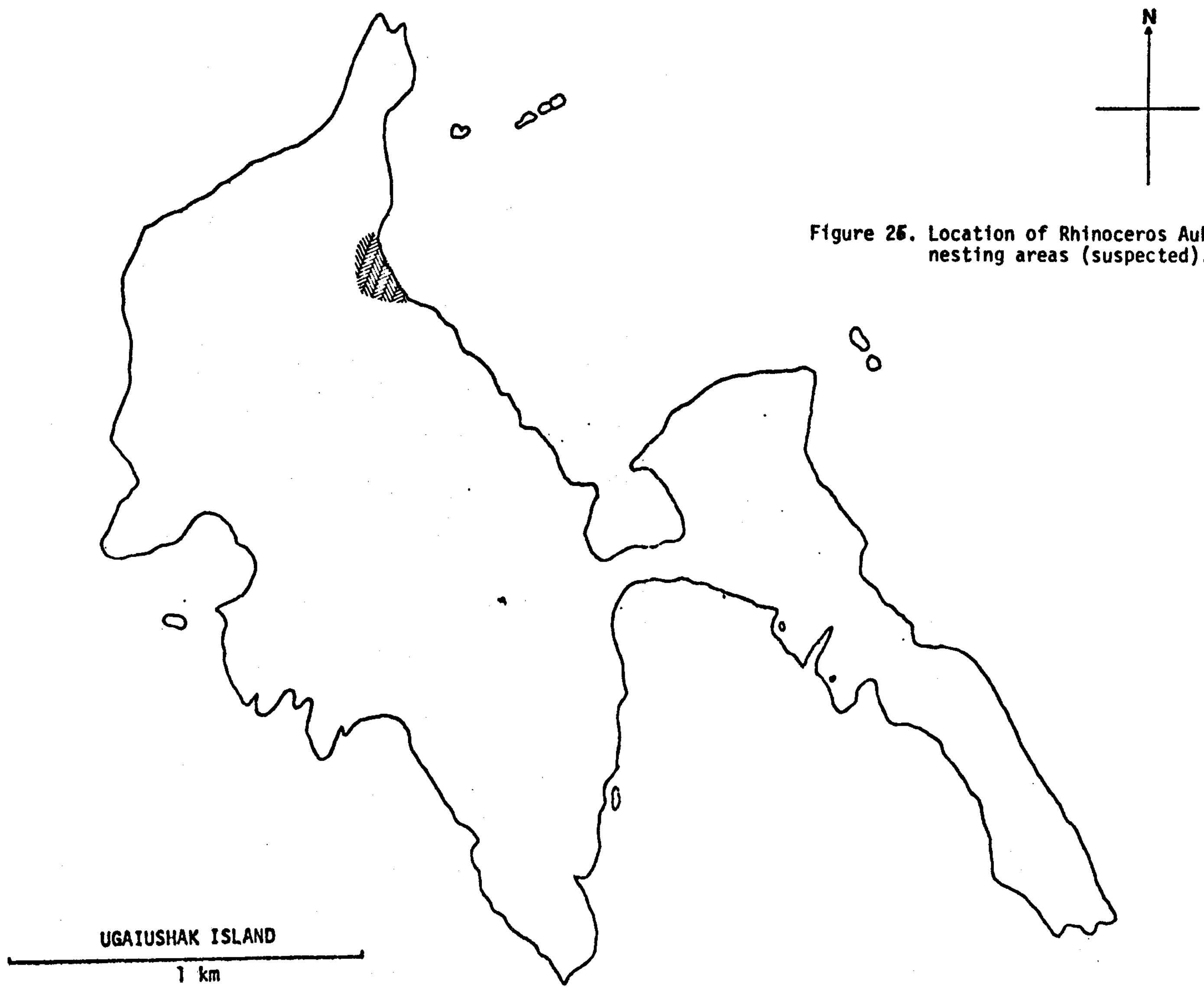


Figure 25. Location of Rhinoceros Auklet nesting areas (suspected).

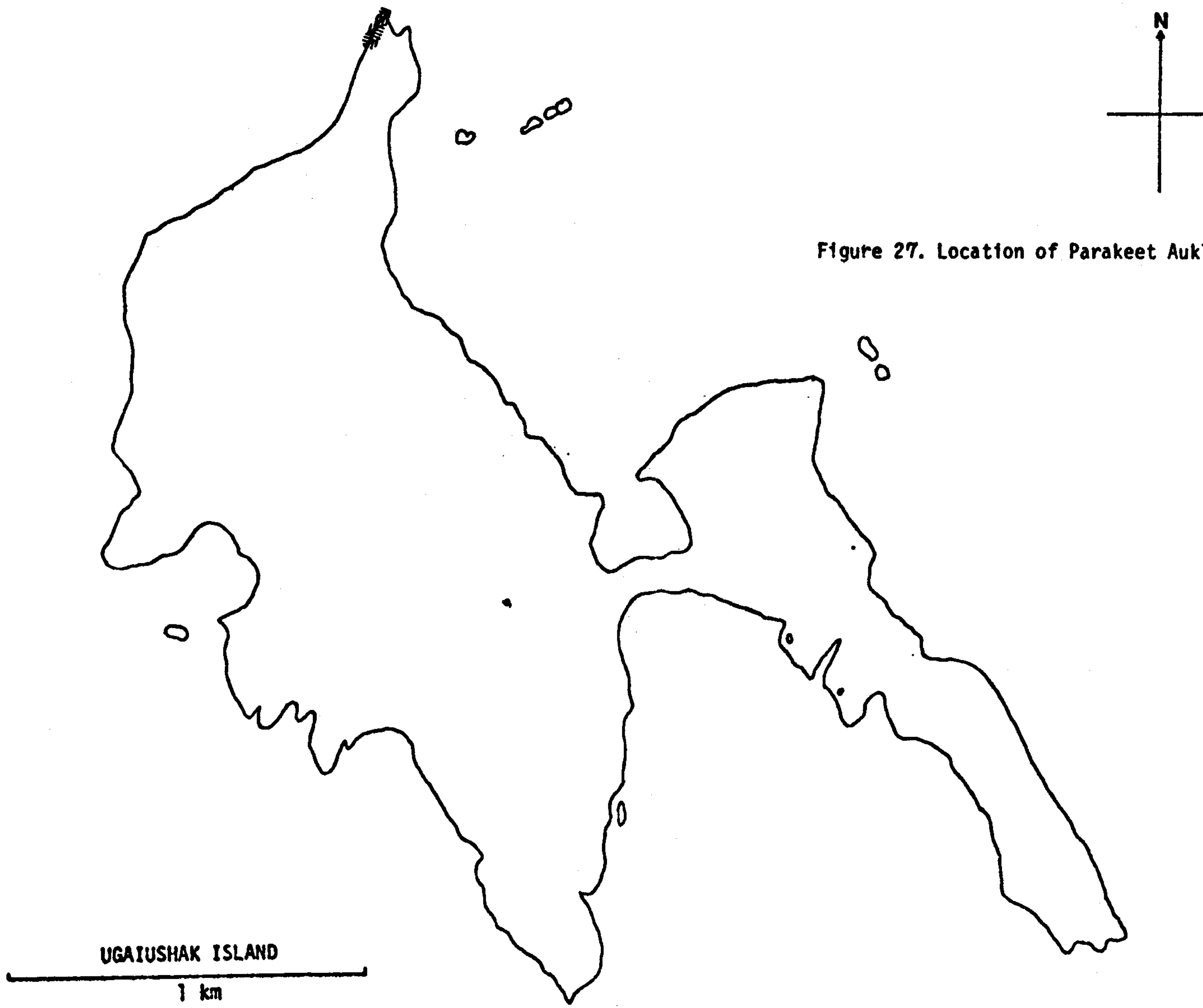


Figure 27. Location of Parakeet Auklet nesting areas

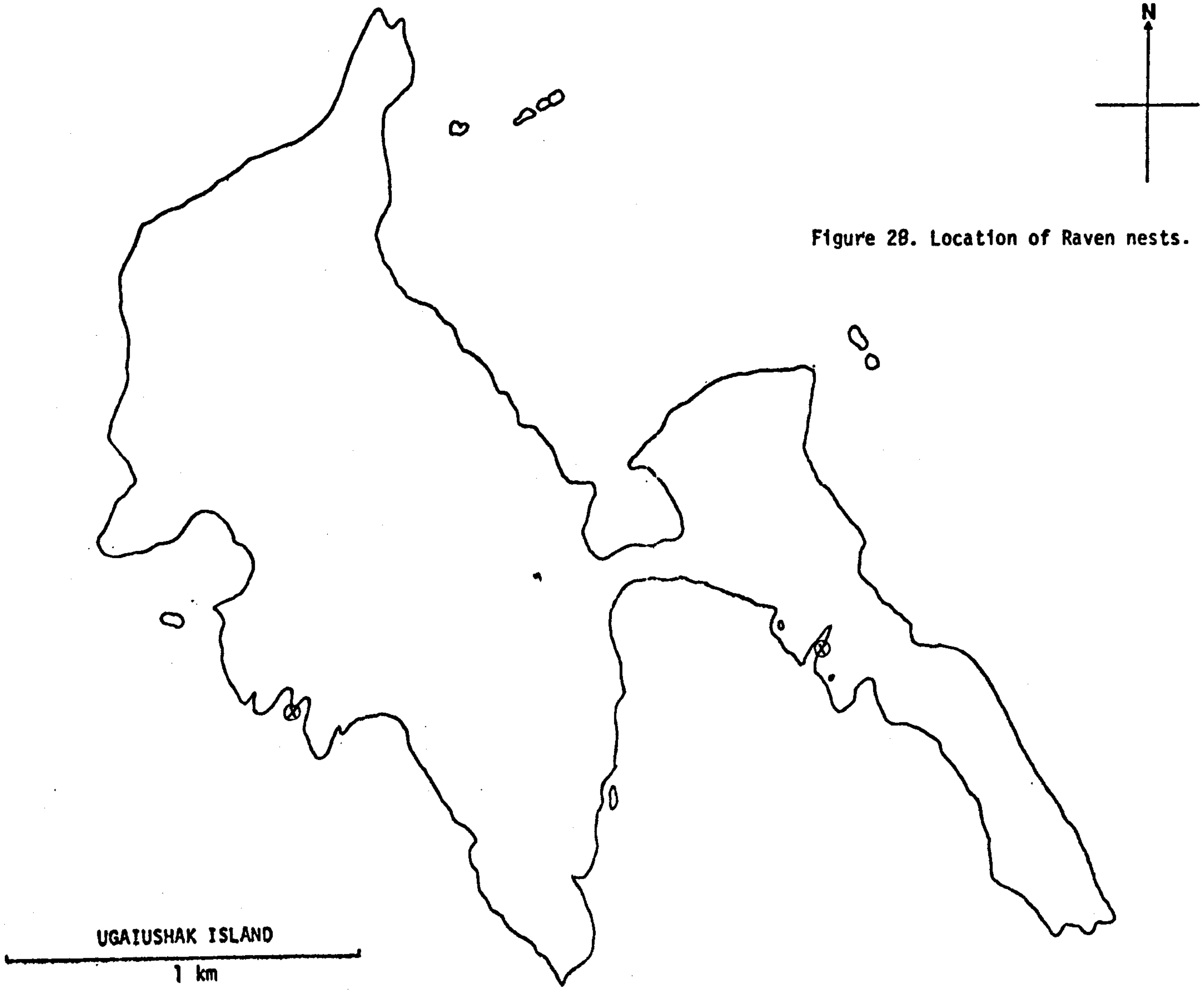


Figure 28. Location of Raven nests.

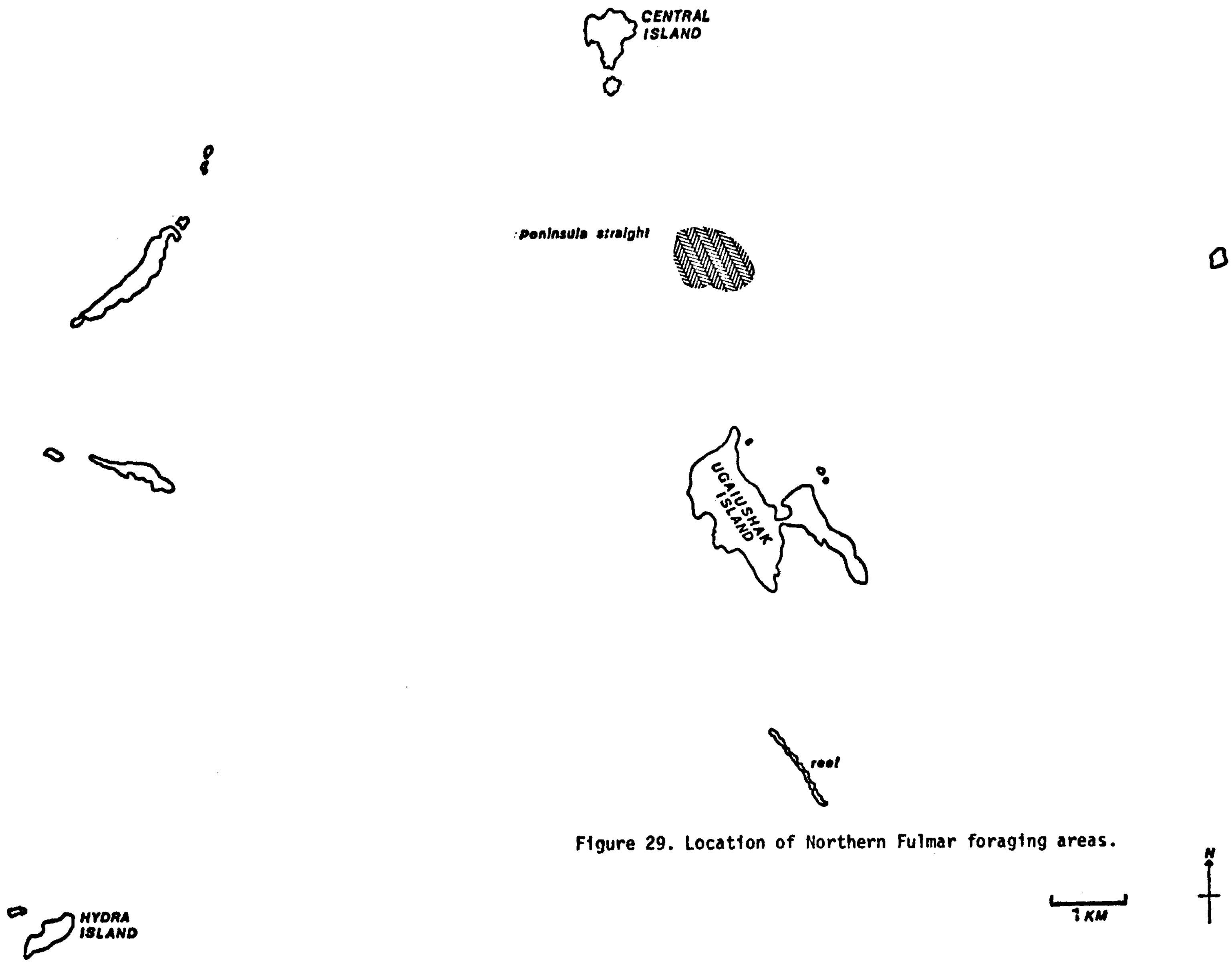


Figure 29. Location of Northern Fulmar foraging areas.

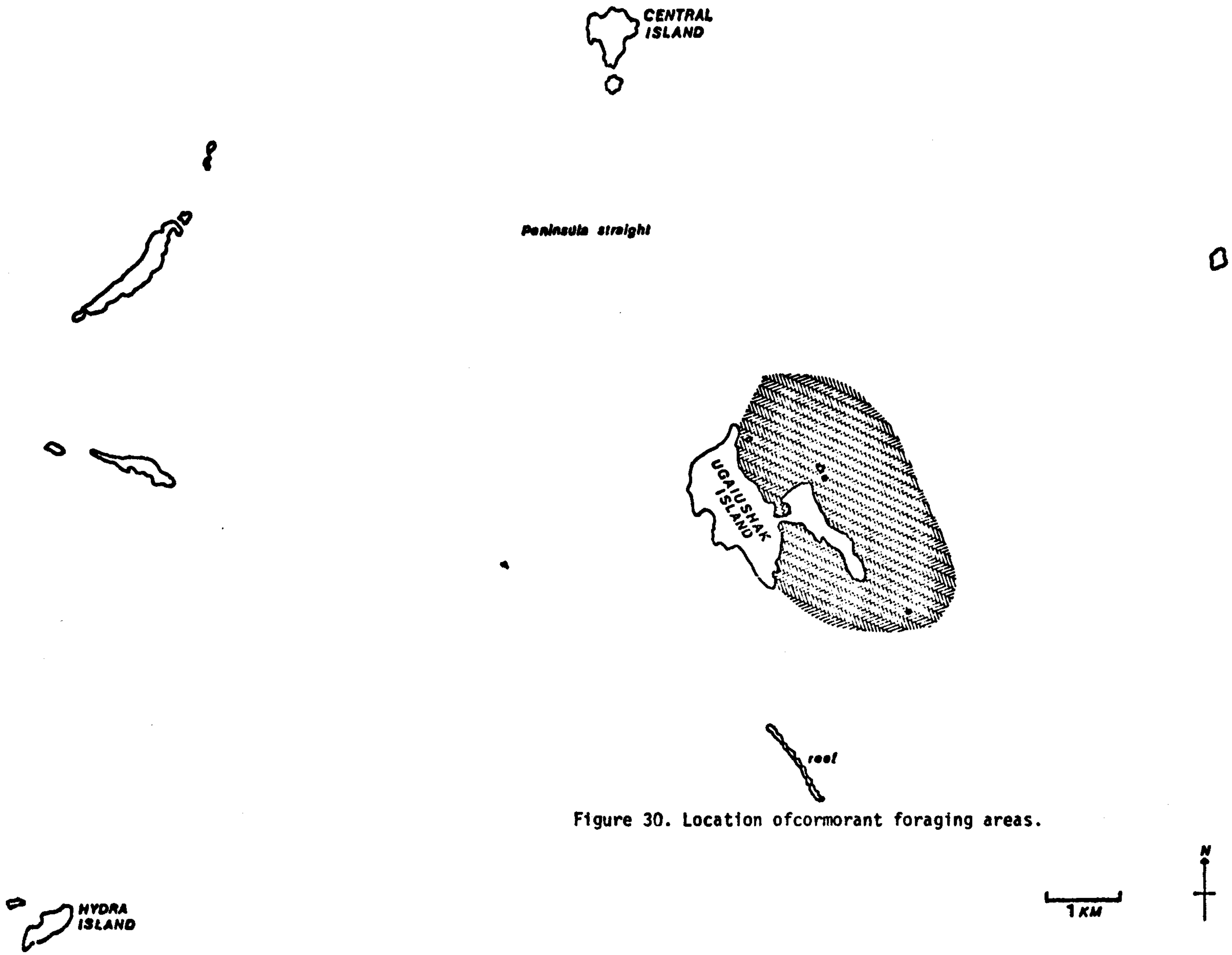


Figure 30. Location ofcormorant foraging areas.

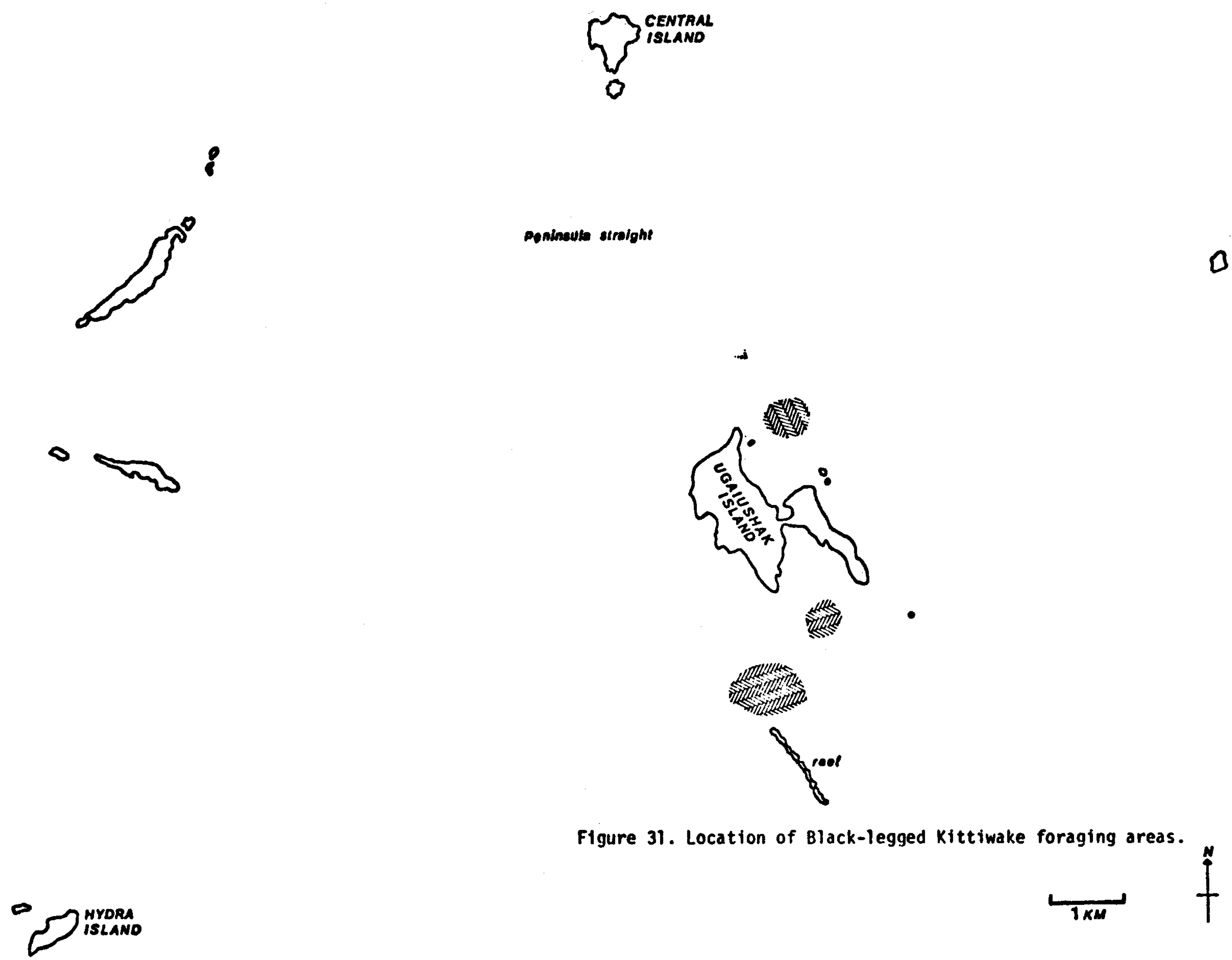


Figure 31. Location of Black-legged Kittiwake foraging areas.

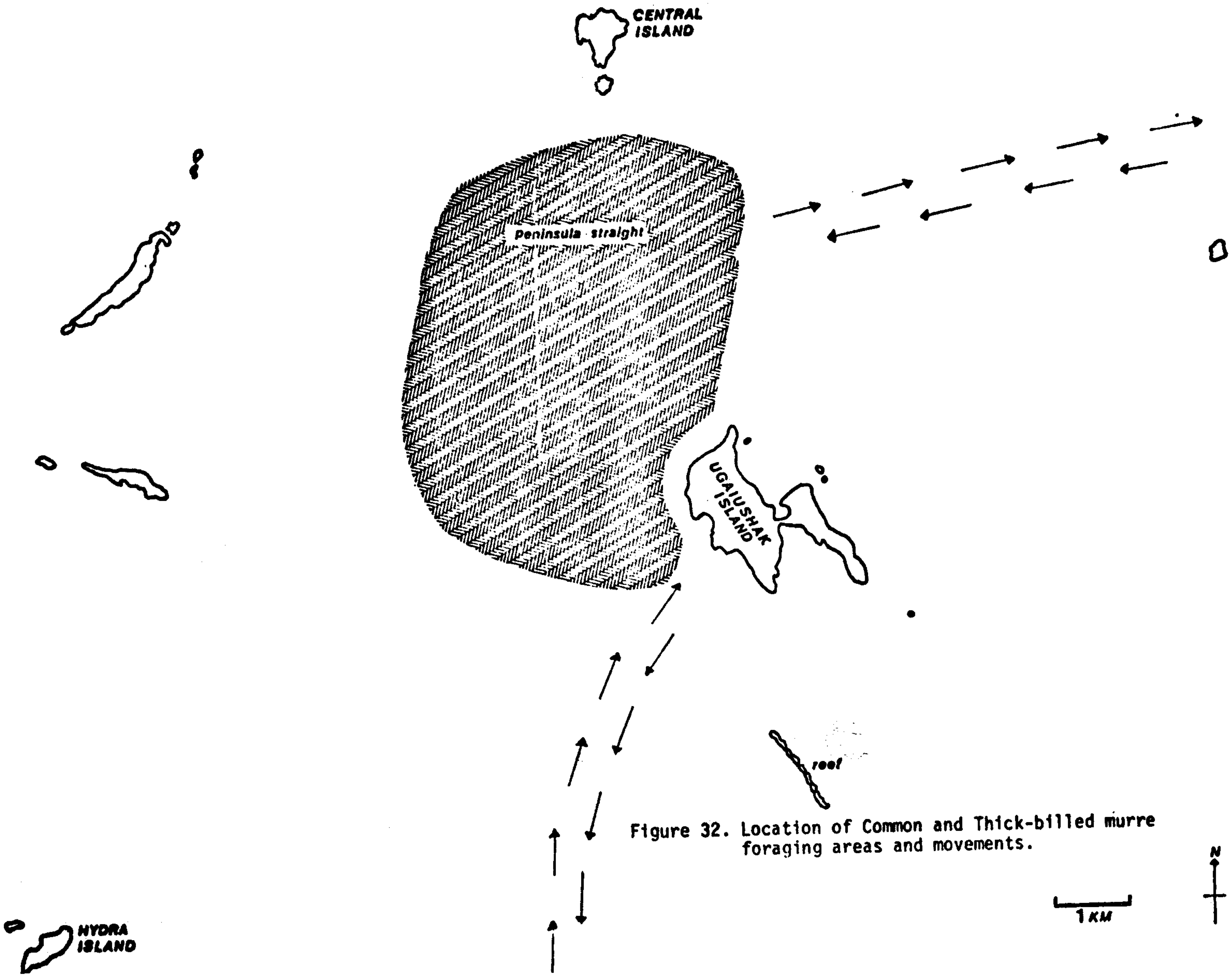


Figure 32. Location of Common and Thick-billed murre foraging areas and movements.

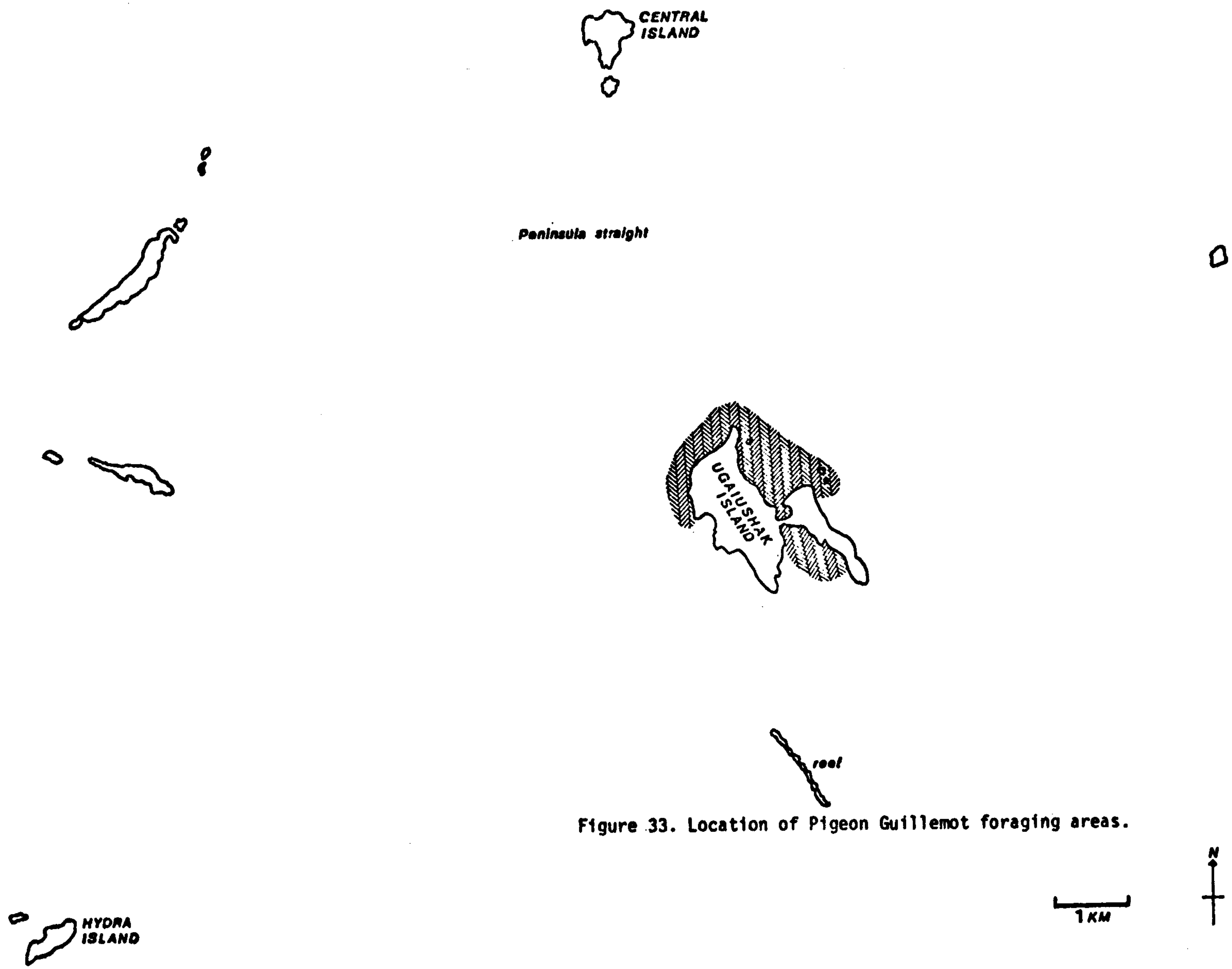


Figure 33. Location of Pigeon Guillemot foraging areas.

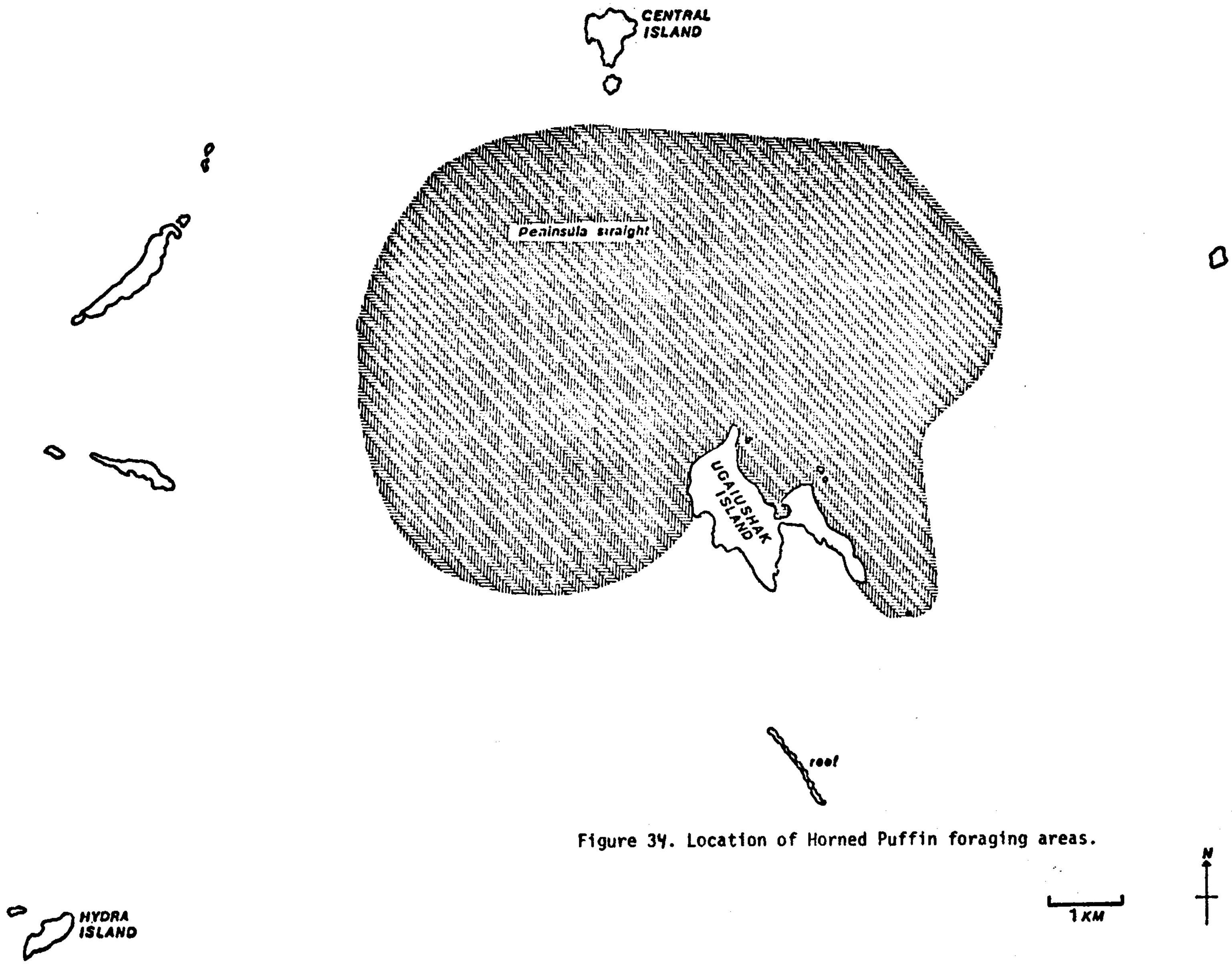


Figure 34. Location of Horned Puffin foraging areas.

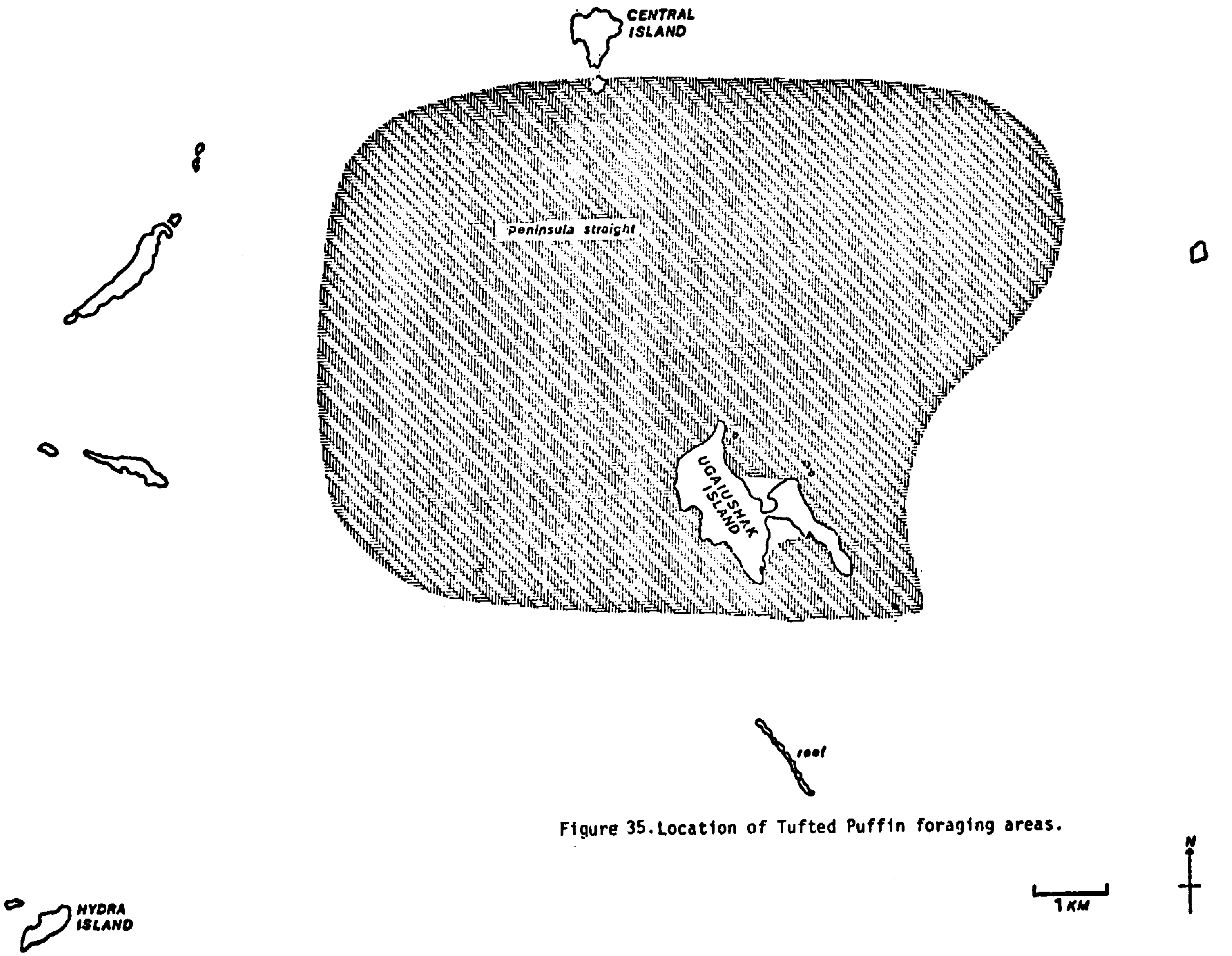


Figure 35. Location of Tufted Puffin foraging areas.

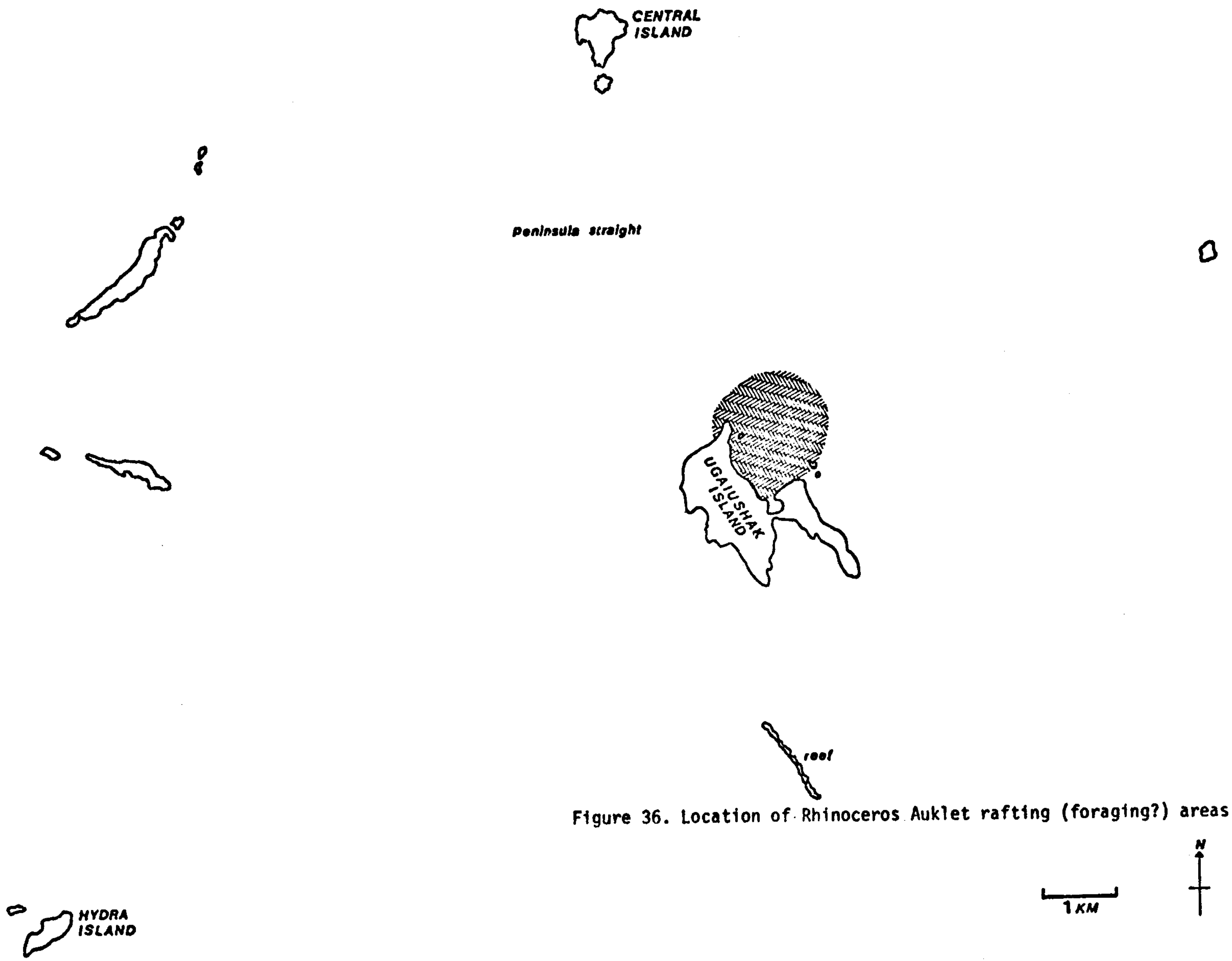


Figure 36. Location of Rhinoceros Auklet rafting (foraging?) areas.

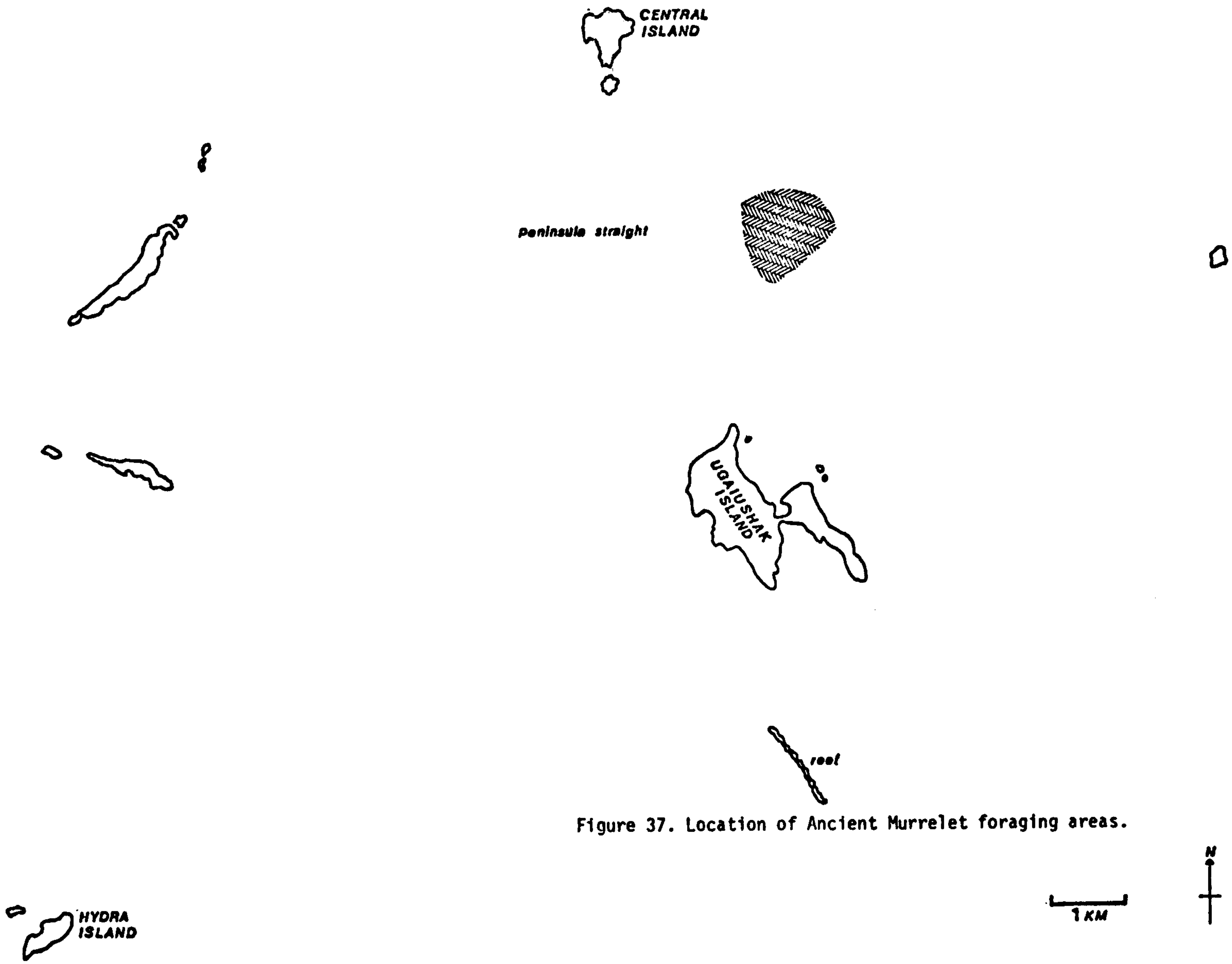


Figure 37. Location of Ancient Murrelet foraging areas.

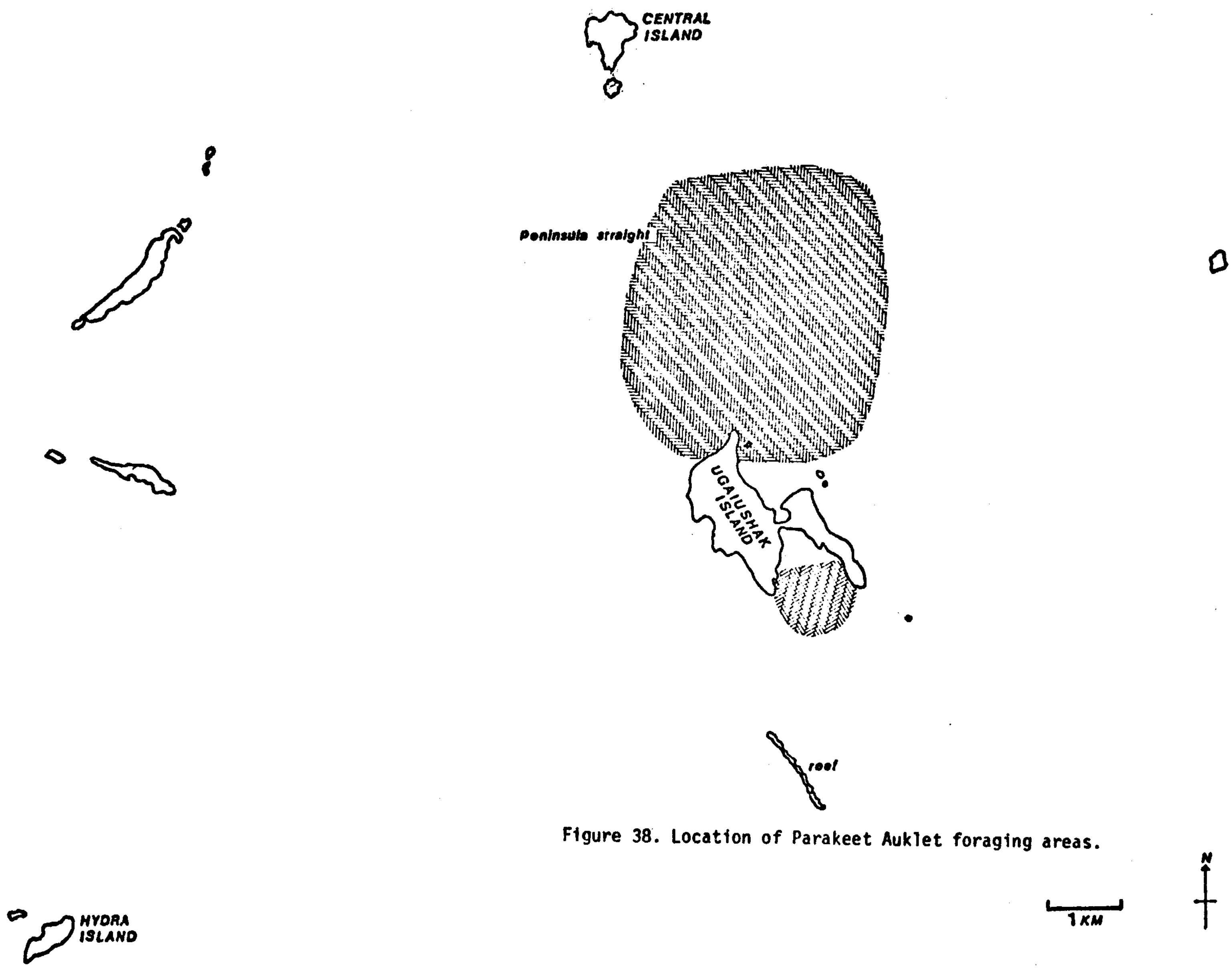


Figure 38. Location of Parakeet Auklet foraging areas.

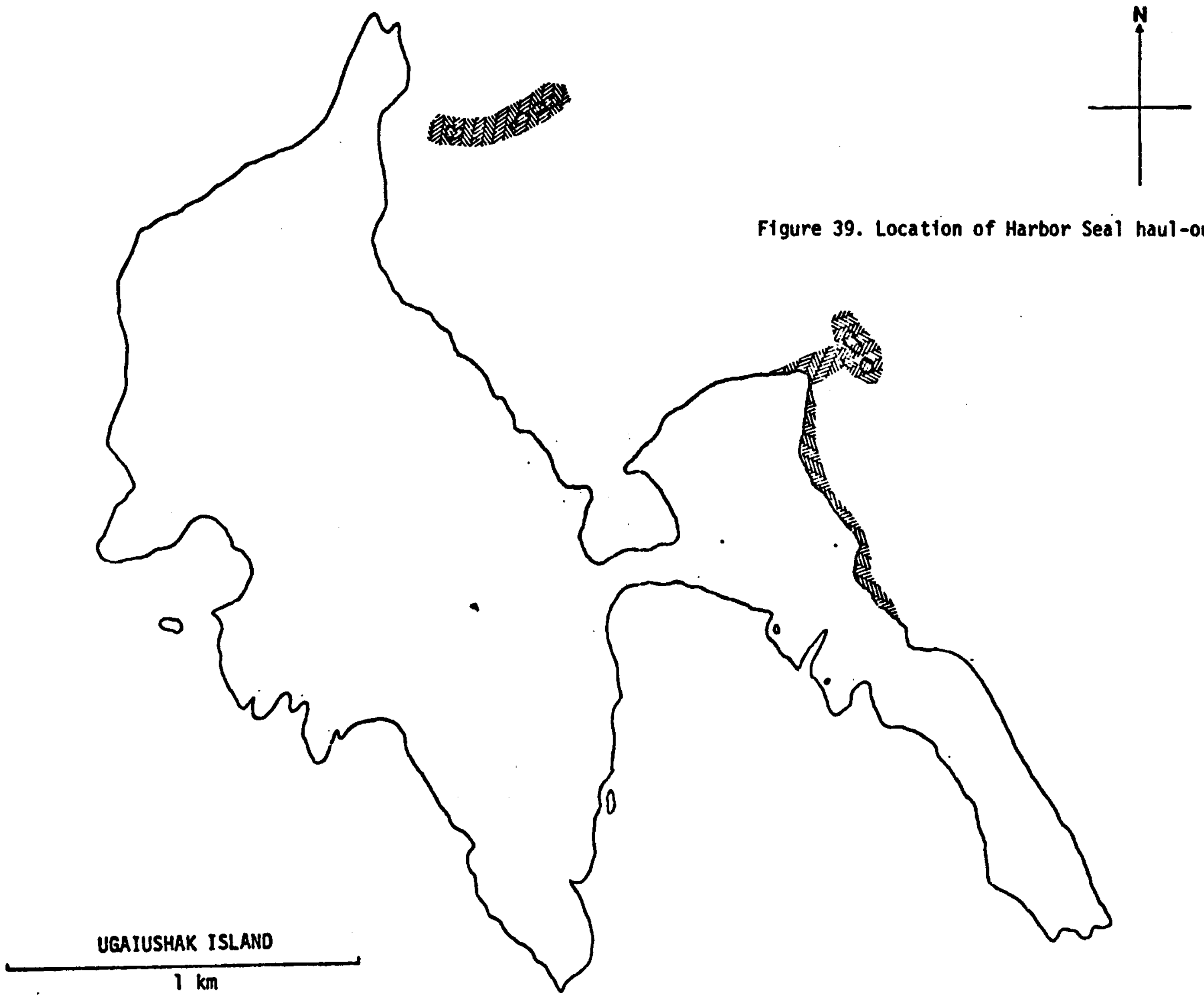


Figure 39. Location of Harbor Seal haul-out areas.

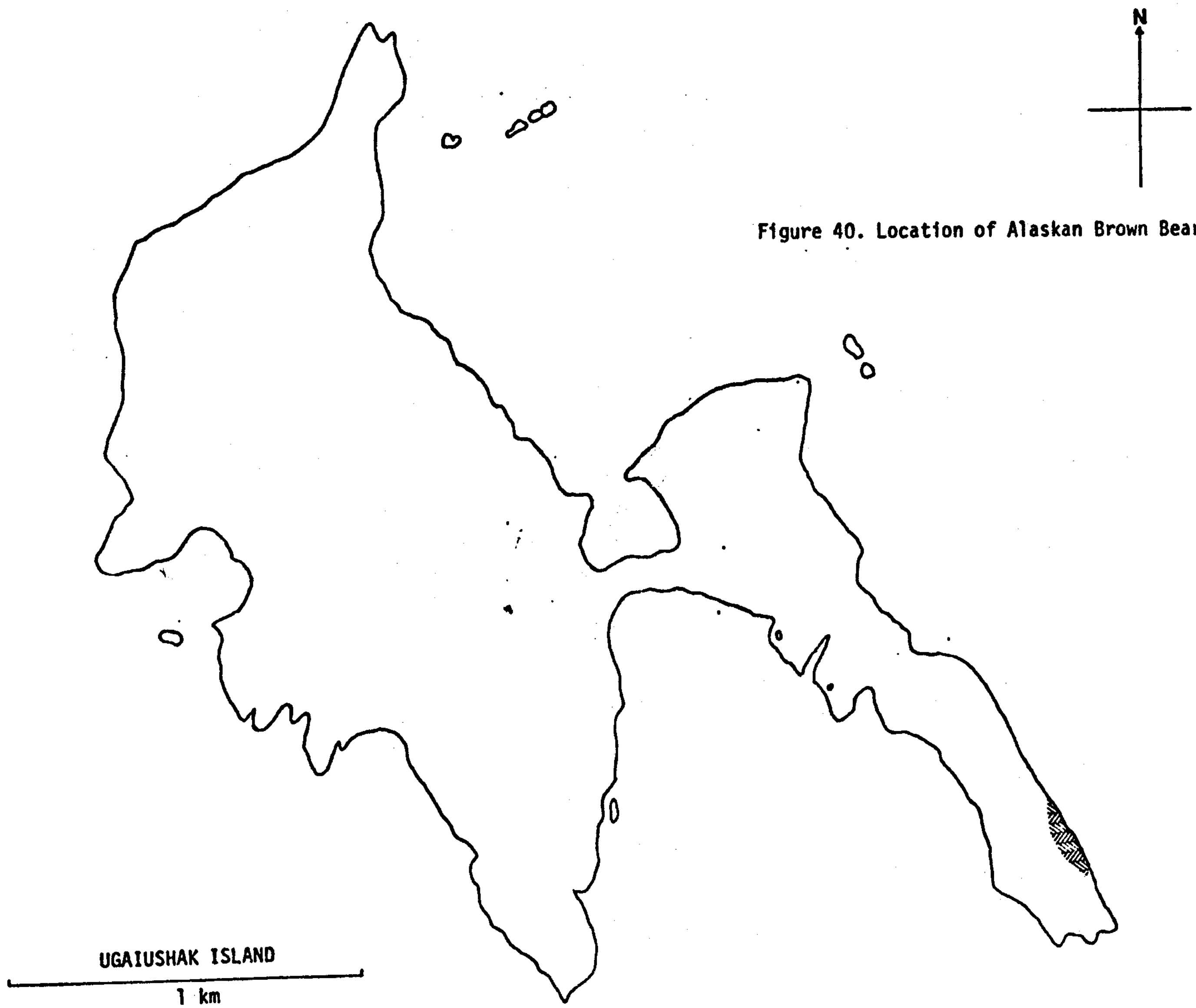


Figure 40. Location of Alaskan Brown Bear sighting.

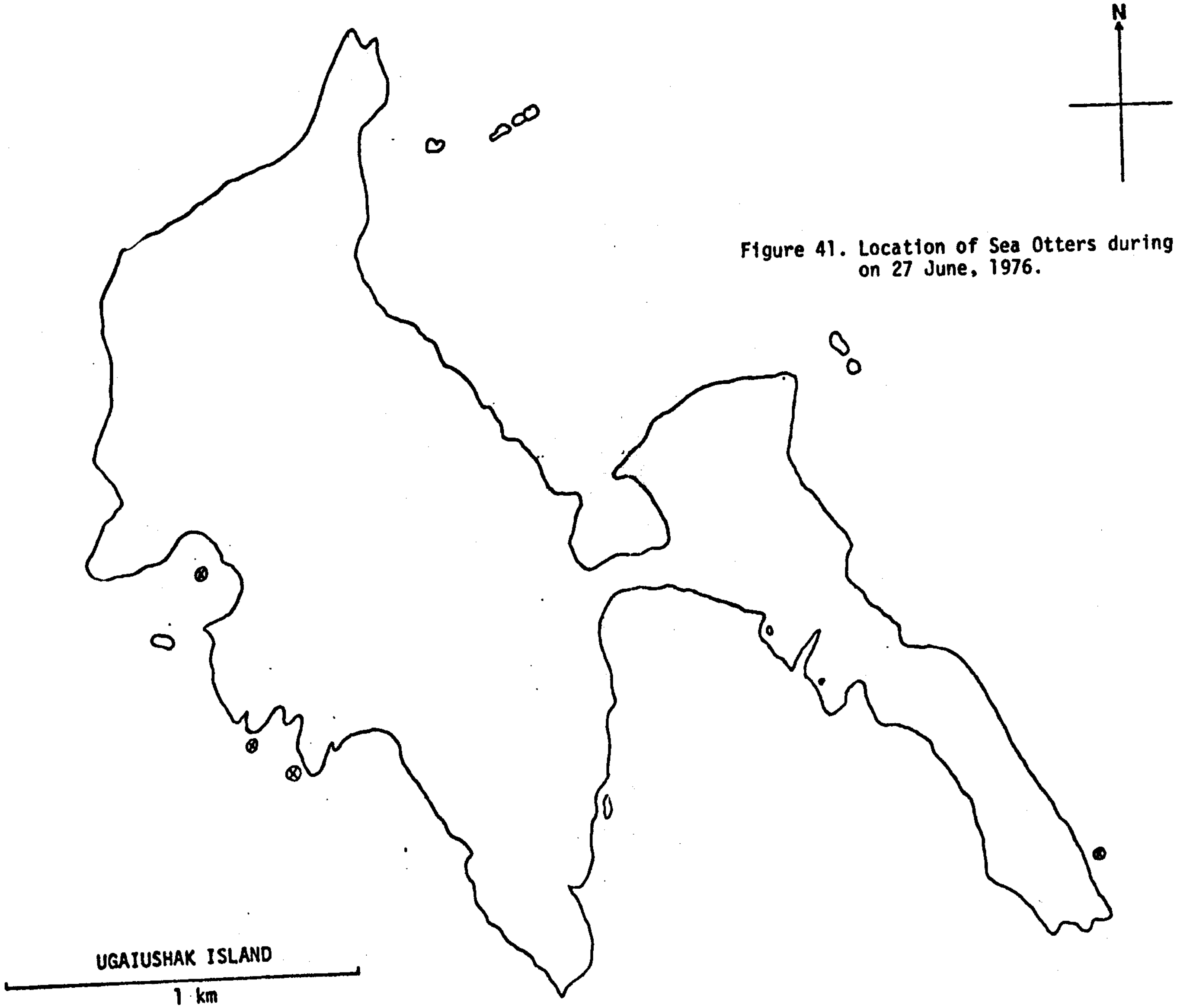


Figure 41. Location of Sea Otters during census on 27 June, 1976.

APPENDIX I

DAILY CHEKCLIST OF BIRDS ON UGIAUSHAK ISLAND

May 26 to August 30, 1976

By

Henry S. Wehle

U.S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

March 1977

APPENDIX I

This checklist of birds includes all species observed on or in close proximity to Ugaiushak Island from 26 May to 30 August, 1976. Resident seabird species were not usually recorded in daily notes unless observations were of particular interest such as arrival dates or observations of species breeding in low numbers on the island. Depending on their abundance, and the degree of importance to our study, quantitative evaluation ranged from actual numbers observed to a check (x) indicating presence.

	MAY	26	27	28	29	30	31
Northern Fulmar	R						
Fork-Tailed Petrel	R						
Leach's Petrel	R						
Double-Crested Cormorant	R						
Red-Faced Cormorant	R						
Pelagic Cormorant	R						
Whistling Swan		2					
Pintail Duck							
Harleqind Duck	R		12	50+			
Common Eider	R			2 PR		8 ♂ 4 ♀	11 ♂ 9 ♀
Red-Breasted Merganser				1 PR			1 PR
Bald Eagle	R	1a 1i	1a 2i	1a 2i	2a 3i	2a 1i	X
Peregrine Falcon	R		2	1			
Black Oystercatcher	R						
Semipalmated Plover							
Bristle-Thighed Curlew		1			1		
Whimbrel							
Wandering Tattler			2	1	2	1	1
Ruddy Turnstone							
Black Turnstone							

KEY:
- X - recorded but not counted
- PR - pair
- ○ - number occurring together
- ♪ - male is song
- R - resident, not recorded in daily notes
- B - broods
- f - fledgling
- a - adult
- i - immature
- ★ - specimen collected
- ♂ - male
- ♀ - female

Table 1. Species list of Ugaiushak Island, 1976.

May

	MAY	26	27	28	29	30	31
Rock Sandpiper							
Dunlin							
Least Sandpiper				1			2
Northern Phalarope				4			
Parasitic Jaeger	R	2		1		2	4
Gloucous-Winged Gull	R						
Black-Legged Kittiwake	R						
Common Murre	R	0	0	2,500-3,000			
Thick-Billed Murre	R	0	0				
Pigeon Guillemot	R						
Horned Puffin	R	0	0	0	0	0	500+
Tufted Puffin	R	2	2	3	6	300+	
Rhinoceros Auklet	R						
Marbled Murrelet							
Ancient Murrelet	R						
Parakeet Auklet	R						
Common Raven	R						

May

	MAY	26	27	28	29	30	31
Winter Wren	R						
Hermit Thrush	R				1		
Gray-Cheeked Thrush	R?						
Water Pipit	R						
Yellow Warbler							
Wilson's Warbler						1	1
Gray-Crowned Rosy Finch	R				1	3	X
Common(?) Redpoll							
Savannah Sparrow	R				2	3	X
Golden-Crowned Sparrow	R		1	1	2	2	X
Fox Sparrow							
Song Sparrow	R						
Lapland Longspur		1♂					

June

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Northern Fulmar	R																									1						
Fork-Tailed Petrel	R									1																						
Leach's Petrel	R																															
Double-Crested Cormorant	R																															
Red-Faced Cormorant	R																															
Pelagic Cormorant	R																															
Whistling Swan																																
Pintail Duck																																
Harlequin Duck	R		X	X	X	X	X		X	X	X	X	X	30+	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	
Common Eider	R		X	X	X	X	X	X	X		X	X	2		15	X	10	X	20+	X		X	X	X	X	X	X	24	X		X	
Red-Breasted Merganser												1PR			1♂	1♀	1♀	1♀	1♀	1♀	1♀							1PR			1♀	
Bald Eagle	R		X	X			X	X	X	X	4i	X	5i	5i	7i 1a	X	X	X	X	X	X		X	X	5i	X	X	X	X	X	X	
Peregrine Falcon	R						1													1												
Balck Oystercatcher	R																															
Semipalmated Plover																																
Bristle-Thighed Curlew																																
Whimbrel																																
Wandering Tattler		1		1		2	1								1																	
Ruddy Turnstone																																
Black Turnstone																																

June

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rock Sandpiper																																
Dunlin																																
Least Sandpiper																																
Northern Phalarope																																
Parasitic Jaeger	R	4	x	4		2		2		3		4	3	4	4	X	X	X	1		X	X	X	X					X	X	X	
Glaucous-Winged Gull	R																															
Black-Legged Kittiwake	R																															
Common Murre	R																															
Thick-Billed Murre	R																															
Pigeon Guillemot	R																															
Horned Puffin	R																															
Tufed Puffin	R																															
Rhinoceros Auklet	R	2																							4	1					1* 3	
Marbled Murrelet																																
Ancient Murrelet	R																														30	
Parakeet Auklet	R			6							1	6						40+	2								43		X			
Common Raven	R																															

		June																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Winter Wren	R																					2			2		X	X	X			
Hermit Thrush	R																									1						
Gray-Cheeked Thrush	R?																						1		X	X	X		X			
Water Pipit	R																					2			4+	1		1				
Yellow Warbler																																
Wilson's Warbler			1								1												1									
Gray-Crowned Rosy Finch	R	X				2	1			X	X					X			1	X		X	X	X	X	X	X	X	X	X	X	
Common(?) Redpoll																																
Savannah Sparrow	R	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Golden-Crowned Sparrow	R	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Fox Sparrow																				1					1		1					
Song Sparrow	R								X			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Lapland Longspur																				1♂							1♂		1♂			

		July																														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Winter Wren	R																												1			
Hermit Thrush	R																															
Gray-Cheeked Thrush	R?																	X	X												1♀	
Water Pipit	R				1				1	1			X		2	X	X	X	X			X	X	X	X	X			X	X	X	
Yellow Warbler																																
Wilson's Warbler																																
Gray-Crowned Rosy Finch	R	X	X				X		X	X			X	X	X				X				X	X	X					X	X	
Common(?) Redpoll					2																											
Savannah Sparrow	R.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X
Golden-Crowned Sparrow	R	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Fox Sparrow																																
Song Sparrow	R	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lapland Longspur															1Pr		1♂	1♂	1♂	1♂	1♂	1♂			1♂				1♂			1♂

July

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Northern Fulmar R		1								20+	20+																				
Fork-Tailed Petrel R															X		X											X			
Leach's Petrel R																														1	
Double-Crested Cormorant R																															
Red-Faced Cormorant R																															
Pelagic Cormorant R																															
Whistling Swan																															
Pintail Duck																															
Harlequin Duck R	62	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X
Common Eider R	X	X	X	X			X	X	X	X	10+ ♀		X	14 ♀	X	X	16 ♀	X	16 ♀	X	16 ♀		X	X	X			6♀		26 ♀	
Red-Breasted Merganser	1♀	1♀	1♀																												
Bald Eagle R	X	X	X	X		X	X		X	X	X	X	X		X	2a 1i	2a 1i	1i			1i	1i	1a 1i	2a 3i	1i	1i	1i	2a 2i		X	X
Peregrine Falcon R																								3					3		
Balck Oystercatcher R																												19		16	13
Semipalmated Plover																												1	2		
Bristle-Thighed Curlew	11																														
Whimbrel																1									1	1			1		
Wandering Tattler																														1	
Ruddy Turnstone																															
Black Turnstone																															

July

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Rock Sandpiper														2	3	2	1				2				2						108	19	
Dunlin																							1										31
Least Sandpiper							1																										
Northern Phalarope											14																						
Parasitic Jaeger	R	4	X	X	X	X	X	X	5	X	X		X	X		X	X	X				1	X	3	X	4	X	X			6	5	
Glaucous-Winged Gull	R																																
Black-Legged Kittiwake	R																																
Common Murre	R																																
Thick-Billed Murre	R																																
Pigeon Guillemot	R																																
Horned Puffin	R																																
Tufed Puffin	R																																
Rhinoceros Auklet	R	2	2 (1*)								1																		1				
Marbled Murrelet																																	
Ancient Murrelet	R	3 (2*)																															
Parakeet Auklet	R																												27			6		
Common Raven	R																																

August

Species		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Northern Fulmar	R																															
Fork-Tailed Petrel	R																						X									
Leach's Petrel	R			1																												
Double-Crested Cormorant	R																															
Red-Faced Cormorant	R																															
Pelagic Cormorant	R																															
Whistling Swan																																
Pintail Duck																					2											
Harlequin Duck	R		X	X			15		X	X	X	X		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	
Common Eider	R	6♀			2		7♀ 3B		8♀ 1B		4♀ 1B			3♀ 3B	5♀ 2B	2♀	2♀ 2B	2♀ 2B	2♀ 2B	2♀ 2B	2♀ 2B	4♀ 2B					2♀ 2B	4♀ 2+B				
Red-Breasted Merganser																																
Bald Eagle	R	1i 2a		X							1a	1a	1a		2a	1f				1f	2i 2a	1a	2i 2a						1a		1i	
Peregrine Falcon	R					1	1		3		1										3	3					2	1				
Balck Oystercatcher	R		11				24			34			29	33												54					38	
Semipalmated Plover			1																													
Bristle-Thighed Curlew																							1									
Whimbrel											4					2						17	6	4				2		2	4	
Wandering Tattler																			1		2						1		1	2		
Ruddy Turnstone								2											1			4										
Black Turnstone																			3		8	6							4	22	12+	

August

Species		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rock Sandpiper		6	2	5	8		3			29	15+			1	9	2			1										5	16		
Dunlin																																
Least Sandpiper																				1												
Northern Phalarope				4	6																									1		
Parasitic Jaeger	R	6	X	6		11	X			8				11		X	X	X		X	X	X	11	9	X	X			16	11		
Glaucous-Winged Gull	R																															
Black-Legged Kittiwake	R																															
Common Murre	R																															
Thick-Billed Murre	R																															
Pigeon Guillemot	R																															
Horned Puffin	R																															
Tufed Puffin	R																												[illegible]	[illegible]		
Rhinoceros Auklet	R				6+		1		11 (10)	1							5	1*														
Marbled Murrelet					1																								1		2	
Ancient Murrelet	R																															
Parakeet Auklet	R	1		1	2				1								1															
Common Raven	R								(8)								(11)															

August

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Winter Wren	B	1																														
Hermit Thrush	B																															
Gray-Cheeked Thrush	B?																															
Water Pipit	B		X				2		1				X	X	X	X	X	2			X							X	X	X	X	
Yellow Warbler																						4								1		
Wilson's Warbler																																
Gray-Crowned Rosy Finch	B	X		X		X	8							X	X		1				X	X	X									
Common(?) Redpoll																																
Savannah Sparrow	B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	
Golden-Crowned Sparrow	B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		
Fox Sparrow																1	1	1			1	X	2	1				1			1	
Song Sparrow	B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X						
Lapland Longspur																																

APPENDIX II

VEGETATION SURVEY OF UGIAUSHAK ISLAND, ALASKA

August, 1976

Field Report No. 76061

By

Kevin Powers

U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

March 1977

INTRODUCTION

This report considers the vascular plant composition of Ugaiushak Island, Alaska (56° 47' N, 156° 41' w). Emphasis is on importance, dispersion, and associations of the island's plant species and plant communities. The vegetation is important to many bird species nesting on the island, however, this report does not directly deal with the vegetation composition of particular nesting areas of those birds. This report is broad-based in scope and its intentions is to characterize the flora of a lowland arctic island.

Scientific nomenclature for all plant species in this report if from Hulten (1968).

METHODS

Ugaiushak Island, Alaska encompasses approximately 350 acres (U.S. Geological Survey Map 1954) of rock cliffs and treeless vegetation, similar to that of lowland arctic tundra. The island was divided into four study areas (Figure 1): west island, east island, main talus slopes and an isthmus. During August 1976, the vascular plant vegetation of west and east island areas was quantitatively evaluated and compared. The isthmus and main talus slope areas were subjectively evaluated and the species composition of those plant communities was listed.

West and east island areas were systematically sampled using 1/1000th-acre circular (radius = 3.71 feet) plots. The sample plots were established every four chains (1 chain = 66 feet) on north-south transect lines four chains apart. The transect lines were determined by the location of the initial sample plot in each study area (Figure 1). The initial plot was selected so that the entire study area would be subject to random sampling.

Sample plots were established on a transect line every four chains until a cliff or some other natural barrier was reached. The next transect line was established four chains, east on east island area and west on west island area, from the last sample plot established before a barrier was reached. Sampling was continued until the opposite end of the study area was reached, thereby further plots and transect lines could not be established.

Within a sample plot each plant species and percent of plot that it covered were listed. All grasses, except *Calamagrostis canadensis*, *Hordeum brachytherum* and *Elymus arenarius mollis* were recorded as Poaceae. The minimum percent cover for any plant species in a plot was five percent and the total percent cover in a plot could exceed 100 percent.

From the data collected using this technique, I was able to calculate relative frequency per species, percent of ground covered per species, and relative cover per species in terms of all species in a plot. Relative cover of a species is the total of all cover values of that species divided by the total of all cover values of all species. An importance value was calculated per species by summing figures for relative frequency, percent cover and relative cover. Curtis and McIntosh (1951) found that an importance value presents an excellent indication of the vegetational importance of a species within an area and expresses disperiosn of vegetation.

A summary list of all vascular plant species found on Ugiaushak Island is provided in Table 3.

RESULTS AND DISCUSSION

West Island Area

From 135 plots sampled on west island over 56 vascular plant species were found. The results of the vegetation analysis are shown in Table 1. Crowberry (Empetrum nigrum) was the most important plant on the study area (importance value=122.17). Crowberry was found in dense mats on flat and poorly drained areas, i.e. heaths (see Griggs 1936). Other plants of less importance that were usually associated with the heaths were Artemisa arctica, Betula nana exilis, Carex spp., Cornus suecica, Ledum palustre, Parnassia palustris, Salix arctica, and S. reticulata. Within the heaths were hummocks crowned with Calamagrostis canadensis, which were similarly described by Griggs (1936).

Small grasslands of Calamagrotis canadensis were also found in the better drained areas of west island. The data indicate an aggregate disperiosn of Calamagrostis canadensis because it was second in percent cover (6.48) but sixteenth in importance value (35.77). Also Achillea borelis, Angelica lucida, Conioselium chinese, Equisetum arvense, Heracleum lanatum and Viola sp. were usually present in the well-drained areas. Griggs (1936) described the Calamagrotis grassland as the only true plant "association" on the Katmai district, i.e. a vegetation type whose composition is determined by competition. Versely, the development of the heath is caused by a lack of drainage. A condition intolerable to most plants, but tolerable to many plants characteristic of the heath e.g. crowberry.

A considerable part of the west island area ia a mixed meadow community with approximately fifty plant species on soil too thin gna weather-exposed for the domination of Calamagrotis. Griggs (1936) classified this community as a transition area between the heath and Calamagrotis grassland. Achillea borealis, Aconitum delphinifolium, Angelica lucida, Carex spp., Equisetum arvense, and Geranium erianthum were species which commonly occurred in each of the three communities.

East Island Area

From 49 plots sampled on east island area over 47 vascular plant species were found. The results of the vegetation analysis are shown in Table 2. Angelica lucida was the most important plant (importance value=130.32). Angelica lucida covered 23.78 percent of the island and was uniformly distributed.

East island area was generally well-drained and supported a more lush Calamagrostis grassland and mixed meadow community than west island area. The elevation of east island did not exceed 150 feet above sea level; whereas, west island had several peaks above 300 feet. Achillea borealis, Aconitum delphinfolium, Calamagrotis cadadensis, Conioselium chinese, Cprnus sueccica, Epilobium angustifolium, Equisetum arvense, and Geranium erianthum were widespread in occurrence, but of less importance than Angelica lucida.

A small crowberry heath was present on the northern tip of the island and two small strand (see Isthmus p. 12) communities with Elymus arenarius mollis and/or Honckenya peploides major were also present in a low-lying wash-out area in the southcentral part of east island.

Main Talus Slopes

The main talus slopes (Figure 1) reached the highest elevations of Ugaiushak Island, i.e. 450 feet. The talus slopes were well-drained Calamagrotis canadensis grasslands. Other species important in cover and in preventingtopsoil erosion of the slopes were: Achillea borealis, Angelica lucida, Artemisia tilesii and Potentilla villosa.

Isthmus

The isthmus area (Figure 1) was the only major beach or strand community (see Griggs 1936) on Ugiaushak Island. It was heavily laden with driftwood, which was probably washed up from winter storms. The south side of the isthmus was a rocky beach and the north side was sandy. Elymus arenarius mollis, seabeach sandwort (Honckenya peploides major), oysterleaf (Martensia maritima maritima) and Senecio pseudoarnica were the characteristics species in this area.

Literature Cited

Griggs, R.F. 1936. Vegetation of the Katmai district. Ecology 17(3): 380-417.

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford Univ. Press. Stanford, CA. 1008 p.

U.S. Dept. Interior, Geological Survey. 1954. Sutwik Island (D-3) quadrangle, Alaska. 1:63360 series (topographic). U.S. Geol. Surv. Washington, D.C.

Figure 1. Map of Ugaiushak Island, Alaska, indicating study areas.

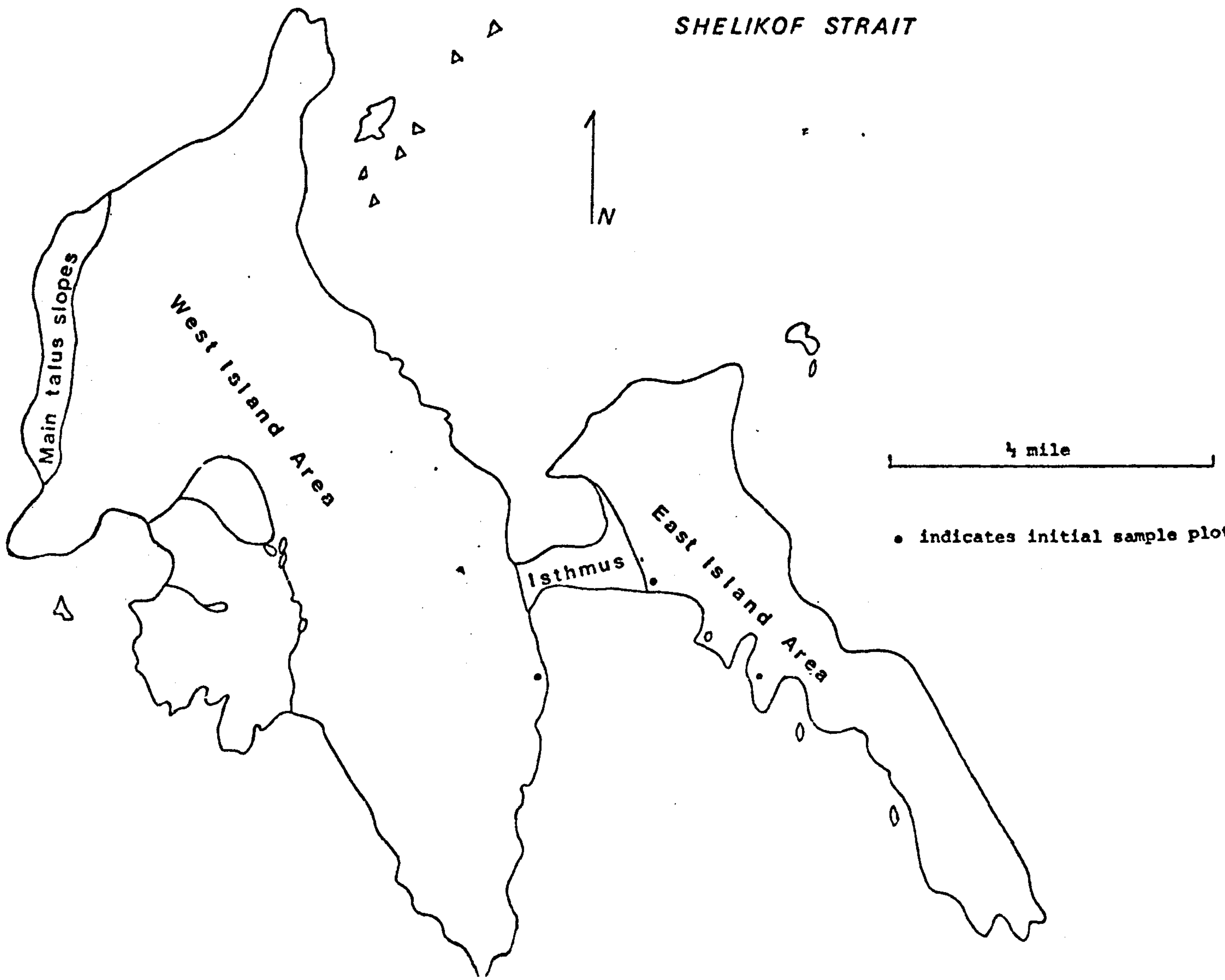


Table 1. Results from vegetation analysis of data collected during August 1976 on west island study area, Ugaiushak Island, Alaska.

Plant species	Relative frequency	Relative cover	Percent cover	Importance value
Empetrum nigrum	57.04	30.17	34.96	122.17
Angelica lucida	69.63	4.89	5.67	80.19
Geranium erianthum	61.48	3.45	4.00	68.93
Poaceae	54.07	2.40	2.78	59.26
Carex spp.	51.85	3.10	3.59	58.54
Achillea borealis	52.59	2.49	2.89	57.97
Equisetum arvense	44.44	4.41	5.11	53.97
Aconitum delphinifolium	46.67	2.01	2.33	51.01
Artemisia arctica	42.96	2.01	2.33	47.30
Cornus sueicica	39.26	3.68	4.26	47.20
Conioselium chinense	40.00	2.84	3.30	46.14
Lupinus nootkatensis	39.26	2.33	2.70	44.29
Pedicularis kenai	38.52	1.69	1.96	42.17
Epilobium angustifolium	35.56	2.27	2.63	40.26
Frittillaria kamschatensis	34.07	1.47	1.70	37.24
Calamagrostis canadensis	23.70	5.59	6.48	35.77
Salix arctica	25.93	3.04	3.52	32.49
Anemone narcissiflora	25.19	2.91	3.37	31.47
Heracleum lanatum	25.19	2.43	2.81	30.43
Sedum rosea	27.41	1.21	1.41	30.03
Viola sp.	22.22	1.73	2.00	25.95

Table 1. (continued)

Plant species	Relative frequency	Relative cover	Percent cover	Importance value
Polygonum viviparum	22.22	0.96	1.11	24.29
Dryas octopetala	18.52	1.76	2.04	22.32
Rhianthus minor	18.52	0.80	0.93	20.25
Vaccinium vitis-idaea	16.30	1.63	1.89	19.82
Rubus articus	17.78	0.83	0.96	19.57
Betula nana	17.04	0.77	0.89	18.70
Lagotis glauca	12.59	0.54	0.63	13.76
Salix reticulata	11.85	0.77	0.89	13.51
Senecio resedifolius	11.85	0.51	0.59	12.95
Solidago multiradiata	11.11	0.48	0.56	12.15
Sanguisorba stipulata	8.89	0.74	0.85	10.48
Juncus spp.	8.89	0.38	0.44	9.71
Geum rosii	8.15	0.48	0.56	9.19
Chrysanthemum arcticum	8.15	0.35	0.41	8.91
Artemisia tilesii	7.41	0.51	0.59	8.51
Rhododendron camtschaticum	7.41	0.35	0.41	8.17
Ligusticum scoticum	5.19	0.26	0.30	5.75
Aythrium filix-femina	4.44	0.22	0.26	4.92
Hordeum brachytherum	4.44	0.19	0.22	4.85
Campanula lasiocarpa	3.70	0.16	0.19	4.05
Cerastium beeringianium	2.96	0.13	0.15	3.24
Saxifraga eschscholtzii	2.96	0.13	0.15	3.24

Table 1. (continued)

Plant species	Relative frequency	Relative cover	Percent cover	Importance value
Elymus arenarius	2.22	0.13	0.15	2.50
Ledum palustre	2.22	0.13	0.15	2.50
Rumex spp.	2.22	0.10	0.11	2.43
Parnassia palustris	2.22	0.10	0.11	2.43
Claytonia chamissoi	1.48	0.06	0.07	1.61
Potentilla villosa	1.48	0.06	0.07	1.61
Oxytropis maydelliana	1.48	0.06	0.07	1.61
Epilobium latifolium	1.48	0.06	0.07	1.61
Gentiana amarella	1.48	0.06	0.07	1.61
Iris setosa	0.74	0.03	0.04	0.81
Ranunculus sp.	0.74	0.03	0.04	0.81
Epilobium glandulosum	0.74	0.03	0.04	0.81
Petasites frigidus	0.74	0.03	0.04	0.81
Prenanthes alata	0.74	0.03	0.04	0.81
		99.98	115.89	

Table 2. Results from vegetation analysis of data collected during August 1976 on east island study area, Ugaiushak Island, Alaska.

Plant species	Relative frequency	Relative cover	Percent cover	Importance value
Angelica lucida	87.76	18.78	23.78	130.32
Geranium erianthum	73.74	4.11	5.20	82.78
Achillea borealis	65.31	6.20	7.86	79.37
Conioselium chinense	65.31	3.71	4.69	73.71
Equisetum arvense	48.98	7.90	10.00	66.88
Aconitum delphinifolium	61.22	2.42	3.06	66.70
Poaceae	57.14	2.90	3.67	63.71
Cornus suecica	40.82	7.49	9.49	57.80
Calamagrostis canadensis	42.86	5.56	7.04	55.46
Epilobium angustifolium	46.94	2.74	3.47	53.15
Carex spp.	38.78	1.93	2,45	43.16
Heracleum lanatum	32.65	4.27	5.41	42.33
Frittillaria kamschatensis	38.78	1.53	1.94	42.25
Pedicularis kenai	38.78	1.53	1.94	42.25
Rubus arcticus	34.69	1.37	1.73	37.79
Viola sp.	32.65	1.69	2.14	36.48
Rhianthus minor	28.57	1.13	1.43	31.13
Elymus arenarius	18.37	5.32	6.73	30.42
Anemone narcissiflora	18.37	3.30	4.18	25.85
Juncus spp.	22.45	0.89	1.12	24.46
Parnassia palustris	22.45	0.89	1.12	24.46

Table 2. (continued)

Plant species	Relative frequency	Relative cover	Percent cover	Importance value
Hordeum bracytherum	16.33	1.45	1.84	19.62
Rumex spp.	16.33	0.64	0.82	17.79
Empetrum nigrum	8.16	3.38	4.29	15.83
Sedum rosea	14.29	0.64	0.82	15.75
Cerastium beeringianum	14.29	0.56	0.71	15.56
Rhododendron camschaticum	12.24	0.64	0.82	13.70
Polygonum viviparum	12.24	0.48	0.61	13.33
Salix arctica	8.16	2.01	2.55	12.72
Sanguisorba stipulata	10.20	0.48	0.61	11.29
Solidago multiradiata	10.20	0.40	0.51	11.11
Ligusticum scoticum	8.16	0.64	0.82	9.62
Chrysanthemum arcticum	6.12	0.24	0.31	6.67
Artemisia arctica	6.12	0.24	0.31	6.67
Honckenya peploides	2.04	1.29	1.63	4.96
Gentiana amarella	4.08	0.16	0.20	4.44
Betula nana	2.04	0.16	0.20	2.40
Artemisia tilesii	2.04	0.16	0.20	2.40
Claytonia chamissoi	2.04	0.08	0.10	2.22
Potentilla villosa	2.04	0.08	0.10	2.22
Dryas octopetala	2.04	0.08	0.10	2.22
Lupinus nootkatensis	2.04	0.08	0.10	2.22
Epilobium glandulosum	2.04	0.08	0.10	2.22

Table 2. (continued)

Plant species	Relative frequency	Relative cover	Percent cover	Importance value
Gentiana prostrata	2.04	0.08	0.10	2.22
Lagotis glauca	2.04	0.08	0.10	2.22
Senecio resedifolius	2.04	0.08	0.10	2.22
Taxacrum sp.	2.04	0.08	0.10	2.22
		99.95	126.60	

Table 3 List of vascular plants found on Ugaiushak Island, Alaska, during August 1976.

Scientific Name	Common Name
Equisitaceae (Horsetail Family)	
Equisetum arvense L.	Horsetail
Athyriaceae (Lady Fern Family)	
Athyrium filix-femina (L.) Roth.	Lady Fern
Potamogetonaceae (Pondweed Family)	
Zostera marina L.	Eelgrass
Gramineae (Grass Family)	
Calamagrostis canadensis (Michx.) Beauv.	
Hordeum brachytherum Nevski	
Elymus arenarius L. subsp. *mollis* (Trin.) Hult.	Lyme Grass
Cyperaceae (Sedge Family)	
Carex spp. L.	
Eriophorum sp. L.	Cotton Grass
Juncaceae (Rush Family)	
Juncus spp. L.	Rush
Liliaceae (Lily Family)	
Frittillaria camschatcensis (L.) Ker-Gawl	Chocolate Lily
Iridaceae (Iris Family)	
Iris setosa Pall. subsp. *setosa*	Wild Flag
Orchidaceae (Orchis Family)	
Platanthera dilata (Pursh) Lindl.	
Platanthera obtusata (Pursh) Lindl.	

Table 3 (continued)

Scientific Name	Common Name
Orchidaceae (Orchis Family)	
Malaxis monophylla (L.) Sw.	Adder's Mouth
Salicaceae (Willow Family)	
Salix reticulata L.	Netted Willow
Salix arctica Pall.	Arctic Willow
Betulaceae (Birch Family)	
Betula nana L. subsp. *exilis* (Sukatsch.) Hult.	Dwarf Birch
Polygonaceae (Buckwheat Family)	
Rumex arcticus Trautv.	
Polygonum viviparum L.	
Portulaceae (Purslane Family)	
Claytonia chamissoi Esch.	
Caryophyllaceae (Pink Family)	
Cerastium beeringianum Cham. & Schlecht.	Mouse-ear Chickweed
Honckenya peploides (L.) Ehrh. subsp. *major* (Hook.) Hult.	Seabeach Sandwort
Ranunculaceae (Crowfoot Family)	
Aconitum delphinifolium DC.	Monkshood
Anemone narcissiflora L. subsp. *villosissima* (DC.) Hult.	
Ranunculus sp. L.	Buttercup
Crassulaceae (Stonecrop Family)	
Sedum rosea (L.) Scop. subsp. *integrifolium* (Raf.) Hult.	Roseroot

Table 3 (continued)

Scientific Name	Common Name
Saxifragaceae (Saxifrage Family)	
Saxifraga oppositifolia L. subsp. *oppositifolia*	Purple Mountain Saxifrage
Saxifraga eschscholtzii Sternb.	Cushion Saxifrage
Saxifraga hirculus L.	Bog Saxifrage
Chrysoplenium wrightii Fr. & Sav.	
Parnassia palustris L. subsp. *neogaea* (Fern.) Hult.	Bog Star
Rosaceae (Rose Family)	
Rubus arcticus L.	
Potentilla villosa Pall.	
Geum rosii (R. Br.) Ser.	
Dryas octopetala L. subsp. *octopetala*	
Sanguisorba stipulata Raf.	
Leguminosae (Pea Family)	
Lupinus nootkatensis Donn	
Oxytropis maydelliana Trautv.	
Lathyrus palustris L. subsp. *pilosus* (Cham.) Hult.	Vetchling
Geraniaceae (Geranium Family)	
Geranium erianthum DC.	Cranesbill
Violaceae (Violet Family)	
Viola sp. L.	Violet
Onagraceae (Evening Primrose Family)	
Epilobium angustifolium L.	Fireweed
Epilobium latifolium L.	River Beauty
Epilobium glandulosum Lehm.	

Table 3 (continued)

Scientific Name	Common Name
Umbelliferae (Parsley Family)	
Ligusticum scoticum L. subsp. *hultenii* (Fern.) Calder & Taylor	Beach Lovage
Conioselium chinense (L.) BSP.	Hemlock Parsley
Angelica lucida L.	
Heracleum lanatum Michx.	Cow Parsnip
Cornaceae (Dogwood Family)	
Cornus suecica L.	Swedish Dwarf Cornel
Empetraceae (Crowberry Family)	
Empetrum nigrum L.	Crowberry
Ericaceae (Heath Family)	
Ledum palustre L. subsp. *decumbens* (Ait.) Hult.	Labrador Tea
Rhododendron camtschaticum Pall. subsp. *camtschaticum*	Kamchatka Rhododendron
Vaccinium vitis-idaea L.	Lingonberry
Plumbaginaceae (Leadwort Family)	
Ameria maritima (Mill.) Willd.	Thrift
Gentianaceae (Gentian Family)	
Gentiana algida Pall.	
Gentiana prostrata Haenke	
Gentiana amarella L.	
Boraginaceae (Borage Family)	
Mertensia maritima (L.) S.F. Gray subsp. *maritima*	Oysterleaf
Scrophulariaceae (Figwort Family)	
Mimulus guttatus DC.	Yellow Monkey Flower
Lagotis glauca Gaertn.	

Table 3 (continued)

Scientific Name	Common Name
Schrophulariaceae (Figwort Family)	
Rhianthus *minor* L. subsp. *borealis* (Sterneck) Löve	Yellow Rattle
Pedicularis *kanei* Durand subsp. *kanei*	Lousewort
Plantaginaceae (Plantain Family)	
Plantago *maritima* L. subsp. *juncoides* (Lam.) Hult.	Plantain
Campanulaceae (Bluebell Family)	
Campanula *lasiocarpa* Cham.	Bluebell
Compositae (Composite Family)	
Solidago *multiradiata* Ait. var. *multiradiata*	Goldenrod
Aster *sibiricus* L.	Siberian Aster
Achillea *borealis* Bong.	Yarrow
Chrysanthemum *arcticum* L. subsp. *arcticum*	Arctic Daisy
Artemisia *tilesii* Ledeb.	Wormwood
Artemisia *arctica* Less.	
Artemisia sp. L.	
Petasites *frigidus* (L.) Franch.	Sweet Coltsfoot
Senecio *resedifolius* Less.	
Senecio *pseudo-arnica* Less.	
Taxacrum sp. L.	Dandelion
Prenanthes *alata* (Hook.) Dietr.	Rattlesnake Root

APPENDIX III

SPECIES LIST

INTERTIDAL FLORA AND FAUNA OF UGIAUSHAK,ISLAND, ALASKA

1976

By

Gretchen Keiser

Intertidal Invertebrate Collections

Intertidal invertebrates were collected from two locations on Ugaiushak Island (see attached figure). A list of those organisms collected is attached. Identification of specimens was made through the courtesty of the Aquatic Collections, University of Alaska Museum. The following people are greatfully acknowledged for their assistance:

Max Hoberg - echinoderms
Nora Foster - mollusks
Linda Schandelmeier - algae
Darleen Masiak - algae
Gretchen Keiser - everything else

All specimens were donated to the algal and invertebrate collection of the University of Alaska Marine Collections.

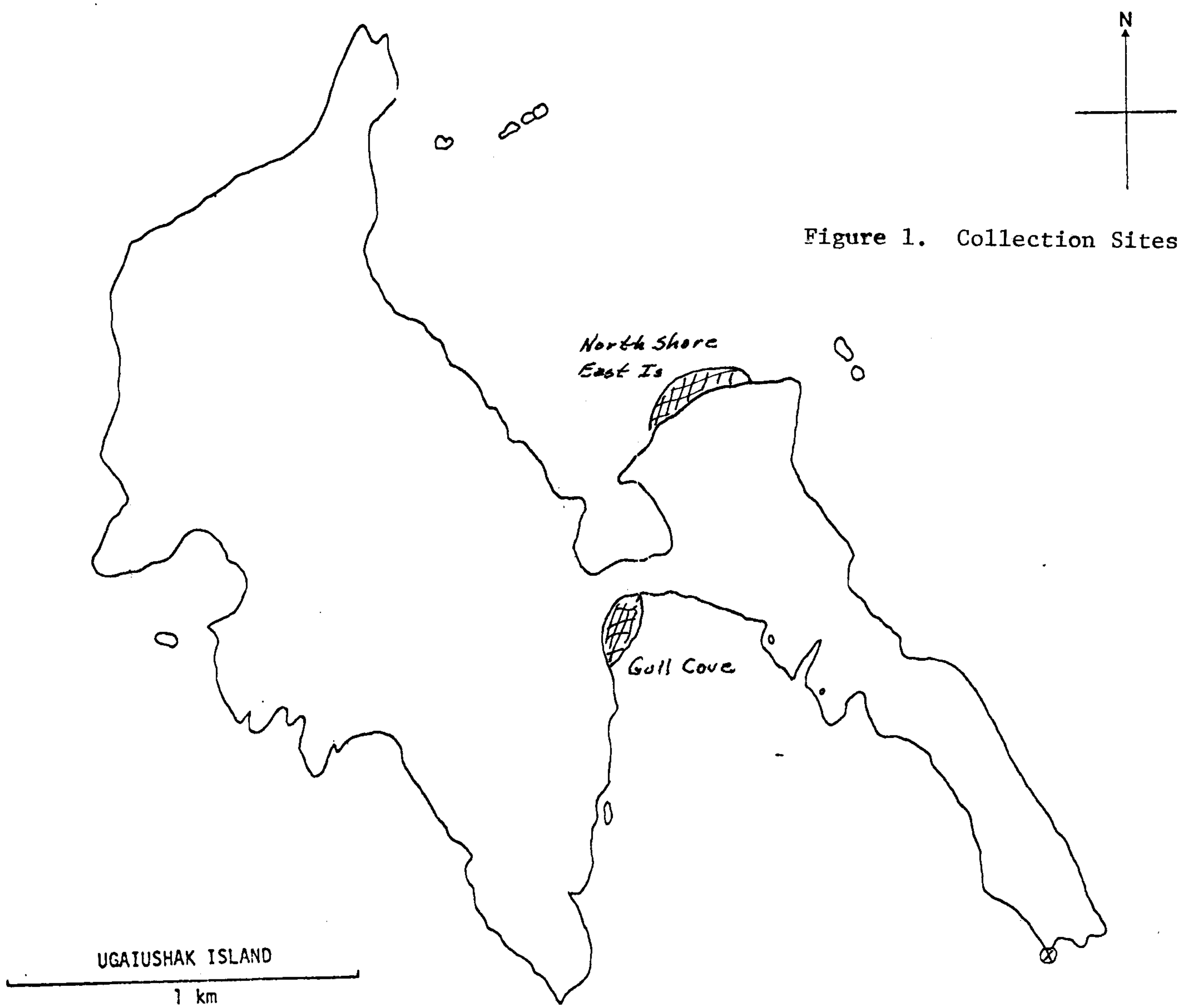


Figure 1. Collection Sites

Gull Cove - 23 August 1976

Chlorophyta

Monostroma fuscum
Spongomorpha spinescens

Phaeophyta

Fucus sp.
Soranthera ulvoidea

Rhodophyta

Endocladia muricata
Odonthalia floccosa
Gigartina papillata (*stellata*) complex

Mollusca

Class Pelecypoda

Mytilus edulis

Class Gastropoda

Littorina sitkana
Nucella lima
Collisella pelta
Musculus vernicosus

Class Polyplacophora

Katharina truncata

Arthropoda

Class Crustacea

Balanus balanoides
Pagurus hirsutiusculus hirsutiusculus
Cancer oregonensis

North Shore, East Island - 24 August 1976

Chlorophyta

Enteromorpha intestinalis

Phaeophyta

Fuscus sp.
Alaria taeniata
Laminaria longipes
Lethesia difformis

Rhodophyta

Ptilota filicina
Iridaea sp. c. f. *I. cordata*
Odonthalia floccosa
O. sp.
Callophyllis sp.
Corallina vancouveriensis
C. sp.
Bossiella sp. c. f. *B. cretacea*
Pterosiphonia bipinnata
Halosaccion glandiforme
Gigartina papillata (stellata) complex

Parazoa

1 unidentified species

Cnidaria

Class Hydrozoa

2 hydroid spp.

Class Anthozoa

1 unidentified sp.

Mollusca

Class Pelecypoda

Mytilus edulis

Mollusca (con't)

Class Gastropoda

Littorina sitkana
Nucella lamellosa
Collisella pelta
C. digitalis
C. scutum
Musculus vernicosus
M. corrugatus
Margarites helcinus
Cingula aleutica
Lacuna vincta
Onchidella borealis

Class Polyplacophora

Katharina truncata

Annelida

Class Polychaeta

at least 4 spp. unidentified

Arthropoda

Class Crustacea

Balanus glandula
B. cariosus

1 isopod, suborder Oniscoidea c. f. *Ligidium sp*. (terrestrial)

amphipod spp.

Pugettia gracilis

Echinodermata

Class Asteroidea

Henrecia leviuscula
Leptasterias hexactis

Class Echinoidea

Strongylocentrotus drobachiensis

APPENDIX IV

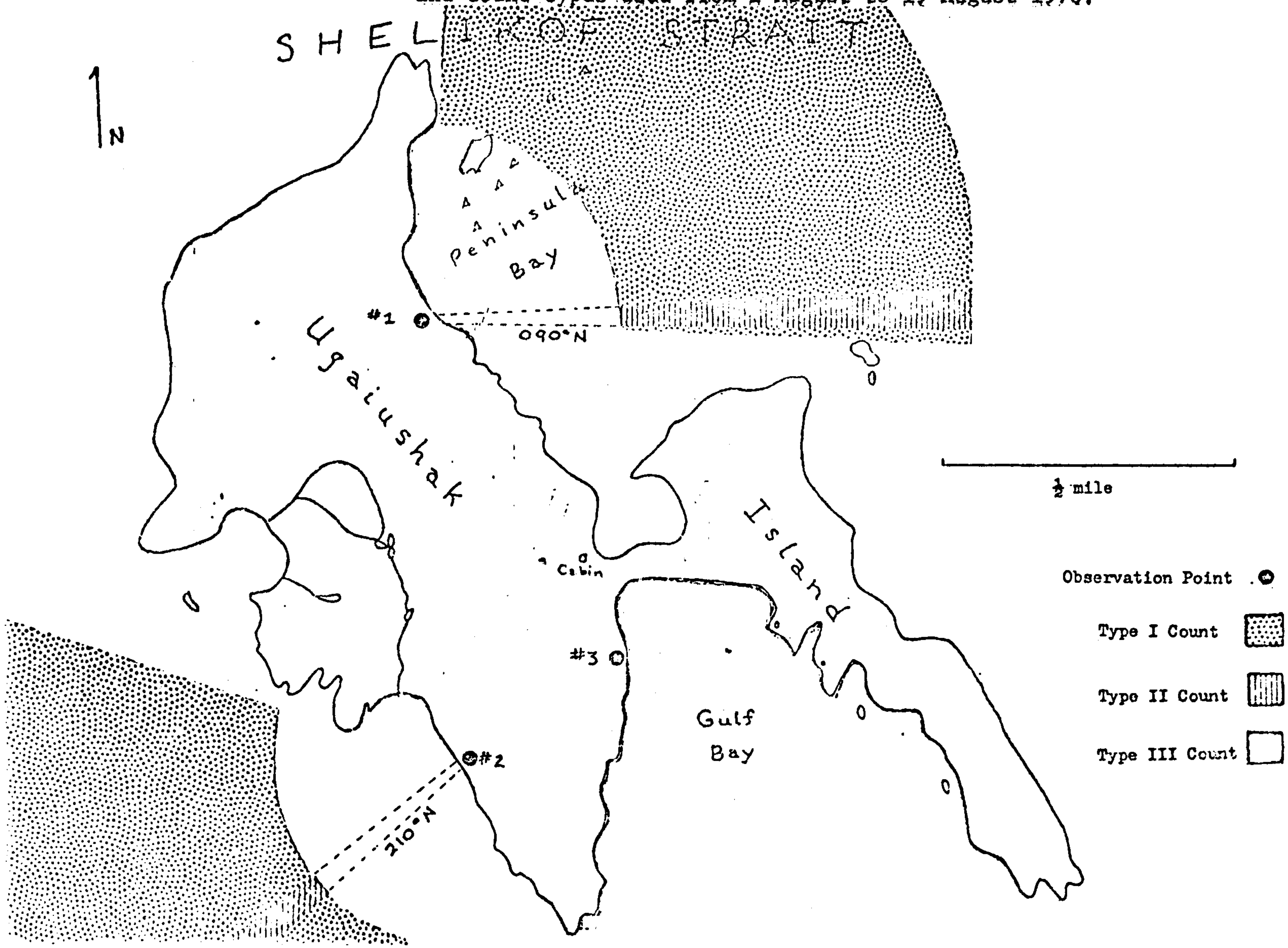
SEA WATCHES CONDUCTED ON UGIAUSHAK ISLAND, ALASKA

1976

SEA WATCHES

Three sea watch stations were established on Ugaiushak Island (see attached figure). Hoberg conducted sea watches during June and the first half of July, and Powers conducted them from 1 to 19 August. Sea watches were conducted according to instructions issued by the U.S. Fish and Wildlife Service (attached) and data were recorded on Sea Watch Program forms (attached) and submitted to USFWS Office of Biological Services - Coastal Ecosystems. Dates and times of Powers' sea watches are attached; however, similar data from Hoberg's observations were not available at the time of this writing.

Figure 1. Map of Ugaiushak Island showing sea watch stations and count types used from 1 August to 19 August 1976.



ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to
March 31, 1977

STUDIES OF SEABIRD PARASITES FROM UGAIUSHAK ISLAND, ALASKA

A Preliminary Review

By

Eric P. Hoberg
University of Saskatchewan
Saskatoon, Canada

Part V

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS

OF MARINE BIRDS IN THE GULF OF ALASKA

AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. J. Gould
R. E. Gill and G. A. Sanger
Co-principal Investigators

U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

March 1977

INTRODUCTION

During the 1976 field season one-hundred and thirty-eight birds of nine species of marine avifauna were collected near Ugiaushak Island, Alaska (156° 51' W, 56° 47' N)as part of an ecological study under the guidance of the U.S. Fish and Wildlife Service (Table I). Breeding biology, feeding habits, and eco-parasitological relationships of numerous seabird species were investigated concurrently. This report is a brief summary outlining the progress and preliminary results in a study of host-parasite relations among seabirds.

Primary emphasis was placed on the study of endoparasitic helminths of four seabird species including, the Black-legged Kittiwake, (*Rissa tridactyla*), Glaucous-winged Gull, (*Larus glaucescens*), Common Murre, (*Uria aalge*), and Tufted Puffin, (*Lunda cirrhata*), as well as five peripheral species including the Horned Puffin, (*Fratercula corniculata*), Thick-billed Murre, (*Uria lomvia*), Rhinoceros Auklet, (*Cerorhinca monocerata*), Pigeon Guillemot, (*Cepphus columba*), and Fulmar, (*Fulmarus glacialis*). The intent of the study being, to determine the effectiveness of parasitological data as a possible indicator of divergencies in feeding strategies, i.e., delineation or further elucidation of possible mechanisms enhancing ecological segregation among the closely related seabird species investigated. It was also hoped that parasite burdens coupled with physiological indices could prove useful in describing the relative conditions of the birds that were collected.

Parasites of four major taxonomic groups were recovered during the course of the study. These included four groups of helminths from the gastrointestinal system, (Nemathelminthes, Acanthocephala, and Platyhelminthes, including the Digenean Trematoda and Cyclophyllidean Cestoda), as well as representatives of the Pentastomida, an aberrant group of endoparasitic arthropods normally occurring in the air sacs and bronchi of seabirds.

ACKNOWLEDGEMENTS

This study was conducted as part of a comprehensive study of population and ecology of seabirds nesting on Ugiaushak Island.

I would like to thank Dr. James Bartonek for allowing this much needed study to be initiated and the U.S. Fish and Wildlife Service for support in the field. Also I would like to thank D.H.S. Wehle and G.C. Burrell who were responsible for some of the seabird collections.

STUDY METHODS

All avian specimens were collected within a few kilometers of Ugiaushak Island (with the exception of several specimens collected at Chowiet Island to the south). Post mortem examination immediately followed, including collections of endoparasitic helminth parasites, ectoparasitic arthropods and food samples from the anterior alimentary system (esophagus, proventriculus, and muscular stomach).

Owing to the field camp conditions it was not feasible to conduct complete and reliable examinations of all internal organs, and accordingly collection of helminths associated with the gastrointestinal system was stressed (intestinal system, gall bladder and liver). Intestines were opened full length in water, contents "stripped" and the helminth specimens allowed to relax a minimum of thirty minutes before being fixed with hot ten percent formalin solution (70°C.). The gall bladder was treated in a similar manner while the liver was examined externally and internally for lesions that may have been associated with parasitic infections. Any other tissue which appeared to be abnormal was also fixed in hot formalin and reserved for histological review. The anterior alimentary tract and total contents were also fixed with hot formalin for later analysis of parasites and prey items.

In the laboratory, helminths were recovered from the preserved intestinal contents and counted. Material is presently being prepared for identification and at this time, it is not practicable to make any taxonomic judgements beyond those that are presented. The contents of this report are for this reason, based solely on analysis of total counts and comparisons of mean helminth burdens by one-way analysis of variance (f test).

An attempt was made to develop criteria to access physiological conditions among seabirds collected. A standard fat index employing a one to five scale (Table II), a weight ratio involving a relation of eviscerated body weight/whole body weight and an emaciation index involving a ratio of muscle depth at keel mm/depth of keel mm, (Cornwell et. al., 1963) were used in the study.

RESULTS AND DISSCUSSION

The salient features of these parasite collections are presented in Figure I and Tables III and IV. It is immediately apparent that *Larus glaucescens* is by far the most heavily parasitized species followed by *Fratercula corniculata*, *Uria lomvia*, *Rissa tridactyla*, *Lunda cirrhata*, and *Uria aalge*. The six species fall roughly into three significantly different groups (P.<.001) based solely on mean total helminth infections between species.

The opportunistic and to some degree littoral feeding *Larus glaucescens* is separated from two distinct groups of predominantly pelagic feeding species represented by: 1) Fratercula corniculata and Uria lomvia, and 2) Rissa tridactyla, Lunda cirrhata, and Uria aalge. The differences observed in the mean total helminth infections between the three groups are highly significant and may represent differences in feeding strategy. However, there are other factors that must also be recognized as possible causal factors including, prey species availability (related to the dilution effect of the marine environment), or viability of larval parasite stages as well as prey species, (Belopolskaya, 1947, 1952, and Threlfall, 1968, 1971), physiological variance in host species or strict host-parasite specificity relationships.

The preliminary findings to some degree parallel those of Threlfall (1968, 1971), who found larids were more heavily infected and harbored a greater diversity of parasites than the alcid species investigated.

Although detailed taxonomic judgement is deferred it appears that at least three families of Cestoda, four families of Trematoda, one family and species of Acanthocephala, an unspecified number of Nemathelminthes and the aberrant arthropods, Pentastomida, are involved in the present infections (Table IV). All of the helminth parasites were recovered from the intestine while members of the trematode family Gymnophallidae were recovered from both the intestine and the lumen of the gall bladder. Pentastomida were found in the intestine (one specimen from Uria aalge) and coiled among the mesentery (sixteen specimens from Rissa tridactyla). Pentastomes are normally found in the air sacs and bronchi of various lariform birds (Bakke, 1972) and these infections may be representative of migrations from the intestine to the respiratory system.

Of interest is the occurrence of gymnophallid trematodes in both Lunda cirrhata (13.3%), and Fratercula corniculata (80%), both believed to be primarily pelagic feeders of fish and marine plankton, (Bedard, 1967, Swartz, 1966, and Wehle, 1976) and occaisionally unspecified molluscs, and crustacea (Belopolskii, 1957, and Bent, 1919). The various Gymnophallus sp. are fairly well known (Bartoli, 1974, Frank, 1969, Loos-Frank, 1969, 1971 a,b) and in the majority of cases their lifecycles involve intertidal lamellibranchs and to a lesser extent polychaetes (Margolis, 1971, 1973) as intermediate hosts. The occurrence of gymnophallids in puffins is interesting in that it could be an indication that these birds are feeding in the littoral/intertidal areas to a greater extent than is presently indicated by food habit analysis.

Trematodes are particularly suited as indicators of differences in feeding strategies between ecologically similar marine birds when their lifecycles and developemental stages are known. Unlike most cestodes, trematodes generally exhibit a host specificity for their particular molluscan intermediate host and an ecological specificity for the definitive host. Following from this observation it would appear that differences in trematode species composition between similar avian hosts might be attributable to definable differences in feeding.

Differences in mean total helminth infections as discussed previously may also be useful as indicators of segregation through feeding and undoubtedly the significant differences observed between *Larus glaucescens* and the two groups of pelagic species is of biological significance and directly related to the ethological, spatial and qualitative aspects of foraging. However, the determinants of differences observed between the group one and two pelagic species are unclear and require further investigation to be elucidated.

In a few cases pathological lesions and/or fibrosis appeared to be associated with helminth infections. This was especially noted in some cestode infections in *Uria* sp., and gymnophallid infections of the gall bladder in both alcids and larids. There appears to be a greater degree of pathogenesis involved with helminth infections in alcids than larids, however, the species composition involved in these relationships has not been identified. It is difficult to determine the physiological importance of helminth associated lesions or to what degree they are representative of the "normal" host-parasite relationship.

Physiological condition as determined by a combination of fat classification and emaciation index would have a wide application on accessing conditions of birds when the period of the breeding season is taken into account. With this small sample and more importantly from a confined period in the breeding season, it is difficult to ascertain the reliability of the observations that have been made. Generally speaking, however, it would appear that those birds exhibiting at E.I. .90 and fat index 3 might be in good condition while those with an E.I. .75 and fat index 2 might be in "fair to poor" condition. The categories must remain fluid to account for physiological variances at the breeding population level during all phases of the reproductive cycle. At this time, the weight ratio method does not appear to be of great reliability due to a high variability as an artifact of feeding frequency.

SUMMARY

The role of parasitism in the marine bird colony ecosystem is a relatively unknown but important factor that has been ignored in the majority of studies concerning seabirds. Knowledge of what constitutes a "normal infection" coupled with emaciation and fat indicies could be reliable indicators of physiological condition. Relationships involving differences in feeding strategies, wintering areas, and dispersal routes could be indicated by species and ecologically specific parasite fauna.

The preliminary data presented clearly indicate significant differences in the mean total helminth infections between the seabird groups studied ($P < .001$). It is thought perhaps, that these differences are a direct relationship of divergencies in feeding strategies among ecologically similar species. This is not a particularly significant revelation when comparing Larus glaucescens to the groups one and two pelagic species. However, if the relationship indicated by this relatively small sample is supported by further collections of the pelagic species, especially the puffins and congeneric murres, it could be important as an indicator of mechanisms enhancing ecological segregation.

REFERENCES

Bakke, Tor, A. 1972. Reighardia sternae (Diesing 1864) Ward 1899 (Pentastomida: Cepholobaenida) from the common gull (Larus canus L.) in a Norwegian locality. Norw. J. Zool. 20. 273-277.

Bartoli, P. 1974. Rechercies sur les Gymnophallidae F. N. Morozov, 1955 (Digenea) parasites d'oiseaux des cotes de camargue: Systematique, biologie et ecologie. Unpub. Phd. Diss.

Bedard, J. 1969. Adaptive radiation of the Alcidae. Ibis 111 189-198.

Belopolskaya, M. M. 1947. Parasitic fauna of the birds of the Seven Islands Sanctuary (East Murman). Lecture, Leningrad State Univ. Library.

__________ 1952. The parasitic fauna of marine birds. Uch. Zap. Leningrad Ordena LeninaGos. Univ. Im. A. A. Zhadanova Ser. Biol. Nauk. 141 (28) 127-180 (In Russian).

Belopolskii, L. O. 1957. Ecology of the colonial seabirds of the Barents Sea. (English trans. 1961. Israel Prog. Sci. Transl. Jerusalem).

Bent, A. C. 1919. Life histories of North American diving birds. U. S. Nat. Mus. Bull. No 107. 239p.

Cornwell, G. W. and A. B. Cowan. Helminth populations of the canvasback (Aythya valisineria) and host parasite environmental relationships. 28th N. Am. Wildlf. Conf. March 4, 1963.

Frank, Brigitte. 1969. The remarkable lifecycle of the marine avian trematode Gymnophallus choledochus. J. Ornithol. 110(4) 471-474.

Loos-Frank, B. 1969. Studies on the gymnophallid trematodes of the North Sea, I. The alternative life cycles of Gymnophallus choledochus Odhner 1900. Z. Parasitenk. 32(2) 135-136.

__________ 1971a. Studies on the Gymnophallid trematodes of the North Sea IV. A survey of gymnophallid larvae of intertidal molluscs. Z. Parasitenk. 36(3) 206-232.

__________ 1971b. Studies on the gymnophallid trematodes of the North Sea III. Gymnophallus gibberosus n.sp. and its metacercaria. Z. Parasitenk 35(4) 270-281.

Margolis, L. 1971. Polychaetes as intermediate hosts of helminth parasites of vertebrates: a review. J. Fish Res. Bd. Can. 28 1385-1392.

__________ 1973. Additional notes on polychaetes as intermediate hosts of helminth parasites of vertebrates. J. Fish Res. Bd. Can. 30 469-470.

Swartz, L. G. 1966. Sea-cliff birds p. 611-678 In N. J. Wilimovsky and J. N. Wolfe eds. Environment of the Cape Thompson Region, Alaska. U. S. Atomic Energy Commission.

Threlfall, W. 1968. The helminth parasites of three species of gulls in Newfoundland. Can. J. Zool. 46.

____________ 1971. Helminth parasites of alcids in the northwestern North Atlantic. Can. J. Z ool. 49.

Wehle, D. H. S. 1976. Summer food and feeding ecology of Tufted and Horned Puffins on Buldir Island, Alaska. Unpub. M. S. Thesis Univ. Alaska.

TABLE I. SEABIRD COLLECTIONS AT UGIAUSHAK I.

Species	# Collected
Larus glaucescens	20
Rissa tridactyla	35
Lunda cirrhata	30
Uria aalge	31
Fratercula corniculata	10
Uria lomvia	8
Cerorhinca monocerata	2
Cepphus columba	1
Fulmarus glacialis	1

TABLE II FAT CLASSIFICATION SCALE

1. Very little vesceral and neck fat. No fat on skin. Feather papillae very evident on breast. Little fascia and grey-orange fat at humerus and femur junctions with body.

2. Some visceral and neck fat. Feather papillae still evident on breast. Slight streak of yellow on back portion of breast muscle (posterior end of sternum). Streak along trachea before it enters clavicles. Slight streak along femur between femur and tibial muscle.

3. Moderate visceral fat. Fat on skin but papillae still visible in dorsal half of belly tracts. Fat between tracts on belly and chest. Fat on bifuration of clavicles, femur and humeral regions.

4. Considerable visceral fat. Feather papillae not visible through skin.

5. Consolidated masses of visceral fat. Skin fat 1/8 - 1/4 inches thick. Heavy fat in bifuration of clavicles and along posterior edge of breast muscles. Fat on neck regions and over lower belly on skin.

TABLE III. OCCURRENCE OF SEABIRD PARASITES

Species Species	Max. #	Min. #	# Hosts Infected	$\overline{x}$/Infected host	% Frequency of occurrence
Larus glaucescens N = 20 $\overline{x}$ = 172.45±370.76					
Cestoda	32	3	20	15.60	100.00
Trematoda	1,601	1	18	165.00	90.00
Nematoda	1	1	2	1.00	10.00
Acanthocephala	0	0	0	0.00	0.00
Rissa tridactyla N = 35 $\overline{x}$ = 3.43±5.20					
Cestoda	21	1	25	3.96	71.4
Trematoda	1	1	1	1.00	2.9
Nematoda	4	4	1	4.00	2.9
Acanthocephala	0	0	0	0.00	0.00
Pentastomida	6	1	4	4.00	11.4
Lunda cirrhata N = 30 $\overline{x}$ = 2.60±3.29					
Cestoda	9	1	15	2.33	50.0
Trematoda	6	2	4	3.75	13.3
Nematoda	13	1	11	2.55	36.7
Acanthocephala	0	0	0	0.00	0.00
Uria aalge N = 31 $\overline{x}$ = 2.13±3.65					
Cestoda	17	1	15	3.73	48.4
Nematoda	2	1	5	1.20	16.1
Acanthocephala	2	1	2	1.50	6.5
Pentastomida	1	1	1	1.00	3.2
Fratercula corniculata N = 10 $\overline{x}$ = 13.80±21.66					
Cestoda	65	1	8	13.50	80.0
Trematoda	6	1	9	3.00	90.0
Nematoda	2	2	1	2.00	10.0
Acanthocephala	1	1	1	1.00	10.0
Uria lomvia N = 8 $\overline{x}$ = 13.50±21.51					
Cestoda	62	3	8	12.75	100
Trematoda	0	0	0	0.00	0.00
Nematoda	4	1	3	2.0	25.0
Acanthocephala	0	0	0	0.00	0.00
Cerorhinca monocerata N = 2 $\overline{x}$ = 18.0±12.73					
Cestoda	2	1	2	1.5	100
Nematoda	25	8	2	16.5	100

TABLE III. OCCURRENCE OF SEABIRD PARASITES (Cont'd.)

Species Species	Max. #	Min. #	# Hosts Infected	$\overline{x}$/Infected host	% Frequency of occurrence
Cepphus columba	N = 1				
Cestoda	2	2	1	--	100
Fulmarus glacialis	N = 1				
Cestoda	202	202	1	--	100

$\overline{X} \pm$ SD for total helminth populations.

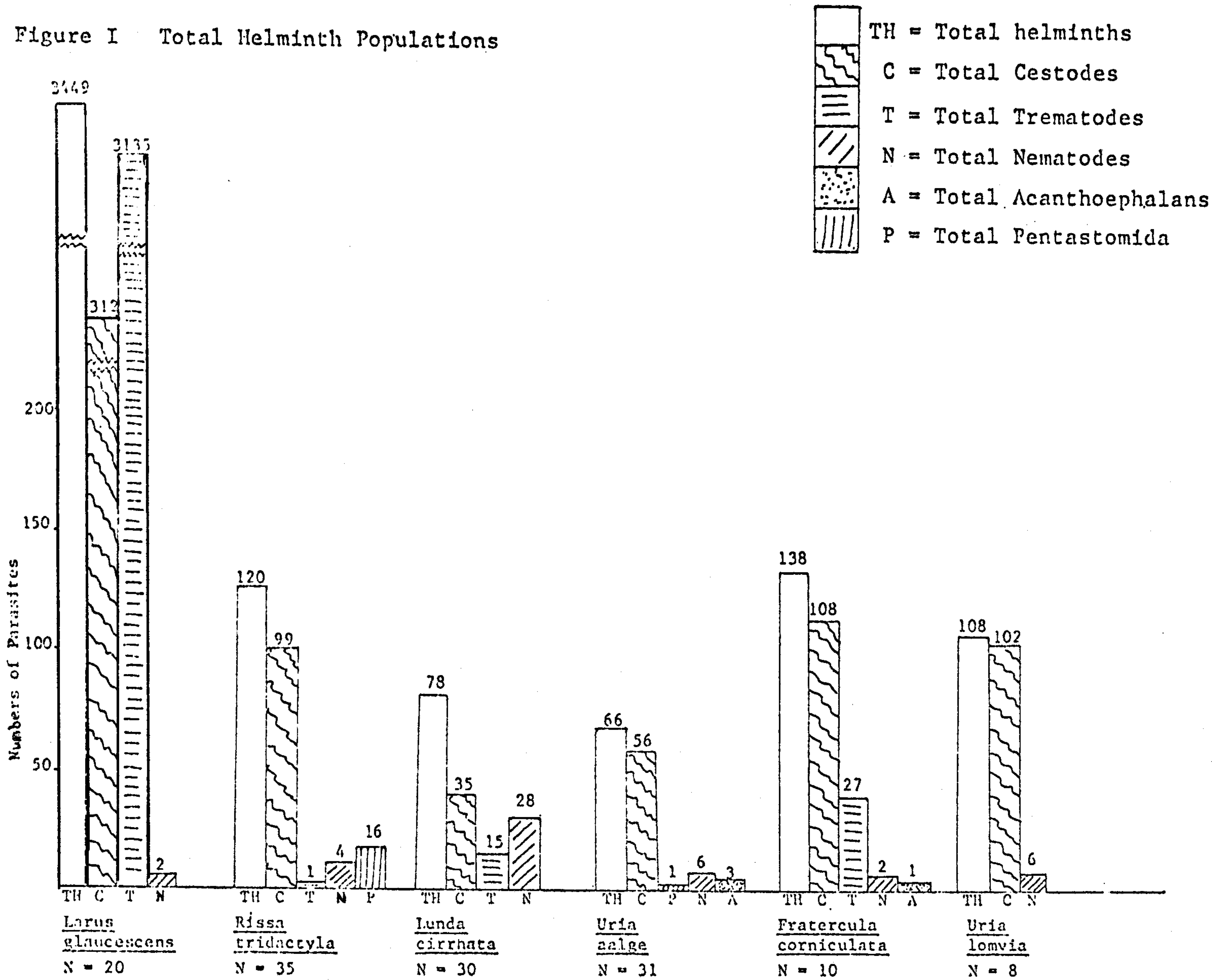
TABLE IV % FREQUENCY OF OCCURRENCE OF PARASITES

	Larus glaucescens	Rissa tridactyla	Lunda cirrhata	Uria aalge	Fratercula corniculata	Uria lomvia
Çestoda (Cyclophyllidea)	100	71.4	50	48.4	80	100
Tetrabothriidae	95	40	--	--	10	---
Others: Dilepididae Hymenolepididae	100	46	50	48.4	70	100
Trematoda (Digenea)	90	2.9	13.3	0.0	90	0.00
Echinostomatidae	65	2.9	--	--	20	---
Aporchis sp.	20	2.9	--	--	--	---
Gymnophallidae	50	--	13	--	80	---
Gymnophallus sp.	50	--	13	--	80	---
Microphallidae	65	--	--	--	--	---
Microphallus sp.	60	--	--	--	--	---
Maritrema sp.	10	--	--	--	--	---

TABLE IV % FREQUENCY OF OCCURRENCE OF PARASITES (Cont'd.)

	Larus glaucescens	*Rissa tridactyla*	*Lunda cirrhata*	*Uria aalge*	*Fratercula corniculata*	*Uria lomvia*
Heterophyidae	45	--	--	--	--	---
Acanthocephala	0.0	0.0	0.0	6.5	10.0	0.00
Nemathelminthes	10	2.9	36.7	16.1	10.0	25.0
Pentastomida	0.0	11.4	0	3.2	0.0	0.00

Figure I Total Helminth Populations



PART VI WAS NOT INCLUDED

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to March 31, 1977
Pages:

DYNAMICS OF MARINE BIRD POPULATIONS ON THE BARREN ISLANDS, ALASKA

By

David A. Manuwal and Dee Boersma

College of Forest Resources
and
Institute for Environmental Studies
University of Washington
Seattle, Washington 98195

PART VII

Of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. J. Gould
R. E. Gill and G. A. Sanger
Co-principal Investigators

U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
Anchorage, Alaska

March 1977

DYNAMICS OF MARINE BIRD POPULATIONS
ON THE BARREN ISLANDS, ALASKA

Annual Report, 1976

David A. Manuwal, Principal Investigator
Wildlife Science Group
College of Forest Resources
University of Washington

Dee Boersma, Co-Principal Investigator
Institute for Environmental Studies
University of Washington
Seattle, WA 98195

January 15, 1977

Table of Contents

INTRODUCTION

This report summarizes field research on marine bird communities conducted by the University of Washington on contract (#14-16-0008-2054) with the U.S. Fish and Wildlife Service. It represents only one of several other investigations on the basic reproductive biology and food chain dynamics of marine birds in Alaska during 1976.

Increased oil development and transportation in the northern Gulf of Alaska area will have an unknown effect on the large populations of marine birds and mammals residing in or migrating through the area. Until recently (Bailey 1976), no accurate information was available for marine birds breeding in the Barren Island Group, northern Gulf of Alaska. Bailey's population estimates indicate that these islands represent the most important seabird rookeries in the region. The sale of offshore oil leases in nearby waters has made necessary an intensive study of the baseline characteristics of important seabird species breeding on the Barren Islands.

Members of the research team include David A. Manuwal (Principal Investigator), Dee Boersma (Co-Principal Investigator), Naomi J. Manuwal (Research Associate), Michael Amaral (Graduate Research Assistant) and Mary Nerini (Research Assistant). All personnel are associated with the University of Washington, Seattle.

Logistic support was provided by the U.S. Fish and Wildlife Service (OBS-Anchorage). A charter vessel, the M/V NORDIC PRINCE transported personnel to and from the island and made three supply trips during the summer. A summary of the itinerary and activity of the research team is found in Appendix A.

OBJECTIVES OF STUDY

1. To determine the species composition and abundance of marine birds.

2. To determine the local distribution and nesting requirements of all breeding seabirds.

3. To determine the productivity of as many breeding species as possible.

4. To determine the types and quantities of food consumed by selected seabird species.

5. To make incidental observations on the migration of waterfowl, shorebirds and seabirds, and distribution and abundance of marine mammals.

DESCRIPTION OF STUDY AREA

The Barren Islands (58°55'N, 152°10'W) are located at the entrance to Cook Inlet, which lies between the Kodiak Island archipelago and the Kenai Peninsula (Figure 1). The Gulf of Alaska lies to the east of the Barren Islands.

Strong tidal currents occur in the Barren islands. These are often compounded by tide rips and severe winds. The wind and ocean currents in this area are usually much stronger than those a few miles away (Bailey 1976). Tidal amplitude ranges between three feet and 18.4 feet during the summer months.

There are seven named islands in the Barrens (Figure 1), which range from 25 to 6,935 acres. The island group totals approximately 10,000 acres and extends over an area about 13 miles long and five miles wide. The elevation ranges from sea level to 1,935 feet; most islands have ridges and cliffs 1,000 feet or higher. A more complete description of the Barren Islands is found in Bailey (1976).

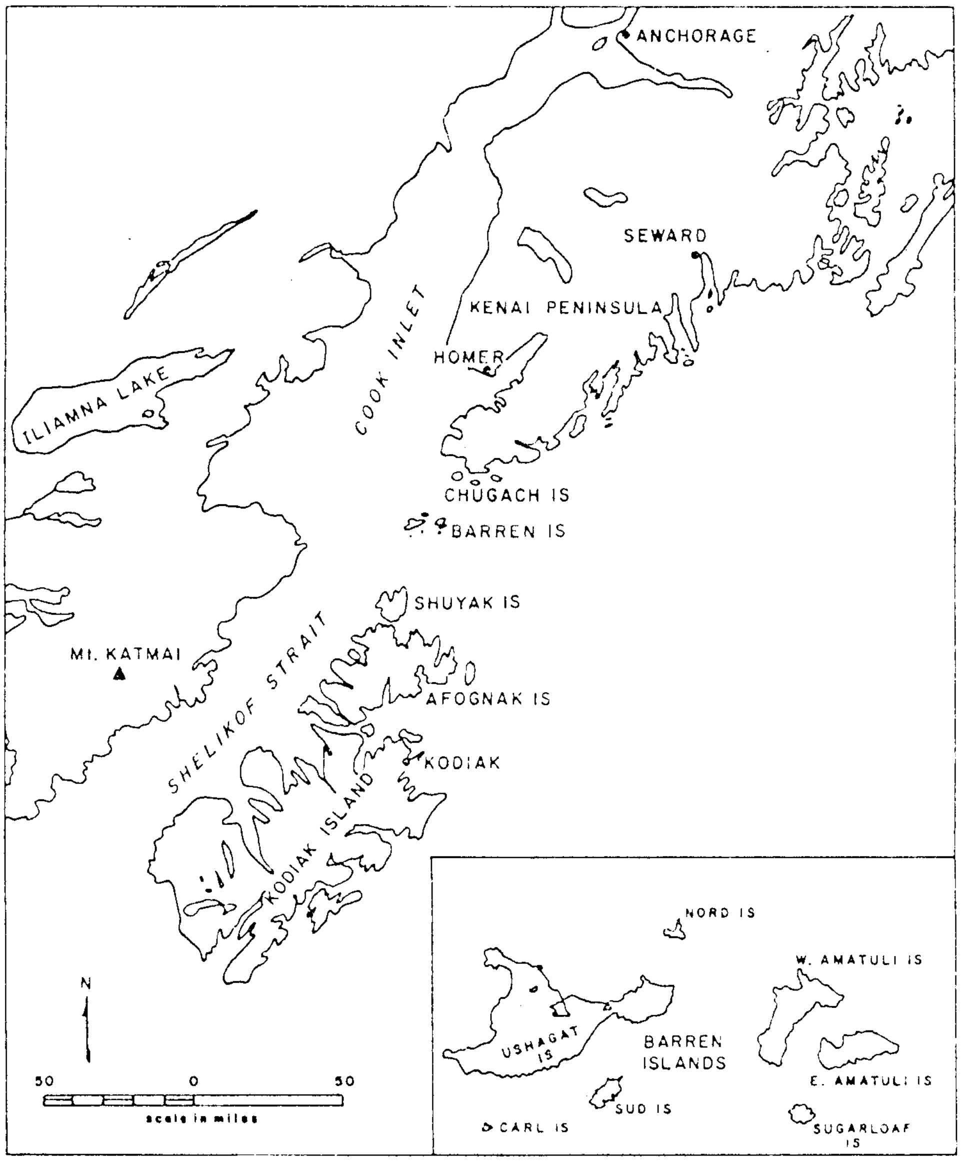


Figure 1. Map of the Barren Islands

CLIMATE OF THE BARREN ISLANDS

Bailey (1976) discusses the temperature and precipitation at weather stations on the Kenai Peninsula and Kodiak Island. The average precipitation is 23 inches and 57 inches per year respectively; the temperature is 36° and 41°. The mean annual wind velocity is 10.1 mph at Kodiak. He infers the climate of the Barrens would resemble that of Kodiak Island, with higher winds.

Weather data were taken on East Amatuli from June through August 1976. The weather station was established at our camp, which was protected by its location in a circular hollow created by dunes. It was further protected by its location in the interior valley formed by two 1,300 foot ridges, a 500 foot ridge and the 1,300 foot ridge of an adjacent island. Thus it was protected from the high winds of the open ocean.

The precipitation increased from near zero (0.12 inches) in June to 3.23 inches in July and to 9.8 inches in August (Figure 2), making a total of 13.15 inches for the three summer months.

The mean maximum temperature remained fairly constant for June, July and August (66.1°, 68.6°, and 66.9°, respectively). The mean minimum temperature rose in June but stabilized in July and August (49.8°, 55.7° and 56.0° respectively). There was considerable daily variation, especially for the maximum temperatures (Figure 3).

The minimum wind velocities for late June, July and August were 5.4, 6.7 and 15.4 mph respectively. The wind velocity measured was an average of the range of constant values; it makes no allowances for wind gusts which often reached 30 mph in our sheltered location (Figure 4).

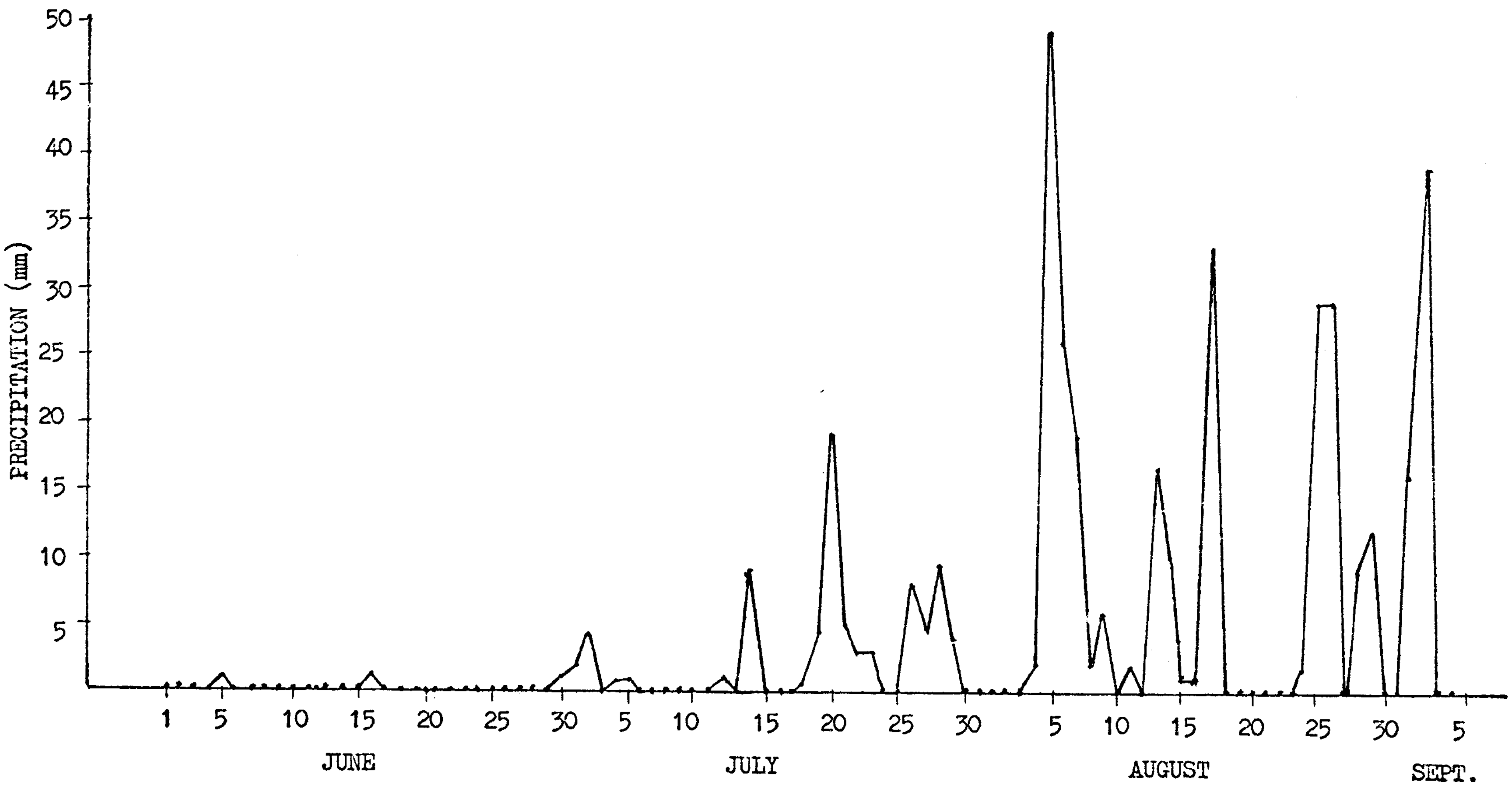


Figure 2. Precipitation falling at East Amatuli Island from 1 June to 8 September 1976.

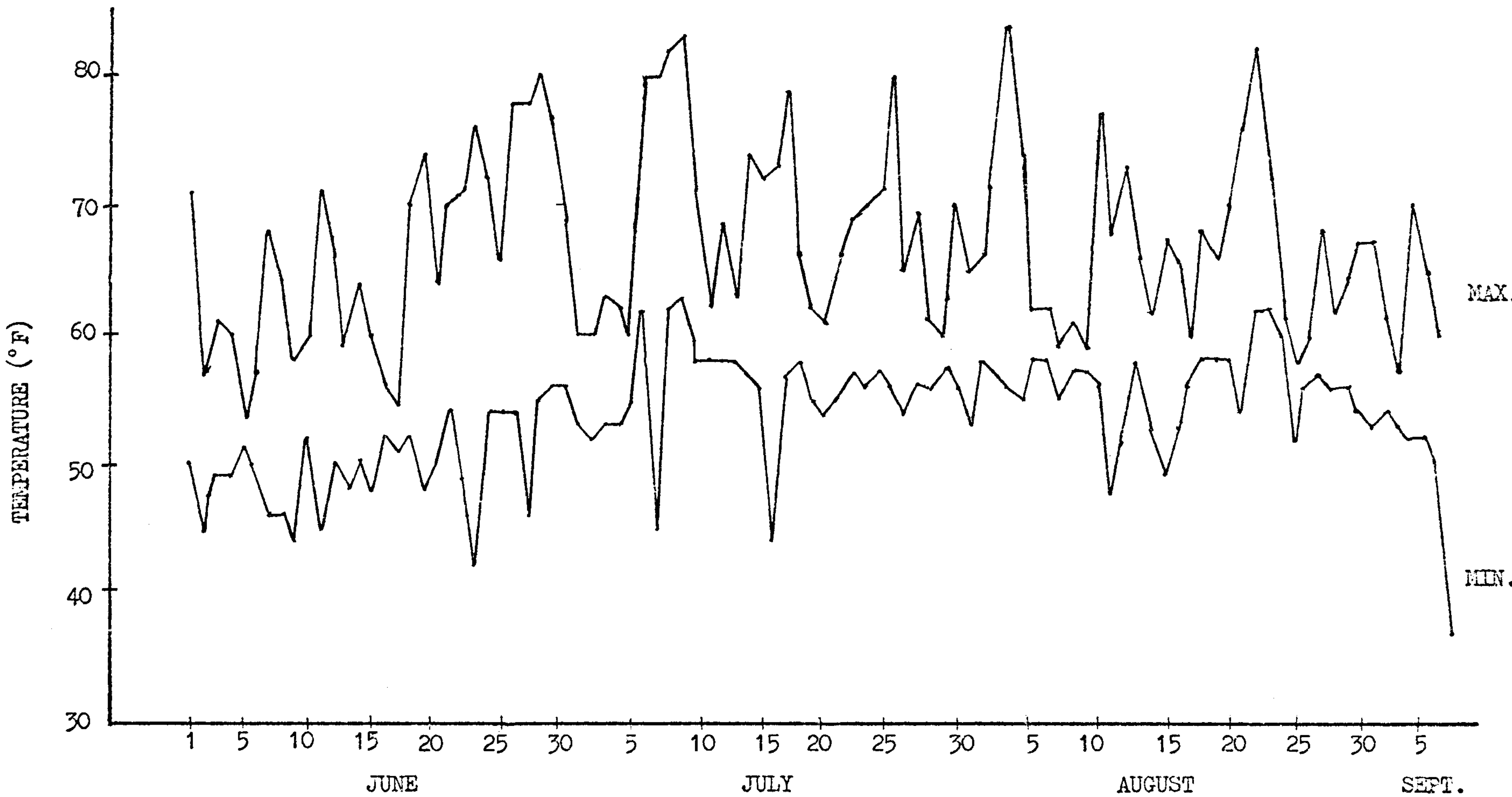


Figure 3. Maximum and minimum temperatures recorded at East Amatuli Island 1 June to 8 September 1976.

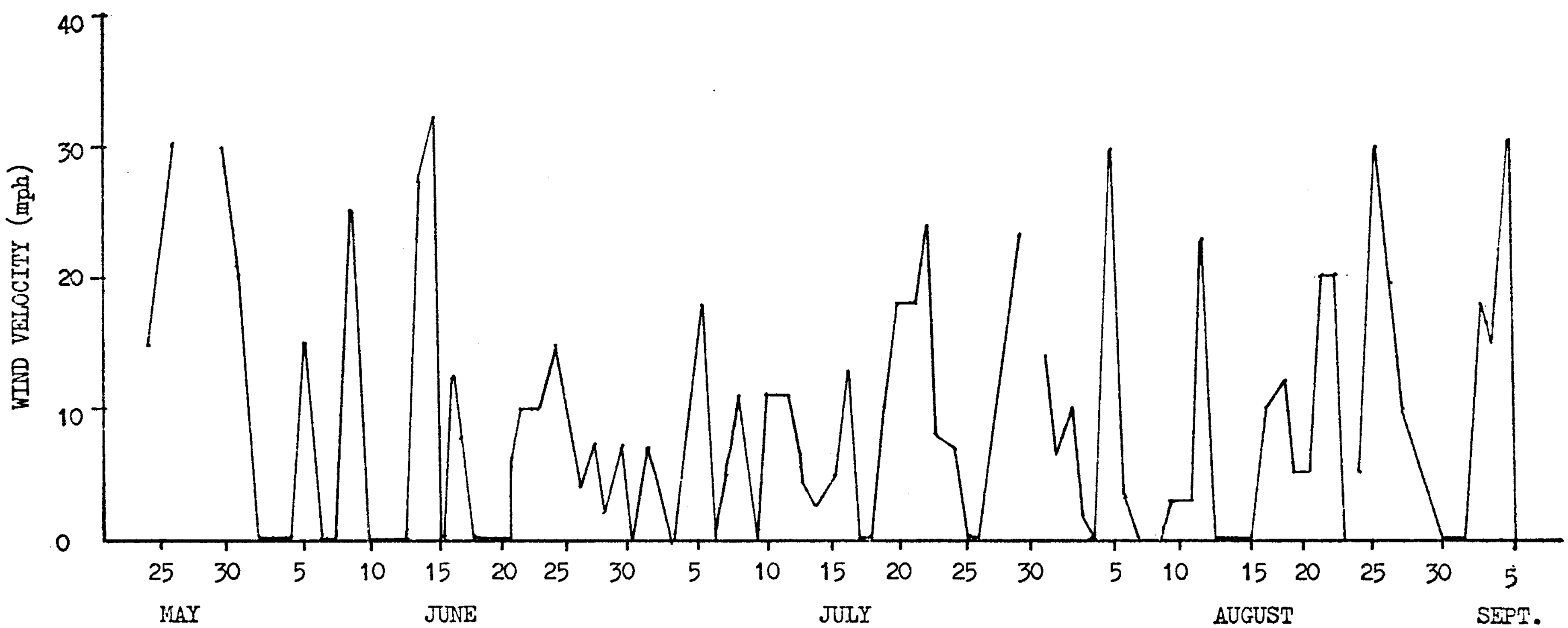


Figure 4. Wind velocities recorded at East Amatuli Cove 24 May to 5 September 1976. There are underestimates for the open ocean in the Barren Islands.

Wind direction was mainly from the southwest in late June. In July the southeast quadrant was the principal direction from which 50 percent of the winds came with about 30 percent coming from the northeast. In August, 50 percent of the winds still came from the southeast, but over 30 percent came from the northwest. Thus, it appears that the winds come mainly from the southeast in summer months, with a slight shift to the northern quadrants as fall approaches. The June data for wind speed and direction were collected only the last week of June and so are biased results for that month. The wind direction and speed are also biased by the location of our camp, but they appear adequate for a general analysis.

During June the skies were totally overcast or obscured by fog 46.7 percent of the time; this increased to 67.7 percent for July and August. Clear days decreased from 40 percent in June to 22.6 percent in July and 19.3 percent in August. These changes paralleled those of the precipitation and wind increases and led to the general deterioration of the weather in August and early September. Table 1 summarizes the weather data.

Table 1. East Amatuli Weather Data, Summer 1976 (mean values).

	June	July	August
Precipitation (inches)	.1	3.2	9.8
Maximum Temperature °C	66.1	68.6	66.9
Minimum Temperature °C	49.8	55.7	56.0
Wind (mph)	5.4*	6.7	15.4
Wind Direction (%)			
Northeast	7.1*	27.8	9.6
Southeast	21.3*	50.0	50.2
Southwest	42.8*	16.7	4.8
Northwest	28.6*	7.4	35.7
Cloud Cover			
0-10%	40.0	22.6	19.3
11-85%	13.3	8.7	12.9
86-100%	46.7	67.7	67.8

*These data are for the last week of June only.

VEGETATION COMMUNITIES OF THE BARREN ISLANDS

Bailey (1976) gives a general discussion of the vegetation of the Barren Islands which is summarized below. East Amatuli, Sugarloaf, Sud, Nord, and Carl Islands are principally covered with grasses and sedges. The largest islands, Ushagat and West Amatuli, are dominated by grass-sedge communities on lower elevations and windward slopes. Crowberry (*Empetrum nigrum*) associations dominate higher elevations and leeward slopes. Ushagat is largely covered by alpine tundra plants. It is the only island to have Sitka spruce (*Picea sitchensis*) groves. Seventy-six plant species were identified from Ushagat which was assumed to have the most diverse vegetation. Several of the islands have beach plant communities. The vegetation on East Amatuli and Sugarloaf is generally more lush than on the other islands, probably because they receive more moisture.

During the summer of 1976 a vegetation survey of East Amatuli was conducted. Preliminary vegetation analysis of the central valley indicates the presence of eight vegetation communities. Figures 5 and 6 illustrate the relative locations of these communities except for the beach community, which was a buffer between the beach and the dunes. Figure 5 is a view southeast; the fellfield is located at an elevation of 300 feet. Figure 6 is approximately northeast and is at a right angle to Figure 5.

The beach and marsh communities were small in area and had the most uniform species composition (Table 2). Even though the dunes were localized, there was a large ecotonal area between the dunes and adjacent

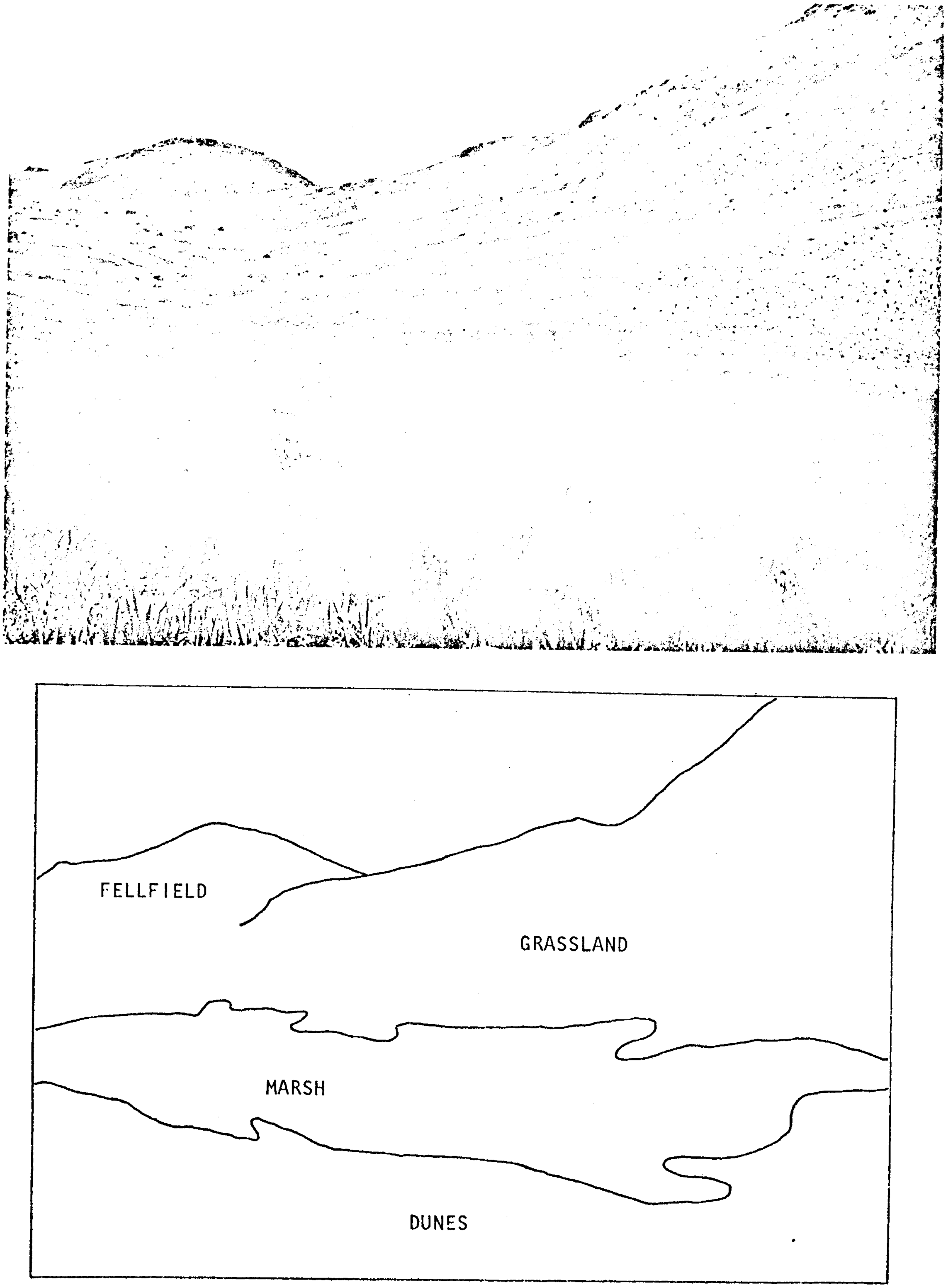


Fig. 5. Vegetation communities of East Amatuli (southeast view).

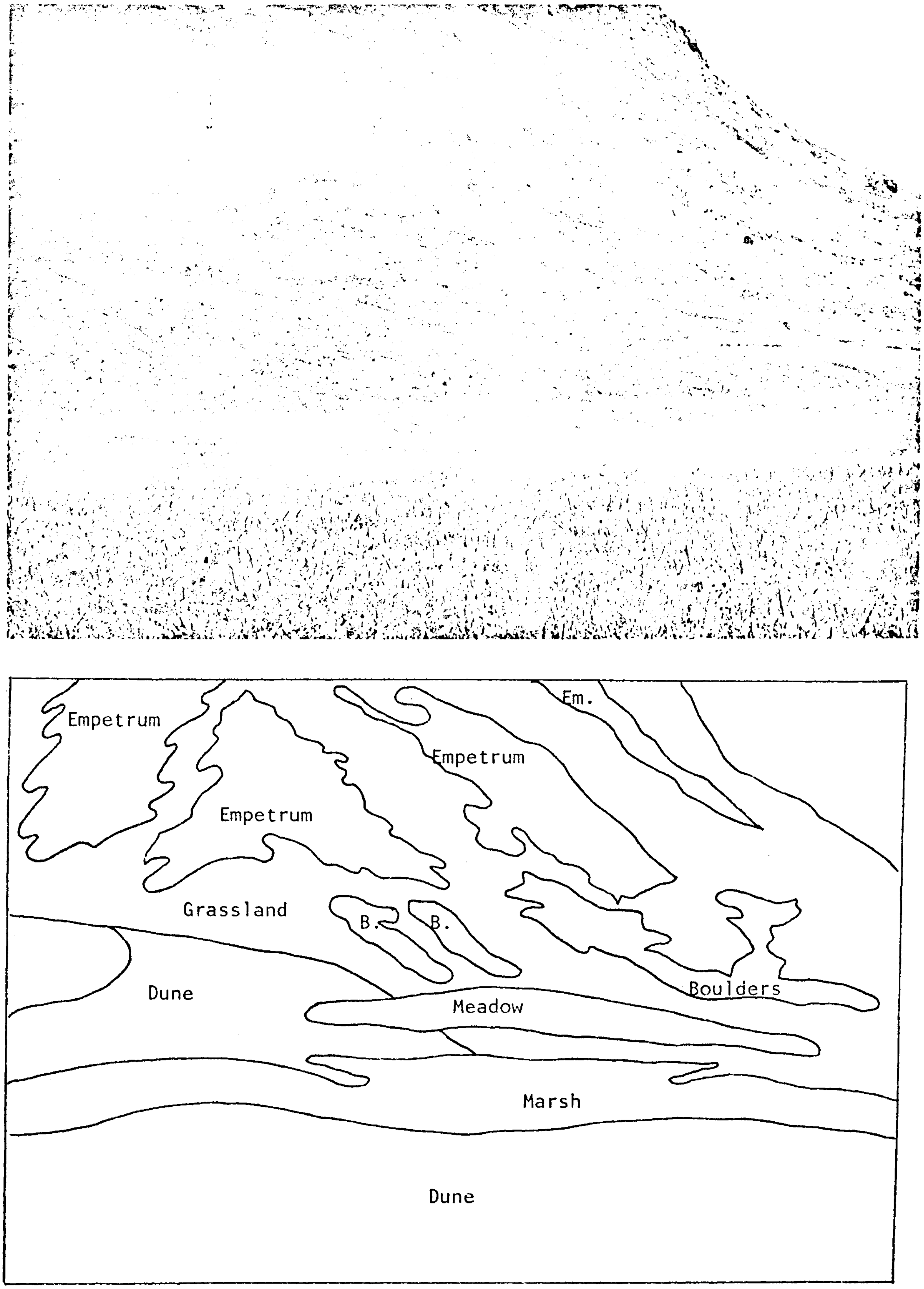


Fig. 6. Vegetation communities of East Amatuli (northeast view).

Table 2. Species Parameters of Each Vegetation Community on East Amatuli.

Community	Total Species	# of Species ≥10% Cover	% Cover
Beach	5	2	100.0
Marsh	19	4	92.0
Dunes	24	4	47.4
Boulders	26	5	93.8
Empetrum	35	2	84.3
Fellfield	52	2	73.0
Meadow	61	1	15.9
Grassland	61	1	16.2

communities, especially with the meadow and grassland. The meadow was on a nearly level plain, whereas the grassland was characteristic of hillsides, especially the west side of the valley. Their species composition was similar and very diverse. Drainage was the physical parameter that delineated their separation into two communities for the preliminary analysis.

The boulder community type was scattered over the hillsides. It was characterized by boulders and seeps or running water. Five major species

The empetrum and fellfield community types are probably closely related; they both have a high proportion of *Empetrum nigrum* (Table 3). The empetrum community may contribute to the stabilization of the hillside areas that are undergoing solifluction (Figure 6). The plants of the fellfield are diverse and stunted. The fellfield exhibits characteristics of tundra vegetation. It appears to exist due to the strong desiccating winds that sweep across the island through the valley trough.

The grassland is the largest vegetation community type with the empetrum next in size. All the communities play important roles in the ecosystem, however, and are characterized by different locations and species composition.

About a dozen shrubby Sitka spruce grow on the island in scattered locations. One hundred and thirty-two plant species were identified; perhaps 25 or more species in the grass, sedge, rush and mustard groups remain to be identified.

Table 3. Species with 10% Cover in Each Vegetation Community on East Amatuli.

Species	Beach	Marsh	Dunes	Boulders	Empetrum	Fellfield	Meadow	Grass
Anemone narcissiflora				26.5				16.2
Athyrium filix-femina				14.6				
Caltha palustris		18.9						
Carex saxatilis		29.0						
Carex sp.		34.4	10.2					
Conioselinum chinense				15.8				
Cornus suecica							15.9	
Elymus arenarius	50.0		15.0					
Empetrum nigrum					55.1	60.0		
Epilobium angustifolium				12.6				
Grass (unk. - purple)		10.0						
Heraculum lanatum			11.8	24.0				
Honckenya peploides	50.0							
Salix sp.						13.0		
Trientalis europaea			10.1					
Vaccinium uligenosum					29.2			

RESULTS AND DISCUSSION

Breeding Marine Bird Populations

There are 15 species of seabirds and one duck nesting in the Barren Islands. Our population estimates are in general agreement with those reported by Bailey (1976:6) but we have yet to analyze our data on Tufted Puffins and Fork-tailed Petrels. The densities and locations of individual populations are discussed in the following species accounts.

Reproductive Biology of Selected Species

Our coverage of individual species is disproportionate since it was necessary to intensively study those species particularly vulnerable to oil pollution. It was further restricted by the inaccessibility of several important species. Consequently, we have extensive information on the Tufted and Horned Puffins, Fork-tailed Storm Petrel, Parakeet Auklet and Rhinoceros Auklet. Our information on other species is more limited.

PARAKEET AUKLET

General

Compared with populations in the Aleutians and the Bering Sea, the number of Parakeet Auklets in the Barren Islands is small. With the exception of Smith Island in Prince William Sound (Nysewander, personal communication) the population in the Barrens represents the easternmost colony of the species. The total estimated population is 900-1,000 pairs in nine different colonies on five islands (Bailey 1976, this study). Colonies vary in size from 10-200 pairs and are found where there are boulders and cliffs with suitable crevices. Sealy and Bedard (1973) have previously discussed nest-site characteristics of this species. We studied part of a 50 pair colony in East Amatuli Cove (Figure 7). All other colonies were inaccessible.

Breeding Biology

Parakeet Auklets were already present at the colony site upon our arrival on May 14. Our knowledge of the general chronology of the breeding cycle is based on a small number of eggs and young found in rock crevices. In general, nearly all the nests were in inaccessible locations. Changes in behavior (not discussed in this report) also indicated approximate hatching times. We have been able to reconstruct the general timing of the nesting cycles (Figure 8).

Parakeet Auklets lay a single egg which is incubated for about 36 days. Nestlings fledged on St. Lawrence Island at 77 percent of adult weight after 35 days in the nest crevice (Sealy and Bedard 1973).

Figure 7. Photograph of Parakeet Auklet colony site on the west side of East Amatuli Cove.

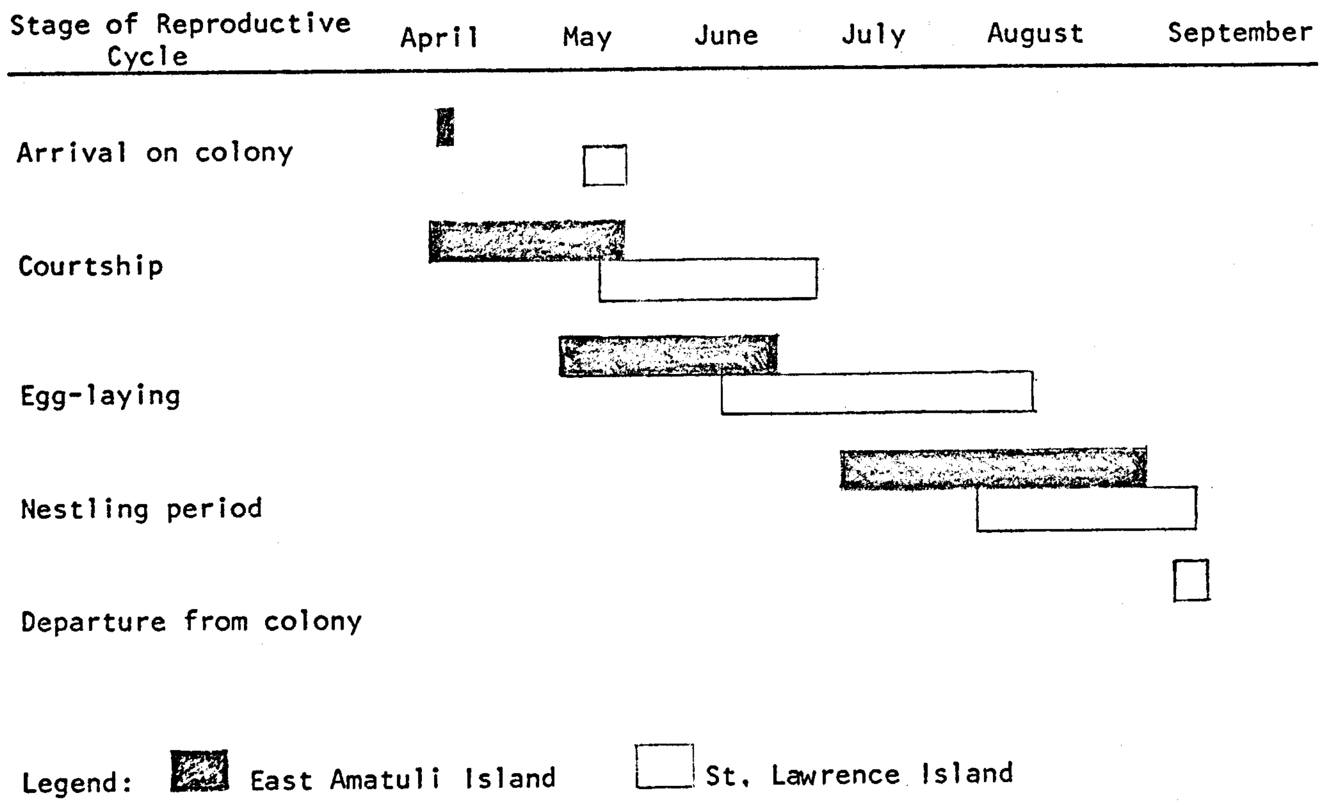


Fig. 8. Reproductive Timetable of the Parakeet Auklet at St. Lawrence Island 1964-66 (Sealy and Bedard 1973) and East Amatuli Island, Alaska 1976.

We have no meaningful data on breeding success or diet. Since the birds nested in inaccessible locations, we concentrated our efforts on the behavioral components of the breeding cycle. We were especially interested to examine how auklets utilized the physical environment. Since a very large portion of their time and energy budget is spent at or near the nest sites, we tried to quantify this as much as possible. This has important implications for assessing the effects of oil.

The Nesting Environment

Figure 9 is a diagrammatic representation of the nesting habitat of the Parakeet Auklet in the Barren Islands. The subdivisions of the environment are based on our intensive observations of auklets at East Amatuli Cove. We believe that auklets recognize these habitat components and our data indicate that the birds utilize them in different ways. Figure 7 is a photograph of the west side of Amatuli Cove where the major portion of the auklet colony nests. The following is a brief description of the various habitat components depicted in Figures 7 and 9.

Nesting Cliffs and Rocks (NR)

The characteristics of this habitat are similar to that described by Sealy and Bedard. However, the majority of auklets nested in crevices in a scarp or splintered parent rock (types A and D, Sealy and Bedard 1973:63). Many of the nest crevices were more than 1.5-2 meters in depth and ranged from 2-10 meters above the intertidal area. Very few appeared to nest in boulders. In this type, few boulders were present. Horned Puffins and Pigeon Guillemots also nested in this habitat type.

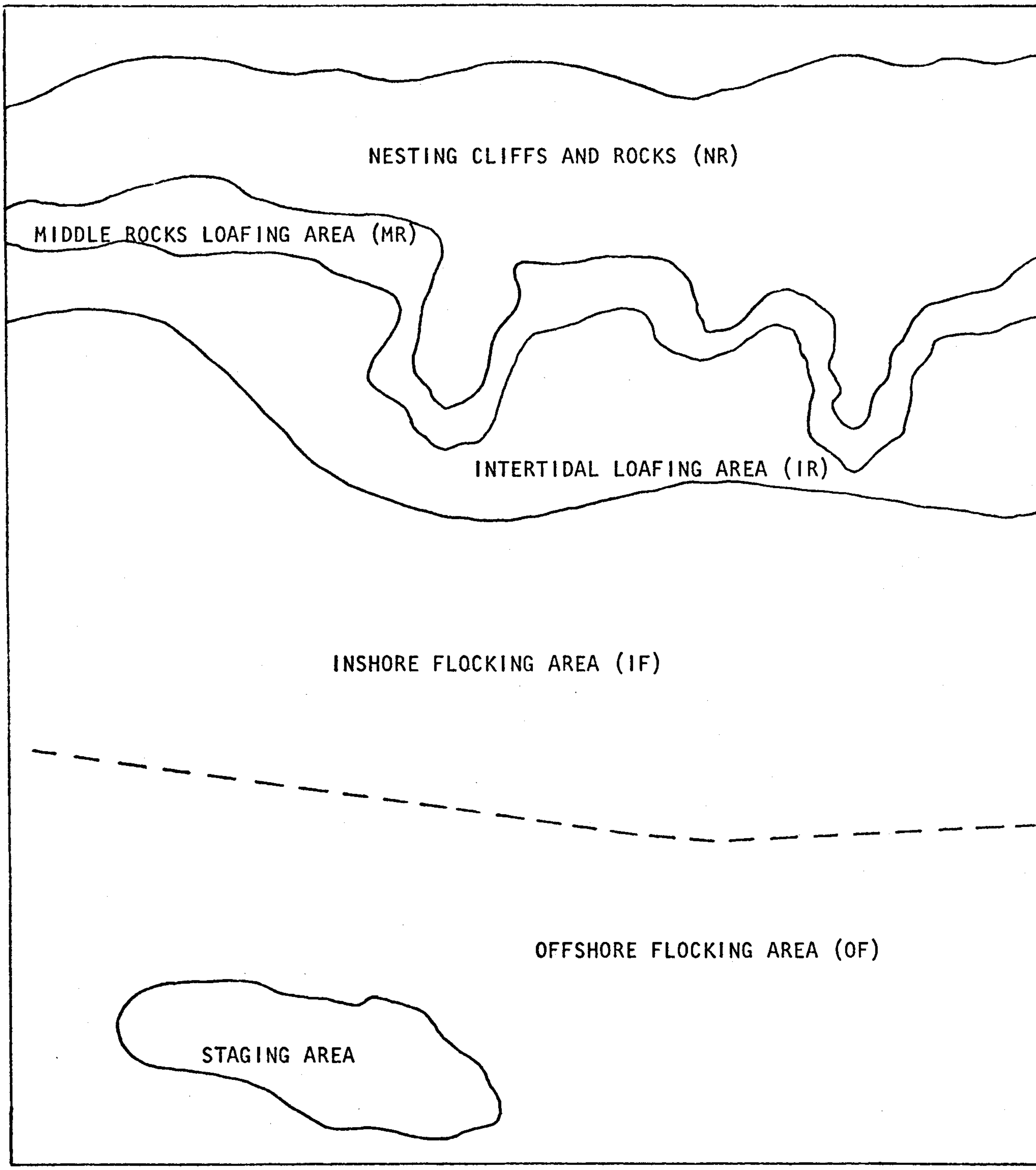


Fig. 9. Components of the nesting environment of the Parakeet Auklet on East Amatuli Island, Alaska.

Middle Rocks Loafing Area (MR)

This area consisted of splintered bedrock and boulders from about 0.5 m to 2 m above the intertidal area. There were a few nests in this area but auklets spent little time in this habitat.

Intertidal Loafing Area (IR)

The large tidal fluctuations made this habitat component important when it was available. In most areas, there was a precipitous drop-off at the lower portions of the intertidal.

Inshore Flocking Area (IF)

This habitat was found from the edge of the intertidal to about 25 m offshore. About 25% of the water surface had kelp on it. Parakeet Auklets spent most of the time in this habitat (Table 4).

Offshore Flocking Area (OF)

This region was considered to be any part of Amatuli Cove beyond 25 m from shore.

Staging Area

The staging area varied somewhat in its location but was generally near the middle or more northwesterly portions of the cove.

General Behavior and Habitat Utilization

We divided the basic behavioral patterns of the Parakeet Auklet into four major subdivisions. The number of specific displays are given in parenthesis: Maintenance Behavior (3), Displacement and Alarm Behavior (4), Courtship Behavior (3) and Agonistic Behavior (4).

In this report we will not present the more specific ethological aspects of the study but instead we will briefly discuss habitat utilization. Much of our data are still unanalyzed.

During the breeding season, the time and energy budgets of Parakeet Auklets are divided into both oceanic and terrestrial components. The oceanic portion consists of a feeding area, usually distant from the nesting area, and a loafing area close to the nesting colony. The effects of oil pollution will be most severe in the oceanic environment. The marine distribution and amount of time spent by Parakeet Auklets in the ocean are important in assessing future effects of oil pollution. Therefore, we determined the time budget for Parakeet Auklets during the latter part of the breeding cycle. Some of these data are summarized in Table 4.

When Parakeet Auklets are in the late stages of incubation or early nestling period, they spend about 60 percent of their time at sea feeding. About 40 percent is spent at or near the colony site. Roughly 20 percent of their time they are engaged in various types of social behavior in the waters (IF) immediately adjacent to the nest sites.

Figure 10 shows the amount of time auklets spend at the colony site. Early in the season, auklets spend five to seven hours in the cove and nest rocks. During the middle portion of the breeding cycle they are in the area nine to ten hours. After hatching and brooding, Parakeet Auklets abandon the nesting area and return only to feed the young.

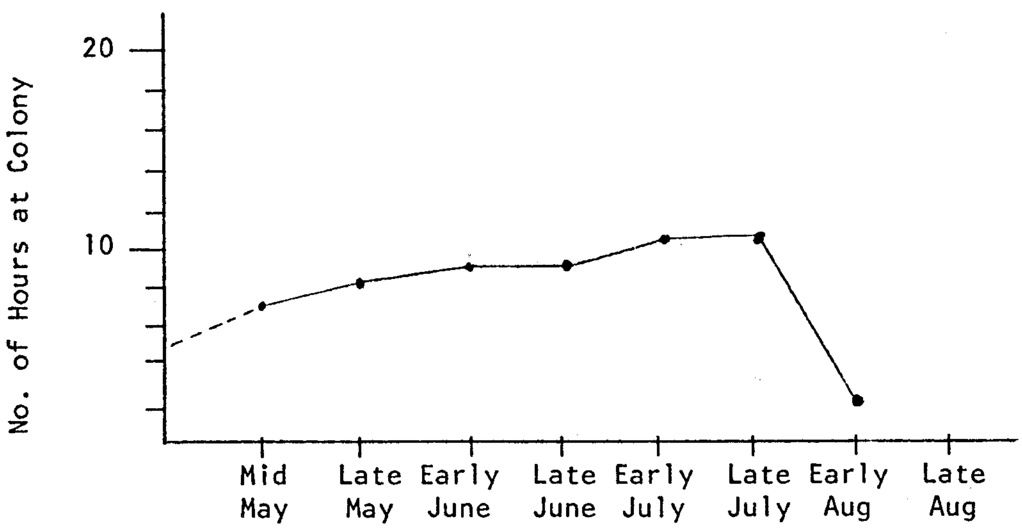


Fig. 10. Colony attendance of Parakeet Auklets at Amatuli Cove, 1976.

Table 4. Habitat-Specific Time Budget of the Parakeet Auklet on 25 July 1976 in the Barren Islands, Alaska.

Habitat Component	No. of Minutes	Percent of Time Budget
Feeding Area	860	59.7
Staging Area	35	2.4
Offshore Flocking Area (OF)	103	7.2
Inshore Flocking Area (IF)	307	21.3
Intertidal Loafing Area (IR)	27	1.9
Middle Rocks Loafing Area (MR)	20	1.4
Nesting Cliffs and Rocks (NR)	88	6.1
Total Time in Nesting Area	580	40.3
TOTAL MINUTES (24 Hours)	1440	100.0

RHINOCEROS AUKLET

General

The Rhinoceros Auklet is found breeding on only a few islands from the Farallon Islands, northern California, to the Semidi Islands, Alaska. All known colonies exist where there is well-developed soil which supports the extensive burrows that the species excavates during the breeding season. Table 5 summarizes the presently known colony sites for the species.

In the Barren Islands, Rhinoceros Auklets were first located in 1975 on Sud Island (Bailey 1976). This colony is located on the north slope (approximately 30°) in a large patch of dunes covered with *Elymus arenarius* and *Festuca rubra* (Figure 11). The breeding population was estimated by both Bailey and us to be about 500 pairs. A large portion of the colony-site is eroding away. Additional study is required to ascertain the occupancy rate and extent of the colony.

Burrow Occupancy

From our brief visits to Sud Island we feel that over 90 percent of the burrows are active but not all appear to have eggs or young. Table 6 shows the results of our burrow check on August 4, 1976. Because of the extensive nature of the burrows and a deteriorating weather situation on that day, we were only able to excavate 38 burrows. From this small number we found only five of 38 burrows empty.

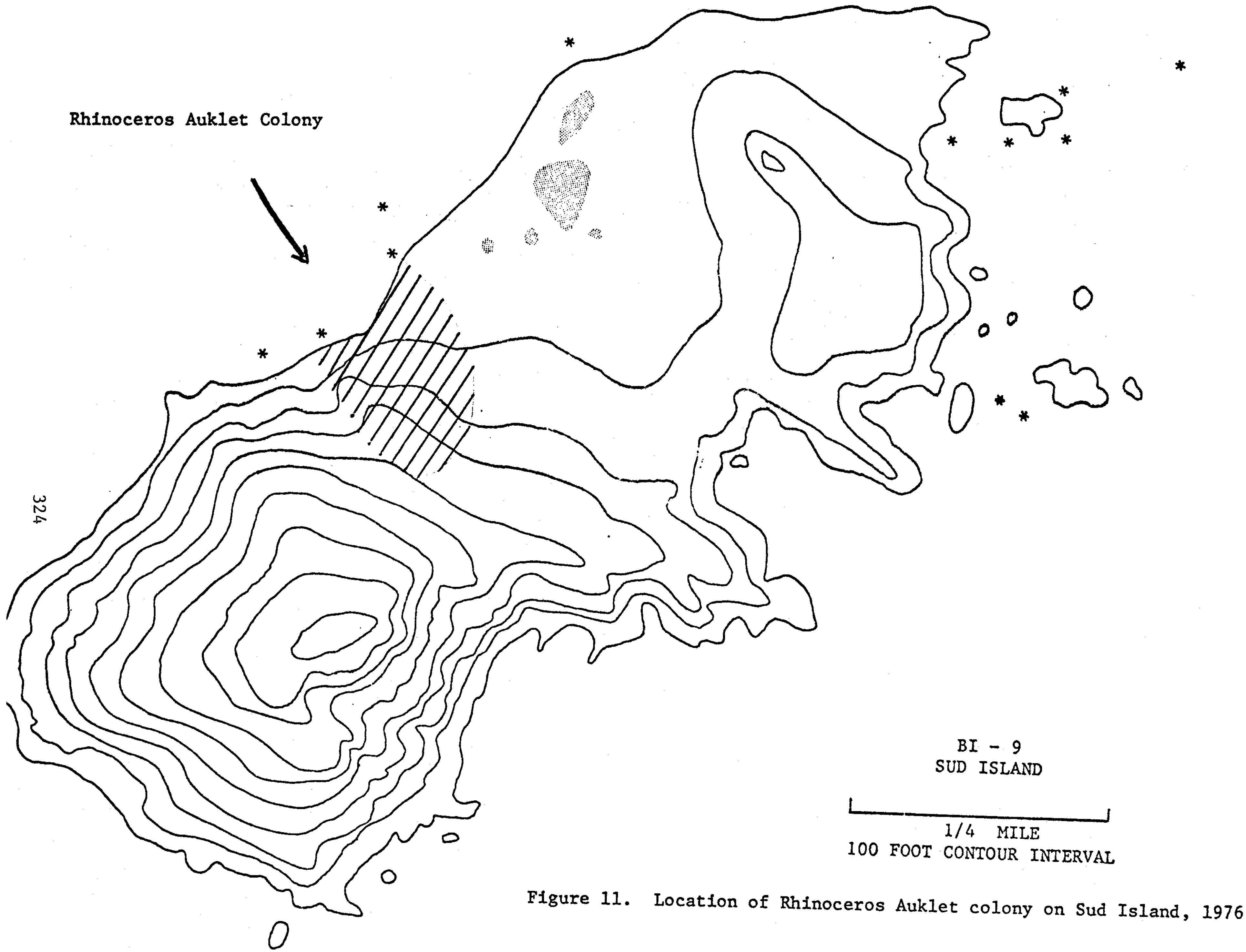


Figure 11. Location of Rhinoceros Auklet colony on Sud Island, 1976.

Egg-Laying and Nestling Growth

The general egg-laying pattern was derived by aging eight nestlings and backdating to the data of egg-laying. Ages were assigned by using wing lengths from Rhinoceros Auklet nestlings on Smith Island, Washington. Using this method, we estimate that egg-laying extended from about May 10 to June 12. Table 7 summarizes nestling weight and wing lengths of auklets found in burrows on August 4, 1976.

Food Delivered to Nestlings

On the night of August 3, 1976 we collected 51 fish from Rhinoceros Auklets delivering fish to their nestlings. This included seven complete loads and 13 miscellaneous individual fish. Table 8 summarizes these data. All fish were identified as Capelin (*Mallotus villosus*).

Table 5. Locations and Estimated Populations of Rhinoceros Auklet Colonies in North America (as of September 1, 1976).

Location	Population Size (Pairs)	Reference
California		
Southeast Farallon Islands	2+	Scott, et al. 1974
Oregon		
Goat Island	20+	Scott, et al. 1974
Washington		
Destruction Island	10,940	Manuwal & Campbell (MS)
Giants Graveyard	150	Manuwal & Campbell (MS)
Cake Rock	50	Manuwal & Campbell (MS)
Carroll Island	250	Manuwal & Campbell (MS)
Tatoosh Island	25	Manuwal & Campbell (MS)
Protection Island	9,200	Manuwal & Campbell (MS)
Smith Island	600	Manuwal & Campbell (MS)
British Columbia		
SW Coast of Vancouver Island	1,200	Manuwal & Campbell (MS)
NW Coast of Vancouver Island	20,000	Vermeer, et al.
West Coast, Queen Charlotte Islands	10,000	Manuwal & Campbell (MS)
East Coast, Queen Charlotte Islands	300	Manuwal & Campbell (MS)
Prince Rupert to Queen Charlotte Islands	200	Manuwal & Campbell (MS)
Alaska		
Forrester Island	20,000	Willett (1912, 1915)
St. Lazaria Island	75	Willett (1912, 1915)
Barren Islands	500	This Study
Semidi Islands	407	Leschner (personal com.)
Ugaiushak Island	---	Wehle (personal com.)
TOTAL ESTIMATED POPULATION	73,919	

Table 6. Status of Rhinoceros Auklet Burrows on Sud Island, August 4, 1976.

Status	Number	Percent
Active but empty	23	60.5
Probably inactive	5	13.1
Nestling present	8	12.2
Adult and nestling	1	2.6
Adult only	1	2.6
TOTAL	38	100.0

Table 7. Weight and Wing Measurements of Rhinoceros Auklets Found in Burrows on Sud Island, August 4, 1976

Auklet Aluminum Band	Red Color Band	Age	Weight (grams)	Wing (mm)
601	101		220	82
602	102		275	91
603	103		245	70
604	104		442	115
605	105		215	63
606	106		405	111
607	107		405	117
608	108		364	94
609	---	Adult	540	175

Table 8. Fish Brought to Nestling Rhinoceros Auklets on Sud Island, August 3, 1976.

Load	No. of Fish	Mean Length (mm)	Mean Weight (grams)
1	6	89.3	3.4
2	9	83.3	2.9
3	6	100.3	5.1
4	3	100.0	5.0
5	3	119.3	7.8
6	4	80.3	2.4
7	7	96.6	4.4
Mean	5.4	98.1	4.6
Mean per loads	---	93.3	22.3
Range	3 - 9	66 - 126	14.9 - 31.0
Miscellaneous	13	112.1	4.6

THE BREEDING BIOLOGY OF THE TUFTED AND HORNED PUFFINS

Introduction

The Tufted Puffin (*Lunda cirrhata*) and Horned Puffin (*Fratercula corniculata*) are two of nine species of alcids breeding in the Barren Islands. For such common and numerous birds in the North Pacific, there is a paucity of information on many aspects of their life cycles. Previous natural history accounts of the Tufted Puffin are of a general nature (e.g., Barlow 1894; Bent 1919; Dawson 1913; Dickerman 1960; Thompson 1967; Willett 1915; and others; Frazer 1975). Recent work includes limited natural history reports by Sealy (1973) and Frazer (1975) and feeding ecology studies by Cody (1973) and Wehle (1976). The only life history studies of the Horned Puffin which span the entire breeding season are those of Swartz (1966) in the Cape Thompson region, Sealy (1973) on St. Lawrence Island, and Wehle (1976) on Buldir Island, Alaska.

Methods

Population Censusing

Population estimates for Tufted Puffins were based on actual burrow counts from land and boat, and counts of birds during hours of peak colony attendance. For particular colonies, numerous "seawatch" observations assisted in estimating population size. Where colonies were large and apparently homogeneous in density, the number of burrows in several 10 x 10 meter square sample plots were determined and extrapolations made for the entire colony. Unfortunately, population size estimates for East Amatuli Island will be delayed until receipt of aerial photographs.

Horned Puffin population estimates were made by direct counts of birds for small colonies, and by observing the percentage of Horned Puffins in offshore rafts, in flight, and on the cliffs for large mixed species colonies. The percentage of occupied burrows was calculated and will be applied to the final estimate. Table 9 indicates the sites when Puffin data were collected.

Courtship

Although observations were made of puffin colonies on West Amatuli, Sugarloaf and Sud Islands, the studies described herein were conducted entirely on East Amatuli Island during the period May 14 to September 6, 1976. Daily observations were made to determine whether the return of Tufted and Horned Puffins to the breeding colonies was synchronous. Off-shore staging flocks were observed with a Spacemaster 15-60x spotting scope and 9x binoculars. Courtship and copulation behaviors were observed with the same optics and timed with a stopwatch. Dates of initial colony visitation were recorded and the establishment and defense of territories was observed. To minimize disturbance, four canvas-covered wood-framed blinds were constructed one week prior to egg-laying. From the blinds close-range observations of both species was possible.

Activity Cycles

Data on the daily activity cycles was obtained in various weather and tidal conditions throughout the breeding seasons for both species of puffin. Approximately 220 blind-hours were spent recording information

Table 9. Site of Data Collection on East Amatuli Island, 1976.

Site*	Data Collected
Colony 1	TUFTED PUFFIN: Colony data, egg weights, egg-laying dates, incubation period, growth rates, bill loads, fledgling dates.
2	Activity cycles, adult weights, cleptoparasitism, bill loads
3	Incubation rhythms, activity cycles, time budgets, bill loads, Bald Eagle harrassment
Colony A	HORNED PUFFIN: Colony data, egg weights, egg-laying dates, incubation period, growth rates, bill loads, activity cycles, fledgling dates
B	Bill loads, growth rates, fledgling dates

* Refers to Figure 12.

such as: onset of activity with first light, number of birds on the water in the vicinity of the colony, percent of each species present, number of birds in flight in predetermined unit of space, behavior in colony, incubation rhythms, time-budget for banded birds, number of fish deliveries per day, cleptoparasitism, and termination of activity with nightfall. To obtain a full diel cycle most observations were made from one-half hour before sunrise to one-half hour after sunset.

Egg-Laying

Prior to initiation of egg-laying a total of 85 burrows in Colony 1 (Figure 12) were marked with orange and white flags. Egg checks were then conducted at five-day intervals until an egg was found. Those burrows in which the nest chamber was beyond reach were accessed and the opening carefully covered with a 10 x 10-inch plywood square. After an egg had been found the burrow was not revisited until hatching was suspect (40+ days later).

Fresh egg weights were determined using a 100 or 300 gram capacity Pesola scale. Egg dimensions were measured in millimeters with a steel caliper.

Incubation

In order to study the incubation rhythm, two Tufted Puffins sitting on eggs were captured and banded. A third could be distinguished from its mate by its split web. The exchange of incubation duties was then observed from a blind located nearby. During the incubation period a diel time budget for a pair of Tufted Puffins was recorded. Although no

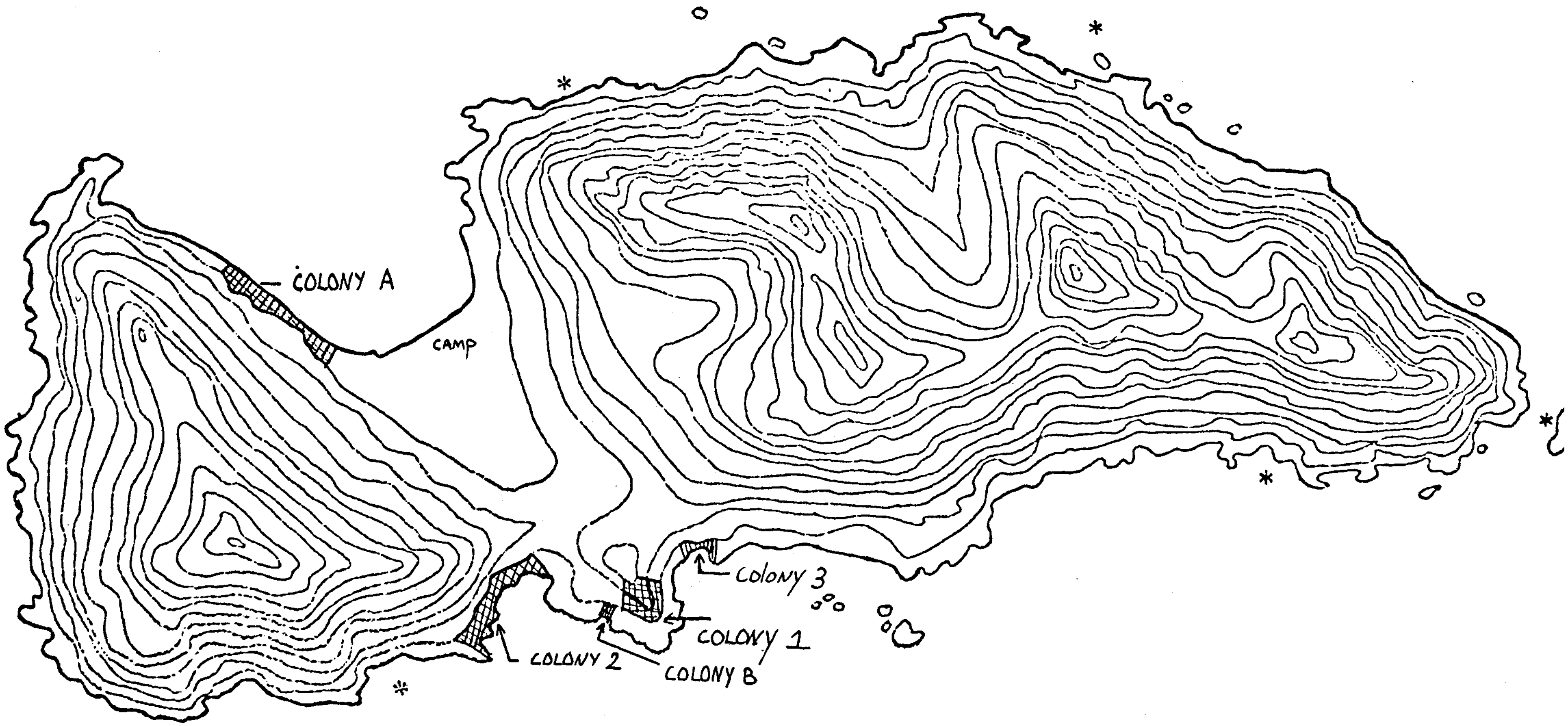


Figure 12 Location of study colonies

BI - 2
EAST AMATULI

1/2 MILE
100 FOOT CONTOUR INTERVAL

incubating Horned Puffins were banded or marked, their incubation rhythm was approximated by direct observation from a blind and by interpretation of activity cycle data.

The laying dates (±3 days) of 11 Tufted Puffin eggs and five Horned Puffin eggs (±2 days) were recorded. Thus, with known hatching dates the incubation period for both puffin species was closely approximated. Wing length was measured along an unflattened right wing.

Hatching Success

Hatching success and desertion rates of Tufted Puffins from Colony 1 were compared with a control group of 50 marked "unmonitored" burrows. The 50 control burrows selected showed definite signs of occupancy. These included: presence of last year's egg shell fragments at the entrance, fresh guano, excavation signs, puffin smell, or an incubating bird or egg. The control group was not visited after the initial marking until it was certain all viable eggs had hatched. Those burrows which proved too deep or inaccessible to determine success or failure were omitted from the analysis.

Growth Rate

The growth and development of Tufted and Horned Puffin chicks was monitored by visiting the nesting-site at five-day intervals. All chicks were weighed between 0800-1200 hours with a 100, 300, 500 and 1000 gram capacity Pesola scale as need required. Chick wing lengths were measured along an unflattened right wing. Data used for fledgling condition (i.e. body weight and wing length) are in most cases those measured the night before fledging (departure from the nest). Weather and predation data were collected throughout the breeding season and is compared with chick mortality.

Nestling Food

Bill loads of fish destined for the chick were collected to examine species composition, seasonal variation, and weight. Various collection methods were employed throughout the chick-rearing stage. The most efficient method was to place several mist nets (1.25-inch mesh) across a puffin colony and wait for adults with fish to return. After becoming entangled in the net, most puffins would drop their fish loads and fly off. Many adult puffins were captured by this method and were weighed, measured, and banded before release. This procedure should not be used at a colony where growth rates or behavior is being monitored because of excessive number of desertions. Occasionally, fish were found lying about the colony or at the burrow or crevice entrance. Hiding near a burrow and startling the returning adult was also somewhat effective. Bill loads destined for Horned Puffin chicks were much more difficult to collect. Due to the nature of their nesting crevices, Horned Puffins could noc be readily approached or mist netted.

Fish samples were weighed with a 30-50 gram capacity Pesola scale. Total length in millimeters was recorded and the specimen was preserved to verify identification. Partial bill loads are treated separately in the analysis. Most of the samples were collected between 1200 and 1600 hours; there was no evidence that prey species composition or weight per load varied throughout the day. Attempts at cleptoparasitism by Glaucous-winged gulls were observed ancillary to the collection of bill loads.

The number of daily food deliveries to each of the six marked Tufted Puffin burrows and four Horned Puffin crevices was observed for both early and late stages of chick-rearing. Observations from shore and from the zodiac provide some information on the location of foraging areas during the nestling stage.

Breeding Success

Breeding success, defined here as the percentage of offspring surviving to fledging, was determined by following the fate of the young in 21 Tufted Puffin nests and 11 Horned Puffin nests.

The Nesting Environment

Information on the physical, vegetative, and edaphic characteristics of three Tufted Puffin colonies was obtained. Slope and aspect were determined with a Silva hand compass. Altitude was estimated with an altimeter-barometer. Burrow density was obtained in each area by counting the number of burrows in a 10 x 10-meter quadrant.

The following data were obtained for 50 Tufted Puffin burrows in Colony 1: diameter of burrow entrance, burrow length, characteristics of the incubating chamber, composition of nest material, and description of the nest. Similar information was obtained for 14 Horned Puffin crevices in Colony A.

Results

Abundance and Nesting Distribution in the Barren Islands

Tufted Puffins are probably the most numerous of all the breeding birds in the Barren Islands. Table 10 is cited from Bailey (1976) with estimates from this 1976 field season included in parenthesis.

Ushagat Island, comprising 6,935 acres (Bailey 1976) probably supported large numbers of seabirds prior to the 1928 introduction of the Arctic fox and ground squirrel. Today there are very few species and low numbers of marine birds using the island. There are small numbers of both Tufted and Horned Puffins nesting on this island.

Sud Island has small numbers of puffins on the south and southeast side which drops abruptly from 980 feet to sea level. 1500 Tufted and 400 Horned Puffins were found in this area. Most puffin burrows and crevices on Sud are located at or below the cliff edge and are inaccessible.

Sugarloaf Island, though only 200 acres in size, supports a substantial number of Tufted Puffins (12,000+) and the densest colony of Horned Puffins in the Barrens. The steep grass-covered slopes found on all sides of this mound-shaped island provide ideal Tufted Puffin habitat. The grassy slopes extend from the 1210-foot summit to about 50 feet above sea level, where large boulders, talus and rubble then dominate the landscape and rocky beach. This peripheral zone of rubble provides an abundance of nesting crevices for the 800-1000 Horned Puffins found here. A large rock slide on the southeast side of the island supports approximately 150 pairs of Horned Puffins. However, the lack of a nearby landing site, and the presence of numerous sea lions make this

Table 10. Estimated Bird Population (Pairs) in the Barren Islands.[1]

Species	Ushagat	Nord	Sud	Carl	Sugarloaf	E. Amatuli	W. Amatuli
Horned Puffin	250	40	400	40	600(800)[2]	13,000[3]	1300
Tufted Puffin	100	5000	1000 (1500)	1000	9500 (12,000)	95,000[3]	93,000

[1]From Bailey (1976).

[2]Estimate from this study.

[3]Estimate contingent upon examination of aerial photographs.

colony logistically a difficult one to study. Interestingly, Horned Puffins on Sugarloaf were observed nesting, loafing and sleeping in close association with sea lions on the upper beach.

West Amatuli Island

Both species of puffins occur in substantial numbers on West Amatuli. This island has a precipitous ten-mile coastline with grassy covered slopes above. There are two large Tufted Puffin colonies. One, numbering about 10,000 birds, was located at the southernmost tip of the island; the other, a large colony of Tufted Puffins on the south slope of the eastern headland. Bailey (1976) estimated this colony at 40,000 pairs in July 1975; general observations throughout the season confirm that this density was not reached in 1976. There are numerous smaller Tufted Puffin colonies on West Amatuli Island that are suitable for study. However, Horned Puffins are too widely scattered and inaccessible to be monitored practically.

East Amatuli Island

East Amatuli is a mountainous island with two sweeping valleys between three prominent peaks. The island abounds in steep sea-facing slopes which support the largest population of Tufted Puffins in the Barrens. The south-facing maritime slopes of this elongate island foster an estimated 50,000 puffins, 95 percent of which are Tufted Puffins. Suitable nesting habitat for Horned Puffins is less abundant, yet they are found scattered around the island usually occupying crevices at or below the cliff edge. A small colony of 15 pairs located along the west side of East Amatuli Cove is probably the only Horned Puffin colony on the island suitable for study purposes. Several sizable Tufted Puffin colonies occur within a half-mile of camp.

The Barren Islands provide an excellent opportunity for the further research of Tufted Puffins. However, considering the sparse population and inaccessibility of Horned Puffin nesting crevices, this species is not easily studied in this area.

Arrival

Tufted Puffins were already present in the waters around the Barrens at our arrival on May 14, 1976. The number of Tufted Puffins seen rafting offshore increased steadily for the next several days. The first sighting of Horned Puffins in the vicinity of East Amatuli occurred on May 20. Their first visitation to the nesting crevices was observed May 24. Thus, occupation of the cliffs occurs about one week after their return to the waters around the colony. Similar arrival/colony visitation intervals were reported for Horned Puffins by Swartz (1966) for Cape Thompson; Fay and Cade (1959) and Sealy (1973) for St. Lawrence Island.

Courtship

During the period from May 20 to June 10 courtship and copulatory behavior was observed among the rafts of Tufted Puffins offshore. These "staging" flocks were usually composed of several hundred to many thousands of birds and were located within 0.5 kilometers of the island. Little or no feeding activity was observed in these near-shore assemblages. Horned Puffin courtship and copulatory behavior were observed during the period from May 29 to June 18. Horned Puffins rafted closer to shore than Tufted Puffins and could often be found within 0.2 kilometers of the island. General observations indicate that some feeding behavior is occurring in these near-shore rafts of Horned Puffins.

Settlement and Nest Building

During the spring period of occupation and settlement puffin numbers varied in a three to five day cyclic pattern. Puffins, after being present in large numbers for several consecutive days, would be almost entirely absent for an equal amount of time. This pattern of colony attendance has previously been reported for Tufted Puffins by Wehle (1976) and Frazer (1975) and for Horned Puffins by Wehle (1976), and for Common Puffins by Nettleship (1972). Although the cyclic attendance pattern continued through the incubation period, once egg-laying was initiated, even on "off-days" some puffins were continuously in the colony (Fig. 13).

Tufted Puffin colonies exist on nearly all sea-facing slopes on East Amatuli Island. Puffins occupy burrows and crevices from 15 feet above sea level to the top of Puffin Peak, 1540 feet. Although most Tufted Puffins do excavate burrows in areas of suitable soil accumulation, about 0.5-1 percent of the population utilizes rock crevices. Horned Puffins on East Amatuli nest entirely in rock crevices or at the rock/soil interface at cliff edges.

The soil on upper slopes remained frozen until late May and north facing slopes had snow cover until about May 20. However, Tufted Puffins

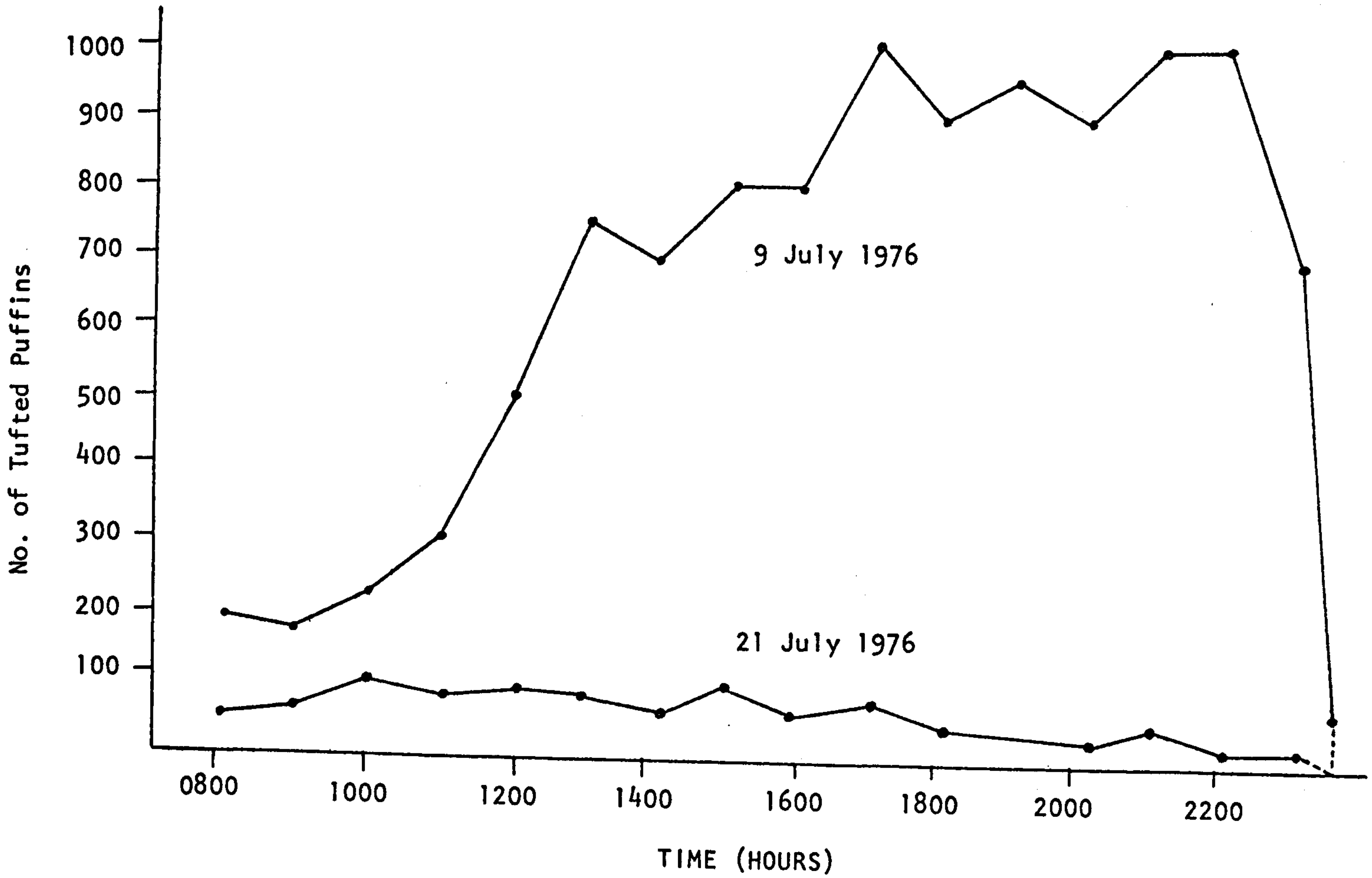


Fig. 13. Comparison of "On-Off" Day Activity for Tufted Puffin Colony 1. (Number of Tufted Puffins in flight in a predetermined unit of space above the colony taken in ten-minute counts each hour.)

appeared to occupy all parts of the habitat simultaneously. The initiation of egg-laying of Tufted Puffins nesting at 1540 feet above sea level was synchronous with those nesting at lower elevations.

Tufted Puffin nests were of four main types. The first and most common nesting situation encountered was a burrow excavated in soil in a maritime slope. Other puffins excavated burrows at the soil/cliff interface or below boulders embedded in soil. The last and least common situation in which nesting Tufted Puffins were found was in the crevices beneath rock talus. About 500 pairs utilized this habitat.

The diameter of the entrance and length of 50 Tufted Puffin burrows was determined early in the breeding season. Twenty-two of the 50 burrows measured were not yet visited by puffins and lacked any recent excavation (Table II).

Early excavation is directed primarily at lengthening and clearing the burrow of debris. Many Tufted Puffins continue to lengthen their burrows throughout the breeding season. The single egg is deposited near the end of the burrow. Nest material, primarily flight and contour feathers from puffins or Glaucous-winged gulls, grasses, and even fishing line is dropped randomly on the burrow floor near the egg site. Puffins burrowing near vegetation (principally Elymus) used it in their nests, while both puffins nesting in barren rock crevices flew to other areas on the island to secure nest material.

Although data from the three 10 x 10-meter sample plots have not yet been statistically analyzed, there appears to be a positive correlation between burrow density and steepness of slope, and burrow density and proximity to the cliff edge. Examination of the three sample plots revealed an average density of 54 burrows per 10 meter quadrant.

Table II. Entrance Diameter and Length of Tufted Puffin Burrows.

	Burrow Entrance Mean Height	Burrow Entrance Mean Width	Length
All burrows (50)	7.24 inches	7.81 inches	24.6 inches
Visited burrows (28)	7.1 inches	7.6 inches	34 inches

Most Horned Puffins on East Amatuli Island nested in vertical or horizontal rock crevices, or in rock rubble below the cliff edge. One nest located at the soil/cliff interface probably required some excavation, otherwise all Horned Puffins utilized natural crevices. Unlike Tufted Puffins, which occupied slopes from 40 feet above sea level to the summit, Horned Puffins nested only in crevices at or below the cliff edge and were not encountered above 600 feet.

Egg-Laying

For the Tufted Puffin population laying began the last few days of May and ended by June 24 (Figure 14). The egg-laying period for the Horned Puffins in colonies A and B exemplified greater synchrony; all laying occurred between June 14 and 20 (Figure 15).

Both Tufted and Horned Puffins lay a single egg which is ovate in shape with a tendency toward ovate pyriform; the shell is thick, roughly granulated and lusterless (Bent 1919). The egg is dull or creamy white in color and lacks conspicuous spots. Table 12 presents dimensions of Horned and Tufted Puffin eggs. Fresh egg weights and egg weight in proportion to adult body weight is presented in Table 13.

Incubation Period

Both sexes of Tufted and Horned Puffins develop two lateral, bare vascularized brood patches during the breeding season (Sealy 1973). The average brood patch dimensions in four adult Horned Puffins measured by Sealy were 55 by 27 mm. The brood patch dimensions of one Tufted Puffin measured on East Amatuli Island was 60 by 30 mm.

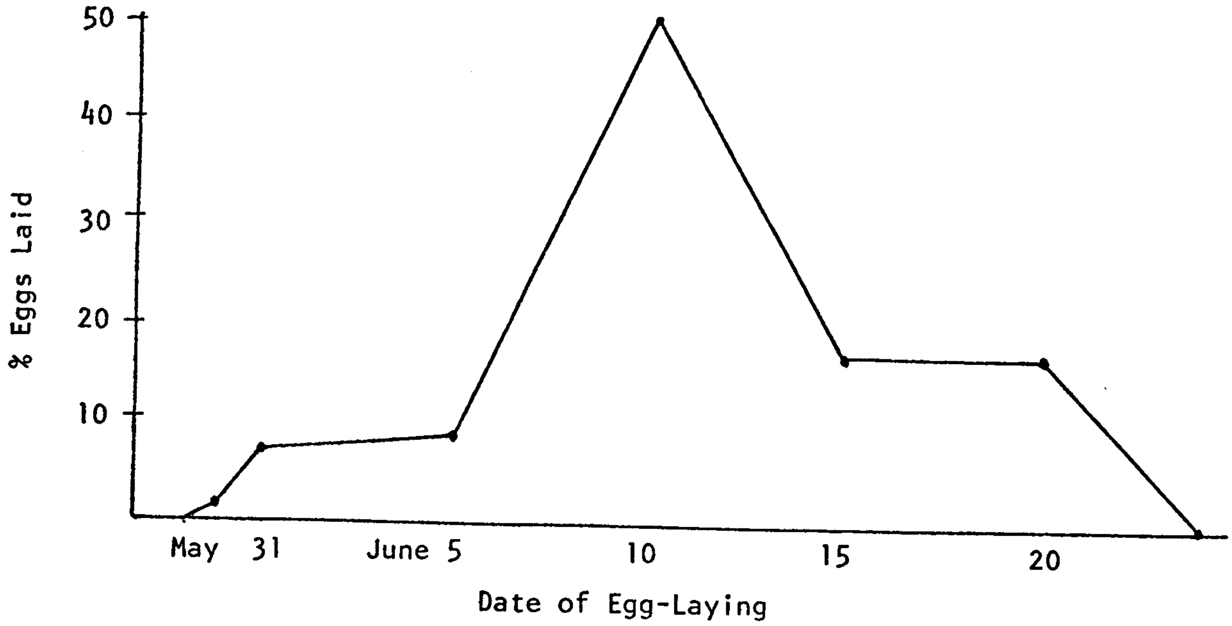


Fig. 14. Frequency Distribution of Egg-Laying for Tufted Puffins on East Amatuli Island, 1976 (N = 60).

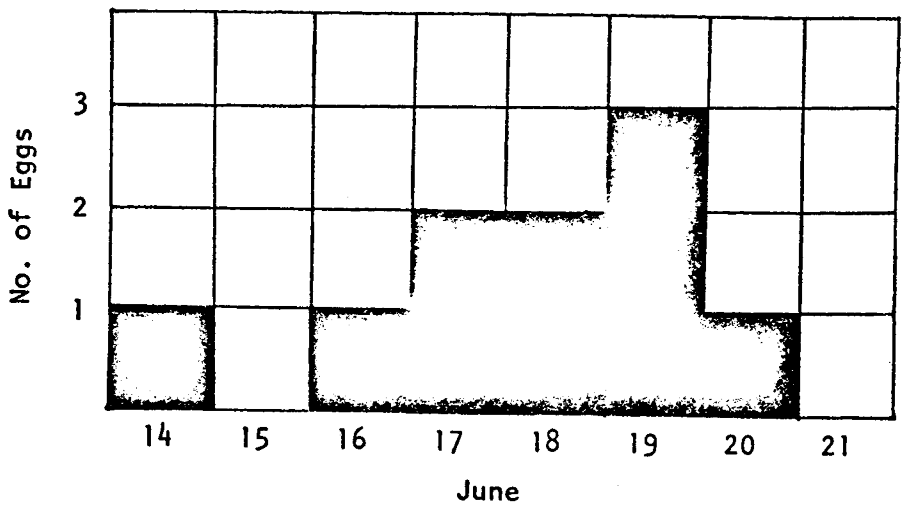


Fig. 15. Dates of Egg-Laying for Horned Puffins on East Amatuli Island, 1976 (N = 10).

Table 12. Dimensions of Puffin Eggs, East Amatuli Island, 1976.

Species/Locality	N	Range (mm)	Mean (mm)	Source
HORNED PUFFIN				
St. Lawrence Island	5	70.9 x 44.8	68.9 x 46.2	Sealy 1973
		68.6 x 44.4		
		66.5 x 46.2		
		68.0 x 50.7		
Bering Sea	38	74 x 50	- - -	Bent 1919
		73 x 50.5		
		61.5 x 41		
		58 x 43.4		
East Amatuli Island	5	68 x 46	66.7 x 45.6	This Study
		66 x 43		
		66 x 48		
TUFTED PUFFIN				
St. Lazaria Island	20	- - -	73.7 x 48.5	Grinnell 1900
Bering Sea	43	78 x --	72.0 x 49.5	Bent 1919
		66.5 x --		
		-- x 51.5		
		-- x 45.0		
Destruction Is., Wn.	6	78.5 x --	72.8 x 48.1	Frazer 1975
		69.7 x --		
		-- x 49.6		
		-- x 47.0		
East Amatuli Island	51	78.5 x 50.5	73.1 x 48.4	This Study
		68 x 48		
		73 x 46		
		73 x 51.5		

Table 13. Egg Weight and Adult Body Weight of Tufted and Horned Puffins.

Species	N	Mean Egg Weight	N	Mean Body Weight (gms)	Proportionate Egg Weight (%)	Source
Horned Puffin	2	57.1 (56.1-58.1)	22	599 (499-574)	9.5	Sealy 1973
	3	74.8 (73.5-76)	1	607	12.3	This Study
Tufted Puffin	?	91	11	797 (689-920)	11.4	Schonwetter 1964 Sealy & Bedard 1973
	32	92.8 (84-107)	33	784 (700-870)	11.8	This Study

From observations of a pair of Horned Puffins that nested within 10 meters of the blind, it was confirmed that both sexes share the incubation duties. Horned Puffins appear to exchange incubation duties after the evening "social hour" when maximum numbers of birds were gathered on colony. The non-incubating parent would fly off, returning to the nest site the following morning. On most days there was a constant influx of non-incubating birds visiting their mates in the crevices; without marked birds, the exact incubation rhythm for Horned Puffins could not be determined.

Observations of three pairs of marked Tufted Puffins confirmed that both sexes share the incubation duties in this species as well. On July 12, 14 and 23, three marked pairs of Tufted Puffins were observed. Tufted Puffin incubation schedules on East Amatuli did not exhibit the regularity reported for some of the other alcids (Manuwal 1972; Richardson 1961; and Lockley 1934). The incubating parent was often relieved by its mate in early morning between 0400 and 0900 hours. The mate would then assume incubation until the relieved parent returned usually in midafternoon. During the afternoon the egg was often left unattended for several hours while the pair loafed out in front of the burrow or flew off together. Much pair bond maintenance activity in the form of billing was observed during this time. Between 1700 and 1900 hours the pair would often enter the burrow or continue to loaf out in front. Before nightfall, one of the birds would assume incubation while its mate either slept nearby or flew off. However, this incubation rhythm was not strictly adhered to. In some burrows a single bird might incubate the entire day while in others many exchanges took place. The nature of the incubation rhythm is largely a function of the availability of food and the distance to foraging areas. From observations of feeding flocks and from chick growth rate and bill load data, food resources for the Tufted and Horned Puffins were apparently in good supply. Hence, it was often possible for adults to visit the nest several times a day, to spend considerable time loafing on colony, and to exchange incubation duties frequently.

The average incubation period of the Horned Puffin on St. Lawrence Island was 41.4 days with a range of 40-43 days (Sealy 1973). Frazer (1975) estimated the incubation period of the Tufted Puffin as 38-48 days and 45 days was reported by Sealy (1973). Because of nest desertion on East Smatuli Island, only approximate incubation period were obtained for both species of Puffins (Table 14).

Nestling Phase

Hatching in Tufted Puffins occurred between July 10 and 31 and between July 22 and 31 in Horned Puffins (Fig. 16). Hatching intervals were determined by direct observation of newly hatched chicks. Four Horned and 14 Tufted Puffin chicks were found within 24 hours of hatching. The hatching success of 50 unmonitored burrows was compared with the 85 burrows in colony 1 (Table 15). The fact that only 40 of 85 burrows contained eggs suggests that early desertions occurred prior to egg-laying. However, it should be noted that 19 of the 85 burrows (22 percent) showed no sign of occupation throughout the breeding season. In the control group seven burrows were deepened beyond reach so that breeding success could not be determined. These burrows were omitted in

Table 14. Incubation Period for Tufted and Horned Puffin Eggs on East Amatuli Island, 1976.

Species	# Eggs	Incubation Period (days)	Average
Tufted Puffin	3	43 ± 2.5	45.2
	5	44 ± 2.5	
	2	48 ± 2.5	
	1	53 ± 2.5	
Horned Puffin	3	39 ± 2.0	40.2
	2	42 ± 2.0	

Table 15. Comparison of Hatching Success in Two Tufted Puffin Colonies on East Amatuli Island, 1976.

	# Burrows	# Eggs	# Occupied by Fork T.S. Petrels	# Deserted	# Hatched	% Success
Control Colony	50	38	5	18	20	52.6
Study Colony	85	40	7	24	16	40

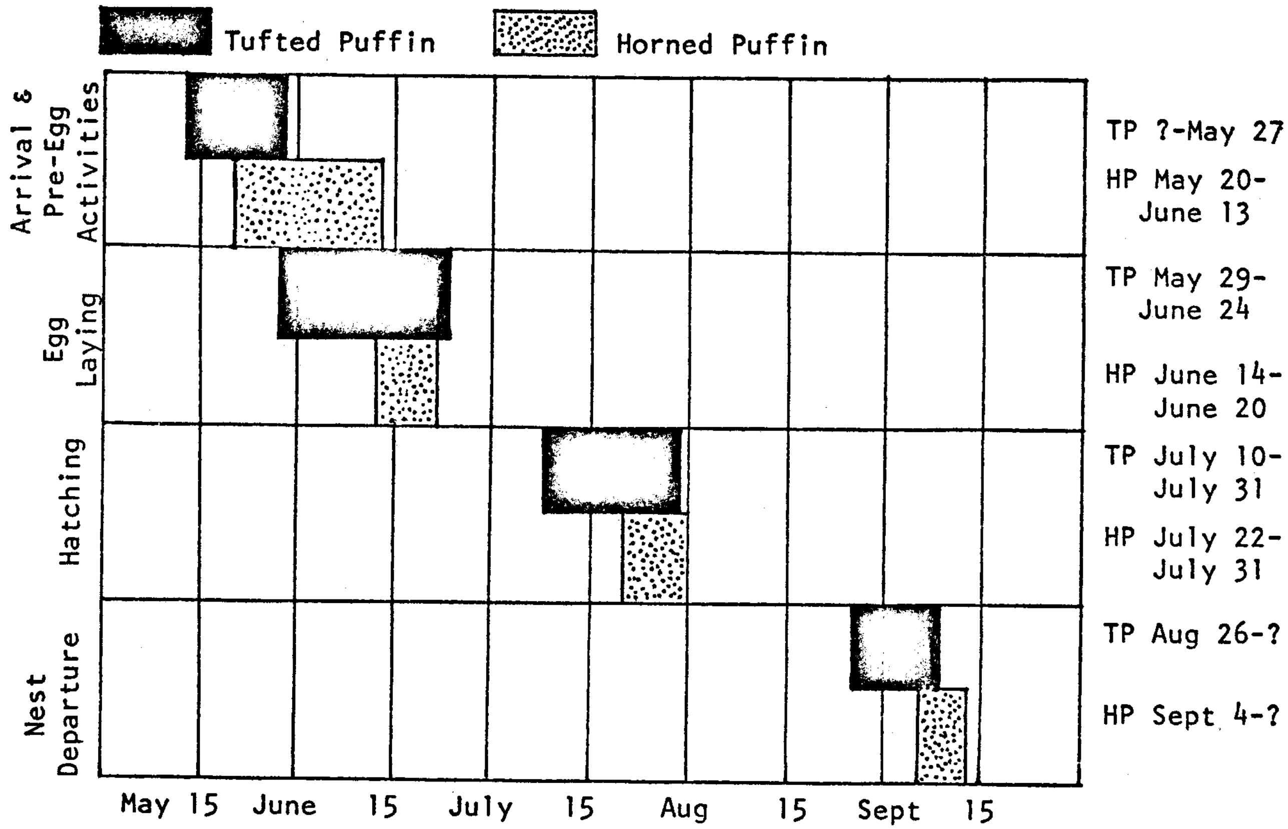


Fig. 16. Chronology of Breeding Activities for Tufted and Horned Puffins on East Amatuli Island, 1976.

the analysis. In an attempt to obtain more chicks for growth rate data, an additional 15 Tufted Puffin burrows were monitored on July 6. All 15 burrows contained eggs; 12 were subsequently deserted and three hatched.

Of 14 known reproductive attempts by Horned Puffins only two eggs were deserted, one infertile egg was incubated for over 50 days and abandoned, and 11 eggs hatched. Newly hatched puffin chicks are incubated by an adult for the next several days. Five Horned Puffins attended their chicks for an average of 6.4 days after hatching, while for 19 Tufted Puffins attendance was either for four days or the chick was left alone right after hatching. Sealy (1967) in experiments on thermoregulation in Horned Puffin chicks, found that by the sixth day the chick was able to maintain its initial body temperature after being exposed to ambient temperatures of 9°C for 50 minutes. It is probable that Tufted Puffin chicks, due to their slightly larger size and the sheltered environment of the burrow, achieve thermoregulatory stability at an even earlier age.

Nestling Food

The initial food delivery to newly hatched young is probably stimulated by vocalizations of the chick. A Horned Puffin was observed delivering a load of two fish to an egg which had just pipped. The soon-to-hatch chick was already vocalizing through the tiny, dime-sized hole in the egg shell.

Although fish carried by adult Tufted Puffins to their chicks were not collected at the onset of hatching, general observations suggest that only one or two fish per load are brought to the young chick. The number of fish per load increased significantly by the middle and latter part of the nestling period. However, the same increase in number of fish per delivery over time was not observed for the Horned Puffin.

The most important fish species, in number and frequency occurrence, brought to the young by both species of puffin was Capelin (*Mallotus villosus*). Capelin composed 94.5 percent of the Tufted Puffin bill loads and 73.7 percent of the Horned Puffin bill loads. Although the number of loads collected from Horned Puffins is small, it suggests that Capelin and Sandlance (*Ammodytes*) are also important in the diet of this species (Table 16).

Table 17 compares the average number of fish per delivery and average weight per load delivered by Tufted and Horned Puffins. Tufted Puffins on East Amatuli Island carried, on an average, more fish per load and heavier loads than did Horned Puffins. The heaviest single specimen brought in by a Tufted Puffin was an 18 gram Prowfish that measured 118 mm total length. The heaviest single fish delivered by a Horned Puffin was a 19 gram Capelin that measured 138 mm. The mean size of Capelin delivered by Tufted and Horned Puffins was similar, i.e. 92.0 mm and 99.7 mm, respectively. Although Tufted Puffins brought more fish or heavier loads to older chicks, no tendency could be detected for puffins to select larger individual fish for older chicks.

Diel colony feeding rhythms and number of daily feeds per chick were examined twice during the nestling stage for both puffin species (Figures 17-20).

Table 16. Species of Fish Brought to Puffin Chicks on East Amatuli Island During 1976.

TUFTED PUFFIN

Species	Number	Percent Total	Number Loads	Frequency Occurrence
Mallotus villosus (Capelin)	104	94.5	34	89.5
Squid	4	3.6	2	5.2
Zaprora silenus (Prowfish)	2	1.8	2	5.2
TOTALS	110	99.9	38	99.9
HORNED PUFFIN				
Mallotus villosus (Capelin)	14	73.7	7	63.6
Ammodytes hexapterus (Sand Lance)	3	15.8	2	18.2
Hexagrammos stelleri (White-spotted Greenling)	1	5.2	1	9.1
Trichodon trichodon (Sandfish)	1	5.2	1	9.1
TOTALS	19	99.9	11	100

Table 17. Number of Fish Per Delivery and Average Weight of Puffin Bill Loads Collected 4 August - 1 September, 1976.

	# Full Loads	Avg. # of Fish per Delivery	Avg. Weight per Load
Tufted	24	3.8* (1 - 8)	14.9 (2 - 36.5) grams
Horned	9	1.5 (1 - 3)	10.7 (3 - 19.0) grams

* Range

The Tufted Puffin Colony monitored for feeding rhythm data contained 20-22 chicks. Chicks 1-7 days old in Colony 3 received 33 fish deliveries on August 1 for an average of 1.6 feeds per day. At 21-27 days old chicks in the same colony received 82 deliveries for an average of four feeds per day. On August 21, the frequency of food deliveries to chicks in five marked burrows was observed. The number of feeds per day ranged from 2-6 with an average of 3.8 per chick. During the 1-7 day old stage most of the feeding activity occurs between 0600 and 1600 hours with an early morning peak at 0700 hours and another between 1000 and 1400 hours (Figure 17). When chicks are older, this pattern continues with one important difference: there is an additional early evening peak between 1800 and 2200 and feeding continues until 2200 hours (Figure 18). Undoubtedly, as the energy requirements of the chick increase, the adults must invest more time fishing.

The Horned Puffin colony monitored for feeding rhythm data contained ten chicks. Chicks 3-8 days old were fed only once per day on August 3, and at 12-17 days old they averaged 2.5 feeds per day (Figures 18, 19). On August 12, the mean number of feeds per day was 2.4 with a range of 2-3. Although the weather on August 3 was favorable, perhaps the low number of fish landings reflects some other local factor affecting food availability. Adults increase the daily frequency of feedings as the chick matures. Horned Puffins initiated chick feeding activity earlier in the day (0500 hours) during the 12-17 days old stage than during the 3-8 days old stage (0700 hours). Otherwise, there were no noticeable differences in the daily rhythm of fish deliveries.

TUFTED PUFFIN

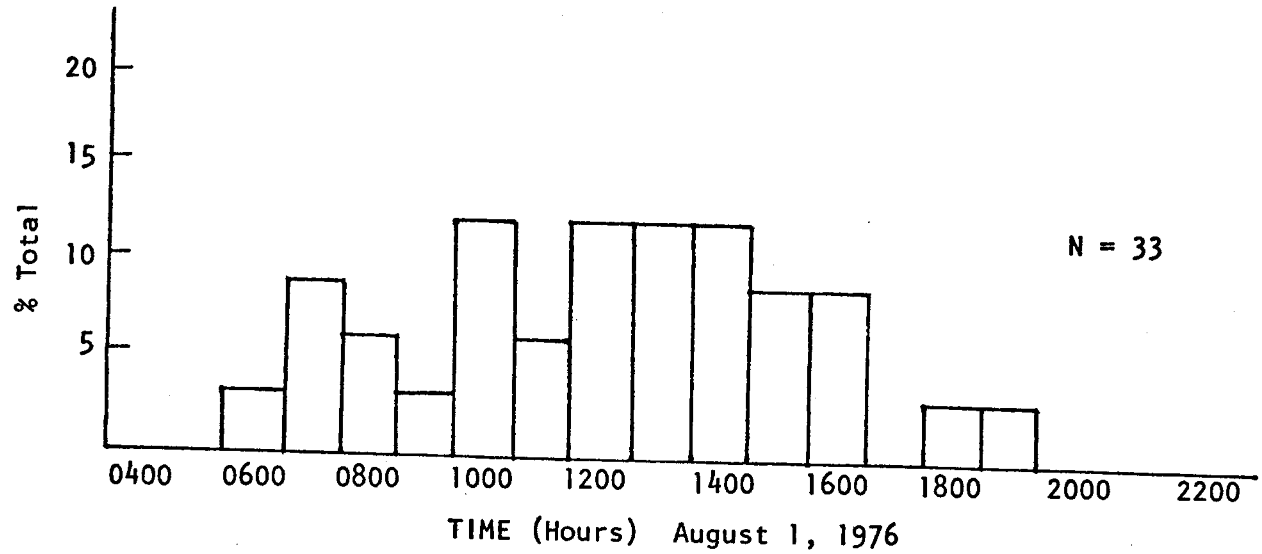


Fig. 17. Rhythm of fish deliveries to chicks 1 - 7 days old.

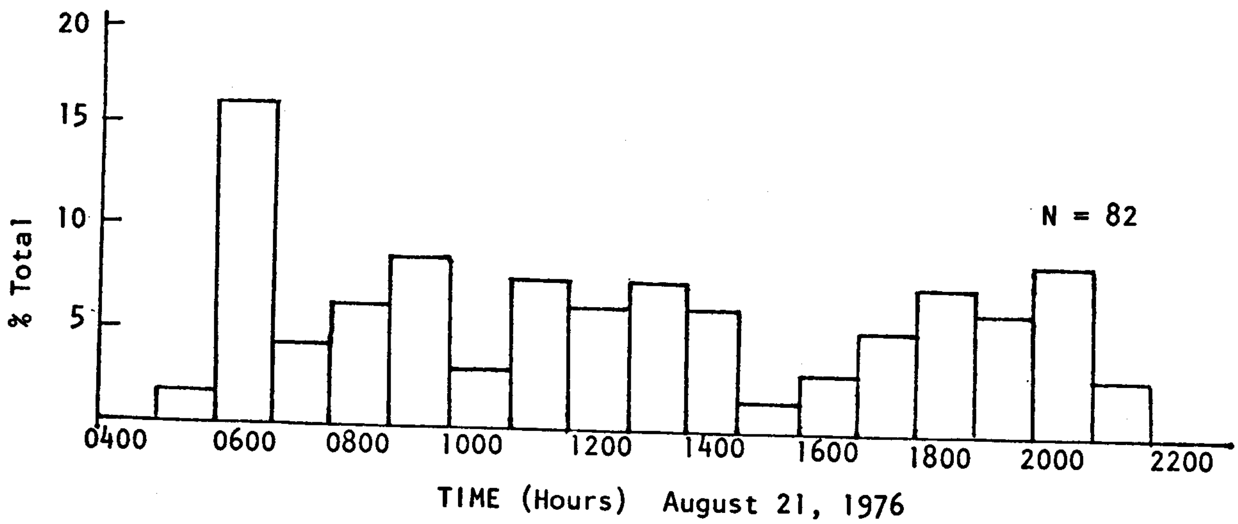


Fig. 18. Rhythm of fish deliveries to chicks 21 - 27 days old.

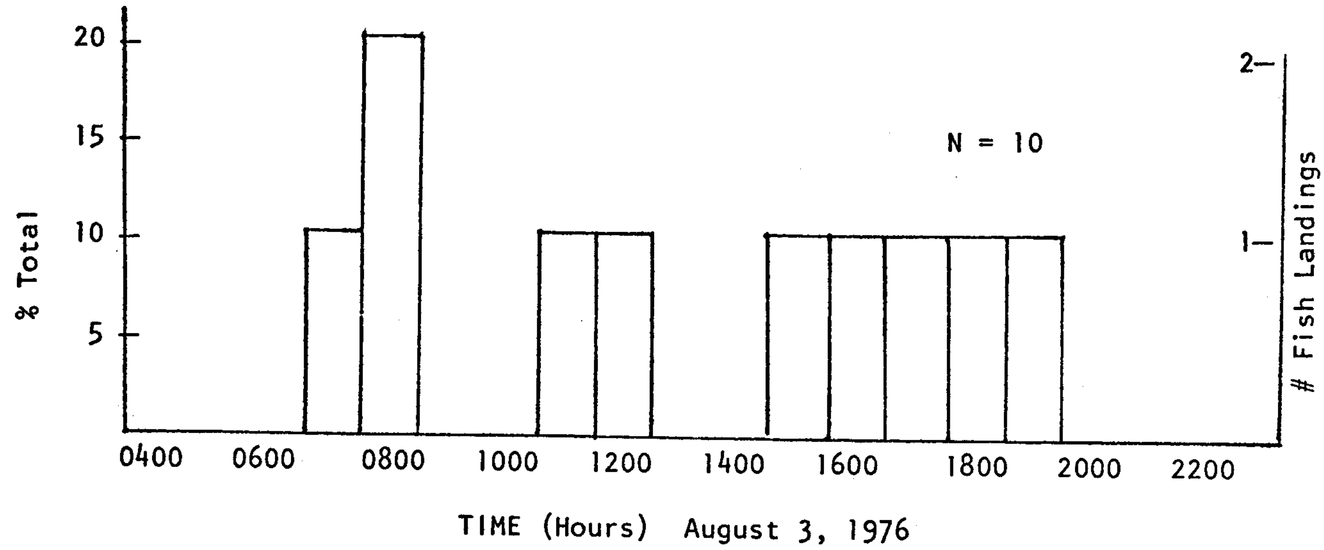


Fig. 19. Rhythm of fish deliveries to chicks 3 - 8 days old.

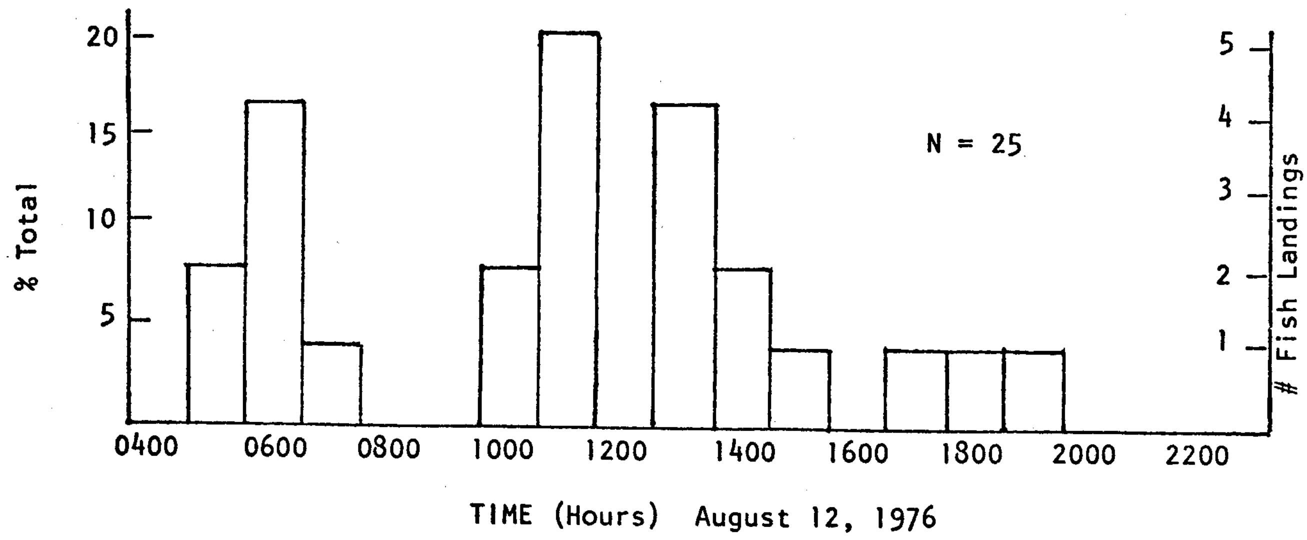


Fig. 20. Rhythm of fish deliveries to chicks 12 - 17 days old.

During the entire chick-rearing period, in which more than 1500 fish landings were observed, only ten observations of attempted cleptoparasitism were recorded. All attempts by Glaucous-winged Gulls were unsuccessful on Tufted Puffins. It is unlikely that Glaucous-winged Gulls exert any measurable effect on the chick-feeding activity of puffins on East Amatuli Island.

Growth of Young

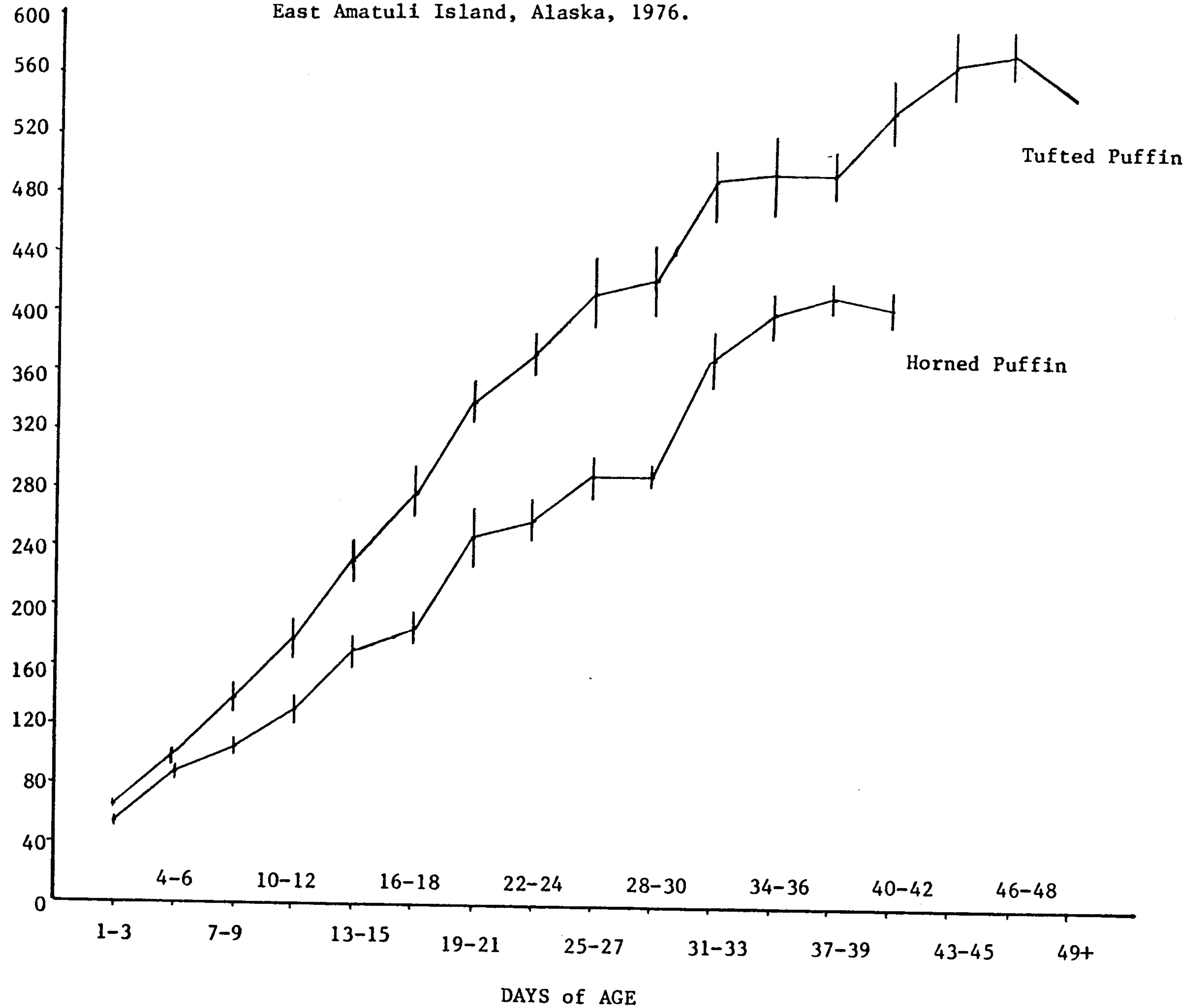
The growth and development of 21 Tufted Puffin chicks were recorded. The growth of the young from hatching to fledging takes six to seven weeks during which the completely downy nestling of about 68 grams develops into a fully feathered fledgling of about 570 grams. The egg tooth present at hatching disappears by 15-20 days of age. Tufted Puffin chicks usually attained maximum nestling weight a few days prior to fledging. For seven chicks, maximum weight was reached between 39 and 46 days of age (mean 43.3), while the mean age at fledging was 47.4 days. Weight gain is rapid and fairly constant for the first 43 days with an average of 13 grams gained per day for 15 chicks (Figure 21). The increase in weight and body measurements of the Tufted and Horned Puffin chicks is presented in Table 18.

The mean weight of 33 adult Tufted Puffins measured during the field season was 784 grams, thus Tufted chicks are fledging at 72.9 percent of adult body weight. Three Tufted Puffin fledglings walking to the sea were observed between 2030 and 2145 hours on September 1, 1976. The fledglings were flightless and somewhat disoriented. One made several unsuccessful attempts to enter our tent. The other two had apparently walked or fluttered down a grassy interior slope and followed

Table 18. Weight and Body Measurements of Puffin Chicks at Hatching and Just Prior to Fledging on East Amatuli Island, 1976.

	Wing(mm)	Weight(grams)	Culmen(mm)	Tarsus(mm)
TUFTED PUFFIN				
within 36 hours of hatching(N=12)	22.3	67.9	22	28.5
Fledging(N=10)	152.2	571.3	39.2	44.3
HORNED PUFFIN				
Hatching(N=3)	20.5	54.3	17.6	25.6
Fledging(N=2)	155	414	31.5	40

Fig. 21. Comparative Growth Curves for 21 Tufted and 10 Horned Puffin Chicks, East Amatuli Island, Alaska, 1976.



or floated down a stream to the sea. This night passage to the sea is essential to the survival of the fledglings on an island inhabited by predatory gulls, falcons, eagles, ravens, and otters.

Although the exact age of Horned Puffins at fledging was not determined, an estimate of 38-42 days was made by comparing the weight and measurements of known age chicks with those of two chicks in an unmonitored colony measured just prior to fledging (Table 18). One chick at 38 days of age weighed 430 grams, and was completely feathered with a wing length of 147 mm. The egg tooth present at hatching disappears by 15-18 days of age. Horned Puffin chicks attained their maximum nestling weight 2 - 3 days prior to fledging. Five chicks exhibited a fairly constant rate of growth up to 36 days of age averaging 9.8 grams gained per day (Figure 21). If 600 grams is assumed to be the mean adult body weight (Table 13) then Horned Puffin chicks on East Amatuli Island were fledging at 60 percent of adult body weight.

Breeding Success

The very high desertion rate initially reduces potential breeding success, particularly of the Tufted Puffin. About 40-47 percent of the Tufted Puffin eggs are deserted. Once the chick hatches, food availability, weather, and predation exert strong influences on nestling survival.

Table 19 shows the fate of nestlings of both species. Horned Puffin nestlings appear to be more vulnerable to storms. The Horned Puffin study colony was located along a seepage slope on East Amatuli Cove. After heavy August rains, some of the crevices were flooded,

Table 19. Fate of 21 Tufted and 11 Horned Puffin Chicks on East Amatuli Island, 1976.

Species	Fledged	Near-Fledging	Disappeared	Deserted	Storm Mortality
Tufted Puffin	9	4	3	3	2
Horned Puffin	0	4	1	1	5

resulting in chick mortality. One chick in a crevice located about 15 feet above sea level was drowned when high surf following a storm completely submerged the crevice. Tufted Puffin chicks are evidently better protected in their deep burrows. However, storm related mortality did occur when heavy rains flooded burrows or led to cave-ins.

During 1976, there were several potential predators present on East Amatuli Island. These included Northern Raven, Glaucous-winged Gull, Peregrine Falcon, Bald Eagle, and River Otter (*Lutra canadensis*). We observed no predation by ravens and gulls. Peregrine Falcons did prey upon both species but did not appear to be a serious predator. The remains of four Tufted Puffins attributable to Peregrine predation were found on the upper slopes of the island. Also on two occasions peregrines were observed stooping and hitting Horned Puffins as they flew off colony. A Bald Eagle nest on West Amatuli Island contained two dead Tufted Puffins, presumably brought to the nest as food for the eaglet. Puffin remains were often found below perches frequented by Bald Eagles, but it is not known whether the puffins were found dead along the beach or whether the eagle actually captured the birds. Bald Eagles were occasionally observed harassing Tufted Puffins, causing panic flights off the colony (Figure 22). Lastly, the prey items utilized by a three-member family of River Otters (*Lutra canadensis*) were recorded and are presented below in Table 20. Due to their use of well-worn trail systems, signs of River Otter predation were more readily observable than that of avian predators.

Considering the thousands of Tufted and Horned Puffins inhabiting East Amatuli Island, predation has little influence on the breeding success or productivity of the puffin populations.

Table 20. Prey Items Utilized by *Lutra canadensis* on East Amatuli Island During Summer 1976.

Species	# Carcasses	% Total
Fork tailed Storm Petrel	75	76
Tufted Puffin (adult)	3	
(juv.)	10	13
Pleuronectid (Flatfish)	2	2
Hexagrammos superciliosus	2	2
Glaucous-winged gull (adult)	1	
(juv.)	2	3
Horned Puffin (juvenile)	1	1
Parakeet Auklet (adult)	1	1
Black-legged Kittiwake (juv.)	1	1
Starfish	1	1
Totals	99	100

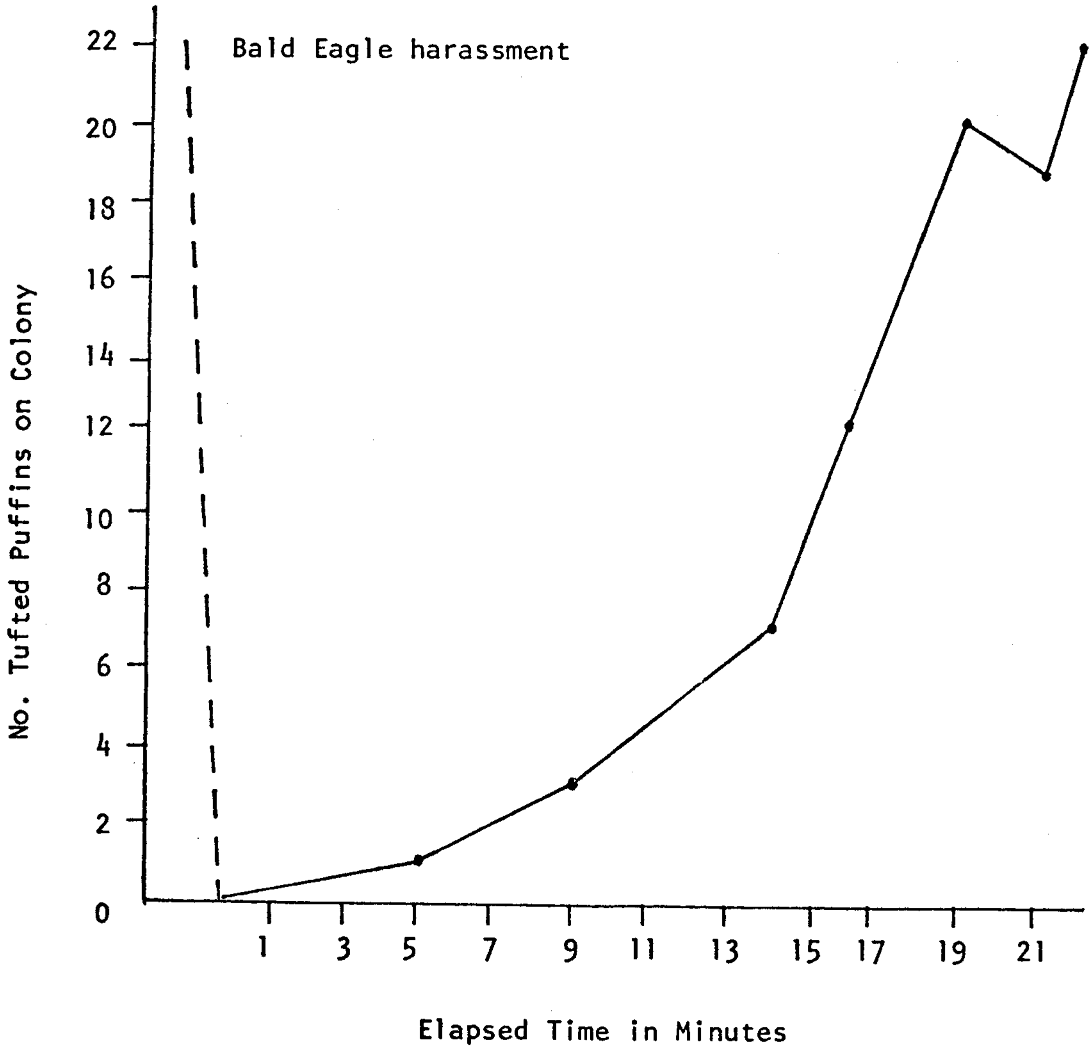


Fig. 22. Flight and colony re-attendance after Bald Eagle harassment, East Amatuli Island, July 23, 1976.

When all factors are considered, the over-all breeding success of both the Horned and Tufted Puffins is relatively low compared to other hole-nesting birds (Table 21). Desertion both before and after egg laying is the single-most important cause of breeding failure.

Table 21. Overall Breeding Success for Tufted and Horned Puffins on East Amatuli Island, 1976.

Species	# Burrows	# Eggs	# Hatched	# Fledged	Overall* Success
Tufted	85	40	16	10	25%
Horned	14	14	11	4	28.5%

*Overall success is the percent of eggs successful to fledging.

FORK-TAILED STORM PETRELS

The Fork-tailed Storm Petrel (*Oceanodroma furcata*) maybe the most abundant seabird in the Barren Islands. It is resident on the islands from at least May to September, and probably are present in the islands longer than other seabirds. Fork-tailed Petrels were thought to breed in the Barrens (Gabrielson and Lincoln 1959), but it was not until Bailey (1976) found an egg that it was confirmed. The largest colony of Fork-tailed Petrels is on East Amatuli Island, but they are present on many of the islands such as West Amatuli, Sugarloaf and Sud (Bailey 1976; this study, personal observations). No other species of petrel is known to breed on the Barren Islands. Petrels feed in the surface layers of the ocean and spend considerable time resting on the water where they are vulnerable to oil pollution. The abundance of petrels suggests they are probably an important component of the Alaska ecosystem and, therefore, any oil development should consider the risks of oil related mortality to this species.

Methods

Since the base camp was on East Amatuli Island, Fork-tailed Petrels were studied intensively on this island and were only surveyed for breeding activity on West Amatuli, Sud and Sugarloaf. Night counts of flying petrels in June and July were recorded at a site facing West Amatuli. Birds were counted once every 15 minutes for five minutes from the time the first petrel was sighted until no petrels were sighted for 15 minutes. On June 21, two observers counted petrels and found that they were within ten birds on any one count. All other counts were made by one observer.

Burrow visitation was monitored in three sample plots by placing toothpick barriers at the burrow entrance daily. These three sample plots located in the southern valley of East Amatuli and a fourth plot of 25 nests located at the base of a lake at 500 feet elevation were checked throughout the breeding season to determine laying dates and nesting success. Adults were not handled but seven chicks were weighed every five days once adults were no longer present in the nest during the day.

Forty-three additional nests were checked daily during June and July to determine the incubation rhythm of the sexes. These banded adults were weighed daily and the importance of repeated disturbance on nesting success was established.

In addition, 113 nests were visited once every five days from late July until September 6. The contents of the nest was determined. If an egg was present we noted whether it was being incubated. Bill length, bill width (depth), tarsus, foot, toenail, wing, third primary, and tail feathers were measured using Venier calipers for 93 chicks every five days. Weight was taken daily using a Pesola scale graduated in 0.5 gram intervals to 50 grams, and in 1 gram intervals to 100 grams for over 50 chicks, except during severe storms. On some days 30 chicks were repeatedly weighed throughout the day and night to determine weight loss. Night observations on feeding and burrow density were made. During nest visits a description of the chick was taken so that a descriptive development of growth could be compiled.

As a further index to breeding success, nest sites with signs of use were checked for birds and eggs. These nests were in different areas from the other nest sites monitored.

Five nests were used in a twinning experiment to determine the importance of food in nesting success. All twin nests had young added that were less than seven days of age.

The significance of predation by gulls was observed by individually releasing 20 birds during the day at the gull colony on the southwest ridge of East Amatuli. A second release was made from the cliffs on the east side. A sample plot in the middle of a dense petrel nesting area was cleared of petrel remains to determine the significance of River Otter predation. Observations on River Otters and their scat were made for a qualitative assessment of the significance of otter predation on the petrel population.

Fork-tailed Petrels were captured either in burrows during the day or in mist nets on 13 nights. The mist net was placed below a large petrel colony where it remained all summer. Measurements such as bill length, bill width (depth), wing length, tarsus length, toenail length, foot length, weight and brood patch state were taken. The duration of netting was recorded and food samples were collected. Wind speed, visibility, wind direction and the number of petrels with fish and oil were recorded. Thirty petrels were collected by mist netting, sexed, measured and stomach contents preserved.

Night Counts

Thousands of petrels were heard calling in the evening. The first petrel was seen arriving on the islands at dusk and leaving at dawn. Flying petrels were counted on five evenings to determine their activity pattern (Figure 23). The greatest number of birds fly and vocalize during the darkest part of the night. On June 21 (the summer equinox)

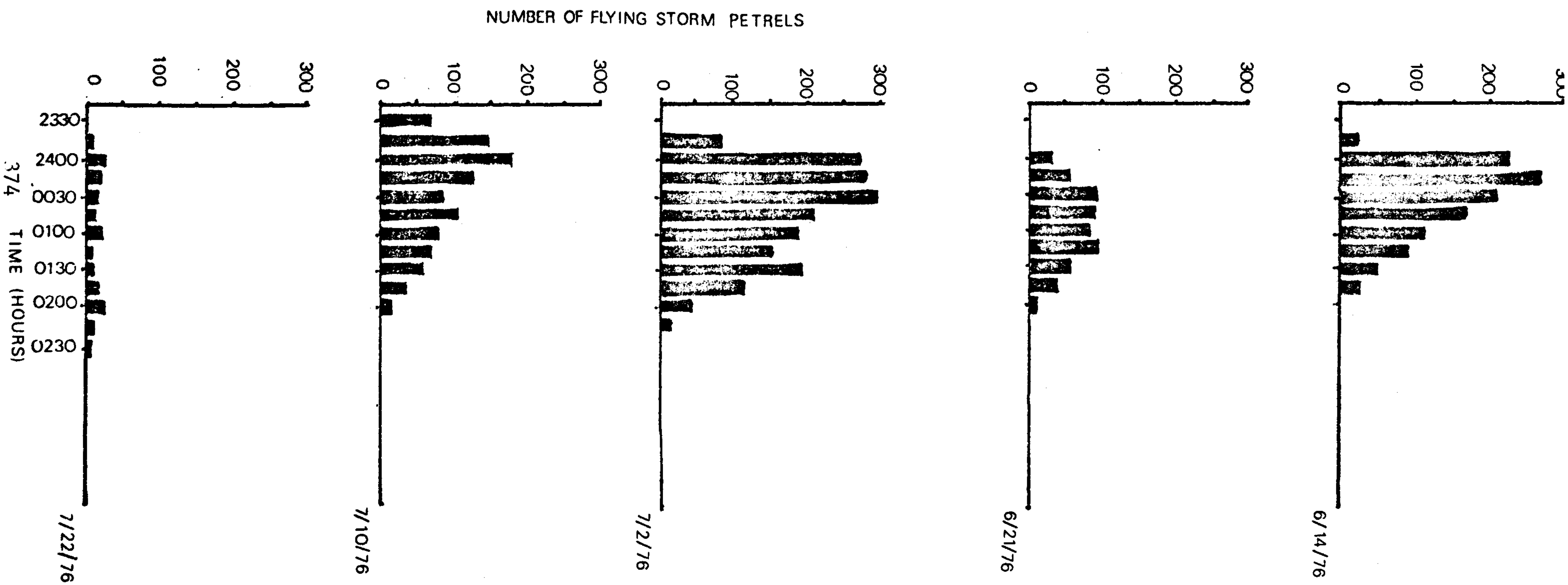


Figure 23. Number of storm petrels flying at 15 minute intervals on 5 different nights on East Amatuli Island.

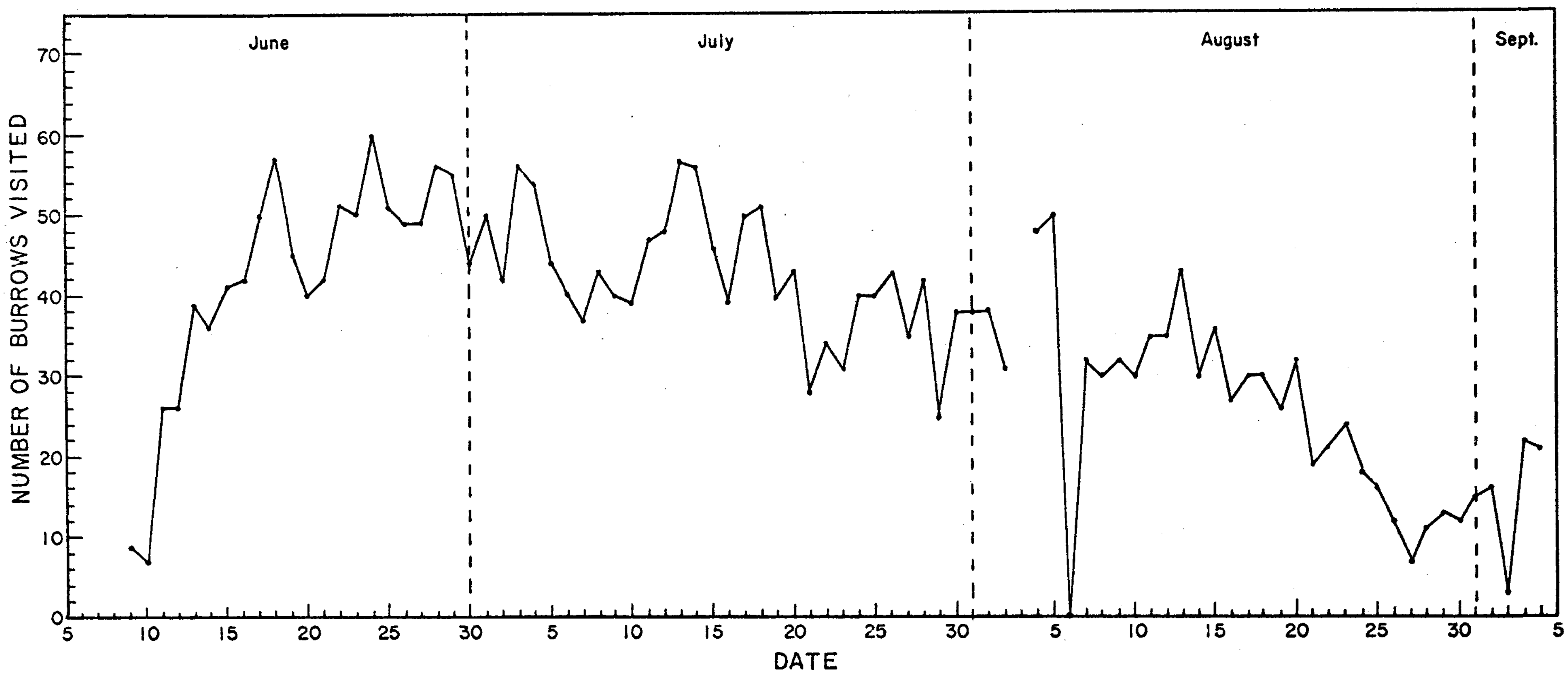
there were fewer petrels flying and their numbers were relatively constant during the darkest hours. The arrival time of the first petrel became progressively later from May to June 21. On May 15, petrels were active at 2300 hours and silent by 0300 hours, while on June 25 they were calling at 0045 hours and were silent by 0200 hours. In September very few petrels were heard, but some chicks had been fed by 2300 hours. Light seems to be an important factor influencing petrels' arrival and departure.

The number of petrels flying at night decreases as the breeding season progresses. Mist netting data also reflects the decrease in numbers. During 30 minutes of mist netting, from June 27 to July 13, we captured an average of 1.11 petrels/minute S.D. =±.22, and from July 19 to August 21 an average of .45 petrels/minute S.D. =±.22. All netting was done when the greatest number of petrels were calling, approximately 0300 hours. In August sampling was done at 2330 hours since petrels were arriving earlier.

Burrow Visitation

The number of petrels visiting the island varies from evening to evening (Figure 24). The 75 nests that were checked daily for toothpick displacement show wide variation. The most severe drops in visitation occurs during storms. During the worst storm, August 5, no petrels visited burrows. Gale warnings for the Kodiak area were in effect June 10, August 5 and September 2. The high visitation days (June 18, June 24, July 13, July 14) were calm days with little wind. Egg-laying was affected by storms as was chick weight gain (Figure 25).

Figure 24. Number of burrows visited by Fork-tailed Storm Petrels on East Amatuli Island, Alaska (June 9 - Sept. 4, 1976).



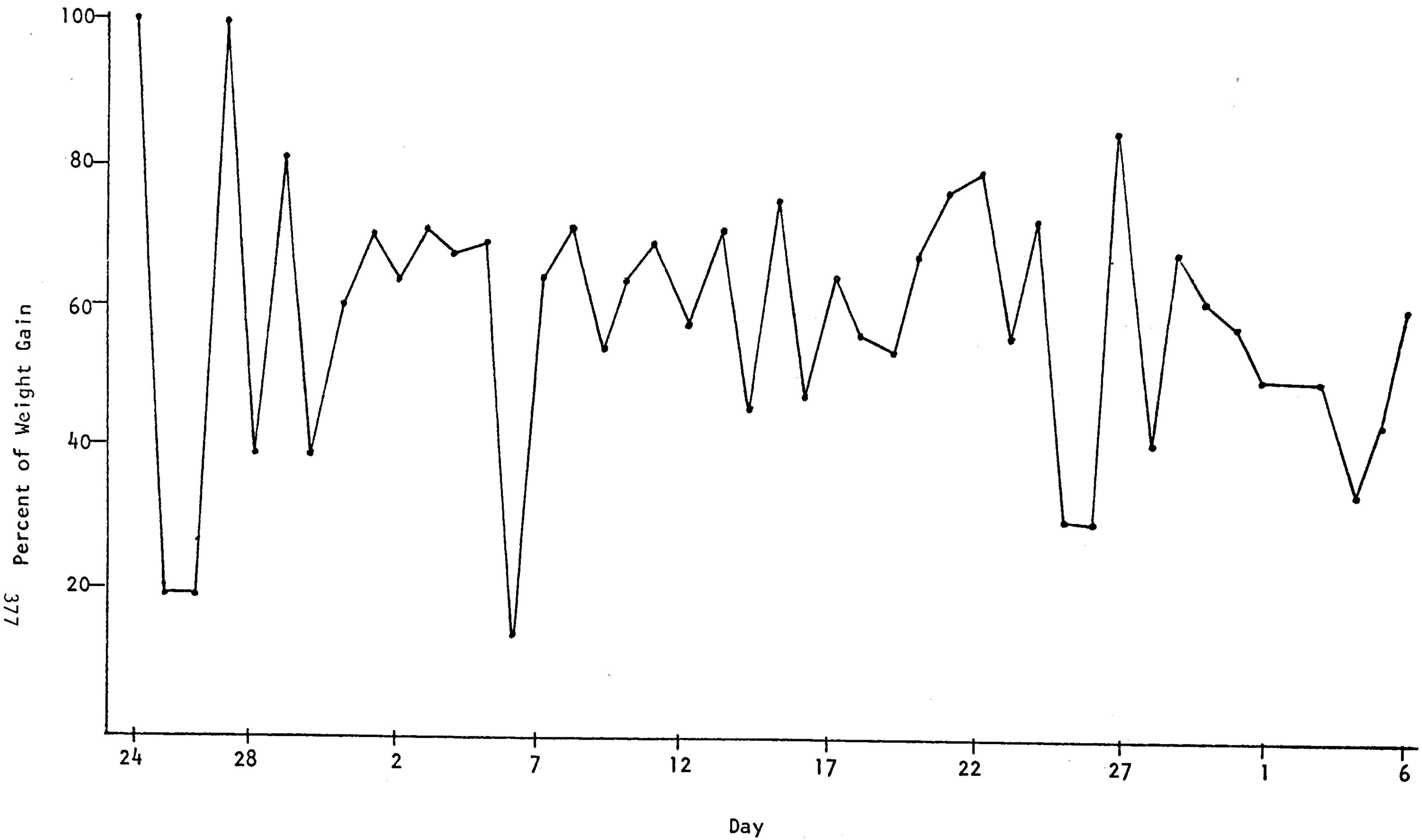


Fig. 25. The percentage of petrels that gained weight from August 24 to September 6. N = 5 from July 24 to August 2. Sample size varies from 17 to 44, with Day 20 having a sample size of greater than 40 young.

Incubation

Twenty-one adults were banded from 43 nests to monitor incubation rhythm. Individuals were weighed and measured but the sexes are not dimorphic. Both sexes incubate. One individual lost 9 grams in three days. With the exception of two birds, the adults remained on the nest for less than three days at a time.

Repeated handling by researchers caused desertion. After 20 days all nests were abandoned. One adult returned after 23 days to resume incubation, and two others after 18 days. Seventeen of 55 adults with eggs were not captured after banding. Nests in well traveled areas fledged chicks if the adults were not removed from the burrow. Apparently, physical contact is necessary to cause desertion. This suggests that an increase in tourism which will mean greater numbers of people walking through Fork-tailed Petrel colonies will have little effect on desertion. However, if guides extract incubating birds then, some desertion will result. In general, this species will not be adversely effected by increases in tourism.

Eggs in 52 nests were monitored for incubation by checking their warmth. On the average, eggs were cold once in four visits (σ= .26). Eggs which hatched were cold from zero to eight days during the incubation period. Eggs which were unattended for two consecutive days hatched. It was not determined whether eggs left unattended for longer periods are viable, because of the frequency of our visits. Both sexes should be equally subject to oil spills throughout the incubation period. Differential mortality by sex should not be caused by oil spills because both sexes appear to spend equal amounts of time away from the nest. Therefore, they are presumably exposed to the same risks.

Hatching

Nests were checked at least once every five days, so the date of hatching, within five days, is known for 94 chicks (Figure 26). Storms with high winds occurred during the weeks of July 1-5 and July 26-30 when hatching was depressed. Burrow visitation by adults was low during this time, suggesting eggs must respond to adult absence by delayed hatching. No eggs hatched after August 24 and the remaining eggs, which we opened on September 4, were all dead. Hatching occurs during a two-month period and, of course, reflects the extended egg-laying period.

The extended laying, hatching and chick period suggests this species will be vulnerable to oil pollution longer than any other species in the islands. Although they are abundant, a major oil spill in the Barrens could decimate the population since breeding adults are closely tied to the islands from early May until mid-October.

Chick Stage

Descriptive Development

Descriptive data on 20 chicks which were found on the day they hatched (day zero) were used to compile a general pattern of growth for Fork-tailed Petrels. Chicks were described in detail at least once every five days; plumage growth, therefore, may occur a few days earlier than indicated. Some chicks died and many had not grown tail feathers by September 6 when we departed, reducing the sample size to seven birds.

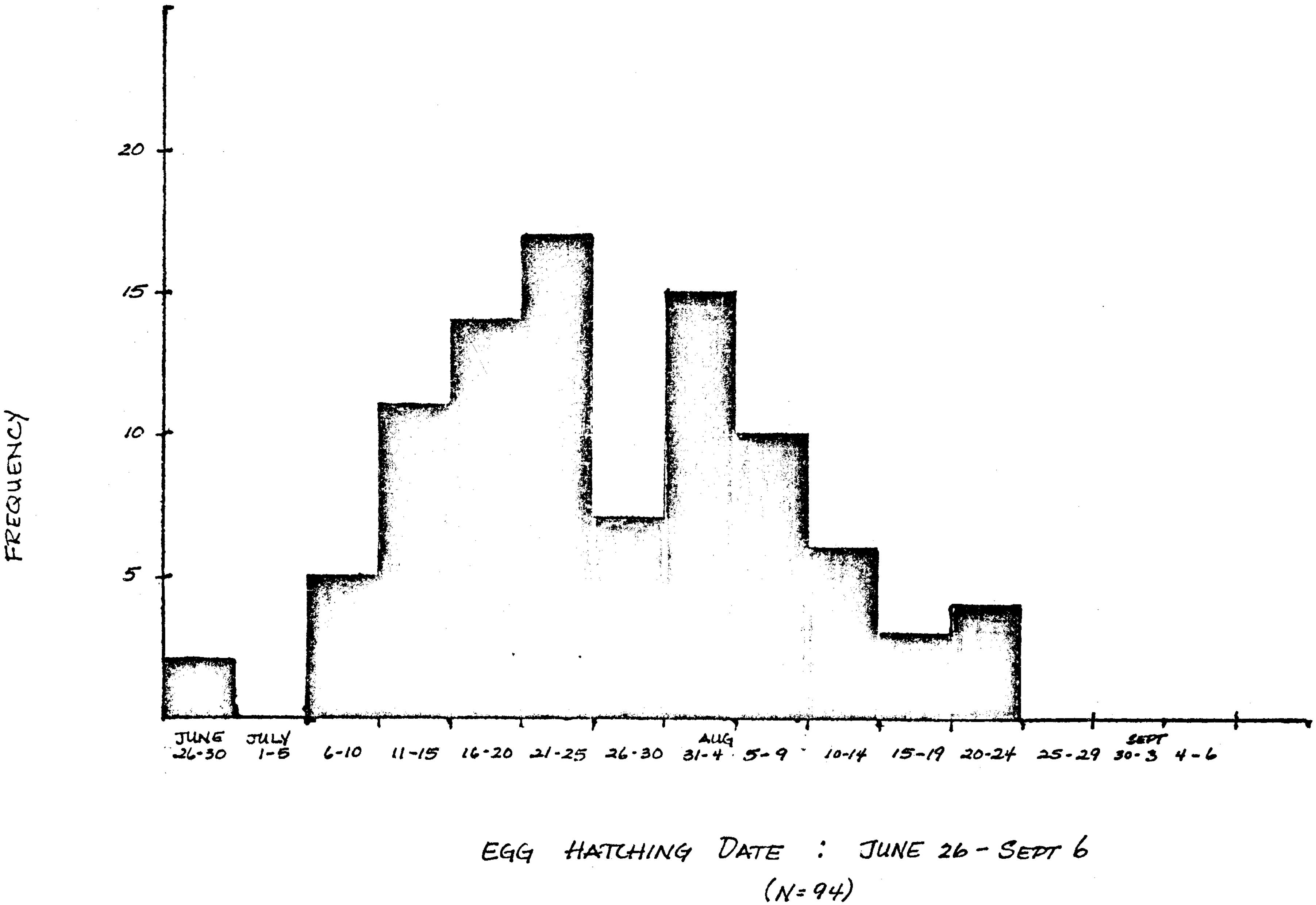


Figure 26. Hatching dates for 94 Fork-tailed storm petrel eggs during 1976.

Newly hatched chicks are distinguishable by the striped appearance of their feathers, which are not completely fluffed for approximately six hours. At hatching, the chicks are tiny balls of charcoal gray down with white wing tips. The eyes are closed and the tarsus is white to light gray.

If an adult is present at hatching, the chick is incubated continuously from one to six days with a mean of 3.1 days for 14 chicks. Five chicks were unattended at two days of age but five of these were incubated at 4 and 5 days of age respectively. Some eggs hatched when an adult was not present but chicks which were left unattended for two days always died. After the first five days the adults are rarely with the chicks during the day. Only one nest in more than 100 nests checked had an adult present when the chick was older than five days of age.

The eyes open as early as day 2 and by day 10 all chicks had their eyes open. Egg tooth loss is variable. Three chicks lost their egg tooth between days 6 and 10, nine chicks between days 11 and 15 and four chicks between days 16 and 20. One chick of undetermined age retained the egg tooth for at least 44 days.

The tarsus color changes with age from white to black. One of the 20 chicks had a light gray tarsus at hatching. The tarsus for 17 chicks was light gray by day 10 with a mode of five days. Tarsus color was medium gray for seven of 12 chicks by 11 and 12 days of age, dark gray for 11 of 16 chicks by day 20 and black for five of seven chicks by day 24.

Feather shafts were first visible beneath the skin on the spinal feather track between days 2 and 4 for seven of 15 chicks. The feathers erupted by day 8 for 11 of 19 chicks but were first visible on day 6 for four chicks. The secondary feather shafts started to grow for 11 of 15 chicks by day 14 and all chicks had primary shafts by day 20. Primary shafts of the tail feathers were noticeable as bumps for one chick on day 16, while 13 of 16 chicks began tail feathers by day 22. The secondaries' and primaries' contours started unfurling between days 22 and 30 while tail feathers unfurled between days 22 and 32. In general, secondaries started unfurling before primaries but grew more slowly. Feathers on the wings first erupt and unfurl closest to the body.

The variability in growth pattern suggests chicks cannot be aged accurately by feather growth, although it is possible to assign a minimum age. A chick is two days of age when feather shafts on the spinal track are visible beneath the skin. The chick is five days of age when feathers erupt on the spinal track. Secondaries begin at eight days, primaries at ten days, tail feathers at 16 days; and at 22 days secondaries, primaries and tail feathers unfurl.

Growth Rate

Bill length, bill width, wing, first primary, tail feathers, tarsus, foot and toenail were measured weekly. Data from 20 known aged chicks were used to complete the general growth pattern for these body parts (Figures 27-31). There is considerable variation between individuals but several body measurements taken together can be used to age a bird. These growth curves will allow investigators to visit the island once during the breeding season and reconstruct the extended hatching period. Furthermore, since no chicks died after 24 days of age from starvation, by measuring dead nestlings after an oil spill, mortality of breeding

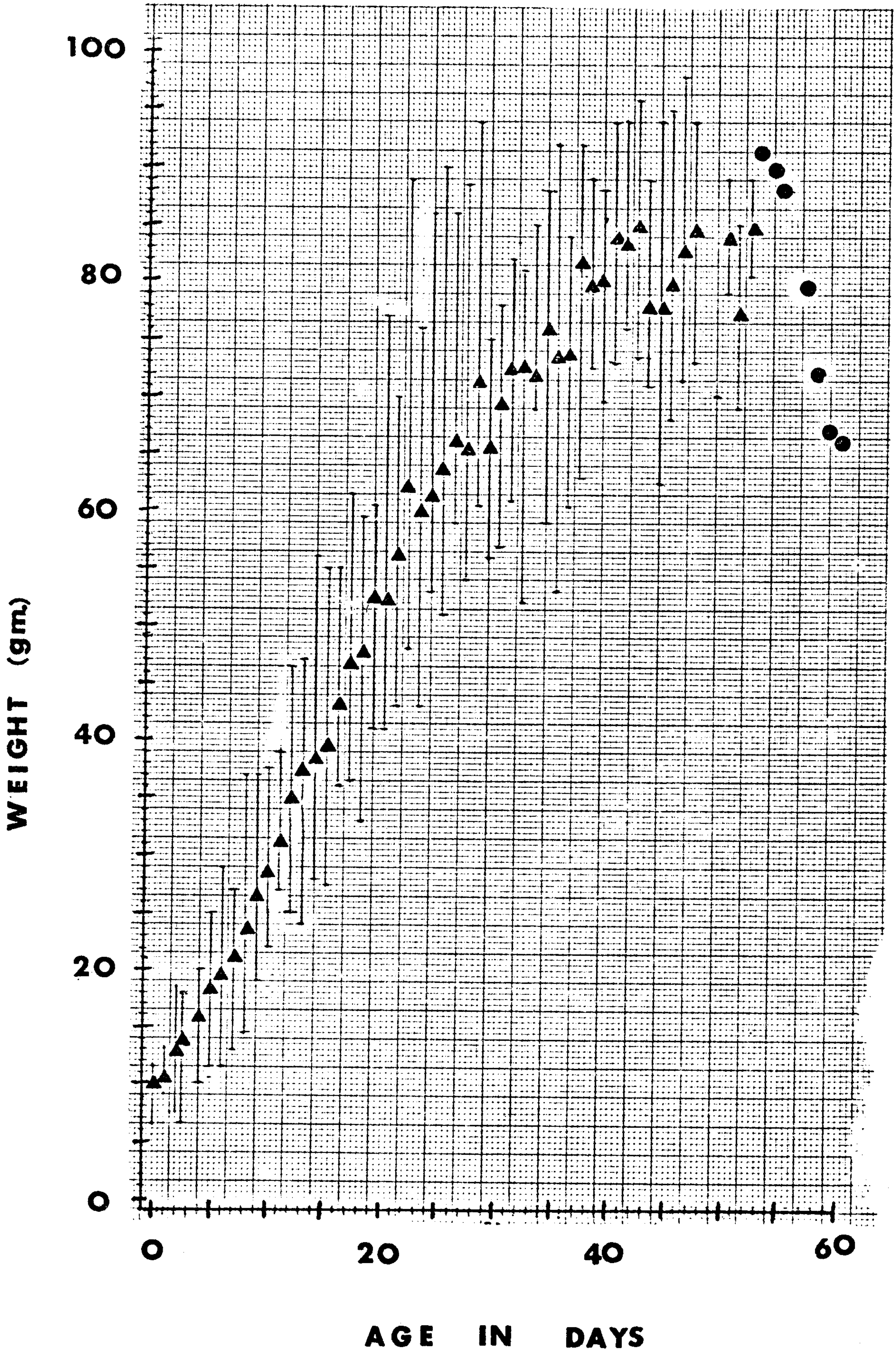


Figure 27. Weight gain of nestling Fork-tailed Storm Petrels on East Amatuli Island in 1976.

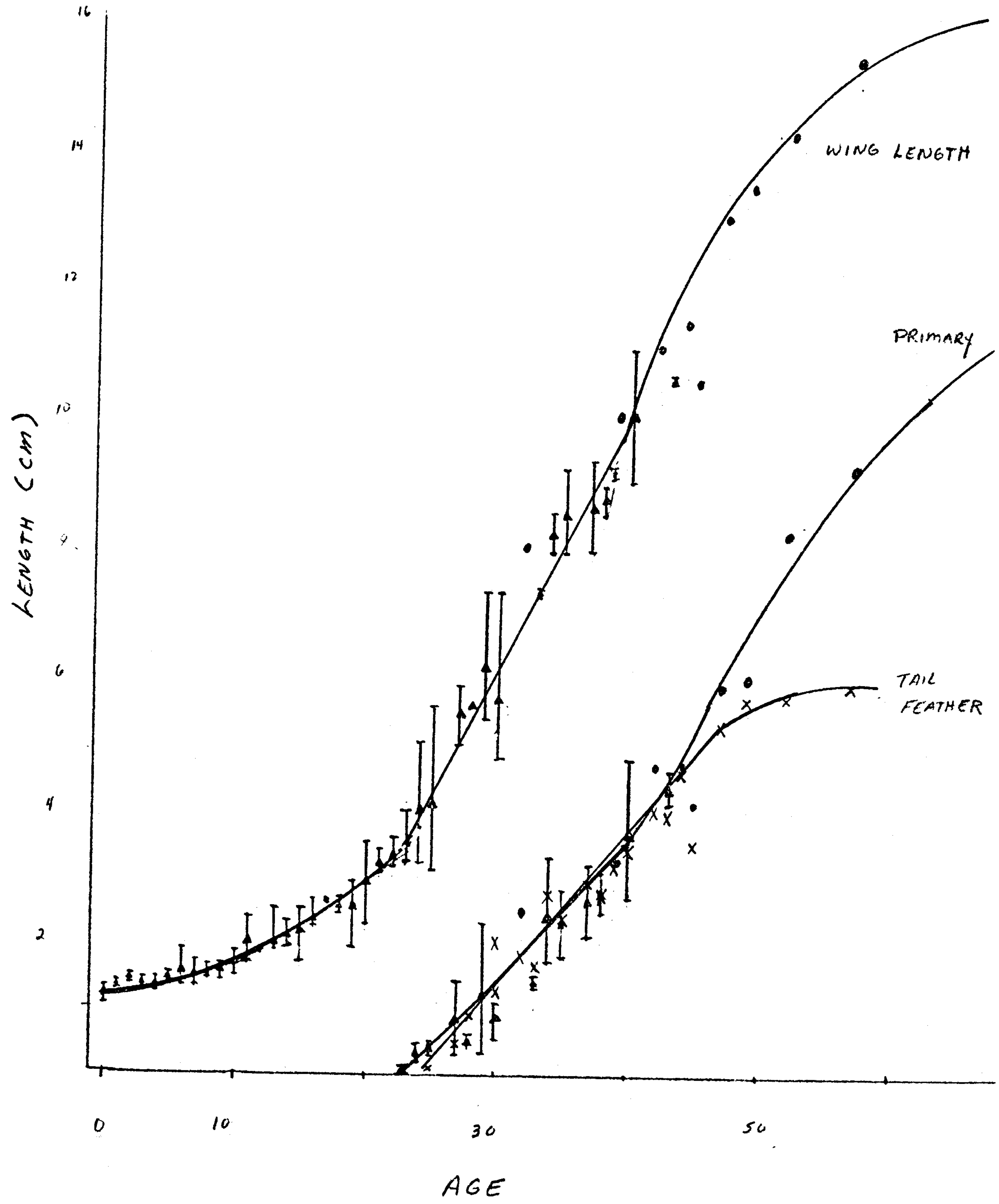


Figure 28. Growth of the wing, primaries and tail feathers of Fork-tailed Storm Petrels on East Amatuli Island in 1976.

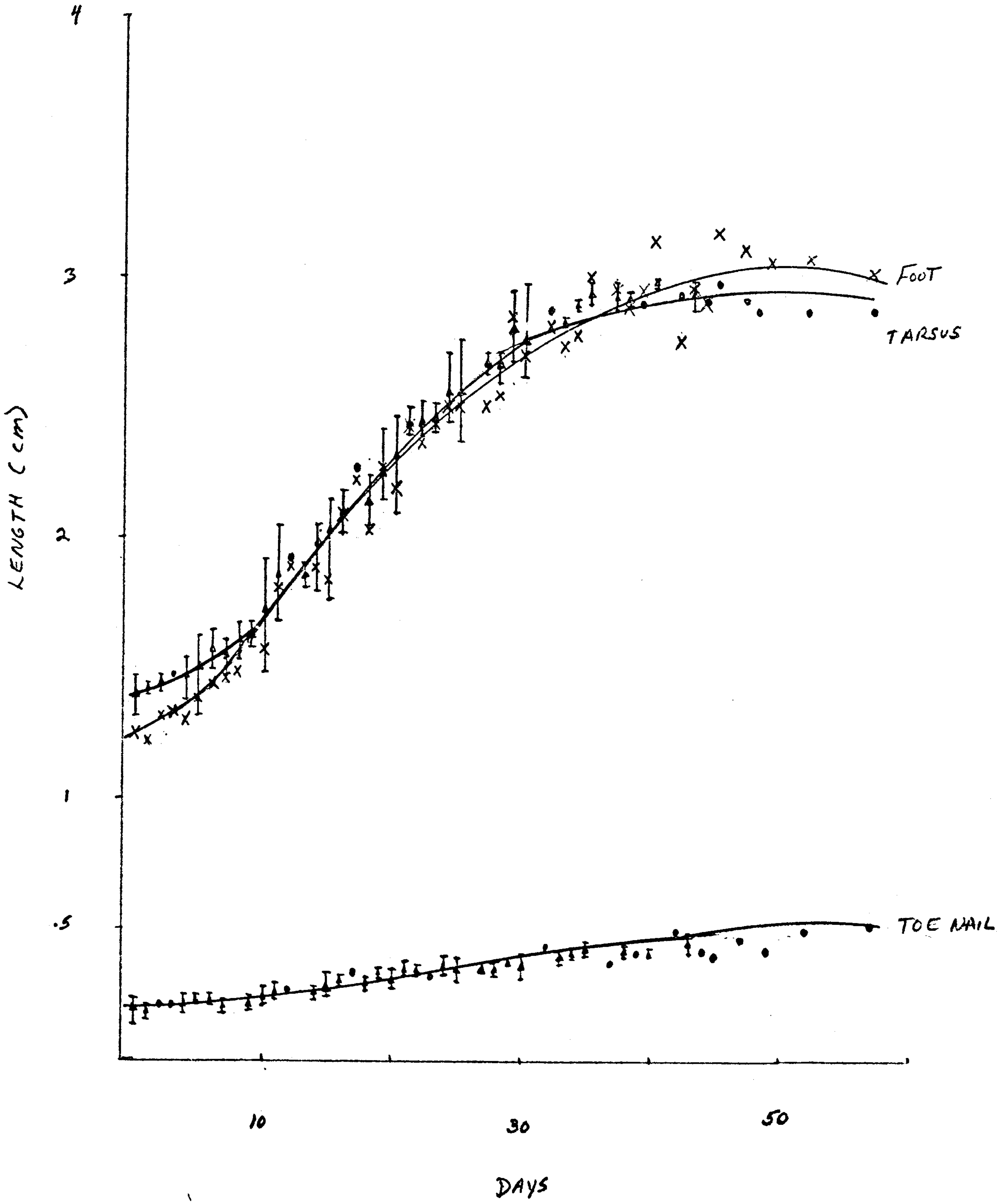


Figure 29. Growth of the foot, tarsus, and toenails of nestling Fork-tailed Storm Petrels on East Amatuli Island in 1976.

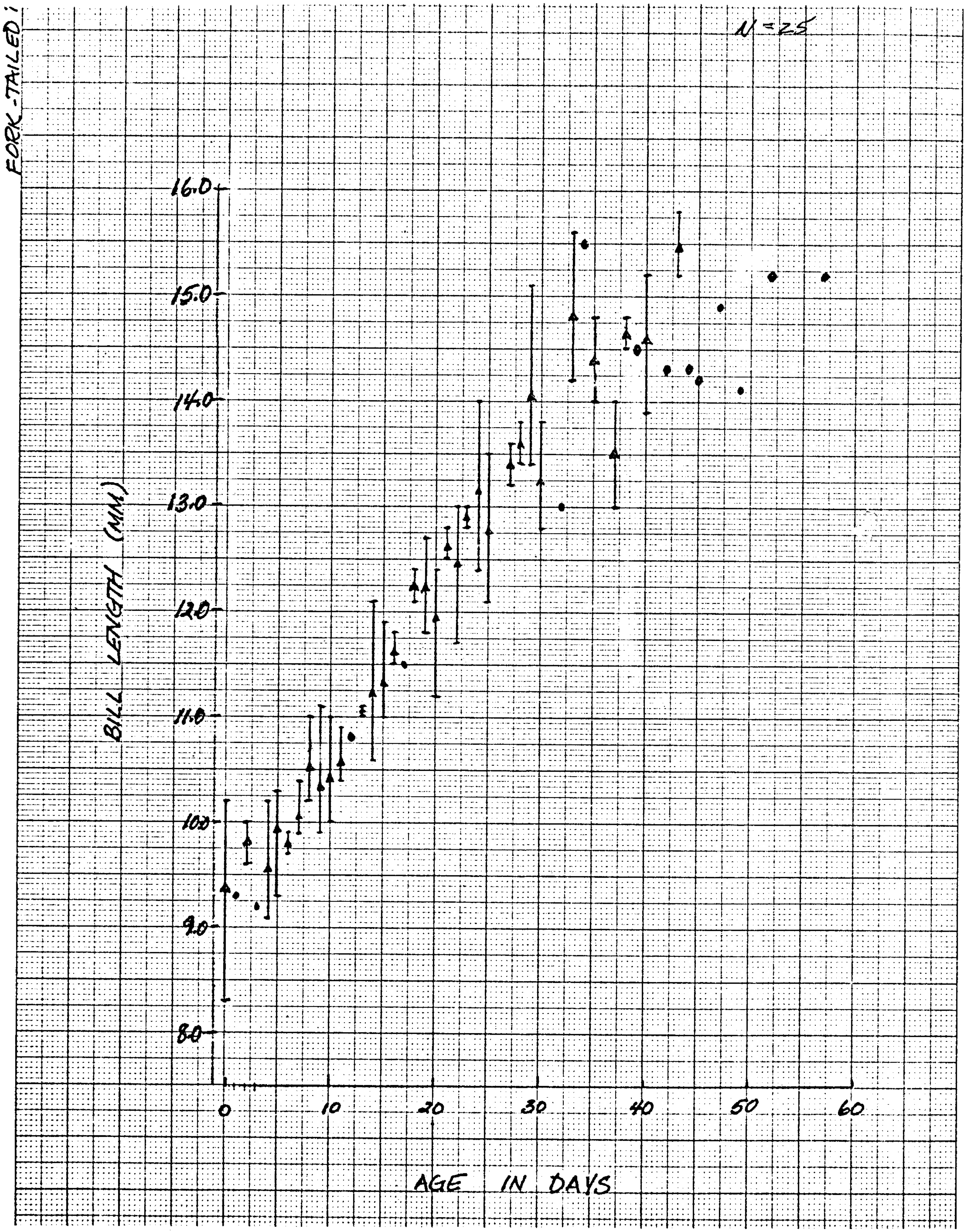


Figure 30. Growth of the culmen in nestling Fork-tailed Storm Petrels on East Amatuli Island in 1976.

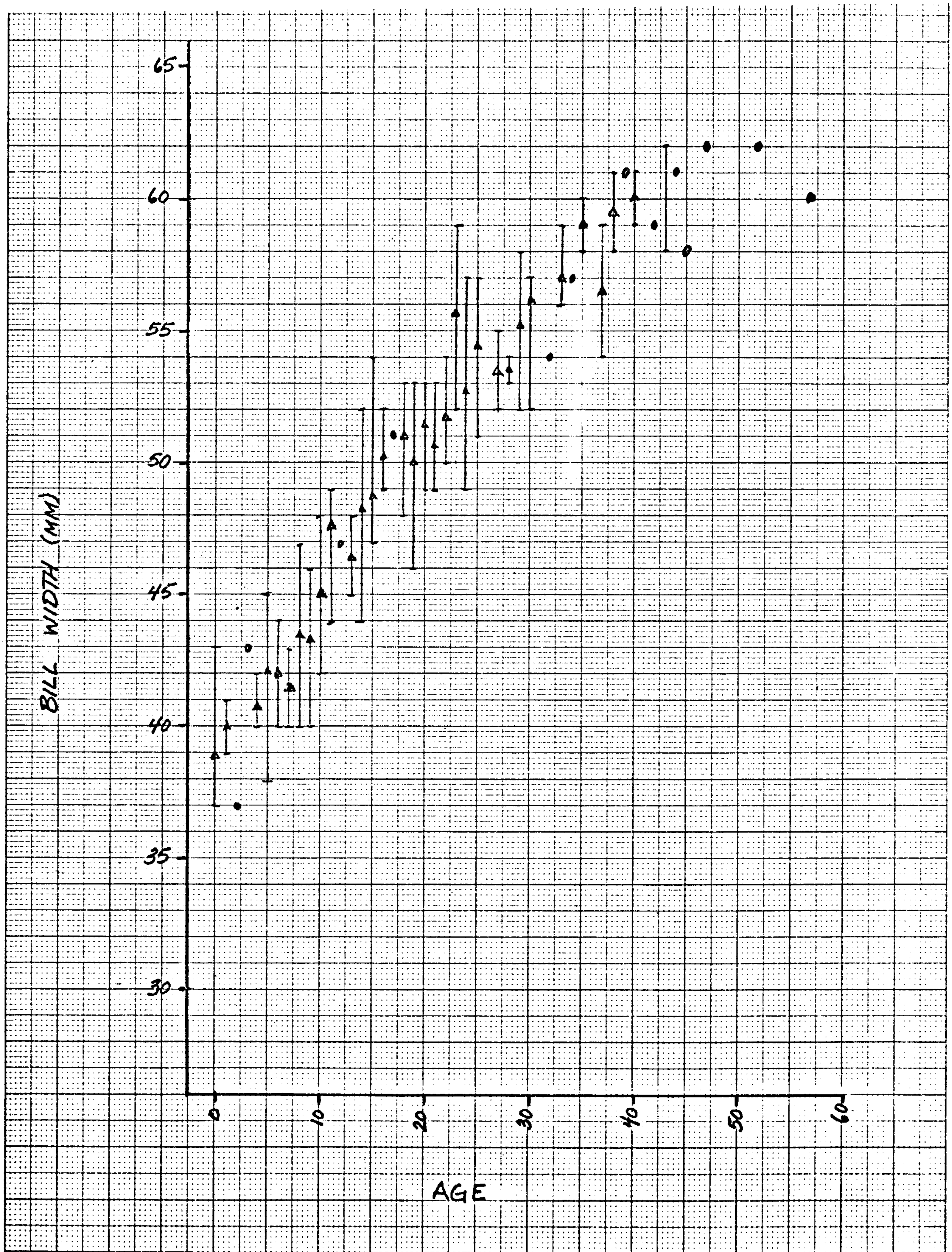


Figure 31. Age-specific changes in culmen width of nestling Fork-tailed Storm Petrels.

adults can be determined. Weight increases almost linearly while most body parts grow slowly at first and more rapidly later. The tarsus and foot grow most rapidly between 10 and 25 days of age. Toenail grows very slowly throughout the nestling period, while the wing, the primaries and the tail feathers grow most rapidly between 23 and 33 days of age. The bill grows linearly until 30 days of age. Prior to fledging the chick loses weight. Since toothpicks were knocked over while the chick was losing weight, signifying a parental visit, the young presumably refused food or is fed little. The three chicks which fledged during the study lost weight for four or five days prior to departure. These three chicks lost on an average 12 grams before fledging at 66 grams.

Twinning

An additional chick was added to five nests to test the ability of adults to rear two chicks. One chick fledged from four of five nests. The extra chick was fed in all but one of the nests. In this nest the young was not brooded although it remained in contact with the adult. This was the only nest where the chicks were not identical in weight. The added chick weighed 6.5 grams and the original 10 grams; both eventually died. After the addition, one of the chicks died within three to eight days in the other four nests. Adults brooded both chicks, suggesting they might not be discriminating between chicks. Four of the successful nests raised the indigenous chick and two raised the introduced chick, suggesting that adults cannot distinguish their own young at this early age. At the time of introduction all young weighed less than 14 grams and were no older than five days.

Chicks weighed between six and 14 grams when they died and were listless before death, suggesting starvation. Apparently, adults cannot rear two chicks because of food limitation. The unpredictability of food in both space and time and not its abundance per se may limit the number of petrels. We can not automatically expect an increase in adult mortality to be followed by an increase in the remaining adult's nesting success.

Breeding Success

Three different methods, checking burrows in new areas, monitoring 100 nests in four sample plots and regularly visiting 113 nests, were used to determine breeding success. Nests which appeared active in May prior to egg laying were marked in four sample plots. These nests had 49 eggs, fledged 14 nestlings for a nesting success of 29 percent (Table 22). The nesting success for the 113 nests with warm eggs marked in July just prior to hatching was 42 percent (Table 23). This value is high since nests that failed in May, June and early July were excluded by the sampling technique. The percentage of chicks which hatched and fledged are similar: 53 percent in the sample plots and 54 percent in the 113 nests.

Burrow checks in previously unvisited colonies indicates that 36 percent of the burrows which appear used have warm eggs or chicks in July (Table 24). From July 21 until September, the 113 nests had a 23 percent failure rate. If we reduce the active nests in the burrows check by a similar percentage we would expect 13.3 percent of the nests to fledge chicks. This is in close agreement with the 16 percent fledging success of the sample plot nests. Thus, a realistic estimate of breeding success for Fork-tailed Petrels on East Amatuli for the 1976 season is below 20 percent.

Such low breeding success suggests that oil induced adult mortality in Fork-tailed Petrels will have a long term population effect. Since survivorship of eggs and young are naturally low, changes in adult mortality will have pronounced and long term population consequences. The breeding biology of this species necessitates protection from oil spills throughout the year.

Mortality

The highest nest mortality is during the egg stage. Only 53 percent of the eggs laid hatched in the sample plot nests. Desertion was the major cause of nest failure. One egg was taken from an exposed nest site by a Savanna Sparrow. Normally, eggs remained in burrow until they were kicked out of the nest sites late in the breeding season by nonbreeders or failed breeders which were frequently near the nest sites.

Frequently, chicks died within the first ten days or during storms (Figure 32). Although predators such as gulls, ravens and otters may take young, none of the chicks in our samples were lost to predators. This suggests predation is an insignificant factor in nesting mortality.

The river otters on East Amatuli were not present last year (Bailey, personal communication). We found remains of petrels over the entire island in May and June, when petrels were laying and incubating eggs. As the season progressed, the otter diet appeared to shift and they took fewer petrels. The heavy predation early in the breeding season may not

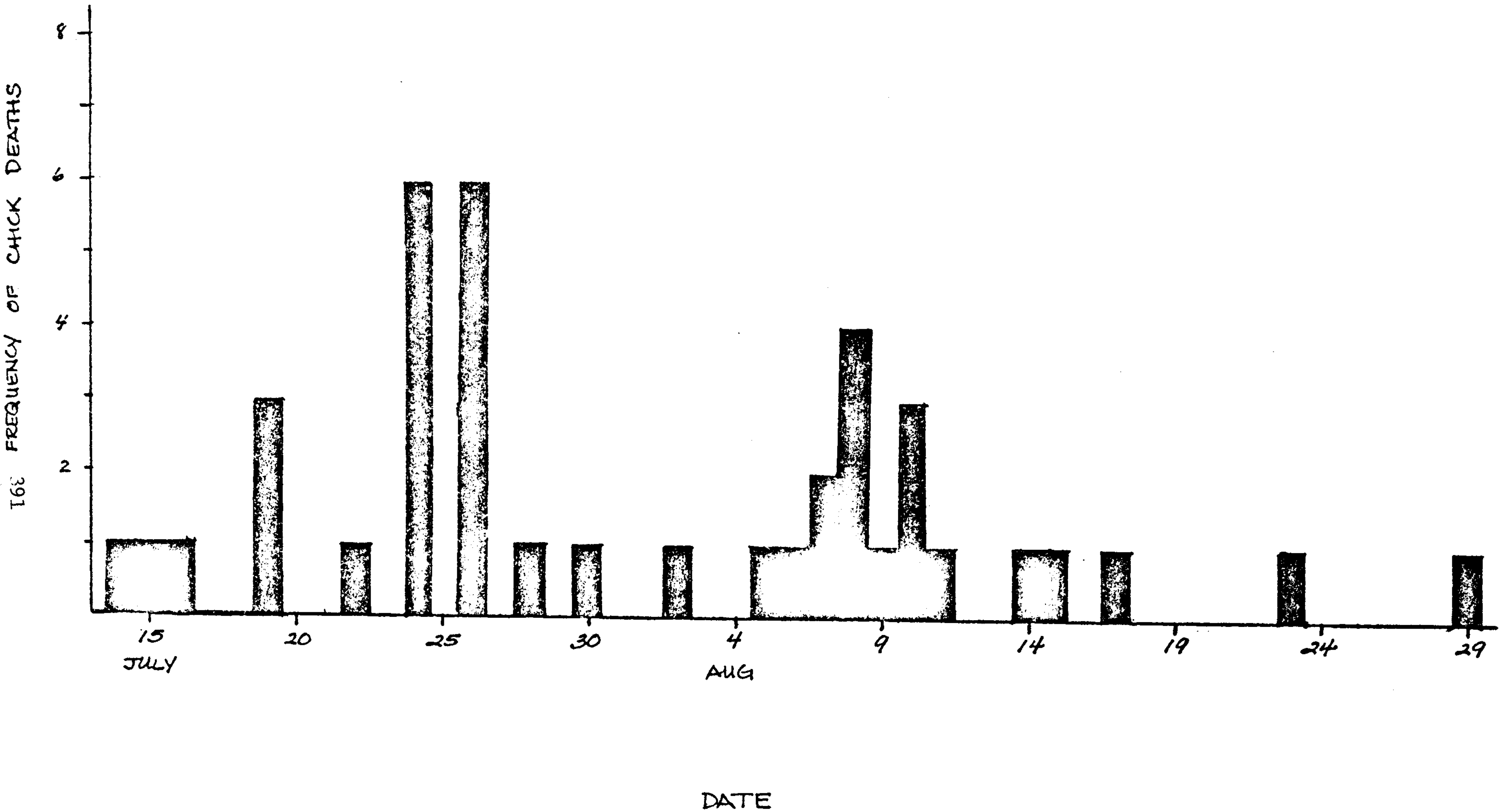


Figure 32. Nestling mortality of Fork-tailed Storm Petrels from July 13 - 29 August 1976 on East Amatuli Island.

have an immediate population effect since they may be taking mainly non-breeders. However, otters must be reducing the recruitment which will have a long-term population effect. It is unlikely that otters will decimate the population, since many of the nests are deep in talus slopes and inaccessible.

Gulls are thought to be important predators on petrels. Adult petrel remains were found in the gull colony and on Sud and East Amatuli Islands. Adult petrels were released during the day at a gull colony and no indication of predation was seen. Many petrels breed in the gull colony, which also suggests that they may not be important predators.

Population Size

Over 430 Fork-tailed Petrels were banded, of which 304 were captured in mist nets below a large colony on the north slope of East Amatuli. We originally hoped to get a crude index of the number of petrels in this one area, but we recaptured only one bird, suggesting approximately 10,000 birds in this air space. We have no reliable index to the population size, but extensive hiking and mist netting leads us to believe that there may be as many as 150,000 Fork-tailed Petrels on East Amatuli.

Sexual Dimorphism

All petrels mist-netted were measured and examined for molt. None of the birds captured in burrows or in the net were molting between May 21 and September 8. Brood patches were well-developed but not vascularized in late May. Well-developed brood patches were characteristic of adults that were no longer incubating their chicks. Mist netted adults in August had highly vascularized brood patches that were just beginning to become refeathered (Figure 33).

Thirty Fork-tailed Petrels were collected, sexed and found to have body parts of similar size. The variation of bill length, bill width, wing, toenail and tarsus are normally distributed (Figure 34, Table 24).

Similarity in the sexes further suggests males and females will be equally subject to the risks of oil pollution. Eggs were displaced from burrows in late August suggests non-breeders or failed breeders were frequenting the nests sites. It is likely that we mist netted some of these individuals, which we might expect to be heavier than breeders.

Weights of mist-netted petrels suggest that breeding is a costly activity. Adult body weight drops until late August. Adults may show an increase in weight because of fish they are carrying and feeding to the chicks in August (Figure 35).

Food

Petrels concentrate an orange oily substance which they readily regurgitate. Both adults and chicks regurgitate this material when handled. Only one chick regularly disgorged oil when weighed and measured. Adults, even after four handlings, do not become accustomed to the procedure. When adults were captured in the mist net they regurgitated either orange oil or a white paste of fish. Chicks are fed both fish and oil (Table 25). Adults have mainly oil in June and July, suggesting that crustaceans are then major food items; but fish became an important dietary component late in the breeding season. Figure 36 shows the percentage of adults captured which disgorged oil or fish.

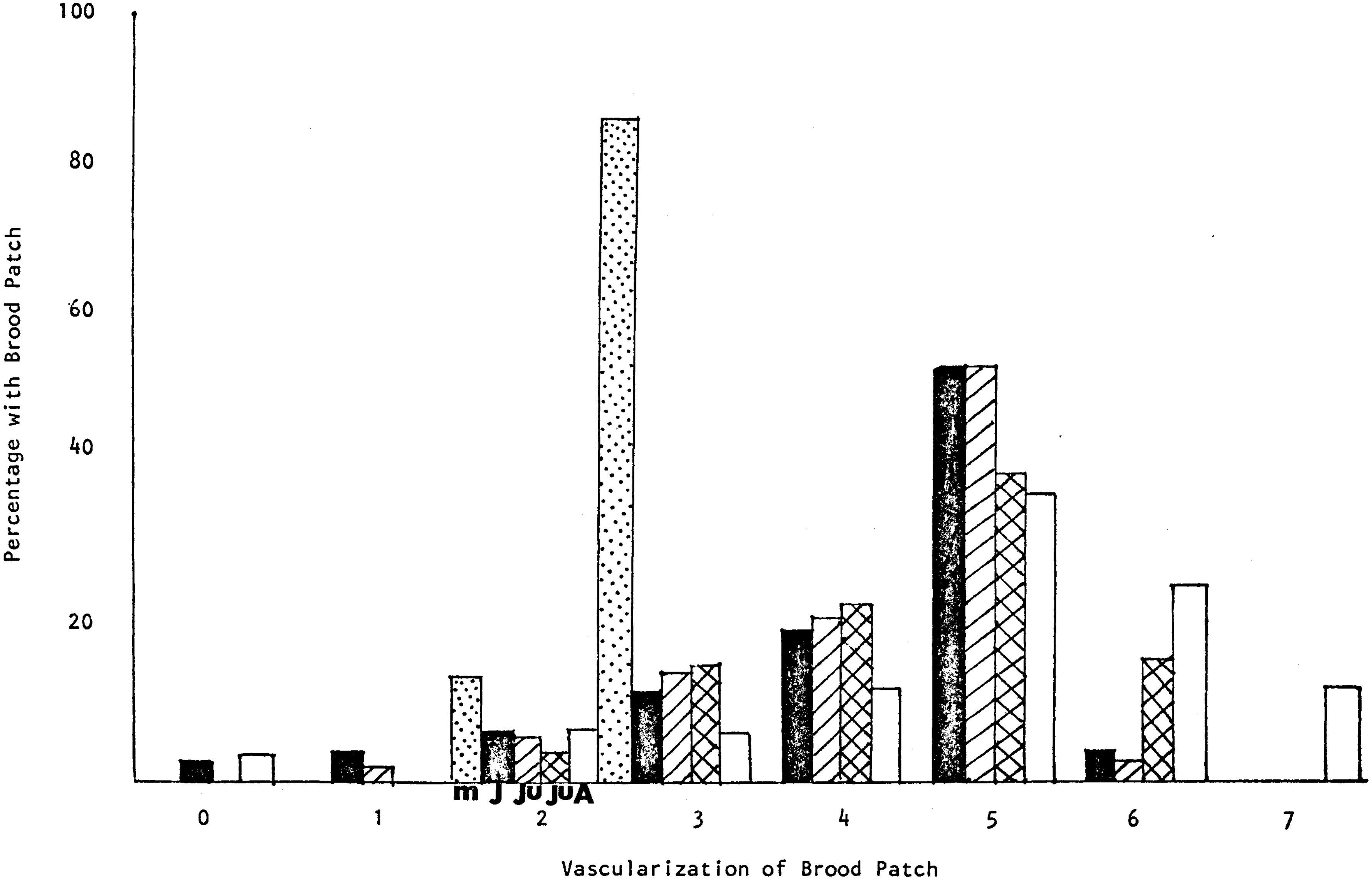


Fig. 33
Changes in vascularization of the brood patch from May to August 1976. Sample size in May = 8, June = 80, July 1-18th = 178, July 19-31st = 39, August = 34.

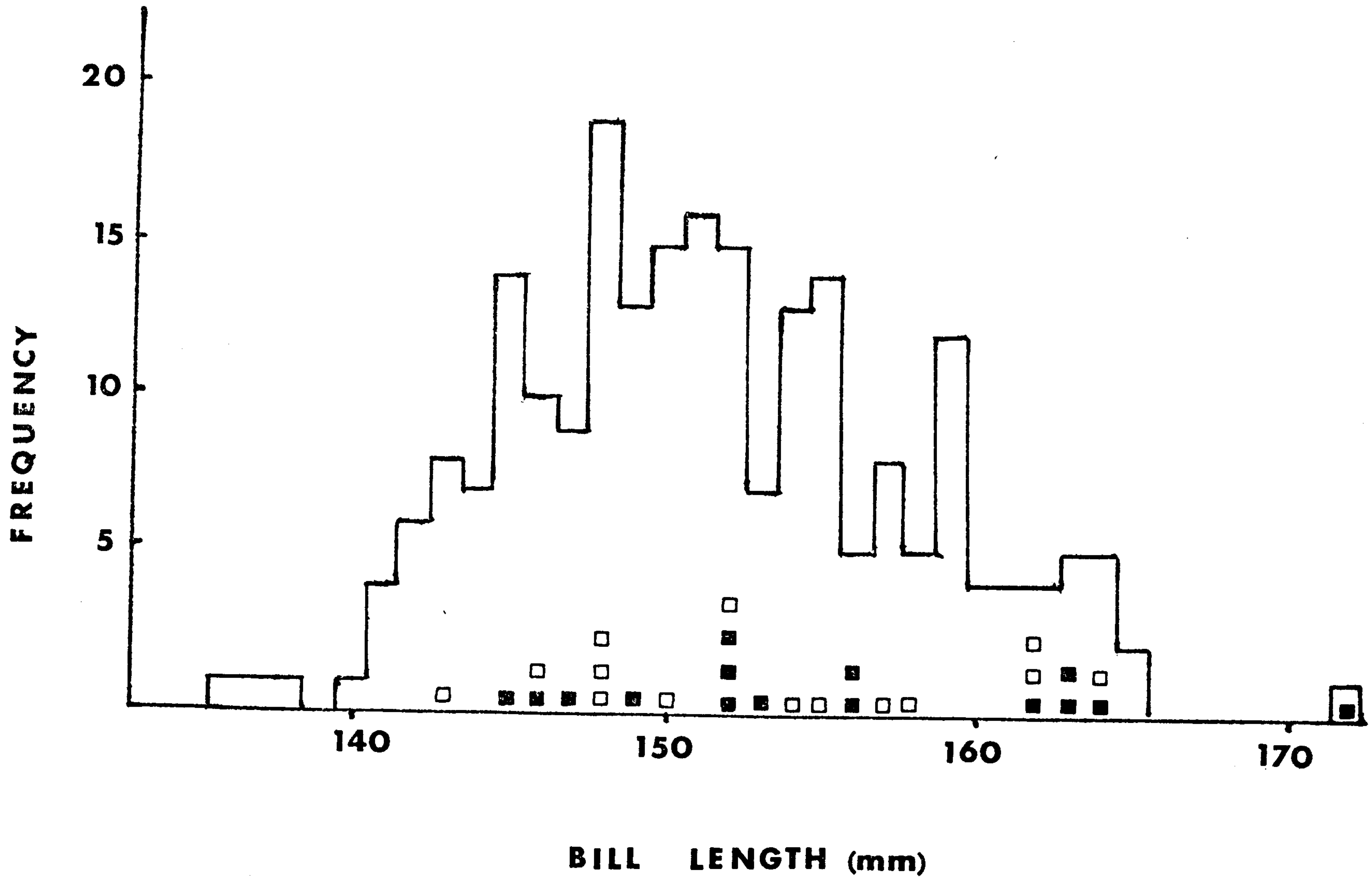


Figure 34. Bill length of Fork-tailed Storm Petrels captured on East Amatuli Island, Alaska.

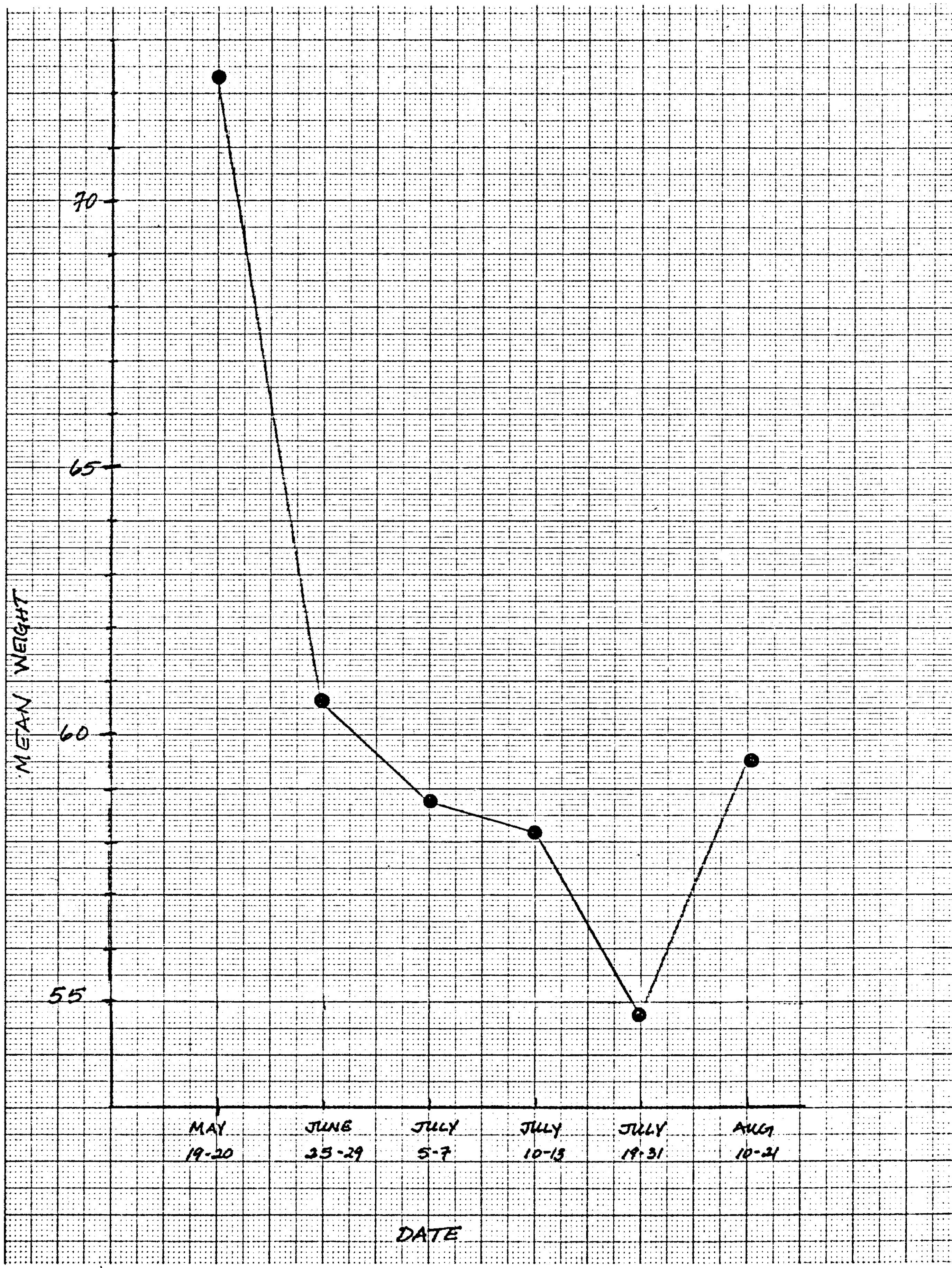
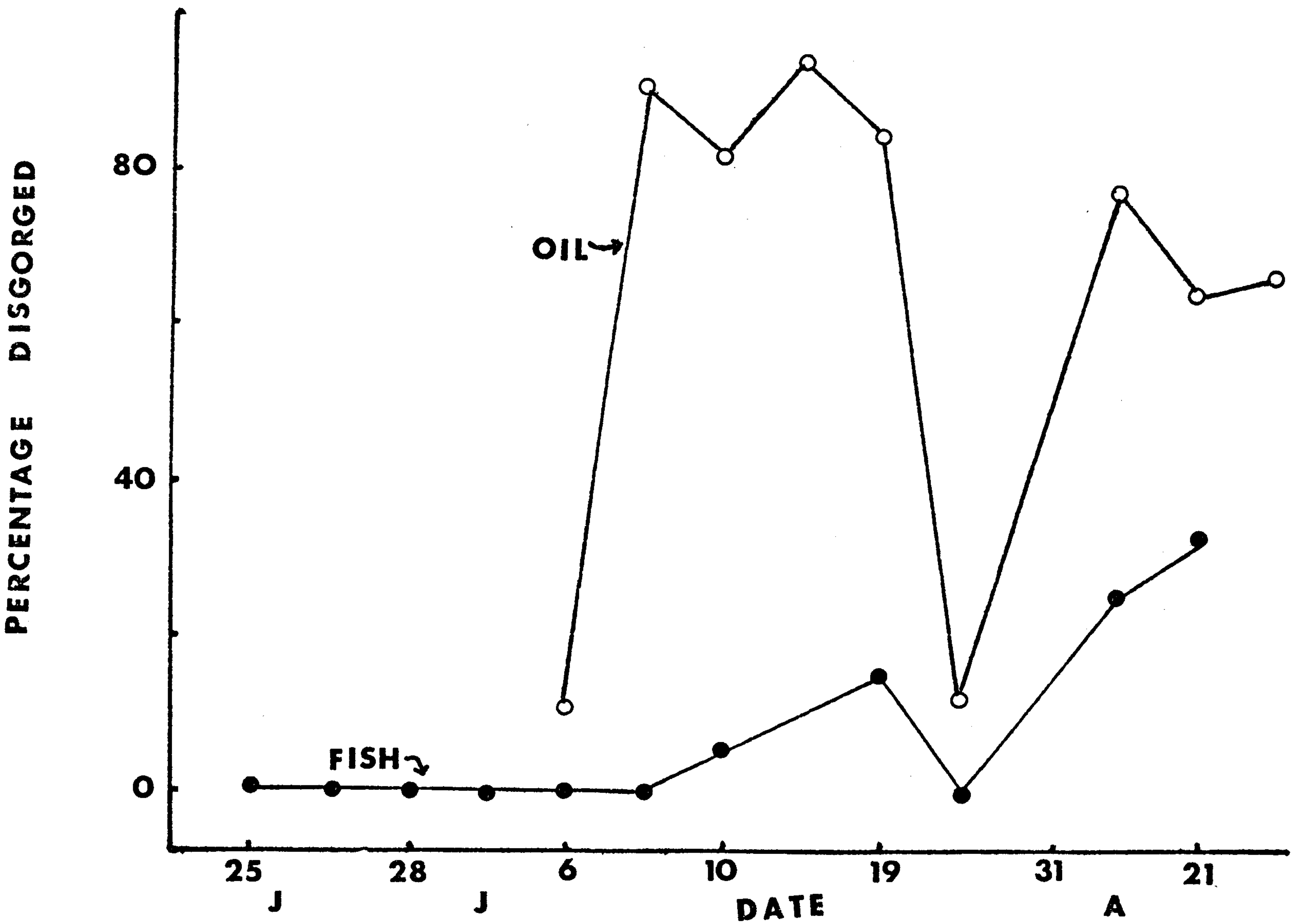


Figure 35. Changes in the body weight of the Fork-tailed Storm Petrel from mid-May to mid-August 1976.

Figure 36. Proportion of Fork-tailed Storm Petrels that disgorged oil or fish.



GLAUCOUS-WINGED GULL

The Glaucous-winged Gull (*Larus glaucescens*) colony on East Amatuli is located beyond the southernmost ridge of the island at an elevation of 900 feet. On May 20 there were approximately 60 gulls sitting in the grass, but there was no sign of nests. On June 19 we surveyed the colony. At that time there appeared to be 151 nests, approximately two-thirds of which had incomplete clutches (Figure 37). There appeared to be 219 birds actively incubating or unemployed. On June 26 we marked 25 nests in what we ascertained to be the densest portion of the colony. Almost all the nests had completed clutches. Measurements from each nest to two of its neighbors were made. The most proximal nests were 3.5 meters distant; the most isolated nest was 10.6 meters from its neighbor. We returned on August 3 to evaluate the nesting success. Our efforts were thwarted by waist-high vegetation through which we could not locate our nests. Once we found a chick we had great difficulty determining its nest site. Out of our 25 marked nests we re-located nine, and discovered four chicks in the vicinity.

Three visits were made to Sud Island to inspect the massive colony on the north slope at an elevation of 700 feet. On May 21, birds were paired and some were courting, but no nests were found. On June 20, 50 nests were marked, 40 percent of which were complete. Nearest-neighbor measurements indicated the closest nests to be within 2.0 meters of one another, while the most isolated was 10.2 meters distant. A sample plot of 30 square meters containing 17 nests was staked out in a dense area between 710 and 640 feet. A return trip on August 2 was again fruitless

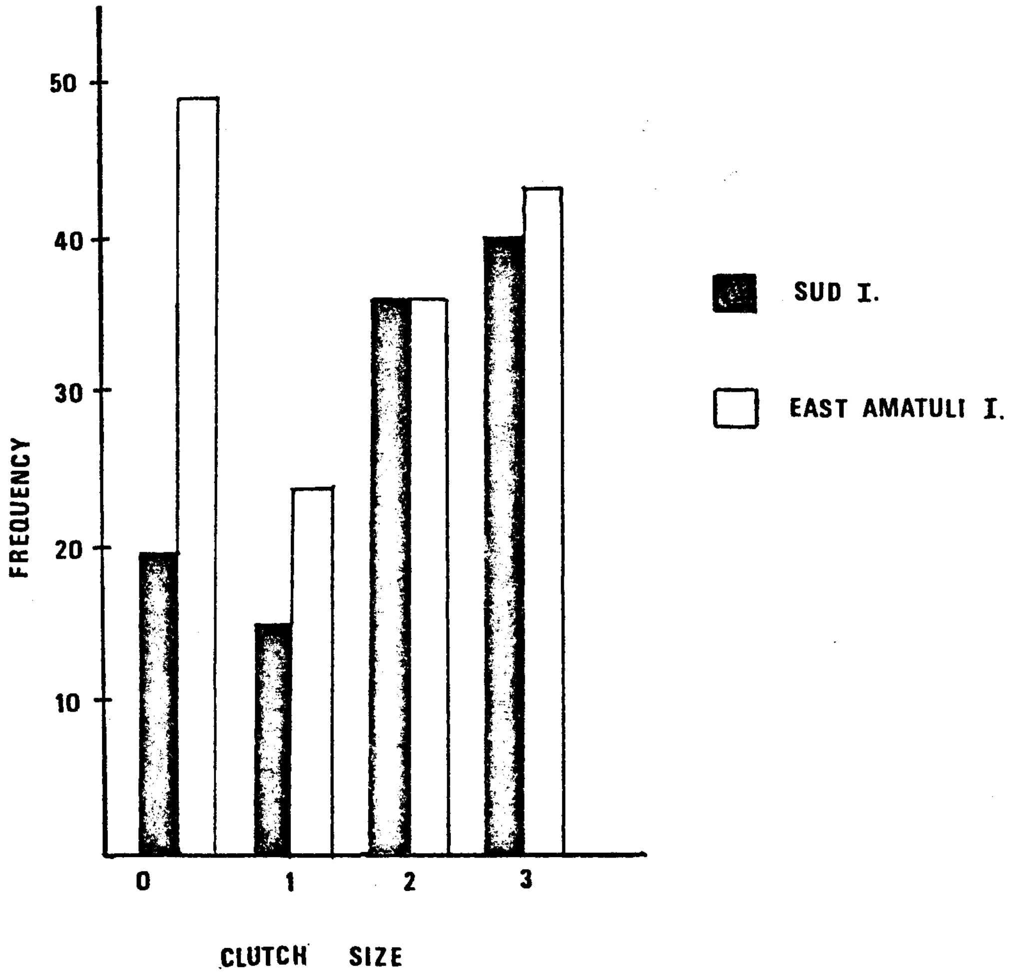


Figure 37. Clutch sizes of Glaucous-winged Gulls nesting on Sud and East Amatuli Islands, 1976.

due to the extensive vegetation. Although chicks were found, no sign of the marked nests remained visible.

The gull colony on West Amatuli was surveyed from the water on July 6. There appeared to be no more than 150 gulls between the three colonies on the west side of the island. Gulls were also breeding in the talus slopes on Sugarloaf.

PIGEON GUILLEMOT

Pigeon Guillemots are relatively common but are nowhere nesting in high densities. Population estimates are difficult to obtain for this species because of its crevice nest-sites. We estimate the population for the Barren Islands to be approximately 200-250 pairs, with 25-30 pairs at East Amatuli Island.

Pigeon Guillemots were already present in the Barren Islands upon our arrival on 14 May; however, the numbers seemed to increase slightly the latter half of May. There were 4 pairs or guillemots nesting in Amatuli cove. All nest-sites were inaccessible but we estimate the time of egg-laying to be around mid-June. This is based on the first appearance of fledgling guillemots in Amatuli cove on 24 August. The fledglings spent the majority of their time feeding in the cove.

COMMON AND THICK-BILLED MURRES

Bailey (1976) estimated the murre population of the Barren Islands to be 45,500 pairs of which 30,500 pairs were on East Amatuli Island. He reported that the Thick-billed Murre was uncommon.

Nearly all murre colonies are inaccessible; consequently it is almost impossible to obtain accurate population estimates and reproductive information. We were able to reach one small murre colony on the south side of East Amatuli Island (Figure 38) on 7 July. This was a mixed colony of 14 Thick-billed and 7 Common Murres. About half the birds were incubating. We saw no chicks. There was a larger colony of several hundred murres nearby but we could not obtain information on reproduction or species composition because the colony was inaccessible.

On 18 July we collected a Thick-billed Murre off the east end of East Amatuli Island. This bird was taken randomly so it appears that the proportion of Thick-billed Murres may be higher than Bailey (1976) reported. We estimate that about 10 percent of the murres in the Barren Islands are Thick-billed.

We have circumstantial evidence that murres underwent a breeding failure in 1976. We saw less than a dozen murre fledglings. Severe storms occurring during incubation and near fledging may have contributed to the failure.

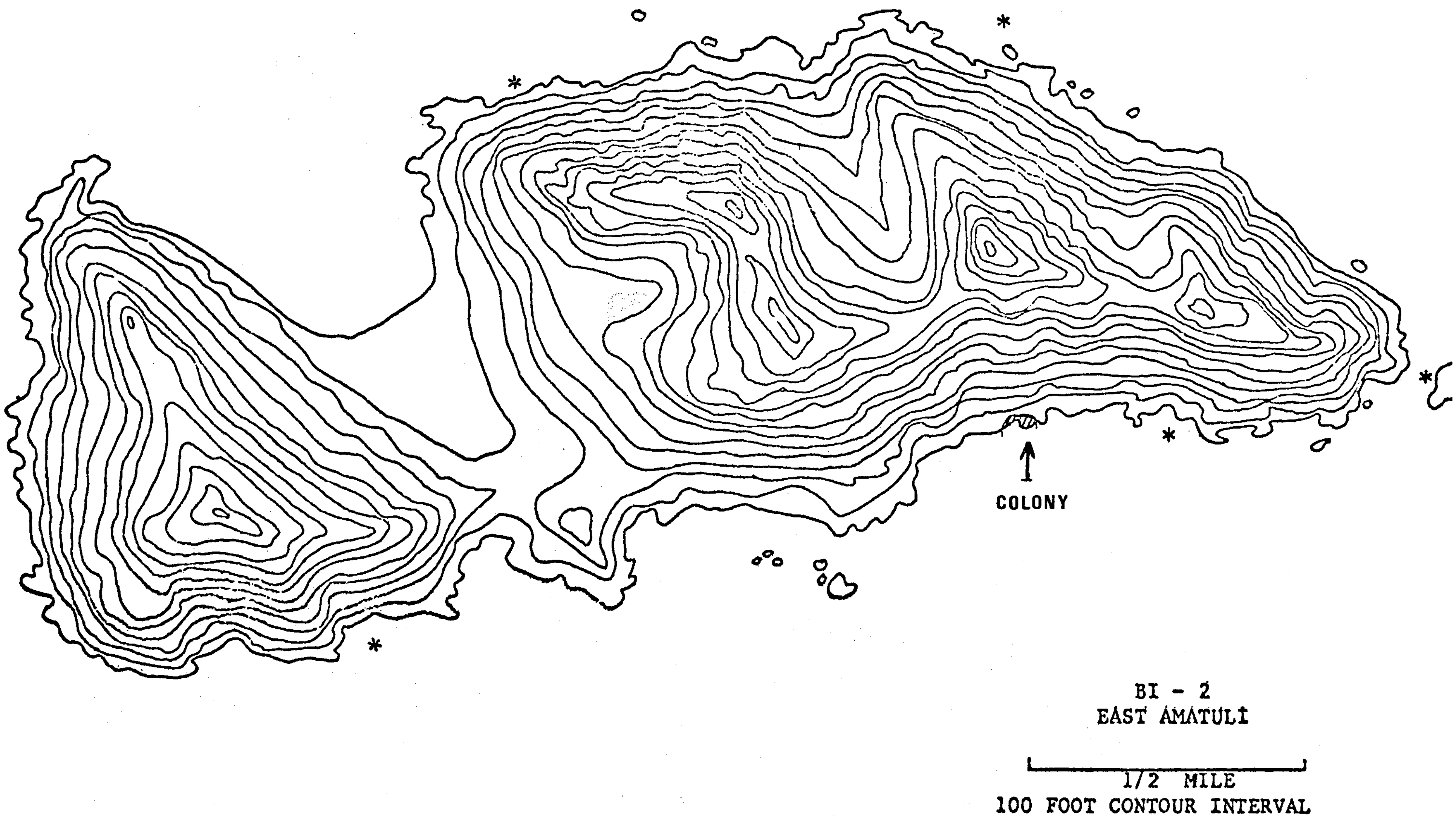


Figure 38. Location of a small murre and kittiwake colony visited in July 1976 on East Amatuli Island.

KITTLITZ MURRELET

Few nests of this species have been located and these have been mostly in montane talus far from the coast (Bailey 1973, 1976). However, Bailey flushed a Kittlitz Murrelet from the north slope of East Amatuli Island in 1975. We did not locate any nests but on 23 August we observed 3 solitary fledgling Kittlitz's Murrelets off the southeast shore of Ushagat Island. We also found 2 more fledglings off the west end of West Amatuli Island. It is possible that these birds came from either the Alaska or Kenai Peninsula, but they were more likely from somewhere in the Barren Islands. Ushagat, East and West Amatuli Islands all contain extensive areas of alpine tundra.

ANCIENT MURRELET

Bailey (1976) found no evidence that this species was breeding in the Barren Islands even though he saw 2 birds near Nord Island. The following is an annotated account of our observations of the Ancient Murrelet:

21 May 1976	Observed 2 Ancient Murrelets between Sud and West Amatuli Islands; another pair near Sud.
31 May	Saw 30 birds between East and West Amatuli Islands in the evening.
4 June	Found 12 birds between East and West Amatuli Islands in the evening.
10 June	Found an incubating adult in a shallow burrow on the west side of Amatuli Cove. Also located 2 old eggs in another burrow 50m away. In the evening we discovered a flock of at least 450 birds between East and West Amatuli Islands.
17 June	Observed 3 birds between East Amatuli and Sugarloaf Islands.
20-26 June	Scattered individuals seen around East Amatuli Islands.
16 July	Saw a single bird between East and West Amatuli Islands.
15 August	A single bird between East and West Amatuli Islands.
23 August	A single bird observed between Ushagat and West Amatuli Islands.

From the above information it seems that Ancient Murrelets nest in small numbers in the Barren Islands. There are probably 200-300 pairs nesting on East and West Amatuli Islands. We never observed fledglings, probably due to our limited use of the zodiac. It appears that after fledging, both adults and young leave the Barren Island area.

BLACK-LEGGED KITTIWAKE

Kittiwakes are abundant in the Barren Islands, particularly on East Amatuli and Nord Islands. Bailey (1976) estimated the population to be around 16,500 pairs. We feel this is a conservative estimate but we have yet to analyze our data for East Amatuli Island. Nearly all colonies are inaccessible. Our only information on breeding phenology is based on a visit to a small colony on the south side of East Amatuli Island on 7 July (Figure 38, Table 26). Only a few nests were visible.

Following several days of wind and rain, we found hundreds of kittiwakes loafing in Amatuli Cove. This occurred during the first week of August. We saw very few fledgling kittiwakes in late August. Therefore, we believe the breeding success of kittiwakes was very low.

Table 26. Reproductive stage and colony attendance of Black-legged Kittiwakes on East Amatuli Island on 7 July 1976.[1]

Reproductive Stage	Number of Nests
Eggs	
0	9
1	11
2	11
Nestlings	
1	3
2	4
1 nestling, 1 egg	1
TOTAL	39
Colony Attendance (1500 hrs)	
one adult	120
two adults	20
TOTAL	140

[1]Data is a sample from a small subcolony of approximately 700 nests.

CORMORANTS

Three species of cormorant breed in the Barren Islands. Because of the inaccessibility of the nests of the Double-crested (*Phalacrocorax pelagicus*), Red-faced (*P. urile*), and Pelagic (*P. Pelagicus*) Cormorants no intensive study was possible.

Sugarloaf Island

Cormorant nests were most common on the southeast side of Sugarloaf Island. Pelagic nests were most numerous with over 200 nests present on August 15. In June there were more than 500 nests, but severe storms probably reduced the number of active nests.

Sud Island

On May 20, Red-faced Cormorants were courting on Sud. Three birds were seen flying with nesting material. By June 20 cormorants were setting on nests. The colony midpoint was at approximately 470 feet and there were 47 nests, mainly Red-faced Cormorants'.

West Amatuli Island

West Amatuli was surveyed for cormorants on July 6; only 24 nests were found on the south side. Almost all nests were Pelagic but all three species were seen. One point on the west side of the island had seven cormorants standing on a rock, but no other nests were found.

East Amatuli

The three species of cormorant breed on the north side of East Amatuli just east of the cove. Thirteen nests were sighted but only one was accessible. It was empty on July 16. Of seven nests examined from land, only three were active on July 20. Two were Red-faced and one Pelagic; contents of the nest were not visible.

BIRD MIGRATION

Despite the relatively isolated location of the Barren Islands, a substantial number of migrants pass through them. Waterfowl and seabirds moving eastward from the Aleutian Islands probably pass in the vicinity of the Barrens. Major movements of these species most likely occur before and after the period of our occupancy on the islands. We did, however, observe small numbers of migrants in the area from the time of our arrival until about mid-June. Fall migrants began passing through the Barrens in large numbers in late July (Figure 39) and continued until our departure in early September.

The largest number of migrants undoubtedly were Sooty and Slender-billed Shearwaters. However, these birds rarely came close to the islands and were thus difficult to count. On 24 July, we negotiated a trip on a visiting fishing boat. We observed 20-30,000 shearwaters about 2 miles south of East Amatuli Island. These birds are undoubtedly numerous in the vicinity of the Barren Islands during most of the summer. Other common aquatic migrants were Arctic and Common Loons, Rednecked and Horned Grebes and Surf Scoters. Among the shorebirds, the Least and Western Sandpipers, Semipalmated Plover and Black Turnstones were the most common.

With the exception of Bald Eagles and Peregrine Falcons, few raptors were observed; Short-eared owls were found on West and East Amatuli Islands; Rough legged Hawks were also observed there and on

Ushagat Island. The extensive Sitka spruce forest of Ushagat offers suitable habitat for other raptors. We observed a Merlin and a Cooper's Hawk (unconfirmed sighting by D. Manuwal) and found feathers of a Goshawk on Ushagat.

A relatively large number of passerine birds migrated through the Barren Islands. Most numerous migrants were Savannah, Fox and Golden-crowned Sparrows, Wilson's Warblers, Pine Siskins, Redpolls, White winged Crossbills, Varied and Hermit Thrushes and Water Pipits. Departure of many of the Savannah and Golden-crowned Sparrows that nested on East Amatuli Island occurred during the last week of July and first week of August. This occurred before the influx of migrant passerines.

Few migrants passed through the Barren Islands between 20 June and 28 July (Figure 39). During the period 28-31 July, the first large movement of fall migrants was observed. The most common species were Least and Spotted Sandpipers, Wandering Tattler, Semi-palmated Plover, Surf Scoter, White-winged Crossbill, Common Redpoll, Pine Siskin, Varied Thrush and Violet-green Swallow. Migration was well underway when we departed on 8 September.

FEEDING FRENZIES

Seabirds in the Barrens sometimes feed in large groups, diving and pursuing small fish. These feeding assemblages--consisting of Horned Puffins, Tufted Puffins, Double-crested Cormorants, Pelagic Cormorants, Red-faced Cormorants, Glaucous-winged Gulls and Black-legged Kittiwakes normally began with diving kittiwakes and gulls. The intense feeding activity, lasting usually less than ten minutes, ended as suddenly as it began, with the birds dispersing. Over 52 feeding frenzies were observed. The feeding time, species composition, dispersal time and spacing of the species were observed. Frenzies were observed at a number of locations but from July 10 to 23 frenzies were monitored for over 24 hours in the straits between East and West Amatuli. These data have yet to be analyzed.

MARINE MAMMALS

Northern sea lions, harbor seals and sea otters appear to be the most common marine mammals in the islands. From one of our blinds we saw sea lions daily between 1500 hours and 1700 hours, presumable returning to Sugarloaf Island. One adult harbor seal was frequently sighted in East Amatuli Cove and often spent the day in one of the sheltered inlets. Sea otters were seen on East Amatuli, West Amatuli, Nord and Sud islands. Casual records were kept on marine mammal sightings. The following is a list of the numbers and types of species observed (Table 27). Since sea lions and sea otters were seen daily, they are excluded from this list.

SPECIES VULNERABLE TO OIL POLLUTION

It is generally recognized that the most vulnerable birds to oil pollution are the diving seabirds and waterfowl. The large number of alcids (species and approximately   pairs) makes the Barren Island colonies particularly valuable. Oil spills from tankers or drilling platforms could produce disasterous effects because of the large number breeding birds and migrating loons, grebes, shearwaters and waterfowl. Contamination may be made more severe by the strong tidal currents in the area.

During the breeding season, there are commonly 13 species classed as vulnerable to oil pollution. Figure 39 shows that this number remains nearly constant from mid-May to early September. Increases are due to the passing of migrants, particularly, loons and grebes.

The strategic location of the Barren Islands makes them vulnerable to the effects of oil pollution throughout the breeding season and during times of seabird and waterfowl migration.

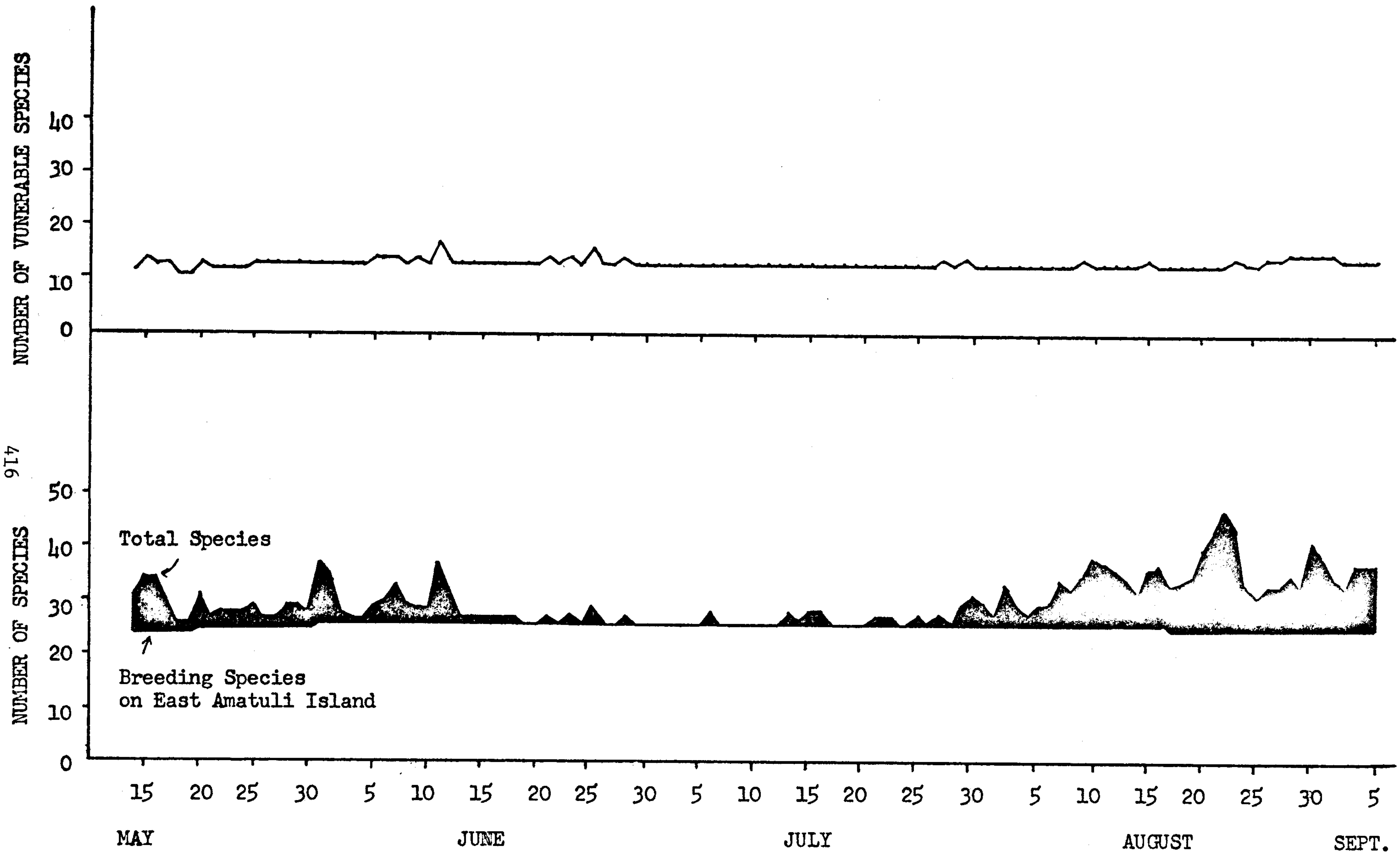


Figure 39. Number of species vulnerable to oil pollution and the total number of species observed on East Amatuli Island 15 May - 5 September, 1976.

Table 27. Marine Mammals Sighted in the Barren Islands, 1976*.

Date	Species	Occurrence
	WHALES (*Cetaceans*)	
June 20	Dall porpoise	0930-15 enroute to Sud Island. 1745-7 headed NE, bow-waking.
August 4	Dall porpoise Killer whale	Returning from Sud off West Amatuli. Pod of 5 west of W. Amatuli, headed north.
May 20	Fin whale	Off Sud Island.
	SEALS (*Pinnipeds*)	
June 20	Harbor seals (*Phoca vitulina*)	1533-26 adults and 7 pups on Sud beach. 1700-27 adults east side of Sud Island.
July 29	Harbor seals	Pup came to E. Amatuli Cove.
August 4	Harbor seals	Pup came to E. Amatuli Cove.
May 20	Harbor seals	Approximately 20 on Sud Island.
August 2	Harbor seals	Sud beach.
	NORTHERN SEA LIONS (*Eumetopias jubata*)	
May 20	Northern sea lion	Dead 12' female on Sud beach.
May 22	Northern sea lion	37 off W. Amatuli on rock (these were normally present from May to September)

*Does not include breeding populations of sea otters and Northern Sealions.

LITERATURE CITED

Bailey, E. P.

1976 Breeding bird distribution and abundance in the Barren Islands, Alaska. *Murrelet* 57(1): 212.

Barlow, C.

1894 A few notes on the Tufted Puffin. *The Oologist* 11: 353.

Bent, A. C.

1919 Life histories of North American diving birds. *U.S. National Museum* 107: 1237.

Cody, M. L.

1973 Coexistence, coevolution, and convergent evolution in seabird communities. *Ecology* 54: 3144.

Corkhill, P.

1973 Food and feeding ecology of puffins. *Bird Study* 20: 207220.

Dawson, W. L.

1908 The bird colonies of the Olympiades. *Auk* 25: 153166.

Dickerman, R. W.

1960 Possible nesting interference of Tufted Puffins by Glaucous-winged Gulls. *The Murrelet* 41: 16.

Fay, F. H. and T. J. Cade

1959 An ecological analysis of the avifauna of St. Lawrence Island, Alaska. *Univ. Calif. Publ. Zoology* 63: 73150.

Frazer, D.

1975 Breeding biology of the Tufted Puffin, a review. Unpublished Prof. paper. University of Washington, Seattle.

Gabrielson, I. N. and F. C. Lincoln

1959 *Birds of Alaska*. Telegraph Press, Harrisburg.

Kenyon, K. W. and J. W. Brooks

1960 Birds of the Little Diomede Island, Alaska. *Condor* 62: 457-463.

Lockley, R. M.

1934 On the breeding habits of the puffin; with special reference to its incubation- and fledging-periods. *Brit. Birds* 27: 214-223.

Manuwal, D. A.

1972 The population ecology of Cassin's Auklet on southeast Farallon, California. Ph.D. thesis, University of California, Los Angeles.

Nettleship, D. N.

1973 Breeding success of the common puffin (*Fratercula arctica L.*) on different habitats at Great Island, Newfoundland. *Ecol. Monogr.* 42: 239-268.

Richardson, F.

1961 Breeding biology of the Rhinoceros Auklet on Protection Island, Washington. *Condor* 63: 456-473.

Sealy, S. G.

1969 Incubation and nestling periods of the Horned Puffin. *Condor* 71: 81.

1973 Breeding biology of the Horned Puffin on St. Lawrence Island, Bering Sea, with zoogeographical notes on the North Pacific puffins. *Pac. Sci.* 27: 99-119.

Sealy, S. and J. Bedard

1973 Breeding biology of the Parakeet Auklet (*Cyclorrhynchus psittacula*) on St. Lawrence Island, Alaska. *Astarte* 6: 59-68.

Scott, J. M., W. Hoffman, D. Ainley and C. F. Zeillemaker

1974 Range expansion and activity patterns in Rhinoceros Auklets. *Western Birds* 5: 13-20.

Swartz, L. G.

1966 Sea-cliff birds, chapter 23 pp. 611-678 in *Environment of the Cape Thompson Region, Alaska*, N. J. Wilimovsky and J. N. Wolfle (ed.). U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Thompson, C. F.

1967 Notes on the birds of the northeast cape of St. Lawrence Island and of the Punuk Islands, Alaska. *Condor* 69: 411-419.

Vermeer, K., D. A. Manuwal and D. Bingham

1976 Seabirds and pinnipeds of Sartine Island, Scott Island Group, British Columbia. *Murrelet* 57: 14-16.

Wehle, D.

1976 Feeding ecology of Tufted and Horned puffins. MS thesis, University of Alaska, Fairbanks.

Willett, G.

1912 Report of George Willett, agent and warden stationed on St. Lazaria bird reservation, Alaska. *Bird Lore* 14: 419-426.

1915 Summer birds of Forrester Island, Alaska. *Auk* 32: 295-305.

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to
March 31, 1977

SEABIRDS OF THE WOODED ISLANDS, ALASKA

by

P. G. Mickelson, W. A. Lehnhausen,
S. E. Quinlan and J. M. Sherwood

Part VIII

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS
OF MARINE BIRDS IN THE GULF OF ALASKA
AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. J. Gould,
R. E. Gill and G. A. Sanger
Co-principle Investigators

U. S. Fish & Wildlife Service
Office of Biological Services/Coastal Ecosystems
Anchorage, Alaska

March, 1977

SEABIRD COLONIES OF THE WOODED ISLANDS, ALASKA

by

Principal Investigator: P. G. Mickelson, Assistant Proffesor of Wildlife Management, University of Alaska, Fairbanks, Alaska 99701

Graduate Research Assistants: William A. Lehnhausen, and Susan E. Quinlan of the Alaska Cooperative Wildlife Research Unit

Field Research Assistant: James M. Sherwood

ACKNOWLEDGEMENTS

This study was funded by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service, Office of Biological Services--Coastal Ecosystems. We are indebted to Drs. Calvin J. Lensink and James C. Bartonek of the U.S. Fish and Wildlife Service for arranging finances and providing especially important supplies including bird bands and outboard motors.

We thank the Chugach National Forest for permitting our research efforts directed at gathering baseline data on seabirds of Wooded Islands as part of the Outer Continental Shelf Environmental Assessment Program. Special thanks go to the staff of the Cordova Work Center for allowing us use of warehouse space and vehicles during the hectic days of leaving for, and coming back from Wooded Islands, and for their concern and efforts to resupply our field camp. Without their logistical support, this project would not have been possible.

Special credit goes to Pete Isleib of Cordova for providing us with data from previous surveys of birds in the Wooded Islands area and for providing a description of the study area.

The field season was made very successful by the able assistance of Jim Sherwood. We were very grateful for his enthusiasm, knowledge, and companionship during the long hours of each day (and night) in the field.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS

The main objective of this study is to obtain information about the breeding distribution, abundance, phenology, and productivity of seabirds using Wooded Islands in the Gulf of Alaska. Major seabird species on Wooded Islands, and those discussed in this report are (in order of abundance): Tufted Puffins, Fork-tailed Storm Petrels, Black-legged Kittiwakes, Leach's Storm Petrels, Glaucous-winged Gulls, Cormorants (Double-crested, Pelagic, and Red-faced), Pigeon Guillemots, Common Murres, Parakeet Auklets, and Horned Puffins.

This group of islands is situated 50 km southwest of Hinchinbrook Entrance, the oil tanker route out of Valdez, and 110 km west of OCS oil and gas lease sites which are being explored now. The counter-clockwise currents of the Gulf may bring oil from these areas to the Wooded Islands and surrounding waters. Thus, information collected in this study is necessary baseline data for environmental impact statements and future analysis of the effects of oil spills in the area.

II. INTRODUCTION

Seabirds are an important component of the marine ecosystem, yet they are some of the least understood avian species in Alaska. Basic biology and ecological relationships are not understood for many seabird species and at many colonies information on bird distribution and abundance is lacking. Increased OCS development and oil transport in the northern Gulf of Alaska necessitates collection of baseline information on the seabird species of the area.

Wooded Islands, on the southeast tip of Montague Island outside of Prince William Sound, have one of the largest seabird colonies in the northern Gulf. Since little information on the seabird species, number, and general biology of the Wooded Islands seabird colonies has been collected, this study is designed to provide a baseline of information on the seabirds of the area.

Objectives

1. Obtain information on the breeding distribution and estimate abundance of all seabird species using Wooded Islands,
2. determine the phenology of all breeding seabird species,
3. delineate colony sites and describe nesting habitat of all seabird species,
4. determine productivity and study factors affecting productivity of Fork-tailed Storm Petrels, and
5. make incidental observations on: seabird and shorebird migration, seabird food habits, seabird mortality, species and abundance of other birds, and distribution and abundance of marine mammals at Wooded Islands.

Justification

Wooded Islands are vulnerable to both oil pollution and direct human disturbance. Following the completion of the trans-Alaska oil pipeline in the summer of 1977, oil transport in the northern Gulf will increase. Wooded Islands are located along the tanker route out of the pipeline terminal in Valdez (U.S.D.I. 1972). The major oil and gas lease areas in the northern Gulf are 110 km east of Wooded Islands. Since the general water currents in the northern Gulf flow in a counter-clockwise direction, oil spilled along the tanker route, or in the lease areas could reach Wooded Islands. Roughly 48 percent of any oil spilled in the drilling areas is expected to reach nearby Montague Island (U.S.D.I. 1976). Clearly, as oil development and transport in the northern Gulf increases, the probability of oil contamination of the marine environment increases. Nisbet (in prep.) considers oil pollution the greatest threat facing north Pacific seabirds.

Wooded Islands are also near population centers (about 110 km by air from both Cordova and Seward) and are thus faced with increased human use and disturbance. The islands may become an attraction to tourists and residents because of their location and the number of breeding seabirds species. Without proper management, humans could have considerable affect on the nesting seabirds (Sowl 1974).

Most of the seabird studies in Alaska have dealt with one or two species at small segments of large colonies. Intensive research on small colonies resulting in accurate estimates of bird distribution and abundance is lacking. The only published study of a seabird colony in the northern Gulf of Alaska is that of Rausch (1958). This study was only a description of the birds present during a 15-day period in June. Nisbet (in prep.) suggests that certain colonies should be selected and intensively studied to provide accurate baseline information. Because of their relatively small size, easy access, and species diversity, Wooded Islands provide a place for such intensive study.

Thus, baseline information on the seabird colonies of Wooded Islands is necessary for monitoring the effects of oil pollution in the marine environment in the northern Gulf, and for management decisions on recreational use of the area. The small size of the colonies relative to others is advantageous in allowing accurate census work, complete coverage of the colony, and minimum expenditure for long term coverage. The proximity of the islands to oil development and transportation corridors will allow future monitoring of pollution near the sources.

III. CURRENT STATE OF KNOWLEDGE

Little seabird work has been done on Wooded Islands previous to this study. Isleib, Haddock, Bergman, and Divoky have made surveys of the seabird colonies at Wooded Islands in 1972, 1973, and 1974 (Isleib, pers. comm.). Their estimates of seabird populations are presented in

Table 1. Isleib and Kessel (1973) reviewed avian distribution and abundance in the northern Gulf of Alaska.

James Brooks, Alaska Departemnt of Fish and Game, conducted studies of Steller sea lion (Eumetopias jubata) food habits and activities on Fish Island in the late 1950's. Sandegren (1970) also studied sea lion behavior on Fish Island during 1967 and 1968.

Some basic biological information of the seabird species nesting on Wooded Islands, and information on closely related species has been collected in other areas. These studies have been consulted for comparison and in development of methods for this study.

IV. STUDY AREA

Description

Wooded Islands are located at 147° 25' W., 57° 52' N. (Fig. 1). Four islands (Wooded, Tanker, South and Fish) make up the group along with numerous exposed offshore rocks (Fig. 2). Montague Island, 75 km long and 15 km wide, is the nearest large land mass. This island is part of the southwestern border of Prince William Sound.

Wooded Island:

The largest island of the group is Wooded Island with an area of approximately 132 ha (Fig. 3). Cliffs ranging from 5 m to 60 m surround the island except for a low stream bed on the north side. The highest cliffs are on the southeast edge of the island; these end directly in the water. Rocky and boulder beaches occur at the base of the cliffs around the rest of the island. A point of rocks, West Spit, extends east toward Montague Island. A smaller projection of rocks extends east towards Tanker Island. During minus tides Wooded and Tanker Islands are connected by this isthmus. On the north side where the stream emerges, a sandy beach is exposed at low tide. This was an excellent landing area and the associated bay was sheltered during most storms.

On top, the island is flatest on the northwestern corner and rises gently to the southwest, and more steeply to the southeast culminating in a hilly plateau on the southeastern and eastern sides. A small freshwater lake of approximately 0.5 ha lies in the center of the island. The deepest portions of the lake are about 1 m, though heavy rains temporarily increase the depth and area. Throughout the summer this lake was used as a freshwater source. Woods and wet bogs make up the rest of the island top. The tallest trees occur around the edge of the island and on well-drained slopes. Trees in the wettest areas are stunted so the muskeg area is interspersed with fingers of small trees. Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla) are the main tree species. Sitka alder (Alnus crispa) occurs along stream bottoms on the island. Muskeg areas are confined to the interior of the island. Sphagnum moss, crowberry (Empetrum nigrum), and blueberry (Vaccinium sp.) are the major plant species in this area. Interspersed throughout the muskeg are small pools of water; some dry out during periods of drought. Just southwest of the lake there is a small sedge meadow.

At low tide about three-fourths of the beach can be walked; the south side is not accessible. Most of the beach areas consist of small rocks and boulders. The whole area was raised about 5 m during the 1964 earthquake as evidenced by the old drift logs high on the beach. High altitude photos of the area before and after the earthquake reveal that much more beach area occurs now. New logs and other debris are constantly washed ashore.

Certain parts of the cliffs seem to be rather stable with grassy vegetation, while other sections are less permanent features as rocks and soil are eroding away more quickly. These latter areas are of little importance to the seabirds.

Offshore rocks occur irregularly around the island. Depending on the tide, some of these are connected to Wooded Island. South Pinnacle is a large pyramid shaped rock on the south side of the island about 200 m offshore.

Tanker Island:

The smallest island of the group, Tanker, is only 2.7 ha (Fig. 3). During minus tides an isthmus of boulders connects Tanker to Wooded Island. This is the only means of access to Tanker Island because good landing sites do not exist for the zodiac raft. By timing our work on Tanker according to the tides we were able to walk to Tanker, spend a number of days and walk back.

Tanker Island is essentially a small butte rising about 40 m above the water. The top of Tanker is only 0.5 ha and slopes upward gently from east to west. Access is limited to the south east side where steep boulder slopes converge to form a steep gravel-soil slope. The remaining sides of Tanker are cliffs. A grass-umbel community (Elymus arenarius, Calamagrostis sp., Heracleum lanatum, and Angelica lucida) covers the top. Trees formerly covered the island and dead tree trunks still remain. The eastern flat portion of the island top is covered with a soil layer approximately 3m deep.

Most of the beach consists of large boulders. The southeast island protrudes outward toward a group of exposed rocks. At minus tides these rocks are connected to the main island. A short distance to the south, another group of rocks permanently surrounded by water are exposed. These two reefs are referred to as Seal Rocks (Fig. 3).

South Island:

South Island is 3 km southwest of Wooded Island (Fig. 4). This 10.7 ha. island lies 1 km east of Montague Island. Because of its isolated location away from the other islands and reefs, most of the shoreline is heavily beaten by waves. Only the northwestern corner is protected to any degree, and this is the only suitable landing site for a raft or boat. This corner is the only wide and flat area along the beach. A pinnacle in this area has a large hole in its base and is suitable as a camp site.

Like the others, South Island is primarily flat-topped with steep sides. The rocky and bouldery beaches are narrow around most of the island except on the northwest end, and on the southeast side where the cliffs drop directly into the water. Two large onshore pinnacles occur on the east side of the island and two others (East and West Flatiron) occur on the southern tip of South. A number of large offshore rocks occur at the southeast end. Pebble talus slopes cover the western side of South Island, while the southern and eastern sides are small boulder slopes with solid rock areas at the bottom. Grass covered boulder and soil slopes typify the northeast end. The northern edge is sheer cliffs.

On top the land slopes gently from the northwest to the southwest with only a slight rise in elevation. The northern half of South is primarily grass (Elymus arenarius and Calamagrostis sp.) while the southern half is a stand of Sitka spruce (Picea sitchensis). A thick growth of salmonberry (Rubus spectabilis) occurs on the southwestern part of the island. The island is partially drained by a small intermittent stream which emerges in the middle of the eastern cliff edge.

Fish Island:

The most exposed island of the group is 4.5 ha Fish Island lying 6.4 km off the shore of Montague Island. The island is composed of a 1.6 ha plateau area surrounded on all sides by cliffs (Fig. 5). These cliffs, varying in height from 10 to 50 m, end in rock and talus slopes which taper out to the rocky beach line around the entire island. Much of the beachline has been exposed only since the 1964 earthquake which raised the island approximately 5 m (Sandegren 1970). Formerly, the cliffs of southern Fish Island plunged directly into the sea, and the west and east spits were not connected to the main island. The newly exposed rock supports little vegetation, however these areas are used by seabirds particularly Pigeon Guillemots and Parakeet Auklets. The older rock slopes, mainly on the north and northwest sides of Fish, support some vegetative growth, mainly Angelica lucida, Heracleum lanatum, and Elymus arenarius. Ledges on the cliffs surrounding Fish Island are mainly vegetated by Campanula lasiocarpa, Potentilla sp., Mimulus guttatus, Cochlearia officinalis, and Dodecatheon pulchellum.

The upper plateau consists of a large northwest portion shaped like an anvil. This area, the highest on Fish Island (70 m) supports several Sitka spruce and some elderberry (Sambucus racemosa). The main vegetation under the spruce and elsewhere on the Anvil is salmonberry. This vegetation becomes nearly impassable by mid-June with nearly 100 percent leaf cover at an average height of 150 cm. Understory is sparse, mainly ferns and mosses. The soil on the Anvil is more shallow and rocky than soil on the rest of upper Fish Island, averaging 34 cm in depth. The Anvil is also more poorly drained so that small pools of water remain under the trees for several days following rain.

As the land slopes down from the Anvil toward camp and the Raven Tree (Fig. 5), the vegetation gradually changes from solid salmonberry to a mixture of salmonberry, umbel, and grass species. Average height of the overstory here is about 95 cm. Understory plants include Claytonia sibirica, Fritillaria camschatcensis, Anemone narcissiflora, and others. The soil in this area averages 55 cm deep and is well-drained due to the slope. This ecotone extends to the east cliff edge of the Anvil, and down to a line parallel with this cliff edge below camp, and also down the south edge of the island for 15-20 m. The remainder of the island is a grass-umbel community with the same species as mentioned above. Soil depth here averages 50 cm but is generally shallower and more well drained near the cliff edge. Average vegetation height is approximately 90 cm though puffin excavations and trampling have resulted in dwarfed plants around the perimeter. The distribution of vegetation may be affecting storm petrel distribution and burrow density but does not appear to affect the other nesting species.

On Fish Island there are only two landing sites suitable for small boats: the west edge of the West Point, and the north Landing Cove. Both are kelp-covered rocky areas and are washed by waves making landing and beaching difficult during stormy weather. While one can land a zodiac on Fish Island during bad weather, the north cove can not be exited safely in seas greater than 1.3 m because of the wave action and tidal currents. The top of Fish Island can be reached from either landing area, however the north cove provides a closer and safer route with minimized disturbance to the sea lion colony. The rest of Fish Island is not suitable for landing due to tidal wash, currents, and sea lion activity.

The West Point extends outward towards Eagle Rock, a small pinnacle 200 m from Fish Island. This rock is used by harbor seals and is a common roost site for Bald Eagles.

Surrounding Waters:

A number of tide rips occur between the four islands (Figs. 3, 4, and 5). These are important factors to the birds and to small boat operation. Between West Spit of Wooded Island and Montague Island there is a major tide rip that can cause high standing waves preventing small boat travel. All three species of scoters were observed on the north side of this on a number of occasions. Killer whales were seen moving through this area on two occasions, and a fin whale was seen lingering in the area on one occasion. Depending on the tidal stage another tide rip occurs between Tanker Island and the East Spit of Wooded Island. Pigeon Guillemots, Black-legged Kittiwakes, Glaucous-winged Gulls and cormorants were often seen using the southward projecting rip during receding tides. The rip between Tanker and Eagle Rock is very obvious during most flooding tides due to disturbance of the water surface. At certain times many birds including Tufted Puffins, Black-legged Kittiwakes, Glaucous-winged Gulls, and Pigeon Guillemots used the north side of the rip area. Another small rip occurs between Eagle Rock and West Point of Fish Island. To the east of Fish Island, a large tide rip is associated with many offshore rocks. Tufted Puffins were seen rafting near this tide rip daily. Glaucous-winged Gulls and Black-legged Kittiwakes were often seen in the area. The only rip which was noticed around South Island was off the northwest end. Glaucous-winged Gulls, kittiwakes, Pelagic Cormorants, and scoters were observed in this area on one occasion.

Four kelp beds were discovered in the waters of the island group. A large bed was found in the vicinity of the tide rip off the north end of South Island. It extended along the west side of the island in the strait next to Montague Island. On the north side of the tide rip between West Spit of Wooded Island and Montague Island is another small kelp bed. Just northwest of the Seal Rocks is a large kelp bed that was used heavily by sea otters. The last kelp bed is just north of the East Point of Fish Island. This bed became obvious after storms because tons of kelp washed ashore at Landing Cove on Fish Island.

Weather

During the summer of 1976 the weather around Wooded Islands seemed to be rather mild compared to previous accounts of the area. Between 16 May and 31 August the lowest temperature recorded was -2°C., the highest was 22°C., and the highest daily fluctuation was 15°C. Most fluctuations were less than 10°C. High winds were encountered, but wind speeds of more than 25 knots were relatively rare. Winds of variable force were constant throughout the summer, however. Of 112 days spent on the islands, 53 days had some precipitation. The northeastern end of Montague Island and the southwestern end of Hinchinbrook Island could be seen on clear days; though on many occasions these areas were obscured by clouds, though Wooded Islands were experiencing dry, sunny weather. Cordova weather reports also indicated that areas north of Wooded Islands received much more rain. These unexpectedly dry conditions probably correspond to the mild summer throughout Alaska, however.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION:

Since 26 species of pelagic seabird species were observed near or at Wooded Islands, methods of data collection varied widely according to the species, their specific nesting habits, and their abundance in the area.

Observations in the field began on 15 May 1976 and continued through 3 September 1976. Two base camps were established: a main camp on Wooded Island and a smaller, semi-permanent camp on Fish Island. Temporary camps were used on Tanker and South Islands. Transportation between islands and Patton Bay on Montague Island was by a Zodiac Mark II compact raft with 25 hp motor.

Miscellaneous observations were made of: weather conditions, species of flowering plants, and number, time, and activities of humans visiting Montague and Wooded Islands.

Data collection for cliff nesting birds was made from land-based observation points, and occasional counts were made from the Zodiac. Since nearly all cliff areas could be observed from points on land, boat observations were not of major importance. During cliff-nesting seabird censuses, nonbreeding birds were separated from breeding birds. Resting, feeding and loafing sites were also censused periodically. Photographic records of all cliff-nesting areas were made.

Surface and burrow nesting birds were studied using techniques outlined by Nettleship (1976). Burrow activity was determined using the lattice method described by Wilbur (1969), and by direct observation in the nest (Drent et al. 1964). Intensive study areas for both cliff and burrow nesting species were delineated for careful observation of nesting success.

When possible, birds were banded with U.S. Fish and Wildlife Service bands for future identification. All young of the year were banded with red plastic color leg bands. According to U.S. Fish and Wildlife Service instructions, all gull chicks were double banded with aluminum bands, and red plastic leg bands.

VI. RESULTS

Twenty-six species of pelagic seabirds, shorebirds and seaducks were observed in the area of Wooded Islands throughout the 1976 field season (Table 2). In addition, 5 species of marine mammals, 4 species of terrestrial mammals (Table 3), and 25 species of terrestrial birds were recorded in the area (Table 4). Other bird and mammal species were observed only in spring and fall, presumably during migration (Table 5). Each bird species or group of species are discussed separately in the order given in the American Ornithologists' Union checklist. Marine mammal data are listed and discussed last.

Forked-tailed and Leach's Storm Petrels (Oceanodroma furcata & O. leuchorhoa)

Fork-tailed and Leach's Storm Petrels breed in the Wooded Islands group. Isleib and Kessel (1973) mention the colony of Fork-tailed Storm Petrels but the colony of Leach's Storm Petrels was unknown until last summer. These colonies constitute the northernmost known breeding colonies for both species of storm petrel. The nearest known colonies of Fork-tailed Storm Petrels are those discovered by Bailey (pers. comm.) on 7 islands in the Kenai Fiords. The nearest known colony of Leach's Storm Petrels is in southeastern Alaska. Fork-tailed Storm Petrels have not been thoroughly studied in any part of their range. Harris (1974) provides some information on the chronology of fork-tails at Trinidad Rocks, California, the southernmost breeding colony. Leach's Storm Petrels have been studied most thoroughly by Gross (1935), Wilbur (1969), Huntington (1963), Ainley et al. (1974) and Harris (1974). Particular emphasis was placed on the breeding biology of fork-tails in this study, however similar information was collected for Leach's Storm Petrels when possible.

Distribution:

Of the four islands of the Wooded Islands group, only Fish and South islands have active breeding colonies of storm petrels. On two occasions individual petrels were heard calling on Wooded Island. Several overnight stays throughout the summer revealed no petrel activity, and diurnal searches for burrows were fruitless. A small area of habitat similar to that used by storm petrels on Fish Island is available above the kittiwake cliffs on Wooded Island, however most of the island is poorly drained. The resulting muskeg and wet soil probably provides little suitable habitat for petrel burrows. The remnants of a fox-farming operation from the early 1900's are still visible on Wooded Island, but no foxes remain. Gabrielson and Lincoln (1959) note that breeding Leach's Storm Petrels were observed on Wooded Islands before the fox farming operation, but that afterwards naturalists were unable to locate any petrels. Thus, a small colony might once have occurred on Wooded Island, but has not re-established itself. Mink (Mustela vison) presently occur on Wooded Island and might prevent re-establishment.

No active petrel burrows were located on Tanker Island and flight activity at night was never observed. One fork-tail was heard on one occasion, and the remains of two fork-tails were found trampled in the entrances to Tufted Puffin burrow, which indicates that fork-tails occasionaly visit the island. These may be non-breeding birds or juveniles, or a few scattered pairs may nest on the island. The plant species and soil depth over most of the island are quite similar to those on Fish Island so Tanker may well be suitable but unoccupied habitat. Tanker, connected to Wooded at low tides, may be visited by mink. The proximity of Tanker to an active breeding colony of Glaucous-winged Gulls, known to prey on fork-tails (Vernon Byrd pers. comm.) may have some affect on petrel distribution. Tanker also has an active den of at least 4 river otters (Lutra canadensis) which prey on storm petrels.

South Island's inaccessible location limited field work during 1976, however the presence of both species of storm petrels was confirmed. On a preliminary visit, a diurnal search of a large area of grass-umbel community (similar to Fish Island habitat) revealed no burrows. A faint smell of petrels in a cliff rock crevice was the only sign of petrels. Devil's club (Echinopanax horridum) and thick salmonberry undergrowth precluded a careful search of the forested areas. During early August another visit to South Island included several nights. During these nights many Leach's Storm Petrels and a few fork-tails were calling and flying. Their activity centered in the wooded areas of South Island. Next year several nights throughout the summer will be spent on South Island studying this colony. Visits early in May will allow careful examination of the forest habitat before plant growth occurs.

Both Fork-tailed and Leach's Storm Petrels nested on Fish Island. Since this island was the most accessible one with a petrel colony, intensive study of storm petrel habitat preferences, breeding chronology, production, and banding operations were limited to Fish Island during 1976. The following information applies only to Fish Island.

Habitat Preferences:

Storm Petrels burrows were found in two habitat types on the plateau of Fish Island and in the vegetated rocky slope areas of lower Fish. On the plateau, most subcolonies were located in the grass-umbel community, but the largest subcolony, and the densest subcolony were located in the salmonberry community on the anvil. No burrows were located in the Sitka spruce area and petrel flight activity through the trees was light. (Preliminary observations indicate petrels may use Sitka spruce habitat on South Island; more field work is needed to verify this and to determine the cause for such variation).

Burrows in the grass-umbel community were usually at the base of grass clumps but entirely in soil. Those in the salmonberry community were shallower on the average and often roofed or sided by rock. Average vegetation height for all active burrows was 124.7 cm (std. dev. .31 cm) and average soil depth was 42 cm (4 cm std. dev.). Location in relation to the cliff edge seemed to be the most important factor determining burrow distribution. Mean distance to the cliff edge was 6.9 m (std. dev. 5.1 m).

Leach's and Fork-tailed Storm Petrels used the same areas on the upper surface of Fish. Abandoned fork-tail burrows were often claimed by pairs of non-breeding Leach's Storm Petrels. On one occasion a Leach's Storm Petrel was found incubating its own egg while sitting next to a recently abandoned fork-tail egg. Both species may use old tunnels or side tunnels of tufted puffin burrows. A near fledging fork-tail chick wandered into a puffin nest chamber and was found when replacing the puffin chick. A side chamber with a petrel nest was found near the burrow entrance. Two Leach's Storm Petrels were found in a burrow sitting next to a year-old puffin egg. Since Tufted Puffins heavily utilize the cliff edge and the adjacent 2m, petrels and puffins may compete for nesting space. This requires further investigation.

Burrows in the rocky slope areas were nearly impossible to locate or examine due to the size of boulders in the area and the small crevices utilized. Further attention to this habitat in 1977 may reveal more about the utilization of this habitat. Tentatively, Leach's Petrels do not appear to use this area, while fork-tails may use rocky slopes nearly as much as soil areas. Techniques for census of the rocky slope area have been developed for 1977 fieldwork.

Abundance:

The nocturnal habits of storm petrels, and the density of vegetation of Fish Island made census work difficult. Two methods of population estimate were used. Capture-recapture techniques using nocturnal banding operations yielded estimates of total active birds on Fish. Transects across the island were used, following the technique of Nettleship (1976).

A net 12 m long and 5 m high was constructed of lawn and garden netting and banding operations were conducted throughout the summer. A total of 43 nights of banding between the 23 May and 2 August yielded 810 Fork-tailed Storm Petrels and 86 Leach's Storm Petrels. Data were grouped for use in the Schnabel method of population estimate based on 50 recaptures. This method yielded an estimate of approximately 4,800 fork-tails and 400 Leach's Storm Petrels. Nest sites varied throughout the summer. These are shown in Fig. 6. While this estimate of storm petrels could be used as an index to population size, there are many inherent faults with the technique. Adults and juvenile birds cannot be separated and juvenile birds may visit the island sporadically. This would have the effect of immigration and emigration which would result in an overestimate of the population. Further, Harris (1974) indicated that Storm Petrels at Trinidad Rocks in California did not fly over the entire island on their nightly visits, but flew over the same areas on each visit. Birds with burrows in the vicinity of the net would be more likely to be caught than birds nesting in another area. Also, since netting with this technique could not be conducted safely on the rocky slope areas of the island, the estimate does not pertain to birds utilizing that area. While future comparisons, using the same technique with nets in the same locations, over the same period of time might be comparative, estimates using this technique appear to be of little value.

According to Nettleship (1976) transects across a petrel colony are useful for population estimation. Thus six, 3 m wide transects across Fish Island were used to determine burrow density. As shown in Fig. 6 subcolonies of petrels were located on the perimeter of Fish Island. Due to the clumped distribution of petrel subcolonies, the transects were not as valuable as originally hoped. However, burrow density obtained in the transects and plots set up in subcolonies, along with estimates of burrow density based on mean distance between burrows in other areas allowed an estimate of burrow density around the perimeter of Fish Island. The major difficulty with this technique is obtaining an accurate estimate of the available habitat within 12 m of the cliff edge (mean distance to the cliff edge plus one standard deviation). High altitude infrared photos were used to map Fish Island and by counting the squares within the 12 m perimeter, an estimate of total area of 8,554 m^2 was obtained. Unfortunately, due to the conversion factor of 1 cm:2904 m there is a great deal of error associated with the estimate of area. Total population estimate for the plateau of Fish, based on this technique yields an estimate 1842 burrows. Conversion factors based on 1976 data for burrow activity and percent burrows with eggs (See Table 6) yield an estimate of 1026 Breeding pairs, further divided into 820 Fork-tailed and 205 Leach's Storm Petrel breeding pairs. Since active burrows not containing eggs are utilized by non-breeding birds, the estimate of active burrows without eggs can be used to estimate non-breeding birds visiting the island. Since each burrow may be utilized by 1, 2 or 3 birds this estimate ranges from 400 to 1200 non-breeding fork-tails, and 50 to 150 Leach's Storm Petrels. Again, however, emphasis on the error associated with this estimate must be stressed. The only way to improve the estimate is to measure all available habitat on the island while in the field this appears to be a loss of valuable time. For the purposes of future comparisons of the population of petrels on Fish Island, selected plots and carefully mapped subcolony areas should yield the most useful information. Three such plots were marked and studied last year and during 1977 several more of these plots will be established. Comparisons of density, breeding success, and activity in these plots over a long period of time will clearly provide more precise information about Storm Petrel population changes than total population estimates based on either of the above techniques.

Similar plots will be established on the rocky areas of Fish Island and on South Island next field season.

Phenology:

The breeding schedules of Fork-tailed and Leach's Storm Petrels on Fish Island differ markedly as shown in Fig. 8. Fork-tailed Storm Petrels were already incubating eggs when field work began on May 24. The first chicks were found June 11, though chicks found subsequently may have hatched as early as 1 June. Vernon Byrd (pers. comm.) found fork-tails have an incubation period of 55 days. Based on this estimate fork-tails probably begin laying eggs in early April. The earliest fledging observed occurred on 7 August. Several birds had not fledged by 3 September. The time between hatching and fledging varied from 65 to 70 days.

Both sexes of fork-tails incubate the egg; incubation shifts varied from 1 to 5 days, 3 days was average. Several eggs were found cold and were later incubated, but most of these did not hatch. One chick began pipping on 27 June. The egg was cold for the next 2 days, pipping ceased, and the chick appeared to be torpid. On 30 June the parent returned and pipping resumed. The chick finally hatched on 2 July, 5 days after first pipping the egg. The first day after hatching, fork-tails weigh 11 gm. but gain weight rapidly. By 35-40 days of age a healthy chick weighs 85-100 gm. This weight is maintained until age 55-60 days when rapid weight loss occurs. Most fork-tail chicks fledged at 60-65 gm. Fork-tail weights were measured daily up until fledging. Culmen length, tarsus, radius and ulna length, wing length, and longest primary length were measured every other day on 15 chicks, and every six days for the latter part of development on 5 other chicks. Unfortunately many chicks were lost to river oter predation and complete data from hatching to fledging was only collected for 4 chicks.

Leach's Storm Petrels were much more difficult to obtain information on because so few use Fish Island. During the summer 12 nests were found. The breeding schedule of Leach's is based on these few nests. The earliest egg laying date was 8 June. One fresh egg was found on 15 June, and 3 fresh eggs were found on 26 June. (Development was determined by the egg flotation method Westerskov 1950). One of these eggs was deserted, and two were destroyed by river otter. All known chicks were hatched by 8 August. One Leach's Petrel was still incubating an egg on 23 August, however. Assuming a 65-75 fledging period as given by Gross (1935), these young should have fledged by late October or early November.

Productivity:

Estimates of productivity and sources of loss are shown in Table 6. Three plots were set up in areas of high petrel burrow density. Plots A and B were examined after river otter predation, but Plot C was examined before substantial river otter predation. River otters later utilized Plot C, however. One hundred twenty active petrel burrows were located and were not sufficiently disturbed during incubation to cause desertion. Thirty other nests were monitored daily for records of incubation spells and length of incubation. This daily disturbance resulted in 100 percent desertion. However, nearly all birds banded were recaptured at least once indicating that one nest disturbance usually does not cause desertion. Several eggs were deserted in burrows that had never been disturbed however.

Nesting success for Leach's Petrels could not be determined since the field season ended long before fledging. On the last day of field season 40.0 percent of the Leach's chicks were healthy and may have survived. Nesting success for Fork-tailed Storm Petrels (number fledged per egg laid) was 30.9 percent (n = 77). Also, 57.9 percent of the eggs did not hatch, and 37.5 percent of the chicks did not reach fledging. River otter predation was the greatest factor affecting nesting success of both species throughout the nesting season. Approximately 48 percent of the unsuccessful nests were destroyed by river otter predation. An additional 23.4 percent of the unsuccessful nests failed as a result of other factors. Several of these nests may have been destroyed by river otters. Other causes of nest failure were desertion, starvation (1), chick killed by adult petrel (2), and other unknown causes.

Predation:

River otters were the main source of nest failure for both species of storm petrels. River otters dug out burrows, ate adults and chicks, but did not eat eggs. The remains of several birds were found in front of inactive, or partially dug burrows indicating river otters may have been active at night. Besides the nests destroyed, 136 Fork-tail remains and 54 Leach's Petrel remains were found that could be attributed to river otter predation. River otter predation has been mentioned by other researchers (Campbell 1975, Boersma and Manuwal 1977) however no estimate of the effect of river otters on storm petrel populations has been made. The nesting success of 30 percent corresponds with an estimate of 30 percent that Harris (1969) reported for _Oceanodroma castro_ on the Galapagos Islands where _Asio galapagoensis_ was preying heavily on storm petrels. He predicts that annual adult mortaility in a stable storm petrel population with 30 percent nesting success could not be greater than 5 to 7 percent. Assuming that the estimate arrived at by the Schnabel method is indicative of population size, river otter predation may account for 2.8 percent or more of the storm petrel population on Fish Island. Harris (1969) further indicated that juvenile birds may be more susceptible to predation than breeding adults. If so, the effect of river otter predation will be difficult to determine unless a method of aging storm petrels is developed.

Other predators on Fish Island include the Peregrine Falcon, Bald Eagle, Glaucous-winged Gull (non-breeding birds), Common Raven, and and an unidentified species of shrew. Of these, only common ravens appear to have been taking petrels. On one occasion two ravens were observed flying along the cliff edge at night, and alighting near where a Storm Petrel had just landed. Petrel remains were found on points of land used by ravens. Castings were collected and these will be analyzed for petrel remains.

Cormorants

Three species of cormorants occur on the Wooded Islands: Double-crested (*Phalacrocorox auritus*), Pelagic (*P. pelagicus*), and Red-faced (*P. urile*). Together these make up an estimated 250 birds with pelagics constituting about 90 percent. Only 2 pairs of Red-faced Cormorants were identified on two occasions. These birds are grouped together due to their failure to breed in 1976. Isleib (pers. comm.) found all three species breeding on South Island during a brief survey on 16 August 1974. More Red-faced Cormorants may have been present this last summer but non-breeding plumaged birds could not be separated from pelagic cormorants.

Although no birds were observed successfully breeding, some birds did initiate nesting. On 23 May a Pelagic Cormorant was seen gathering nest material. The beginnings of nests were first seen on 30 May on the East Slope of the Bird Cliffs of Wooded Island (Fig. 9). Twelve pelagic nests and one double-crested nest had been initiated by 3 June. A pair of Pelagic Cormorants was observed copulating on 10 June. The first red-faced was seen on the East Slope on 11 June. Four days after the raven chicks fledged from the nest on East Slope (See species account for ravens) a pair of double-cresteds occupied the abandoned raven's nest. Throughout this time period cormorants were observed and heard displaying around their individual nest sites. All of these observations are of birds on the East Slope of the Bird Cliffs at the southern tip of Wooded Island. The cormorants were using wide ledges situated primarily at the edge and above most of the kittiwake nests. By 20 June, 22 of the nests which had been built were unoccupied and partially destroyed. Five pelagics still remained on nests. On 26 June no cormorants were on their nests and most of the nest material was gone. Only 4 Pelagic Cormorant nests were seen on South Island on 23 June (Fig. 10). The southeast side of the island is a series of rough ledges with a couple of deep vertical notches in them. These ledges had a great deal of white wash on them when we motored around the island, although no nests could be seen. A five-day stay on South Island in early August resulted in the finding of no active cormorant nests. Two old nests were seen in back of the deep vertical notches on the southeast side. Cormorants first showed nesting tendencies at Fish Island on 2 July (Fig. 11). Seven birds were on some ledges of the northeast cliffs and the raven's nest was also occupied by a cormorant. These birds were vocalizing and displaying as if initiating breeding. Birds were seen carrying small bits of vegetation to the ledges but no nests were built. This activity lasted for about two weeks, after which cormorants were only rarely seen on the ledges. Cormorants were never observed on Tanker Island.

The offshore rocks around the islands are important to roosting cormorants. Heaviest use by loafing birds seemed to occur at the tide stages below high tides. Certain of these roosts were used habitually, notably the largest of the rocks southeast of South Island. On Wooded Island the following roosts were occupied: South Pinnacle, the rock just below the Grassy Observation Point at the Bird Cliffs, Roost Rock below the Middle Slope of the Bird Cliffs, and the rocks at the northeast tip of the entrance to Anchor Bay on the north side. The rocks of Harbor Point (north sea lion haul-out area) and the rocks offshore from East Point of Fish Island were also used. Throughout most days some cormorants would be loafing in these areas.

Eagle harrassment may have been a factor in the nesting failure of cormorants on Wooded Island. Twelve immature Bald Eagles were soaring and flying by Tanker and the East Slope of the Bird Cliffs of Wooded on 20 June. A number of times eagles landed on the ridge at the south edge of East Slope. Also, when eagles soared low by the cliffs a panic flight of kittiwakes and cormorants would occur. This is the same day when many cormorant nests were first observed to be unoccupied. Van Tets (1959) found gulls and crows would take cormorant eggs only after the nest was left unguarded due to disturbance by man or eagle. We made no observations of gulls or crows landing on cormorant nests even though these birds were constantly in the area. Since no eagles were observed on South Island, other unknown factors probably caused the nesting failure.

Harlequin Duck (Histrionicus histrionicus)

Throughout the summer Harlequin Ducks were around Wooded and Fish Islands. These birds were also seen at the entrance to and in the lower part of Nellie Martin River in Patton Bay, Montague Island. Sixteen birds in one group on the east side of Wooded Island was the greatest number seen. Possibly 20 to 25 harlequins utilized the intertidal areas around the Wooded Islands. Whether the birds bred on the islands is not known. Chicks were not observed but breeding plumaged males did occur. The intertidal water and rocks were used heavily by these birds for feeding and loafing.

Scoters

All three species of scoters (Black, Surf, and White-winged) occured in the general area of Wooded Islands. These birds were seen generally as a flock using the areas north of the islands to Box Point and in Patton Bay. On one occasion scoters were using the area north and northwest of South Island over the kelp bed. Whenever we made trips to Patton Bay a flock of scoters were using the northwest end. Probably 150 to 175 scoters are in this area during the summer.

Glaucous-winged Gull (Larus glaucescens)

Glaucous-winged Gulls utilized all four islands to a varying degree. An estimated 25 pairs bred on the Bird Cliffs of Wooded Island and 50 pairs are estimated to have bred on South Island. Isleib during his 16 August 1974 survey estimated 68 pairs on Wooded Island and 275 pairs on South Island (pers. comm.). No gulls nested on Fish or Tanker Islands. Most observations of breeding gulls were restricted to Wooded Island. Many gulls were observed landing on the Bird Cliffs for the first time on 23 May. At this time eleven were seen standing primarily on the two vertical ridges and the top edge of Middle Slope (Fig. 12). Actual nesting activity was not seen until 3 June when three birds were sitting on nest bowls and two pairs copulated. This nest initiation had probably started between 1 June and 3 June. On 10 June three eggs were found in one nest. Two chicks and one egg were in this same nest on 6 July. Chicks fledged during the second and third weeks of August.

Nests on the Bird Cliffs were scattered around the edges of the kittiwake nesting area (Fig. 12). Only six nests could be observed directly on the Middle Slope. Other nests were either hidden from view due to our positioning or by the lush growth of grass (Elymus) and umbels (Heracleum and Angelica). An observation point on the beach was used for the East Slope so nests on the cliff face could not be observed directly. Nest sites varied from a narrow rock ledge just below the cliff edge with no cover to the bases of heavily vegetated ledges in the grassy slope. This latter area was found to have the highest number of nests. In early August gulls were observed on South Island. Only the remnants of nests could be found since the chicks were well grown by this time. Nests were located on the heavily vegetated rocky slope at the northeast end, on the unvegetated rocky slope of the east side, and the top and sides of East Flatiron (Fig. 13).

In all areas direct counts were made of birds on nests, standing on the slopes or cliffs, flying, on loafing rocks at the beach edge, and sitting on the water. Gulls were also counted a number of times on the beach at Patton Bay and on the beach near the stream mouth draining Jeanie Lake on Montague Island (Fig. 2).

Attempts were made to band Glaucous-winged Gull chicks on the Middle Slope during the 4th and 5th of August. Since this is a 75-80° slope and 60 m high, rappelling was necessary. This allowed us to get to many nest sites and a number of measurements were taken when these were encountered. Capturing the chicks was the most treacherous part of the operation because of their well developed mobility. Twenty-three chicks were banded (aluminum and color bands) and measured (culmen, tarsus, weight, wing span, wing length, and longest primary), representing twelve nests on the Middle Slope. Five additional nests were known in the area but could not be reached. Most of the birds were near fledging, but one nest contained three chicks which were around a week old. An additional 9 more gull chicks were banded but not measured on South Island during 11, 12 and 13 August. All of these were near fledging. This presented a problem when the nests were on steep slopes. Six chicks attempted to fly when we approached them, but they only glided to the water below. These birds were not followed to see if they survived. One chick climbed onto a rock and was attacked by two adult Glaucous-winged Gulls. On South Island the day after two chicks were banded, they were swimming in the water near shore.

Although we may have caused some mortaility of gull chicks, it probably had little affect on the population due to the large number of non-breeding sub-adults in the area. These birds were seen most often loafing on the tidal and offshore rocks in flocks of up to 200 birds. Areas used for loafing sites on Wooded Island by gulls included: the offshore rocks at the northeast entrance to Anchor Bay, the rocks around East Spit, and Roost Rock below Middle Slope (Fig. 3). Seal Rocks south of Tanker often were used by loafing and non-breeding gulls. On Fish Island gulls loafed on the rocks of Harbor Point and East Point. The primary loafing areas on South Island were the large offshore rocks to the southeast. These areas are the most obvious loafing sites mainly for nonbreeders because they could be easily observed and frequently were on these locations. Gulls also were seen below the Bird Cliffs around loafing kittiwake rafts. These birds often engaged in bathing.

Glaucous-winged Gulls were never observed taking kittiwake eggs or chicks, although many egg remnants were found above and below the Bird Cliffs. A number of gull castings were looked at on the rocks below East Slope. Blue mussel (Mytilus) shells were the predominant remains. Gulls often were observed picking through kelp washed up along certain parts of the beaches. The East Spit always had a large mat of kelp washed up and the non-breeding flock used this area. In late August gulls were scavenging on spent salmon in the small stream at Jeanie Beach. This stream was also used by the gulls throughout the summer, as was the beach of Patton Bay (primarily the north end were there was always a large kelp mat).

Other Gulls

The only other gulls, besides kittiwakes, observed in the area were Mew and Herring. Both species were seen with the nonbreeding group of Glaucous-winged Gulls around Wooded, Tanker, and Fish Islands, and also in the small flock which used the Patton Bay beach. An estimated 75 Mew Gulls and 10 Herring Gulls occurred in the area. Only immature Herring Gulls, while both mature and immature Mew Gulls were seen.

Black-legged Kittiwake (Rissa tridactyla)

Probably the most obvious bird using the Wooded Islands is the Black-legged Kittiwake. Nesting was confined to the Bird Cliffs of Wooded Island and South Island. An estimated 1,125 pairs nested on the Bird Cliffs (50 pairs on Grotto Slope, 450 pairs on Middle Slope, and 625 pairs on East Slope as shown in Fig. 14). Nests primarily were restricted to East Flatiron (30 pairs) on South Island with scattered birds (20 pairs) nesting on the pinnacle at the northeast end of the island (Fig. 15). During his 16 August 1974 survey Isleib (pers. comm.) estimated 1,140 nests on Wooded and 540 nests on South.

Three observation points were established to watch the kittiwakes of Wooded Island (Fig. 14). Two of the points (a grassy point of land used to observe Middle Slope, and the top of an overhang on the cliff edge used to observe Grotto Slope) were located on the cliff edge at the southeast end of Wooded Island. The third observation point was on a large boulder on the beach 30 m seaward of East Slope. From these three points approximately 90 percent of the nests could be seen. Periodically throughout the summer counts of total birds, single birds on nests, and pairs on nests for each slope were made. Birds in rafts and standing on Roost Rock below the cliffs were also counted. On 24 and 25 June a 24-hour count of birds (hourly counts) for Middle Slope was made from the grassy observation pint. Free-hand sketches were made of the nest locations relative to each other for all of Middle Slope in mid-June and the northern half of East Slope in late-July. Overlapping 35mm black and white photographs using a 400 mm telephoto were taken of Middle and East Slopes. These pictures will be used for verification of nest site location in comparison with the sketches, as a permanent record of the colony structure, and for comparison with next year's colony.

The first kittiwake copulaton we observed was on 16 May with the peak of this activity probably occurring in the last two weeks of May. Copulations continued to occur until the end of June, although one attempted copulation was observed on 30 July. Eggs were first seen in nests on 10 June but could have been layed after 4 June. The first chicks were observed on 6 July but could have hatched during the previous week. Some nests still had one chick and one egg while others had chicks or eggs only. Fledging occurred after 4 August. Of 392 observable nests on Middle Slope, by 1 August 38 were destroyed, 42 deserted, 46 contained two chicks, and 66 contained one chick. This results in an average of 0.40 chicks per nest. No chicks were seen on South Island during the second week of August.

On both islands predation was probably an important factor in reducing production. Glaucous-winged Gulls, ravens, and Peregrine Falcons contributed to mortality of birds and eggs on Wooded Islands. The peregrines preyed on adults and probably fledgings later in the summmer. As mentioned before kittiwake egg shells were encountered often. Remains along the beach and on rocks may have resulted from gull predation while those on the ground under the trees may be attributed to ravens. A raven's nest was located just above and to the north of the kittiwake ledges on East Slope. On one occasion an adult raven was seen leaving a kittiwake ledge with a whole egg in its bill. With the scattered distribution of nests and the high number of nesting Glaucous-winged Gulls on South Island, gull predation may have been the significant mortality factor. Another factor which killed a few chicks is stormy weather. After two days of a gale force storm on 26 and 27 August three chicks were found washed up on the beach below East Slope.

Roost Rock, a large tidal rock below Middle Slope, and the waters off the Bird Cliffs were the areas used most frequently by kittiwakes for loafing. From the two cliff edge observation points the activity at these areas could be easily seen. On 17 May at 0900 all of the kittiwakes were rafted below the Bird Cliffs and none were on the nesting ledges. This is the only time such a complete "desertion" occurred. Kittiwakes were also seen many times on Jeanie Lake and Jeanie Beach (Fig. 2). During late summer large feeding aggregatons of kittiwakes were over the water throughout the area.

<u>Shorebirds</u>

Only three shorebirds were in the area throughout the summer. The most obvious of these were the Black Oystercatchers. Oystercatchers were seen in tidal areas of all four islands, along Jeanie Beach, and on the beach at Patton Bay. An estimated 20 birds used the area. A nest with two eggs was found on the north side of East Spit on Wooded Island. One of the eggs never hatched while a chick was seen near the nest on 26 June. In a 5 square meter area of gravel on South Island, an active nest with three eggs was found along with four other nest bowls, possibly old nests. No active nests were found on Tanker or Fish Islands but territorial pairs were present. Characteristically oystercatchers heavily used the intertidal areas.

Semipalmated Plovers were seen on Wooded Island and the beach of Patton Bay. A pair probably had their nest on the upper beach of Anchor Bay. These birds used this beach area throughout the summer. Semipalmated Plovers also were present on the beach at Patton Bay and two chicks were seen there. Only 10 to 15 of these birds use the area around Wooded Islands.

Least Sandpipers were only observed on the beach at Patton Bay during beached bird surveys. Ten to fifteen birds use the Patton Bay beach all summer.

Wandering Tattlers were on Fish Island throughout the summer. They were first seen on 31 May with four birds being together and in late August five birds was the highest number ever observed at one time. Tattlers were only seen on the rocky beach of the Landing Cove at Fish Island. One other tattler was seen on South Island in early August. In mid-May tattlers were seen once on Jeanie Beach.

Common Murre (Uria aalge)

Common Murres nested only on Wooded Island but were observed flying by Fish and landing on South Island. On Wooded Island the murres nested in a large vertical crack diagonal to the cliff face. This small cave was seven meters below the cliff edge and approximately 23 m above the water at the western corner of Middle Slope of the Bird Cliffs (Fig. 16). The birds would fly up, land on a shelf of rock then walk towards the cliff and down into the crack. Upon closer inspection by rappelling, the lower eastern edge of the crack was a large opening approximately a meter wide and two meters high. During this inspection on 21 August we were able to capture nine adult birds and two chicks to measure and band. During this process a burlap bag containing two adult birds accidentially fell to the rocks below presumably killing the birds.

Counts of murres were done from the two cliff edge observation points. The birds rafted a couple hundred meters south of the cliffs along with Tufted Puffins. Usually the murres would segregate in small groups or one large group within or at the edge of the Tufted Puffin rafts. An estimated 30 pairs nested on Wooded Island. No murres were observed on Wooded Island by Isleib during his 16 August 1974 survey, but he did see five pairs on South Island. In early August murres were also observed flying by and landing on parts of South. Ten murres are estimated to have been in the area of this island, but whether breeding occurred is not known. Only occasionally were murres seen near Fish Island and usually this was one or two birds (except seven once flying north of Fish). On 16 July a murre was collected which had slight oil staining on its breast.

Parakeet Auklet (Cyclorrhynchus psittacula)

Parakeet Auklets were found in the area of Fish Island only. The first birds were seen on 5 June in the Landing Cove. Birds were observed from this area and around the north side of the island to the northwest tip. Auklets were often seen displaying in the water just offshore of the rocks on Harbor Point and the northwest tip (Fig. 17). Only 25 birds are thought to have used the island. On 19 July near Harbor Point two actual nests and the general area of a third nest were found. All of the nests were in the cracks of large boulder piles and 15m or less from the water line. A number of measurements were taken of the physical features of the two actual nests (entrance height and width, entrance angle, general angle of area, angle from the taking off spot, aspect of the entrance, distance to nearest neighbor, distance to the taking off spot, distance to high water line, depth to nest, and diameters of boulders surrounding the nest). No nests were found at the northwest area. One of the nests was very accessible through the rocks and we were able to reach the chick. Growth measurements were taken for 12 days until it fledged on 31 July. We were also able to capture both parents of this chick and band all three.

Pigeon Guillemot (Cepphus columba)

All four islands had some Pigeon Guillemots on them. Forty-seven pairs are estimated to have nested on the islands, 10 pairs on Wooded, 5 pairs on Tanker, 30 pairs on Fish and 2 pairs on South. On 16 August 1974 Isleib estimated 31 pairs using the island group but in a 1972 survey he estimated 500 pairs in the area. The 1974 survey may have missed some guillemots since it would have been around the fledging period.

One guillemot nest was found on Tanker Island in a small crevice in the cliff face 28.5 m up from the base of the cliff and 8.5 m below the cliff edge (Fig. 18). Nine other nests were located on the north side of Fish Island (Fig. 19). Of these, three were in crevices of the cliff face. The other six were between boulders of the rocky slopes and these were measured for the same characteristics as the Parakeet Auklet nests.

In a small cove on the south side of Wooded and northeast of South Pinnacle (Fig. 20), 15 Pigeon Guillemots were observed displaying for over an hour at which time two copulations occurred. The first fish carrying activity was seen on 12 July at Tanker. Then on 19, 21, and 22 July a nest was found each day containing two chicks each. On 19 July another nest was found containing an incubating adult and one egg. This nest was later deserted. The six chicks from these three nests were measured daily until fledging occurred during the second week of August. Each bird fledged within one to two days of its nest-mate. Another single chick was found at the northwest end of Fish on 24 August. Based on body measurements in comparison to the other six chicks, this bird would fledge in 2 to 3 weeks. After mid-August guillemot activity seemed to be very low and few birds were observed.

Two types of fish were seen being carried to the young, flatfish (Pleuronectiformes) and sand lance (Ammodytidae). The sand lance was the most frequent food item carried. In two instances immature Glaucous-winged Gulls harrassed fish-carrying guillemots but no actual clepto-parasitism occurred.

Tufted Puffin (Lunda cirrhata)

The most abundant bird of the Wooded Islands is the Tufted Puffin. These birds nested on all four islands and used the water surrounding the islands for rafting and loafing. Using both raft counts and burrow density for habitats, an estimated 1,125 Tufted Puffin pairs nested on Fish Island, 650 pairs on Tanker, and 225 pairs on Wooded. Based on habitat types at South Island 400 pairs probably nested there. Isleib (pers. comm.) in 1972 estimated 7,000 pairs using all the islands. During his 16 August 1974 survey he estimated 1,100 pairs at Fish, 500-1,000 pairs at Tanker 1,300 pairs at Wooded, and 1,650 pairs at South.

Tufted Puffins habitually used certain areas for rafting before flying up to their nests. Birds coming in from out at sea would land in these areas, sit on the water for a period of time, then fly to the island. Major rafting locations were 200-300 m northeast of Fish, 200-300 m south of Fish, 300-400 m northwest of Fish, 200-300 m north of Tanker, and 200-400 m south of the Bird Cliffs of Wooded (Fig. 22). Rafts were not identified around South Island due to the late date of observation. This rafting behavior tended to be less prominent after hatching when puffin activity was spread throughout the day. During incubation rafting and flying by the islands began around 1900 hours with peak activity around an hour before and after 2000 hours. This seemed to hold true for all areas except Woooded Island where rafts occurred during the day with peak activity an hour before and after 1200 hours. Upon flying up to the islands definite flight patterns seemed to be established with only a few birds deviating from these courses. In the early morning hours activity was less evident with birds leaving the nesting areas primarily between 0100 and 0500. Rafting and definite flight patterns did not characterize the morning flights.

The only observations of puffin copulations were in the rafting area off the Bird Cliffs on 23 May. Eggs were first discovered at Fish Island on 28 May, although a bird was observed in one of these burrows on 22 May (the burrow was not checked for an egg at that time). On 8 July the first chicks were found in rocky burrows on Tanker Island. During the following week both chicks and eggs were found in burrows on Tanker Island. For 37 days starting on 25 July chick growth measurements were made on two chicks at Fish Island which were probably around 7 days old and should have fledged within the first week of September. One Tufted Puffin chick was known to have fledged on 16 August. Judging from the various sizes of chicks found, hatching seemed to be spread over the entire month of July and the first week of August.

Four types of habitats were used by Tufted Puffins for nesting--cliff edge, grassy slope, rocky slope, and cliff face (Figs. 27-30).

Transects were established in each habitat type except cliff face. Upon rappelling down the cliff face at the southwest end of Fish, tufteds were found nesting in small rock crevices. Each transect was clearly marked with a rock cairn for future reference. On 1 July transects to obtain puffin burrow measurements and densities were started. Much of this work required the use of ropes for rappelling. At the cliff edge, transects consisted of a 5 m line stretched along the edge which served as the sample unit. All burrows within 5 m of both sides of the line in every other 5 m section were measured. In alternate 5 m sections the burrows were counted only. Nettleship (1972) working with the Common Puffin (Fratercula arctica) measured nine different habitat factors. He concluded distance from the cliff edge and angle of slope were the two most significant factors affecting breeding success. Grant and Nettleship (1971) found distance from cliff edge and perimeter of boulders correlated closely with burrow density. Measurements taken in my cliff edge transects were: entrance size, entrance angle, surrounding angle, take-off angle, entrance aspect, distance to nearest neighbor (and species), distance to take-off, distance to cliff edge, distance to below, vegetation height, soil depth at entrance, Daubenmire Area Cover (only a sample of burrows), soil sample, and activity (if possible). On Fish Island the cliff edge transect started at the tip of the bare rock point overlooking the sea lion rookery at the south end of the island beneath the old observation tower used by Sandegren in 1967 and 1968 (Fig. 23). From here the transect ran east around the cliff edge. In 1976 over 140 m of cliff edge were searched for burrows with an average of 0.11 burrows per square meter. Another cliff edge transect was conducted completely around Tanker Island (Fig. 24). The transect started at the eastern most part of the top beneath a dead tree trunk and ran to the northwest and west. For the 377 m of cliff edge around Tanker there were 510 burrows for an average of 0.14 burrows per square meter of cliff edge. Although these averages are deceiving because in both transects 83 percent of the burrows were within 2m of the cliff edge.

For grassy slopes, consecutive 1 square meter plots from the cliff edge to the bottom were used as the transect. The same measurements as above were taken with the addition of five vegetation heights and five soil depths in each square meter plot. On some grassy slopes all burrows in the area were counted and measured. On Fish Island two transects were run down the grassy slope on the southcentral part of the island immediately south of the camp site (Fig. 23). This 15m long and 23m wide area was also searched for every burrow and 25 completed burrows were found for an average of 0.07 burrows per square meter. Another grassy slope transect was set up on the northern part of East Slope of the Bird Cliffs at Wooded Island (Fig. 25). This 20m long transect was in a very low density burrow area. Approximately 20m north there was another grassy slope which had a high density of puffin burrows but time did not allow another transect to be set up.

A 14m wide belt transect from the water's edge to the top of the slope was used for rocky slope habitat. A systematic search was then made within the transect for all nesting birds. Measurements of nests included those mentioned above plus two or three diameters of the rocks surrounding the nest. The rocky slope transect on the north side of Fish west of Harbor Point was 55m long and in an area of partially vegetated rocks (Fig. 23). Only 14 burrows were found in this transect for an average of 0.02 burrows per square meter. Another rocky slope transect at the west end of the main island was in an unvegetated boulder slide (Fig. 23). In this transect the average number of burrows per square meter was 0.04 (34 burrows in the 64m transect). On Tanker going up the south side of the southwestern ridge (Fig. 24) a 62m transect had an average of 0.07 burrows per square meter (60 burrows). A rocky slope transect was also established on the east side of South Island in the extensive bare rock slide on the southeastern edge (Fig. 26). This transect was not completed but within the lower 45m 22 burrows were found giving an average of 0.03 burrows per square meter, and this was probably representative for the rest of the transect. In all a total of 370 Tufted Puffin burrows were measured.

Rafting puffins were counted from specific observation points. On Fish the observation spot was at the cliff edge on a point of land east of the trail from the Landing Cove (Fig.23). In addition to raft counts four 30-second counts separated by 15-seconds every 10 minutes were made. It is hoped these counts can be used to indicate the relationship between numbers rafted and flying. Using the highest ridge on the west side of Tanker as the observation point the whole area around the island could be seen (Fig. 24). On Wooded Island the same observation points at the cliff edge that were used for kittiwakes were also used to observe Tufted Puffins. Two observation points were located on South Island, on the cliff edge at the southwestern end and the other on a rock shelf protruding from the grassy slope of the northeast corner of the island (Fig. 26).

During the transects all burrows were checked for activity. Sixty-five adults and 36 chicks encountered in the burrows were banded.

Adults were often seen carrying food to the burrows during chick rearing. Only two complete bill loads were examined. One contained four sand lances (Ammodytidae) with an average length of 11.85 cm, and the second had seven sand lances (average length 4.6) and three small octopi (which were still alive).

Little mortality of Tufted Puffins was observed. Puffin legs were found below the Peregrine Falcon eyrie on Wooded and peregrines were seen diving at puffins but no killing was observed. Eagles may have taken a few puffins especially on Tanker where eagles would often sit on the cliff edge. Signs of river otter predation on puffins were found on Tanker and Fish Islands. The only other mortality factor known was that caused by the researchers. Although kept to a minimum, some burrows were caved in and some desertion of eggs occurred.

Horned Puffin (Fratercula corniculata)

In comparison with Tufted Puffins, Horned Puffins were very few. Isleib estimated 300 pairs using Wooded Islands in 1972 and in 1974 50-100 pairs on Fish Island, 3 pairs on South Island, and 1 pair on Wooded Island. The estimate for 1976 is 5 pairs on South Island and 5 pairs on Fish Island. Horned Puffins were not seen until 3 June when they occurred at Wooded and Fish Islands. On 23 June and the second week of August Horned Puffins were also observed on South Island (Fig. 31). No definite nests were found but one bird was seen going into a cavity underneath a large boulder on the north side of Fish Island. Birds often sat by rock crevices in the cliff face at the southwest end of Fish Island (Fig. 32).

Other Alcids

Only two Rhinoceros Auklets (Cerorhinca monocerata) were observed on 13 July near the north shore of Tanker Island. U.S. Fish and Wildlife Surveys in 1972 revealed a small number of these birds that may have been nesting on the islands (Isleib and Kessel 1973). Our observations in mid-August at South Island may have missed any Rhinoceros Auklets nesting there.

Marbled Murrelets (Brachyramphus marmoratum) were observed from 5 June throughout the summer. Most of these birds occurred in the area between the islands and Patton Bay. Both nonbreeding and breeding plumaged birds were seen. Twelve is the highest number of birds observed at one time (on 13 June between Wooded and the southern point of Patton Bay).

The only time Ancient Murrelets (Synthliboramphus antiquum) were observed was 20 August. Six birds were offshore along Montague Island between the southern point of Patton Bay and Jeanie Beach.

Terrestrial and Non-marine Birds

Twenty-five other species of birds were observed at various times throughout the summer and were not considered to be transients. These species are listed in Table 4 and only those birds which may be somewhat directly affected by oil contamination will be considered further.

In May and early June Canada Geese (Branta canadensis) were observed in the upper beach areas of Jeanie Beach and Patton Bay. Probably 10 to 15 birds used these areas for feeding and loafing. Some of these geese may have been migrating. There was a pair nesting on Wooded Island and Montague Island probably had nesting birds.

Two Bald Eagle (Haliaeetus leucocephalus) nests were active on Wooded Island and another nest was occupied by Northwestern Crows (Fig. 33). An inactive nest was on Fish Island (Fig. 34). Twelve immature and 4 to 6 adult Bald Eagles utilized the island group. These birds probably scavenged the beaches for food and preyed on seabirds, although no observations were made.

A Peregrine Falcon (Falco peregrinus) eyrie was located on a small ledge of a flat rock face at the northwest tip of the eastern point of Anchor Bay on Wooded Island (Fig. 33). Close inspection of the nest site was not made but one observation in the general area below the nest revealed puffin and kittiwake remains. The adult birds defended the area from both humans and other birds such as Bald Eagles. Before August only once was one bird seen flying near the Bird Cliffs at Wooded Island. In August up to 3 peregrines at a time were often seen around the Bird Cliffs diving at kittiwakes and puffins. One bird was also seen over Fish Island in late August.

One pair of Common ravens (Corvus corax) nested on the East Slope of the Bird Cliffs at Wooded Island (Fig. 33) and a second pair nested on the southeast side of Harbor Point of Fish Island (Fig. 34). Three young fledged from the Wooded Island nest and the Fish Island nest had 4 young fledge. Ravens preyed on a number of seabird species.

Song (Melospiza melodia) and Fox (Passerella iliaca) Sparrows were common along the beaches of all islands except Tanker Island. These sparrows foraged in the decaying kelp and on other parts of the beach.

Marine Mammals

Steller Sea Lion (Eumetopias jubata)

A colony of Steller sea lions bred on Fish Island. The breeding group was on the southern edge of Fish Island, identified in Fig. 5 as "The Rookery". It was occupied by a maximum of 555 sea lions. Harbor Point was occupied by a maximum of 134 non-breeders. Sandegren (1970) estimated 930 sea lions at Fish Island. This was based on 30 separate counts at various times of day. He found peak numbers in early morning. Most of our counts were made at 1200 hours or later. Sandegren found a similar distribution of sea lions on the island although he also mentioned that 5 to 10 percent of the breeders occupied East Point. Only a few sea lions were observed in that area during the breeding season.

Pups were first noted on 7 June. On 14 June 17 pups were counted at The Rookery. Biologists from the Alaska Department of Fish and Game landed by helicopter on The Rookery on 26 June. They branded 28 sea lion pups with an E on the right shoulder. After their visit, sea lions did not use the area where the helicopter had landed but continued breeding and suckling young on the rocks nearer the surf. The breeding and non-breeding sections soon disbanded, however, and sea lions began using the entire shoreline of Fish Island. Part of the breeding group moved out to East Point. By August 10-15 sea lions utilized The Rookery.

The nonbreeding section at Harbor Point moved to the west side of West Point. By the end of the summer animals were sparsely distributed along most of the shoreline of Fish Island, excepting the east edge of West Point where no animals occurred.

One animal, probably a young male, had a yellow tag in its left ear. This was reported to the Alaska Department of Fish and Game, however the origin of the tag has not been discovered. Two other animals were observed on different occasions with nylon fish net around their neck. The netting was cutting into their flesh and they did not look as healthy as the other animals.

Harbor Seal (*Phoca vitulina*):

Harbor seals hauled out on the beach rocks and offshore rocks around Tanker, Fish, and South Islands. Seals also were seen close to shore around Wooded Island, but not on any of the beach rocks. Seal Rocks south of Tanker and the east shore of Tanker Island were the most intensively used areas. During low tide the greatest numbers were hauled-out. On 17 May 105 harbor seals were loafing on Seal Rocks. Only one pup was observed high on the beach of Tanker in late May. Seals used the offshore rocks along the east side of South Island and also the rocky beach at the northwest end of the island. Fifty to 60 seals probably used the area around South Island.

Sea Otter (*Enhydra lutra*):

All the waters near the islands and north into Patton Bay were used by sea otters. Throughout the summer sea otters were observed scattered in the area, usually in groups of 2 or 3, or individually. Only in the kelp bed northwest of Seal Rocks did concentrations of sea otters occur (Fig. 3). Sixteen to 20 sea otters probably utilized the Wooded Islands area. Two or three of these were females with pups. Two sea otter pups were found dead during beach surveys at Patton Bay.

Other Marine Mammals:

On 30 June a fin whale (*Balaenoptera physalus*) was first observed in the west end of Patton Bay. Later in the day it was seen lingering in the area of the channel between Wooded and Montague Island.

Three pods of killer whales (*Orcinus orca*) presumably on migration were observed. One pod in the spring (24 May) consisted of 8 animals. On 13 August 7 animals and on 30 August 3 animals were observed. In the spring the killer whales passed between Fish and Tanker Islands heading southwest. The first pod in the fall passed south of Wooded Island but came close to Fish Island going northeast. The last pod was swimming in the area between Wooded Island and Jeanie Beach.

Migration

During May and early June, then again starting in August, a number of bird species were observed migrating. A few of these did not land in the area, but only passed over. Most of the species were observed (Table 5) on the surrounding waters or on the beaches. One interesting observation was of a concentration consisting of 407 Arctic Loons (Gavia arctica), 18 Red-necked Grebes (Podiceps auritus), 12 Red-breasted Mergansers (Mergus serrator), and 350 other seabirds which were probably locals. This aggregation was recorded on 23 May just offshore north of Wooded Island during a storm. On three occasions, 5 June, 17 June, and 27 July, Sooty Shearwaters (Puffinus griseus) were observed. The largest group, 2,700, was just offshore from Fish Islnad during a storm from the south and southwest on 5 June.

Beached Bird Surveys

The 3.5 km beach at the west end of Patton Bay was an excellent location for beached bird surveys. Only the 3 km section north of Nellie Martin River to the start of the rocky shore at the north end was used for the surveys. The beach was walked every 10 days, weather permitting. The entire beach was searched intensively by walking three abreast while going away from and coming back to the zodiac. Scavenging brown bears (Ursus arctos) and river otters may have removed some of the remains. Whenever animal remains were encountered on other beach sections, these were also recorded. Most notable was a beached toothed whale (later identified from a photograph as being of the genus Ziphius, J. Hall, pers. comm.). This was found on the western side of Wooded Island. A summary of the beach surveys is in Table 7.

VII. SELECTED OBSERVATIONS AND DISCUSSION

Species Diversity

Wooded Islands have a unique seabird colony. Sixteen species of breeding seabirds including 2 hydrobatids, 3 cormorants, 6 shorebirds, and 5 alcids occur on Wooded Islands. Ten other species use the area throughout the summer, but do not breed. Included in the Wooded Islands seabird colony are the northernmost known breeding colony of both Fork-tailed and Leach's Storm Petrels, and one of the easternmost colonies of Parakeet Auklets. As a whole, Wooded Islands seabird colony is one of the largest in the north & eastern Gulf of Alaska. Interaction between species was noted in some instances, but more research on interspecific relations will be conducted next field season.

Distribution and Abundance

Distribution maps of the breeding areas for all nesting seabirds are provided in the Appendix. Briefly, Tufted Puffins are the most numerous seabirds, numbering approximately 2,400 breeding pairs.

Fork-tailed Storm Petrels were second most numerous, however an accurate estimate of storm petrel abundance could not be obtained during 1976. A tentative estimate for the upper portion of Fish Island only is 1,030 breeding pairs, and 400 to 1,200 non-breeding birds. Lower Fish Island may harbor an equal number of fork-tails. Fork-tails also breed on South Island, however no estimate can be made at this time. Black-legged Kittiwakes number third in abundance with 1,125 pairs. This species was restricted to the Bird Cliffs on Wooded Island, and the East Flatiron and east side of South Island. Leach's Storm Petrels on Fish Island were estimated at 200 breeding pairs plus 50 to 150 non-breeding birds. Leach's Petrels also nested on South Island so total population size for Wooded Islands is actually much larger. All three species of Cormorants--Double-crested, Pelagic, and Red-faced--number about 250 birds. Also breeding on Wooded Islands in 1976 were: 47 pairs of Pigeon Guillemots, 35 pairs of Common Murres, 12 pairs of Parakeet Auklets, and 10 pairs of Horned Puffins.

Breeding Schedules and Nesting Success

Phenology of breeding for all nesting seabirds is shown in Fig. 8. Nesting success estimates were obtained for Fork-tailed Storm Petrels (0.31 young fledged per egg laid), Leach's Storm Petrel (0.40 young alive at end of field season per egg laid), Black-legged Kittiwakes (0.40 young fledged per nest), and all species of cormorants (nesting failure). Major factors resulting in storm petrel nest failure were river otter predation, egg desertion, starvation, and other unknown causes. Common Raven predation and storms were the most significant causes of kittiwake nest failure. The reason for cormorant nest failure is unknown, but harrassment by eagles leading to nest predation by gulls and/or ravens might have been a contributing factor.

VIII. CONCLUSIONS

Wooded Islands and the surrounding waters are threatened with oil pollution in the near future. Outer Continental Shelf oil and gas exploration has already begun in the northern Gulf, and the Valdez terminal of the Trans-Alaska oil pipeline is scheduled to begin operation in the summer of 1977. Since currents in the Gulf flow in a counter-clockwise direction, oil spilled near Hinchinbrook Entrance or in the lease area near Kayak Island may be expected to reach Wooded Islands. Royer (pers. comm.) indicates that oil spilled near Kodiak could also be washed to the Wooded Islands by a countercurrent from the southwest.

The effects of oil spills on Wooded Islands seabirds and other birds using the area depends largely upon the amount of oil spilled, the time of year of the spill, the stage of tides, wind velocity when oil reaches Wooded Islands area, and the success of clean-up measures. Possible effects can be separated into two groups: the effects of floating oil slicks, and the effects of chronic oil pollution.

Floating oil slicks will probably have the greatest effect on alcids and other species commonly rafting on the sea, and on birds using the intertidal rocks for loafing and feeding sites. Rafting seabirds, particularly alcids, including Tufted and Horned Puffins, Common Murres, Parakeet Auklets, Marbled and Ancient Murrelets, are quite susceptible to floating oil slicks as evidenced by tragedies of oil spills in other areas of seabird concentrations. During seas greater than 1.3 m, many alcids have difficulty taking off from the water surface. Tufted Puffins at Wooded Islands often rafted in numbers exceeding 1000 birds. A single oil slick in the area during May and June when Tufted Puffin rafts are largest, could result in massive mortality. Later in the summer, rafts are smaller but constant interchange of birds to and from the nests occurs. During winter alcids would be more widely distributed and single incidents of mass mortality would be unlikely. However, the net effect might be similar since wintering birds in moult are unable to fly, and might have a much smaller chance of avoiding a spill. Other birds including White-winged, Black, and Surf Scoters; Arctic and Common Loons; Red-necked Grebes, and Northern Phalaropes would also be susceptible to floating oil slicks.

Ten species of seabirds, including Double-crested, Pelagic, and Red-faced Cormorants; Harlequin Ducks, Black Oystercatchers, Wandering Tattlers, Glaucous-winged Gulls, Black-legged Kittiwakes and Pigeon Guillemots extensively utilize the intertidal rocks of Wooded Islands throughout the summer for feeding and loafing. Because of heavy wave action and large tidal fluctuations in the area, oil will likely wash on to these rocks. Birds visiting the rocks later for roosting or feeding would undoubtedly become oiled. Food sources might also be eliminated by oil residues. In the event that oil reached the islands, Black Oystercatchers, Harlequin Ducks, and Wandering Tattlers would suffer from food loss alone.

Other seabirds, gulls, storm petrels, and shearwaters can be expected to suffer less from direct oiling than alcids and other species that frequently alight or rest on water. Few observations of the reactions to oil by these birds have been made, however oiled birds have been found, so these groups are not immune to the effects of oiling. However the numbers of these birds affected by oiling can be expected to be less than the numbers of alcids (for example) affected by oiling. The greatest effect of oil pollution on these groups may be a result of chronic oil pollution. The effects of this may be manifested in lower population size, nesting success, and nesting density. The small size of the Wooded Islands colony allows accurate estimates of gull populations, and precise delineation of nesting habitat and measurements of nesting success for both storm petrels and gulls. Thus, the effects of chronic oil on these seabirds may be noticeable at Wooded Islands, if long-term monitoring is conducted.

Since kittiwake breeding success is known to be related to the size of the colony (Coulson and White 1960), a decrease in population size or breeding density might thus result in a more marked change in reproductive success of the birds. If so, good estimates of productivity in small colonies such as Wooded Islands, and careful monitoring could be useful in detecting low level effects of chronic oil pollution. Early detection of chronic oil pollution and its effects could be of major importance in correcting the problem before the pollution reached high levels and major effects at larger and more distant colonies became noticeable.

Storm petrel population monitoring offers the same opportunity for detection of chronic oil pollution. Because storm petrels rarely alight on the water and do not use offshore rocks, there would be little likelihood of direct oiling. However, oil pollution could effect food availability, and reduce survival and production as a result of hydrocarbon build-up in the food chain. Because storm petrels are known to utilize the same burrows year after year (Wilbur 1969), probably do not breed until 3 to 4 years of age, and may live for 10, 15, or more years (Huntington 1969), their colony size and density could be expected to change very little under normal conditions. Thus, measurements of colony size, density, and nesting success in established areas over a period of even a few years might indicate population changes resulting from chronic oil pollution. Further, since storm petrel reproduction may be limited by food availability (Huntington 1969), lowered nesting success, slower chick growth rates, and/or increased chick mortality from starvation might indicate scarcity of food brought on by chronic oil pollution. The Wooded Islands colony offers an excellent opportunity to monitor these parameters over long periods of time because of the small size of the colony and its proximity to the mainland (for easy access), and its proximity to the source of oil pollution.

Because of the location of Wooded Islands and the breeding seabirds they harbor, this area may become an attraction to tourists and residents of Alaska. Last summer the islands were visited by several groups of fishermen. Some of these fishermen harassed sea lions, and were observed shooting seabirds for target practice or fish bait. Fishermen used the protected cove on the north side of Wooded Island for anchorage. Boats were often anchored less than 50 m from the active Peregrine Falcon eyrie. Daily activities and pastimes of some fishermen (including rifle shooting) could disturb the peregrines as well as other species in the area. On three occasions during the summer small private planes buzzed the islands. While Tufted Puffins were panicked by the planes and left their cliff-edge burrows *en masse*, the reactions of other birds were not observed. Nearby Patton Bay and Jeanie Lake on Montague Island were often used by recreationists from Anchorage, Seward, and Cordova. On one day in late August, 4 separate planeloads of people had flown out to the area. In all, at least 17 people other than ourselves were on the beach at Patton Bay. Several expressed their thoughts of visiting Wooded Islands. When visitation to the islands begins, (and this will probably occur soon), careful regulation will be necessary to preserve the seabird colonies.

Oil development in the Gulf of Alaska is expected to create an influx of people into Alaska. U.S.D.I (1976) predicts the number of people employed in Alaska will rise from 113,000 in 1973 to 218,000 in 1983, almost a two-fold increase. Clearly, the influx of people and resulting increased human use of the area caused by oil development could indirectly affect seabirds on Wooded Islands.

Marine mammals, by virtue of their biology, could be severely affected by oil pollution. Direct mortality from a spill could occur, although the animals may be able to avoid such contamination. In this case their marine habitat, such as food supplies and breeding areas, would most likely be altered and the animals displaced. If no other favorable habitat is available, or if other favorable habitat is occupied, the marine mammals of the contaminated area would most likely die. The 900 Steller sea lions, 150 harbor seals, and 20 sea otters around Wooded Islands would be affected by oil pollution. In addition, those species migrating through the area such as killer whales could be affected if a spill occurred during the times they use the area. The effects of low level chronic oil pollution would be more difficult to recognize, therefore continuous or short-interval monitoring of the marine mammal populations would be necessary.

IX. NEEDS FOR FURTHER STUDY

This study was designed to obtain baseline information on the seabird colonies of Wooded Islands. During 1976, breeding areas were delineated, tentative population estimates were made, and estimates of nesting success were obtained for some species. This yields only a single estimate of population size, distribution, and productivity, but gives no estimate of the yearly variation. Some species of seabirds (Glaucous-winged Gulls, Horned Puffins, and Pigeon Guillemots) may show wide fluctuations in population size over a relatively short period of time as indicated by comparisons of 1972 and 1974 estimates (Isleib, pers. comm.) with those obtained in 1976. Detection of the effects of oil pollution without baseline information spanning at least two years will be impossible, since wide fluctuations normal in the populations could cause a major decline. Attribution of the decline to oil pollution would thus be refutable.

Providing good baseline information is obtained, changes in population sizes could be detected and the effects of oil pollution quantified. Nisbet (in prep.) indicates that changes in seabird populations can be more accurately established in small colonies. The small size of the Wooded Islands colony provides the opportunity for accurate measurement of population size changes. Since the islands harbor both species susceptible to oiling (i.e. alcids) and species susceptible mainly to chronic oil pollution (i.e. storm petrels), they provide a suitable location for measurement of the effects of both sorts of contamination.

Those species which do not normally show large fluctuations in numbers over a short period of time, particularly storm petrels, also allow measurement of the effects of low levels of chronic oil pollution as reflected in their reproductive success. As reproductive success may fluctuate annually, more than one year of data is needed as a baseline. Also because river otter predation on Fish Island is resulting in high mortality of adult storm petrels, and low nesting success, further study is needed to determine the effects of this predation on the population. During the 1977 field work, emphasis will be placed on this aspect.

Since interspecific competition for nest sites could result in population changes, some possible competitions will be carefully studied in 1977. Leach's Storm Petrels and Fork-tailed Storm Petrels may compete for burrow sites and this relationship will be evaluated in 1977. Nest site utilization of the four species of alcids (Pigeon Guillemots, Parakeet Auklets, Tufted Puffins, and Horned Puffins) using similar habitats on Fish Island will be examined more closely in 1977. Little work has been done on nest site selection by seabirds, and especially for birds at the edge of their breeding range. Birds in such marginal areas would most likely show a fast reaction to any alteration of their habitats.

Further work is needed on South Island, since we could not adequately cover the seabirds there last field season. Further measurements of growth rates for all species, and estimates of reproductive success for those species not evaluated in 1976 are needed.

As the trans-Alaska oil pipeline is scheduled to begin operation this summer, and tanker traffic through the Gulf will also begin, this year may be the last opportunity to establish a baseline of information before the effects of oil pollution occur. Further study at Wooded Islands along with continuing work at Hinchinbrook Entrance, and Middleton Island will result in accurate coverage of seabird colonies most likely to be affected by oil development in the northeastern Gulf of Alaska.

Literature Cited

Ainley, D.G., S. Morrell, and T.J. Lewis. 1974. Patterns in the life histories of storm petrels on the Farallon Islands. Living Bird 13:295-312.

Campbell, R.W. 1975. Sea-birds breeding on the Canadian west coast. Can. Nat. Fed. Spec. Pub. 5:39-65.

Coulson, J.C. and E. White. 1960. The effect of age and density of breeding birds on the time of breeding of the kittiwake Rissa tridactyla. Ibis 102:71-86.

Gabrielson, I.A. and F.C. Lincoln. 1959. The birds of Alaska. Wildl. Mgmt. Inst., Wash. D.C. 922 pp.

Grant, P.R. and D.N. Nettleship. 1971. Nesting habitat selection by puffins (Fratercula arctica L.) in Iceland. Ornis Scand. 2:81-87.

Gross, W.A.O. 1935. The life history cycle of Leach's Petrel (Oceanodroma leucorhoa leucorhoa) on the outer sea islands in the Bay of Fundy. Auk 52(4):383-399.

Harris, M.P. 1969. The biology of storm petrels in the Galapagos Islands. Proc. Calif. Acad. Sci. 37:95-166.

Harris, S.W. 1974. Status, chronology, and ecology of nesting storm petrels in northwestern California. Condor 76:249-261.

Huntington, C.E. 1963. Population dynamics of Leach's Petrel Oceanodroma leucorhoa. Proc. Inter. Ornithol. Congr. 13:701-705.

Isleib, M.E. and B. Kessel. 1973. Birds of the North Gulf Coast-Prince William Sound region, Alaska. Univ. Alaska Biol. Pap. No. 14. 149 pp.

Nettleship, D.N. 1972. Breeding success of the Common Puffin (Fratercula arctica L.) on different habitats at Great Island, Newfoundland. Ecol. Monogr. 42(2):239-268.

_____. 1976. Census techniques for seabirds of arctic and eastern Canada. Can. Wildl. Serv. Occas. Pap. No. 25. 31 pp.

Rausch, R. 1958. The occurrrence and distribution of birds on Middleton Island, Alaska. Condor 60(3):227-242.

Sandegren, F.E. 1970. Breeding and maternal behavior of the Steller sea lion (Eumetopias jubata) in Alaska. M.S. Thesis, Univ. Alaska, Fairbanks. 138 pp.

Sowl, L.W. 1974. Seabirds--Alaska's most neglected resource. Trans. N. Am. Wildl. Nat. Resour. Conf. 39:117-126.

U.S. Department of Interior, Interagency Task Force. 1972. Final environmental impact statement, proposed Trans-Alaska Pipeline. Natl. Tech. Info. Serv., U.S. Dept. Comm., Wash. D. C. 6 vols.

_____, Bureau of Land Management. 1976. Final environmental impact statement, Northern Gulf of Alaska proposed oil and gas leasing. Alaska Outer Continental Shelf Office, Anchorage. 2380+ pp.

Van Tets, G.F. 1959. A comparative study of the reproductive behaviour and natural history of three sympatric species of cormorants, (*Phalacrocorax auritus*, *P. penicillatus* and *P. pelagicus*) at Mandarte Island, B. C. M.A. Thesis, Univ. Brit. Col., Vancouver. 86 pp.

Westerskov, K. 1950. Methods for determining the age of game bird eggs. J. Wildl. Manage. 14(1):56-57.

Wilbur, H.M. 1969. The breeding biology of Leach's Petrel, *Oceanodroma leucorhoa*. Auk 86:433-442.

Table 1. Estimated numbers of seabirds occurring in the Wooded Islands area based on 1972 and 1974 surveys by Isleib (pers. comm.) and this study in 1976.

Species	1972	1974	1976
Fork-tailed Storm Petrel	Est. many 100's of pairs	3,000 pairs	5,000+ birds
Leach's Storm Petrel			400+ birds
Pelagic Cormorant	72 nests	29 nests	250 birds for all cormorants
Double-crested Cormorant		6 nests	
Red-faced Cormorant		8 nests	
Glaucous-winged Gull	50 pairs	348 pairs	75 pairs 200 non-breeders
Black-legged Kittiwake	780 pairs	1,680 pairs	1,175 pairs
Common Murre	present	5 pairs	30 pairs
Parakeet Auklet	100+ pairs		25 birds
Pigeon Guillemot	500 pairs	31 pairs	47 pairs
Tufted Puffin	7,000 pairs	4,550-5,050 pairs	2,400 pairs
Horned Puffin	300 pairs	54-104 pairs	10 pairs
Rhinoceros Auklets	15+ pairs		2 birds
Ancient Murrelet	present	present	6 birds
Marbled Murrelet			12 birds

Table 2. Summer resident pelagic seabirds, shorebirds, and seaducks observed around Wooded Islands in 1976.

Fork-tailed Storm Petrel	Black Oystercatcher	Common Murre
Leach's Storm Petrel	Semipalmated Plover	Pigeon Guillemot
Double-crested Cormorant	Least Sandpiper	Marbled Murrelet*
Pelagic Cormorant	Wandering Tattler*	Ancient Murrelet*
Red-faced Cormorant	Glaucous-winged Gull	Parakeet Auklet
Harlequin Duck*	Herring Gull*	Rhinoceros Auklet*
White-winged Scoter*	Mew Gull*	Horned Puffin
Surf Scoter*	Black-legged Kittiwake	Tufted Puffin
Common Scoter*	Arctic Tern	

*Non-breeders

Table 3. Mammals observed in the Wooded Islands area, summer 1976.

Shrew sp.	Mink	Steller Sea Lion
Killer Whale	River Otter	Harbor Seal
Fin Whale	Sea Otter	Black-tailed Deer

Table 4. Summer resident terrestrial and non-marine birds observed in the Wooded Islands area, 1976.

Canada Goose	Common Raven	Blackpoll Warbler
Bald Eagle	Northwestern Crow	Wilson's Warbler
Peregrine Falcon	C.-b. Chickadee	Hoary Redpoll
Common Snipe	Brown Creeper	Common Redpoll
Rufous Hummingbird	Varied Thrush	Savannah Sparrow
Violet-green Swallow	Hermit Thrush	Fox Sparrow
Tree Swallow	Ruby-crowned Kinglet	Song Sparrow
Bank Swallow	Water Pipit	
Black-billed Magpie	Yellow Warbler	

Table 5. Migrant birds observed in the Wooded Islands area from 12 May to 1 September 1976.

Arctic Loon	Common Merganser	Hudsonian Godwit
Red-necked Grebe	R.-b. Merganser	Whimbrel[5]
Sooty Shearwater	Sharp-shinned Hawk[2]	Northern Phalarope
Whistling Swan	Osprey[3]	Parasitic Jaeger
Black Brant[1]	Surfbird	Long-tailed Jaeger
White-fronted Goose	Black Turnstone	Bonaparte's Gull
Mallard	Western Sandpiper	Pine Grosbeak
Pintail	Baird's Sandpiper	White-crowned Sparrow
Green-winged Teal	Rock Sandpiper[4]	Golden-crowned Sparrow
Greater Scaup	Yellowlegs sp.	
King Eider	Spotted Sandpiper	

[1]Last observed on 23 May

[2]Five on 31 August, Wooded Island

[3]One in mid-May, Jeanie Lake

[4]Thirty-nine on 22 August and 64 on 23 August at Fish Island

[5]Twelve on 11 July, Tanker Island

Table 6. Nesting success of storm petrels on Fish Island in 1976. Plots A and B were disturbed by river otters before the study began; plot C was disturbed by otters after study began. All values are expressed as percentages.

	Plot			Mean[3]
	AA	B	C	
Inactive burrows	40 (24)[2]	24 (15)	37 (11)	19 (134)
Active burrows	60	86	63	81
Active with eggs	85	54	77	69
Eggs destroyed/otter	67	29	29	25
Eggs deserted	17	14	29	17
Eggs hatching	17	57	43	58
Chicks lost to otter	100	50	33	33
Chicks lost to other[1]	0	0	25	5
Young fledged/egg	0	29	14	31
Production lost/otter	83	57	43	48
Production lost/other	17	14	43	21

[1]Other causes include starvation, chick killed by adult, and unknown.

[2]Parentheses indicate the sample size, n.

[3]Mean for all burrows studied, inside and outside plots.

Table 7. Dead organisms found during beach surveys in the Wooded Islands area, summer 1976.

Patton Bay Beach	
26 May	1 shearwater; 1 sea otter pup
9 June	1 medium-sized duck; 3 shearwaters, 1 Green-winged Teal
20 June	2 Sooty Shearwaters
30 June	none
18 July	1 gull; 1 Northern Fulmar
29 July	1 gull; 1 skate (Rajidae)
10 August	1 Northern Fulmar; 1 sea otter pup
20 August	1 Black-legged Kittiwake; 1 Sooty Shearwater
30 August	none
Jeanie Beach	
8 June	1 goose
18 June	1 Steller sea lion yearling
29 July	1 Steller sea lion pup
Wooded Island	
26 May	1 Steller sea lion bull
13 June	1 toothed whale (*Ziphius*); 1 Steller sea lion cow
26 August	1 Steller sea lion bull
28 August	3 Black-legged Kittiwake immatures
Fish Island	
24 July	1 Glaucous-winged Gull immature

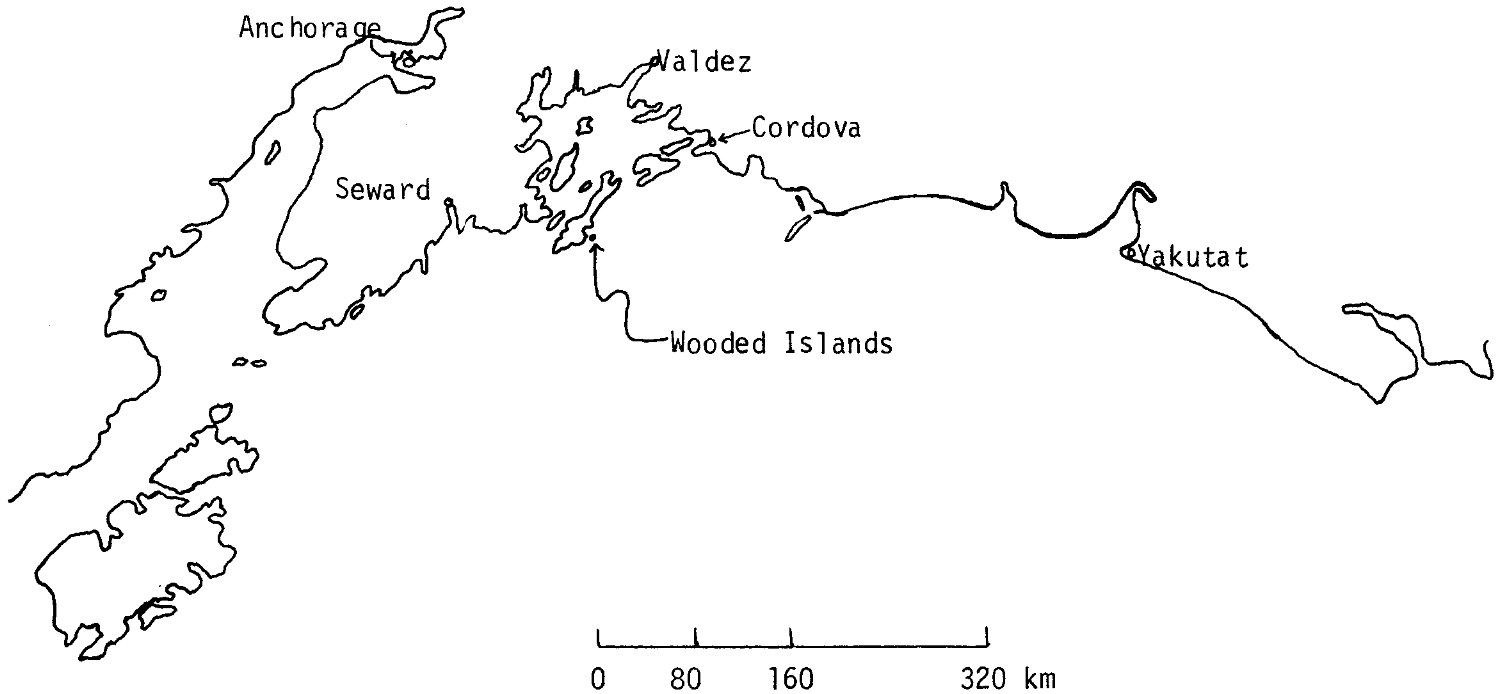


Fig. 1. Location of the Wooded Islands in relation to other areas of the northern Gulf of Alaska.

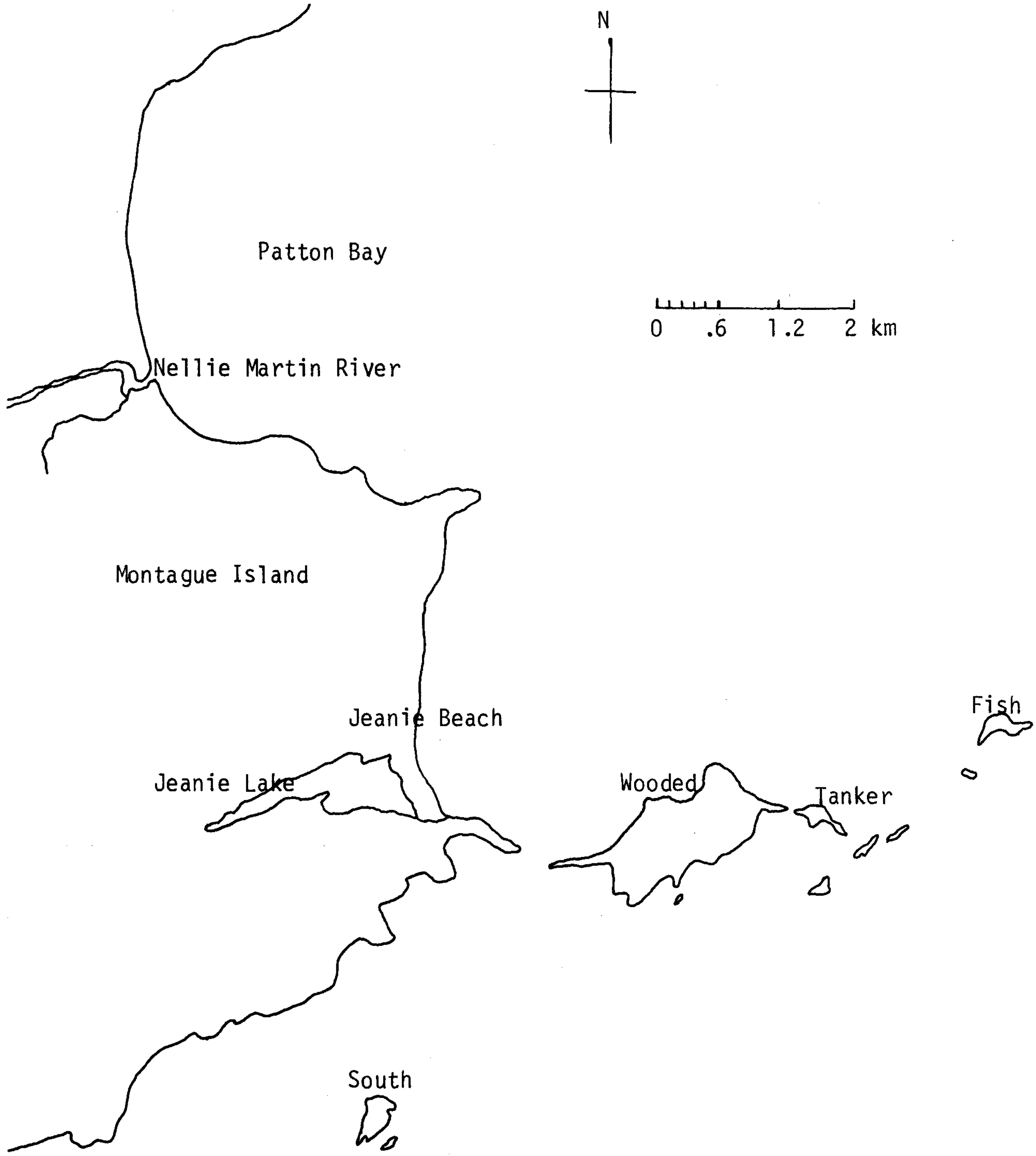


Fig. 2. Wooded Islands study area including parts of Montague Island and the surrounding waters.

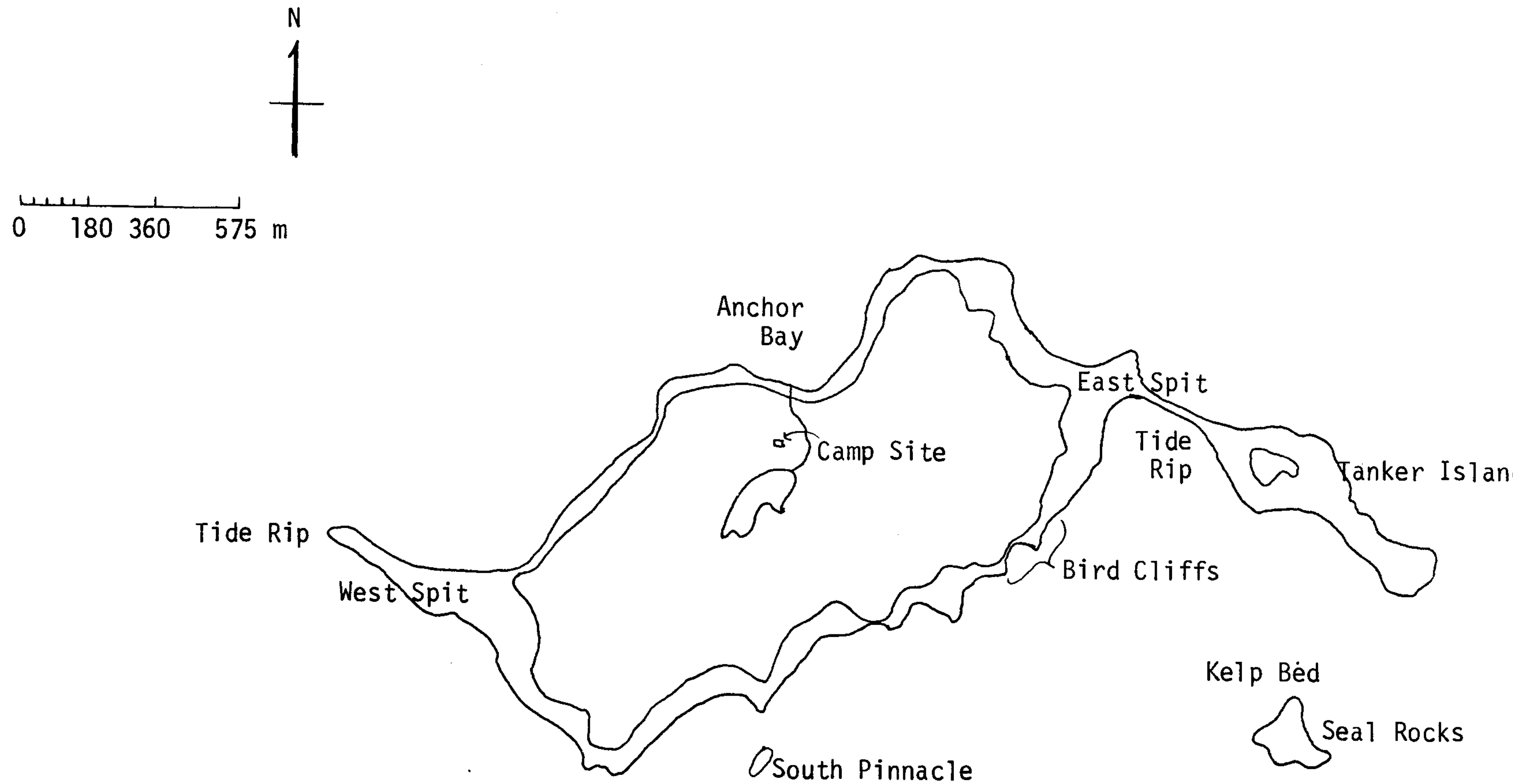


Fig. 3. Wooded and Tanker Islands showing location names, tide rips, and kelp beds.

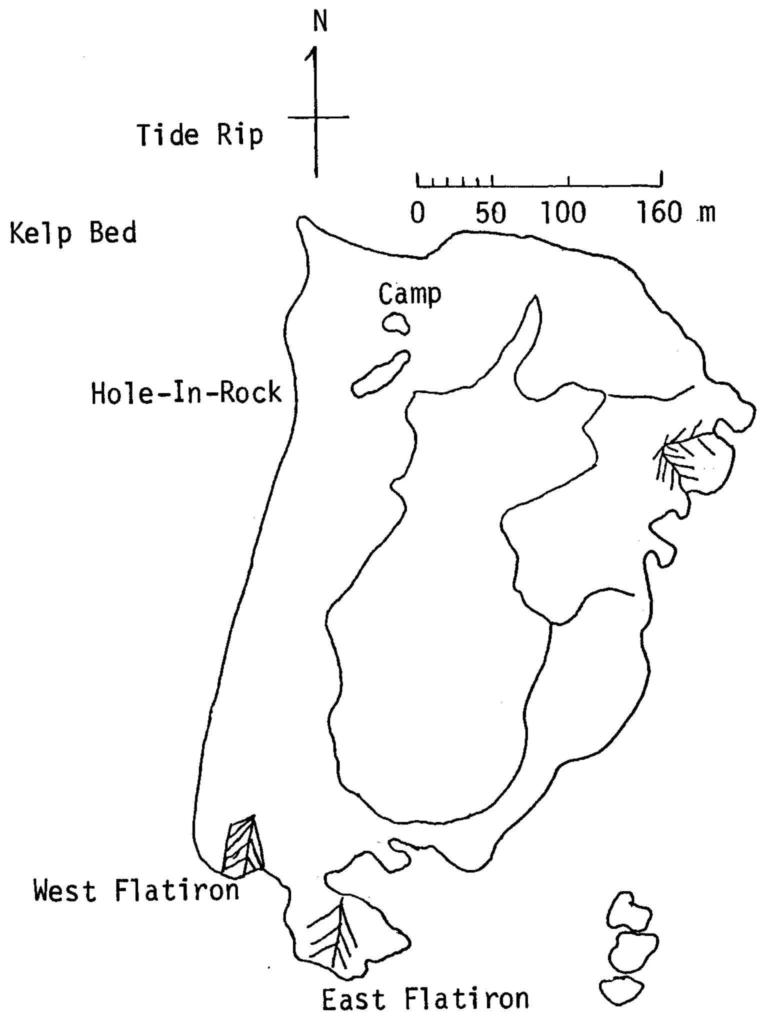


Fig. 4. South Island showing location names, tide rip, and kelp bed.

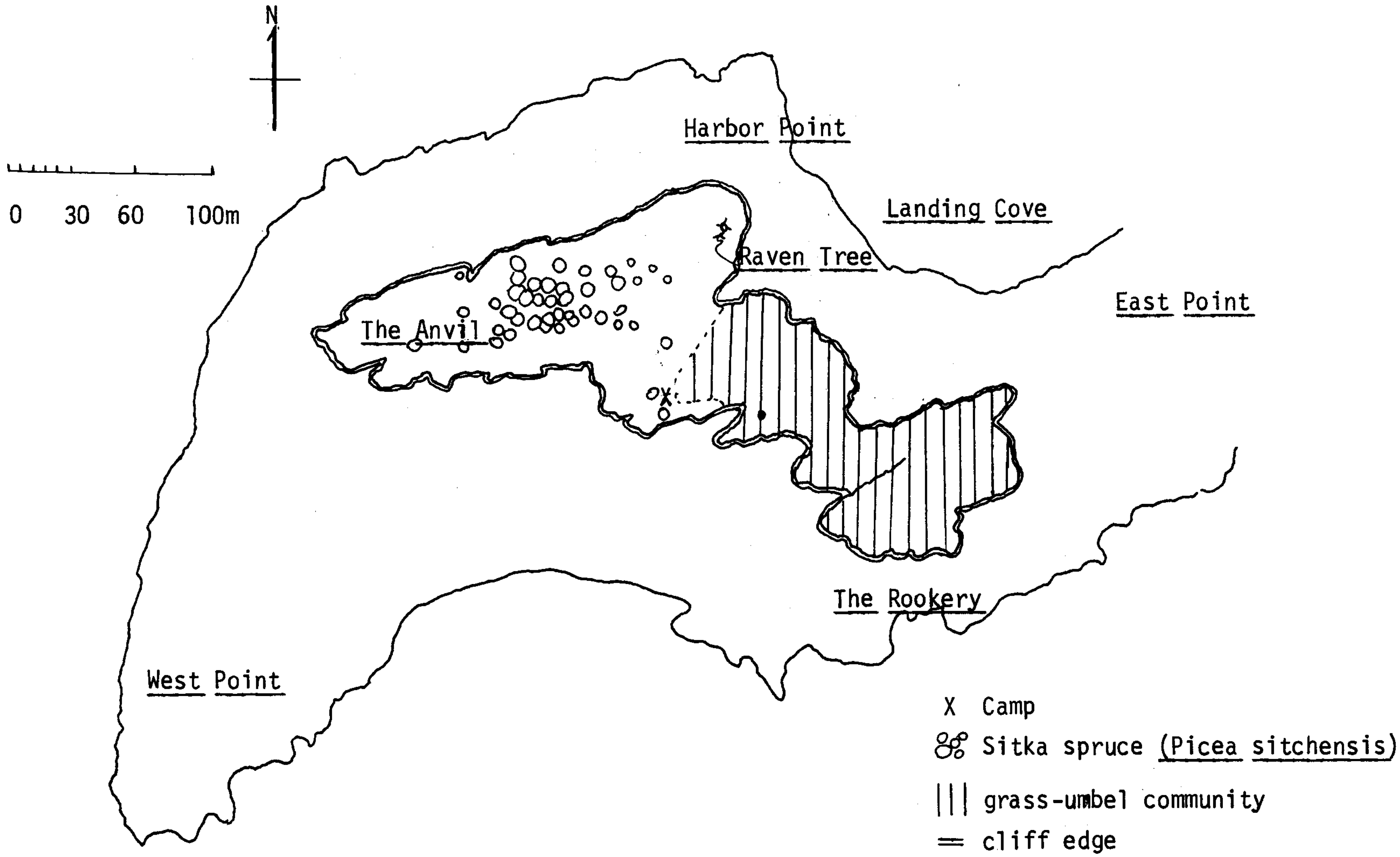


Fig. 5. Fish Island showing location names, general topography, and vegetation.

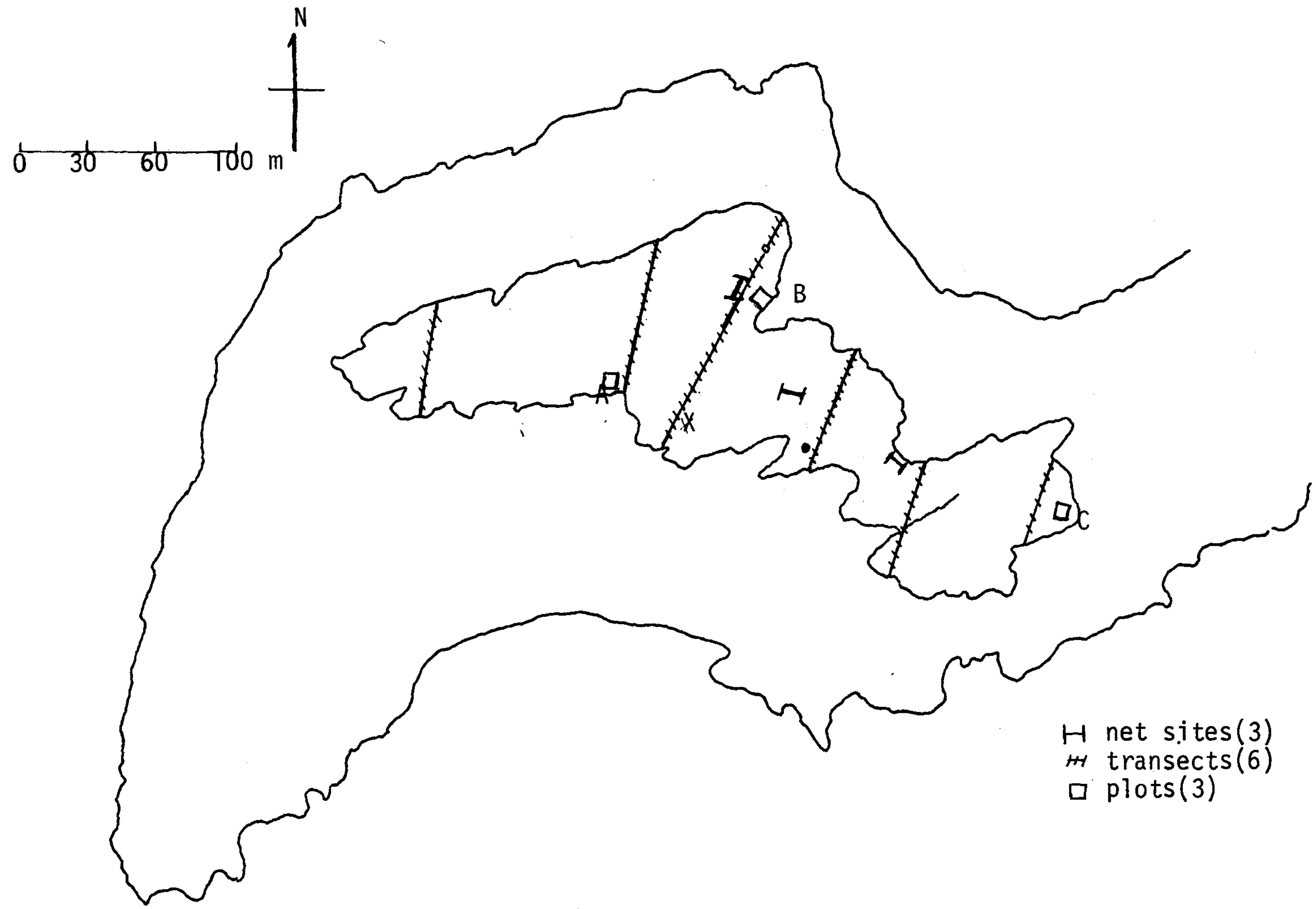
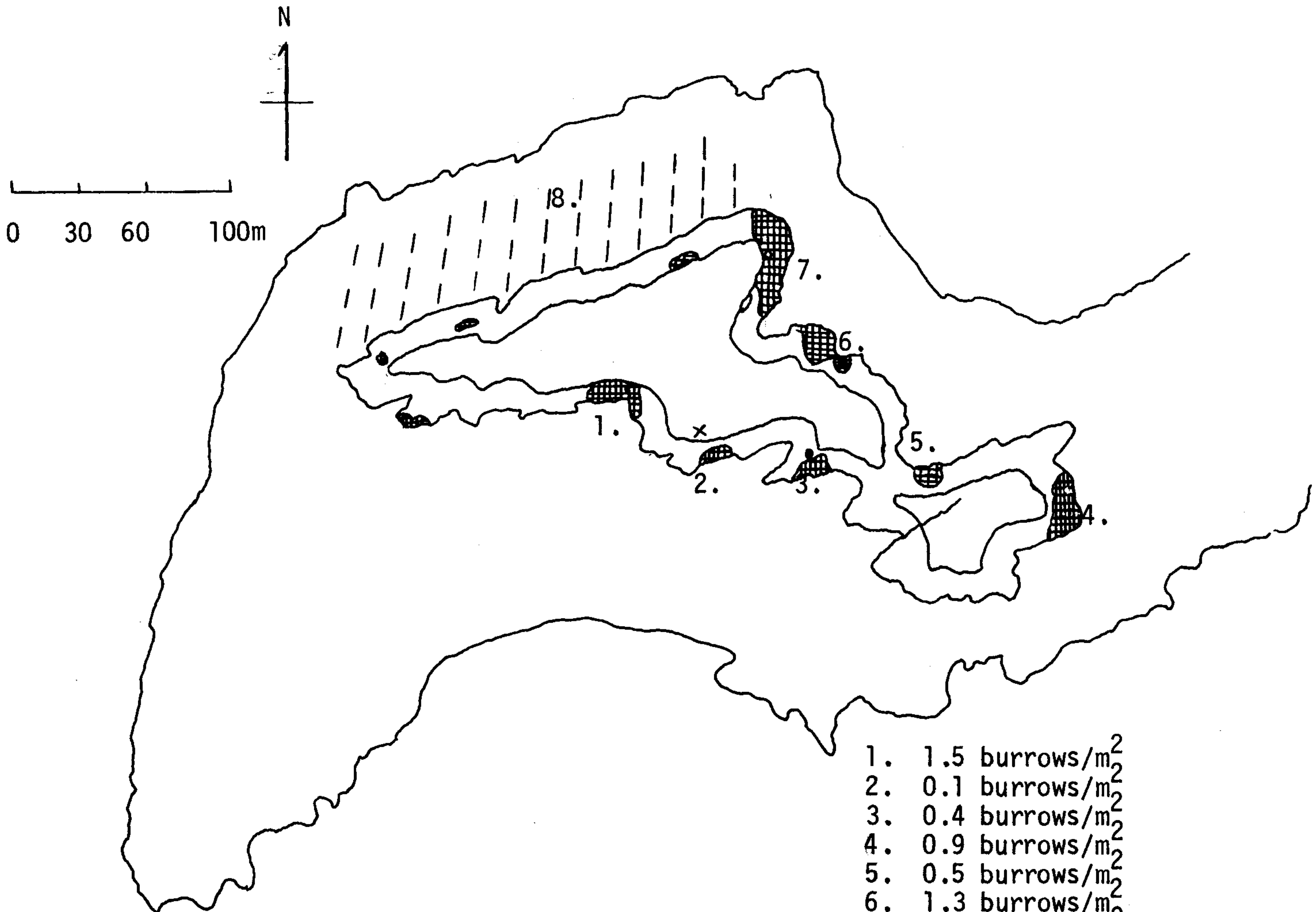


Fig. 6. Fish Island showing storm petrel transects, plots, and net sites.



1. 1.5 burrows/m^2
2. 0.1 burrows/m^2
3. 0.4 burrows/m^2
4. 0.9 burrows/m^2
5. 0.5 burrows/m^2
6. 1.3 burrows/m^2
7. 0.9 burrows/m^2
8. Rocky slope area used by petrels

Figure. 7. Fish Island showing the location of petrel sub-colonies.(hatched areas), suitable petrel habitat based on 1976 data,(periphery of island plateau), and area utilized by storm petrels on lower Fish Island. For those subcolonies where an estimate of nesting density was obtained, the estimate is indicated.

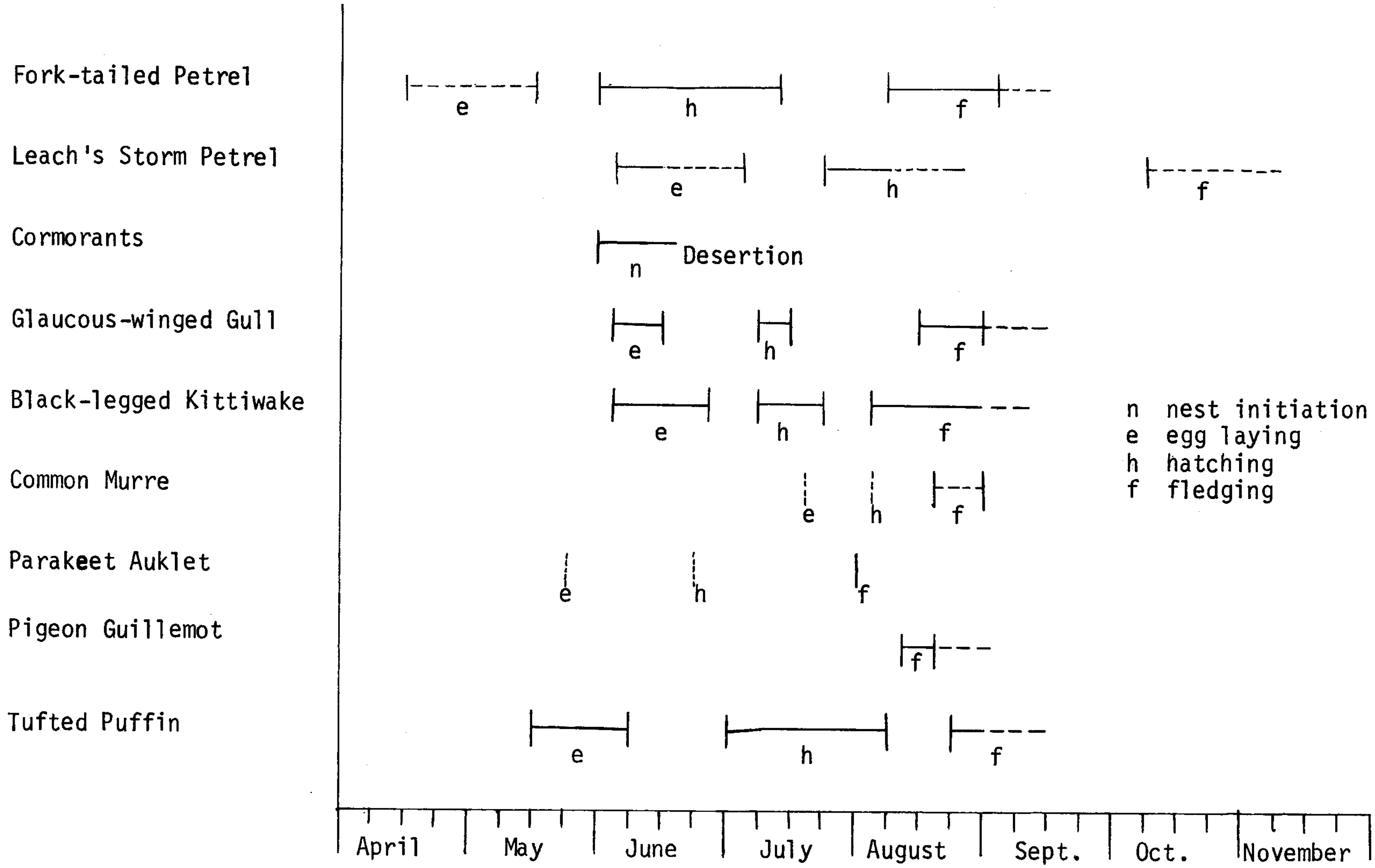


Fig. 8. Solid lines are observed stages of phenology during 1976. Dashed lines are estimated phenological events using the available literature.

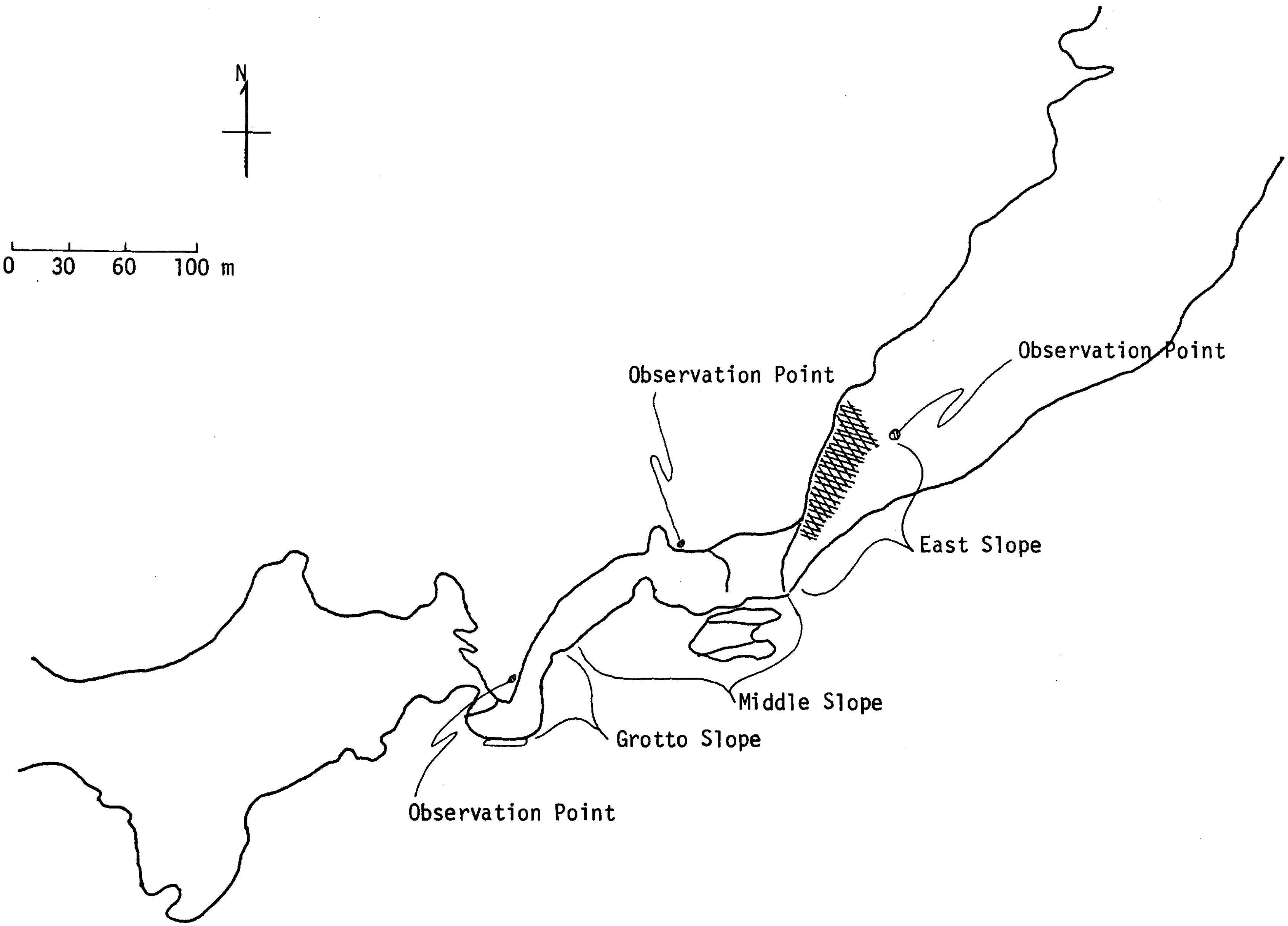


Fig. 9. Distribution of nesting attempts by cormorants on the Bird Cliffs of Wooded Island in 1976.

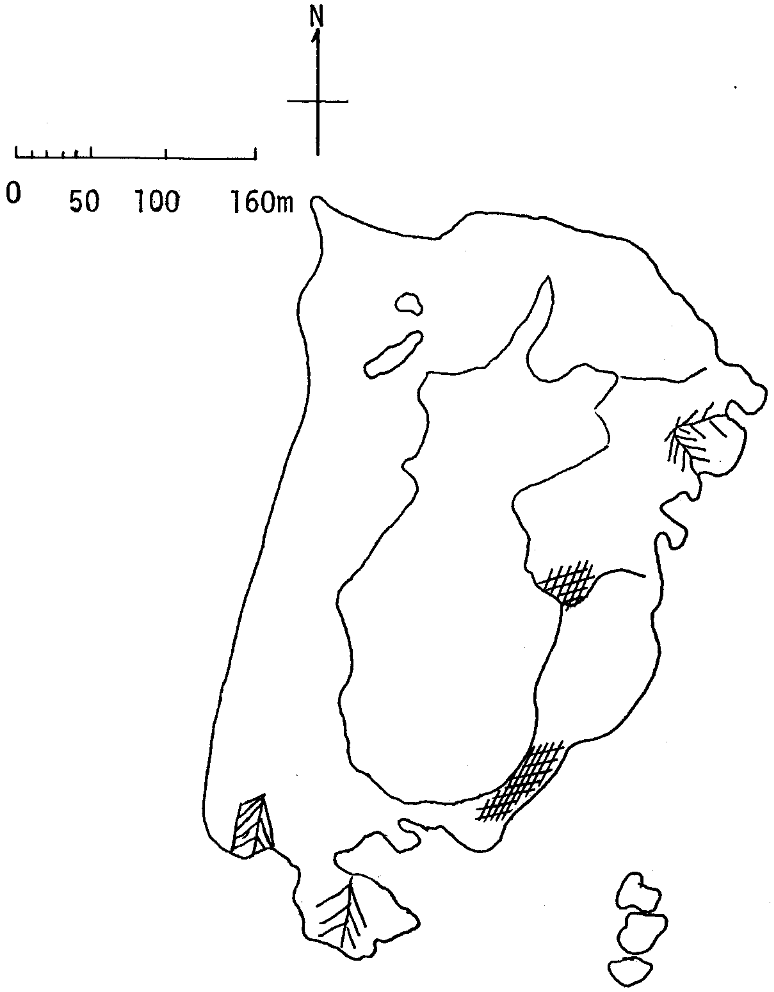


Fig. 10. Distribution of nesting attempts by cormorants on South Island in 1976.

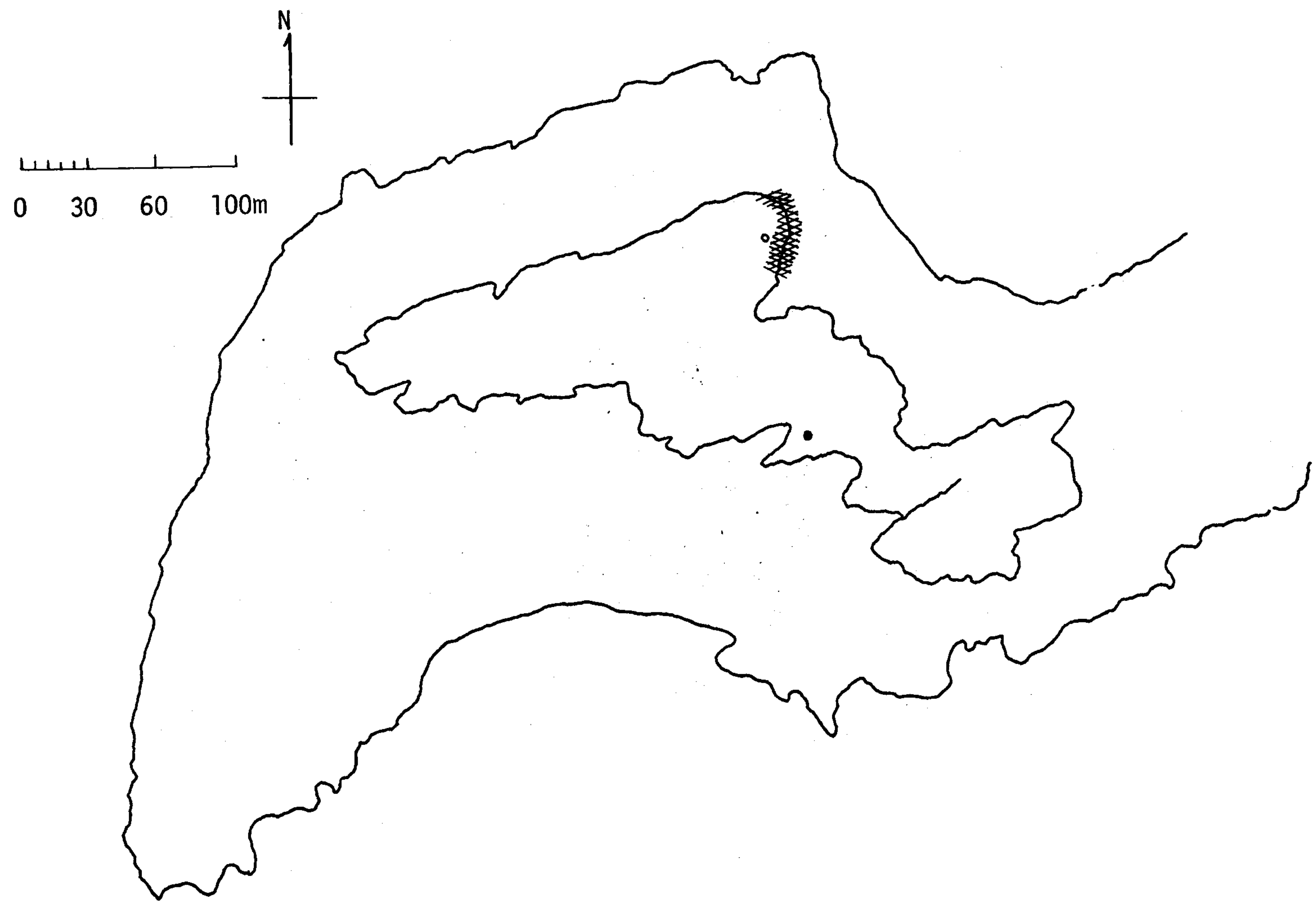


Fig. 11. Distribution of nesting attempts by cormorants on Fish Island, 1976.

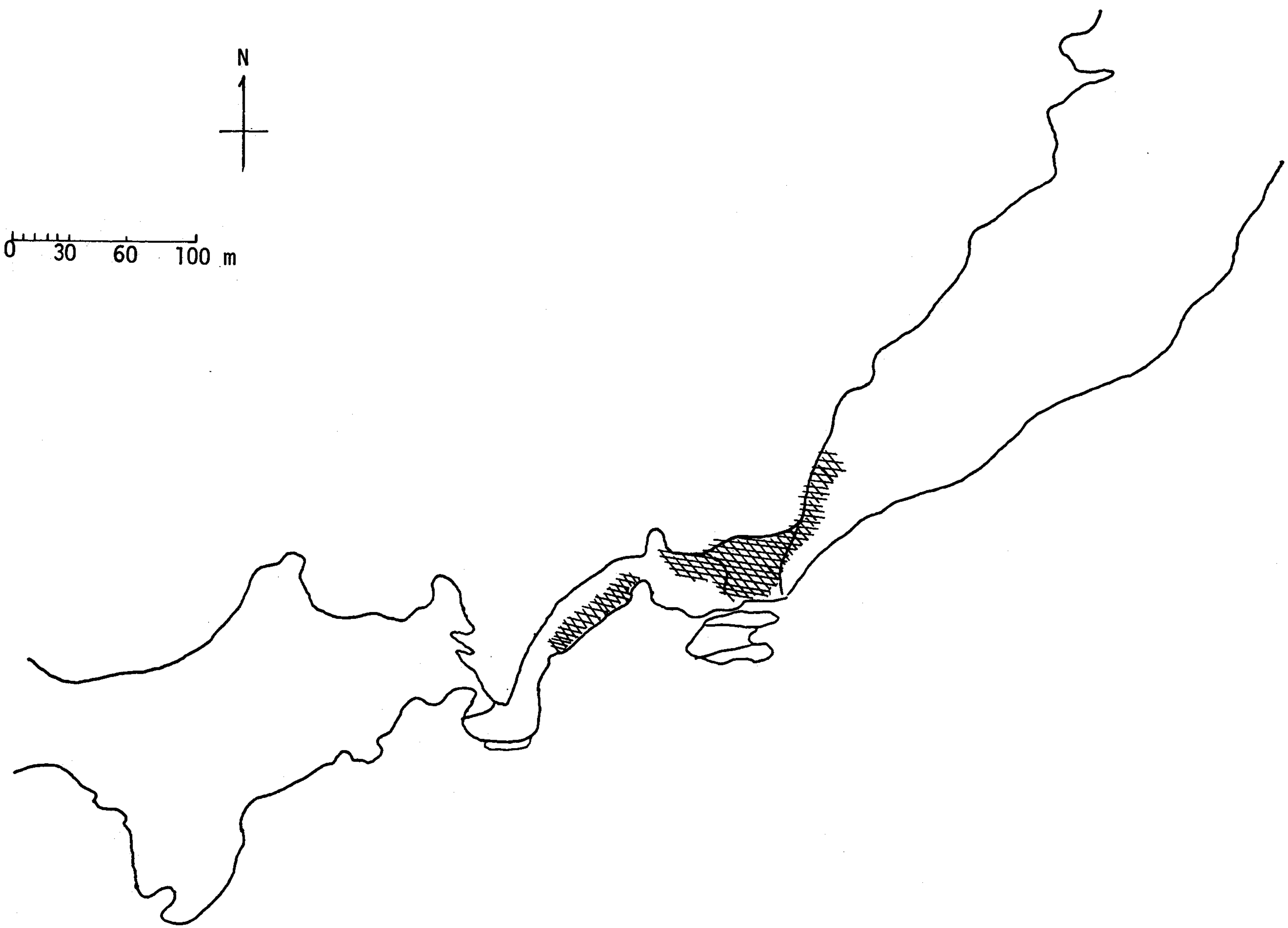


Fig. 12. Nesting distribution of Glaucous-winged Gulls on Bird Cliffs of Wooded Island in 1976.

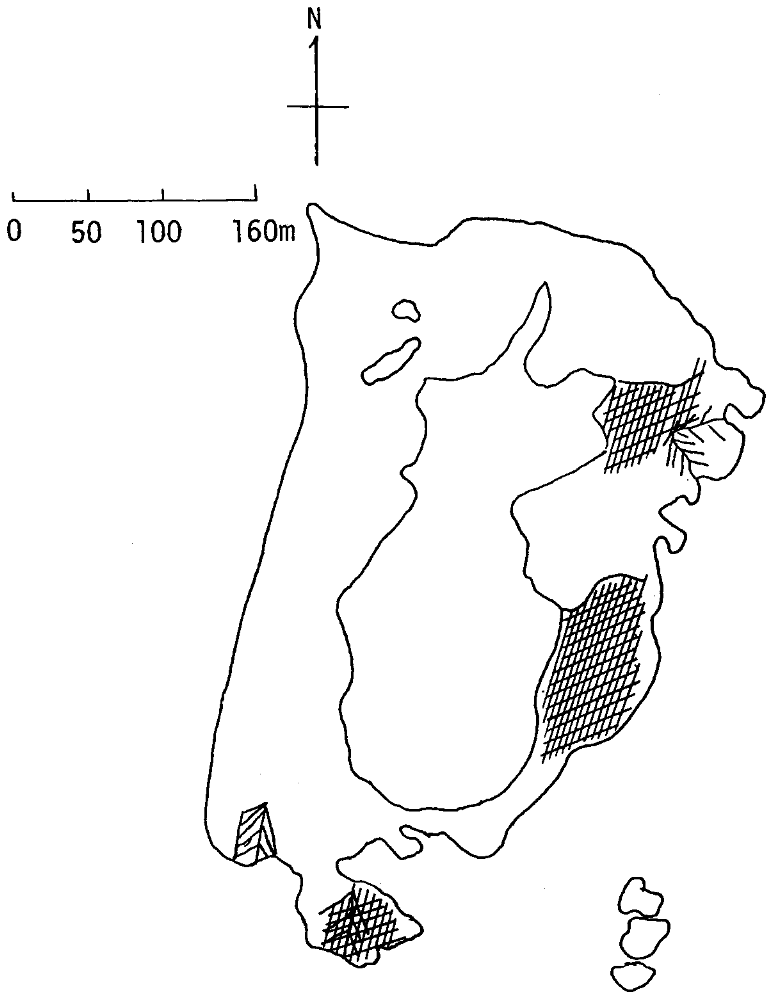


Fig. 13. Glaucous-winged Gull nesting distribution on South Island in 1976.

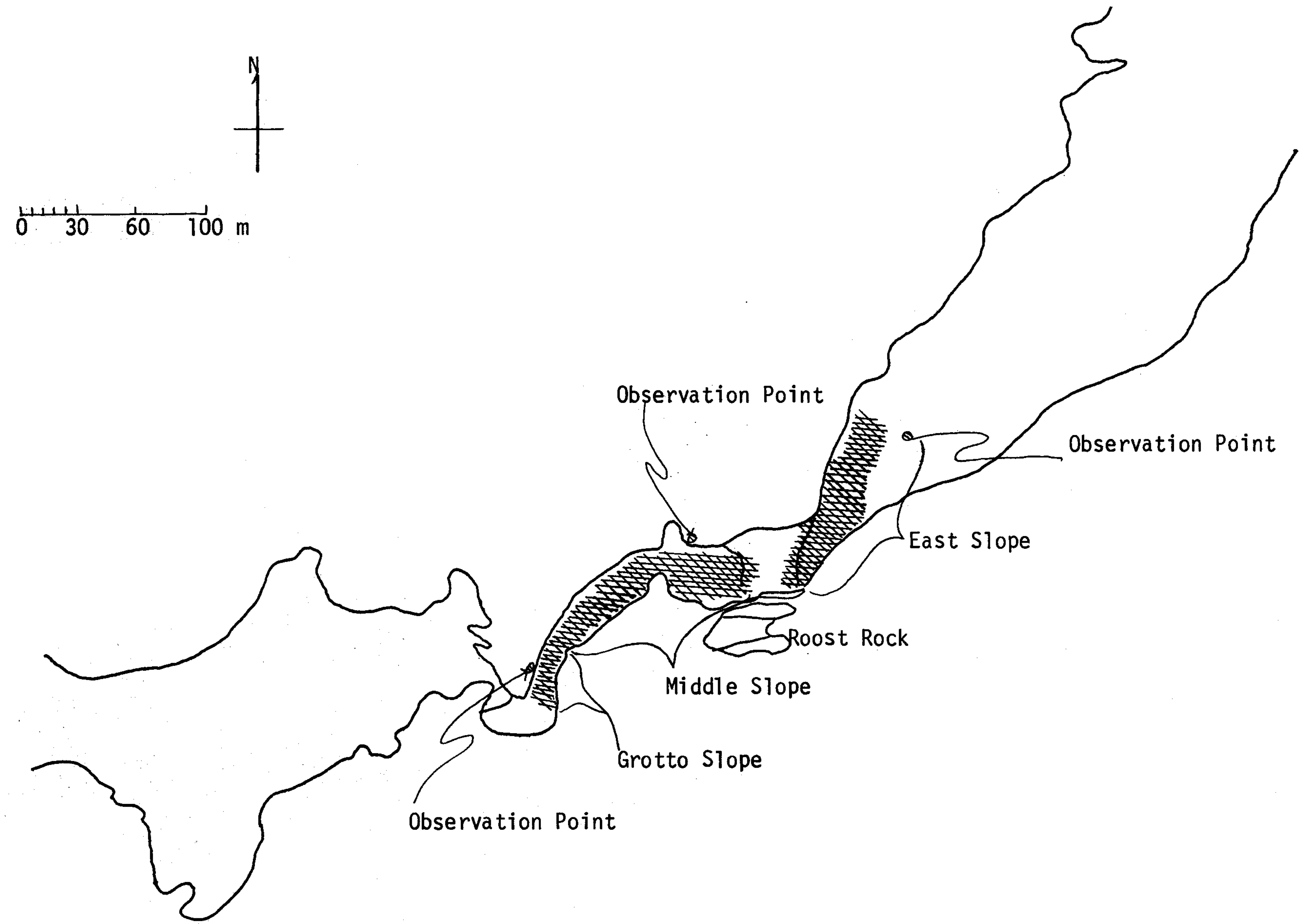


Fig. 14. Distribution of nesting areas of Black-legged Kittiwakes on the Bird Cliffs of Wooded Island in 1976.

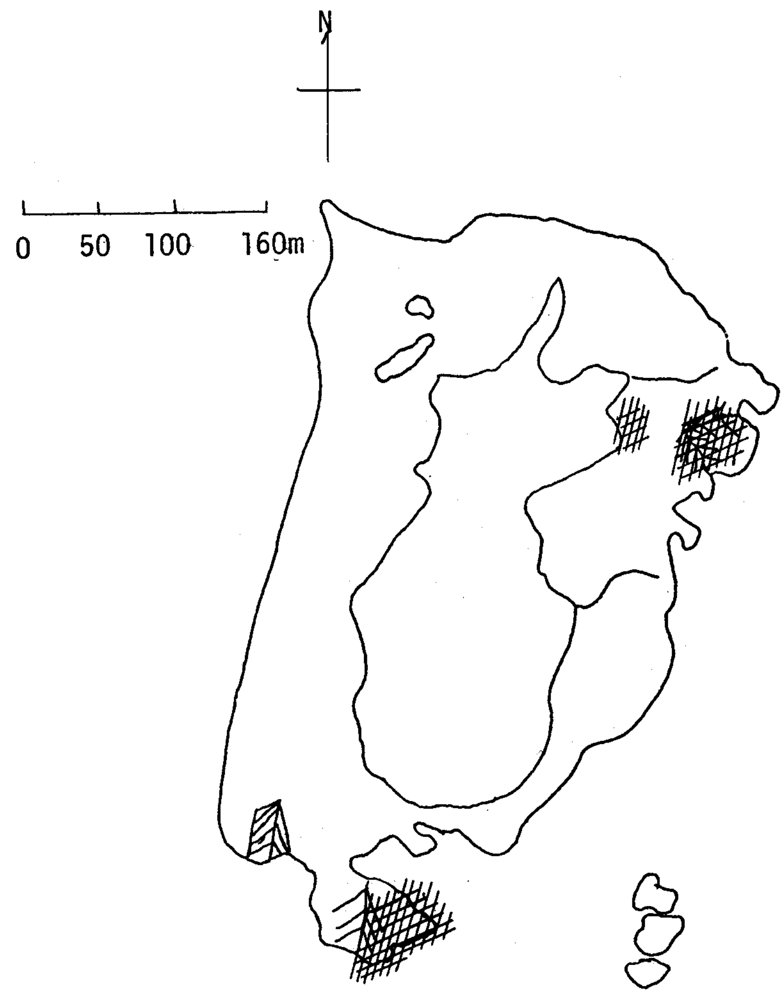


Fig. 15. Black-legged Kittiwake nesting areas on South Island in 1976.

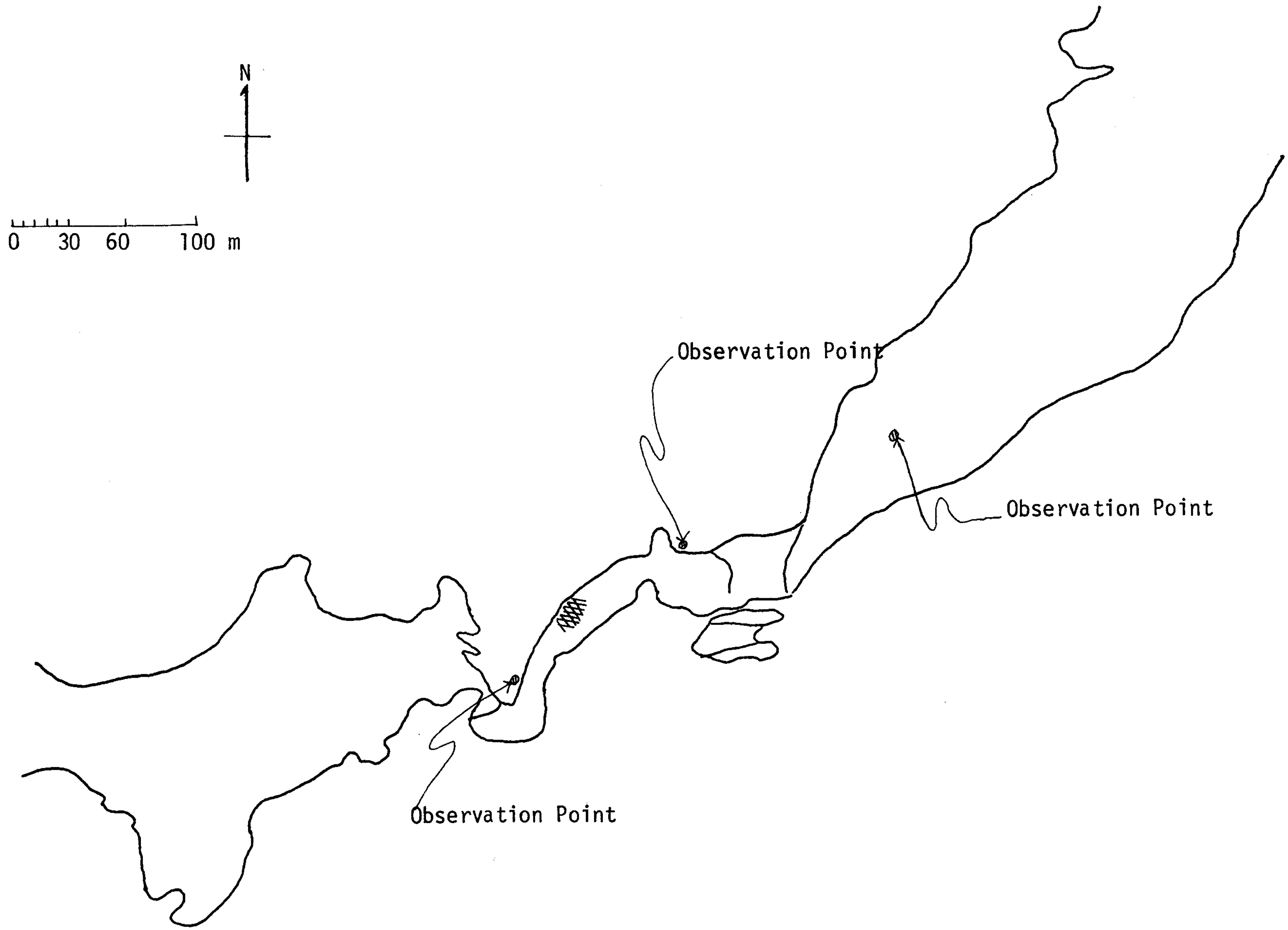


Fig. 16. Nesting area of Common Murres on the Bird Cliffs of Wooded Island in 1976.

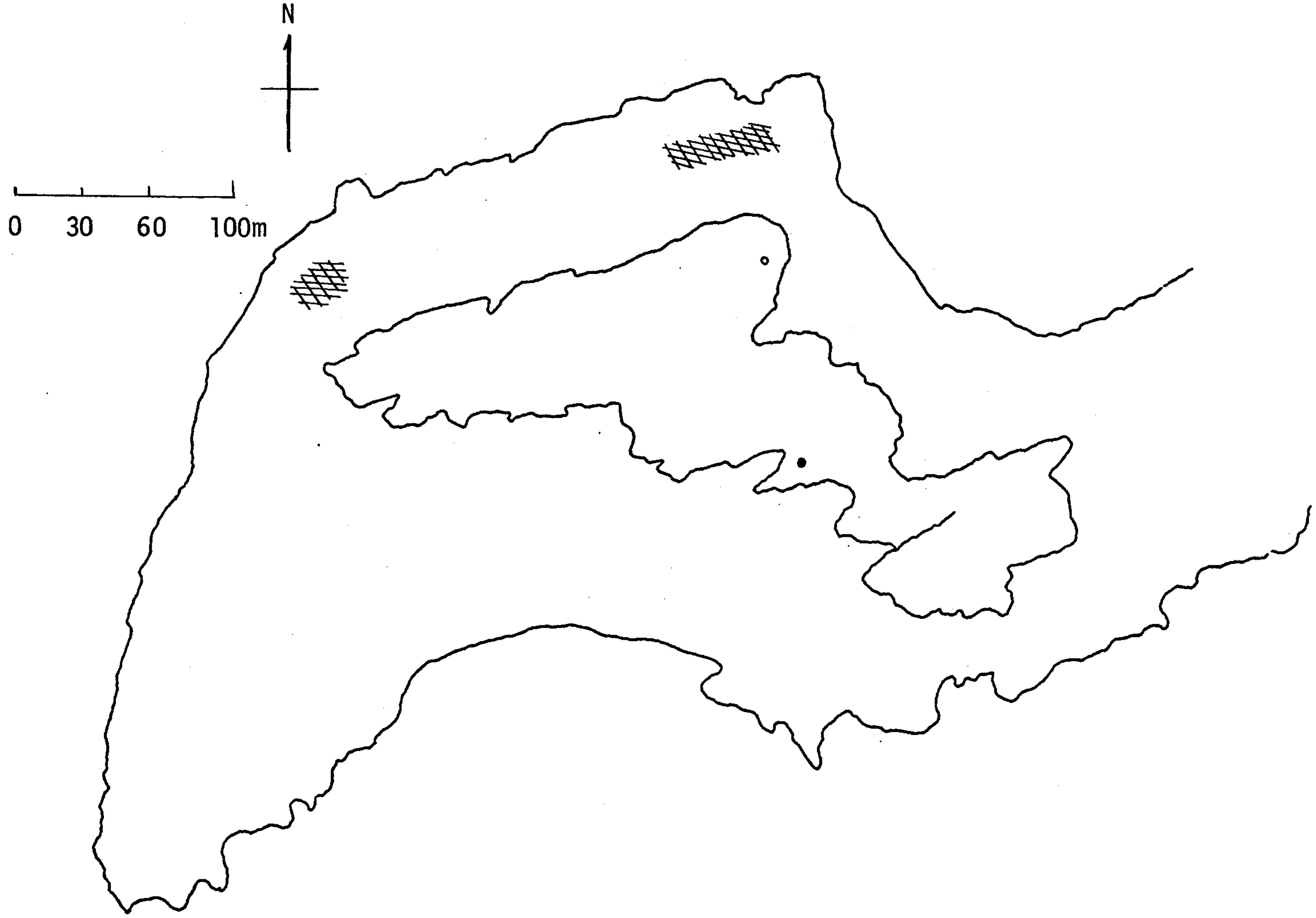


Fig. 17. Distribution of Parakeet Auklet nesting areas on Fish Island in 1976.

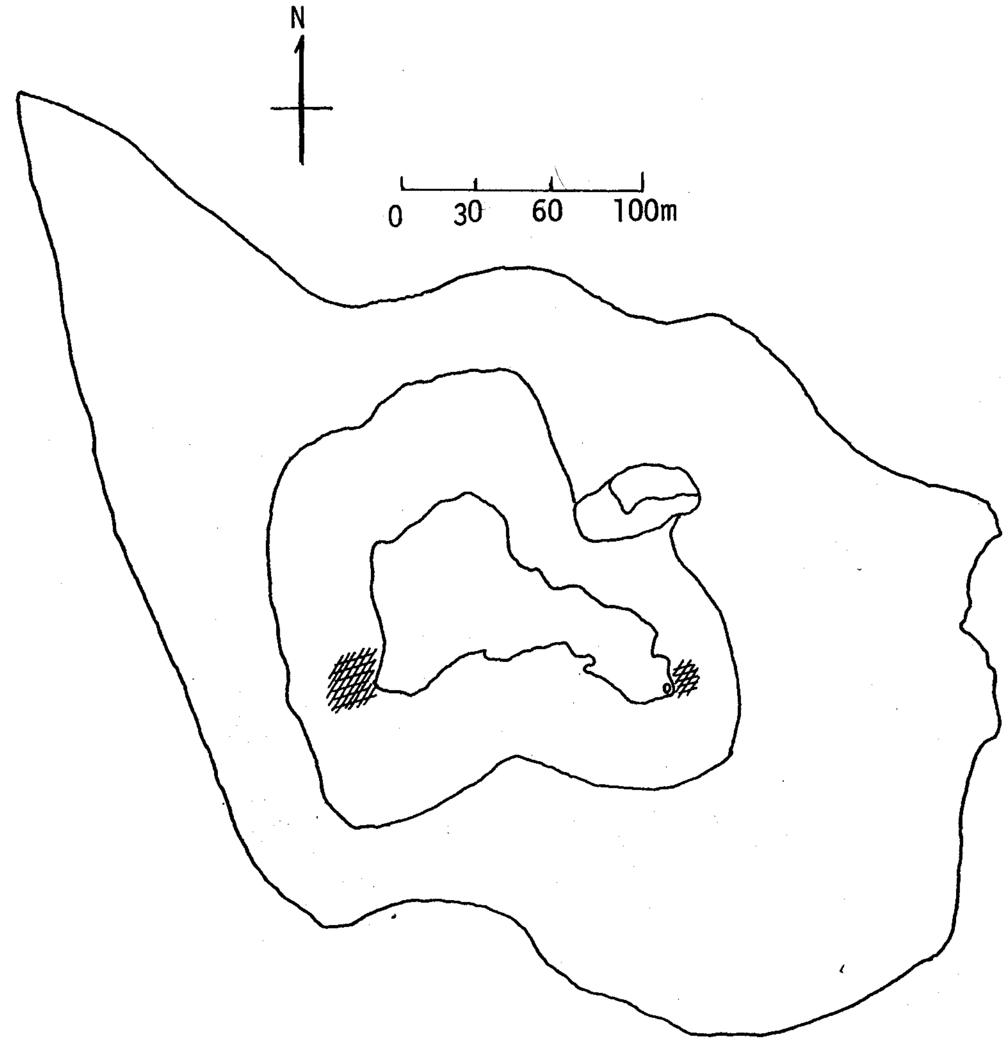


Fig. 18. Probable Pigeon Guillemot nesting areas on Tanker Island in 1976.

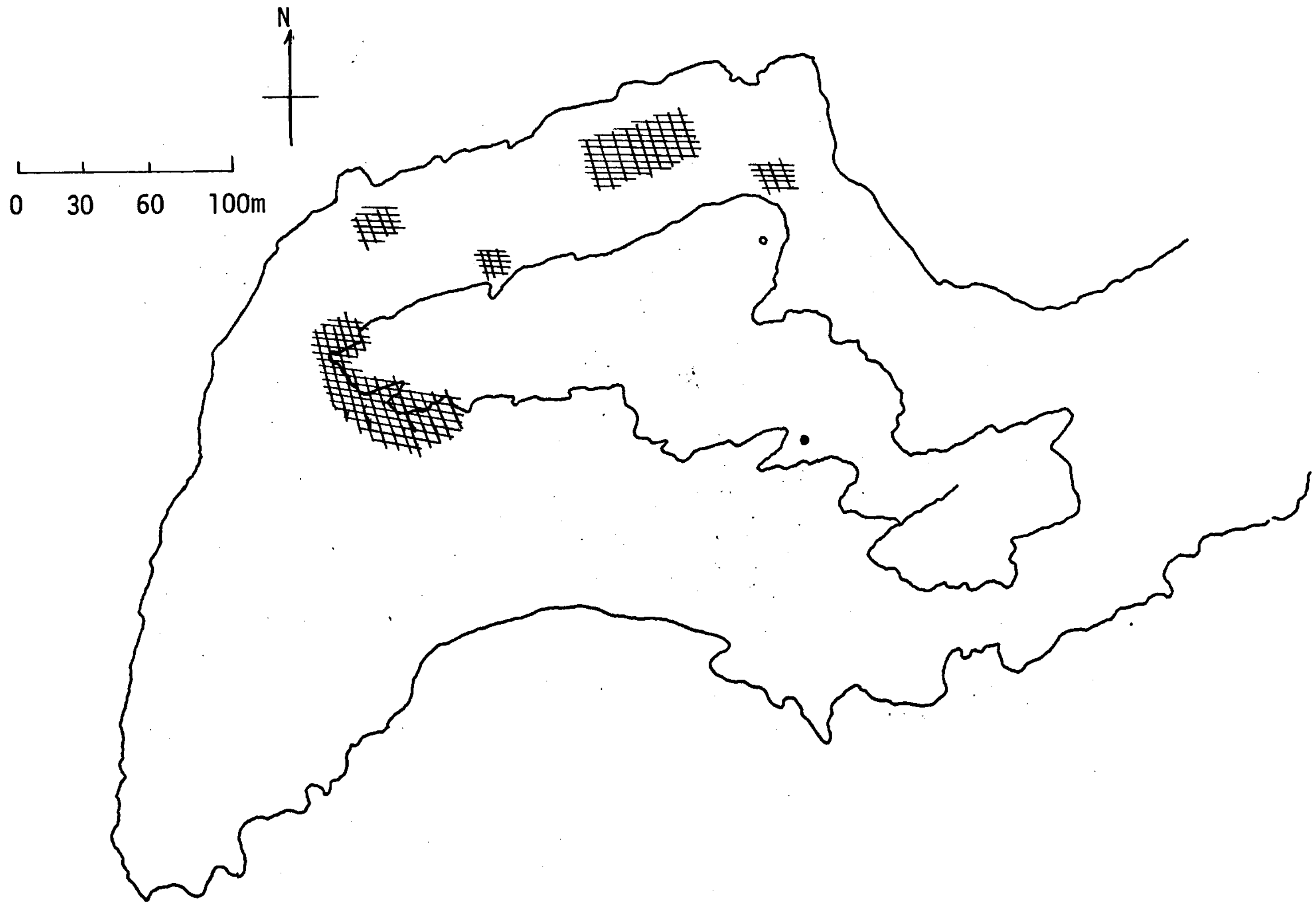


Fig. 19. Distribution of Pigeon Guillemot nesting areas on Fish Island in 1976.

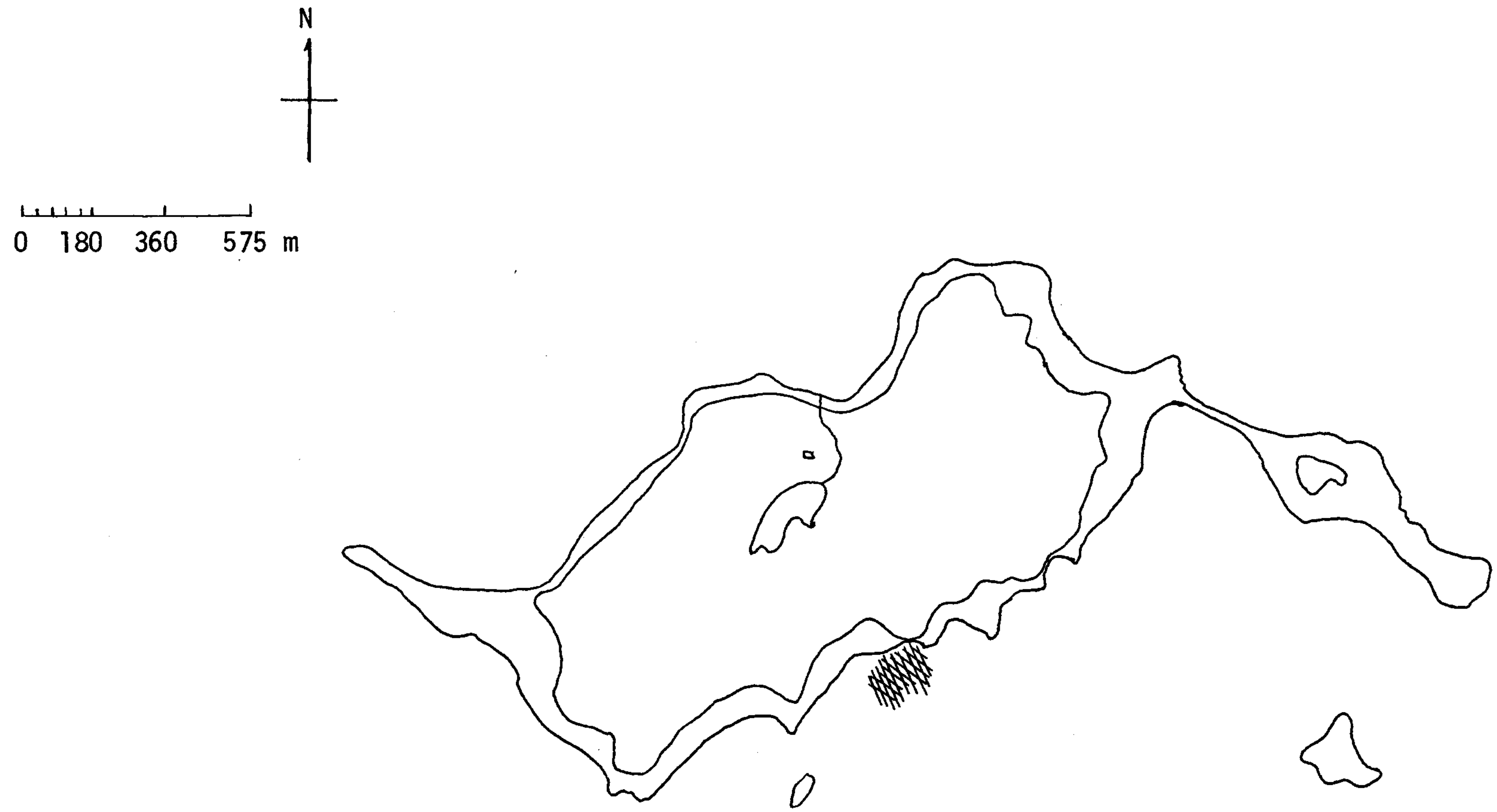


Fig. 20. Area in which Pigeon Guillemots were seen displaying off Wooded Island in 1976.

Fig. 22. Areas where Tufted Puffins normally rafted before flying to the islands.

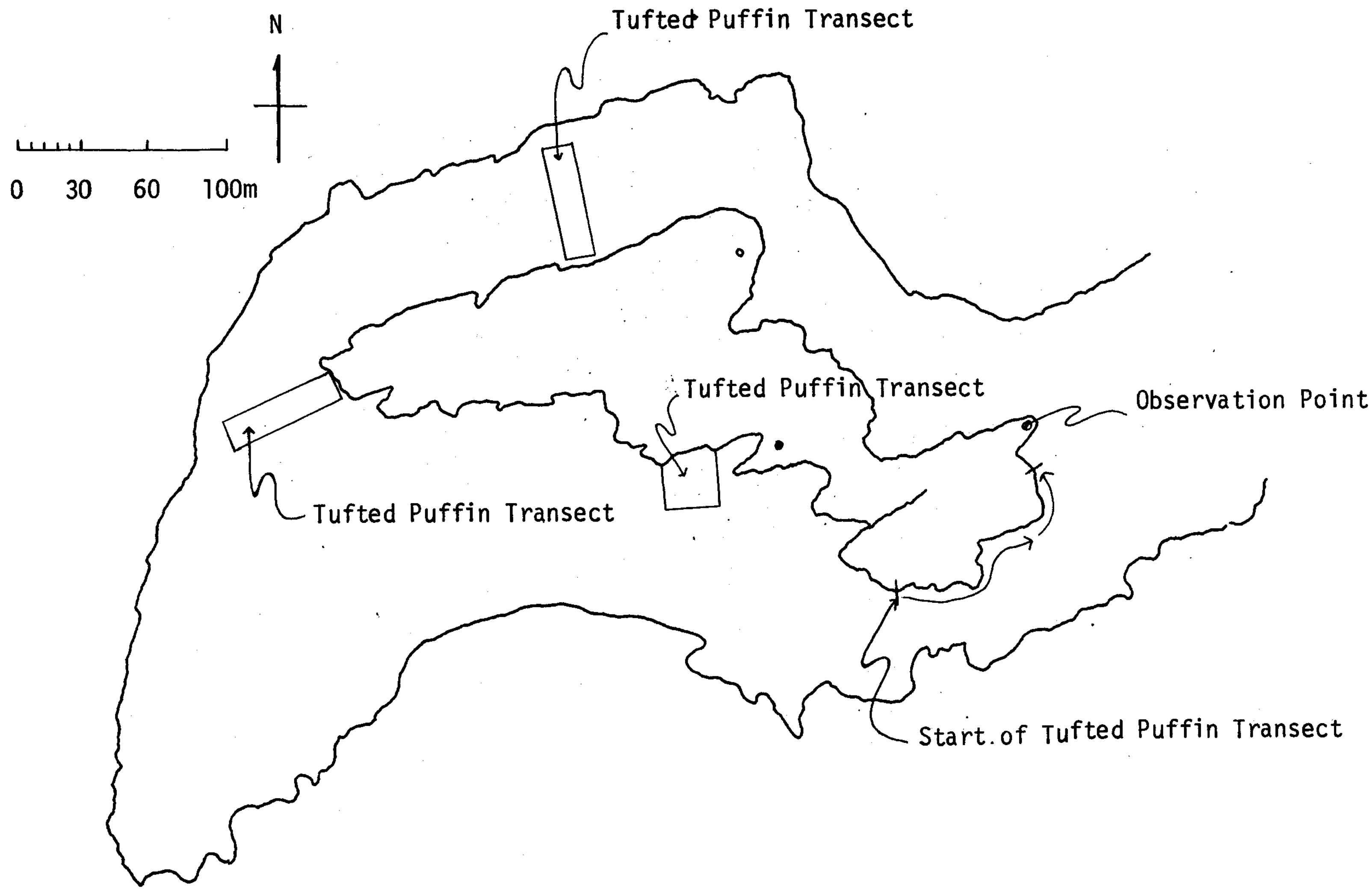


Fig. 23. Observation point and Tufted Puffin transects on Fish Island in 1976.

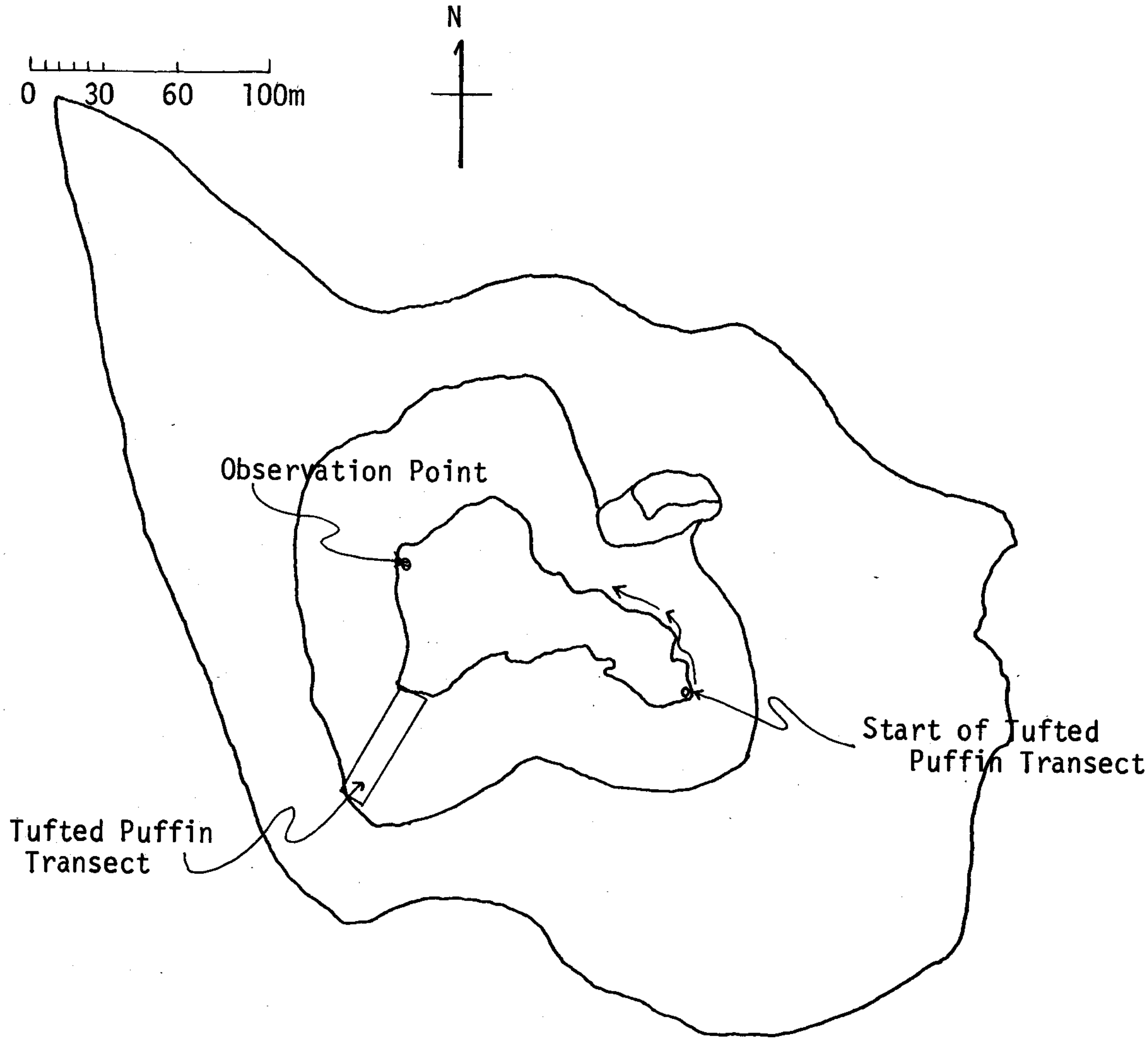


Fig. 24. Observation point and Tufted Puffin transects on Tanker Island in 1976.

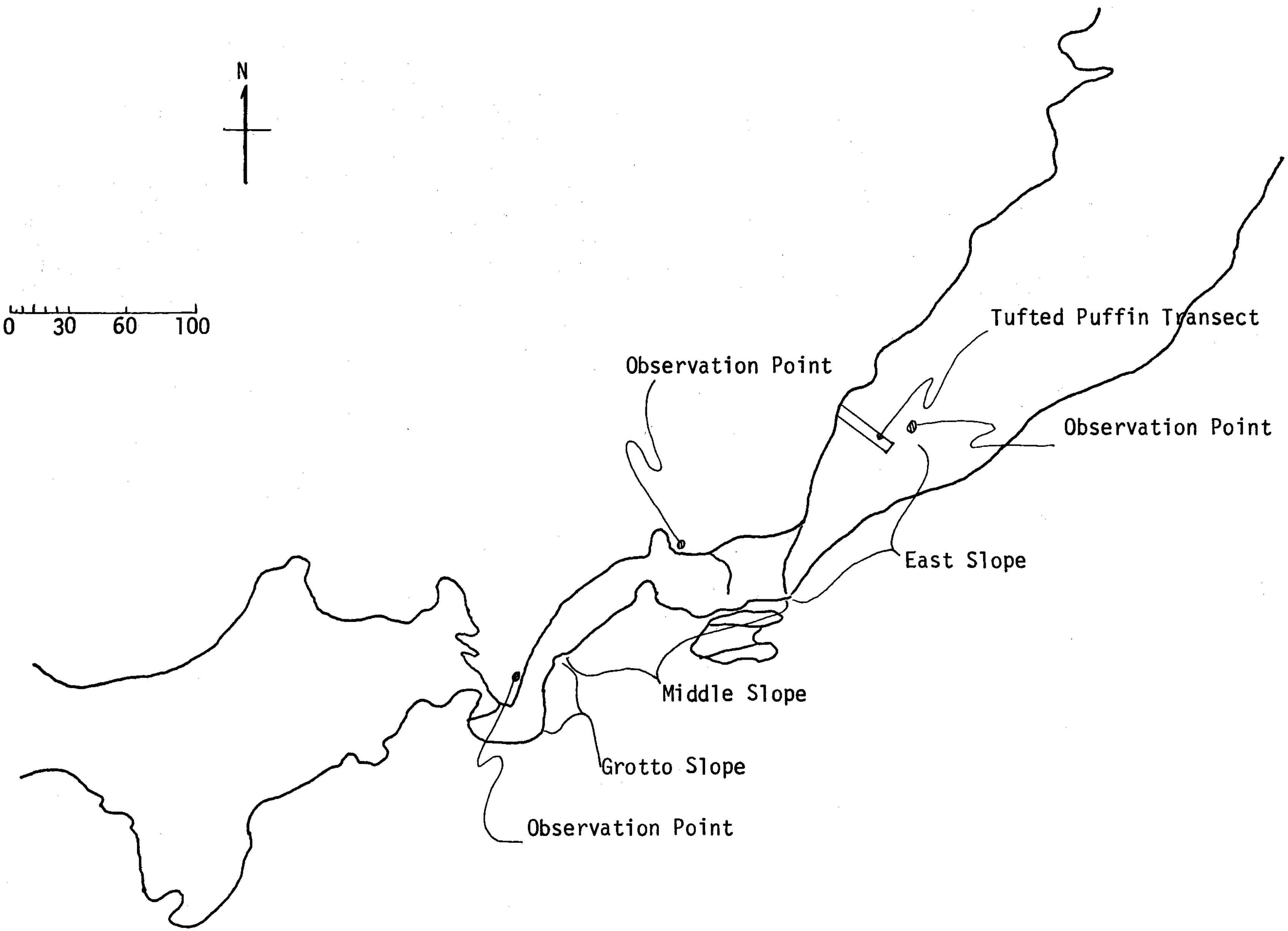


Fig. 25. Observation points and Tufted Puffin transect on the Bird Cliffs of Wooded Island in 1976.

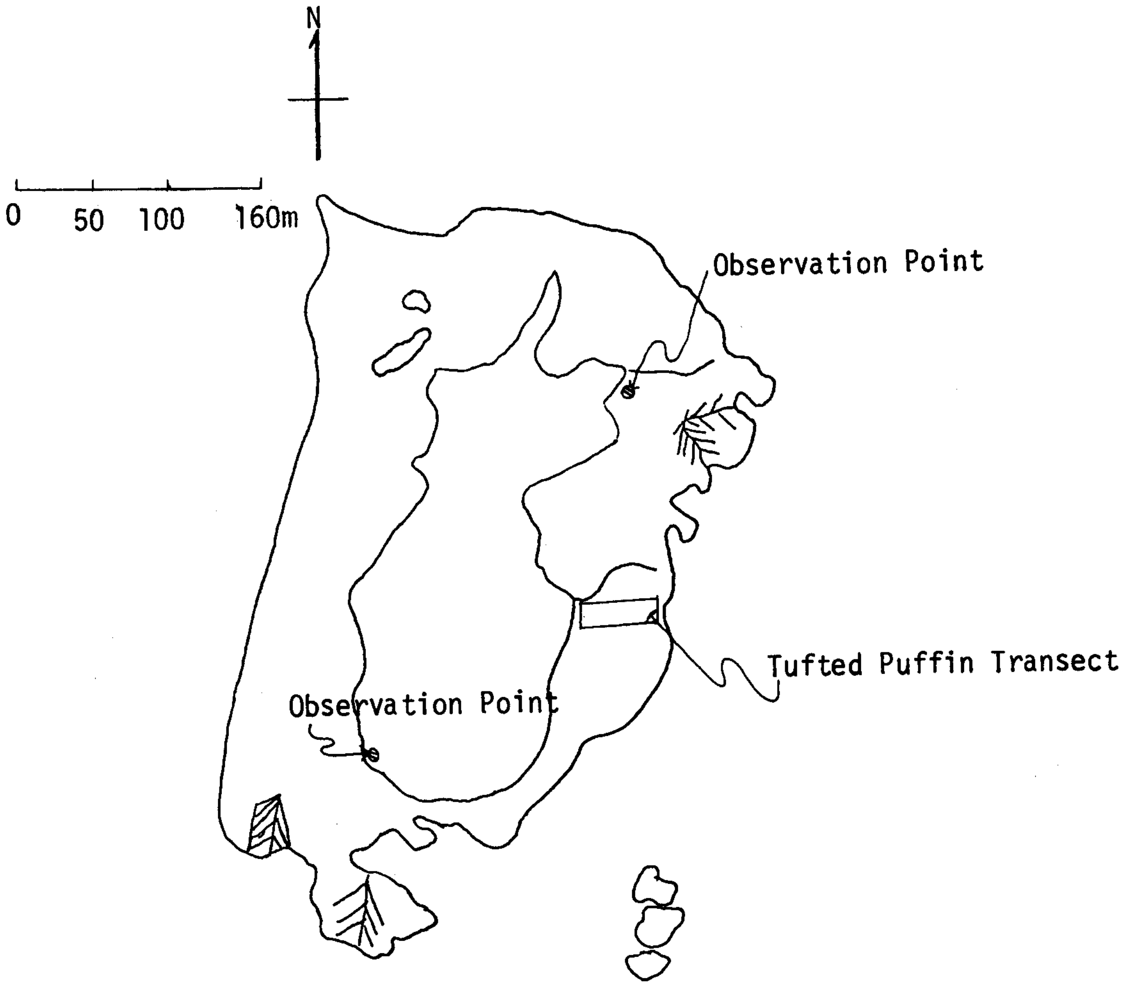


Fig. 26. Observation points and Tufted Puffin transect on South Island during 1976.

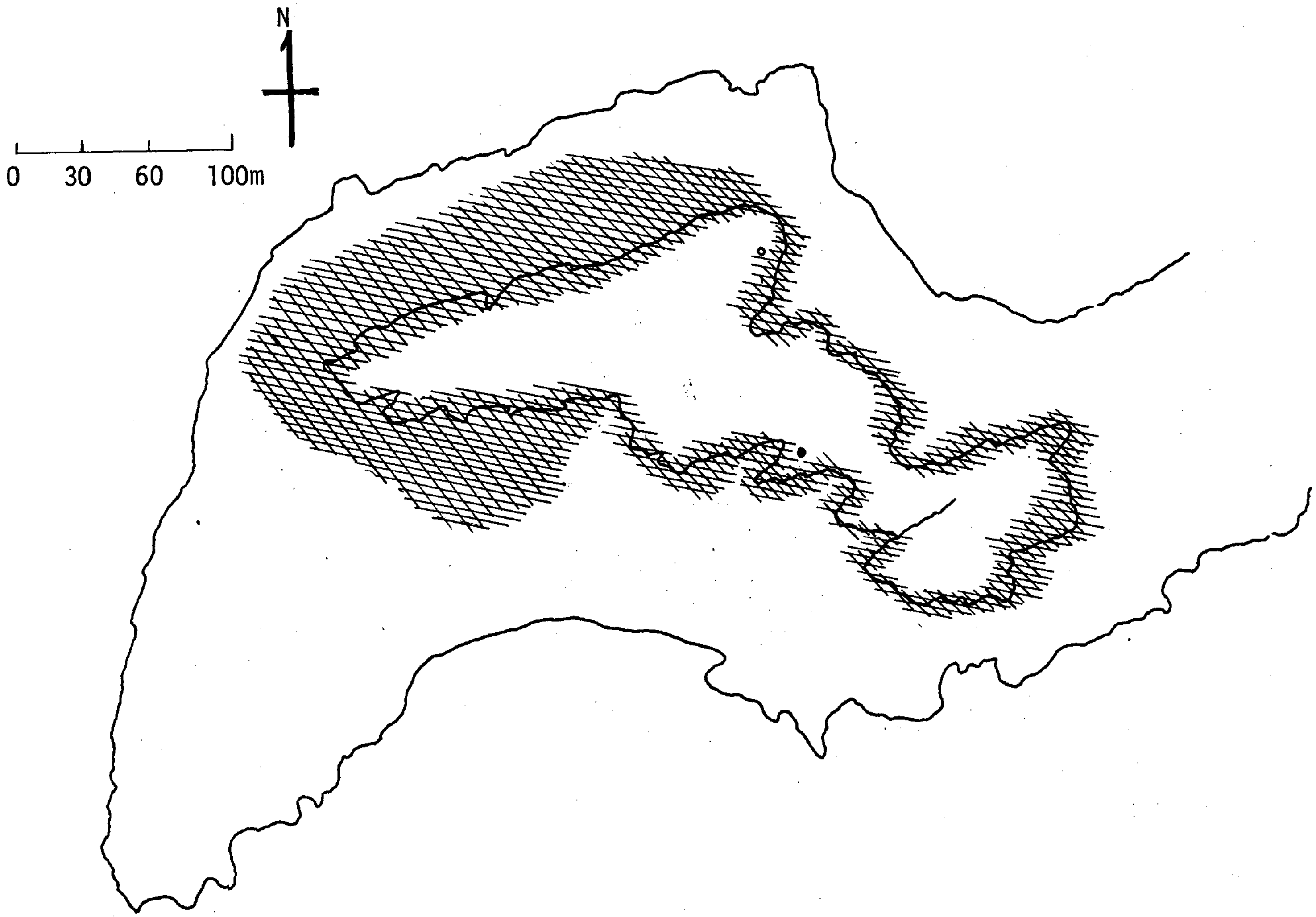


Fig. 27. Distribution of nesting areas of Tufted Puffins on Fish Island during 1976.

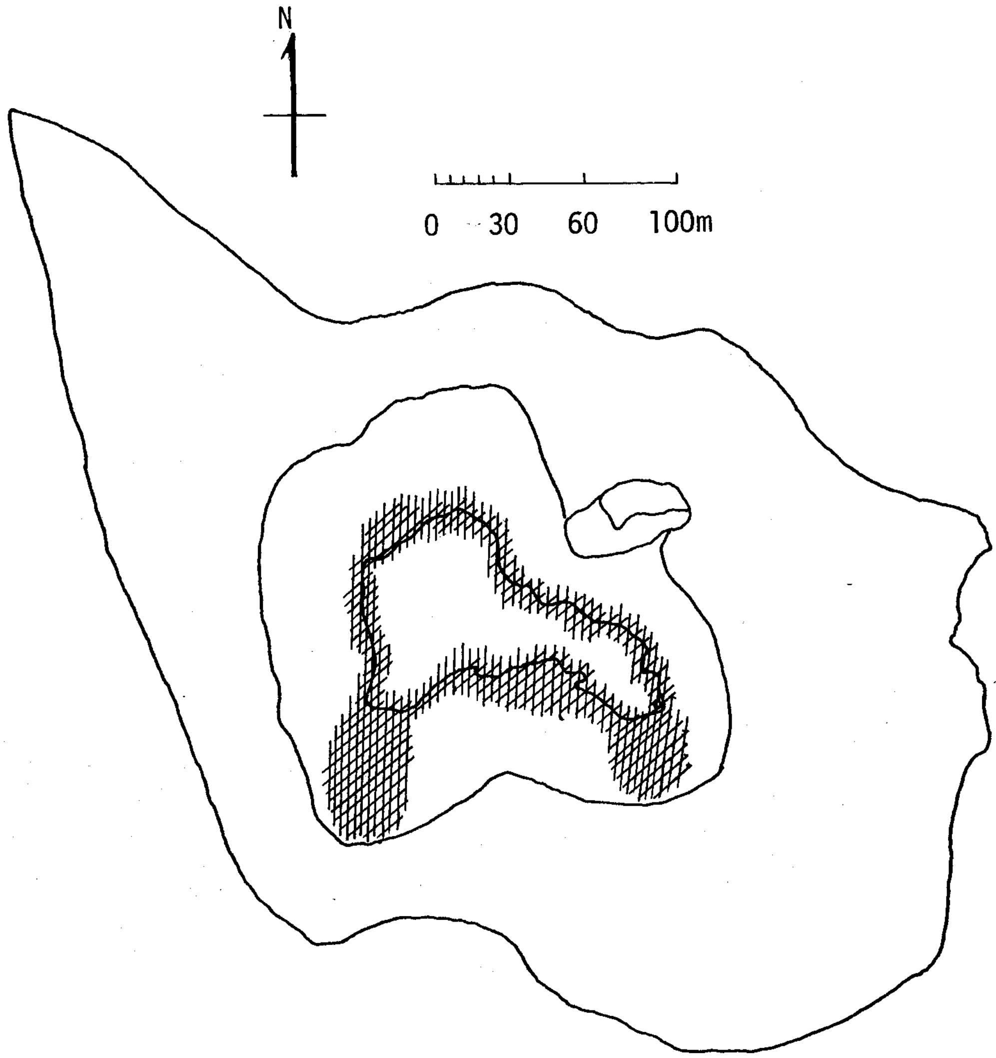


Fig. 28. Nesting distribution of Tufted Puffins on Tanker Island in 1976.

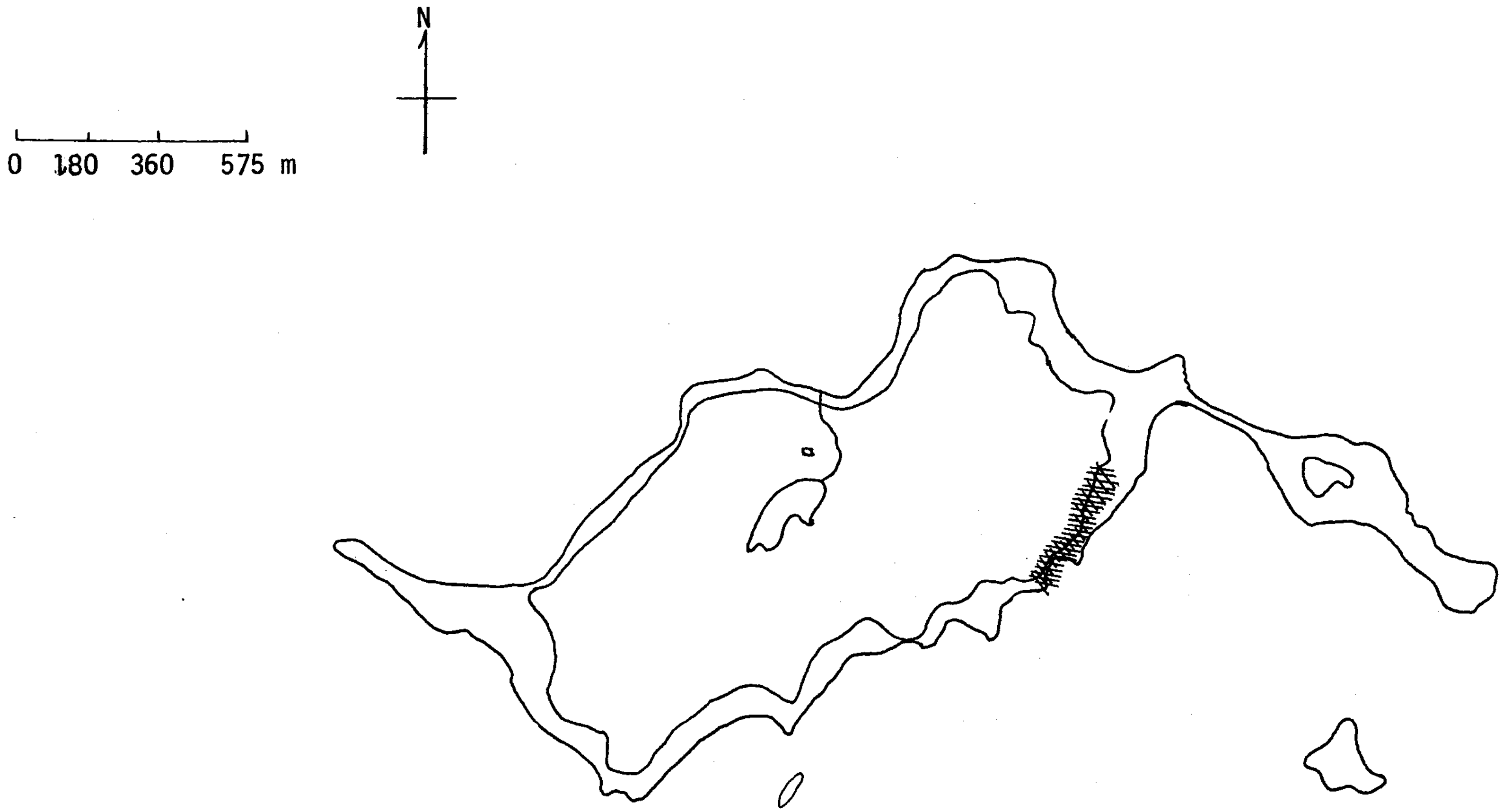


Fig. 29. Nesting distribution of Tufted Puffins on Wooded Island in 1976.

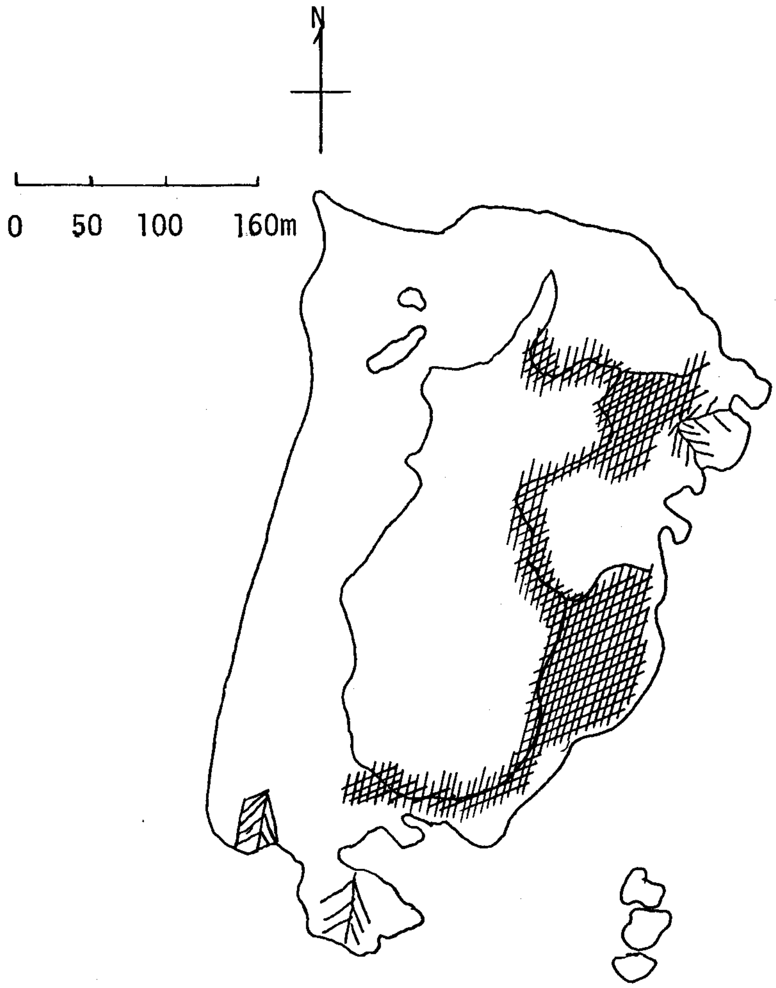


Fig. 30. Distribution of Tufted Puffin nesting areas on South Island in 1976.

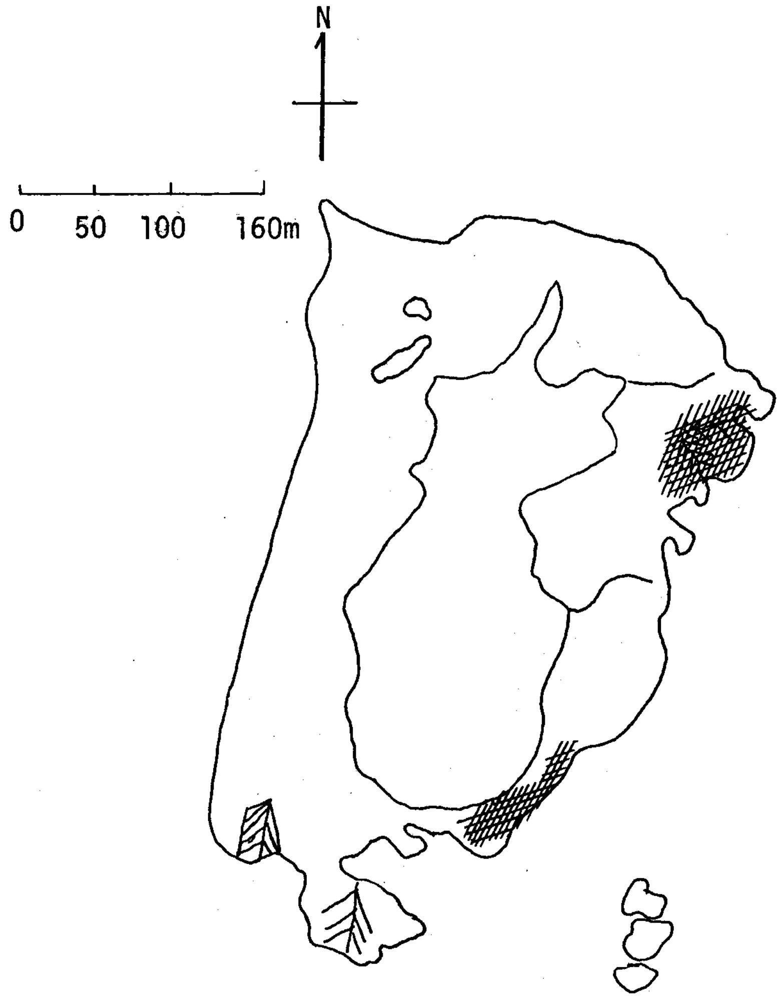


Fig. 31. Areas where Horned Puffins were observed sitting on South Island in 1976.

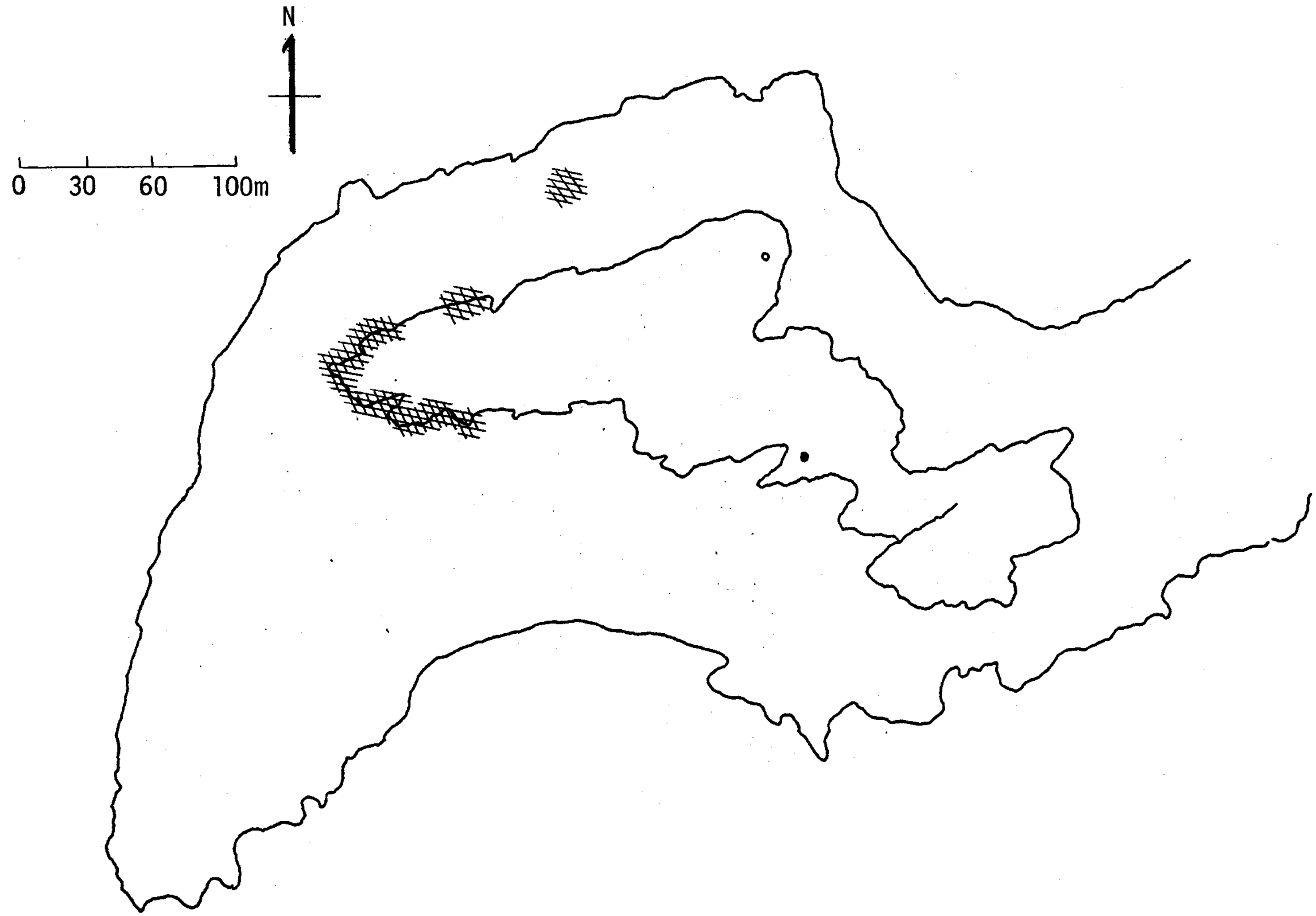


Fig. 32. Areas where Horned Puffins were observed sitting on the cliff face or on the rocks at Fish Island in 1976.

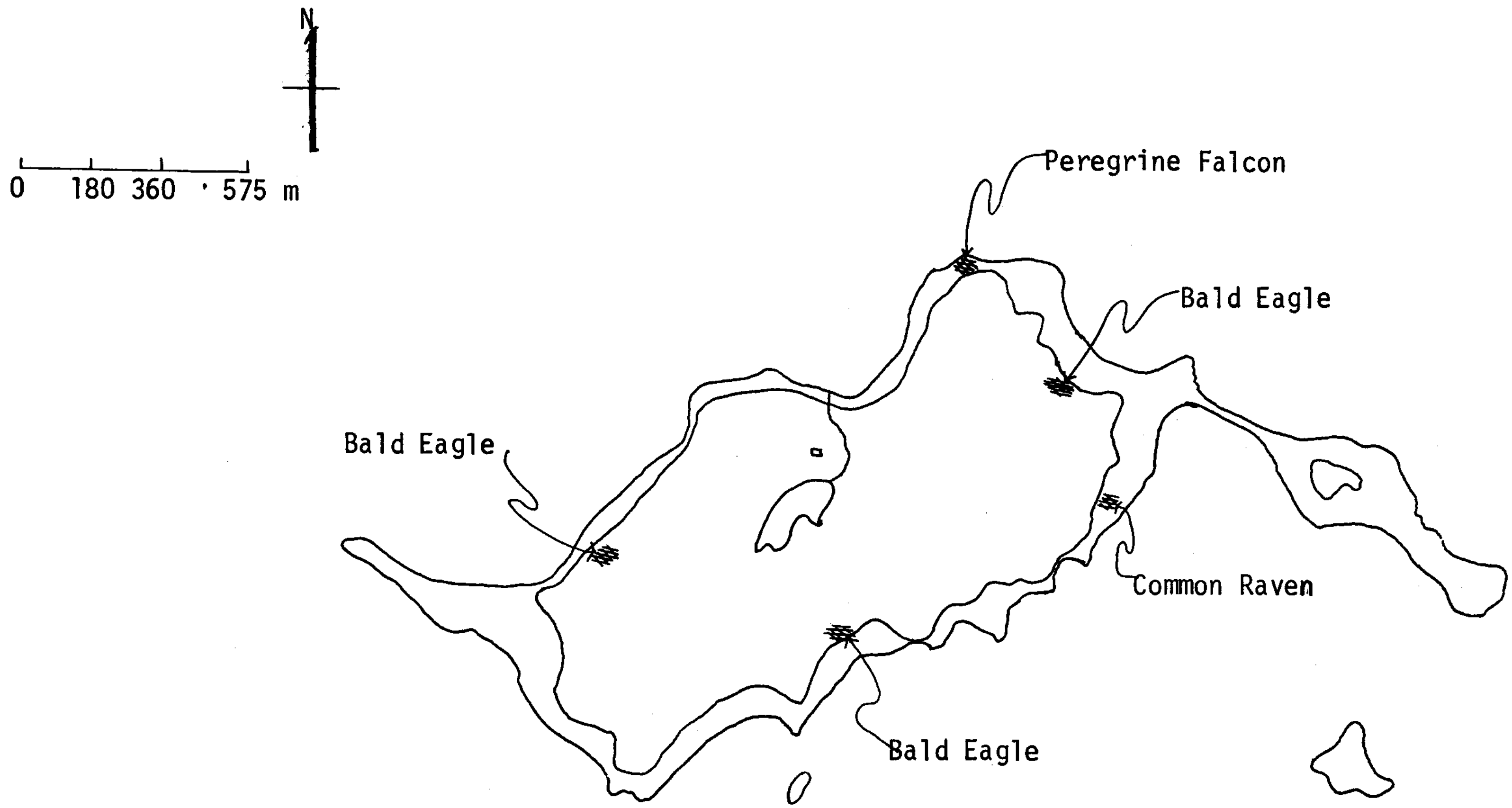


Fig. 33. Location of Bald Eagle, Peregrine Falcon, and Common Raven nests on Wooded Island in 1976.

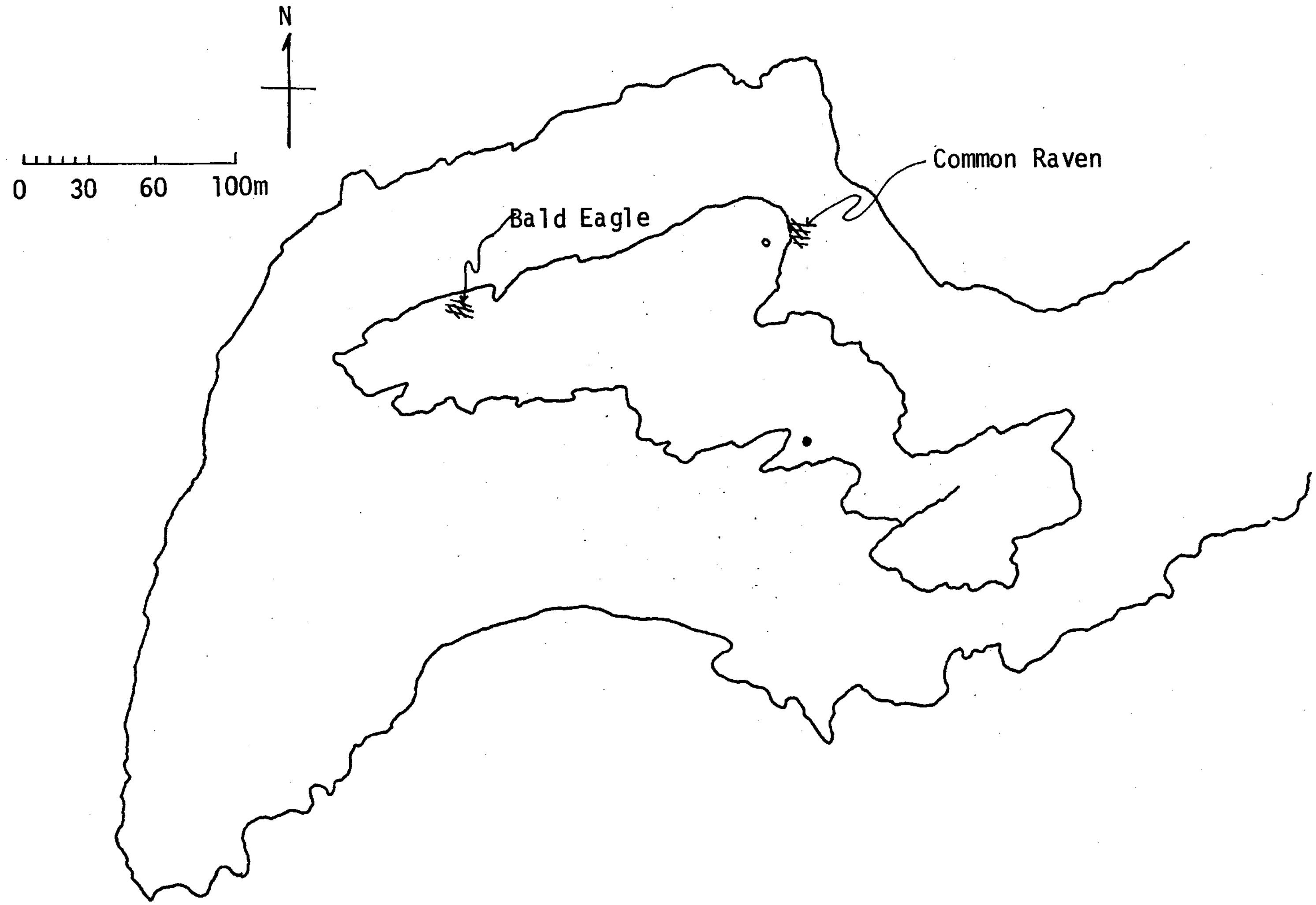


Fig. 34. Location of the Bald Eagle nest and the Common Raven nest on Fish Island. (1976).

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to
March 31, 1977

The Population Ecology and Migration of Seabirds, Shorebirds, and Waterfowl Associated with Constantine Harbor, Hinchinbrook Island, Prince William Sound, 1976

by

David Nysewander
and
Peter Knudtson

Part IX

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS
OF MARINE BIRDS IN THE GULF OF ALASKA
AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, R. G. Gould,
R. E. Gill and G. A. Sanger
Co-principal Investigators

U. S. Fish & Wildlife Service
Office of Biological Services/Coastal Ecosystems
Anchorage, Alaska

March, 1977

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

ABSTRACT

Ten breeding colonies of seabirds in Prince William Sound were revisited in 1976. Cliff nesting birds had declined in numbers on most sites compared with 1972 censuses run by Isleib and Sowl.

One colony, Porpoise Rocks, and one estuary, Constantine Harbor, were studied intensively from 28 April to 1 August 1976. Breeding phenology was determined for eight bird species.

Black-legged Kittiwakes raised only 0.01 chicks per breeding pair. Tufted Puffins had a maximum possible productivity of 0.6-0.7 chicks per breeding pair whereas Glaucous-winged Gulls had one of 1.8 chicks per pair and Arctic Terns produced 1.1 chicks per pair.

Between 1 May and 1 August a total of 44 sea watches were periodically taken along the edge of Hinchinbrook Entrance and in Constantine Harbor. A comparison of the sea watches on the straits with the counts taken in Constantine Harbor provided information on the patterns of migration, and the distribution of birds and their habitat requirements during spring, summer, and fall.

Beached bird surveys run weekly north of Nuchek in 1976 revealed no carcasses on the 1 km transect.

Examination of 48 freshly-killed bird carcasses showed Bald Eagle predation at Porpoise Rocks occurring in the following proportions: Tufted Puffin (57%), Black-legged Kittiwake (29%), Glaucous-winged Gull (10%), and Common Murre (4%).

Preliminary work in analysis of stomach contents of seabirds showed Pacific Sand Lance (*Ammodytes hexapterus*) and Capelin (*Mallotus villosus*) to be the two most common food items. Capelin showed up primarily in the latter half of the summer starting about the middle of July.

Eelgrass beds cover 149.64 hectares of Constantine Harbor.

INTRODUCTION

The Hinchinbrook Entrance to Prince William Sound is centered among many proposed human and commercial activities as well as being associated with large wildlife populations and a focal point of migration for marine birds and mammals moving between Prince William Sound and the Gulf of Alaska. The leasing of OCS areas in the northern Gulf of Alaska for oil production, the passage of the major transport lanes through these straits, and the possibilities of commercial development of a tugboat harbor in Port Etches all pose a substantial threat to fish and wildlife populations of the region. Baseline data should be gathered in this region so as to be able to evaluate any future impact.

The authors arrived in Constantine Harbor on 28 April 1976 and set up a field camp consisting of a shed and wall tent on the south shore of Constantine Harbor. Absolute counts, sea watches, and shorebird transects were taken in or looking from Constantine Harbor. Data on breeding populations of seabirds were collected at weekly intervals on Porpoise Rocks which are approximately 2 kilometers offshore from Nuchek and the Constantine Harbor area. Censusing of colonies took us to numerous other islands in the Sound from the Cordova area on the east to Little and Big Smith Islands on the north and Seal Rocks on the south (offshore 6 n. miles from Cape Hinchinbrook)(Figure 1). Parts of Montague and Green Island were examined in terms of beached bird surveys, but no colonies were seen there.

Some additional data were collected on nesting populations of shorebirds and waterfowl found in the vicinity of Constantine Harbor. Numerous observations of marine mammals including sea otters, harbor seals, Steller sea lions, and the many cetaceans that frequent and pass through this area were also obtained. This latter information is partially summarized in the appendix and much has been passed on to the interested parties: Ancel Johnson (USFWS), Ken Pitcher (ADF&G), and John Hall (USFWS, OBS-CE).

DESCRIPTION OF STUDY AREA

The weather of the North Gulf Coast-Prince William Sound region has a maritime climate, with moderate temperatures, high humidity, frequent overcast and fog, and high levels of precipitation.

The study area included all of the avian habitats described by Isleib and Kessel (1973). Their relative occurrences in the Port Etches-Constantine Harbor area are: 1) tundra--common; 2) shrub thickets--common; 3) hemlock-sitka spruce forest--common; 4) bogs--common; 5) mixed deciduous-spruce woodlands--rare; 6) marshes--occasional; 7) lacustrine waters--occasional; 8) fluviatile waters--common; 9) cliffs, bluffs, and screes--common; 10) moraines, alluvia, and barrier islands--rare (seen however in colony visits to Boswell Rocks and Cordova area); 11) beaches and tidal flats--common; 12) rocky shores and reefs--common; 13) inshore waters--common; and 14) offshore waters--occasional. Detailed descriptions of some of the region's vegetation may be found in Cooper (1942) and Crow (1968).

Porpoise Rocks, an area of major interest, consist of three large rocky islands surrounded by smaller rocks and reefs (Figure 2). The three major rocks extend 14-15 meters above sea level. Vegetation and soil were found primarily on Table and Arch Rocks (Figure 2). The summit of Table Rock has an area of 0.30 hectares and is covered by grass (*Elymus* and *Calamagrostis* spp.) and umbellifers (*Angelica*, *Conioselinum*, and *Heracleum* spp.)(Table 1). Shorelines are sheer cliffs and the only access to the top is up the southeast corner by crossing from Arch Rock at low tide. Arch Rock has a lesser top area of 0.03 hectares of similar vegetation (except *Calamagrostis* and *Heracleum*) with cliffs of gentler slopes in several places. The access to the top is possible by passing through the arch to the south and then circling to the east up the ridge over the arch, or by going through the arch from the landing beach and angling to the west around to the southwest face of the island climbing this face. The only landing beach giving access to either of the islands is a gravel beach below the arch on the north side of Arch Rock and this beach is only accessible at a high tide. The third large rock or bird colony site, Beach Rock, has a gravel spit that is accessible at low tide (covered at high tide), but mountaineering equipment is needed to safely cross the intertidal crevices and ascend the steep walls (dangerous even with equipment because of crumbling rock, slope of rock strata, and drainage of water).

METHODS

Censuses

Colony census techniques conformed with those recommended by Nettleship (1976). Nests of kittiwakes, gulls, and cormorants were counted by two observers with one using binoculars and the other not using any aid to avoid duplication. Counts were compared after a section was censused and adjusted to provide a final estimate. Counts were repeated if there was much difference in the comparisons. Burrowing birds were censused in two different ways: 1)On a colony visited only a few times, several counts were taken at varied time and tidal situations, the highest count being considered to best approximate actual populations. 2)On Porpoise Rocks sample plots and line transects were used to provide estimates by two formulas: a)active burrows of island = percentage of active burrows in sample plot X total number of burrows (old, new, and partial ones) on island top; b)active burrows of island = density of active burrows in sample plots X area of island top. Murres were censused both by counting individuals on rock ledges or nest sites and by the number of eggs found or seen.

Reproductive Phenology and Success

Sample plots were set up for each breeding species and these were checked at approximately weekly intervals to determine presence of eggs and chicks. A line transect of 5 X 5 meter quadrats (Nettleship, 1976) extended from one side of Table Rock to the other sampling all parts of the largest puffin colony.

Migration

Three types of sea watches (USFWS, 1976) were used to record and evaluate the use of Constantine Harbor and the eastern edge of Hinchinbrook Entrance (Figure 3). These were taken weekly during migration and biweekly during the early summer. A linear shoreline transect was run 2 km along the southern shore of Constantine Harbor between the field camp and the old town site of Nuchek. All birds within 50 meters of the high tide line were recorded. This shoreline transect was usually run at a tide level or condition that maximized the number of shorebirds feeding.

Mortality

Beached bird surveys were run weekly along a fixed transect that ran 1 km north from Nuchek on the Hinchinbrook Entrance beach. Other sites were evaluated intermittently during the summer.

Predation on seabirds was observed and recorded giving relative indices of predation per seabird species on Porpoise Rocks.

Trophic Relationships

Stomach Collections

Collection of certain species of seabirds (Sanger, USFWS, OBS-CE, procedure directive, 1976) were made at periodic intervals to determine diet. Only birds actively feeding were collected. These birds were evaluated in terms of reproductive condition, feeding habits, plumage, and general morphological data. Stomach contents of collected birds as well as food samples brought to chicks were preserved for identification and quantification at a later date. Weights of birds were taken immediately after the collection.

Waterfowl Food Resources

Eelgrass beds in Constantine Harbor, the predominant waterfowl food resource, were inventoried and mapped at low tides in June. Hence the areas are minimum figures as the eelgrass grows and expands its coverage through the summer.

RESULTS AND DISCUSSION

Censuses

Eight seabird colonies censused in previous years were recensused in 1976: Seal Rocks, Cape Hinchinbrook, Porpoise Rocks, Phipps Pt. Rocks (Constantine Harbor entrance), Big Smith Island, Little Smith Island, Canoe Passage entrance, and Boswell Rocks (Appendix 2). Seal Island, Applegate Rock reefs, parts of Green Island around Gibbon Anchorage, and parts of western Montague Island were also examined in the course of the summer work. Constantine Harbor was listed as a new colony site because of the Arctic Tern colonies located there with the associated Semi-palmated Plover and Black Oystercatcher nests.

Variations were noticed in numbers of active nests of four cliff nesting species of birds between 1972 and 1976 (Table 2). The general trend appears to be a reduction in numbers in 1976. Most of the reduction occurred in the smaller colonies. The two largest colonies of kittiwakes either show no loss or the least percentage of colony lost.

Tufted Puffin numbers varied considerably at the colony sites from day to day. At Porpoise Rocks, Beach Rock had no puffins while Arch Rock and Table Rock had approximately 2400 birds judging from censuses of active burrows. A sample plot of 41.1 m^2 on Arch Rock had 16 active burrows out of 52 burrows (new, old, and partially collapsed). A total of 414 burrows of all types were found on 340.6 m^2. The indicated total of active burrows for Arch Rock varied from 127 to 133 by the two methods of estimation. Sample plots of 150 m^2 on Table Rock had 56 active burrows out of a total of 91. The island top was 2962.8 m^2 and 1720 burrows of all types were found there. These figures give a total of active burrows for Table Rock of 1058 to 1106 by the two methods of estimation.

Common Murre numbers at Porpoise Rocks also varied greatly both at nest sites and in nearby waters. On 8 May 1976 we estimated 1000 murres on Beach Rock, 100-150 on Arch Rock, and 200-400 on Table Rock. Eagles were constantly harassing and disturbing the seabirds, but the rocks usually had the same relative ratio of birds distributed between them.

Black-legged Kittiwakes varied in their daily colony attendance at Porpoise Rocks. On 8 May 1976 a total of 1963 birds were distributed in the following way: Beach Rock, 975; Arch Rock, 138; and Table Rock, 850. There were 992 nests that appeared active. Later on 27 May an influx of additional kittiwakes swelled the total numbers to approximately 3000 birds, but the number of nests did not noticeably change.

Attempts were made to estimate populations of Marbled Murrelets by use of methods proposed by Sealy (Manuwal, et. al., 1975). Two problems were encountered: 1) Murrelets were often seen in pairs or even numbers raising doubts about doubling the figures seen. 2) The hydrography and topography of Prince William Sound allows the murrelets to feed farther from shore (up to 10-12 km near Seal Rocks) than Sealy recommended. We compromised and ran several small boat transects through areas when high densities were noted counting all birds within 50 m of either side of the Zodiac for a fixed distance. Feeding flock densities varied from 62 to 158/km^2 in four transects: 1) Seal Rocks to Cape Hinchinbrook--75/km^2; 2) Nuchek to Bear Cape Light (Deer Cove) --62/km^2; 3) Bear Cape (Hinchinbrook Island) to Schooner Rock (Montague Island)--158/km^2; 4) the east end of Green Island to the Tagu marker on the north shore of Montague Island--116/km^2. In these four transects, the depth, distance from land, and the dates of observation varied. Nothing was consistent except possibly the food resources upon which the murrelets fed.

Attempts were more successful in estimating Pigeon Guillemot densities in appropriate habitat because the birds stayed closer to their nesting territories. Pigeon Guillemots in Prince William Sound nested on and frequented shorelines that had abundant talus at bases of cliffs. A shoreline census of this habitat on Cape Hinchinbrook extending 5.9 km had populations of 6.6 birds/km. Similar shoreline habitat was censused on the south shore of Big Smith Island (5.8 km) where the density was 25.5 birds/km. Here Parakeet Auklets nested in association with the Pigeon Guillemot.

Reproductive Phenology and Success

Table 3 compares the hatching success of the seven major species of seabirds and shorebirds found breeding in the Port Etches-Constantine Harbor area. Other shorebirds nested in adjacent bogs, marshes, and riparian habitats, but incidental data on these are included in the annotated species list in the appendix.

Black-legged Kittiwake (*Rissa tridactyla*)

Table Rock had 733 m^2 of cliff face utilized by kittiwakes for nesting. Three major parts of the cliffs were used: south face, 141 m^2; southwest face, 149 m^2; and the northwest face, 483 m^2. Arch Rock had 241 m^2 of cliff face utilized for nest sites including: the south face, 72 m^2; west and southwest faces, 144 m^2; and a northwest ledge, 25 m^2.

Egg laying for the Black-legged Kittiwake began the first week of June continuing through the month with the peak occurring during the third week of June. Kittiwakes on Table Rock were consistently earlier in their egg laying and clutches were larger than those on Arch Rock (Table 4). Between 16 June and 8 July as eggs were hatching, approximately 98-99% of total eggs were lost through predation. It is uncertain whether this predation occurred on eggs or chicks as other studies on murres necessitated that we be away from the island for two weeks. The following indirect evidence suggests that eagles played an important part in this predation: 1) the presence of immature kittiwake parts (wings) in eagle pellets on Porpoise Rocks;

2) the continual presence and harassment of the seabird colony by up to six eagles (seen by spotting scope from sea watches); 3) the presence of kittiwake remains in one eagle nest examined; and 4) the presence of numerous eagle feathers mixed in with the many broken nest remains of kittiwakes found at bases of cliffs. The presence of freshly hatched egg shells in these nest remains and the lack of any measurable egg loss before this time suggest that the appearance of chicks may have triggered the predation. Glaucous-winged Gulls may have also participated in this predation, but Ravens and Crows were never seen on the colonies at any time during the summer.

The field camp was closed before any of the remaining kittiwake chicks fledged, but a total of 6 chicks out of 210 nests gives a maximum productivity estimate of 0.01 chicks per breeding pair. All of the surviving chicks were in nest sites that were cave-like or with overhanging rocks immediately above the nest and, thus, were protected from eagles or gulls. Five of the six chicks were on the southwest portion of Arch Rock.

Tufted Puffin (*Lunda cirrhata*)

The first puffin egg was discovered on 3 June and hatching in this species occurred from the first through the fourth week of July, indicating that egg laying began about the end of May. An average of 0.4 active burrows/m^2 was found in 291.1 m^2 of sample plots established on Porpoise Rocks. The average densities for Table and Arch Rock were not very different, being respectively 0.37/m^2 and 0.39/m^2. This density of active burrows is exactly the same as that found on both Cape Peirce (Margaret Petersen, pers. comm.) and Forrester Island (Tony DeGange, pers. comm.). The highest density of active burrows (0.64/m^2) occurred in a sample plot on the colony periphery that had good soil depth and few rocks.

The shallow soil depth in these puffin colonies facilitated examination of burrows. In the 11 sample plots there were 49-55 chicks surviving in 78 active burrows when the field camp was closed. This gives the maximum possible productivity of 0.6-0.7 chicks per breeding pair. Two of these sample plots were disturbed approximately once a week for 4-5 weeks. This resulted in a 39% and 36% loss of abandoned eggs. Lesser losses (0-33%) occurred in three other less disturbed sample plots.

Adult puffins nesting in the interior portions of the flat top of Table Rock were often killed by eagles. Of 48 recent eagle kills examined, 58.7% were puffins.

Common Murre (*Uria aalge*)

The first egg was discovered on Table Rock on 19 June. Egg laying continued in low numbers with heavy predation by Glaucous-winged Gulls until the fourth week of July when 55% of the 169 recorded eggs (on Arch and Table Rocks) were laid. The rate of egg predation appeared to decrease this last week because the majority of these eggs were in unusually protected habitat: 1-2 m grass on the island top, puffin burrow entrances, and caves in the cliff face. Harassment by eagles was responsible for keeping the murres off the eggs which were then predated by Glaucous-winged Gulls. There were 107 eggs left of the 169 recorded when observations were discontinued.

Glaucous-winged Gull (Larus glaucescens)

The density of nesting Glaucous-winged Gulls seemed small compared to similar colonies of the same species seen in Puget Sound in Washington or on the Egg Islands near Cordova. Arch Rock had 19 nests while Table Rock had 18. Beach Rock was estimated to have only 20-25 more.

Egg laying commenced the first week of June and continued through the end of June with the peak occurring during the third week of June. Hatching success was 70% with an average clutch size of 2.5 for 35 nests. Since clutches were collected for analysis at Patuxent Wildlife Research Center, only 23 nests could be used for measures of productivity. The chicks had not fledged when we left and still were hidden in the tall grass, but the maximum possible productivity would have been 1.8 chicks per breeding pair.

Arctic Tern (Sterna paradisaea)

A small colony was present at the western end of Constantine Harbor. The principal nesting area was on a spit on the north shore although some later nesting occurred on the peninsula immediately north of Nuchek (Figure 4). Because a Coast Guard helicopter which landed in the midst of the main colony caused desertion of some nests, birds nesting on the Nuchek peninsula may have originated from the larger colony.

Hatching began the second week of June (11 June), but 67% of all hatching occurred in the third week of June. Hatching at the smaller second colony occurred 11 July. These hatching dates indicated that laying started about 21 May with a peak between 23 and 31 May. The few late nests were laid on approximately 19-20 June. This is two weeks after the helicopter landed in the main colony and hence the later nests are probably renests. Out of 24 eggs there were 17 chicks giving a hatching success of 71%.

Mortality was due to three factors. The helicopter incident caused the loss of 2-3 eggs. Predation accounted for the loss of 2-4 eggs. High tides were responsible for the loss of 2 eggs and 2 chicks.

Studies by Lemmetyinen (1973) indicated that chick mortality usually occurs within the first 14 days and that fledging success can be determined from this period. This approach would give the maximum possible productivity of 1.1 chicks per breeding pair for the Constantine Harbor colony.

Semi-palmated Plover (*Charadrius semipalmatus*)

The increase in gravel shoreline caused by uplift resulting from the 1964 earthquake has made this species one of the most abundant shorebirds breeding in Constantine Harbor. A 2 km shoreline transect had 5 plover nests along it giving an average of 2.5 plover nests/km of suitable beach, and indicating a total of about 20-25 nests for Constantine Harbor.

In the nine nests monitored, two had eggs that hatched in the second week of June, five had eggs that hatched in the third week of June, and one had eggs that hatched during the fourth week (22 June). If the 26 day incubation period noted in one nest is typical, then egg laying extended from 16-26 May with the peak from 18-23 May.

There were 29 chicks hatching out of 36 eggs giving a hatching success of 81%. One brood of chicks was color banded when hatching. The next day one of these was found 75 meters from the nest site.

Black Oystercatcher (*Haematopus bachmani*)

Egg laying extended approximately from 16-21 May with hatching occurring the second and third week of June (12, 13, 16, 17 June). In the four nests monitored there was a 92% hatching success, although partial data from additional nests indicated overall nesting success was probably closer to 61% (Nysewander, 1976).

Canada Goose (*Branta canadensis*)

Canada Geese were seen occasionally on Constantine Harbor when we arrived in late April, but by the first week of May they had left the harbor and moved inland onto the bogs. Geese were seen all over Prince William Sound in these scattered bog and muskeg clearings and up to fourteen pairs were observed in the bog area immediately east of Nuchek. Two nests with eggs were discovered and checked on 24 and 28 May, but they were gone (hatched?) on 13 June. Judging from these dates the geese probably laid between 1-15 May. By June the geese were silent and had moved further inland onto the highest ridges and ponds of the Phipps peninsula where moulting took place (Figure 4). Measurements of one goose killed by an eagle were: anterior nares, 26 mm; posterior nares, 37 mm; total culmen, 50 mm; gape, 55 mm; total tarsus, 113 mm. According to Delacour (1954) these measurements conform with those of *Branta canadensis fulva*.

Bald Eagle (*Haliaeetus leucocephalus*)

Nests of Bald Eagles were common in the study area and, although not censused, were recorded opportunistically during the summer (Figures 5 and 6). On 9 July one nest with a single chick on the north side of Constantine Harbor was examined after heavy predation of seabirds had occurred on Porpoise Rocks. Feathers were beginning to form on the body and wings of the chick; down was mostly gone from the head; and the primaries had erupted 4 cm from the sheaths. One fresh pink salmon was present on the nest platform along with many feathers and down. The feathers in the nest were 40% eagle, 40% puffin, and 20% kittiwake and unknown materials.

Migration

Between 1 May and 1 August, 12 sea watches of the fixed and sweep types were conducted from a position overlooking Hinchinbrook Entrance while 10 pairs of counts were made of birds in Constantine Harbor. The absolute counts cover 350 hectares of Constantine Harbor while the major part of the sweep seawatch covered roughly 700 hectares of the east side of Hinchinbrook Entrance (Figure 3). Censuses of these two areas permitted comparison of the numbers and kinds of birds found at different times and in two different marine habitats, a protected estuary and an exposed straits with strong tidal currents (Figures 7 to 19), or of feeding differences between species as illustrated by the Arctic Tern and the Marbled Murrelet (Figures 20 and 21).

Several basic patterns emerge from this sea watch data. The latter part of the spring migration was dominated by migrant Common Loon, Arctic Loon, Grebes, Greater Scaup, Bufflehead, Barrow's Goldeneye, Oldsquaw, Black Scoter, White-winged Scoter, and Surf Scoter. Both marine habitats observed were frequented by some species such as the Common Loon, the Black Scoter, the White-winged Scoter, and the Arctic Tern, but other species such as the Arctic Loon, the Bufflehead, the Surf Scoter, the Common Merganser, and the Mew Gull appeared to prefer one habitat over the other. The end of breeding cycles and the reappearance of birds in coastal staging areas for fall migration were evident for Bonaparte's Gulls, Mew Gulls, and Arctic Terns. The Arctic Tern (Figure 20) is especially interesting in this regard, for while birds were leaving constantly at the end of July, the numbers remained very high as new birds replaced those leaving. The return in summer of non-breeding birds was evident for species such as the Surf Scoter, the White-winged Scoter, the Harlequin Duck, and the Arctic Loon. Arctic Loons returned in large numbers in late June and Harlequin Ducks congregated and molted in large numbers in Constantine Harbor during June remaining abundant there through July. Marbled Murrelets foraged in large numbers in areas which shifted, probably as they followed moving schools of forage fish. At any one spot the number of murrelets varied greatly from day to day.

The seasonal occurrence of shorebirds and passerines was determined from censuses of a shoreline transect in Constantine Harbor (Figures 22 and 23). Again, the end of spring migration was recorded as Figure 22 clearly illustrates. Spotted and Least Sandpipers nesting in the vicinity of Constantine Harbor were not seen on transects in May or early June, but returned to shoreline habitats later in late June and July. The reappearance of Western Sandpipers was a reverse migration of possibly failed or non-breeders since they do not breed in the Prince William Sound vicinity. Golden-crowned Sparrows and Varied Thrushes were observed on shoreline transects in spring, but left the shore when the snow melted from their preferred habitat.

Mortality

Twelve beached bird surveys were run between 1 May and 1 August. No birds were ever found. In fact, most of the beaches on Hinchinbrook Island were remarkably clear even of driftwood or kelp. Several trips to the outer shoreline of Montague Island convinced us that either this area or the Montague Island side of Hinchinbrook Entrance south of Zaikof Point were the ideal locations for beached bird surveys as prevailing currents throw everything up on these beaches.

Weekly checks revealed the new carcasses of 48 birds and 2 seal pups killed and/or eaten by eagles at Porpoise Rocks. Analysis of a few eagle pellets and the debris around the nearest eagle nest confirmed the results of the carcass analysis at Porpoise Rocks. Species composition of prey species were: Tufted Puffin (57%), Black-legged Kittiwake (29%), Glaucous-winged Gull (10%), Common Murre and Harbor Seal (4%). Major use of seabirds by eagles occurred primarily during June and the first part of July. Thereafter salmon started running up the local streams, and eagles switched to this food resource. An immature Bald Eagle (in its second or third year) was found dead on the beach near Nuchek in May. The carcass was emaciated, and starvation appeared to be the cause of death. Seabirds may be a crucial food source for eagles during June and early July.

Trophic Relationships

Stomach Collections

Eighteen birds were collected for food analysis: 2 Glaucous-winged Gulls, 1 Kittlitz's Murrelet, 3 Marbled Murrelets, 6 Black-legged Kittiwakes, 1 Common Murre, 2 Pigeon Guillemots, and 3 Parakeet Auklets. The Pacific Sand Lance (*Ammodytes hexapterus*) was the main fish found in all species until the middle of July when the Capelin (*Mallotus villosus*) began running into the Prince William Sound area. The number of birds in feeding flocks and occurrence of such flocks increased at this time although both species of forage fish continued to be found in stomachs collected later in the summer.

Plastic particles were not found in stomaches from Parakeet Auklets collected on the study area although such particles were common in birds from the Shumagin Islands in 1976. Gular pouches of adults were at maximum development (94.6 mm and 111.1 mm) on 22 July indicating that young were being fed and the one immature bird had a gular pouch measurement of 31.3 mm (virtually no pouch since measurement goes out to the bill tip).

A Kittlitz's Murrelet collected on 27 May contained a fully shelled egg low in the reproductive tract. Thus, egg laying must apparently occur either the last week of May or the first of June for this species.

Waterfowl Food Resources

The area covered by eelgrass in Constantine Harbor was measured both by visual estimate when traveling in a small boat at minus tides and with a compensating polar polimeter of major map areas dominated by eelgrass (Figure 24). The first method gave a total of 60.85 hectares of eelgrass beds while the second method had a total of 149.64 hectares. I believe the first method underestimated the larger areas of eelgrass because of 1) human error in estimating dimensions of large areas and 2) eelgrass leaf biomass is at a peak in late July (McRoy, 1966) and our estimates occurred in June. The eelgrass in Constantine Harbor produced seeds and was covered heavily in July and August with either fish or invertebrate eggs.

NEEDS FOR FURTHER STUDY

The research in 1976 at this study area gives a single estimate of population sizes and productivities, but baseline data need some idea of the yearly variations that are normal for any one species. Without at least two years of research at any one spot, it will be impossible to separate normal population fluctuations from those caused by oil pollution.

The general failure of kittiwakes to reproduce in 1976 at Porpoise Rocks needs to be compared with another year. Eagle predation on seabirds should be examined a second year. More extensive research on murre reproduction is needed since we could not estimate the reproductive success of this species in 1976.

In general, research should intensify more on the seabird population at Porpoise Rocks and decrease on the research of the waterfowl and shorebird populations found in Constantine Harbor. This is especially important in light of the fact that next year is the first year for tanker traffic to begin. Next year may be the last year to obtain baseline information before the effects of oil pollution occur.

LITERATURE CITED

Cooper, W. S. 1942. Vegetation of the Prince William Sound region, Alaska; with a brief excursion into post-Pleistocene climatic history. Ecol. Monogr. 12: 2-22.

Crow, J. H. 1968. Plant ecology of the Copper River Delta, Alaska. Ph. D. thesis, Washington State Univ., Pullman. 120pp.

Grinnell, J. 1910. Birds of the 1908 Alexander Alaska Expedition with a note on the avifauna relationships of the Prince William Sound district. Univ. Calif. Publ. Zool. 3: 361-428.

Isleib, M. E. and B. Kessel. 1973. Birds of the North Gulf Coast-Prince William Sound Region, Alaska. Biological papers of the Univ. of Alaska, #14: 149pp.

Lemmetyinen, R. 1973. Breeding success in *Sterna paradisaea* and *S. hirundo* in southern Finland. Ann. Zool. Fennici 10: 526-535.

McRoy, C. P. 1966. The standing stock and ecology of eelgrass (*Zostera marina* L.) in Izembek Lagoon, Alaska. M. S. thesis, Univ. of Washington, Seattle. 130pp.

Nettleship, D. N. 1976. Census Techniques for Seabirds of Arctic and Eastern Canada. Occasional paper #25, Canadian Wildlife Service, Ottawa. 33pp.

Nysewander, D. R. 1977. Reproductive Success of the Black Oystercatcher in Washington State. M. S. thesis, Univ. of Washington, Seattle. 77pp.

Manuwal, Anderson, Knoder, Nettleship, and Sealy. 1975. Seabird colony census techniques (preliminary draft). The Pacific Seabird Group. 18pp.

Table 1. Vegetation of Two Rocks of Porpoise Rocks, near Port Etches, Prince William Sound.

Agrostis alaskana	Bent Grass
Angelica lucida	Wild Celery*
Arabis lyrata	Rock Cress
Calamagrostis canadensis	Bluejoint*
Campanula latisepala	Harebell
Claytonia sibirica	Siberian Spring Beauty
Cochlearia officinalis	Scurvygrass
Conioselinum chinense	Hemlock Parsley*
Draba kamtschatica	Draba
Elymus arenarius	Beach Rye*
Festuca rubra	Fescue Grass
Fritillaria camschatcensis	Black Island Lily
Heracleum lanatum	Cow Parsnip
Hordeum brachyantherum	Squirreltail Grass
Ligusticum scoticum	Wild Celery
Maianthemum dilatatum	False Lily of the Valley
Matricaria matricarioides	Pineapple Weed
Potentilla villosa	Wild Sweetpotato
Rubus sp.	Wild berry?
Rumex fenestratus	Dock
Saxifraga bracteata	Saxifrage
Sedum rosea	Roseroot
Veratrum veride	False Hellebore

*Predominant plants. Cover percentages on sample plots were:

Angelica lucida (Table Rock 20%, Arch Rock 35%)
Elymus arenarius (Table Rock 20%, Arch Rock 35%)
Calamagrostis canadensis (Table Rock 55%, Arch Rock 0%)
Conioselinum chinense (Table Rock 2%, Arch Rock 30%)

Table 2. Variations in Numbers of Nests of Black-legged Kittiwake, Pelagic Cormorant, Double-crested Cormorant, and Brandt's Cormorant in Prince William Sound, 1972 and 1976.

Colony	Number of Nests in 1972	Number of Nests in 1976
Black-legged Kittiwake		
Porpoise Rocks	975	992
Cape Hinchinbrook	90	0
Seal Rocks	275	46
Canoe Passage	47	0
Boswell Rocks	4936	4038
Double-crested Cormorant		
Cape Hinchinbrook	30	0
Boswell Rocks	27	31
Pelagic Cormorant		
Cape Hinchinbrook	32	28+
Boswell Rocks	41	11
Brandt's Cormorant		
Seal Rocks	4	0

Note: 1976 data comes from Nysewnader and Knudtson. 1972 data comes from Isleib and Sowl.

Table 3. Comparative Hatching Success of Seven Species in Porpoise Rocks-Constantine Harbor Area, 1976.

Species	Number of Nests in Colony	Number of Active Nests Sampled	Hatching Success
Tufted Puffin	1200	78	61%
Black-legged Kittiwake	992	210	1-2%
Common Murre	310-500	169	??*
Glaucous-winged Gull	60	26	70%
Arctic Tern	12+	12	71%
Black Oystercatcher	7***	4	61%(92%)**
Semi-palmated Plover	25	9	81%

* Colony was left before the eggs hatched. Predation occurred so quickly that it is impossible to know total number of eggs laid.

** Observed success of a small sample was 92%, but past experience would indicate a probable success closer to 61% if all possible nesting attempts had been checked.

*** Area indicated here is Constantine Harbor since these birds are abundant but not colonial.

Table 4. Variations in Observed Clutch Size Averages of Black-legged Kittiwake between Sample Plots of Two Rocks, Porpoise Rocks, 1976.

Dates and Island	Observed Clutch Size Average (Number of Active Nests)		
	South Faces	Southwestern Faces	Northwestern Faces
June 3:			
Table Rock	0.29(28)	0.32(38)	0.12(69)
Arch Rock	0.09(17)	0.00(21)	0.00(5)
June 10:			
Table Rock	0.83(24)	1.06(33)	1.12(77)
Arch Rock	0.41(17)	0.56(25)	0.20(5)
June 19:			
Table Rock	1.41(22)	1.93(30)	1.93(97)
Arch Rock	data lost	data lost	data lost

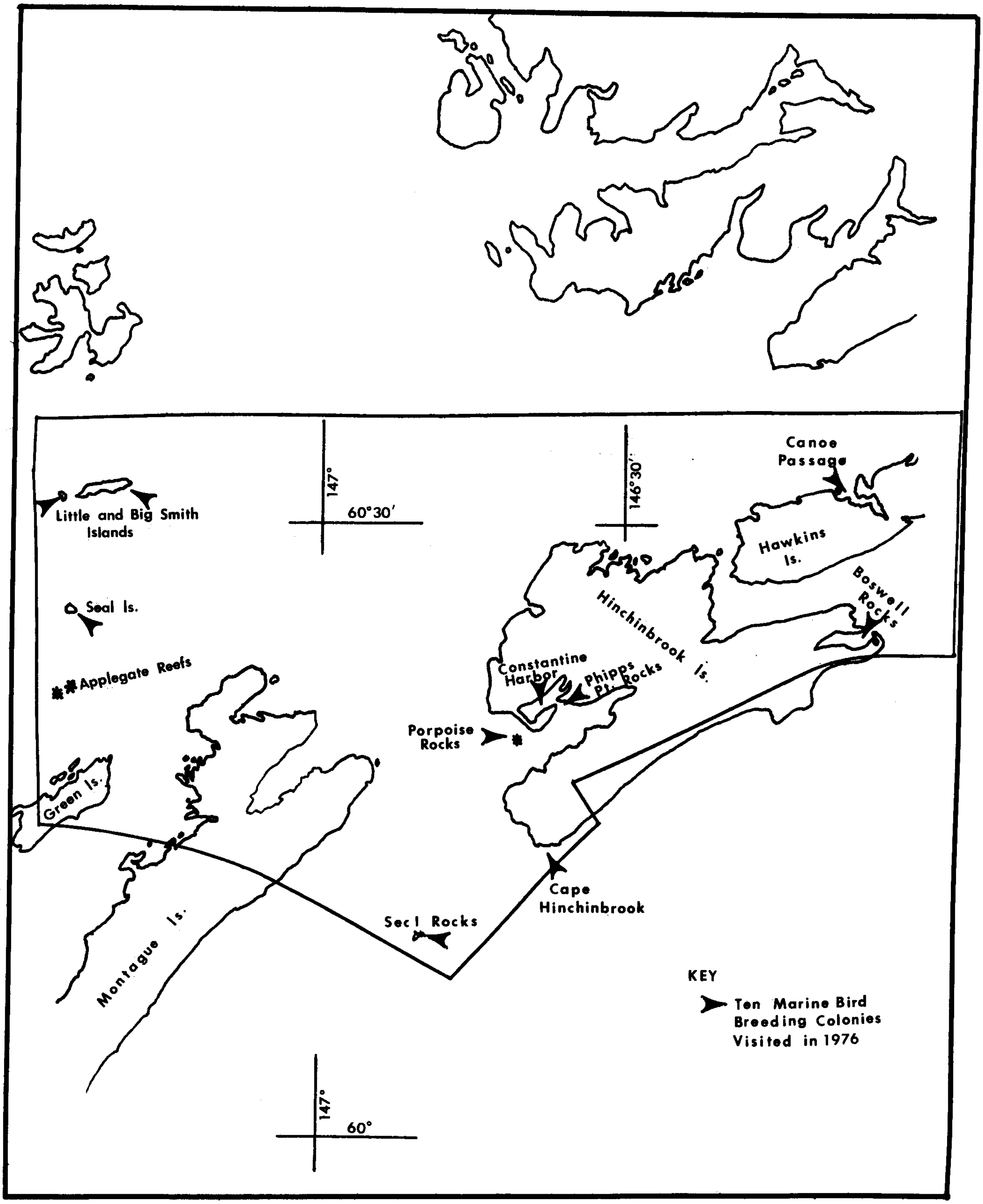


Figure 1 Location of Study Area and Island Shorelines Visited in 1976.

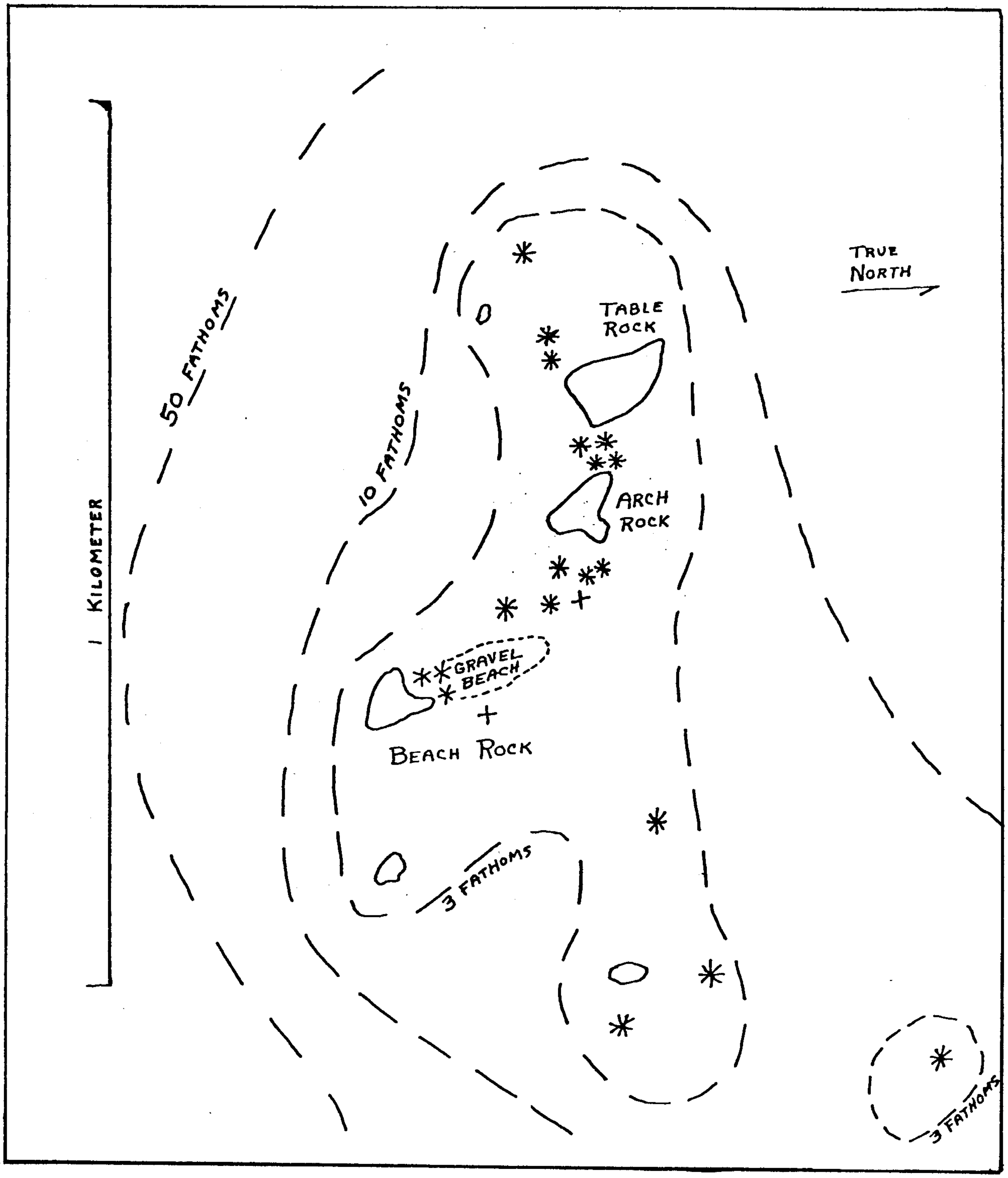


Figure 2. Porpoise Rocks, Port Etches, Hinchinbrook Island.

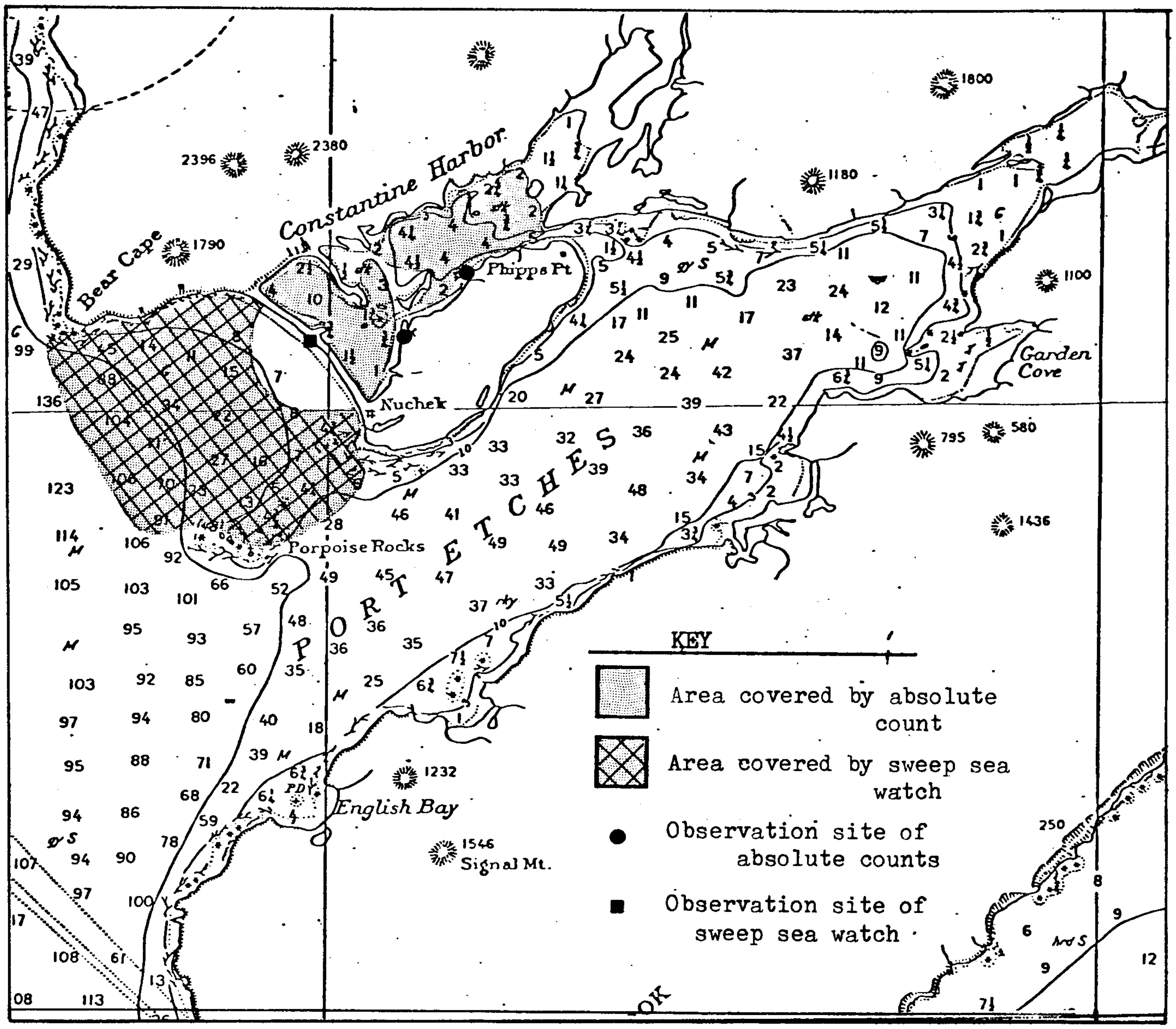


Figure 3. The Sweep Sea Watch and Absolute Counts Conducted in the Port Etches-Constantine Harbor Area, 1976.

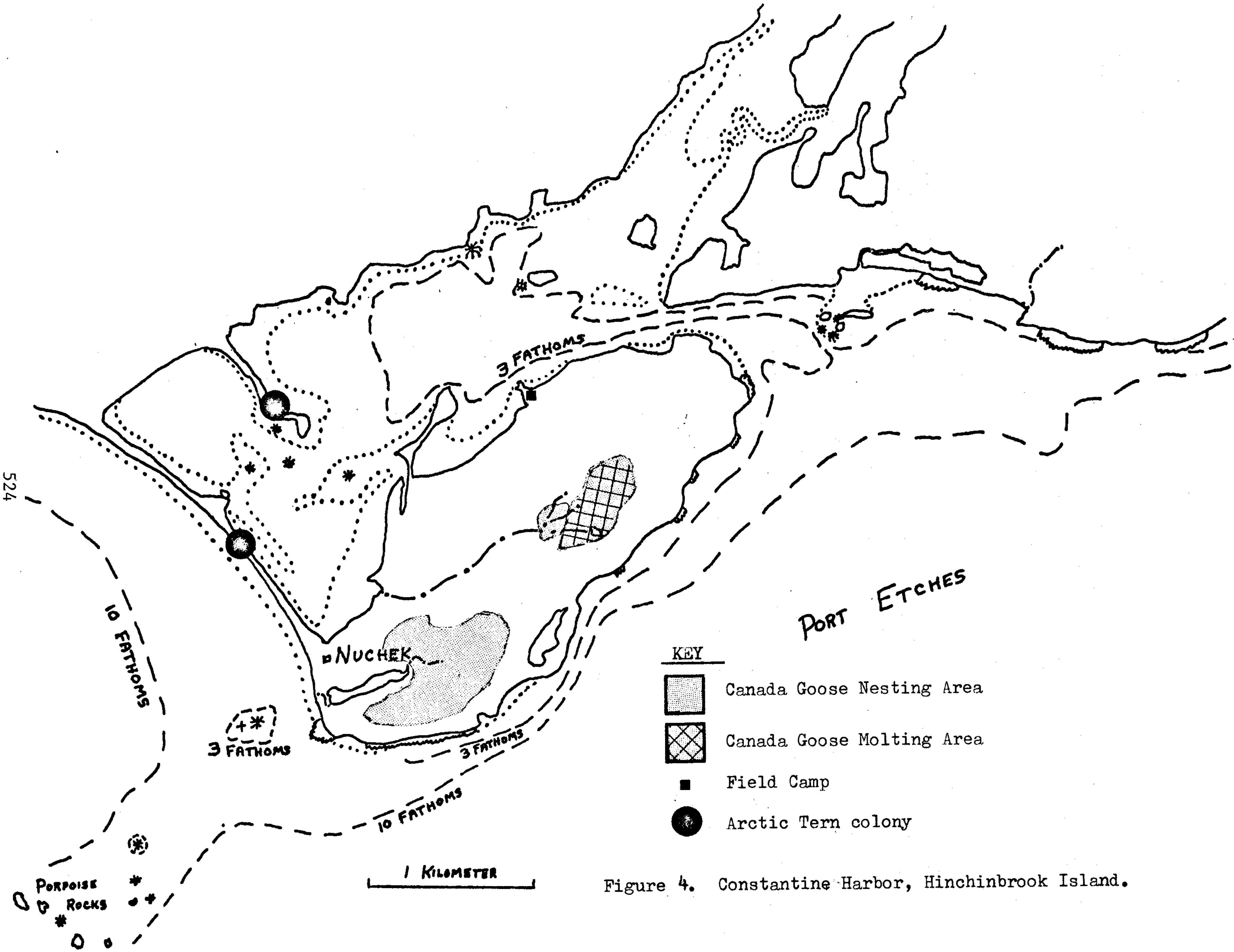


Figure 4. Constantine Harbor, Hinchinbrook Island.

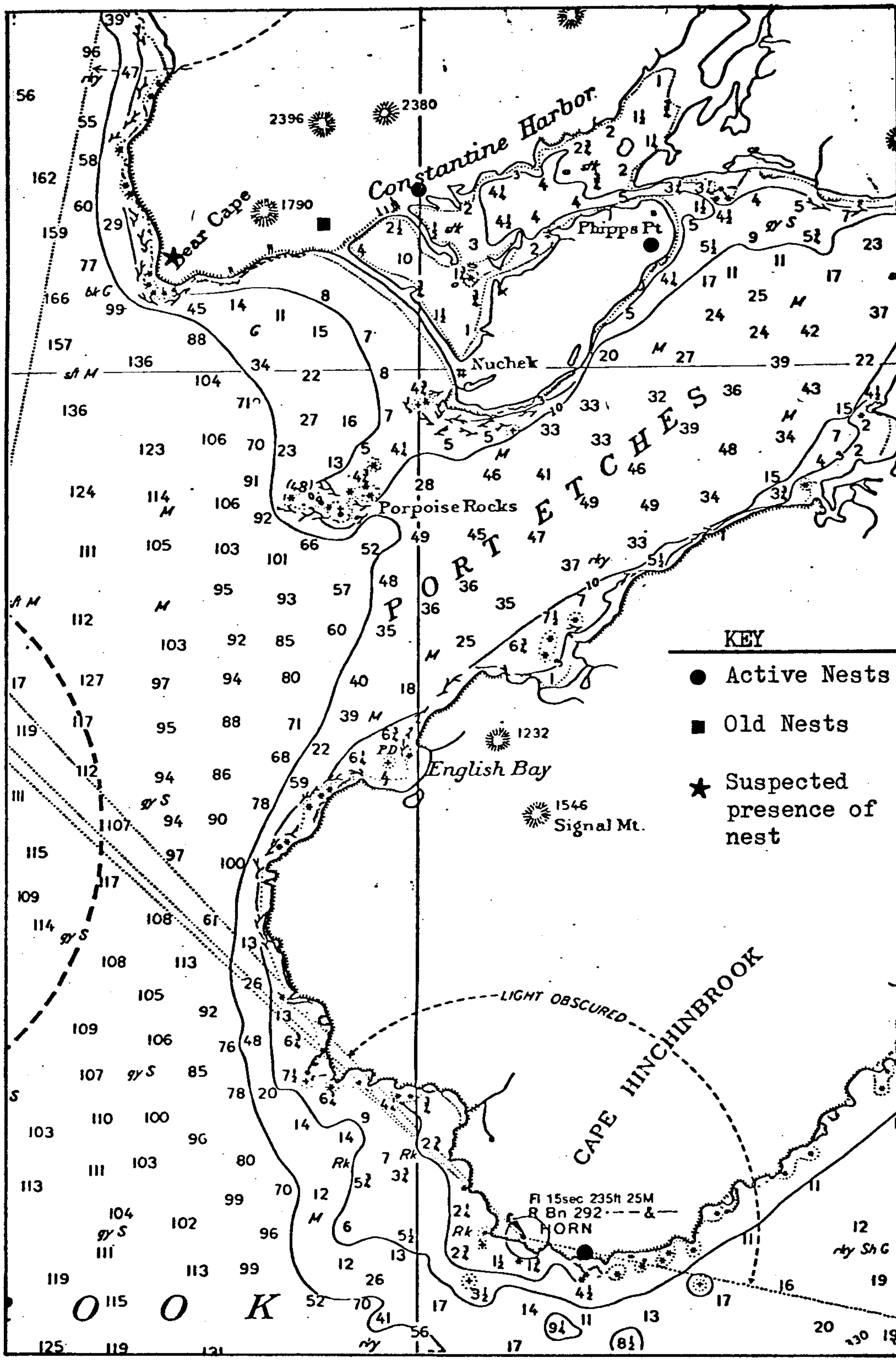


Figure 5. Bald Eagle Nests Noted at Constantine Harbor and Cape Hinchinbrook, Hinchinbrook Island, 1976.

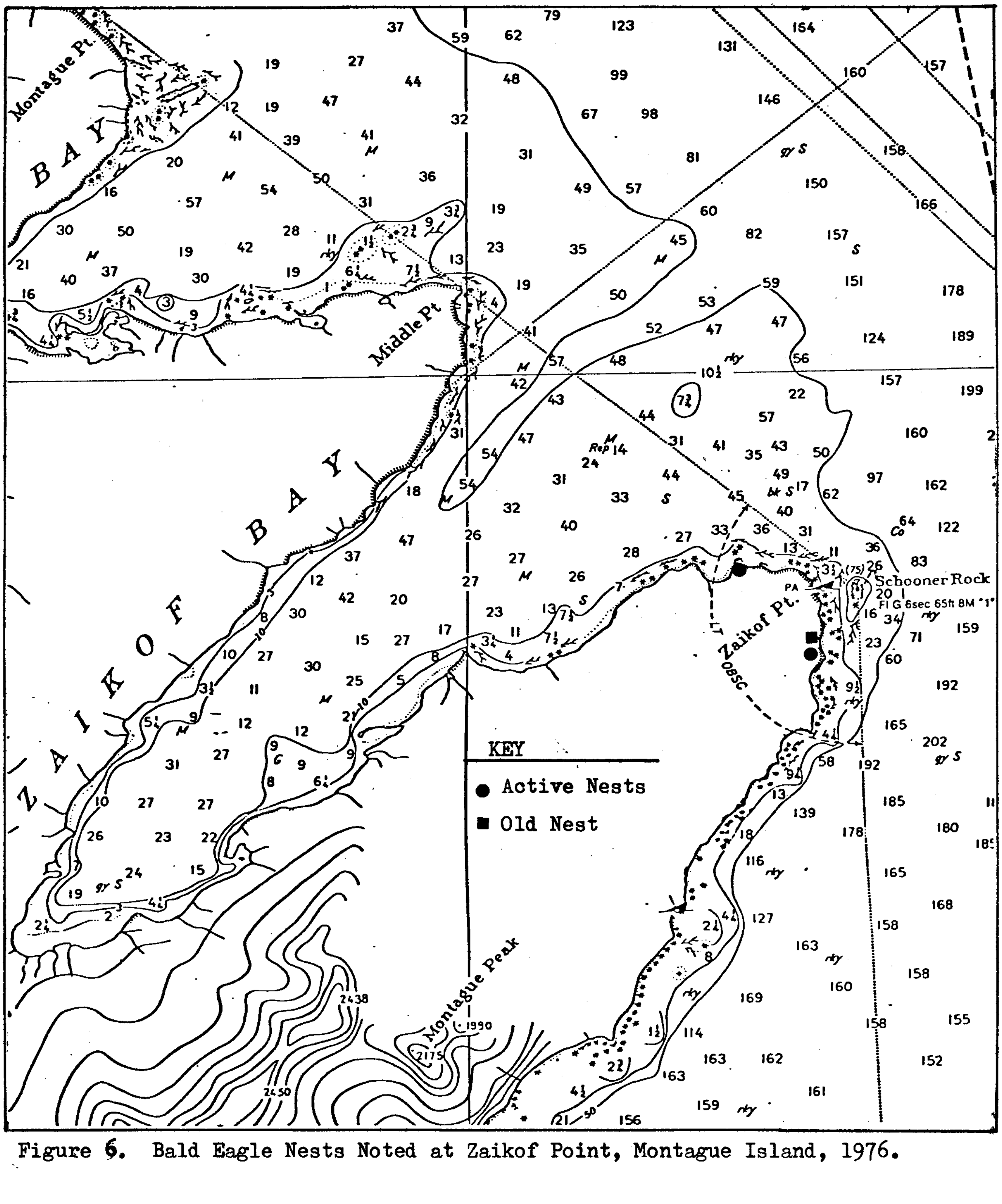


Figure 6. Bald Eagle Nests Noted at Zaikof Point, Montague Island, 1976.

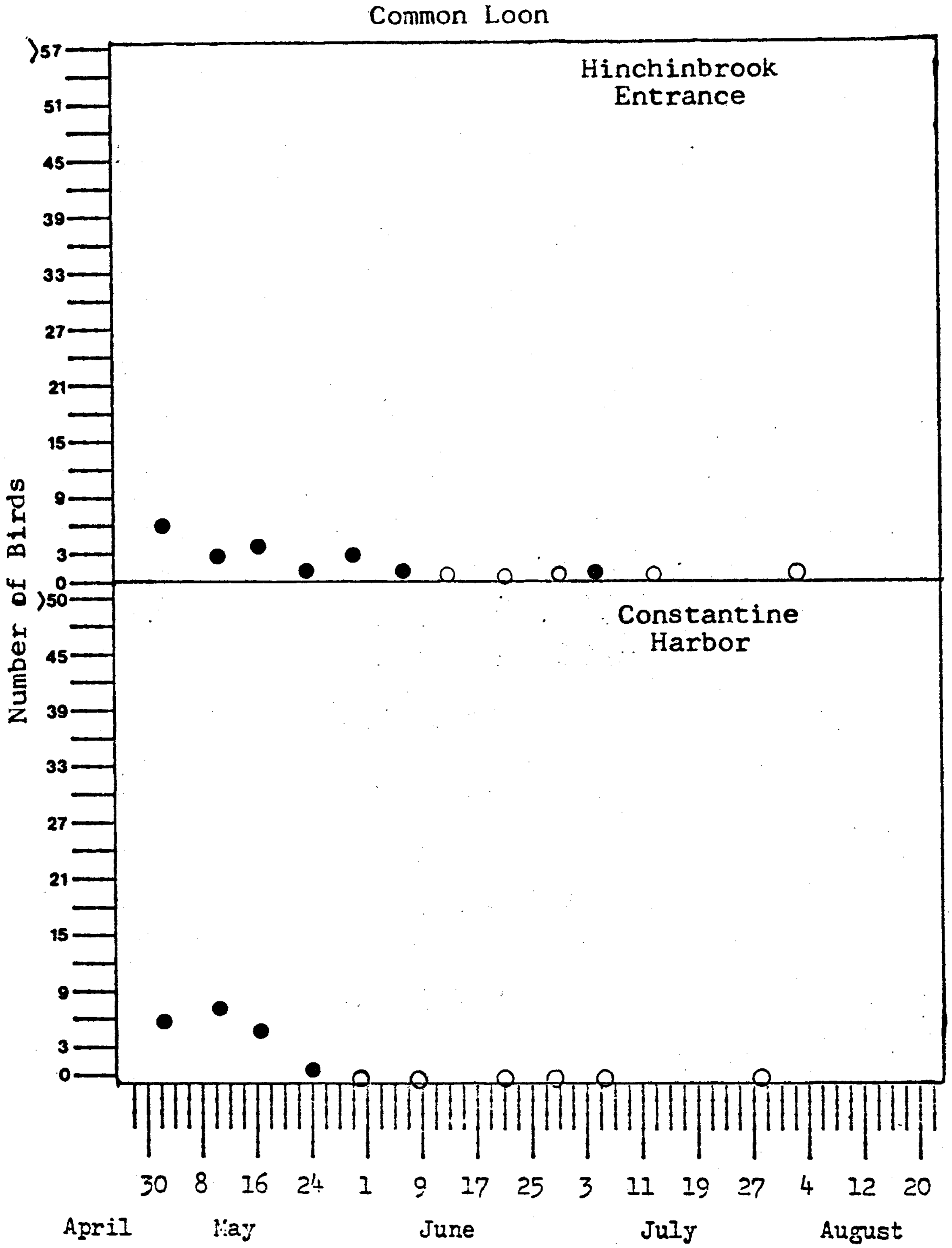


Figure 7. Highest Count of Common Loon for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

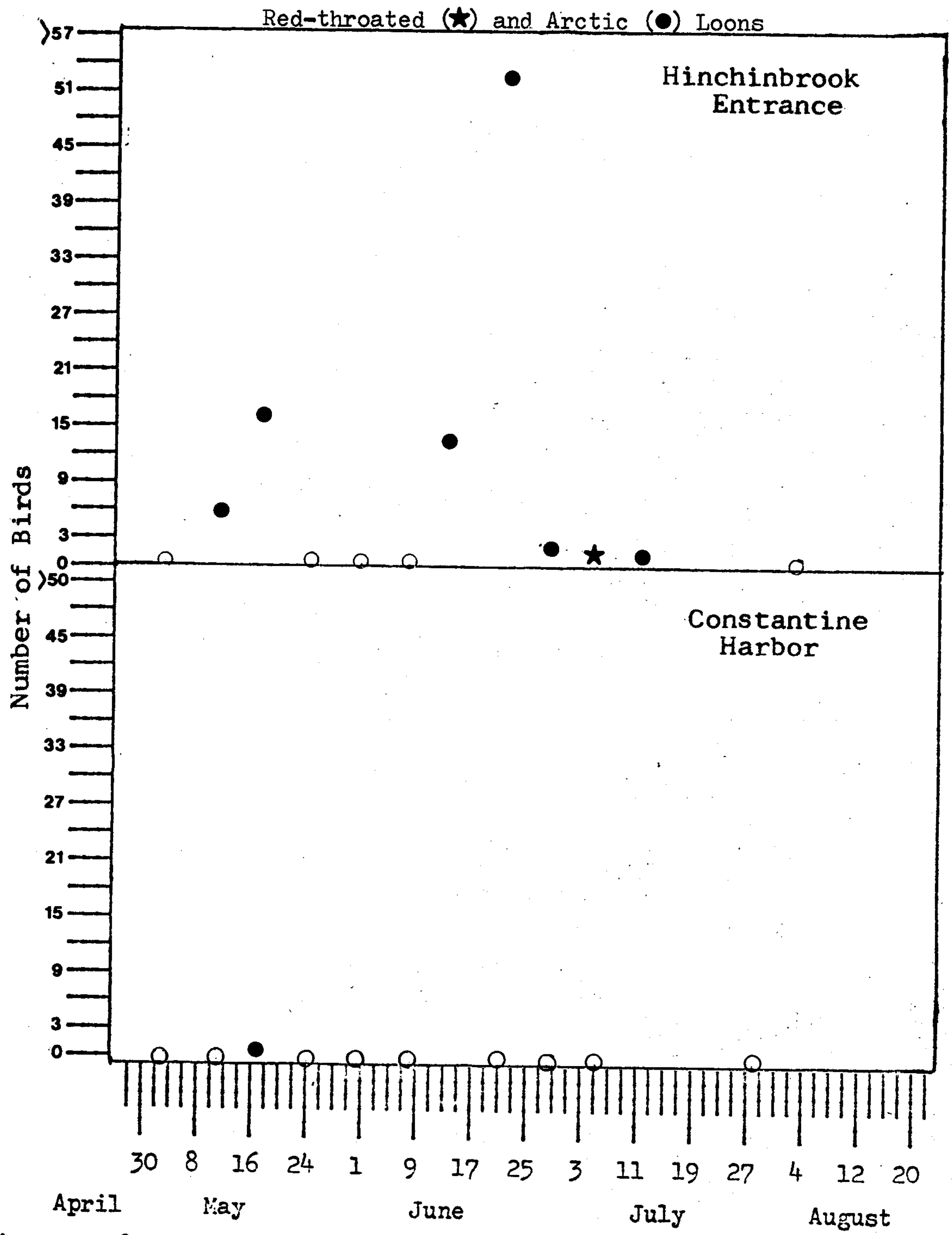


Figure 8. Highest count of Red-throated and Arctic Loon for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

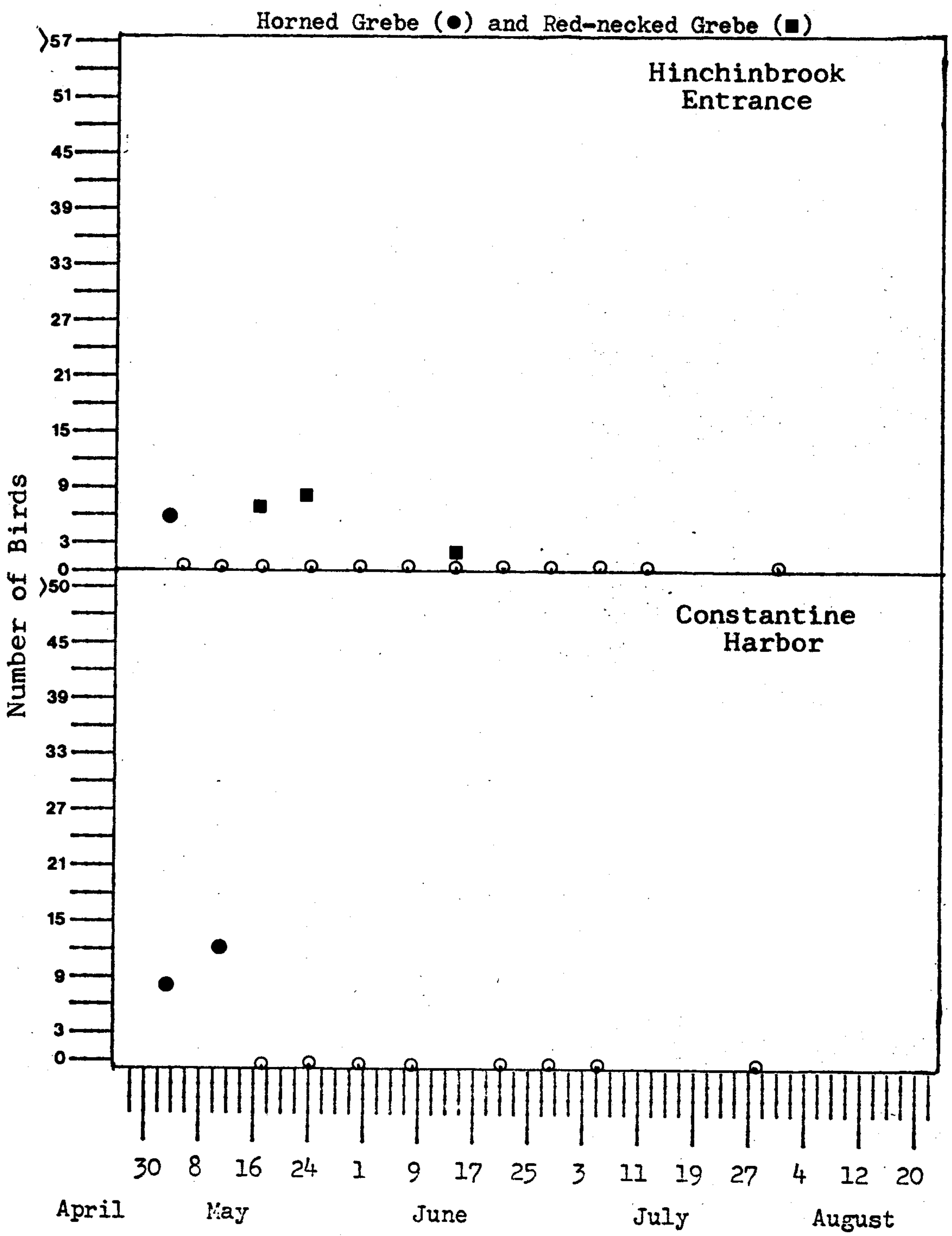


Figure 9. Highest Count of Horned and Red-necked Grebe for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of Horned Grebe on sea watch).

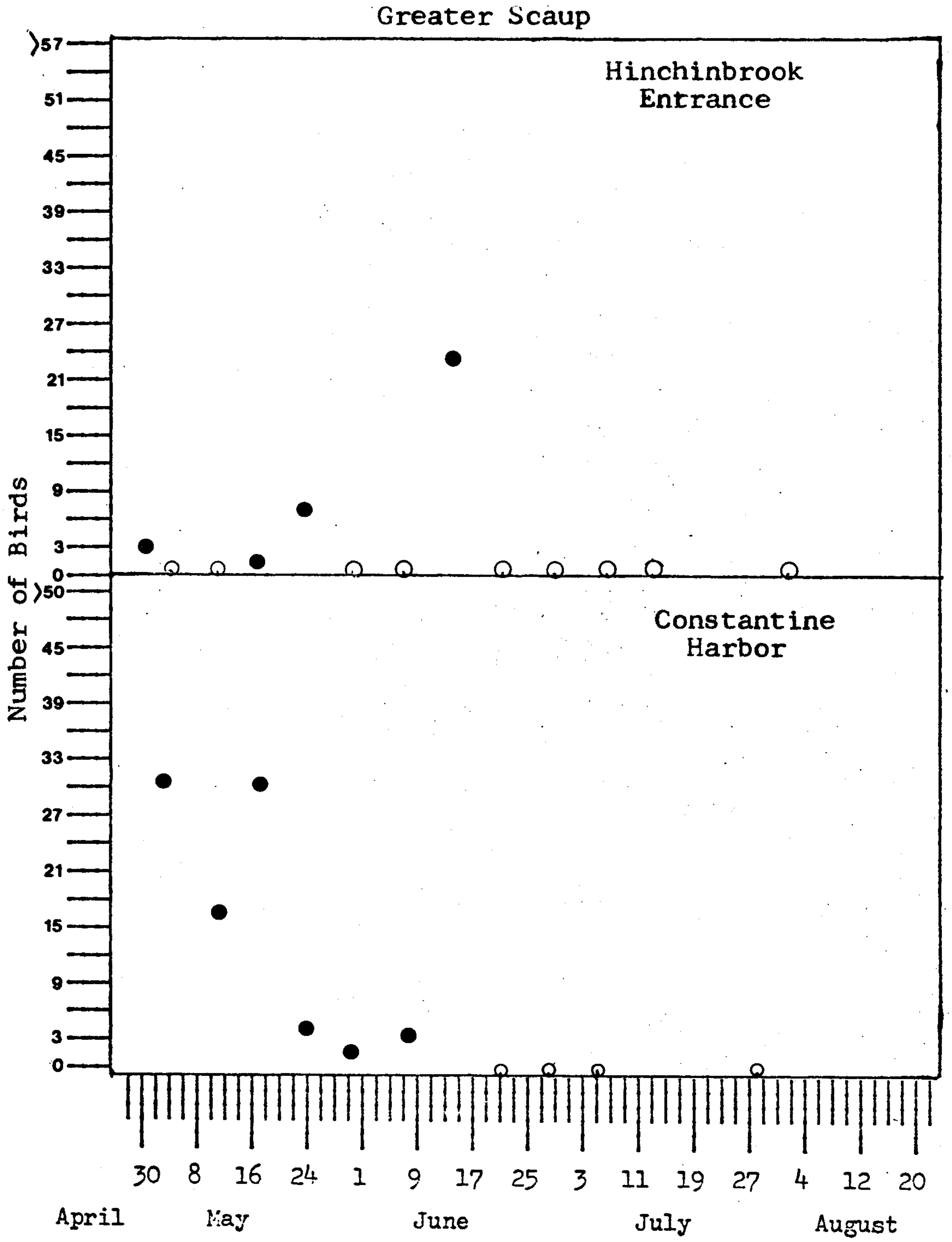


Figure 10. Highest Count of Greater Scaup for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

Bufflehead

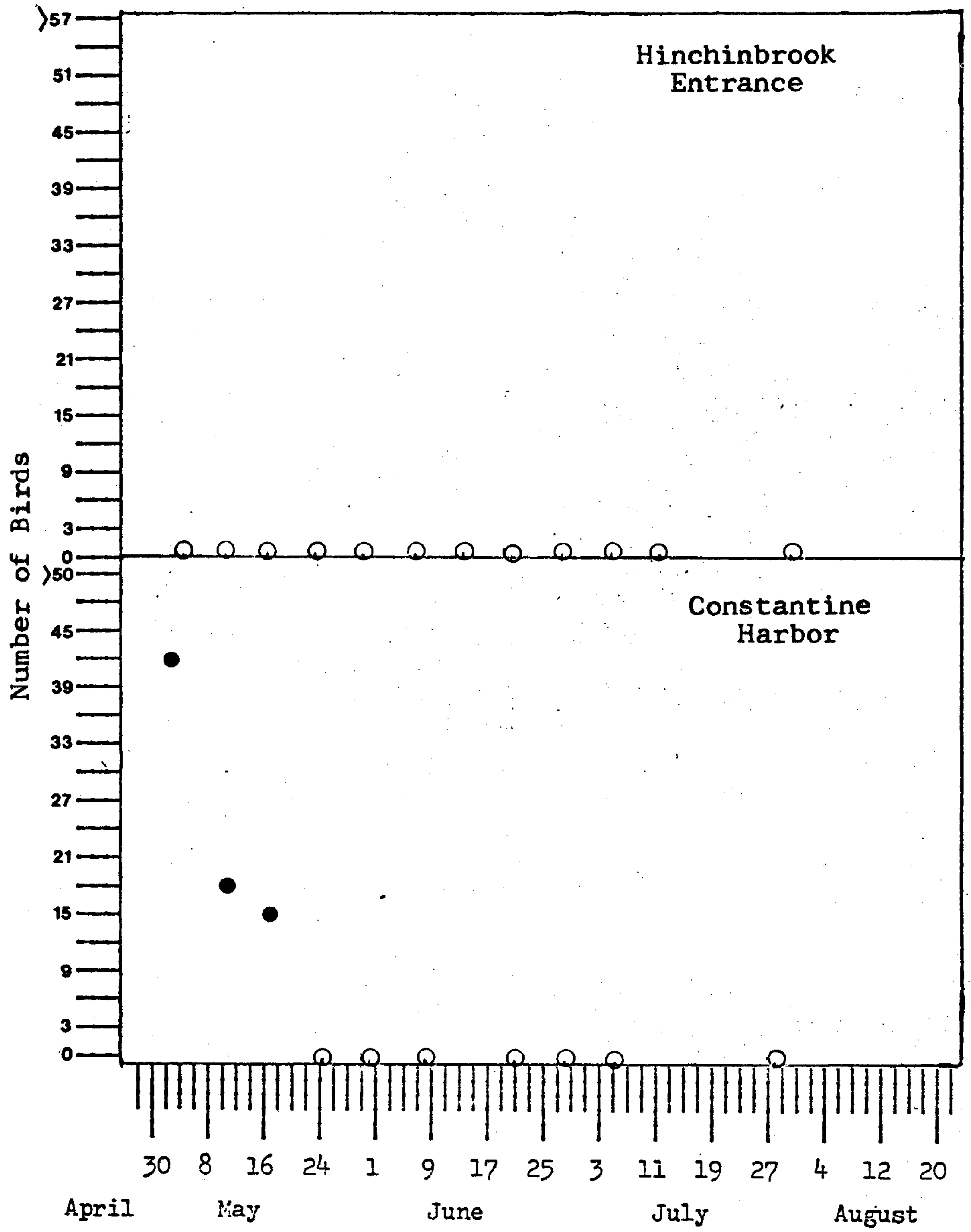


Figure 11. Highest Count of Bufflehead for Any One Sea Watch (per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

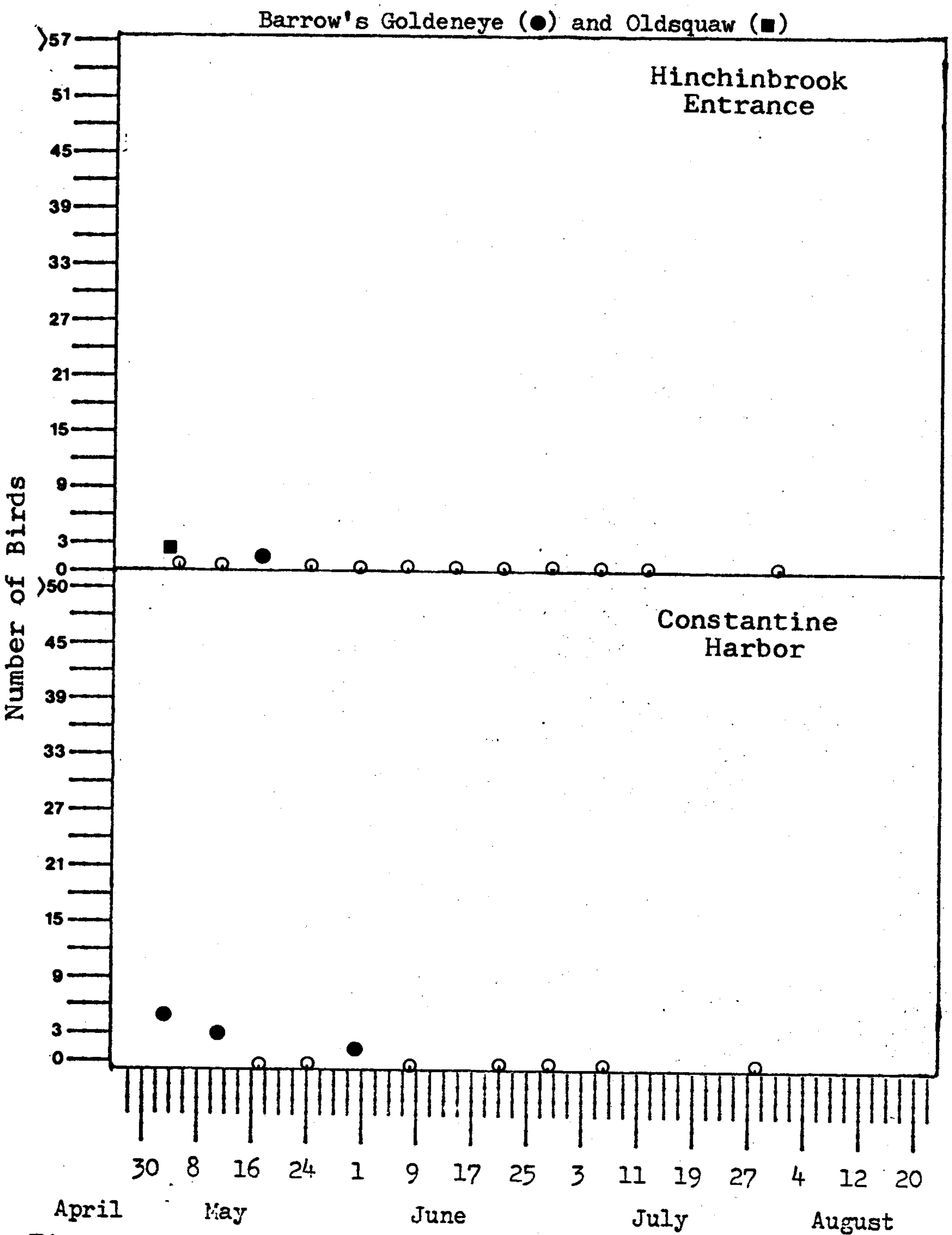


Figure 12. Highest Count of Barrow's Goldeneye and Oldsquaw for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

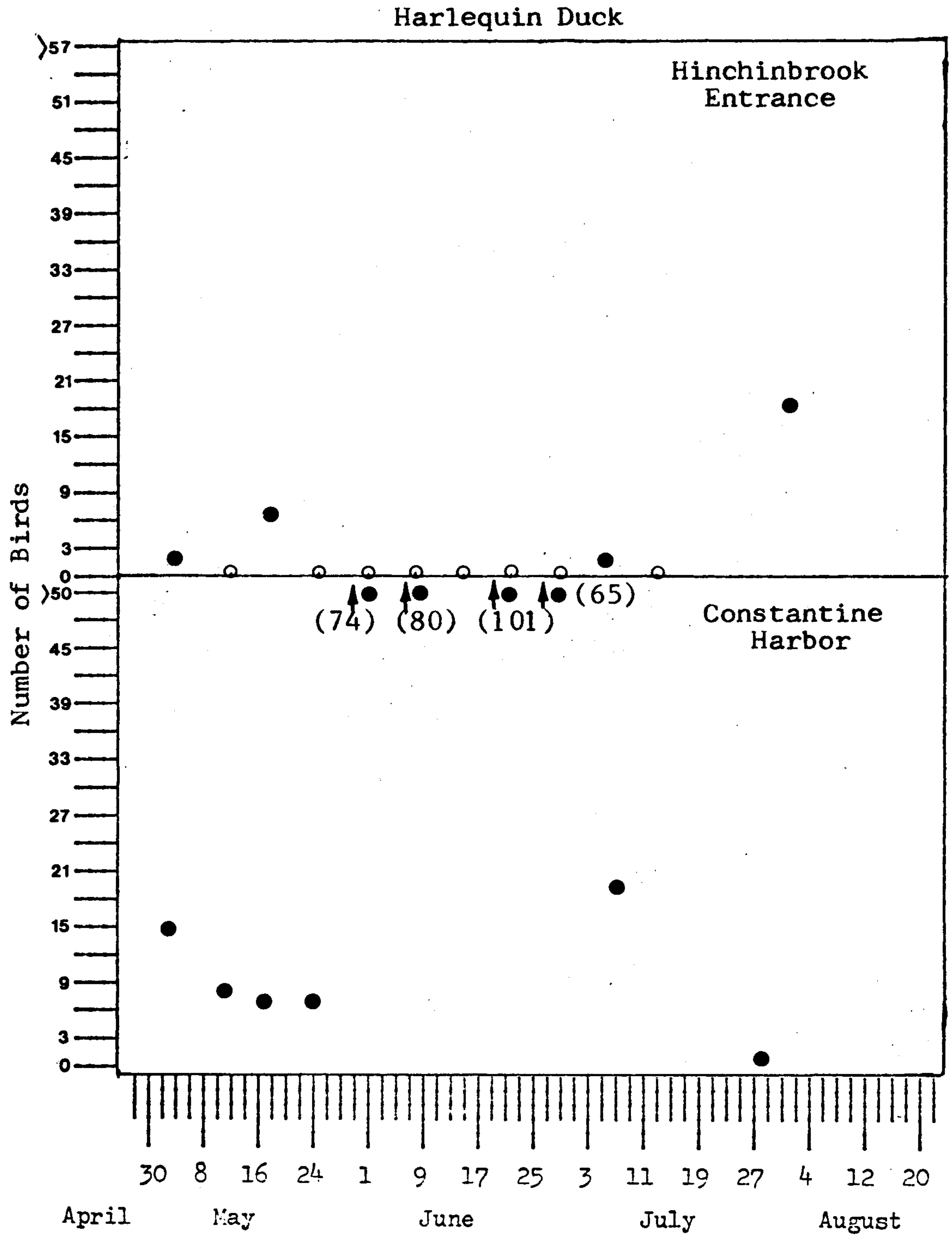


Figure 13. Highest Count of Harlequin Duck for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

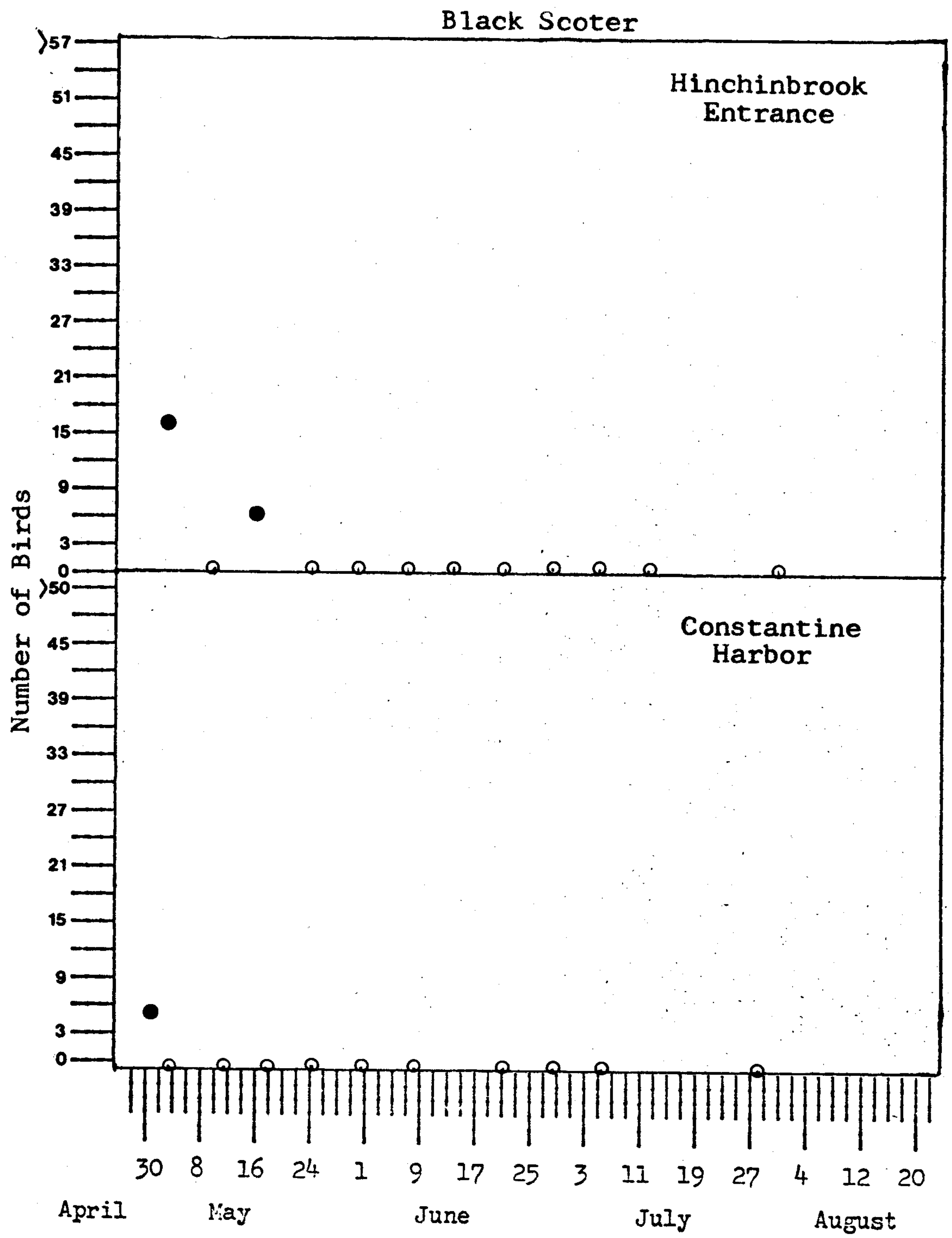


Figure 14. Highest Count of Black Scoter for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

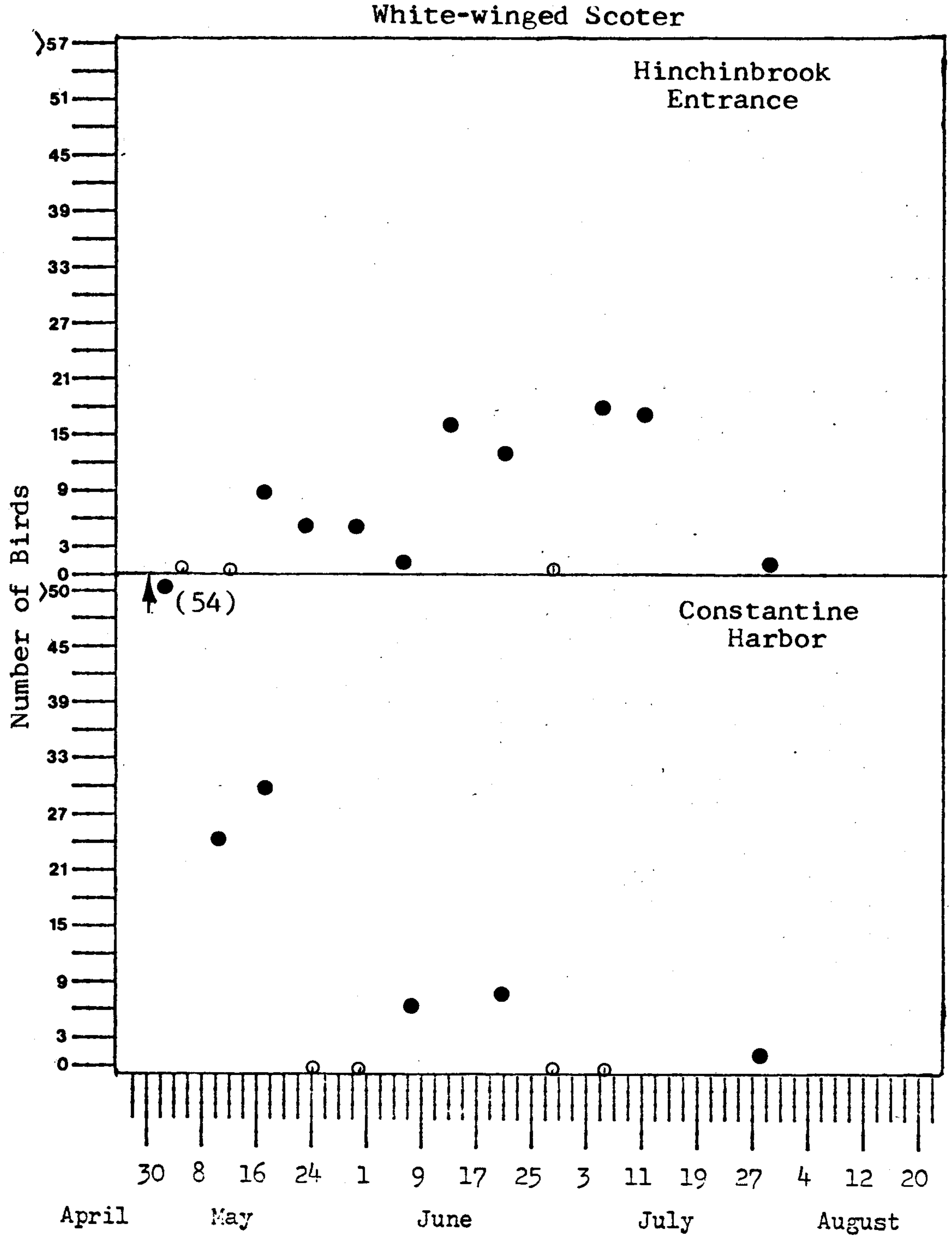


Figure 15. Highest Count of White-winged Scoter for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

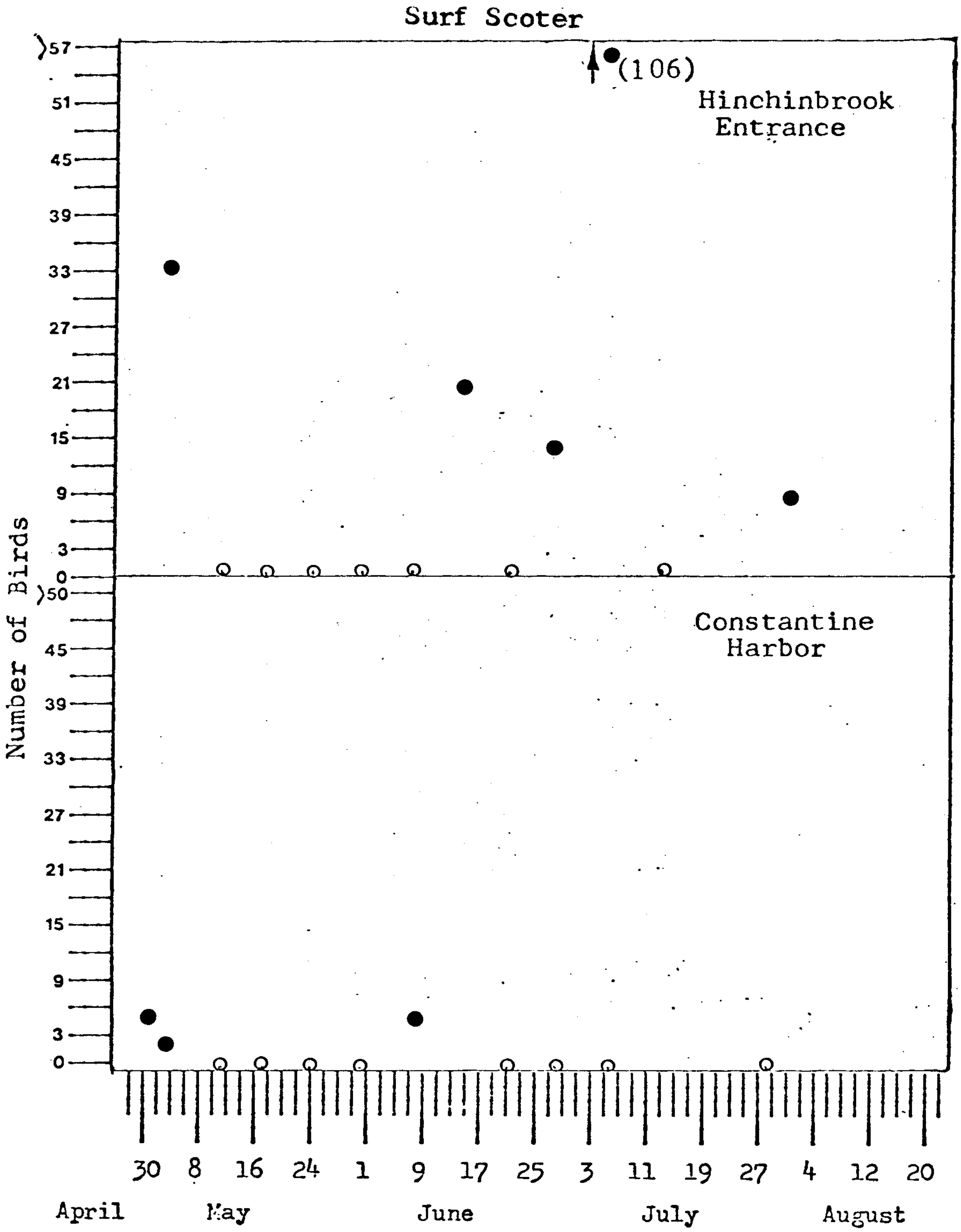


Figure 16. Highest Count of Surf Scoter for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

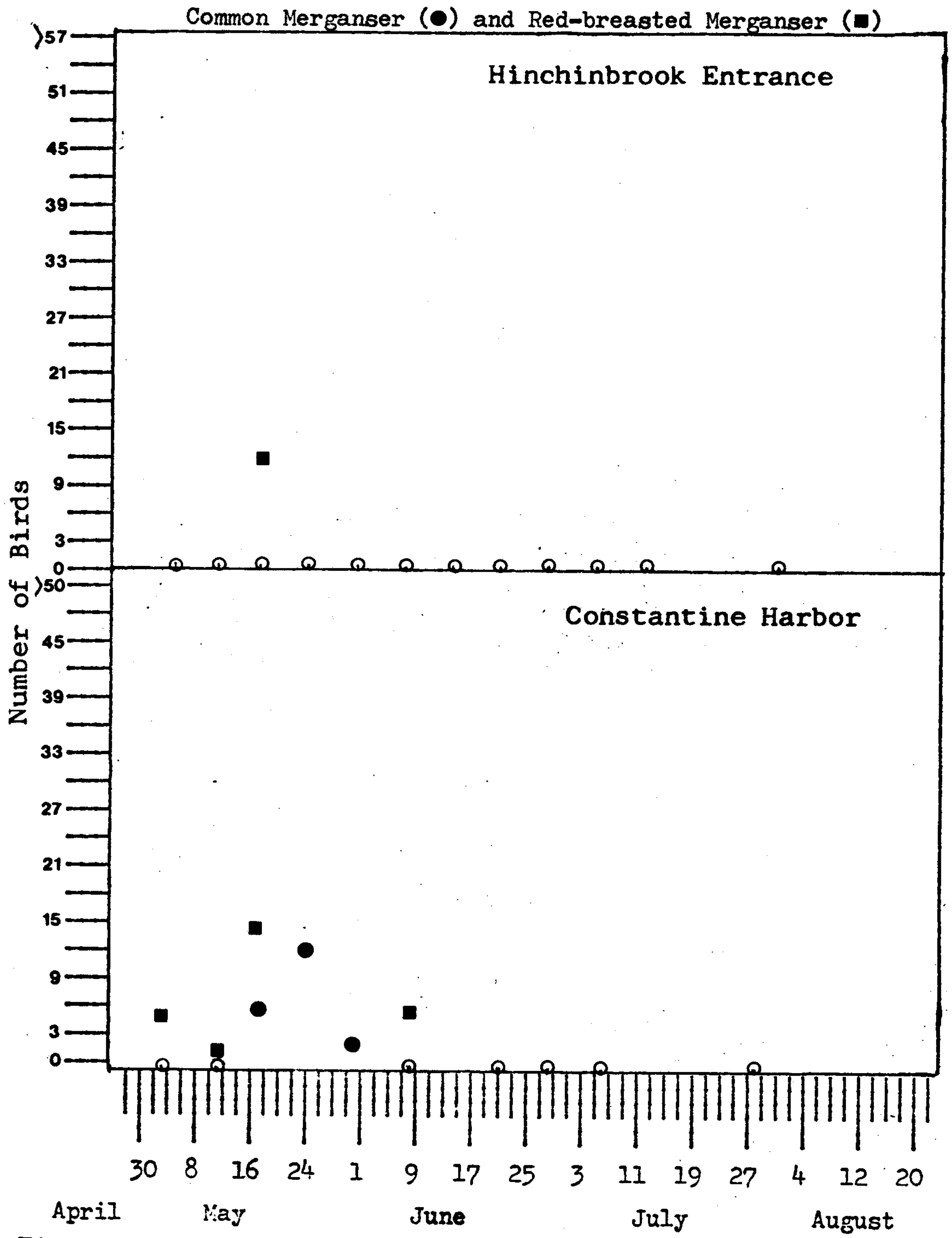


Figure 17. Highest Count of Common and Red-breasted Mergansers for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

Mew Gull

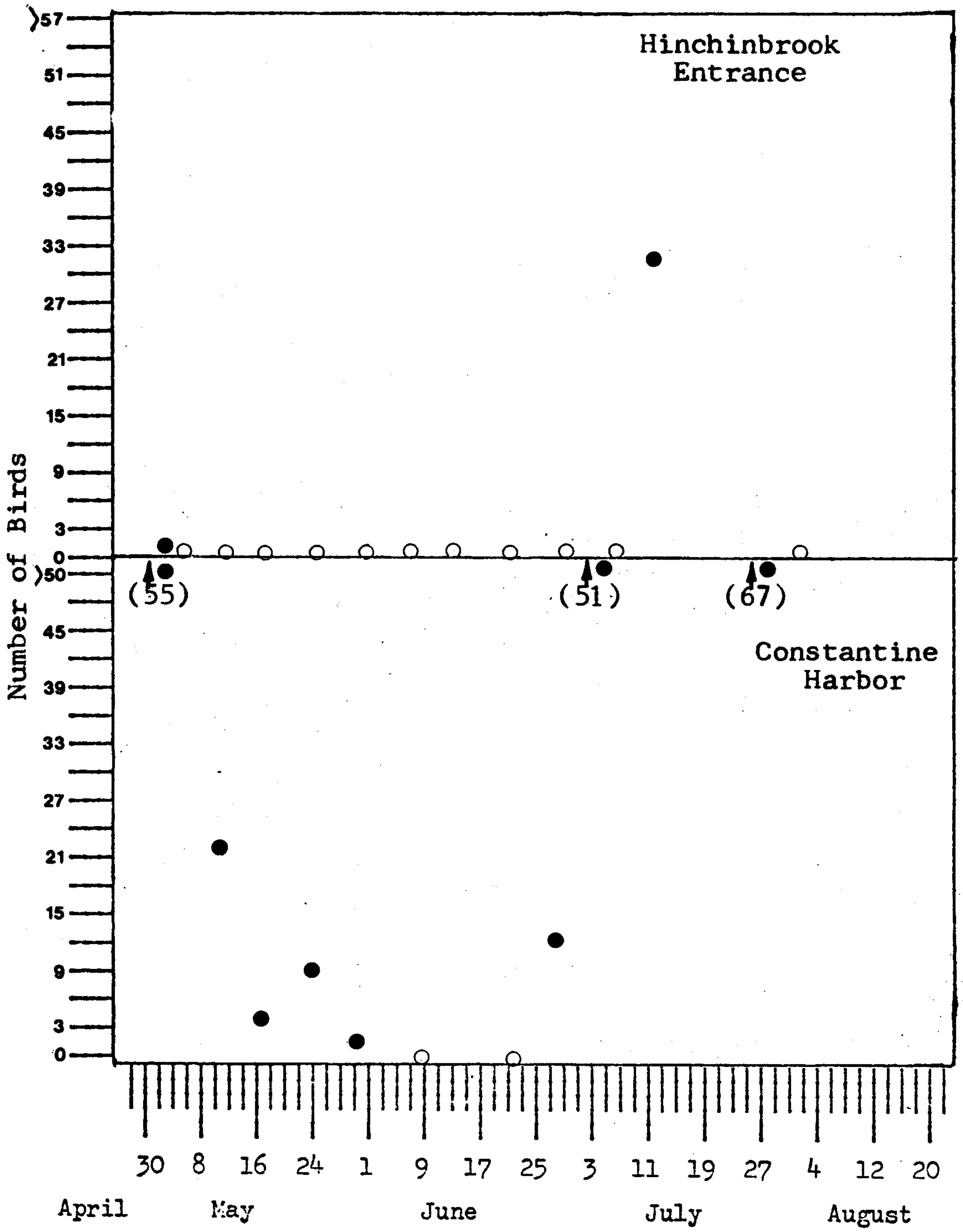


Figure 18. Highest Count of Mew Gull for Any One Sea Watch (per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

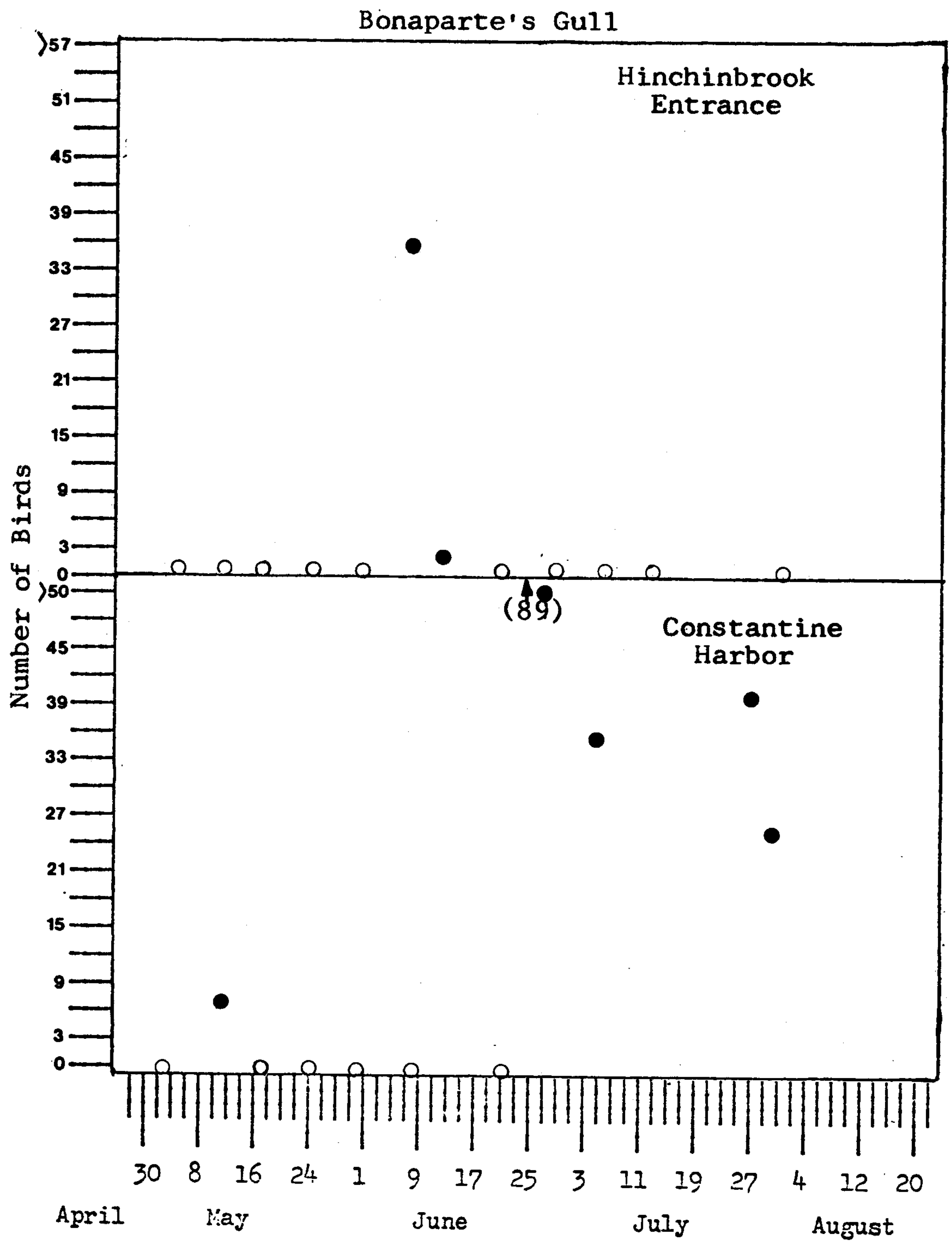


Figure 19. Highest Count of Bonaparte's Gull for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

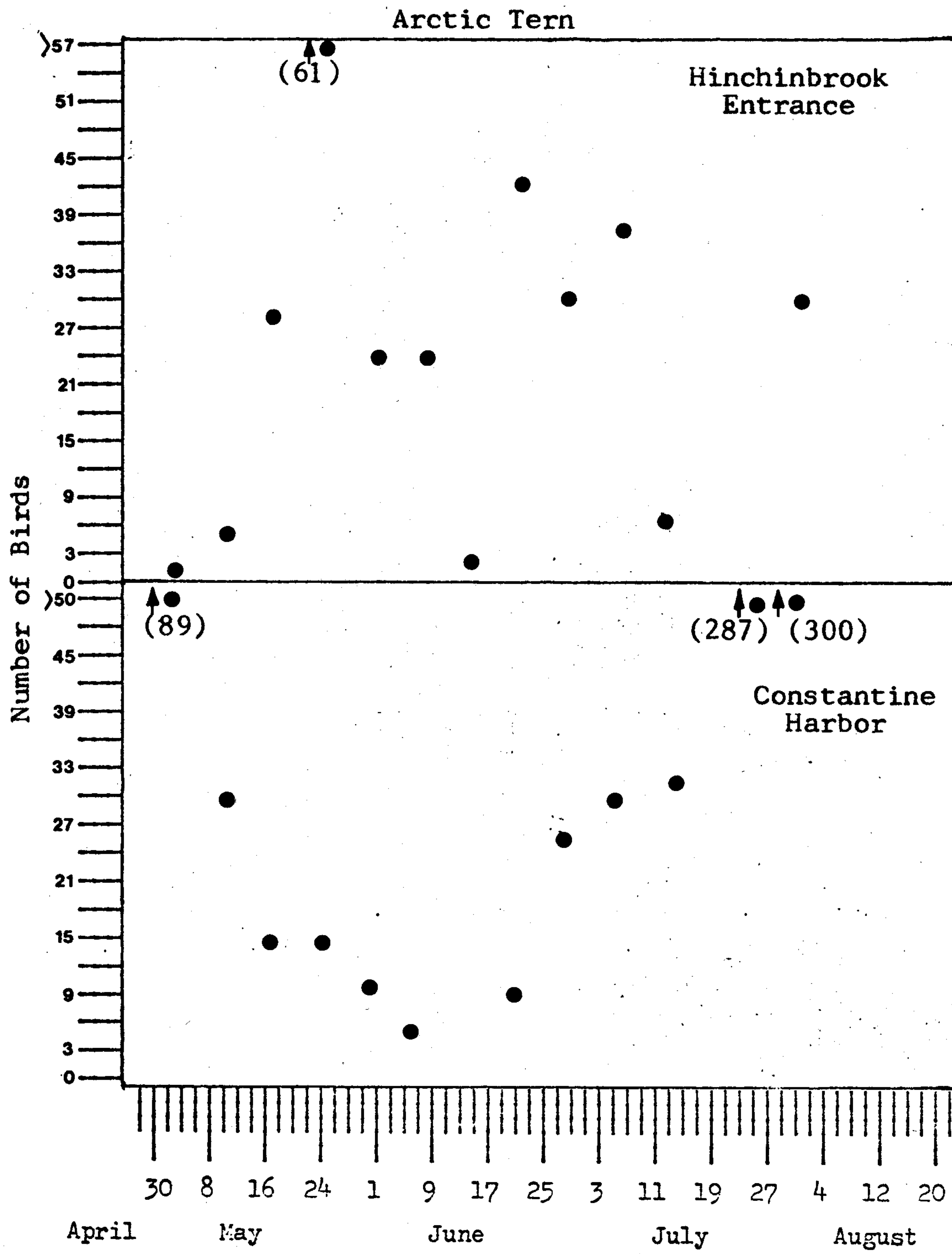


Figure 20. Highest Count of Arctic Tern for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

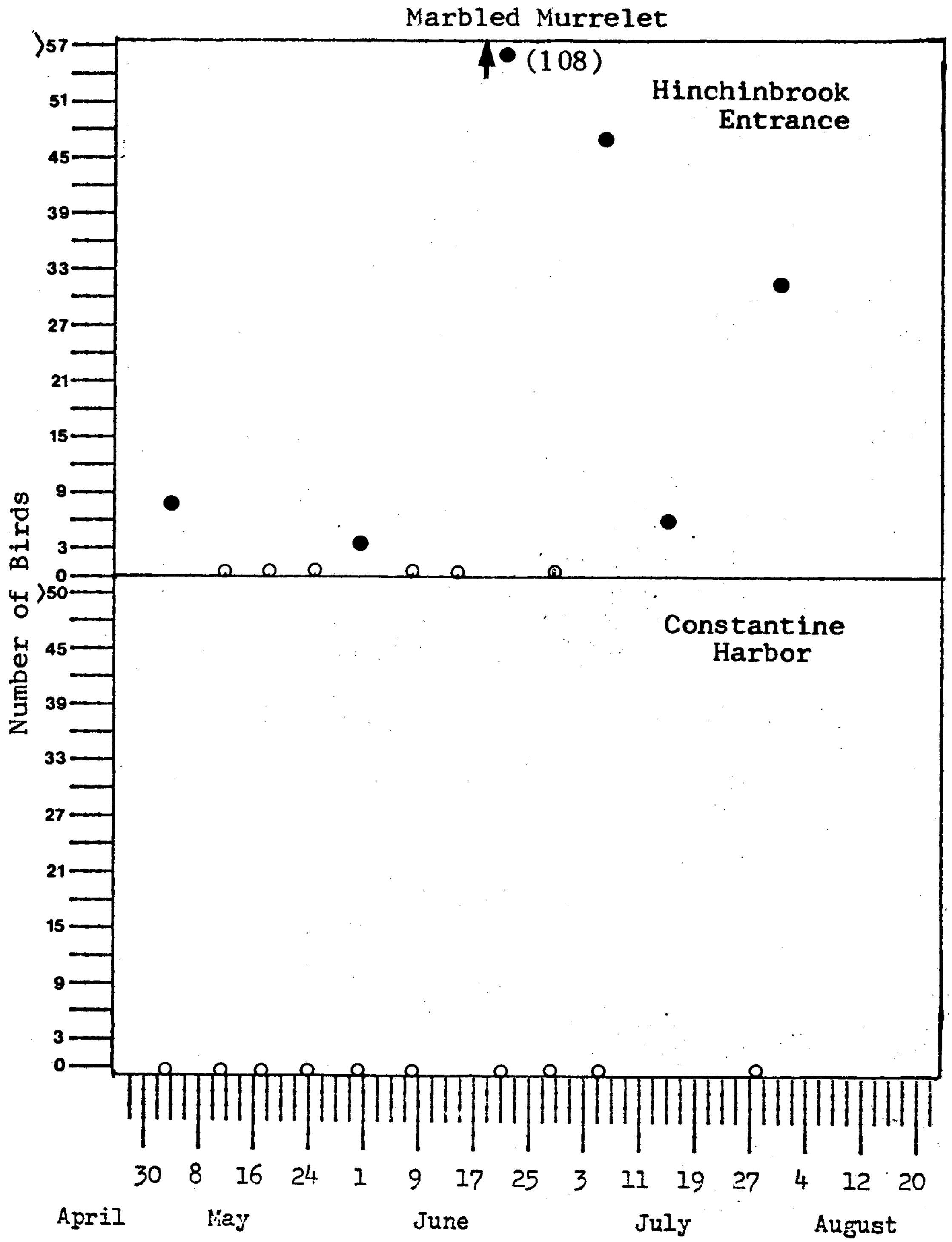


Figure 21. Highest Count of Marbled Murrelet for Any One Sea Watch(per day) for Two Marine Habitats, Hinchinbrook Island, 1976(o denotes absence of species on sea watch).

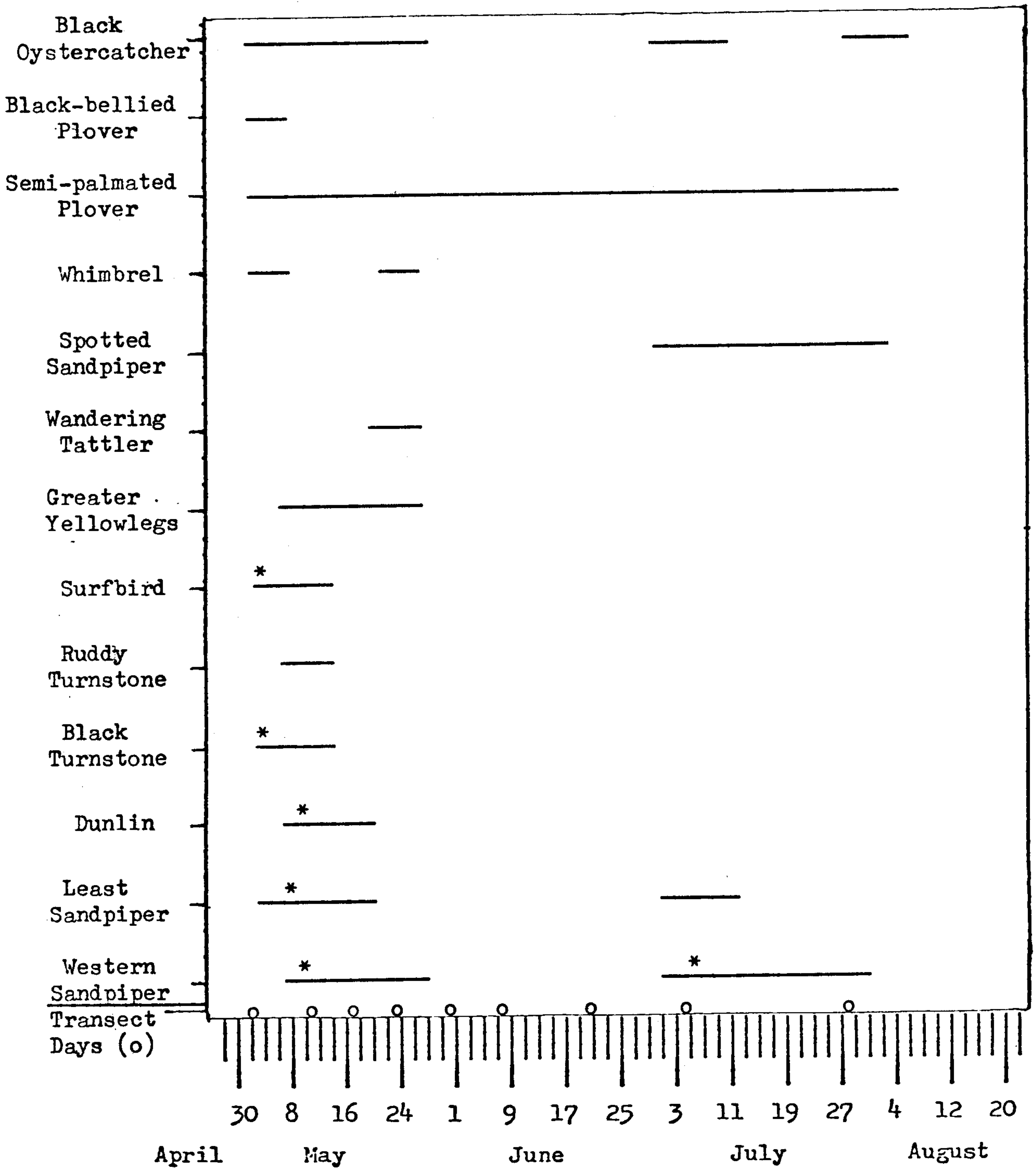


Figure 22. Occurrence (—) and Peak Migration (*) of Shorebirds on Shoreline Transect in Constantine Harbor, Hinchinbrook Island, 1976.

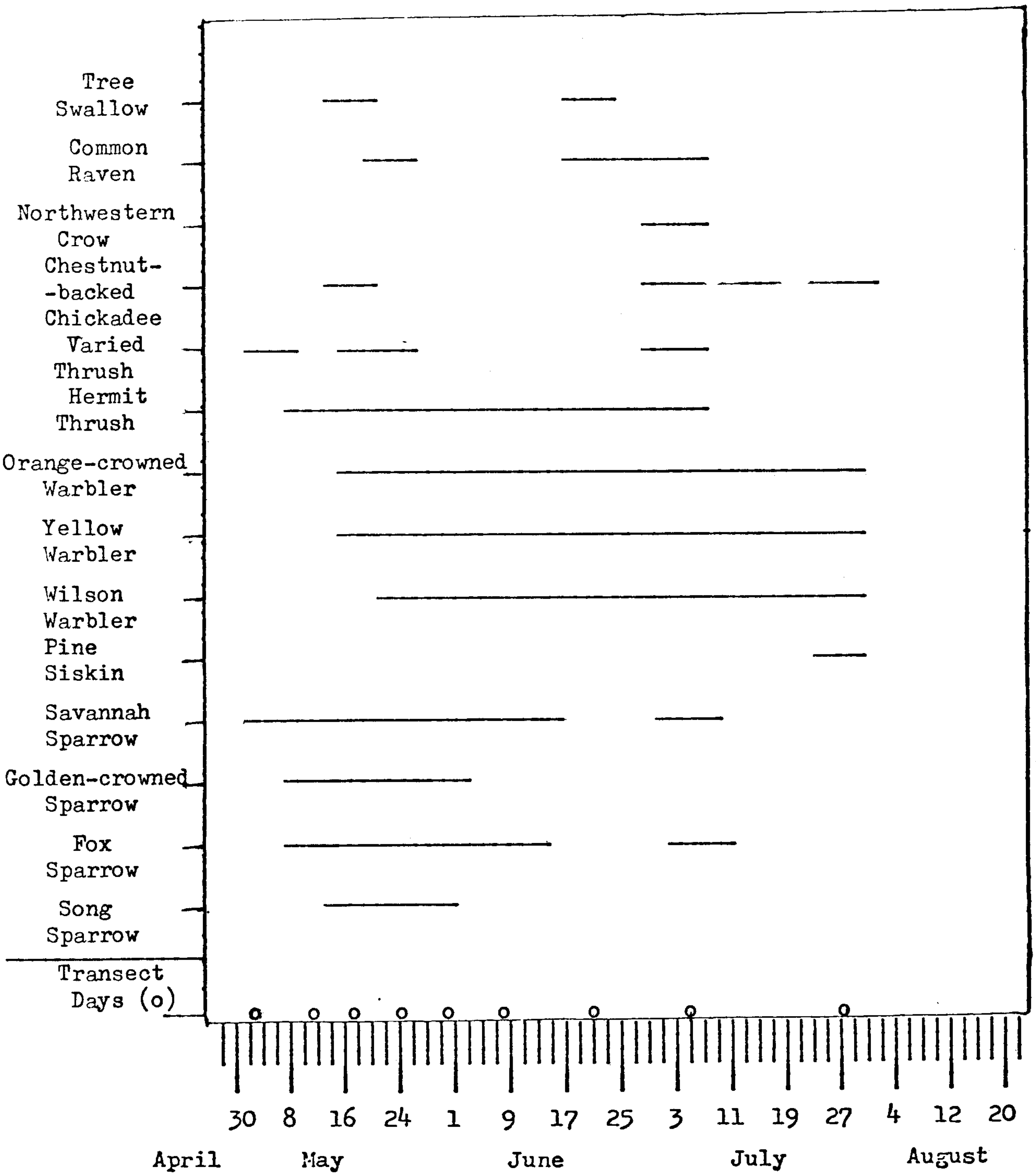


Figure 21. Occurrence (—) of Passerine Birds on Shoreline Transect in Constantine Harbor, Hinchinbrook Island, 1976(Note: Five other passerine species were seen once on transect: Alder Flycatcher, Winter Wren, Robin, Ruby-crowned Kinglet, and Lapland Longspur).

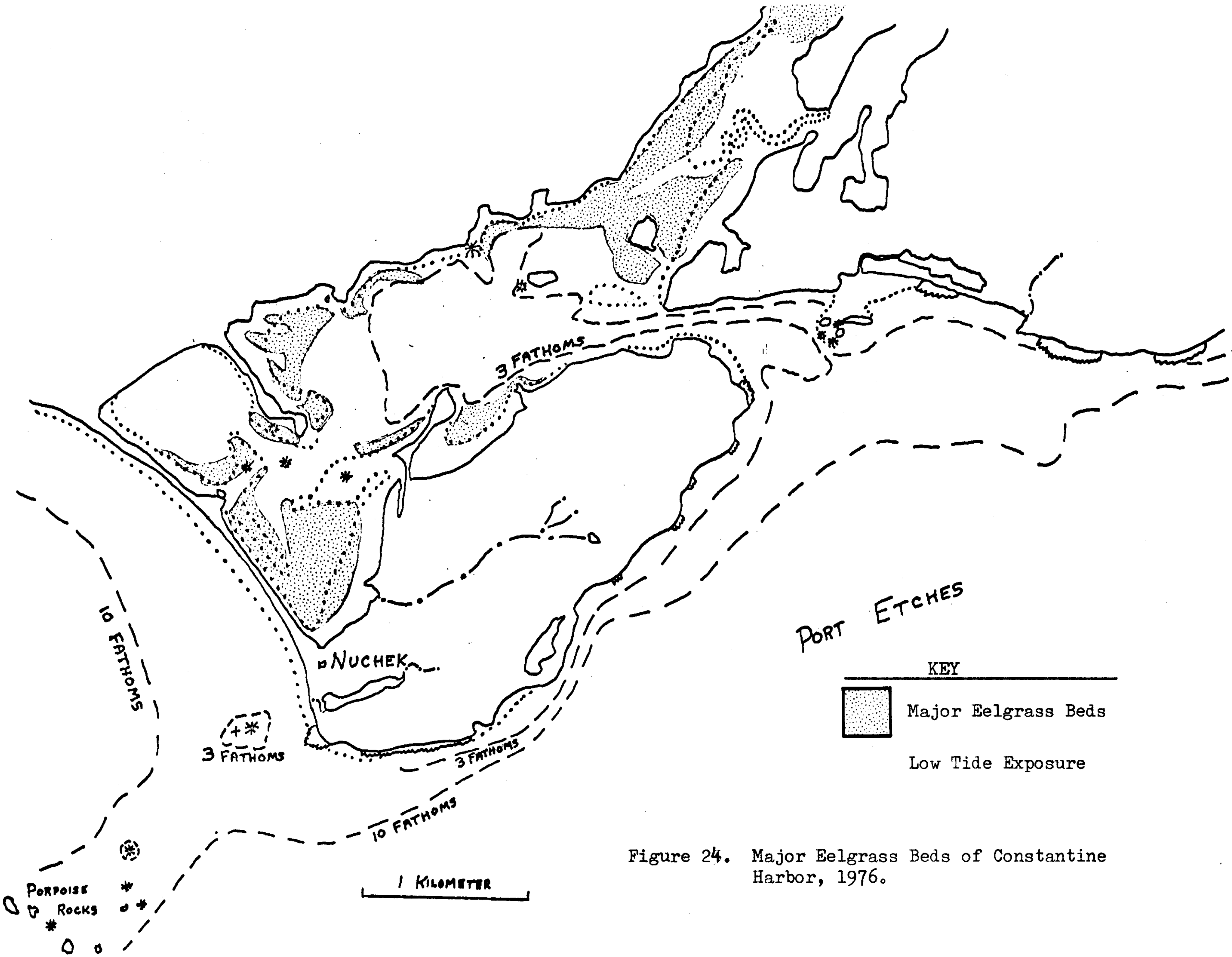


Figure 24. Major Eelgrass Beds of Constantine Harbor, 1976.

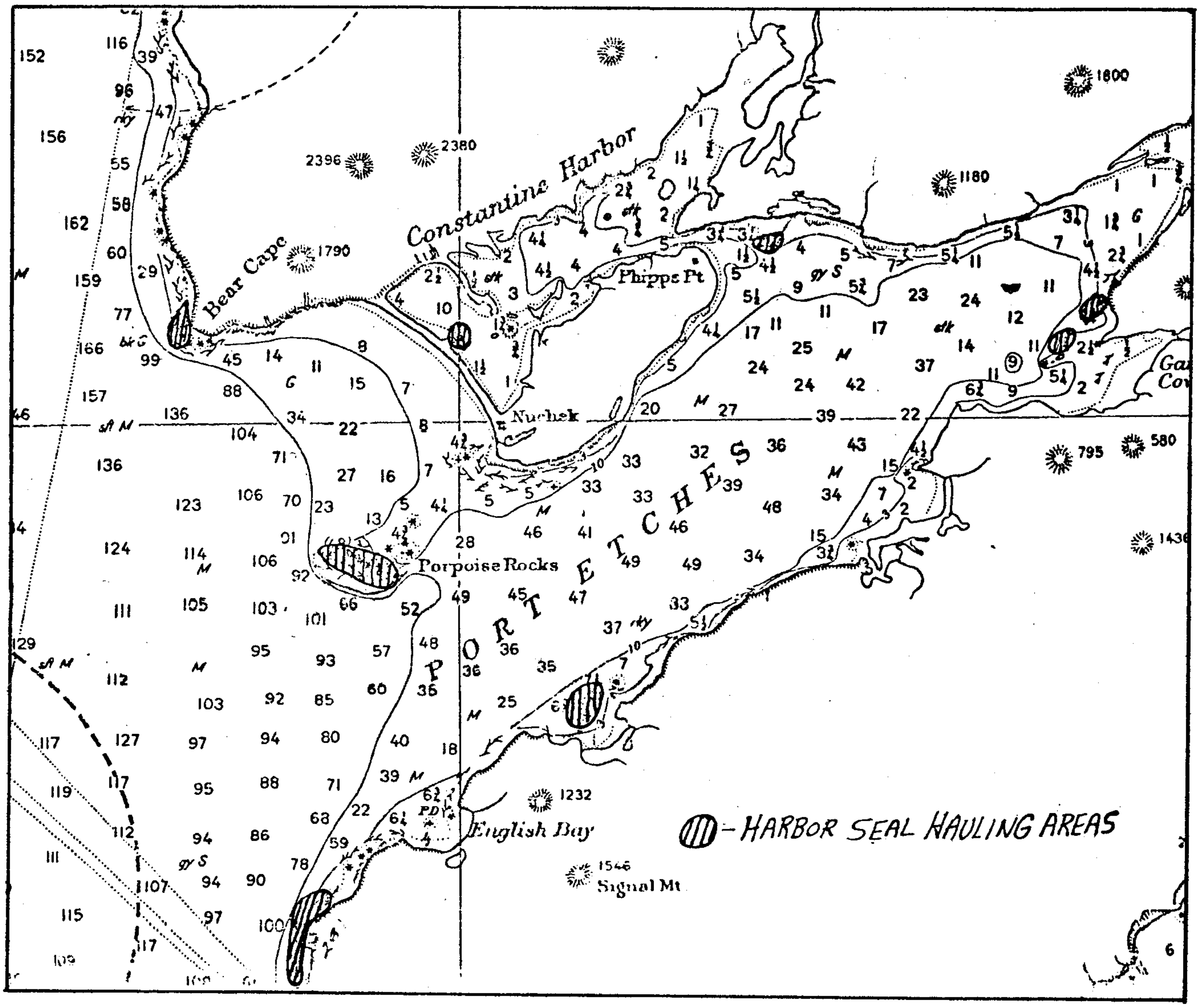


Figure 25. Harbor Seal Hauling Areas in the Port Etches-Constantine Harbor Vicinity, Hinchinbrook Island, 1976.

APPENDIX 1

ANNOTATED LIST OF BIRDS OBSERVED NEAR HINCHINBROOK ISLAND, 28 APRIL TO 4 AUGUST 1976

Gavia immer (Common Loon) - Seen regularly in low numbers in the spring.

Gavia arctica (Arctic Loon) - Seen regularly in the spring but large flocks again appeared in the last half of June.

Gavia stellata (Red-throated Loon) - One was seen on 28 April and one was seen on 5 July.

Podiceps grisegena (Red-necked Grebe) - Seen primarily in the spring.

Podiceps auritus (Horned Grebe) - Seen primarily in early May.

Oceanodroma furcata (Fork-tailed Petrel) - In July this species was observed near Seal Rocks in moderate numbers. Other individuals were seen the same month just south of Little Smith Island in Prince William Sound proper.

Phalacrocorax penicillatus (Brandt's Cormorant) - Although this species had been recorded nesting on Seal Rocks in the past, no nests were present in either June or July.

Phalacrocorax auritus (Double-crested Cormorant) - Common.

Phalacrocorax pelagicus (Pelagic Cormorant) - The most common cormorant species.

Olor sp. (unidentified swan) - The first week in Constantine Harbor (30 April) we discovered the carcass of a swan that had died one to two weeks earlier.

Branta canadensis (Canada Goose) - On 28 April a flock of 58 was seen migrating while the harbor appeared to have a resident population of about 10. By the first week of May all the local geese had moved from the harbor into the bogs where nesting occurred. However, many of the geese had apparently left the harbor for the bogs by the time we first arrived.

Anser albifrons (White-fronted Goose) - One flock (75-100) was seen migrating west along the outer coast of Montague Island on 28 April.

Anas platyrhynchos (Mallard) - Seen in low numbers throughout the spring and summer.

Anas acuta (Pintail) - Seen in low numbers in May with one individual seen in June. The major migration apparently just preceeded our arrival at Hinchinbrook Island.

Anas americana (American Wigeon) - Two were seen on 23 May and one was seen 30 May.

Aythya marila (Greater Scaup) - This was one of the two most common ducks in the Constantine Harbor area during early May. Twenty percent were males. By the end of the month this species had disappeared.

Bucephala clangula (Common Goldeneye) - One group of four females and one male were seen on 1 May.

Bucephala islandica (Barrow's Goldeneye) - This was the most common goldeneye seen. Low numbers were seen in May and July. One brood was seen in late July.

Bucephala albeola (Bufflehead) - This was the second of the two most abundant ducks seen in the Constantine Harbor area in early May. Males constituted 40-50% of the flocks. This species also left by the end of the month.

Clangula hyemalis (Oldsquaw) - Low numbers were seen primarily in the first half of May. Two individuals were seen in Zaikof Bay on 4 July.

Histrionicus histrionicus (Harlequin Duck) - Up until the first week of May males were 50% of the birds observed. From the end of May to the end of June large flocks of molting males congregated in Constantine Harbor and dominated the population. In July three Harlequin broods (5, 4, and 9 chicks in each brood) were observed moving down the major stream at the head of Constantine Harbor.

Melanitta deglandi (White-winged Scoter) - Were seen throughout the field season. The largest numbers recorded were in late June, but it is possible that migrants passed through the study area before our arrival. Several places in Port Etches as well as the Cordova mudflats in Hawkins Cutoff area had molting flocks of two species of scoters.

Melanitta nigra (Black Scoter) - Seen only in early May in low numbers.

Melanitta perspicillata (Surf Scoter) - Seen in low numbers in April and May. Large numbers reappeared in June and July with the peak on 5 July.

Mergus merganser (Common Merganser) - Peak numbers during migration came on 24 May roughly. Some birds were resident the whole summer. One brood of 6 was seen on 15 July while another brood of 7 chicks was seen on 29 July. The appearance of these broods coincided with the appearance of the Harlequin broods.

Mergus serrator (Red-breasted Merganser) - This species was primarily seen during April and May with peak numbers around 17 May. Low numbers were seen occasionally in June and July.

Haliaeetus leucocephalus (Bald Eagle) - This species was extremely abundant with many nests scattered along shorelines. Nests required some effort to locate because of the abundant timber. Five active nests, two inactive nests, and one probable active nest were discovered in the Constantine Harbor-Bear Cape area, the Zaikof Point of Montague Island, and Cape Hinchinbrook. More would have been discovered if time and manpower were available. Seabirds were heavily utilized for food in June by the resident eagles at Constantine Harbor. In July salmon runs became the primary food source. One immature eagle was found dead on 18 May in Constantine Harbor.

Circus cyaneus (Marsh Hawk) - One individual male was seen on 1 May while another of unknown sex was seen on 3 May. On 11 May an immature or female was found dead in Constantine Harbor and which appeared to have starved (deterioration of muscle and protruding of sternum).

Canachites canadensis (Spruce Grouse) - One pair was first seen on 28 May near the field camp. The same pair apparently was seen two more times later in the summer at the field camp.

Lagopus mutus (Rock Ptarmigan) - This species was common at or above timberline. On 11 June three birds were noted that were still in winter plumage.

Grus canadensis (Sandhill Crane) - The last three days of April were sunny and clear. During that time a dozen flocks totaling 1080 birds were observed flying west along the mountains north of Constantine Harbor. They flew between 1200 and 1500 feet in elevation heading northwest after leaving Hinchinbrook Island. On 1 May severe storms set in and no more flocks were heard. Isleib (pers. comm.) reported that at this time cranes continued along the north shore of the Sound instead of cutting across it as they did in the good weather.

Haematopus bachmani (Black Oystercatcher) - Nested commonly on gravel spits or peninsulas. All nests (except one probable) were located in the western half of Constantine Harbor. Post-breeding flocks began to appear in the harbor by the end of July.

Charadrius semipalmatus (Semipalmated Plover) - This was the most abundant breeding shorebird in Constantine Harbor. Nest sites were most common in the western half of the harbor.

Pluvialis squatarola (Black-bellied Plover) - Two individuals were seen on both 1 and 3 May.

Aphriza virgata (Surfbird) - Large numbers were seen the last week of April and the first week of May. This species left the area completely by 16 May but returned in early July and was common in numbers from 8 July through the rest of the summer.

Arenaria interpres (Ruddy Turnstone) - One was seen on 30 May.

Arenaria melanocephala (Black Turnstone) - The largest numbers were seen during the first and second week of May, but all were gone by the 16th of May. Two were observed on 31 July.

Capella gallinago (Common Snipe) - This species was first noticed on 24 May in the bogs near Nuchek. On 28 May there were 2-3 displaying birds making their courting flights and calls in the same vicinity.

Numenius phaeopus (Whimbrel) - Low numbers were occasionally seen through May. None were seen in June but on 22 July they returned to the harbor with the largest numbers seen during that last week of July.

Actitis macularia (Spotted Sandpiper) - Although a few were seen earlier, this species became most evident in July when adult birds began moving their broods to shoreline habitats of Constantine Harbor.

Heteroscelus incanus (Wandering Tattler) - This species was first noticed on 23 May. Large numbers remained until the first week of June. Returning migrants were observed during the last week of July.

Tringa melanoleucus (Greater Yellowlegs) - This species nested commonly in local bogs and wet meadows. A flock of 16 observed on 22 July indicated the beginning of the return migration.

Calidris melanotos (Pectoral Sandpiper) - One individual was observed on 14 May.

Calidris minutilla (Least Sandpiper) - The largest numbers were associated with spring migration in the first half of May. Thereafter low numbers were found breeding in scattered bog and wet meadow areas. Numbers increased in July as some fall migration began and breeding birds nesting locally began to bring broods to the harbor shoreline.

Calidris alpina (Dunlin) - The peak migration appeared to be the second week of May. This species had left the area by 16 May.

Limnodromus griseus (Short-billed Dowitcher) - Some initial fall migration was noted when five individuals were noted feeding in Gibbon Anchorage, Green Island, on 22 July.

Calidris mauri (Western Sandpiper) - This was probably the dominant shorebird in migrant flocks of shorebirds found in Constantine Harbor during the first two weeks of May. This species had left the area by the end of the month. A flock (103 individuals) was observed on 5 July denoting the beginning of the return migration.

Lobibes lobatus (Northern Phalarope) - Low numbers were observed in early May. On 21 July large flocks were observed feeding along windrows in the middle of Hinchinbrook Entrance.

Larus hyperboreus (Glaucous Gull) - One second year immature was observed in Constantine Harbor on 7 May. Another immature was noted on 7 June.

Larus glaucescens (Glaucous-winged Gull) - This was the most common large gull found in Constantine Harbor during the summer.

Larus argentatus (Herring Gull) - Some individuals were noted when we first arrived on 28 April. They soon left the area and only a few individuals of this species were seen during the summer.

Larus canus (Mew Gull) - This species was present by our arrival in April. Numbers increased to a peak during the first week of May, but the species had left the area by the end of the month. On 18 June immature individuals appeared at the harbor. By the 28th of June and throughout the rest of the summer, large numbers including many immatures were present in Constantine Harbor.

Larus philadelphia (Bonaparte's Gull) - Seven adults were noted in Constantine Harbor on 11 May. On 14 June immatures were noted in gull resting flocks. By 28 June a flock of six adults and eighty-three immatures was observed in the harbor. There were large numbers of this species present the rest of the summer.

Rissa tridactyla (Black-legged Kittiwake) - This was the most common gull in the straits, but a few would occasionally come into Constantine Harbor.

Sterna paradisaea (Arctic Tern) - This species foraged in Constantine Harbor more frequently than other species. The terns appeared to feed on the schools of small fish there. A few sampling efforts identified chum and pink salmon parr or fingerlings as part (if not the major part) of these schools. Towards the end of July there was a large influx of terns into the harbor. The numbers (300+) increased 600% over the normal level of the breeding population. These high numbers continued until our departure. Protected waters such as in Constantine Harbor may be staging areas for fall migrations of this species.

Sterna aleutica (Aleutian Tern) - Two individuals were observed near Boswell Bay on 24 June.

Uria aalge (Common Murre) - One of the larger breeding colonies of the North Gulf of Alaska is located at Porpoise Rocks.

Cepphus columba (Pigeon Guillemot) - This species is common in appropriate habitat throughout the Prince William Sound region. The highest breeding densities were observed at Big Smith Island.

Brachyramphus marmoratus (Marbled Murrelet) - The first subadult was observed on 6 July but we believed this was a second year bird. On 29 July the first immatures (hatched this year) were observed. Hence, the movement of chicks to sea must have occurred sometime during the last week of July. Low productivity was indicated by the presence of only 4-5 immatures for every 50 adults in feeding flocks.

Brachyramphus brevirostris (Kittlitz's Murrelet) - One of the four murrelets collected turned out to be this species. The specimen had a fully shelled egg low in the reproductive tract (27 May) indicating that the species nested within the study area.

Cyclorrhynchus psittacula (Parakeet Auklet) - On 20 and 24 June small groups of this species were seen near Porpoise Rocks. On 21-22 July over 400 birds were observed at the colonies at Little and Big Smith Islands. These islands constitute the farthest east extension of this species' known breeding range.

Fratercula corniculata (Horned Puffin) - This species is common in low numbers in the appropriate shoreline habitat. The nearest breeding sites to Constantine Harbor are those at Cape Hinchinbrook.

Lunda cirrhata (Tufted Puffin) - This is one of the most common alcids in breeding season in the Hinchinbrook Entrance.

Bubo virginianus (Great Horned Owl) - One was heard on 1 May.

Nyctea scandiaca (Snowy Owl) - One carcass was found on 1 June in the bogs above Nuchek.

Selasphorus rufus (Rufous Hummingbird) - This species was commonly seen in May (3-31 May).

Megaceryle alcyon (Belted Kingfisher) - A few were seen occasionally throughout the summer.

Empidonax alnorum (Alder Flycatcher) - One individual was seen on 17 May.

Iridoprocne bicolor (Tree Swallow) - Several were sighted in May at different times.

Hirundo rustica (Barn Swallow) - This species was first sighted on 11 May and was often seen after that especially in the vicinity of the abandoned village of Nuchek.

Cyanocitta stelleri (Steller's Jay) - This species was seen occasionally in low numbers throughout the field season.

Corvus corax (Common Raven) - Occasionally a few would be noticed near the field camp.

Corvus caurinus (Northwest Crow) - This species was more common than the Raven, but it was not numerous and was seen mainly along the shorelines of Constantine Harbor. Immature crows began following adult crows around in July.

Parus rufescens (Chestnut-backed Chickadee) - This species was first seen on 11 May and occurred throughout the rest of the summer.

Troglodytes troglodytes (Winter Wren) - One was seen on 17 May.

Turdus migratorius (Robin) - One was seen on 17 May.

Ixoreus naevius (Varied Thrush) - This species was common along the shoreline habitat in early May until the snow melted. Then it moved into the deeper woods away from the shore.

Catharas guttatus (Hermit Thrush) - One was seen on 1 May, but they continued to arrive the rest of May with the peak somewhere around 24 May. From then on they seemed like the most common passerine in the harbor near the shore.

Regulus calendula (Ruby-crowned Kinglet) - One was seen on 11 May.

Anthus spinoletta (Water Pipit) - Two were seen on 30 May foraging along the salmon stream at the head of Constantine Harbor. Later when the snow had melted from higher altitudes, they left the harbor area because on 24 July they were common in some parts of the alpine area.

Bombycilla garulus (Bohemian Waxwing) - Two were seen on 5 July. A flock of 15-25 were seen on 30 July in the harbor area.

Vermivora celata (Orange-crowned Warbler) - The first was noted on 17 May. This was the most common breeding warbler in the harbor.

Dendroica petechia (Yellow Warbler) - This species was noted about the same time as the Orange-crowned Warbler. This was probably the third most common warbler found in the harbor area.

Wilsonia pusilla (Wilson's Warbler) - This species was present on 23 May and was the second most common warbler seen around the harbor.

Carduelis pinus (Pine Siskin) - A flock of 64 was observed foraging on the beach vegetation near Nuchek on 28 July. Another flock (17) was noted on 31 July.

Passerculus sandwichensis (Savannah Sparrow) - This species was first noted on 1 May becoming quite common by the end of May. A nest was discovered on 5 July (with chicks hatched within the week) on the bogs above Nuchek.

Zonotrichia atricapilla (Golden-crowned Sparrow) - This species was extremely abundant the first week of May. By the end of May the species had essentially left the harbor area.

Passerella iliaca (Fox Sparrow) - This species was common throughout the summer.

Melospiza melodia (Song Sparrow) - Low numbers were occasionally seen.

Calcarius lapponicus (Lapland Longspur) - One was seen on 11 May in breeding plumage (male).

APPENDIX 2

TEN SEABIRD COLONY CENSUSES, PRINCE WILLIAM SOUND, 1976

Seal Island, Colony # 063 017

Little Smith Island, Colony # 063 018

Big Smith Island, Colony # 063 019

Seal Rocks, Colony # 064 003

Cape Hinchinbrook, Colony # 064 005

Porpoise Rocks, Colony # 064 008

Phipps Pt. Rocks, Colony # 064 010

Boswell Rocks, Colony # 064 012

Canoe Passage, Colony # 064 014

Constantine Harbor, Colony # 064 021

COLONY STATUS FORM

Colony Number: OG3 017

Colony Name SEAL ISLAND Field Number FWG022 Observer(s) NYSEWANDER KNUDTSON

Map USGS SEWARD B-2 Lat. 60°26'N Long. 147°25'W Time 1300-1330 Date 22 JULY 1976

Weather 03 Wind: Direction N Speed 5-15 Sea: Wave 1-2 Swell 0 Tide – HT. –

Species	Code No. (88+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100		5	SEEN NORTH OF ISLAND (2-3 NMI.)
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200		15	
Brandt's Cormorant	0404010400			
Pelagic Cormorant	0404010500			
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			
Glaucous-winged Gull	1008010300		26	BREEDING ?
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100			
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400		3+	BREEDING?
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100			
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200		29+	BREEDING
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinoceros Auklet	1010120100			
Horned Puffin	1010130200			
Tufted Puffin	1010140100			
Rough-legged Hawk	0702103500			
Bald Eagle	0702140202		2	
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other MEW GULL	1008011300		2	
MARBLED MURRELET	1010060100		2	
BLACK OYSTERCATCHER	1002010300		6	BREEDING
N. PHALAROPE	1006030100		1	
SURFBIRDS	1004130100		65	
WANDERING TATTLER	1004100100		1	
HARBOR SEAL			231	BREEDING
Total (BIRD)			152+	

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ✓

COLONY STATUS FORM

Colony Number: 063 018

Colony Name LITTLE SMITH ISLAND Field Number FWG022 Observer(s) NYSEWANDER KNUDTSON

Map USGS SEWARD C-2 Lat. 60°31'N Long. 147°26'W Time VAR. Date 21-22 JULY 76

Weather 03 Wind: Direction ES Speed 5-20 Sea: Wave 1-3 Swell 0 Tide LOW + HIGH Ht. —

Species	Code No. (SS+)	No. Nests	No. Birds	Remarks: # BIRDS 1230 21 JULY LOW TIDE	1000 22 JULY HIGH TIDE
Northern Fulmar	0302020100				
Fork-tailed Storm Petrel	0303020100				
Leach's Storm Petrel	0303020200				
Cormorant	0404000000				
Double-crested Cormorant	0404010200		4		4
Brandt's Cormorant	0404010400				
Pelagic Cormorant	0404010500				
Red-faced Cormorant	0404010600				
Glaucous Gull	1008010100				
Glaucous-winged Gull	1008010300		1		1
Herring Gull	1008010800				
Black-legged Kittiwake	1008030100				
Red-legged Kittiwake	1008030200				
Sabine's Gull	1008050100				
Arctic Tern	1008070400		4	3	4
Aleutian Tern	1008070600				
Murre	1010030000				
Common Murre	1010030100				
Thick-billed Murre	1010030200				
Pigeon Guillemot	1010050200	EST. 40	84	51	84
Ancient Murrelet	1010080100				
Cassin's Auklet	1010090100				
Parakeet Auklet	1010100100	EST. 90-95	186-200	186	151+ (EST. 200)
Crested Auklet	1010110100				
Least Auklet	1010110200				
Whiskered Auklet	1010110300				
Rhinocerous Auklet	1010120100				
Horned Puffin	1010130200	EST. 35+	35	35	27
Tufted Puffin	1010140100	EST. 83+	83	57	83
Rough-legged Hawk	0702100800				
Bald Eagle	0702140202				
Gyrfalcon	0704020101				
Peregrine Falcon	0704020300				
Other					
BL. OYSTERCATCHER	1002010300	2	4	4	
SURFBIRDS	1004130100		49	49	PRESENT (NO COUNT)
N. PHALAROPE	1006030100		6	6	5
MARB. MURRELET	1010060100		4	4	
Total			474		

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ✓

COLONY STATUS FORM

Colony Number: 063 019

Colony Name BIG SMITH ISLAND Field Number FW6022 Observer(s) NYSEWANDER KNUDTSON

Map USGS SEWARD C-1 + C-2 Lat. 60° 31.5' N Long. 147° 22.5' Time VAR. Date 21 + 22 JULY 1976

Weather 03 Wind: Direction E S Speed 5-20 Sea: Wave 1-3 Swell 0 Tide Low, HIGH Ht. —

Species	Code No. (88+)	No. Nests	No. Birds	# BIRDS Remarks: 1300 21 JULY LOW TIDE	1100 22 JULY HIGH TIDE
Northern Fulmar	0302020100				
Fork-tailed Storm Petrel	0303020100				
Leach's Storm Petrel	0303020200				
Cormorant	0404000000				
Double-crested Cormorant	0404010200				
Brandt's Cormorant	0404010400				
Pelagic Cormorant	0404010500				
Red-faced Cormorant	0404010600				
Glaucous Gull	1008010100				
Glaucous-winged Gull	1008010300				
Herring Gull	1008010800				
Black-legged Kittiwake	1008030100				
Red-legged Kittiwake	1008030200				
Sabine's Gull	1008050100				
Arctic Tern	1008070400		5		5
Aleutian Tern	1008070600				
Murre	1010030000				
Common Murre	1010030100				
Thick-billed Murre	1010030200				
Pigeon Guillemot	1010050200	EST. 150	302	186	302
Ancient Murrelet	1010080100				
Cassin's Auklet	1010090100				
Parakeet Auklet	1010100100	EST. 100+	214	150+	214
Crested Auklet	1010110100				
Least Auklet	1010110200				
Whiskered Auklet	1010110300				
Rhinoceros Auklet	1010120100				
Horned Puffin	1010130200	EST. 37+	37	37	17
Tufted Puffin	1010140100	EST. 277+	277	277	111
Rough-legged Hawk	0702100800				
Bald Eagle	0702140202	EST. 1	2	1	2
Gyrfalcon	0704020101				
Peregrine Falcon	0704020300				
Other					
BL. OYSTERCATCHER	1002010300	EST 6	12+	12+	PRESENT
MEW GULL	1008011300		1		1
N.W. CROWS	2005070400		PRESENT		PRESENT
Total			850+		

Recommended Classification: Colony ✓ Sub-colony ___ Sample Unit ___ Roost Area ✓

COLONY STATUS FORM

Colony Number: 064 003

Colony Name SEAL ROCKS Field Number FW6022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA A-7 A-8 Lat. 60°09.9' Long. 146°50' Time 1030-1200 Date 20 JUNE

Weather 03 Wind: Direction SW Speed 0-5 Sea: Wave ____ Swell ____ Tide ____ HT. ____

Species	Code No. (S8+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200			
Brandt's Cormorant	0404010400	0		NONE ON 4 JULY EITHER
Pelagic Cormorant	0404010500			
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			
Glaucous-winged Gull	1008010300			
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100	46		
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400			
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100		7	FEEDING NEARBY
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200		12	
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100		4	FEEDING NEARBY
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinocerous Auklet	1010120100			
Horned Puffin	1010130200		1	FEEDING NEARBY
Tufted Puffin	1010140100		4	FEEDING NEARBY
Rough-legged Hawk	0702100800			
Bald Eagle	0702140202			
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
MARBLED MURRELET	1010060100		140-150	FEEDING NEARBY
Total		46		

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ✓

COLONY STATUS FORM

Colony Number: 064005

Colony Name CAPE HINCHINBROOK Field Number FWS022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA A-7 + A-8 Lat. 60°14.1' Long. 146°38' Time 1400 Date 25 MAY + 20 JUNE

Weather 03 Wind: Direction SW Speed 0-15 Sea: Wave ____ Swell ____ Tide ____ HT. ____

Species	Code No. (88+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200			
Brandt's Cormorant	0404010400			
Pelagic Cormorant	0404010500	28+	20-40	# NESTS FOUND IN 3.2 NAUT. MILE TRANSECT EAST FROM CAPE
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			
Glaucous-winged Gull	1008010300	21	34	
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100			
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400			
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100			
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200	EST. 20	39	IN 3.2 NAUT. MILES OF COAST
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinocerous Auklet	1010120100			
Horned Puffin	1010130200	EST. 1	2	
Tufted Puffin	1010140100	EST. 15	25	
Rough-legged Hawk	0702100800			
Bald Eagle	0702140202	1	2	
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
Total		86		

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ✓

COLONY STATUS FORM

Colony Number: 064008

Colony Name PORPOISE ROCKS Field Number FWG022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA B-8 Lat. 60°19.2' Long. 146°41' Time VARIABLE Date 5/8-7/30 1976

Weather 03 - 00 Wind: Direction VAR. Speed VAR. Sea: Wave VAR. Swell VAR. Tide VAR. HT. —

Species	Code No. (88+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200	—	VARIED	ROOSTING AND REST AREAS
Brandt's Cormorant	0404010400	—	1 POSS.	" " "
Pelagic Cormorant	0404010500	—	VARIED	" " "
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100	—	VARIED	RARE MIGRANT
Glaucous-winged Gull	1008010300	60	140	37 NESTS ON ARCH AND TABLE ROCKS
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100	992	1963-3000	
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400			
Aleutian Tern	1008070600			
Murre	1010030000			{169 NESTS (MINIMUM) ON TABLE, ARCH ROCKS
Common Murre	1010030100	310-500	838-1550	{BEACH: 500 BIRDS; ARCH: 124 BIRDS; TABLE: 214 BIRDS
Thick-billed Murre	1010030200	—	—	NONE THIS YEAR
Pigeon Guillemot	1010050200			
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinocerous Auklet	1010120100			
Horned Puffin	1010130200	—	4 (MAX.)	OCCASIONAL VISITORS
Tufted Puffin	1010140100	1185-1239	2320-2478	{TWO DIFFERENT CENSUS TYPES (SEE REPORT) ARCH: 254 BIRDS; TABLE: 2200 BIRDS}
Rough-legged Hawk	0702100800			
Bald Eagle	0702140202	0	2-6	FREQUENT PRESENCE (6 on 5 JULY)
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
Total		2547-2791	7174+ (MAX.)	

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ✓

COLONY STATUS FORM

Colony Number: 064 010

Colony Name PHIPPS PT. ROCKS Field Number FWG022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA B-7 Lat. 60°21.1° Long. 146°36' Time VAR. Date VAR.

Weather VAR. Wind: Direction VAR. Speed VAR. Sea: Wave VAR. Swell — Tide VAR. HT. —

Species	Code No. (88+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200			
Brandt's Cormorant	0404010400			
Pelagic Cormorant	0404010500			
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			
Glaucous-winged Gull	1008010300			
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100			
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400			
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100			
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200			
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinocerous Auklet	1010120100			
Horned Puffin	1010130200			
Tufted Puffin	1010140100	30-35	18-13	USUAL # SEEN IN WATER 25-30
Rough-legged Hawk	0702100800			
Bald Eagle	0702140202			
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
Total		35		

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ____

COLONY STATUS FORM

Colony Number: 064 012

Colony Name BOSWELL ROCKS Field Number FWG022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA B-6 Lat. 60°24.6' Long. 146°06.2' Time 1500 Date 25 JUNE 1976

Weather OO Wind: Direction W Speed 10-15 Sea: Wave ____ Swell ____ Tide ____ HT. ____

Species	Code No. (88+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200	31		ROCKS # 1 AND 2
Brandt's Cormorant	0404010400			
Pelagic Cormorant	0404010500	11		ROCKS # 1-3
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			SEE ATTACHED MAP
Glaucous-winged Gull	1008010300	15-30		ROCK # 1 AND 5
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100	4,038		ROCKS # 1-6
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400			
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100			
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200			
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinoceros Auklet	1010120100			
Horned Puffin	1010130200			
Tufted Puffin	1010140100		0	NONE ON WATER ANYWHERE IN THIS BAY EITHER.
Rough-legged Hawk	0702100600			
Bald Eagle	0702140202			
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
Total		4,110		

Recommended Classification: Colony ✓ Sub-colony ____ Sample Unit ____ Roost Area ____

COLONY STATUS FORM

Colony Number: 064 014

Colony Name CANOE PASSAGE Field Number FWG 022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA C-6 Lat. 60°32.4' Long. 146°06.6' Time 0900 Date 24 JUNE 1976

Weather OO Wind: Direction ____ Speed ____ Sea: Wave ____ Swell ____ Tide ____ HT. ____

Species	Code No. (SS+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200			
Brandt's Cormorant	0404010400			
Pelagic Cormorant	0404010500			
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			
Glaucous-winged Gull	1008010300			
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100	0		DID NOT LOCATE NESTS THIS YEAR
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400			
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100			
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200			
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinocerous Auklet	1010120100			
Horned Puffin	1010130200			
Tufted Puffin	1010140100			
Rough-legged Hawk	0702100800			
Bald Eagle	0702140202			
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
Total				

Recommended Classification: Colony ? Sub-colony ____ Sample Unit ____ Roost Area ✓

COLONY STATUS FORM

Colony Number: 064 021

Colony Name CONSTANTINE HARBOR Field Number FWG022 Observer(s) NYSEWANDER KNUDTSON

Map USGS CORDOVA B-7 Lat. 60°20.7' Long. 146°39.5' Time VAR. Date 28 APR- 8 AUG 1976

Weather VAR. Wind: Direction VAR. Speed VAR. Sea: Wave VAR. Swell NO Tide VAR. HT. VAR.

Species	Code No. (88+)	No. Nests	No. Birds	Remarks
Northern Fulmar	0302020100			
Fork-tailed Storm Petrel	0303020100			
Leach's Storm Petrel	0303020200			
Cormorant	0404000000			
Double-crested Cormorant	0404010200			
Brandt's Cormorant	0404010400			
Pelagic Cormorant	0404010500			
Red-faced Cormorant	0404010600			
Glaucous Gull	1008010100			
Glaucous-winged Gull	1008010300			
Herring Gull	1008010800			
Black-legged Kittiwake	1008030100			
Red-legged Kittiwake	1008030200			
Sabine's Gull	1008050100			
Arctic Tern	1008070400	12+		TWO COLONY SITES (SEE MAP)
Aleutian Tern	1008070600			
Murre	1010030000			
Common Murre	1010030100			
Thick-billed Murre	1010030200			
Pigeon Guillemot	1010050200	6+		WESTERN HALF OF HARBOR
Ancient Murrelet	1010080100			
Cassin's Auklet	1010090100			
Parakeet Auklet	1010100100			
Crested Auklet	1010110100			
Least Auklet	1010110200			
Whiskered Auklet	1010110300			
Rhinoceros Auklet	1010120100			
Horned Puffin	1010130200			
Tufted Puffin	1010140100			
Rough-legged Hawk	0702100800			
Bald Eagle	0702140202	2+		ONLY LOCATED TWO NESTS IN HARBOR PROPER.
Gyrfalcon	0704020101			
Peregrine Falcon	0704020300			
Other				
HARLEQUIN DUCK		3+		BREEDS IN ADJACENT STREAMS
COMMON MERGANSER		2		"
CANADA GOOSE		14+		BREEDS IN NEARBY MUSKEG
SEMIPALMATED PLOVER		EST. 25 (5/1 KM. TRANSECT)		HARBOR SHORELINE (WESTERN 10 KILOM. USED)
BL. OYSTERCATCHER		7		"
COMMON SNIPE		BREEDING		IN NEARBY MUSKEG
LEAST SANDPIPER		BREEDING		IN NEARBY MUSKEG
Total		71+		

Recommended Classification: Colony ✓ Sub-colony ___ Sample Unit ___ Roost Area ✓

APPENDIX 3

SUMMARY OF NON-CETACEAN MARINE MAMMAL OBSERVATIONS, HINCHINBROOK ISLAND FIELD CAMP, 1976

Sea Otter (*Enhydra lutris*)

The Port Etches-Constantine Harbor area of Hinchinbrook Island supports a dense population of sea otters during the summer months. Throughout the May-July field season at Constantine Harbor field camp, efforts were taken to monitor the size, productivity, and distribution of this population---as well as those of harbor seals (*Phoca vitulina*) and Steller's sea lions (*Eumetopias jubatus*) in the immediate vicinity. Periodic absolute counts of sea otters in both Port Etches and Constantine Harbor were carried out by systematically approaching and counting all visible sea otters from a motorized inflatable boat. For the purpose of these counts, a "pup" was defined as any sea otter seen resting (i.e. ventral to ventral) upon another sea otter's chest. Counts were usually taken within a few hours of ebb or low tide, since at these times sea otters tended to form highly visible resting groups; during higher tide levels the animals were often dispersed and actively diving and feeding.

Distributional patterns of otters were dependent on time of census, weather, local disturbance (e.g. salmon-seining fishing boats), and other factors. However, concentrations of otters in dense resting-herds were generally found in northeastern-most Port Etches (beginning at Garden Cove) and northwestern Constantine Harbor. Scattered individuals and small groups were encountered over most of the Port Etches-Constantine Harbor study area including areas immediately surrounding Porpoise Rocks. Large herds generally contained a high proportion of the mothers and pups in the population.

Sea otters in Constantine Harbor ranged in number from a low of 69, including 11 pups, in mid-May to a high of 131, including 27 pups, in late July. In Port Etches, counts ranged from a low of 30, including 2 pups, in early May to a high of 89, including 18 pups, in late June. The total count for the combined Port Etches-Constantine Harbor study areas increased from a May 7 count of 128, including 16 pups, to a peak of 210, including 43 pups, on July 29. These data suggest that 1) there is progressive immigration of sea otters into the study area during the course of the summer, and 2) there is a marked increase in the number of pups in the area during these months, either because of immigration or, more likely, in expression of the supposed peak pupping season of the sea otter during summer.

Sea otters were clearly observed in copulation in Constantine Harbor on 12 May. The interaction between two sexed adults involved alternate bouts of active aquatic mounts (with male grasping the female with front paws or teeth, *more canem*) and leisurely but closely associated periods of resting, feeding, and self-grooming through the daylight hours. After 13 May this courting pair was no longer seen in the area, although a subsequent copulation was observed there on 15 May in what appeared to be an interaction between the same male and a distinctly different female.

Only limited data was collected on sea otter feeding habits in Constantine Harbor, but these point clearly to the importance of bivalves in the local sea otter diet. A count and composition estimate of fecal deposits (each consisting of an average of 10 stools) along the entire southern shore of Constantine Harbor yielded the following: 714 total deposits: of which 65% were composed predominantly (i.e. 3/4 or more) of mussel shell fragments; 19% were composed of roughly equal parts of mussel shell and white bivalve shell fragments; 15% were composed predominantly of white bivalve shell; and less than 1% were composed of pink crab exoskeleton remains. The latter deposits were all found in a limited area at the junction of Constantine Harbor with Port Etches, suggesting Port Etches as their probable source.

On only one observation, despite repeated attempts, was detailed information obtainable concerning the actual feeding habits of sea otters in this area. On 20 July a 15 minute continuous observation of an adult male sea otter at a distance of approximately 30 meters provided the following: the actively feeding otter dived a total of 8 times (avg.=85 sec.) and consumed 118 mussels and the soft contents of 2 white bivalves (probably cockles). The observation that all mussels (Mytilus edulis) were consumed unshelled while the larger white bivalves were opened with the otter's teeth, their contents eaten and the shell discarded, suggests that the latter food source may well be under-represented in analysis of fecal deposits.

The crunching (with the teeth) and consumption of mussels is a noisy process easily heard on windless days. As a result it was noted several times that sea otters fed at night. Any other behavioral differences (i.e. feeding versus resting at different tide levels and conditions) can be taken and analyzed from the absolute count type of sea watches done in Constantine Harbor (FW6022-00003 and FW6022-00004, May-July 1976). See also the sea otter census summary sheet (this report) for otter observations noted in other parts of Prince William Sound.

The sea otter population of Constantine Harbor in particular is a remarkable reflection of the high productivity of an estuarine ecosystem. Kenyon (in "The Sea Otter in the Eastern Pacific Ocean", North American Fauna Series #68, 1969) states that "a growing sea otter population in an unexploited habitat may reach a temporary maximum density of 40 or more animals per square mile of habitat. After such a high density is attained, a period of population reduction occurs, either through emigration, a high rate of mortality, or both concurrently during seasons of stress." Densities in Constantine Harbor reached a peak of over 100 sea otters per square mile during the summer of 1976 (e.g. 104 non-pup otters on 29 July; approx. area of Constantine Harbor = 1 sq. mile). Since there was no evidence of high mortality in this area, it appears that the estuary is sufficiently productive to support this unusually dense population of otters---at least on a seasonal basis.

Summary of Port Etches-Constantine Harbor Sea Otter Census, May-July 1976

Number of totals of sea otters followed by number of pups in parentheses.

May 7	Constantine	98(14)
	Port Etches	30(2)
	Combined Count	128(16)
May 14	Constantine	69(11)
	Port Etches	36(6)
	Combined Count	105(17)
May 23	Constantine	99(15)
June 8	Constantine	75(20)
June 23	Constantine	83(21)
	Port Etches	89(19)
	Combined Count	172(39)
July 6	Constantine	118(23)
July 29	Constantine	131(27)
	Port Etches	73(14)
	Porpoise Rocks	6(2)
	Combined Count	210(43)

Other counts taken during the course of the 1976 field season:

May 22 Port Etches to Cordova nearshore transect (via Hawkins Cutoff):
40(6) (includes herd of 32(4) at Rip Rock in Hawkins Cutoff)

June 24 Port Etches to Cordova nearshore (via north shore of Hawkins Is.):
7(0) (no herds seen)

July 4 Zaikof Bay (south to Schooner R.), Montague Is.:
11(1)

July 21 Big Smith Island (east end):
63+(12+)

July 21 Little Smith Island (south end):
21(5)

July 22 Seal Island:
0

July 22 Applegate Rock Reefs:
0

July 22 Green Island (partial count of Gibbon Anchorage):
6(0)

July 27 Middle Ground Shoal (just north of Hawkins Cutoff):
40-50(?)

Harbor Seal (Phoca vitulina richardi)

An effort was made to census the harbor seal population in the Port Etches-Constantine Harbor area in order to determine breeding chronology, principal hauling areas, and numbers of harbor seals for use in future impact studies. Data were gathered by periodic absolute counts of hauled out harbor seals from a motorized inflatable boat. The census area covered the entire Port Etches area east of an imaginary line extending from Bear Cape to the westernmost points adjacent to English Bay. In addition, occasional counts were taken from the tops of Porpoise Rocks during routine seabird colony work.

The maximum harbor seal count during the field season recorded 115 seals within this census area, 70 of which were concentrated on the major hauling area in Port Etches---Porpoise Rocks. Additional hauling grounds included intertidal rocks off of Bear Cape, either side of English Bay, Garden Cove, "Puffin Rocks" near entrance to Constantine Harbor, and western Constantine Harbor (see map of Harbor Seal Hauling areas---Figure 25).

The first pup of the 1976 season was sighted near Porpoise Rocks on 2 June, although fresh remains of a harbor seal pup carcass were observed by Nysewander at the base of a Bald Eagle nesting site on 1 June, indicating a possible earlier birth. On 3 June a total of 5 pups were counted in the Porpoise Rocks area, 2 of which still had visible remnants of umbilical cords. One of the 5 pups was dead (a male with umbilical remnants---see specimen list) and was still actively attended by its mother. The number of pups at the Porpoise Rocks colony peaked at 8 on 10 June, suggesting that in Port Etches pupping is confined largely to the first week of June. Pupping apparently took place on a smaller scale in the Garden Cove area (1 pup) and western Constantine Harbor (1 pup), and pups were observed during the course of other studies at Seal Rocks (1 pup) and Cape Hinchinbrook (1 pup). By 16 July there were no mother-pup pairs visible at Porpoise Rocks, suggesting that weaning (normally at 4-6 weeks in harbor seals) had already taken place. Breeding activity, as is generally the case with harbor seals, remained obscure, although on 16 July an adult female seal with visibly swollen vulva was observed hauled-out on Porpoise Rocks. The Porpoise Rocks harbor seal colony count rose from a 29 April low of 11 seals to a 29 July high of 70 seals, a reflection probably of the cohesive activities of both early summer pupping and late summer pelage molt.

Summary of Port Etches-Constantine Harbor Seal Censuses, 1976

29 April	Porpoise Rocks	11
8 May	Porpoise Rocks	15
25 May	Porpoise Rocks	38
	South shore of Port Etches	54
	Combined count	92
3 June	Porpoise Rocks	40 (5 pups)
10 June	Porpoise Rocks	46 (8 pups)
19 June	Porpoise Rocks	33 (6 pups)
16 July	Porpoise Rocks	50 (3 pups)
29 July	Porpoise Rocks	70
	Port Etches	42
	Constantine Harbor	3
	Combined count	115

Other counts taken during the course of the 1976 field season:

20 June	Seal Rocks	4+(1 pup)
	Cape Hinchinbrook (3.2 n.mi. of cliffs)	13 (1 pup)
21 July	Little Smith Island (south end)	61
	Big Smith Island (east end)	146+
22 July	Seal Island, PWS (east side mostly)	231
	Applegate Rock Reefs (only partially surveyed)	180+

Steller Sea Lion (Eumetopias jubatus)

Only very limited work was carried out on Steller sea lions during the 1976 field season. The suggestion by the BLM Gulf of Alaska Environmental Impact Statement that Steller sea lion rookeries were located on both Porpoise Rocks and at the northern mouth of Canoe Passage, Hawkins Island proved erroneous. During the course of the summer only 2 sightings of hauled-out sea lions were sighted for Porpoise Rocks (29 April; 10 June); no sea lions were sighted in the vicinity of Canoe Passage. Both of these areas are apparently minor hauling areas at best during the summer. Ken Pitcher (ADF&G, pers. comm.) informs us that the sea lions utilize the inner parts of Prince William Sound much more heavily in winter.

On a reconaissance trip concerning seabirds at Seal Rocks on

20 June an estimate of sea lions at this major rookery was obtained. A total of 1800 sea lions were estimated to have been hauled-out during this 1230 observation; 1 pup was observed at this time. A ratio of 1 adult bull to 17 non-bulls was obtained in 5 different areas of breeding territories on the island. All this was done without landing on the rocks, but by observing from a small boat. On 4 July Seal Rocks was revisited in order to recensus seabirds and sea lion pups, but the latter effort was abandoned when it became evident that a major pup-branding effort had taken place during the intervening weeks, as part of a study of the Seal Rocks Colony (ADF&G). Although no count was taken, it was clear that pupping activity was approaching its peak at this time.

Hinchinbrook Island Field Camp Mammal Mortality List

Sea Otter (*Enhydra lutris*): (Specimens given to A. Johnson, USF&WS, Wildlife Research)

Spec. #1 - Skull (damaged) found above high tide level on gravel substrate on southern shore of Constantine Harbor (W. Island) 17 May 1976.

Spec. #2 - Partially decomposed carcass (std. length = 96 cm), full skeleton, minus forelimbs and sternum, collected; unsexed because of decomposition but apparently lacking os penis---i.e. probably female. N. shore of Constantine Harbor (Village Penin.) 23 May 1976.

Spec. #3 - Complete skull from intertidal of s. shore of Constantine Harbor 10 July 1976.

Note: In none of above specimens was cause of death determined.

Harbor Seal (*Phoca vitulina*):

Spec. #1 - Entire carcass of newborn pup, still attended by mother on intertidal rocks of Porpoise Rocks; eyes blood-filled, only minor external lesions, 4-6 inches long umbilical cord remnant; milk-teeth erupted, male (est. age: 1 day to 1 week); std. length = 84 mm. 3 June 1976.

Spec. #2 - Partial carcass and skin of pup at base of eagle nest on north shore of Constantine Harbor, 1 June 1976.

Steller Sea Lion (*Eumetopias jubatus*):

Spec. #1 - Entire carcass of beached female on n. shore of Port Etches; located high on rock above high tide--- no indication of cause of death, measurements:
ant. foreflipper 1 = 71 cm.
ant. hindflipper 1 = 46 cm.

standard length = 198 cm.
blubber depth at lower sternum (exc. hide) = 0.7 cm.
axillary girth = 135 cm.

This was probably a subadult judging from the length. 2 July 1976.

Spec. #2 - Entire carcass of male inland 90-100 meters in the dunes of beach between Boswell Bay and Pt. Bentinck---no indication of cause of death; no measurements taken. 25 June 1976.

APPENDIX 4

ANNOTATED LIST OF LAND MAMMALS OF HINCHINBROOK ISLAND

Dusky Shrew (*Sorex obscurus*)

Traps were set occasionally near the field camp and this was the only species commonly caught there.

Brown Bear (*Ursus arctos*)

The late spring and heavy snow cover delayed the appearance of this species in 1976. The first bears noted coming out of dens (hunters, pers. comm.) were on 18 May. After the hunters left it became common in June to see bears down on the shoreline and wet meadows associated with the heads of Constantine Harbor and Port Etches. Only one bear was noted on the Nuchek peninsula. Once the salmon seining season started in mid July bears were never seen due to fishing boat activity.

Weasel (*Mustela erminea*)

One was seen near camp in winter pelage near the end of April. On 23 May one in summer pelage was active around the field camp.

Mink (*Mustela vison*)

None were observed by us, but Grinnell (1910) recorded them for northern Hinchinbrook Island.

River Otter (*Lutra canadensis*)

River otter commonly used the point where the field camp was located as a hauling and feeding area when we first arrived. One feeding platform contained over a period of several days (before otters abandoned the area) the heads of three species of fish (fish length range = 30-50 cm.); Rock Flounder (*Lepidopsetta bilineata*), Starry Flounder (*Platichthys stellatus*), and Irish Lord (*Hemilepidotus hemilepidotus*). On 29 July near Nuchek Creek (head of Port Etches) an adult and three pups were observed frequenting a spit on the south shore.

Hoary Marmot (*Marmota caligata*)

From May on marmots were occasionally seen at varied locations and altitudes on Hinchinbrook Island.

Bog Lemming (*Synaptomys borealis*)

Grinnell (1910) recorded this species on Hinchinbrook Island. We did no trapping up on the bogs, but the many trails and signs indicated the presence of these animals there.

Red-back Vole (*Clethrionomys rutilus*)

None were observed by us, but Grinnell (1910) trapped them on northern Hinchinbrook Island.

Meadow Vole (*Microtus oeconomus*)

Grinnell (1910) records them for Hinchinbrook Island. Peter

Knudtson observed a vole on Village Point in Constantine Harbor and it was probably this same species judging from size.

Sitka Black-tailed Deer (Odocoileus hemionus)

Deer were not as common as reported due to bear hunter and fisherman hunting. However, they were fairly common in the muskeg areas early in the season moving to the alpine meadows later in the summer. One fawn was seen with doe on 5 July.

APPENDIX 5

FISH RESOURCES NOTED IN CONSTANTINE HARBOR-PORT ETCHES VICINITY, 1976

Rock Flounder (Lepidopsetta bilineata)

Starry Founder (Platichthys stellatus)

Irish Lord (Hemilepidotus hemilepidotus)

Black Rockfish (Sebastes melanops)

Kelp Greenling (Hexagrammos decagrammus)

Halibut (Hippoglossus stenolepis)

Pink Salmon (Oncorhynchus gorbuscha)**

Dog Salmon (Oncorhynchus keta)**

Capelin (Mallotus villosus)*

Sand Lance (Ammodytes hexapterus)*

Saffrom Cod (Eleginus gracilis)

Dolly Varden (Salvelinus malma)

Note: * Smaller individuals of these species are important as forage fish to seabirds.

** Arctic Terns appeared to feed on schools of salmon parr in Constantine Harbor.

APPENDIX 6

CETACEAN SIGHTINGS SUMMARY, 1976

Orcinus orca (Killer Whale) - Six groups of this species were noted throughout the summer. Pod size varied from 1 to 12.

Balaenoptera physalus (Fin-backed Whale) - On 5 July a total of 6 individuals of this species were observed off the outer shore of Montague Island in the Seal Rocks vicinity.

Balaenoptera acutorostrata (Minke Whale) - A few individuals were occasionally seen in June and July.

Megaptera novaeangliae (Humpback Whale) - This species was commonly seen in July. Group size ranged from 1 to 7. One juvenile seen on July 9 near Porpoise Rocks appeared to be a Minke Whale, but later examination of slides taken determined that it was a very small individual of this species.

Phocoena phocoena (Harbor Porpoise) - This was one of the two very common porpoise species found in high numbers in late May and early June in Hinchinbrook Entrance. The highest number seen on any one sea watch (10 minute fixed or sweep type) was 37.

Phocoenoides dalli (Dall Porpoise) - This species was very abundant in late May and early June in Hinchinbrook Entrance. The largest number noted on any one sea watch was 18. Although both of these last two species were seen in low numbers throughout the summer, the late May-early June period seemed to involve much larger numbers as well as a change of behavior. Dall Porpoise would swim slowly like the Harbor Porpoise usually does. Hence there were probable mistakes in identifying distant porpoise. It should also be noted that the porpoise noted on the sea watches were just those close to the eastern edge of Hinchinbrook Entrance. So in reality numbers are much higher for the whole entrance as the large numbers of porpoise would follow the tide in all across the straits.

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Report Period: October 1, 1976 to
March 31, 1977
Pages: 1-15

FOOD HABITS OF MIGRANT DUNLINS AND WESTERN SANDPIPERS ON THE COPPER RIVER DELTA, ALASKA

By

Stan Senner
Alaska Cooperative Wildlife Research Unit
University of Alaska

PART X

Of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS

OF MARINE BIRDS IN THE GULF OF ALASKA

AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. G. Gould,
R. E. Gill and G. A. Sanger
Co-principal Investigators

U. S. Fish & Wildlife Service
Office of Biological Services-Coastal Ecosystems
Anchorage, Alaska

March 1977

Table of Contents

INTRODUCTION

Tide flats of the Copper River Delta in the Northern Gulf of Alaska are major local point for migrant shorebirds, particularly for Dunlins (Calidris alpina) and Western Sandpipers (Calidris mauri) which nest principally in coastal regions of the Bering Sea. The pending development of petroleum resources of the Outer Continental Shelf possess a serious threat to intertidal habitats upon which migrant shorebirds depend. Because adverse impacts from development would occur primarily through reduction or contamination of food resources, this study addresses seasonal use and availability of potential food resources. Specific objectives are:

1. To determine the diet of shorebirds with principal emphasis on that of Dunlins and Western Sandpipers while they are feeding, primarily on tidal flats. Food habits will be considered in relation to time of year, location within region, daily tide cycles, and intrahabitat utilization.

2. To determine the availability, abundance and productivity of food items utilized on the tidal flats. The prey species will be considered in relation to time of year, location within region, daily tidal cycles, and intrahabitat distribution.

3. To determine the condition of Dunlins and Western Sandpipers in terms of body fat as they arrive in and leave the region.

Procedures and Activities

Field work partially covering the fall shorebird migration through the Copper River delta system was conducted from 27 July to 4 September 1976. This study period included a substantial portion of the fall migration of the Western Sandpiper (Calidris mauri), but apparently preceded the migration of the Dunlin (Calidris alpina pacifica). Much of the fall work was a repetition of procedures followed in the spring study period.

Between 28 July and 2 September more than 80 hours were spent at Hartney Bay in which bird species were censused hourly within each zone of two transects (previously described in Senner, 1976). Invertebrate fauna within the transects were sampled on 29-30 July. A total of 26 Western Sandpipers 6 Least Sandpipers (Calidris minutilla), 2 Semipalmated Sandpipers (Calidris pusillus), and 1 Baird's Sandpiper (Calidris bairdii) were collected, primarily on the Hartney Bay mudflats, for analysis of stomach contents. No Dunlins were collected during the fall study period.

Habitats other than intertidal mudflats were surveyed to determine whether Western Sandpipers and Dunlins were utilizing them during the fall migration. Freshwater ponds and intertidal sloughs in the Alaganik Slough area were visited several times. Visits were also made to the sandy beaches and interior wetlands of Egg Island and to the mudflats and rocky intertidal areas of Mummy Island. Species seen and estimated numbers of individuals within the respective habitats were noted for each survey.

The investigator, with Dr. David W. Norton, presented a paper entitled, "Shorebird Migration and Oil Development in the Copper River Delta Area" in a session considering the biological impacts of offshore development. The abstract of the paper is attached at the end of this report (Appendix A).

Preliminary Results and Discussion

A summary of field observations from both spring and fall study periods is included in Appendix B. It is hoped that these notes will be of assistance to investigators visiting the region or wishing to gain insight into the chronology of the 1976 migrations. Actual transect census data are not presented here.

Stomach content analysis of *C. alpina* and *C. mauri* specimens were continued. Some preliminary results from specimens collected in 1976 are presented in Tables 1 and 2. In general, the 1976 data indicate that *C. alpina* rely heavily on pelecypods, while *C. mauri* are more diverse in their food habits. These data were contrasted with the results of a small sample of birds collected in 1975 on the Copper River Delta (Senner 1976). One obvious difference in both bird species is that fewer amphipods were taken in 1976 than in 1975.

Laboratory analysis of the lipid and water levels and fatty acid composition of *C. alpina* and *C. mauri* specimens have been begun by a technician at the Institute of Arctic Biology. Among the shorebirds collected was a banded Semipalmated Sandpiper taken on 9 August at Hartney Bay. This individual had been banded as a juvenile (sex unknown) on 30 July at the Peyton-Shields, Norton Bay avian study site -- 10.5 miles southeast of Koyuk, Alaska, at the mouth of the Ingultalik River. Peyton and Shields (per. comm) believe that the banded individual left the study site within a few days of being banded; thus a maximum of about 10 days were required for it to travel between the two study sites. A coastal route along the Bering Sea coast with an overland cross to the east through the Iliamna region seems a likely path for this and other shorebirds coming from western Alaska.

Trapping and Banding

Investigators have utilized various traps with differing degrees of success in capturing shorebirds. For example, Serventy et. al. (1962)

used traps with considerable success while Gerstenberg and Harris (1976) used traps with no success. For my project, two Skikholm Dunlin Traps and lead fences were constructed according to Hollom and Brownlow (1955). The traps were deployed, usually on rising rides, at Hartney Bay as shown in Figure 1. Though the traps were not intended for use in areas with "appreciable" tides (Hollom and Brownlow, 1955), the rising tide served to concentrate birds in relatively small areas and to actually "drive" them toward the traps.

In 25.5 trap-hours six Sandpipers and three Western Sandpipers were trapped and banded at Hartney Bay. In seven trap-hours on the Egg Island mudflats no birds were trapped. There are at least two reasons for this low capture rate. Looking at Hartney Bay specifically, the density of birds utilizing the Bay in the fall is low - often only 100-200 birds. The lower the density of birds, the lower the probability that one will deploy traps where the birds are and that they will enter the traps. This is true even if one can predict about where the birds will be located on the rising tide. Second, at least several dozen peep sandpipers entered the traps and then escaped through the trap-opening before the investigator could pick them up. The traps were modified in an attempt to correct this problem, but the modified traps were not sufficiently tested to warrant reporting here.

A single mist nest was used at a freshwater pond along Alaganik Slough where the water level had been artifically lowered by the U.S. Forest Service for management purposes. The pond's exposed mud attracted moderate numbers of some shorebird species to a relatively small area. The net was set to span one corner of the pond and was open for a total of 9.5 hours on three days. During this time nine Common Snipe (Capella gallinago), a Short-billed Dowitcher (Limnodromus griseus), two Pectoral Sandpipers (Calidris melanotos), and two Savannah Sparrows (Passerculus sandwichenis) were captured and banded. The concentration of birds in the relatively small area and the fact that the net blended into the green "background" of vegetation surrounding the pond account for the fair success.

Cut-out decoys resembling "generalized shorebirds" were placed upwind of the net during some hours. They seemed to help, though their use was too limited for a meaningful evaluation. It is possible that incoming birds would focus on the decoys rather than the net, thus flying into the net rather than avoiding it.

A single net was set on the Hartney Bay mudflats perpendicular to tide line for one hour on each of two days. No birds were captured, but the two net-hours are insufficient as a test of this method's potential. It should be noted that Gerstenberg and Harris (1976) made effective use of mist nets on the Humboldt Bay mudflats.

It is clear that a number of factors would influence the success of a large-scale banding effort at study sites in the delta. High densities of birds behaving in reasonable predictable ways with respect to the local geography, tide cycles, etc. are required for a successful effort. These conditions are met during spring migration. With sufficient manpower and support I believe a successful large-scale program is feasible.

Literature Cited

Gerstenberg, R. H. and S. W. Harris. 1976. Trapping and marking of shorebirds at Humboldt Bay, California. Bird Banding 47(1): 1-7.

Hollom, P. A. D. and H. G. Brownlow. 1955. Trapping methods for bird ringers. British Trust for Ornithology Field Guide No. 1, Revised Edition.

Senner, Stan. 1976. The food habits of migrating Dunlins and Western Sandpipers in the Copper River Delta area, AK. Progress Rept., ACWRU 27(4): 2-9.

Serventy, D. L. and D. S. Farner, C. A. Nicholls, and N. E. Stewart. 1962. Trapping and maintaining shorebirds in captivity. Bird Banding 33 (3): 123-130.

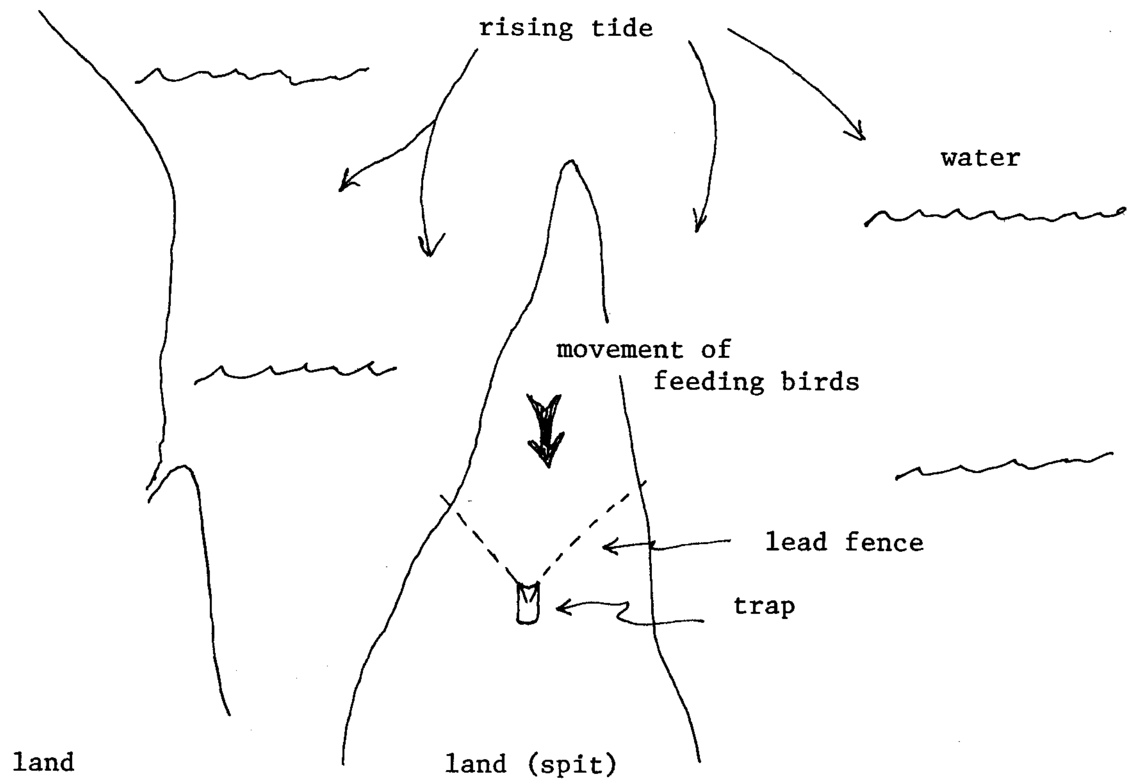


Figure 1. Typical deployment of Skokholm Dunlin Trap at Hartney Bay. As land areas are covered by the rising tide birds become more concentrated and directed towards the trap. The trap is picked-up before being covered by the tide.

Table 1. Stomach contents of 15 *Calidris mauri* and 22 *Calidris alpina* collected while feeding on the Hartney Bay mudflats, May 1976. A = Frequency (percent of stomachs with item). B = Average number of items per stomach. Items which could not be quantified are indicated by a +.

Food Items	Calidris mauri A	Calidris mauri B	Calidris alpina A	Calidris alpina B
Pelecypoda				
Macoma balthica	60	4.1	95	27.9
Mytilus edulis	40	2.7	13	13.0
Mya spp.	20	24.0	13	1.0
Astarte spp.	6	1.0	--	--
unidentified	6	2.0	--	--
Copepoda				
Harpacticoida	20	13.7	--	--
Amphipoda				
Corophium spp.	--	--	4	1.0
unidentified	6	1.0	23	+
Insecta				
Chironomidae	47	48.7	4	1.0
Ephydridae	6	1.0	--	--
Acarina				
unidentified	6	1.0	--	--
Plants				
Seeds	27	3.5	9	21.5
unidentified debris	73	+	54	+
Grit				
$<$ 1 mm	60	299.2	90	10.7
$\geq$ 1 mm	60	43.3	23	7.6
Animal				
unidentified frag.	6	2.0	4	1.0

Table 2. Stomach contents of 20 *Calidris mauri* collected while feeding on the mudflats at the mouth of the Eyak River, May 1976. A = Frequency (percent of stomachs with item). B = Average number of items per stomach. Items which could not be quantified are indicated by a +.

Food Items	A	B
Nematoda		
unidentified	5	1.0
Pelecypoda		
Macoma balthica	60	7.6
Mytilus edulis	5	1.0
Mya spp.	20	1.8
Insecta		
Chironomidae	65	8.1
Ephydridae	55	3.7
Tipulidae	5	1.0
Staphylinidae	5	1.0
Plants		
Seeds	25	1.8
unidentified debris	55	+
Grit		
$<$ 1 mm	100	186.6
$\geq$ 1 mm	100	40.5

Appendix A

SHOREBIRD MIGRATION AND OIL DEVELOPMENT IN THE COPPER RIVER DELTA AREA

BY

Stan Senner and David Norton

During spring the Copper River Delta is the major focal point for waterfowl and shorebirds migrating to and through the northern Gulf of Alaska. Numbering in the millions, virtually the entire North American breeding population of the Western Sandpiper (*Calidris mauri*) and the Dunlin (*Calidris alpina* pacifica) utilize the vast intertidal zones of the delta system in about the first three weeks of May.

Energy-related activities including marine oil tanker traffic through Prince William Sound and the exploration and development of outer continental shelf oil tracts in the Gulf of Alaska may affect the delta's coastal ecosystems. If energy development-related events should render intertidal habitats in portions of the Copper River delta system less suitable for use by the millions of migrant shorebirds, how will their fitness for reproductive activities be affected?

Research in progress attempts to evaluate to what extent the delta system can be considered a critical habitat in the annual cycle of the Western Sandpiper and the Dunlin. Food habits, distribution within the intertidal zone, and the physiological state of migrant shorebirds are being examined. Working hypotheses and preliminary results are presented.

Appendix B

SELECTED OBSERVATION FROM SPRING AND FALL BIRD MIGRATION IN THE COPPER RIVER DELTA AREA, ALASKA

Spring Observations: 27 April - 27 May, 1976

Black Brant: On 27 April, six in Prince William Sound on Valdez/Cordova ferry route.

Semipalmated Plover: First seen on 2 May at Hartney Bay. Thereafter, common in small numbers at Hartney Bay.

Black-bellied Plover: First seen on 27 April, 30 at Hartney Bay. Thereafter, common in small numbers at Hartney Bay and at mouth of Eyak River. On 16 May, about 20 at mouth of Eyak River.

Surfbird: First seen on 3 May at Hartney Bay. Peaks at Hartney Bay with Surfbirds numbering up to 100 were seen on 5 May and 10 May. Last seen on 14 May at Hartney Bay. As one might expect, no Surfbirds were seen at the Eyak River study site.

Ruddy Turnstone: First seen on 3 May at Hartney Bay. Common in moderate numbers throughout my field time at Hartney Bay. 10 May, 45 at Hartney, 18 May, 100 and on 23 May, 75.

Black Turnstones: First seen at Hartney Bay on 27 April. A few individuals were seen at Hartney Bay until 5 May, after which there were no more observations.

Whimbrel: First seen 12 at Eyak River uplands (grass banks) on 7 May. (Isleib noted first spring birds on 6 May in his sea migration watch). Common in small numbers at both Hartney Bay and Eyak River, especially in latter half of May. I noted peaks of "several dozen" at the Eyak River on 16 May, 50 at the Eyak River on 19 May, and 29 at Hartney Bay on 23 May.

Spotted Sandpiper: On 15 May, abundant along Eyak River. None were noted on my preceding trip, 9 May, suggesting an influx between those dates.

Yellowlegs, Greater and Lesser: Abundant throughout field time along Copper Highway, especially noticeable at Mile 19-20. At Mile 19 I noted Greaters on 30 April, but did not see Lessers until my next trip out on 6 May. No yellowlegs were seen in intertidal habitats in the spring, and only one (a Greater) was seen in the Eyak River uplands (24 May).

Knot: First, five at Hartney Bay on 27 April. Knots were abundant at Hartney Bay from 9-14 May, with peaks of several 100's on 5-6 May and 1,000 + on 18 May. (Isleib's migration watch showed many Knots on 5 May and 13-14 May.)

Pectoral Sandpiper: First, five in sedges about road at Hartney Bay on 5 May; on 11 May, one in sedges below road at Hartney Bay. Use of intertidal (mud) zone in spring virtually nil. On 16 May, 3-4 in uplands at Eyak River.

Western Sandpiper and Dunlin: These two sandpipers far outnumbered all other shorebird species in the spring migration.

Ninety Dunlins were recorded at Hartney Bay on 27 April, but it wasn't until 2 May that Westerns were specifically identified. However, flocks of unidentified peeps -- more than likely Westerns -- were seen at Hartney Bay on 29-30 April and 1 May.

On 27-30 April Hartney Bay shorebirds numbered at most a few 100's. By 1 May there were 200 + including Dunlins, dowitcher spp., and unidentified peeps. On 2 May there were 1000's of both Westerns and Dunlins at the mouth of the Eyak River. On 4-5 May there were about 10,000 at Hartney Bay with 15-20,000 by 6 May. These were mostly Dunlins, but there were many Westerns too. (On 5 May 1975, I recorded several 1000's of Westerns - maybe 10,000 and several 1000's of Dunlins at Hartney Bay.) On 7-8 May at the Eyak River the rank was reversed. There were 5,000 shorebirds with Westerns predominating and Dunlins ranking second in numbers.

From 9-14 May, Hartney Bay had 5,000 + shorebirds with Dunlins predominating while on 15-16 May, the Eyak River mudflats had 1,000's of Westerns with many Dunlins too.

Through 17 May Hartney Bay still had 2000-3000, mostly Dunlins; from this date both Dunlins and Western numbers clearly tapered off. On 19 May, at the Eyak mudflats, there were still a few 1000's (Westerns and Northern Phalaropes most common). By 22-23 May, virtually no Westerns were recorded at Hartney Bay and only 200 Dunlins (on 23rd). At the Eyak River mudflats on 24 May there may have been a few individual Westerns, but no Dunlins were recorded. On 25 May, at Hartney Bay there were a few Dunlins, but no Westerns.

Based on changes in numbers and the composition of flocks, it was my impression that turn-over times were anywhere from a few hours to about two days (for shorebirds in general including Westerns and Dunlins).

Baird's Sandpiper: Baird's were seen on only two occasions: two on the Hartney Bay mudflats on 30 April and one on 17 May (by Norton).

Least Sandpiper: In spring Least Sandpipers almost exclusively occupied "upland" wetlands (e.g., grass banks at Eyak River) or the sedge fringe of the upper intertidal zone. Most birds seen were as singles, in pairs, or in small groups in these habitats.

On 29 April, I had 19 Leasts among the Mtyilus beds on the banks of Hartney Creek. I did not note any Leasts on the Eyak River on 2 May, but by 7 May, they were abundant.

Dowitcher spp: I am not confident of the field identification of the two dowitchers so I called everything dowitcher spp. Most, I think, were Short-billed.

First seen on 1 May at Hartney Bay, migrant dowitchers were abundant on the Hartney Bay mudflats during the first half of May, tailing-off in the latter half of May. They were also abundant in the Eyak River area, but primarily in the uplands. I assume these were mostly locally-breeding birds. On 24 May I found a nest, presumable Short-billed, with one egg in the Eyak River uplands (behind Pirtle's cabin).

Godwits, Hudsonian and Bar-tailed: On 7 May six unidentified Godwits were on the Eyak mudflats. One individual was viewed from 40 m with a 25-x spotting scope under very poor visibility conditions. I noted a rusty breast and barred tail; no white on rump or wings was noted when it flew. It appears to have been a Bar-tailed; however, conditions were poor and I did not get a look at the other five birds. A single godwit was again seen at the same location on 8 May.

Single Hudsonian Godwits were seen at Hartney Bay on 18 May and at the Eyak River on 20 May.

Sanderling: First seen on 5 May, 10 + at Hartney Bay. (A single bird was also seen at Hartney on 5 May,1975). Seen again at Hartney Bay on 10-11 May in small numbers. Thereafter seen in increasing numbers so that by 23 May at least 1500 of 2000 birds on Hartney Bay mudflats were Sanderlings. They persisted in comparable numbers until I left on the 27th.

Northern Phalarope: On 27 April, several in Orca Inlet seen from ferry. On 9 May, several in Eyak River, and abundant on 15 May. On 19 May, 1,000+ on Eyak mudflats.

Mew Gull: On May 24, Mew Gull incubating three eggs at nest on Eyak River uplands (behind Pirtle's cabin).

Aleutian Tern: My impression was that this tern was fairly common at the mouth of the Eyak River (upland and mudflats), though I did not spend much time checking-out each tern I saw.

Common Flicker (Yellow-shafted): On 10 May, one in roadside alders at Hartney Bay. On 15 May I found remains of one individual under the snow at Hansen's cabin on the Eyak River -- it was likely a fall mortality.

Yellow-rumped Warbler (Myrtle): On 10 May, one at Hartney Bay. (10 May was a good day for Passerines in general at Hartney Bay). My impression was that this Warbler was not uncommon moving through the alders along the road at Hartney Bay, but my notes do not bear that out.

White-crowned Sparrow: On 27 April, one at Valdez.

Golden-crowned Sparrow: On May, two in Cordova.

Fall Observations: 27 July - 4 September, 1976

Common Merganser: On 21 August, about 20 females on creek in back part of Hartney Bay. On 19 August, a female (probably Red-breasted) with a brood of 8-9 small young on an Alaganik slough area "drawdown pong".

Dusky Canada Goose: Through field period, about 50-75 usually in vicinity of Hartney Bay. On 26 August, I noted one of Bob Bromley's yellow neck-collared individuals among the flock at Hartney Bay.

White-fronted Goose: On 30 August, about 25 at Mile 7 on Copper River Highway, and on 31 August, about 20 in flight over Hartney Bay.

Pintail: Common at Hartney Bay, usually floating in on the high tide. On 25 August, there were 250 + at Hartney Bay (in eclipse plumage). On 10 August, 800-1000 at Egg Island (may have been a storm-related build-up).

Green-winged Teal: On 10 August, 250-300 at Egg Island (associated with Pintails mentioned above). Few 10's with Pintails at Hartney Bay on 25 August.

Goldeneye spp: Female, probably Barrow's with two young at Hartney Bay.

Blue-winged Teal: Single on 31 August in upland pond across Alaganik Slough from mouth of Tiedeman Slough.

Sharp-shinned Hawk: On 15 August, one flew out of the alders chasing a songbird at the U.S. Forest Service warehouse in Cordova. On both 31 August and 2 September single individuals were seen at Hartney Bay. On the latter date the bird unsuccessfully chased a sandpiper and then sat down on the mudflats before returning to the forest on the edge of the flats.

Peregrine Falcon: On 21 August, one dark immature bird flew low over Hartney Bay mudflats. It scared up many shorebirds but did not pursue them.

Black Oystercatcher: On 8 August, two were on Hartney Bay mudflats for a short time. On 20 August, two were seen south of Big Points along the beach and two on Mummy Island. Mummy Island also had two birds on 1 September.

Semipalmated Plover: Common at Hartney Bay - seen in small numbers throughout field period. On 31 July, there were 17 at Hartney Bay, and on 20 August, there were about 15 on a bar in Orca Inlet southwest of Big Point.

Black-bellied Plover: On 10 August, 5-6 + on Egg Island and at least one on the next day. On 20 August, three at Mummy Island (two in winter plumage and one in transitional plumage).

American Golden Plover: On 22 August, two in complete winter plumage at Hartney Bay. On 31 August, seven on an exposed mud bank at low tide in the Alaganik Slough. These birds were both in winter and transitional plumages.

Surfbird: On 20 August, 60 at Mummy Island. All but one individual were in winter plumage. The single bird which was not appeared to have an injured wing.

Turnstones, Ruddy and Black: There was some difficulty in separating Ruddys from Blacks when both were in winter plumage. Ruddy Turnstones seemed to predominate,however. On 8 August, there were three Ruddys at Hartney Bay and four on 9 August. On 11 August, there were two unidentified turnstones at Egg Island. From 15 August through 5 September, turnstones, mostly Ruddys with some Blacks, were present in moderate numbers (20-30) nearly every day at Hartney Bay.

Common Snipe: Abundant, especially at "drawdown" ponds along Alaganik Slough.

Whimbrel: Common in small numbers at Hartney Bay throughout field period. First, two at Government Slough on 1 August. On 10 August, 2-3 at Egg Island. Peaks were 32 on 8 August and 40 on 9 August at Hartney Bay.

Spotted Sandpiper: Common throughout study period. Most often seen in upper intertidal habitats on coast (rocky or gravelly areas more so than mudflats, however).

Solitary Sandpipers: On 19 August, two at freshwater "drawdown" ponds along Alaganik Slough.

Yellowlegs, Greater and Lesser: Both present in small numbers at Hartney Bay in latter half of study period. The first seen was a Lesser on 3 August at Big Point. All other intertidal sightings were after 13 August. On 20 August, 10's of Greaters at Mummy Island mudflats. On 19 and 23-24 August, Greaters were common at Alaganik Slough "drawdown" ponds and intertidal areas.

Knot: On 20 August, 150-200 at Mummy Island with numerous dowitchers. Knots were in both winter and transitional plumages.

Pectoral Sandpiper: On 11 August, 100 + on intertidal sedge flats in the interior of Egg Island. On 21 August, 3+ at Hartney Bay mudflats. On 23-24 August, banded two at one of the Alaganik Slough "drawdown" ponds, though I saw no birds other than those in the mist net.

Western, Least, Baird's and Semipalmated Sandpipers: Throughout the study period "peep" numbers at Hartney Bay had a "baseline" level of 100-200 birds. Most fluctuations were above that level. The species proportions changed frequently.

The low recorded was about 20 Leasts on 2-3 August at Hartney Bay. Moderate levels of 400-500 were recorded on 9 August (85% Least, 15% Western) and 15 August (50% Least, 50% Western). Peaks were recorded on 21 August, 1500-2000 (50% Least 50% Western); 29 August, 3000 + (80% Western, 20% Least); and on 31 August, 1000 (90% Western, 10% Least). It should be noted that on 21 August, there were also several 100's, mostly Westerns, at the overlook between 3 Miles and Hartney Bay, and that the peak on the 29th followed several days of stormy weather.

While the Least/Western ratio was often even or in favor of Leasts, Westerns predominated on some occasions: On 29 July and on 26, 27, 29 and 31 August. Adult Westerns appeared to move through in July, while immature birds moved through in August. This is based on observations, specimens collected, and discussions with other investigators. (Ruth Isleib reported that there were up to 10,000 Westerns on the Cordova Harbor mudflats one day in about the tird week in July. I suppose this was a big "push" of adult birds.)

Baird's Sandpipers were present in small numbers until about 14 August, as were Semipalmated Sandpipers. The Semipals were seen or collected as single individuals among the other peeps. I would characterize both Baird's and Semipals as uncommon until the 14th; none were seen thereafter.

A banded Semipal was collected on 9 August on the Hartney Bay mudflats. It was an immature bird banded on 30 July by the Peyton-Shields OCS project group 10.5 miles southeast of Koyuk, Alaska. A banded adult Western Sandpiper was seen but not collected on 28 July at Hartney Bay.

At places other than Hartney Bay, we found 100 + Westerns at Egg Island on 11 August, 15 Leasts and Westerns at Alaganik Slough (exposed mud at low tide) on 19 August, and a few Leasts at the same location on 23-24 August. No peeps were seen at Mummy Island on 20 August or 1 September.

Dunlin: The only Dunlins seen during the study period were about 11 in flight over Cordova boat harbor observed by Pete Isleib on 3 September.

Dowitcher spp: Most sightings appears to have been of Short-billed dowitchers. On 9 August, 59 at Hartney Bay. At Egg Island, 20 on 10 August and 30 on 11 August. On 20 August, 1500 on Mummy Island mudflats (on Little Mummy side). On 23-24 August, saw several flocks of up to 50 birds and individuals at "drawdown" ponds and intertidal areas.

Hudsonian Godwit: On 16 August, four at Hartney Bay. On 18 August, two at Hartney Bay. On 20 August, ten at Mummy Island. On 21 August, four at Hartney Bay. On 25 August, three at Hartney Bay. On 26 August, two at Hartney Bay. On 29 August, one at Hartney Bay.

Sanderling: A single bird in winter plumage was seen on 25 August at Hartney Bay.

Northern Phalarope: On 22 August, about 150 on mudflats at mouth of Eyak River. On 8 August, five on Hartney Bay mudflats.

Parasitic Jaeger: Fairly common in all areas visited. Usually seen as singles or in pairs cruising shorelines and mudflats. Several unsuccessful pursuits of shorebirds were observed. Both adults and immatures seen at Cutoff Cabin near Alaganik Slough on 19, 23, and 24 August.

Glaucous Gull: On 27 July, a single second year bird at Cordova ferry terminal. On 12 August, a single second year bird on shore of Eyak Lake.

Glaucous-winged Gull: On 16 August, I saw two banded juveniles begging from an adult at Hartney Bay (young banded presumably by S. Patten.) On 25 August, one of the Pattens' color-marked adults was noted at Hartney Bay among other Glaucous-winged, Mew, and Bonapart's Gulls.

Bonaparte's Gulls: On 25 August at Hartney Bay we observed these gulls walking swiftly, running and even jumping on the mudflats as they caught shoreflies flushed by their actions.

Common Flicker (Yellow-shafted): On 23 August, one along raod to U.S. Forest Service Alaganik Slough boat landing.

Yellow Wagtail: On 18 August, at about 15:10 hours my wife and I were parked on the Hartney Bay road about 200 miles south of the bridge. A bird flew out of the alders along the road and landed at a clump of sedges/grasses on the flats at the base of the road. Immediately obvious were the bird's long, slender, white-margined tail and fairly bright yellow underparts. It may have had a white line over the eye, but I did not take note of it until after looking at a picture of the bird. I watched the bird for about a minute with binoculars at a distance of about 15 m as it flitted about on the ground.

As it flew back into the alders, my wife was able to see it well enough to note the long white-margined tail. I looked for the bird in the alders for about ten minutes, but was unable to find it again. The bird was not collected or photographed.

There is no doubt in my mind that I saw a Yellow Wagtail. Looking at specimens in the University of Alaska further reinforced my conclusions. I should add, however, that I have not seen Yellow Wagtails in the field.

PART XI WAS NOT INCLUDED

ANNUAL REPORT

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: 341/342
Study Task: A3
Reporting Period: April 1, 1976 to
March 31, 1977
Number of pages: i + 1-38

AVIFAUNAL ASSESSMENT OF NELSON LAGOON, PORT MOLLER AND HERENDEEN BAY, ALASKA

BY

Robert Gill
Paul D. Jorgensen
Anthony R. DeGange

and

Peter Kust, Sr.

Part 12

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

J. C. Bartonek, C. J. Lensink, P. J. Gould
R. E. Gill and G. A. Sanger
Co-principal Investigators

U. S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
800 A Street - Suite 110
Anchorage, Alaska 99501

April 1, 1977

Abstract

Studies of occurrence, abundance, and habitat selection and utilization of waterbirds found in the Port Moller - Nelson Lagoon estuary were undertaken between April 1976 and February 1977, Approximately 80 species were found to be directly or indirectly dependent on the estuary during various phases of their annual cycle. Numbers of waterfowl and shorebirds using Nelson Lagoon exceed several hundred thousand each fall. The estuary is a major fall staging area for Dunlin, Bar-tailed Godwit, Western Sandpiper, Steller's and King Eider and Emperor Geese.

A preliminary assessment of population levels, timing of migration, and critical foraging and roosting areas is presented in an annotated species format. An in depth study of migratory shorebird use of Nelson Lagoon is appended.

TABLE OF CONTENTS

Introduction

Between 22 April 1976 and 3 February 1977 field studies were conducted along the northcentral Alaska Peninsula at Nelson Lagoon, Herendeen Bay and Port Moller. The preliminary results reported here represent part of the U.S. Fish and Wildlife Service's effort to obtain baseline natural resource data from outer continental shelf and intertidal areas throughout Alaska. These data will be used to help evaluate the potential impacts on natural resources from accelerated development of oil and natural gas reserves in Alaska outer continental shelf waters.

The objectives of this, the first year of a planned two year study were:

1. To conduct general avifaunal assessments of Nelson Lagoon, Port Moller and Herendeen Bay.
   a. To determine the number and distribution of each species relative to other species, to periods of the breeding season, and to characteristics of available habitat within the colony or study area.
   b. To provide estimate of production or nesting success of principal species.
   c. Catalog colony sites and identify important feeding and roosting areas.
2. Identify and evaluate the importance of intertidal substrates to locally breeding and migratory shorebirds and waterfowl.
3. Collect, incidental to the above, observations on marine mammals and identify and map major plant communities within the study area.

Current State of Knowledge

Comparatively few studies have been directed at the avifauna of the central Alaska Peninsula. Those which have are often cursory and confined to brief periods in late spring and early fall; none covering more than a few consecutive weeks. Certain components of the Peninsula avifauna such as shorebirds are poorly known while more extensive information exists on waterfowl.

The Alexander Stone Expedition of 1903 (Chapman 1904) represents the first effort to catalog the birds of the Port Moller-Herendeen Bay area. This was followed by the Stoll-McCracken Expedition of 1928 (Jaques 1930) which also centered its studies around the Port Moller area. Combined, the two expeditions reported on only 30 species from the Port Moller-Herendeen Bay area. Murie (1959), in his faunal survey of the Alaska Peninsula and Aleutian Islands in 1937-1938, added little new information about the bird life of this segment of the Peninsula.

McKinney (1959) was apparently the first to investigate the Nelson Lagoon area; however, his efforts were directed at only three or four species and for only a two week period in May 1958. In the mid 1950's, the U.S. Fish & Wildlife Service (FWS) began conducting spring waterfowl surveys on the Peninsula. While these have never been flown south of Ugashik they provide data from which inferences can be made about the waterfowl of the central peninsula for the same period. From 1964 there exists a spring waterfowl survey, also conducted by the FWS, with considerable information about the Port Moller-Nelson Lagoon area. It was not until the early 1970's, however, that significant data on late summer and early fall bird use of the area became available. Several aerial and ground surveys conducted by the Alaska Department of Fish and Game (Arneson, 1976) and the FWS provide good quantitative data on waterfowl and other waterbird use of the area; particularly Nelson Lagoon. These references are cited as: G. V. Byrd, E. P. Bailey, and R. D. Jones, Jr., pers. comm. or unpublished data.

Pelagic and inshore avifauna off Port Moller and Nelson Lagoon have only been recently looked at (King and McKnight 1969; Bartonek and Gibson 1972). While these investigations are major contributions and increase our understanding of occurrence and abundance of birds in the Bristol Bay region, there still remain gaps in our knowledge of bird use in this area; especially in winter, early spring, and late fall.

STUDY AREA

The study area is located centrally along the north side of the Alaska Peninsula (Figure 1). The combined area of 540 km^2, comprised of Nelson Lagoon (100 km^2), Port Moller (240 km^2), and Herendeen Bay (200 km^2) represents the largest estuarine area along the Alaska Peninsula and accounts for approximately 44 percent of all such habitat along the north Peninsula.

The north central portion of the Alaska Peninsula is typified by a broad lowland extending inland 10-20 km to the base of the Aleutian Range. Several river systems originating in the Aleutian Range drain out over the lowlands to Bristol Bay. The Peninsula coastline is relatively regular and comprised of numerous sand beaches, low terraces and alluvial fan deposits.

The extensive intertidal mud and sand flats are the most noticeable feature of the western Bristol Bay coastline and particularly so within the study area. Over 230 km^2 of intertidal flats are exposed at MLLW (mean lower-low water) in the Port Moller-Nelson Lagoon area. Open water covers an additional 265 km^2 of the study area at MLLW. Coastal sand dunes (8.2 km^2) barrier islands (4.8 km^2), upland heath (16 km^2) and salt meadows (10 km^2) comprise the remaining major habitat types within the study area.

The major freshwater source to the estuary comes from the combined discharge of the Caribou and Sapsuck Rivers and enters Nelson Lagoon at its western end. Several additional smaller drainages feed the shoreline and headlands of Herendeen and Moller Bays.

The tidal regime of the study area is typical of that along the west coast of North America with two high and two low tides occurring in a 24 hour period. The mean diurnal tide range at Port Moller is approximately 3.2m.

Weather during our study was quite variable. Mean monthly maximum and minimum temperatures were recorded as: May 7°-2°C, June 11°-6°C, July 13°-9°C, August 13°-9°C, September 10°-4°C. The water temperature on 26 May at mid-channel, opposite our cabin, was 3°C. Between 15 June and 15 October water temperature ranged between 9°-10°C. By 15 November water temperature had dropped to 4°C. The estuarine waters are usually ice free between mid-April and October. Prevailing winds between May and September are from the NW and SE. Precipitation at Nelson Lagoon averages 25 inches per year. Prevailing NW and NE winds during winter keeps snow cover to a minimum along the immediate coastal portions of the estuary.

METHODS

The study was headquartered on Nelson Lagoon approximately .5 km east of the village of Nelson Lagoon (Fig. 1). During 1976, Gill conducted an aerial survey of the area between 22-25 April and was present on the study area from 17 May to 22 June, 1 July to 9 August, 13 September to 15 October, 15 to 23 November and during 1977 between 27 January and 3 February. Jorgensen was present from 17 May to 3 September while DeGange was present from 13 September to 15 October and from 15 to 23 November. Gerry Sanger, FWS - Office of Biological Services (OBS), Anchorage visited the camp from 23 May to 1 June.

Logistics and field investigations over the vast study areas were facilitated by: (1) Cessna 180, Piper Super Cub and Grumman amphibious aircraft; (2) the M/V Glazenap from the Peter Pan Seafoods Cannery at Port Moller; (3) a 10' Zodiak inflatable raft and a 15' Grumman Sport canoe, each powered by a 10 HP outboard motor; and (4) several trips to Port Moller from Nelson Lagoon on Nelson Lagoon-based fishing boats.

A number of census and survey techniques were employed during the study. Migratory and local seabird populations were monitored from the Bering Sea beach immediately north of the study headquarters using Type II Sea Watch counts as developed by the FWS-OBS staff. These counts were conducted on the average of once every three days between 17 May and 15 October. Several additional Type II counts were conducted from other sites throughout the study area. Type III counts were conducted over a 57 ha portion of Nelson Lagoon between the Village and Cannery Island. These counts were usually conducted during low tide to maximize shorebird and waterfowl use of the intertidal area. Type III counts were conducted on the average of once every four days during the period 17 May to 15 October. Several Type II and III counts were conducted during subsequent visits to the study area between October 1976 and February 1977.

Intensive studies of shorebird and waterfowl distribution, abundance and habitat utilization in Nelson Lagoon were conducted over several different intertidal substrates using both aerial and ground census techniques. Aerial surveys were flown approximately every seven days between 1 July and 15 October and then every 20 days between 16 October and 31 January 1976. Results, methodology, and descriptions of census areas are included in the appended paper (Appendix A) presented at the Pacific Seabird Group meeting in Asilomar, California on 8 January 1977.

Breeding colonies were initially located by aerial survey and then, where practical, follow-up investigations were conducted from within the colonies. Colony size and productivity data were derived from random observations, line transects, sample plots, and photographic interpretations.

Major foraging and roosting areas of waterfowl, shorebirds and several species of gulls and terns were identified by aerial and ground surveys. Food habits data were collected from: (1) within colonies by noting frequency and amounts of prey items being brought to the colony; (2) by collecting prey items found in colonies and from regurgitations by adults and young within colonies; and (3) from collections of adults and volant young within colonies, over foraging areas, or in transit between the two.

A limited banding and color making program was directed at Glaucous-winged Gulls, Arctic Terns, and several species of shorebirds. Mist nets were used to capture adult terns and shorebirds. Gull chicks were banded by walking through colonies and banding young which were usually between 1-2 weeks pre-fledging.

RESULTS

Because the following data represent a preliminary evaluation of the first year of a planned two-year study, we will offer little comparative material or draw conclusions at this time. Instead, we are presenting an overview of our findings in the form of annotated species accounts. These data were synthesized from: 40 Type III sea watch counts, 53 Type II sea watch counts, 46 hours of aerial surveys, 300 man days of field investigations in addition to the aforementioned, and several hours of interviews with residents of the study area.

Since the study was headquartered on Nelson Lagoon and since logistics did not allow for as extensive evaluation of Port Moller and Herendeen Bay as we would have liked, most of the species accounts pertain to the Nelson Lagoon area unless otherwise stated. Where applicable, pertinent supportive and/or negative data from previous studies are included.

We remind the reader that a permanent camp was not established until mid-May and, therefore, data on early spring occurrence and abundance are incomplete. Also, our late fall and winter observations represent the first collected for the study area and considering the record mild weather for 1976-77, these observations should be interpreted accordingly.

ANNOTATED SPECIES ACCOUNTS

Gavia immer - Common Loon: A regular spring and fall migrant. Found breeding on small lakes and ponds along the Caribou-Sapsuck River drainage. First recorded on 21 May and last seen on 22 September. Ed Bailey (pers. comm.) observed at least one at the mouth of the Caribou River on 23 October 1971.

Gavia adamsii - Yellow-billed Loon: Seen only once during the study. A breeding plumaged bird was seen 200 m offshore during a sea watch on 23 May.

Gavia arctica - Arctic Loon: A common spring and fall migrant. Breeding status unknown for the area. Several breeding plumaged adults were sighted along the Caribou River and several fresh water lakes between June and August. Jaques (1930) reported it "common" about Port Moller between 1-23 June 1928. We recorded a high of 26 birds on 21 May. Birds were still present in the area on 2 February 1977.

Gavia stellata - Red-throated Loon: Common in early summer and then present in reduced numbers through October. Breeding status uncertain. Still present at Nelson Lagoon on 1 February 1977.

Podiceps grisegena - Red-necked Grebe: Locally breeding and common spring and fall migrant. Frequently observed on fresh water lakes and rivers from 23 May through 22 September. Nests reported on small lakes south of Franz Point (Peter Kust, pers. comm.). Jaques (1930) reported several on fresh water ponds near Port Moller on 4 and 20 June 1928. A bird was also observed near Gull Island, Herendeen Bay on 2 August 1976.

Podiceps auritus - Horned Grebe: Frequently seen during spring and fall migration. Horned Grebes were first recorded on 20 May and last observed on 6 October; although none was observed between 1 June and 15 September. This species prefers larger lakes and inshore waters of Bristol Bay.

Puffinus spp. - Sooty and Short-tailed Shearwaters: Shearwaters could not be identified to species from our sea watch site. From previous works (Bartonek and Gibson 1972; Murie 1959; Jaques 1930; and others), the great majority of shearwaters in Bristol Bay is Short-tailed. A look at over 50 beach cast shearwaters revealed all were P. tenuirostris. We first observed shearwaters on 20 May when an average 300 per minute, passed westerly offshore during a 10-minute period. Peak movements occurred between 20-27 May, 14-18 June, 10-15 July and 20-25 August. On 18 June we estimated a passage of over 1,000 per minute during a 90-minute period. On 14 August, a flock of 14 shearwaters was observed within Nelson Lagoon flying west towards the upper lagoon. This species was last observed on 16 November.

Fulmarus glacialis - Northern Fulmar: A total of eight observations was recorded between 8-14 June. Fulmars were not observed again until 30 September. Single beach cast birds were found on 9 July 1976 and 30 January 1977.

Oceanodroma furcata - Fork-tailed Storm Petrel: This species was observed on five occasions between 21 May and 30 September. Usually observed during or following storms. One was collected (O. f. furcata) feeding on the remains of a beached Gray whale (Gill, in press) and another was observed within the Lagoon on 30 September.

Phalacrocorax auritus - Double-crested Cormorant: Breeds locally in Nelson Lagoon and Port Moller, and is a common spring and fall migrant immediately offshore. Observed continuously between 21 May and 23 November. Found nesting (10 + pairs) on Barrier Islands in Nelson Lagoon; also on Egg Island, Port Moller (75 pairs); and on an unnamed island in the Right Head of Moller Bay (25-35 pairs). Downy young were still being attended by adults on 27 September.

Phalacrocorax pelagicus - Pelagic Cormorant: Several "white-patched" cormorants were observed on the sea watches but none could be identified to species. Bailey (pers. comm.) observed a Pelagic Cormorant at the mouth of the Caribou River on 23 October 1971 and one was identified near Franz Point on 2 February 1977.

Phalacrocorax urile - Red-faced Cormorant: A flock of 13 was observed .5 km off Lagoon Point on 8 June and a single bird was observed within a flock of 14 P. auritus on Gull Island in Nelson Lagoon on 5 June. Jaques (1930) observed P. urile near Port Moller on 22 May 1928. We found no evidence of nesting in the study area.

Olor columbianus - Whistling Swan: A year-round resident of the central and western Alaska Peninsula. A common nester on small ponds and lakes adjacent to the study area. Post-breeding populations began congregating along the delta of the Caribou-Sapsuck Rivers in late August. A count of 100 was recorded on 19 September. Peter Kust (pers. comm.) reported a high of 154 from the same area in early October 1974. Last observed on 3 February 1977 (P. Kust, pers. comm.).

Branta canadensis taverneri - Lesser Canada Goose: Observed twice on the intertidal portions of the study area. A flock of five, mixed with seven Emperor Geese, was observed off Big Hill on 28 August; and a flock of 20 was seen in this same area on 12 October. Much more common inland along the upper reaches of the Caribou and Sapsuck Rivers. A high count of 500 was recorded on 8 October along the Sapsuck River.

Branta bernicla nigricans - Black Brant: Common spring and fall migrant along the westcentral portion of the Peninsula. First observed on 21 May and last seen on 19 November. Intertidal areas within the study area received little use by this species. A flock of 17 was observed on Mud Bay on 19 and 28 September and several additional sightings of single birds within the Lagoon were made between 1 September and 1 November. During fall migration, P. Kust (pers. comm.) reported several hundred passing inside Nelson Lagoon during a storm on 15 September.

Anser canagica - Emperor Goose: A year-round resident of the western Peninsula and Aleutian Islands. Present continuously on the study area between 22 April 1976 and 3 February 1977. Depending on ice conditions, spring migrants begin arriving in numbers on the study area around 1 April. On 1 April 1964, 5,700 were counted on Nelson Lagoon and Mud Bay. By 5 April numbers had increased to 13,000 and on 1 May over 19,000 were present (un-published data, FWS, Anchorage). We counted over 3,000 on the mudflats opposite our cabin on 20 May. Numbers during fall migration are more impressive. Populations begin to build in late August. Peak numbers of 47,000 were recorded on 2 December. On 3 February 1977 numbers were down to 11,000. Major foraging areas occur in Mud Bay, along the extensive mud/sand flats west of the village, on the flats west of Cannery Island and east of the village, and over all intertidal flats between Big Hill and Cape Rozhnof. Small flocks ($<$1,000) have been observed foraging between Pt. Divide and Hotspring and in upper Port Moller. During 1976-77 Emperor Geese prefered to roost along the barrier islands in Nelson Lagoon and along the Kudobin Islands.

Anser albifrons - White-fronted Goose: A flock of six was observed with Emperor Geese on 19 September southwest of Cape Rozhnof. Ed Bailey (pers. comm.) observed two birds with a flock of three Emperor Geese on Nelson Lagoon on 22 October 1971.

Anas platyrhynchos - Mallard: Common local breeding species, fall migrant and occasional winter resident. Found throughout Nelson Lagoon, Herendeen Bay and Port Moller. We recorded a high of 140 birds near Franz Point on 3 October; however, Bailey (pers. comm.) saw 1-2,000 daily between 22-25 October 1971.

Anas strepera - Gadwall: Common breeding species and fall migrant. Neither Chapman (1904) nor Jaques (1930) reported this species in the study area. Bailey (pers. comm.) reported that scattered birds and small flocks were seen regularly in late October 1971. Our last sighting was on 28 September. Our high count was of 92 on 28 August.

Anas acuta - Pintail: Breeds locally on islands in the upper Lagoon delta and on small ponds adjacent to the estuary. A high of 7,000 was recorded during fall migration on 28 September. Last observed on 18 November when 100 were recorded on an aerial survey of the study area.

Anas americana - American Wigeon: Uncommon breeding species on salt meadows and ponds along major freshwater drainages. Seen regularly on the study area during fall migration. A high of 50 was recorded on 24 September. Bailey (pers. comm.) observed a flock of 30 on 23 October 1971 near David River.

Anas penelope - European Wigeon: A male with an unidentified female wigeon was observed in the river delta of Nelson Lagoon on 30 June. We found no evidence of breeding.

Anas spatula - Northern Shoveler: Seen on five occasions between 30 May and 6 August. No evidence of nesting.

Anas carolinensis - Green-winged Teal: Nests locally and is common in migration in late summer and fall. Observed regularly between 6 June and 15 October. A high of 300 was recorded on a 21 August aerial survey of the study area.

Aythya marila - Greater Scaup: Probably the most abundant nesting waterfowl in the study area. Seen regularly between 23 May and 2 October. Twenty-three nests were found during this period and a high count of over 1,500 was recorded on 12 October in upper Moller Bay. Prefers delta and upriver areas but occasionally seen on Nelson Lagoon and Herendeen Bay.

Bucephala clangula - Common Goldeneye: Uncommon spring, late summer, and fall migrant. Occasionally winters on the area (P. Kust, pers. comm.). River delta and freshwater lakes are prefered. A high of 75 was recorded on 18 November. Bailey (pers. comm.) reported several hundred seen in the upper Lagoon between 22-25 October 1971. Approximately 25 were seen along the Caribou River on 30 January 1977.

Bucephala albeola - Bufflehead: One immature female was shot on the Caribou River by a villager on 6 October and a male was observed on a lake along the Caribou River on 6 October.

Histrionicus histrionicus - Harlequin Duck: Probably an uncommon nester along streams in upper Herendeen Bay and Port Moller. We observed this species on seven occasions between 19 May and 10 October. A mixed group of 14 males and females was seen along Cannery Island on 13 June. A flock of 13 was seen in Mine Harbor, Herendeen Bay on 31 July. Bailey (pers. comm.) reported small groups of 5-10 birds in Nelson Lagoon between 22-25 October 1971. He also observed four birds approximately 10 km up the Sapsuck River on 24 October 1971.

Clangula hyemalis - Oldsquaw: Common spring and fall migrant and occasional winter resident. Our last spring record was on 22 May. Not seen again until 11 July, following which numbers increased steadily through November. A high of 5,000 was recorded on 28 January 1977. This species prefered to forage in Nelson Lagoon between the peninsula and barrier islands and also south of the village. Other feeding concentrations were found offshore during sea watches and off Gull Island and the western Kudobin Islands.

Polysticta stelleri - Steller's Eider: Abundant spring and fall migrant and common summer and winter resident. There is no evidence of breeding in the area. Observed regularly between 18 May 1976 and 3 February 1977. We recorded a high of 44,000 birds on a 28 September survey of the Nelson Lagoon-Mud Bay area. Bailey (pers. comm.) and Robert Jones, Jr. (pers. comm.) also reported this species as occurring over the area in the tens of thousands from August through December. There is one report of over 100,000 birds on the study area on 5 April 1964 (FWS unpublished data, Cold Bay NWR). That same year some 70,000 were recorded on Nelson Lagoon on 1 May. Steller's Eiders prefered the same foraging areas as Oldsquaws.

Somateria mollissima - Common Eider: Common spring and fall migrant. Breeds locally on fox-free barrier islands. McKinney (1959) reported several thousand birds nesting on these islands in Nelson Lagoon in 1958. During our study the breeding population probably did not exceed

200 birds. A high spring count of 2,000 birds was recorded on 21 May 1976. R. D. Jones, Jr. (pers. comm.) has a record of 4,500 birds in Nelson Lagoon on 1 May 1964. Fall numbers begin to build in late August. A high of 3,000 was recorded on a 18 November survey and Bailey (pers. comm.) reported approximately 5,000 Common Eiders in Nelson Lagoon between 22-25 October 1971. By 1 December most birds have left the study area. A single pair was present between 1-3 February 1977. We do not know the timing of early spring migration.

Somateria spectabilis - King Eider: A common early spring and late fall migrant and occasional winter resident. Over 120,000 were reported on 1 April 1964 in Herendeen Bay and Nelson Lagoon (R. Jones, Jr. pers. comm.). That same spring only 22,000 were recorded on 1 May for the same area. We saw none after our arrival on 18 May until 9 July when 12 were seen south of Walrus Island. A high of 20,000 was recorded on a 3 February 1977 census of Nelson Lagoon. Major concentrations of eiders were observed foraging in the channel immediately east of the village and off the east end of Gull Island and the southeast end of Walrus Island. Several hundred were seen foraging at sea off Lagoon Point on 2 February 1977.

Melanitta deglandi - White-winged Scoter: A regular spring and fall migrant. Suspected of breeding locally on small ponds along the Caribou/Sapsuck Rivers. Approximately 1,000 were recorded on 1 August in a mixed flock of molting Black, Surf and White-winged Scoters between Deer Island and Point Divide. Also commonly seen during sea watches from August through February 1977. Jaques (1930) reported seeing a few about Port Moller between 22 May and 2 June 1928. Bailey (pers. comm.) reported several thousands in Nelson Lagoon between 22-25 October 1971.

Melanitta perspicillata - Surf Scoter: Observed on five occasions between 21 May 1976 and 3 February 1977. Approximately 750 were recorded from the mixed flock of molting scoters observed on 1 August near Point Divide. Three individuals were seen during sea watches during May, June and July. A single male was seen with a flock of 800 King Eiders off Gull Island on 31 January 1977.

Oidemia nigra - Black Scoter: The most common of the three scoter species recorded from the study area. Found breeding on freshwater ponds along the Caribou/Sapsuck River drainage. Jaques (1930) also reported birds on fresh water pools about Port Moller between 23 May and 20 June 1928. R. D. Jones, Jr. (pers. comm.) has a record of 21,000 birds near Port Moller on 1 May 1954. We had a high fall count of 20,000 on 28 September. Major concentrations were found on Bristol Bay off Lagoon Point, off Gull Island and the Kudobin Islands and between Walrus and Deer Islands. Over 5,000 birds were counted in the assemblage of molting scoters observed on 1 August.

Mergus merganser - Common Merganser: Seen on four occasions. On 22 May a pair was seen near Cannery Island. A flock of seven was seen south of Walrus Island on 9 July, and a single adult male was observed along the Caribou River on 24 July. Two adult males were seen on the river delta on 30 January 1977. We found no evidence of nesting. Jaques (1930) reports this species as abundant in the Port Moller region in late May and June 1929 but most were adult males.

Mergus serrator - Red-breaster Merganser: Common migrant and winter resident. Breeds locally on delta islands and upriver. A raft of 100 birds was observed off Ross Point on 22 July and a similar sized group was observed at the mouth of the Caribou River on 28 October. A flock of 15 mixed male and female birds was seen along the river delta on 30 January 1977.

Haliaeetus leucocephalus - Bald Eagle: A year-round resident and common nesting species on sand dunes, bluffs and rocky cliffs around Nelson Lagoon, Herendeen Bay and Port Moller. Nineteen active eyries were located within the study area between 18 May and 31 August.

Circus cyaneus - Marsh Harrier: A female was observed behind our cabin on 19 May and a pair was observed foraging over Cape Rozhnof on 22 July.

Buteo lagopus - Rough-legged Hawk: Seen on three occasions during the study. Probably nested along cliffs of upper Port Moller and Herendeen Bay. A dark phase bird was flushed from a cliff along the west side of Mud Bay in Moller Bay on 2 August. Chapman (1904) reports a set of eggs taken from Herendeen Bay on 17 May 1903. We also saw light phase birds over Walrus Island on 19 September and along coast slough on 22 September.

Falco rusticolus - Gyrfalcon: Seen regularly between 22 May 1976 and 29 January 1977. Three active eyries were located in the study area.

Falco peregrinus - Peregrine Falcon: A regular but uncommon bird of the study area. We have eight observations from the area between 19 May 1976 and 3 February 1977. No active nests were found but suitable habitat exists.

Lagopus lagopus - Willow Ptarmigan: A common resident of the Alaska Peninsula and seen regularly throughout the upland portions of the study area.

Grus canadensis canadaensis - Lesser Sandhill: Commonly seen on the salt meadows adjacent to the study area and on upland heath throughout the upriver area of Nelson Lagoon. Post-breeding populations began using intertidal areas adjacent to Miner and Big Hills in late August.

Charadrius semipalmatus - Semipalmated Plover: Found nesting near Port Moller, the Kudobin Islands and Lagoon Point. Jaques (1930) also reported nesting near Port Moller in 1928. This species was present in the study area between 20 May and 28 August.

Pluvialis dominica - American Golden Plover: Regular spring and fall migrant. Present from 22 April to 19 May and again from 20 September through late October. Less than 100 birds observed throughout these periods. A flock of 19 was observed at Port Moller on 8 August 1969 (FWS, unpublished data).

Arenaria interpres - Ruddy Turnstone: Present in large numbers between 19 May and 2 October. Bailey (pers. comm.) found them still present in Nelson Lagoon on 22 October 1971.

Arenaria melanocephala - Black Turnstone: Found nesting on delta islands in upper Nelson Lagoon. Present in migration for a brief period in late August, but not as common as the Ruddy Turnstone.

Capella gallinago - Common Snipe: Irregular. Seen from early June through mid-October, usually along the south shore of the upper lagoon. A small migratory wave of snipe came through the lagoon between late September and early October.

Numenius phaeopus - Whimbrel: Present in Nelson Lagoon between 3 June and 2 August. A high count of 900 was recorded on 29 June. The entire population remained in one flock and regularly roosted on upland heath behind Franz Point. A flock of 33 was observed at Port Moller on 13 August 1969 (FWS, unpublished data).

Tringa melanoleucus - Greater Yellowlegs: Common summer and fall migrant along the upper Lagoon and between Big Hill and Franz Point. Present between 7 July and 15 October. A high of 60 was recorded on a 27 September census.

Tringa flavipes - Lesser Yellowlegs: Regular late summer early fall migrant but much less common than the Greater Yellowlegs. A total of 12 birds was seen between 6 August and 1 October. Habitat preferences similar to the Greater Yellowlegs.

Calidris ptilocnemis ptilocnemis - Rock Sandpiper: Common year-round resident found nesting on upland areas adjacent to the estuary. Peak numbers of 3,000 + were recorded during mid-October.

Calidris acuminata - Sharp-tailed Sandpiper: This Asiatic breeder was observed on the Lagoon for a brief period during fall migration. A flock of 21 was seen along the upper reaches of the Lagoon on 22 September. On 6 October, two Sharp-tailed Sandpipers were again seen at this same location.

Calidris melanotos - Pectoral Sandpiper: A single bird was observed with the above flock of Sharp-tailed Sandpipers on 22 September.

Calidris minutilla - Least Sandpiper: Breeds locally and common during early summer migration. Peak numbers of approximately 1,000 were recorded on 1 July. Regularly seen around Franz Point, Miner Hill and upriver. Jaques (1930) reported them abundant about Port Moller after 25 May.

Calidris alpina - Dunlin: A common breeding species and abundant fall migrant. Populations were present from early April through mid-November. Peak numbers were recorded during late September. A high count of over 50,000 was recorded on a 27 September survey of Nelson Lagoon and Mud Bay; 36,000 of these were found on the western portion of Nelson Lagoon.

Limnodromus griseus - Short-billed Dowitcher: Common spring and fall migrant and local breeder on delta islands in upper Nelson Lagoon. Peak fall migration occurred around 1 August when a count of 2,000 was recorded. This species was last observed on 15 October.

Limnodromus scolopaceus - Long-billed Dowitcher: A late summer and early fall migrant, but less common than the Short-billed Dowitcher. Present from 15 August through 15 October, peak numbers recorded on 2 October. Populations prefered the upper reaches of the Lagoon.

Calidris mauri - Western Sandpiper: An abundant early summer and fall migrant. Western Sandpipers were present on the study area between 7 June and 24 September with peak numbers of 9,000 recorded on 10 July.

Limosa lapponica - Bar-tailed Godwit: An uncommon spring migrant but abundant late summer-fall migrant. We had a single observation of a flock of five birds in Nelson Lagoon on 27 May. Post-breeding birds began arriving on 11 July. Numbers peaked on 19 September when we recorded over 10,000 on Nelson Lagoon. We last observed them on 12 October.

Phalaropus fulicarius - Red Phalarope: Common spring and fall migrant. Observations extend from 19 May through 16 November. Peak numbers were recorded during mid-July.

Lobipes lobatus - Northern Phalarope: Found nesting on fresh water ponds adjacent to the estuary. Present on the study area from early May through 16 November. Peak fall migration occurred during early August. Northern Phalaropes were seen regularly about Port Moller in early July 1973 (V. Byrd, pers. comm.).

Stercorarius pomarinus - Pomarine Jaeger: Observed between 27 May and 9 July. A total of 16 birds was seen during this period; 14 of which were light phase. Murie (1959) reported seeing several near Nelson Lagoon on 22 May 1936.

Stercorarius parasiticus - Parasitic Jaeger: The most common of the three jaegers observed during the study. Scattered nesting was recorded throughout the uplands and wet heath surrounding the area. Birds were observed between 18 May and 27 September with light and dark phases occurring about equally.

Stercorarius longicaudus - Long-tailed Jaeger: A total of 13 birds, from seven separate observations, was recorded between 24 May and 24 July.

Larus hyperboreus - Glaucous Gull: Immature birds were observed at Neson Lagoon on 22 and 25 May and again on 16 November.

Larus glaucescens - Glaucous-winged Gull: A year-round resident and common breeding species on fox free islands in Nelson Lagoon, Herendeen Bay and Port Moller. Four colonies and eleven sub-colonies were located during 1976. Combined, they represented approximately 6,500 breeding pairs. The largest colony was comprised of approximately 500 pairs while the smallest had 50 pairs. The average nesting density for all barrier island colonies (n=12) was one nest per 54 m^2. Volant young were first observed on 1 August. The majority of young had fledged by 1 September; however, adults were still tending flightless young on one island on 15 September. Five hundred young were banded and color marked. To date, the only recovery has been from the Kodiak Island area in early February 1977.

Larus canus - Mew Gull: A common year-round resident and local nesting species. Breeding was apparently confined to the upper delta of the Lagoon and adjacent small lakes throughout the Caribou-Sapsuck River drainage. A "colony" of approximately 100 pairs nested on the most easterly island in the river delta. Post- and non-breeding populations numbered about 1,000 birds in the Lagoon in early October. By late November numbers were down to 330. On 31 January 1977 approximately 50 birds, almost all adults, were concentrated upon the delta area of the Lagoon.

Larus philadelphia - Bonaparte's Gull: Regularly observed between 29 May and 1 October, and very abundant from late July through early September. A total of 2,000 was counted along the periphery of Moller Bay on 2 August. Breeding was not confirmed but is highly suspect for the central Peninsula.

Rissa tridactyla - Black-legged Kittiwake: A colony of between 200 and 250 pairs was found on Gull Island, Herendeen Bay on 17 July. This species was also commonly seen offshore during sea watch periods between 19 May and 1 October. Large numbers began roosting on the barrier islands in Nelson Lagoon in late July. We recorded a high of 1,400 birds in the study area on a 22 July aerial survey.

Xema sabini - Sabine's Gull: Uncommon but seen regularly between 23 May and 20 November. A high of nine was recorded during a ten minute sea watch on 23 September. The species was observed inside the Lagoon on three occasions and several beach cast birds were found in October and November.

Sterna paradisaea - Arctic Tern: A common summer resident and breeding species throughout the study area. Arctic Terns were present upon our arrival on 18 May and were seen continuously through 23 September. Both Jaques (1930), and Bartonek and Gibson (1972) reported this species as common about the Port Moller area. We located four major colonies and noted numerous isolated nesting pairs on small ponds throughout the study area. Colonies were located on Entrance Point near the Port Moller Cannery (300 pairs), on Cannery Island in Nelson Lagoon (350-400 pairs), on Lagoon Point, Nelson Lagoon (500 pairs) and on an unnamed delta island in upper Nelson Lagoon (50-75 pairs). Peak laying for all colonies occurred during the first week of June. Volant young were first observed on 12 July. Post-breeding flocks of over 2,000 birds were seen on Lagoon Point through August and early September.

Sterna aleutica - Aleutian Tern: Observed regularly between 21 May and 30 August and found nesting along Entrance Point at Port Moller and on an unnamed island in the upper Nelson Lagoon delta. The Port Moller colony has had one of the longest recorded histories dating to Jaques (1930) and probably represents the largest known colony in Alaska (400 + pairs in 1976). The Nelson Lagoon colony was comprised of between 100 and 125 pairs. Volant young were first observed on 24 July.

Uria aalge - Common Murre: Seen frequently during sea watches and occasionally inside the lagoon between 8 June and 17 November. We found no evidence of nesting within the study area. Bartonek and Gibson (1972) reported this species as common off Port Moller and Port Heiden in August 1969. During a massive die off of Common Murres in Bristol Bay in April 1970, over 3,400 dead birds per mile accumulated on the beach along Entrance Point and Port Moller (Bailey and Davenport 1972).

Uria lomvia - Thick-billed Murre: Three were seen immediately W of Walrus Island on 9 June.

Cepphus columba - Pigeon Guillemot: Found nesting on Gull Island in Herendeen Bay and along cliffs of upper Moller and Herendeen Bays. The Gull Island population was figured at between 25 and 30 pairs on 1 August. This species was also occasionally observed during sea watch periods between 1 June and 2 September.

Brachyramphus brevirostre - Kittlitz's Murrelet: We saw five along the outer Kudobin Islands on 8 June and seven between Walrus Island and Port Moller on 9 June. Small alcids, probably of this species, were observed in Herendeen Bay in late July and early August and are suspect of nesting in the area. However, while we did not positively identify any as such, Marbled Murrelets have also been reported in Port Moller (V. Byrd, unpublished data, FWS).

Synthliboramphus antiquum - Ancient Murrelet: This species was observed on four occasions during the study. A pair was seen on 9 June off Walrus Island and four separate sightings were recorded on a sea watch on 10 June. On 23 September we observed three winter plumaged birds between Cannery Island and the village of Nelson Lagoon and two birds were recorded on a sea watch on 1 February 1977.

Aethia cristatella - Crested Auklet: Two adults were seen between Walrus Island and Port Moller on 9 June. Bartonek and Gibson (1972) recorded an adult on 8 August 1969, several km northwest of Port Moller.

Fratercula corniculata - Horned Puffin: Found nesting on Gull Island in Herendeen Bay. Between 18 and 25 pairs were nesting there on 1 August. This species was also seen on several sea watches between 10 June and 30 July. Jaques (1930) observed the bird "sparingly" about Port Moller in 1928.

Lunda cirrhata - Tufted Puffin: A common migrant and local nesting species. Our observations of this species were confined to the period 20 May through 28 August. This species nested on several small barrier islands in Nelson Lagoon and is thought to have nested on Egg Island in Moller Bay. On an aerial survey of the latter area on 22 July approximately 50 adults were seen on the water at the base of the island and an additional 20-25 adults flew from the cliffs as we circled the area.

Bubo virginianus - Great Horned Owl: Several primary and contour feathers as well as pellets were found in the remains of an abandoned cannery in upper Herendeen Bay on 30 July. Murie (1959) makes no reference to this species occurring along the central and western portions of the Peninsula.

Nyctea scandiaca - Snowy Owl: Four birds were seen between 28 January and 3 February 1977; three of which were present on Lagoon Point during this time. This species is a regular winter visitor to the area (P. Kust, pers. comm.).

Asio flammeus - Short-eared Owl: This species was observed several times between 5 June and 19 November. We suspect nesting based on a 2 August sighting over Cannery Island of three volant young accompanied by an adult. Our most frequent sightings occurred between mid-September and late November.

Iridoprocne bicolor - Tree Swallow: A common nesting species around all suitable manmade dwellings. We observed them on the study area between 23 May and 30 July.

Riparia riparia - Bank Swallow: A common nesting species throughout the study area. Major nesting colonies were found at Franz Point, Miner Hill, Point Divide, Doe Point and Mine Harbor.

Pica pica - Black-billed Magpie: An uncommon nesting species and winter resident, most frequently found in association with alder and willow habitat around Moller and Herendeen Bays. We seldom observed them away from these areas during the breeding season. Occasionally magpies are found at the Port Moller Cannery and the Nelson Lagoon Village in winter. (P. Kust, pers. comm.).

Corvus corax - Common Raven: Seen regularly between 22 April and 3 February 1977. We did not find nests but suitable habitat exists around both Herendeen and Moller Bays. On 30 January 1977 over 75 were observed in association with Mew and Glaucous-winged Gulls and Bald Eagles along the upper reaches of the Lagoon.

Parus atricapillus - Blackcapped Chickadee: Two were seen singing in scrub alder along Crow Point, Herendeen Bay on 31 July. Two others were observed along the upper Caribou River on 6 October and a flock of five was seen in willows behind Franz Point on 20 November. Chickadees were also found at Port Moller between 7-8 July 1973 (V. Byrd, pers. comm.).

Turdus migratorius - Robin: Single birds were observed near Mine Harbor, Herendeen Bay on 30 July and at the Port Moller Cannery on 9 August.

Catharas guttatus - Hermit Thrush: Three were seen and heard in moist overhanging vegetation along the southwest side of Gull Point, Herendeen Bay on 31 July, and others were seen near Mine Harbor on 31 July and along Coast Lake on 22 September.

Anthus spinoletta - Water Pipit: Seen on four occasions between 6 August and 2 September. Single birds were found at Miner Hill, Franz Point and our cabin. Two others were observed between Miner Hill and Franz Point.

Lanius excubitor - Northern Shrike: Single birds were observed near Crow Point, Herendeen Bay on 31 July, at the Port Moller Cannery on 29 August, along Coast Lake on 22 September and along the Caribou River on 7 October.

Dendroica petechia - Yellow Warbler: Several singing males were seen on 14 June near the mouth of the Caribou River and upstream for approximately five miles. Yellow Warblers were also very common about Mine Harbor and Herendeen Bay in late July and early August.

Dendroica coronata coronata - Yellow-rumped Warbler (Myrtle): A singing male was seen and another heard approximately 3 km south of the mouth of the Caribou River on 12 June. A pair was seen near Franz Point on 22 July.

Wilsonia pusilla - Wilson's Warbler: What was probably the same female was captured inside our cabin on 24 August and observed again on 29 August capturing insects in front of the cabin. Several were observed in alders at Port Moller between 7-8 July 1973 (V. Byrd, unpublished data).

Carduelis hornemanni - Hoary Redpoll: A male was collected near Franz Point on 25 July and others were seen near Mine Harbor on 31 July and along Coast Lake on 22 September.

Carduelis flammea - Common Redpoll: Seen more frequently than the Hoary Redpoll. Common upriver along willow rows in June and July, and in alders near Port Moller and Herendeen Bay in July and August.

Junco hyemalis hyemalis - Dark-eyed Junco (Slate-colored): A flock of three remained near our cabin between 17-25 September.

Passerculus sandwichensis - Savannah Sparrow: Probably the most abundant land bird on the study area. Very common nester on adjacent habitats and abundant during migration on virtually all parts of the study area. Fall migration peaked in late July and extended into August.

Zonotrichia leucophrys gambelii - White-crowned Sparrow: Seen during spring migration in the village (21 May) and throughout the upland tundra and alder thickets in summer and early fall. Last recorded on 6 October.

Zonotrichia atricapilla - Golden-crowned Sparrow: A group of three was seen on 23 May immediately east of our cabin. Golden-crowned Sparrows were also present, but less common than the White-crowned Sparrow, around Herendeen Bay and along the dense upland vegetation along the Caribou River. V. Byrd (unpublished data) saw and heard several at Port Moller in early July 1973.

Passerella iliaca - Fox Sparrow: Seen regularly in Herendeen Bay between 30 July and 1 August. Also seen at Port Moller on 29 August and at our cabin on 17 September and in the village on 6 October.

Calcarius lapponicus - Lapland Longspur: Seen regularly between 17 May and 10 August. A common nesting species on adjacent tundra and wet heath.

Plectrophenax nivalis - Snow Bunting: Common fall migrant and winter resident on coastal dunes and barrier islands. We had good looks at several flocks of buntings but could not positively identify McKay's Buntings (P. hyperboreus) among them.

Marine Mammal Observations

Eschrichtius robustus - Gray whale: Gray whales were observed almost daily between 18 May and 21 November. On a 23 April aerial survey of the study area, 18 were counted between Entrance Point, Port Moller and Lagoon Point, Nelson Lagoon. Whales were most frequently seen feeding inside the Lagoon between Cannery Island and the Village peninsula and between Gull Island and the Kudobin Islands. Gray whales were also frequently seen offshore during sea watches, especially in late May and early June. During late September whales were observed foraging in upper Nelson Lagoon almost 12 km southwest of Lagoon Point. Gray whales have been reported in Herendeen Bay and upper Port Moller (Paul Gundersen, pers. comm.), although we did not observe any there during our study. We detected no fall passage of whales during our 13 September - 15 October and 15-23 November sea watches. Gray whales might, therefore, possibly pass farther offshore during southern migration—or fall migration is much more abbreviated and occurred during our absence in late October and early November. We last observed Gray's feeding in Nelson Lagoon on 21 November.

Phocoena phocoena - Harbor Porpoise: This species was observed in small numbers (<10) between Walrus Island and Port Moller on 9 and 16 June and again on 30 August. They were also occasionally seen off Nelson Lagoon in August during several sea watches. They have been reported in upper Herendeen Bay (P. Gundersen, pers. comm.).

Eumetopias jubata - Steller Sea Lion: One was observed inside Nelson Lagoon on 25 May and several (<10) were observed during sea watches between 18 May and 15 October.

Phoca vitulina - Harbor Seal: Very abundant throughout the area during the study period. Pupping occurred around mid-June. A high count of approximately 1,500 was recorded on a 13 September aerial survey. Harbor seals winter in the area and have been reported as far as 25 km up the ice covered Caribou River in January - March (B. Johnson and P. Gundersen, pers. comm.).

Enhydra lutris - Sea Otter: Observed on several occasions offshore during sea watches and inside the lagoon as far south as Big Hill.

CONCLUSIONS

The open waters and intertidal areas of Nelson Lagoon, Port Moller and Herendeen Bay were found to support directly or indirectly 80 of 106 avian species identified from the study area. Included are 36 species of waterfowl, 20 species of shorebirds and an additional 20 species of gulls, terns, jaegers and alcids. With regards to waterfowl and shorebirds, the area probably supports several hundred thousand of each during spring migration and over a million during fall migration and winter. Fall and winter populations of Black Scoter, Steller's Eider, King Eider, Oldsquaw, and Emperor Geese foraged extensively over the intertidal portions of Nelson Lagoon, Mud Bay and Port Moller. Shorebird populations exhibited more restricted foraging preferences and were seldom found outside Nelson Lagoon or Mud Bay. With respect to Bar-tailed Godwits, probably the majority of the entire North American breeding population stages on Nelson Lagoon prior to transpacific migration.

ACKNOWLEDGEMENTS

We thank the Nelson Lagoon Village Council and all other members of the village for allowing us to conduct our studies over much of their lands. Mr. Paul Gundersen is especially thanked for providing living quarters for us during the study and for sharing with us his extensive knowledge of the area. Messrs. Sherman Johnson, Jr., Harold Johnson, Tommy Johnson, Paul E. Gundersen, Billy Johnson, and the late Sherman Johnson, Sr., similarly provided vaulable background information about the area. Ms. Leslie Becker spent many hours collecting and identifying the flora of the study area and assisting us in many other aspects of the study. The Peter Pan Seafood's Cannery at Port Moller provided much of the logistic support for out study.

The often extended periods away from home were compensated for by the hospitality and friendship extended to us by the families of Nelson Lagoon. We thank them all for a most rewarding and enjoyable summer.

NEED FOR FUTURE STUDIES

This represents the only OCS related study to determine bird use of intertidal substrates in Bristol Bay. In order to complete this study and develope meaningful base line data, we feel the following objectives need be completed during 1977:

1. More clearly defined foraging strategies and trophic relationships of shore- and waterbirds using intertidal substrates in the Nelson Lagoon Area.

2. Continue quantitative assessments of breeding and migratory bird populations throughout the study area with more emphasis directed at the Port Moller and Herendeen Bay areas.

3. Begin in late summer, a complimentary study of avifaunal use of intertidal areas in Izembek Lagoon. This study should then be continued through fall 1978.

ESTIMATE OF EXPENDITURES
(15 April - 13 December 1976)

Salaries	$20,000
Per Diem and Travel	2,000
Logistics	3,000
Commodities	3,300
Equipment	400
Total	$28,700

LITURATURE CITED

Arneson, P.D. 1976. Identification, documentation, and delineation of coastal migratory bird habitat in Alaska. In: Environmental Assessment of the Alaska Continental Shelf, Vol. II. Annual Reports, April 1976. U.S. Dept. Comm., NOAA and U.S. Dept. Inter., BLM

Bailey, E.P. and G.H. Davenport. 1972. Die-off of common murres on the Alaska Peninsula and Unimak Island. Condor 74:215-219.

Bartonek, J.C., and D.D. Gibson. 1972. Summer Distribution of Pelagic Birds in Bristol Bay, Alaska. Condor 74:416-422.

Chapman, Frank M. 1904. List of Birds Collected in Alaska by the Andrew J. Stone Expedition of 1903. Bull. American. Mus. Nat. Hist. Vol. XX, Art. XXXIV.

Jaques, F.K. 1930. Water Birds observed on the Arctic Ocean and Bering Sea. Auk 47: 353-366.

McKinney, Frank. 1959. Waterfowl at Cold Bay, Alaska with notes on display of the Black Scoter. The Wildfowl Trust, Tenth Annual Report, 1957-1958. p 133-140.

Murie, O. J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. U.S. Dept. Inter., Fish and Wildl. Serv., N. Amer. Fauna 61:1-364.

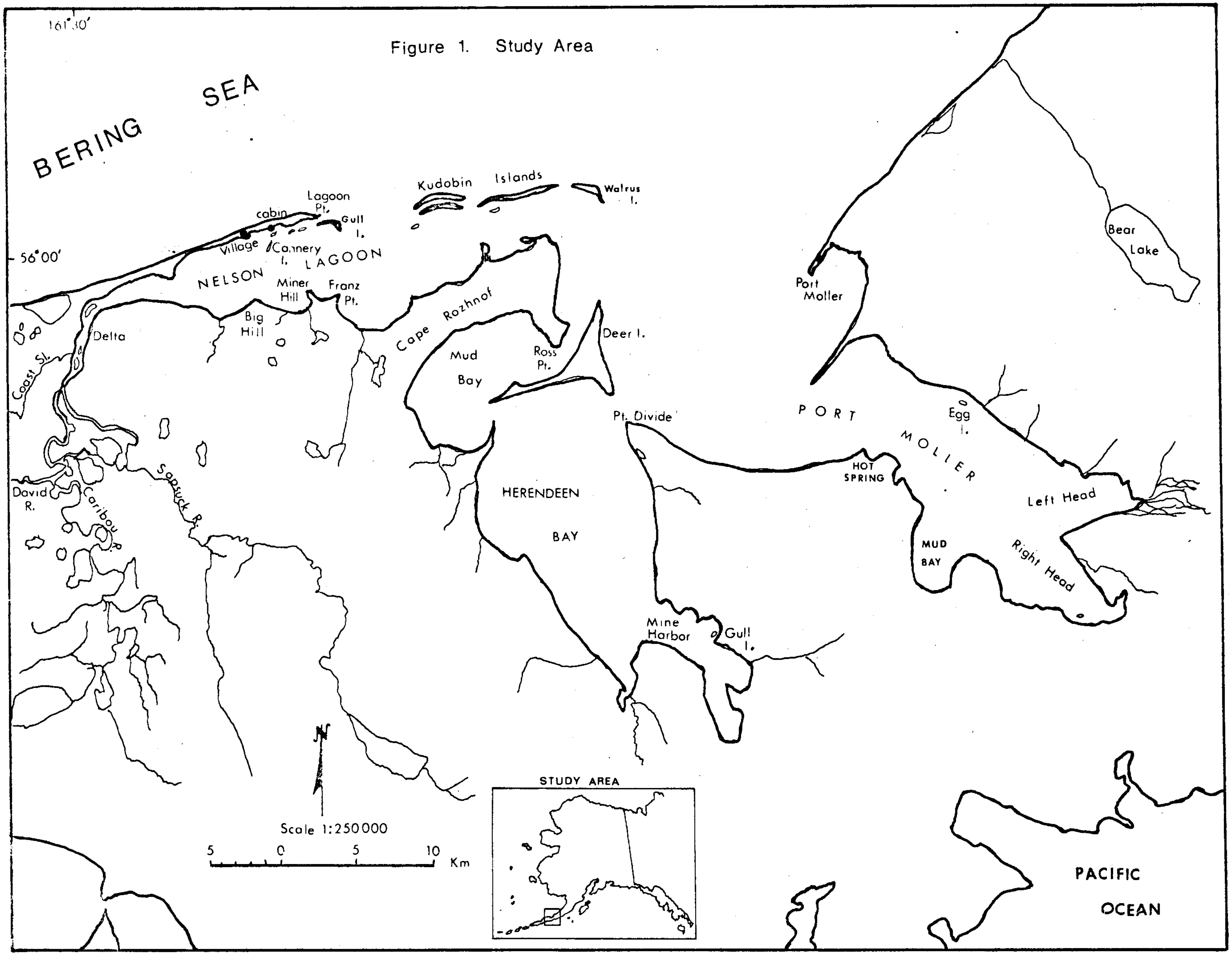


Figure 1. Study Area

APPENDIX A

A PRELIMINARY ASSESSMENT OF TIMING AND MIGRATION OF SHOREBIRDS ALONG THE NORTHCENTRAL ALASKA PENINSULA

ROBERT GILL, JR.
U.S. FISH AND WILDLIFE SERVICE
ANCHORAGE, AK 99501

and

PAUL D. JORGENSON
3570 Glade Street
San Diego, CA 92115

It is understandable that almost all Alaska shorebird investigations have concentrated on aspects of reproductive biology or other physiological processes while on the breeding grounds (for reviews, see, e.g. Holmes 1966a, 1966b, 1966c, 1971, 1972; Holmes and Pitelka, 1968; MacLain and Holmes, 1971; Norton 1972; Pitelka 1959 and Pitelka, et. al., 1974). Comparatively few Alaska studies have focused on post-breeding movements or staging patterns of migrant shorebirds. Indeed, over much of southwest Alaska and the Alaska Peninsula, an area with over 2000 km^2 of intertidal substrates and 1800 km of coastline, there have been no studies directed specifically at migrant shorebird use of intertidal habitats; albeit mudflats, sandy or rocky beaches or salt meadows. We know from cursory observations that over 30 species of shorebirds utilize these habitats during migration: often by the tens if not hundreds of thousands (Chapman 1904; Jaques 1930; Hurley 1931, 1932; Murie 1959; P. Arneson, M. Dick, D. Gibson, J. King, M. Petersen, unpublished data).

In this paper we report the results of the first quantitative assessment of the timing and migration of shorebirds along a major estuary of the north Alaska Peninsula.

STUDY AREA

The study was conducted along the northcentral Alaska Peninsula at Nelson Lagoon (56°00'N, 161°10'W) from 22 April through 1 December (Fig. 1). The north Alaska Peninsula is typified by a relatively regular coastline comprised of numerous sand beaches, low terraces and alluvial fan deposits. The coastal lowland, which is dotted by numerous small lakes and drained by several river systems, extends inland between 10 and 20 km to the base of the Aleutian Range.

Nelson Lagoon is a 100 km^2 component of the larger 540 km^2 Herendeen Bay-Port Moller estuarine complex which, in itself, comprises approximately 44 percent of all estuarine habitat along the north Alaska Peninsula (P. Arneson, unpublished data). The Lagoon is fed by the combined discharge of the Caribou and Sapsuck Rivers which originate in the Mt. Pavlof and Mt. Dana areas, respectively. The upper Lagoon is a delta of several small, unstable islands grown to *Calamagrostis canadensis*, *Carex aquatilis* and *C. Lyngbyaei*. The adjacent uplands are grown predominantly to

Elymus arenarius mollis, interspersed with Honckenya peploides major and Lathyrus maritima pubescens. Several beds of Zostera marina occur throughout the estuary; however, none is present in Nelson Lagoon.

The study was conducted over approximately 34 km^2 of western Nelson Lagoon (fig. 2). Intertidal substrates within the study area were indentified as: mudflats, 950 ha; mixed mud- and sandflats, 3250 ha; and rocky beaches, 300 ha. Barrier islands (150 ha) and vegetated coastal sand dunes and beaches (280 ha) were used as high tide roosts by shorebirds. Approximately 575 ha of open water remains at MLLW (mean lower-low water).

The estuarine waters of the study area are usually ice free between late April and October. The weather during the study was quite variable. May, July and September mean minimum and maximum temperatures were recorded as: 2°-7°, 9°-13°, and 4°-10°C. Estuarine water temperature averaged 3°, 9° and 4°C during May, August and November, respectively. Prevailing winds are from the NW and SE during this period. The Lagoon experiences two low and two high tides each lunar cycle and has a recorded mean diurnal tide range of 3.2 m.

METHODS

Shorebird data were derived primarily from aerial and ground censuses. Numerous incidental shorebird observations were collected while investigating other components of the study area avifauna. An initial aerial survey of the study area was made by Gill on 23 April. A permanent field camp was established along Lagoon Point on 18 May, approximately 1 km E of the village of Nelson Lagoon. We were present on the study area between 18 May and 3 September, 13 September through 15 October and again between 17-24 November. Interim observations were provided by Mr. Peter Kust, Sr. who also acted as our pilot throughout the study.

Seven census areas were delineated within the study area and their intertidal substrates identified and mapped (fig. 2). Census areas ranged between 56- and 950 ha.

Ground censuses

Between 21 May and 16 September, ground shorebird surveys focused on census area II, in front of our study headquarters. Censuses were conducted approximately every four days using a 20X spotting scope. We counted all birds on the area but made no distinction among species use of substrate types. A second type of census, also conducted approximately every four days throughout this same period, was directed specifically at shorebirds and their substrate selection. Several additional ground censuses were conducted on census areas I and III - VII but were conducted too infrequently to evaluate patterns of occurrence and abundance. The chief value in these surveys was in providing comparative data between aerial and ground censuses over the same area during the same tidal cycle.

Aerial censuses

Between 1 July and 15 October, weekly aerial surveys were flown over census areas II-VII. Only one census was conducted over area I during July. No censuses were flown over any of the areas between 3 - 13 September. From 16 October through 1 December, bi-weekly censuses were flown over all areas.

Censuses were flown in a Piper Super Cub at an elevation of between 50 and 75 m and at an airspeed of 75 knots. The pilot plus one observer conducted most censuses. Only the observer counted shorebirds but often relied on the pilot to locate concentrations of birds. Of 16 total censuses, Gill conducted 10, Jorgensen 4, while Kust flew 2 during our absence in October and November. Censuses were flown between 1.5 hours before or after low, slack tide. Census duration averaged 45 minutes. Censuses started at area I and followed in sequence through area VII.

Shorebird numbers were voice recorded on magnetic tape and later transcribed to census forms. Censuses were conducted by first flying the edge of the substrate/water interface since most shorebirds were found concentrated along this area during early stages of each low tide. We then returned to survey other potions of each census areas as we saw shorebird concentrations. The airplane invariably disrupted concentrations of foraging shorebirds; however, we found most concentrations re-settled within several hundred meters of their initial area. We feel duplicate counts from any one area or between areas were, therefore, at a minimum. During most of the study, shorebirds were recorded in groups of 100's except during peak migration in September and early October when we often counted shorebirds in groups of 1000's.

Shorebirds were usually identified to species except during late June through August when populations of Western Sandpipers (*Calidris mauri*), Dunlins (*C. alpina pacifica*) and Least Sandpipers (*C. minutilla*) occurred together over much of the study area. For purposes of this study these species were recorded as "small sandpipers" during censuses. Populations of each were subsequently determined from periodic comparisons of population ratios of all three species. These were derived from ground censuses conducted usually within 72 hours of an aerial census. Only ground and aerial censuses conducted over the same area or similar substrate types were used for such comparisons. We found numbers of *C. minutilla*, however, to be too small and the species'occurrence too irregular to accurately evaluate use patterns for each census area.

Numbers of Short-billed (*Limnidromus griseus*) and Longbilled Dowitchers (*L. scolapacius*) were similarily derived but presented less of a problem since the two species exhibited different habitat preferences and only briefly overlapped in occurrence during the study.

RESULTS

Occurrence

Twenty species of shorebirds were recorded during the study; eight of which nested (fig. 3). Of the nesting species, only Northern Phalaropes (Lobipes lobatus), Rock Sandpipers (C. ptilocnemis), Least Sandpipers and Dunlin nested in significant numbers; probably fewer than several hundred pairs each.

Since we did not open a permanent field camp until 18 May, early spring occurrence data are incomplete. During the aerial survey of Nelson Lagoon and Port Moller on 22 April much of the intertidal area was still ice fast. Nevertheless, small numbers of Golden Plovers (Pluvialis dominica), Sanderlings (C. alba), Dunlins and Rock Sandpipers were present along ice free intertidal areas. We detected small numbers of Golden Plovers, Bar-tailed Godwits (Limosa lapponica), Red Phalarops (Phalaropus fulicarius) and Dunlins moving northeast along the Peninsula through early June. Beginning mid-June, populations of post - and non-breeding shorebirds began congregating on the study area. We found that once a migrant species settled onto the area it remained at various population levels until fall departure. Populations of Dunlins, Ruddy Turnstones (Arenaria interpres), Red and Northern Phalaropes and Short-billed Dowitchers remained for approximately 100 days. Golden Plover, Greater Yellowlegs (Tringa melanoleucus), Lesser Yellowlegs (T. flavipes), Black Turnstone (A. melanocephala), and Long-billed Dowitchers were present for less than 70 days during autumn migration, while Pectoral (C. melanotus) and Sharp-tailed Sandpipers (C. acuminata) were present for less than 30 continuous days.

Most species departed by the second week of October just prior to a major storm system which passed over the southwest Peninsula. Rock Sandpipers and Sanderlings were both present on the study area on 22 November as were Red and Northern Phalaropes. The former two species are considered winter residents of the Alaska Peninsula and Aleutian Islands (Gabrielson and Lincoln 1959). Neither phalarope has been reported in the Bristol Bay area after the first week of November, but we do not consider our late November sightings unusual since much of Alaska experienced a abnormally mild fall and winter during 1976-1977.

Habitat utilization

Table I breaks down the various substrate types within each area by size and composition. A mixture of fine sand and mud was the predominant intertidal substrate and it occurred over all but census area IV. This area encompassed the delta region of the Caribou and Sapsuck Rivers. As such, the substrate was a mixture of fine silt and organic materials. Census area I, Lagoon Point, was comprised mostly of barrier sand dunes and sand and rock beaches. During August and early September this area was used as a high tide roost by virtually all Dunlins and Western Sandpipers within the study area. Counts of both species returning to roost at Lagoon Point on 8 and 18 August and 2 September were only 6, 4, and 12 percent higher, respectively, than aerial counts of all "small sandpipers" taken within 48 hours of the same dates over census areas I-VII.

We did not find shorebird selection of Lagoon substrates to vary appreciably from previously reported habitat preferences for each species (Table 2). Rock Sandpipers and Ruddy Turnstones were most frequently observed along rocky intertidal beaches while few were observed on mud/sandflats. Both Greater and Lesser Yellowlegs preferred mudflats and to a lesser extent mud/sandflats. We did not, however, record either species on area III which accounts for 16 percent of the mudflat substrate in the study area and which lies immediately adjacent to the extensive mudflats in area IV. Three species, Dunlin, Western Sandpiper and Short-billed Dowitcher utilized portions of mud/sandflats within all census areas. Golden Plovers, Bar-tailed Godwits, Sanderlings, and Whimbrels (*Numenius phaeopus*), were only found on mixed sand/mud substrate. Whimbrels, however, were never recorded on area III which accounts for 30 percent of this substrate type within the study area. Long-billed Dowitchers tended to prefer mudflats, especially along the upper reaches of the Lagoon, while Short-billed Dowitchers were most frequently observed on mud/sand substrate. This difference in substrate selection between the two species has also been observed on their wintering grounds (Lenna 1969; Page 1975). Most of the shorebirds recorded on sand dunes and beaches were roosting.

Abundance

Table 3 presents percent shorebird composition in each census area as recorded during 16 aerial censuses. Total numbers reflect cumulative census results; since we did not quantify shorebird turnover, or determine ingress and egress to and from the study area, they do not represent overall numbers of shorebirds using Nelson Lagoon during autumn and fall migration. Comparative temporal abundance of all species is presented in Figure 3. These data incorporate aerial and ground census data obtained prior to migratory buildups beginning in late June. Numbers depicted prior to 1 July do not necessarily reflect overall shorebird use of the study area, but do accurately reflect timing of migratory buildup.

Overall, total numbers increased steadily between late June and early October. Two peaks of migration were recorded during this period (fig. 4). Western Sandpipers, Short-billed Dowitchers, Least Sandpipers and Whimbels peaked between early June and early August. Whimbrels exhibited the earliest migration but it is unknown whether these birds represented non-breeders or unusually early autumn migrants. Isleib and Kessel (1973) report small numbers of non-breeding Whimbrels as uncommon from late May through July on the Copper River Delta (61°N). Fall migrant Whimbrels are reported to arrive on the Copper River Delta by late June and are common by mid-July (op. cit.).

A second, much larger, fall peak comprised of Dunlins, Rock Sandpipers, Bar-tailed Godwits and Long-billed Dowitchers occurred between the last week of September and the first week of October. Twenty-seven percent of all shorebirds counted during the study were recorded during this period. This bimodal migratory movement was reflected on all census areas except area II, where shorebird use virtually ceased in late September just as fall numbers peaked over all other areas (fig. 4). A possible explanation is over exploitation of food resources, however, we conducted no benthic studies to confirm this.

DISCUSSION

We found little comparative material concerning migratory chronology or abundance of fall migrant shorebirds along other coastal areas of the Alaska Peninsula. Robert Jones (pers. comm.) reports tens of thousands of Dunlins occurring each fall (1960 - 1973) on Izembek Lagoon, approximately 100 km W of Nelson Lagoon. More recently, Paul Arneson, Alaska Department of Fish and Game (pers. comm.) recorded 45,000 "small", 20,000 "medium" and 600 "large" shorebirds during a 13 - 16 October 1976 aerial survey of the north Alaska Peninsula between Ugashik and Izembek Lagoon.

Away from the Peninsula on Angyoyarvak and Hooper Bays (61°N), Holmes (1971) found post-breeding Dunlins concentrating on tidal flats in late July, and by late August he reported tens of thousands along several miles of coastline. Although he made no September observations, Holmes felt, based on the timing of arrival on wintering areas, that Dunlins remained through most of the month.

At Nanvak Bay (59°N) along the northwest corner of Bristol Bay, M. Dick and M. Petersen (unpublished data) found comparatively little fall Dunlin use of mudflats in 1971 and 1973. Between July and September 1976, Petersen observed Dunlins on Nanvak Bay on only four occasions. Other species using this area, including Whimbrel, Least and Rock Sandpiper, Ruddy Turnstone and Greater Yellowlegs had similar fall occurrence patterns as those found at Nelson Lagoon (M. Dick and M. Petersen, pers. comm.).

We also found that the occurrence of these species at Nelson Lagoon coincided with fall movements of the same species through Prince William Sound and the North Gulf of Alaska (60°N) (Isleib and Kessel 1973). However, the period of peak fall migration of Western Sandpipers and Dunlins through Prince William Sound has been recorded as much as 30 days ahead of Nelson Lagoon and both species are reported to occasionally overfly the Sound in fall (S. Senner and P. Isleib, pers. comm.).

These fragmentary occurrence patterns corraborate the suggestions of Holmes (1966) and Holmes and MacLean (1971) that the fall migration from staging to wintering areas of Dunlins is direct and rapid. Furthermore, the large concentrations of Dunlins along the Alaska Peninsula, the comparatively later staging period at Nelson Lagoon and elsewhere along the Peninsula, and the lack of such reported concentrations along coastal south and southeast Alaska during this period, allows us to hypothesize that Dunlins (*C. a. pacifica*, see Holmes and MacLean 1971) staging on Nelson Lagoon embark for their winter quarters on a direct transoceanic migration of the northeast Pacific. It seems unlikely that Dunlins coming from northern breeding grounds on the Yukon-Kuskokwim Delta, and staging along the western Alaska Peninsula, would move northeast again to Prince William Sound before continuing south along or off the coast of British Columbia. Dunlins reported from Prince William Sound in fall are probably flying directly from the Yukon-Kuskokwim breeding grounds, while an additional segment of this population moves south across Bristol Bay to Nelson Lagoon and other estuaries along the western Peninsula. We hope to confirm this by extensive banding and color marking in 1977.

The heretofore unreported large numbers of Bar-tailed Godwits observed on Nelson Lagoon in 1976 and the absence of such concentrations from elsewhere in Alaska suggests that Nelson Lagoon is probably the major fall staging area for most of the Alaska breeding population and not Nunivak and areas farther north as Gabrielson and Lincoln (1959) suggests. Confirmation of this will require observations during subsequent seasons.

ACKNOWLEDGEMENTS

We thank the villagers of Nelson Lagoon for allowing us to conduct this study over much of their lands and for their hospitality and support throughout the study. We especially thank Peter Kust, Sr., our pilot, for making available his airplane, piloting skills and knowledge of the study area. Mr. Anthony DeGange, U.S. Fish and Wildlife Service, assisted in much of the field work and provided helpful comments on earlier drafts of the manuscript. Gerry Sanger and Jim Bartonek are also thanked for their critical reviews of the manuscript.

This study was funded by the Bureau of Land Management through the National Oceanic and Atmospheric Administration as part of the Outer Continental Shelf Environmental Assessment Program.

LITERATURE CITED

Chapman, F.M. 1904. Lists of birds collected in Alaska by the Andrew J. Stone Expedition of 1903. Bull. Amer. Mus. Nat. Hist. v. XX. 399-406.

Gabrielson, I.N., and F.C. Lincoln. 1959. The birds of Alaska. Harrisburg, Pennsylvania, The Stackpole Co.

Holmes, R.T. 1966a. Breeding ecology and annual cycle adaptions of the Red-backed Sandpiper (*Calidris alpina*) in northern Alaska. Condor, 68: 3-46.

Holmes, R.T. 1966b. Feeding ecology of the Red-backed Sandpiper (*Calidris alpina*) in Arctic Alaska. Ecology, 47: 32-45.

Holmes, R.T. 1966c. Molt cycle of the Red-backed Sandpiper (*Calidris alpina*) in western North America. Auk, 83: 517-533.

Holmes, R.T. 1971. Latitudinal differences in breeding and molt schedules of Alaska Red-backed Sandpipers (*Calidris* alpina). Condor, 73: 93-99.

Holmes, R.T. 1972. Ecological factors influencing the breeding season schedule of Western Sandpipers in sub-arctic Alaska. Am. Mid. Nat., 87: 472-491.

Holmes, R.T. and F.A. Pitelka. 1968. Food overlap among co-existing sandpipers on north Alaska Tundra. Syst. Zool., 17: 303-318.

Hurley, John B. 1931. Birds observed in the Bristol Bay Region, Alaska. Murrelet, 12: 7-11; 35-42; 71-75.

Hurley, John B. 1932. Birds observed in the Bristol Bay Region, Alaska. Murrelet, 13: 16-21; 38-40.

Isleib, M.E., and B. Kessel. 1973. Birds of the North Gulf Coast - Prince William Sound Region, Alaska. Biol. Pap. of the U. of Alaska, no. 14. p. 1-149.

Lenna, P. 1969. Short-billed and Long-billed Dowitchers in the Point Reyes, California area. Point Reyes Bird Observatory Newls. 12: 2-10.

MacLean, S.F., and R.T. Holmes. 1971. Bill lengths, wintering areas and taxonomy of North American Dunlins (*Calidris alpina*). Auk, 88: 893-901.

Murrie, O. J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. N. Amer. Fauna, no. 61, USFWS, p. 1-261.

Norton, D. W. 1972. Incubation schedules of four species of Calidridine sandpipers at Barrow, Alaska. Condor 74: 164-176.

Page, G., and L. Stenzel. 1975. Aspects of the ecology of shorebirds on Bolinas Lagoon. A report for the Department of Parks and Recreation, County of Marin, California. p. 1-89.

Pitelka, F. A. 1959. Numbers, breeding schedule, and territoriality in Pectoral Sandpipers of North America. Condor 61: 233-264.

Pitelka, F. A., R. T. Holmes, and S. F. MacLean. 1974. Ecology and evolution of social organization in Arctic Sandpipers. Amer. Zool. 14: 185-204.

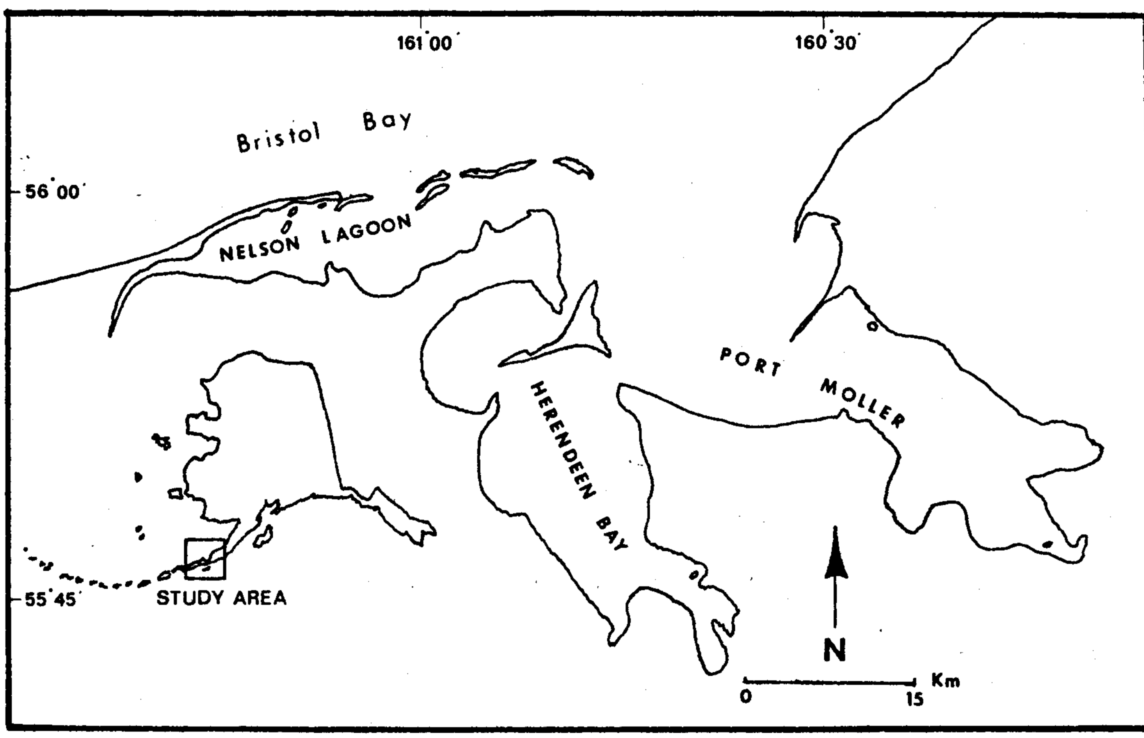


FIGURE 1. The study locale showing its position on the Alaska Peninsula.

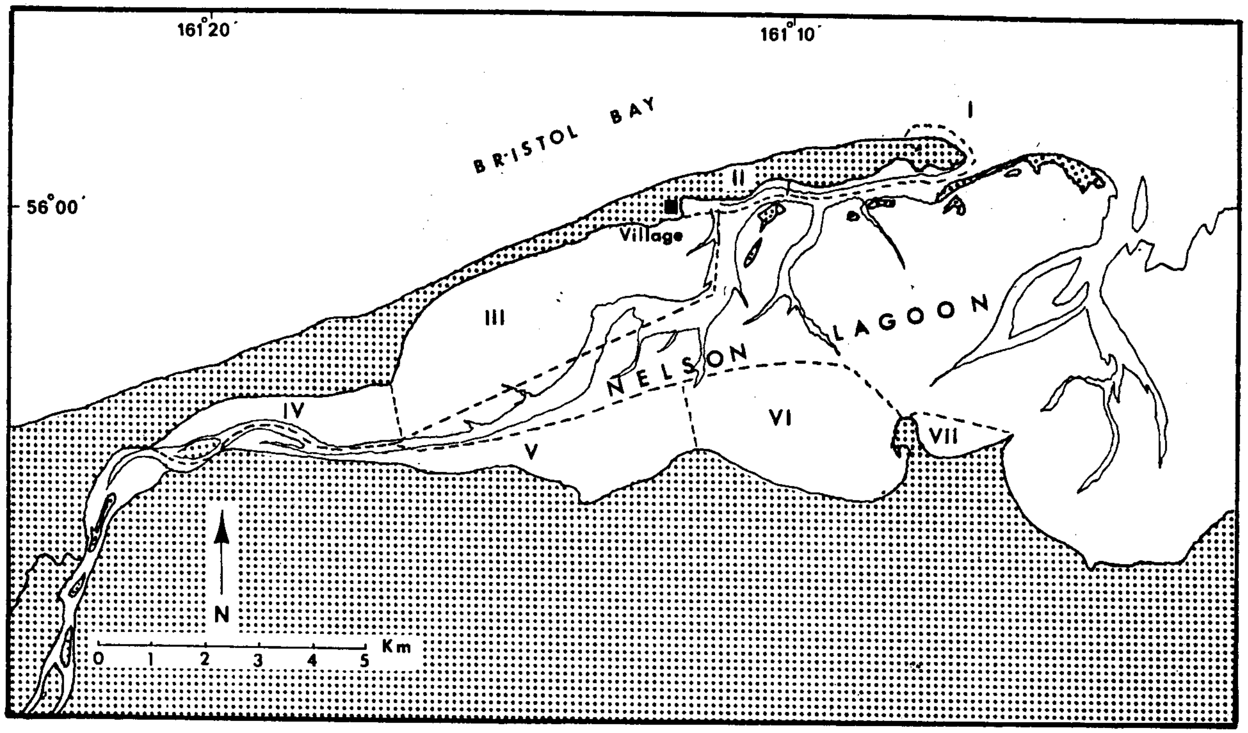


FIGURE 2. The Nelson Lagoon study area showing shorebird census area I - VIII.

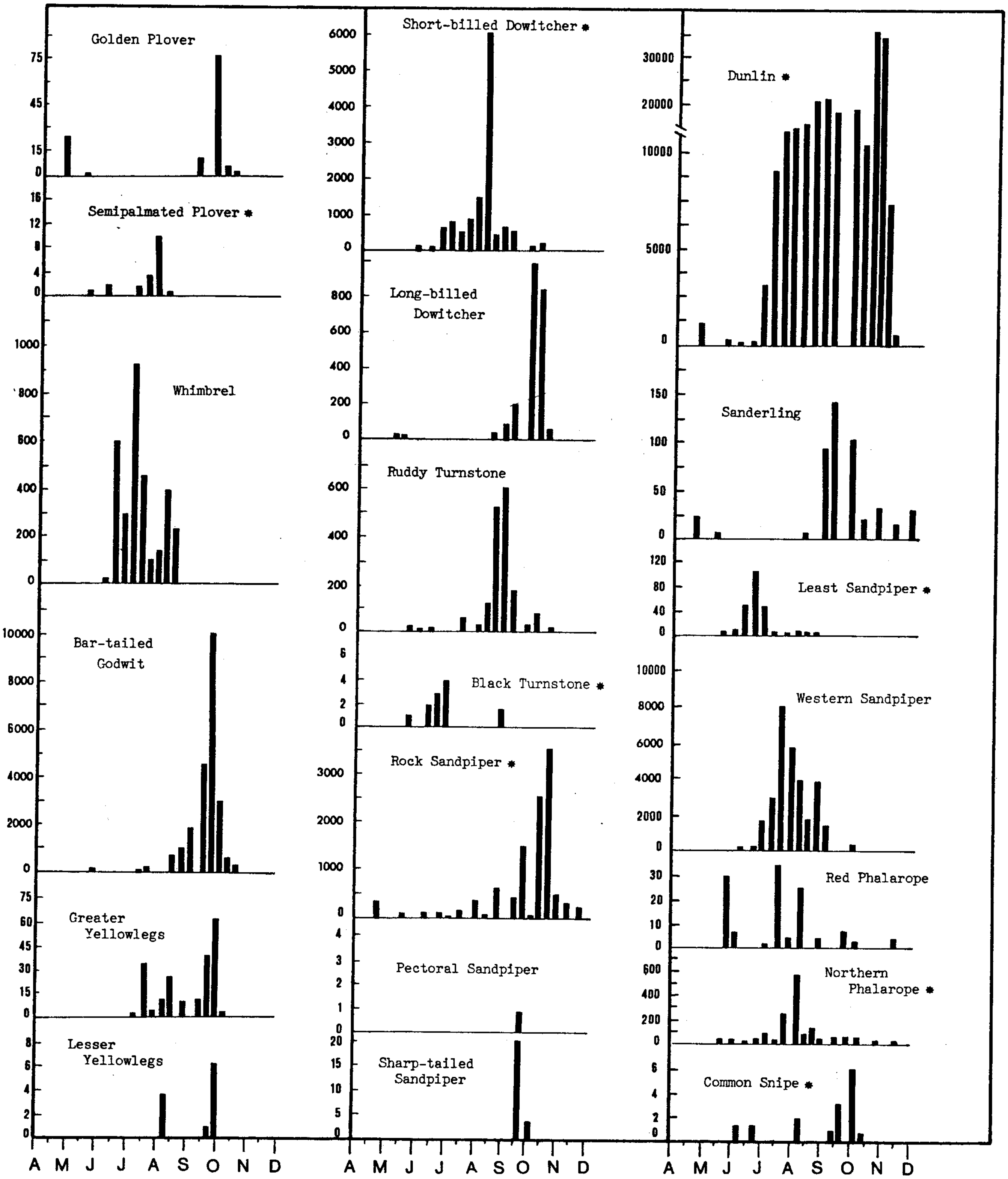


FIGURE 3. Comparative temporal abundance of 20 shorebird species at Nelson Lagoon, 22 April - 1 December 1976. Species histograms incorporate aerial as well as ground census data obtained prior to migratory buildups beginning in late June. Numbers prior to 1 July do not necessarily reflect overall shorebird use of the study area but do accurately reflect timing of migratory buildups. Species noted by asterisk nested on the study area.

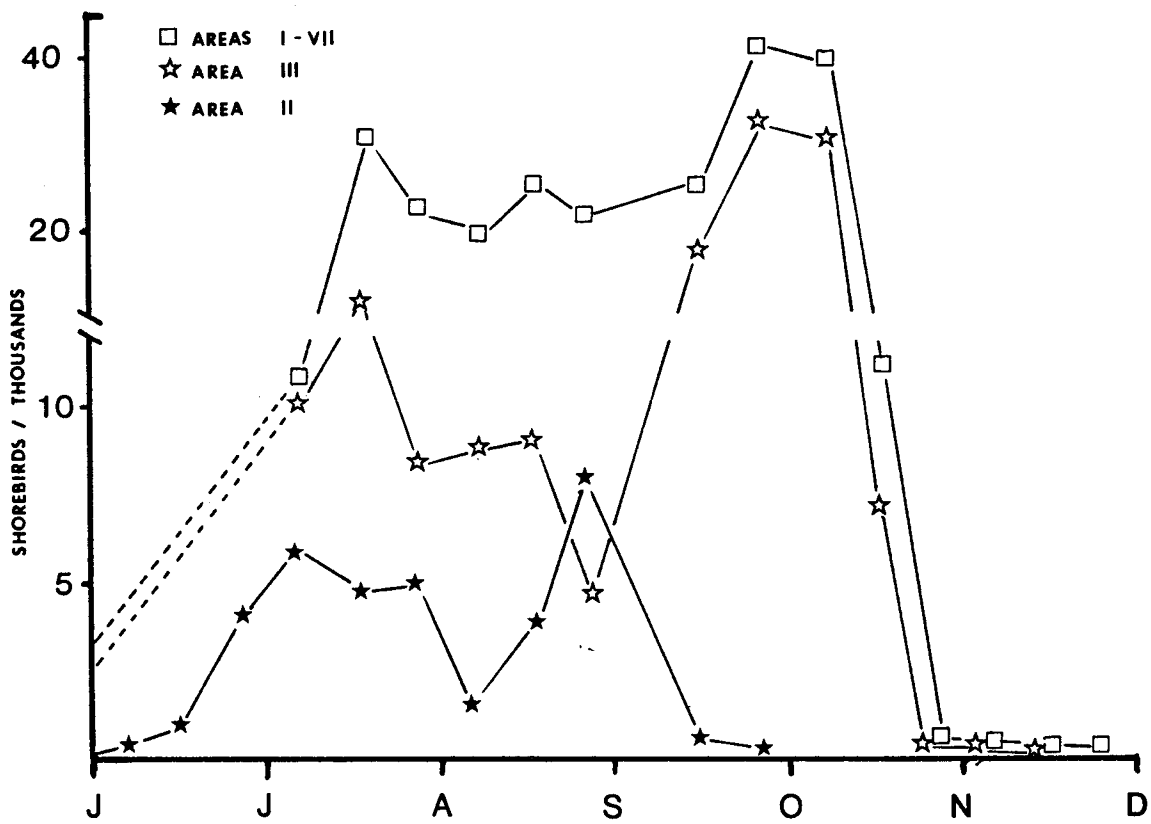


FIGURE 4. Peak periods of migration and approximate total numbers of shorebirds on all census areas (□), on census area II (★) and on census area III(☆). Census area II incorporates ground census data prior to 1 July.

TABLE 1. Amount and composition of substrate types within each census area, 1 July - 1 December 1976, Nelson Lagoon, Alaska.

Substrate type	Census Area I	II	III	IV	V	VI	VII	Total
Sand dunes and beaches	40[a](100.0%)[b]							40(1.0%)[c]
Rocky inter-tidal beaches	6(35.0)	4(24.0)	6(35.0)				1(6.0)	17(0.5)
Mudflats			101(16.0)	486(75.0)	40(6.0)	18(3.0)		645(19.0)
Mixed mud and sandflats	10(0.5)	53(2.0)	830(30.5)		769(28.0)	930(34.0)	130(5.0)	2722(79.5)
Total	56(1.5%)[d]	57(1.5)	937(27.0)	486(14.0)	809(24.0)	948(28.0)	131(4.0)	3424(100.0)

a. Amounts are in Hectares
b. % of all such substrate within the study area
c. % composition of total study area
d. % by census area of total study area

TABLE 2. Percent shorebird composition by substrate type from 16 aerial censuses, 1 July - 1 December 1976, Nelson Lagoon, Alaska.

	Habitat types				
	Sand dunes and beaches	Rocky inter-tidal beaches	Mudflats	Mixed mud/ sandflats	Open water
Species					
Northern Phalarope					100.0%
Short-billed Dowitcher			0.8%	3.0%	
Long-billed Dowitcher			2.5	1.0	
Rock Sandpiper		72.0%		<0.5	
Dunlin	84.5%		75.1	80.0	
Western Sandpiper	15.5		20.7	9.7	
Bar-tailed Godwit				4.9	
Sanderling				<0.5	
Greater Yellowlegs			1.0	<0.5	
Lesser Yellowlegs			<0.5	<0.5	
Whimbrel				<0.5	
Golden Plover				<0.5	
Ruddy Turnstone		28.0		<0.5	
Total #'s recorded	52500	4000	10000	260000	130
Percent of total	16.0	1.0	3.0	80.0	0.1

TABLE 3. Total shorebirds and their distribution by census area as recorded from aerial censuses, 1 July - 1 December 1976, Nelson Lagoon, Alaska.

	Total #'s recorded	Census area						
		I	II	III	IV	V	VI	VII
Species								
Northern Phalarope	130	77.0%						23.0%
Short-billed Dowitcher	8600	0.5	23.0%	45.0%	0.5%	2.5%	2.5%	26.0
Long-billed Dowitcher	2500		23.0	23.0	7.0	28.0	5.0	14.0
Rock Sandpiper	4000	25.0	47.0	27.0				0.5
Dunlin	260000	20.0	10.0	54.0	1.5	5.0	7.0	2.5
Western Sandpiper	36000	24.0	21.0	34.0	1.5	6.0	9.5	4.0
Bar-tailed Godwit	13000			87.0		1.0	12.0	<0.5
Sanderling	400			97.0		3.0		
Greater Yellowlegs	130				32.0	48.0	20.0	
Lesser Yellowlegs	6				33.0		67.0	
Whimbrel	1000					15.0	28.0	57.0
Golden Plover	75			10.0		90.0		
Ruddy Turnstone	1000	85.0	6.0	4.0		<0.5	0.5	4.5
Total numbers	326000	62500[a]	38000	169500	4700	16500	24000	11000
Percent of total		19.0	12.0	52.0	1.5	5.0	7.0	3.5

[a] Predominantly roosting birds

Annual Report

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: RU-341/342
Study Task: A3
Reporting Period: October 1, 1976 to March 31, 1977
Pages: i-vi + 55

FIELD STUDIES AT CAPE PEIRCE, ALASKA - 1976

by

Margaret R. Petersen

and

Marilyn J. Sigman

Part XIII

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

J.C. Bartonek, C.J. Lensink, P.J. Gould,
R.E. Gill, and G.A. Sanger
Co-principal Investigators

U.S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
800 A Street - Suite 110
Anchorage, AK 99501

April 1, 1977

Table of Contents

List of Tables

List of Figures

ABSTRACT

Breeding biology of seabirds.

Colonies of Double-crested Cormorants (Phalacrocorax auritus), Pelagic Cormorants (P. pelagicus), Glaucous-winged Gulls (Larus glaucescens), Black-legged Kittiwakes (Rissa tridactyla), Common Murres (Uria aalge), and Tufted Puffins (Lunda cirrhata) were studied from 28 April to 9 September 1976. Abundance, distribution, breeding status, reproductive success, and factors influencing that success was determined for each species. General distribution of colonies in 1976 was the same as found by previous observers for all species except Pelagic Cormorants which shifted breeding areas. All suitable nesting areas were occupied by species for which the habitat appeared most appropriate. Although data from previous studies was not adequate to permit direct comparison of nesting densities, populations seemed to be similar to other years.

Breeding success of some species of seabirds nesting at Cape Peirce during 1976 differed from that observed in 1970 and 1973. Unusually low numbers of pairs of Common Eiders (Somateria mollissima), Glaucous-winged Gulls, and Double-crested Cormorants raised young, normal numbers of pairs of Black-legged Kittiwakes and Common Murres probably fledged fewer young, normal numbers of pairs of Pelagic Cormorants raised significantly more young, and fewer pairs of Tufted Puffins probably fledged young in 1976. Loss of eggs was attributed to red foxes (Vulpes fulva), Common Ravens (Corvus corax), or Eskimo egging activities. Reasons for varied brood success are obscure, but may reflect available food resources.

Predation on seabirds.

Bird and mammal predators were observed on the Cape Peirce peninsula and on Shaiak Island from 28 April to 9 September. The Common Raven was the primary avian predator, and the red fox was the primary mammalian predator. Rough-legged Hawks (Buteo lagopus), Bald Eagles (Haliaeetus leucocephalus), Gyrfalcons (Falco rusticolus), and Peregrine Falcons (F. peregrinus) were not observed taking seabirds, or their eggs and young, and had minor impact on nesting seabirds. Glaucous-winged Gulls (Larus glaucescens) opportunistically took eggs and young of seabirds, and normally have a minor impact on nesting seabirds.

Avian and mammalian predators take accessible nests, thus selection of nest sites by seabirds occurs in part due to selection pressure by those predators. Common Murres minimized losses to avian predators by crowding together to preclude predators from landing among them. Black-legged Kittiwakes nested on parts of the cliffs where avian predators could not land. All seabirds nested on shear cliffs or on the offshore island which were normally inaccessible to mammalian predators.

Spring migration, molt, and foraging areas of loons and waterfowl.

Loons and waterfowl were censused regularly from 28 April to 9 September to determine the pattern of spring migration, the location and

importance of feeding areas, and the chronology of molt. Migration of Red-throated Loons (Gavia stellata) began 3 May, and migration of Arctic Loons (Gavia arctica) began 5 May. Peak migration of Red-throated Loons, however, preceeded that of Arctic Loons by 14 days. Peak migration of most waterfowl past Cape Peirce was during May, except for Surf Scoters (Melanitta perspicillata) whose peak migration occurred 20 June. Most waterfowl migrated in flocks of nearly equal sex ratios. Exceptions were flocks of male Pintail (Anas acuta), male White-winged Scoters (Melanitta deglandi), and female Oldsquaw (Clangula hyemalis).

Pre-molt flecks of waterfowl arrived after the peak of northward migration. Molting flocks of scoters, eiders, Harlequin (Histrionicus histrionicus), and Red-breasted Mergansers (Mergus serrator) were flightless from mid-July through September. Flightless birds were either adult males, or non-breeding subadults. Throughout the field season, each species foraged in areas that were non-overlapping in time or space.

I. Introduction.

This study of the birds of Cape Peirce is one of several site specific studies of marine birds conducted as part of the BLM/NOAA Outer Continental Shelf Environmental Assessment Program (OSCEAP). The objectives of these studies include:

1. To determine the number and distribution of each species relative to other species, to periods of the breeding season, and the characteristics of available habitat within the colony or study area.

2. To provide estimates of production or nesting success of principal species.

3. To establish and describe sampling areas or units which may be utilized in subsequent years or by other persons for monitoring the status of populations.

4. To determine the amount and kinds of foods utilized by principal species, when possible to determine the relationship of food selected to that available, and to describe daily foraging patterns.

5. To describe the chronology and phenology of events in the biology of breeding birds including changes in population from the onset of site occupancy in the spring through departure in fall.

6. To provide a comparison of current data with recent historical data.

Colonies of seabirds at Cape Peirce and Shaiak Island are part of a large complex of colonies included in the Cape Newenham National Wildlife Range which collectively may form the largest population of seabirds in the eastern Bering Sea. Birds from these colonies would be vulnerable to any extensive pollution by oil in the southern Bering Sea such as may occur with the development of petroleum in Outer Bristol Bay of the St. George Basin. In addition to the large colonies of nesting birds, large numbers of migrants pass the Cape or use the adjacent Nanvak Bay as a foraging area during migration.

Selection of the Cape Peirce study area was based primarily on its importance to marine birds, but the availability of prior information and long term continuation of studies by refuge personnel were considered in the selection process.

Observations of birds at Cape Peirce and Nanvak Bay were made intermittently by the refuge staff and other Fish and Wildlife Service (FWS) personnel between 1963 and 1971 (King 1966, King and Monson 1968, Hout 1969 and 1971) and provided general knowledge of species occurring in the area and numbers of waterfowl using Nanvak Bay. The most important effort to the present study was that by Dick and Dick (1971) who conducted a careful biological survey of the area during the summer of 1970. The Dick's report contains extensively annotated accounts of all species of plants, mammals, and birds observed during their study. Much of the data collected is adequate for comparison with that of the present study.

Field work in 1976 was conducted by Margaret R. Petersen and Marilyn J. Sigman. Petersen arrived at the Cape Peirce field camp 28 April, and Sigman arrive 2 June. Both left 9 September. Data on spring migration and colony establishment were collected by Petersen; that on plants was collected by Sigman. Data on all other aspects of the study were collected jointly by both observers.

The study depended primarily upon direct observations of birds from various vantage points. Procedures necessarily varied with species and the nature of the habitat in which they occurred. The report is divided into major topics including breeding biology (Section III), predators (Section IV), and migration, molt, and use of foraging areas (Section V). All birds and mammals are listed in Appendix I, and a possible aging technique for Common Murres is described in Appendix II. Procedures used to evaluate individual species and habitats are described in these sections as appropriate.

The Cape Newenham National Widlife Range supplied use of the field camp at Cape Peirce, and communications and logistic support throughout the field season.

II. Study Area.

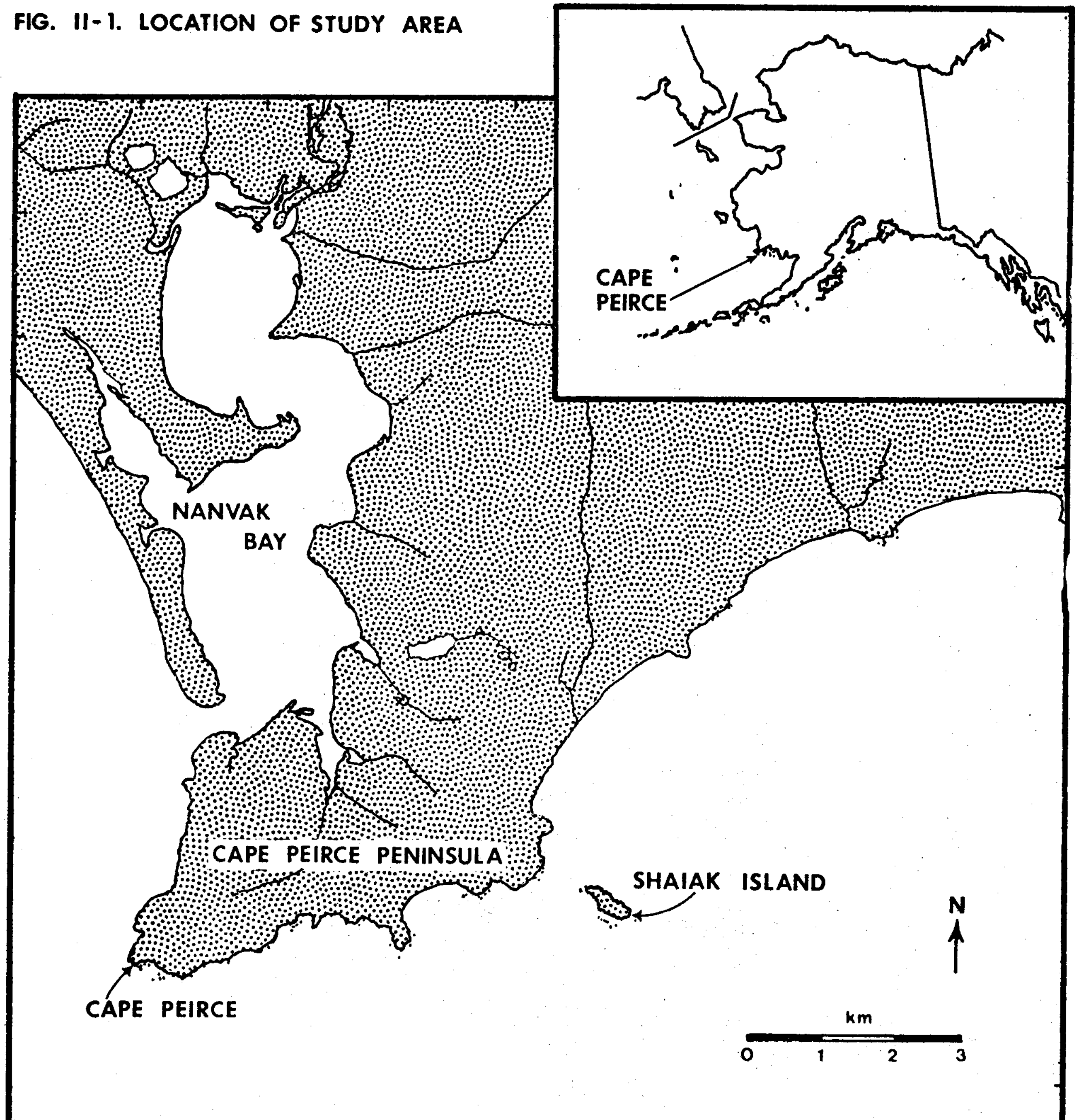
Cape Peirce (58°35'N, 161°45'W) is located on the base of Cape Newenham which forms the northern boundary of Bristol Bay (Figure II-1). The cliffs of the Cape Peirce peninsula and Shaiak Island range in height from 30 to 122 meters. The west facing cliffs of the peninsula are of schistose and phyllitic rocks, while the south facing cliffs and those of Shaiak Island are of volcanic rocks, siliceous siltstone, and chert (Hoare and Coonrad 1961). The cliffs have numerous ledges, cracks, and outcrops which provide nest sites for Pelagic Cormorants, Black-legged Kittiwakes, and Common Murres. Horned Puffins (*Fratercula corniculata*), Pigeon Guillemots (*Cepphus columba*), and Parakeet Auklets (*Cyclorrhynchus psittacula*) nest in the cracks and crevices of inaccessible rubble beaches.

Vegetation of the study area is described in Dick and Dick (1971). The area is generally treeless, with willows up to 1.5 meters in height found along streams. Heath tundra and fell-field tundra are the predominant vegetation types found on the Cape Peirce peninsula. Shaiak Island differs vegetatively from the peninsula, with *Elymus arenarius*, *Artemisia arctica*, and *Calamagrostis canadensis* being the predominant plants.

Waters near the Cape Peirce peninsula vary from 18 meters deep between the peninsula and Shaiak Island, to shallow soals 4 to 5 meters deep off the cape (Coast and Geodetic Survey 1954). Nanvak Bay is shallow with most of the sandy bottom exposed during minus tides. The bay supports extensive eelgrass beds used by migratory and resident waterfowl (King 1966, Dick and Dick 1971).

The climate of nearby Cape Newenham has been described by King (1966) as being generally inhospitable to man. Cape Peirce weather generally approximates that of Cape Newenham (Hout 1970). Most days in 1976 had either wind, fog, rain, snow, or combinations of those. The weather was generally milder in 1976 than that recorded by Dick and Dick (1971), with only one day of winds over 50 knots in the summer of 1976 (Appendex III). Nanvak Bay and offshore waters are normally ice covered in winter, although open leads caused by wind and tidal currents are common.

FIG. II-1. LOCATION OF STUDY AREA



III. Breeding Biology of Seabirds.

Previous studies of the breeding biology of seabirds at Cape Peirce are limited to the field seasons of 1970 (Dick and Dick 1971), and 1973 (M. H. Dick pers. comm.), and to general information on abundance and distribution of colonies (King 1966, Hout 1969 and 1971, J. C. Bartonek pers. comm.). Information on the abundance, distribution, breeding status, and reproductive success of all species is necessary for predicting the long term biological effect of losses that may occur as a result of the development of the petroleum resources of the outer continental shelf. These losses would have the most significant effect on those species having the lowest reproductive rate under normal conditions.

METHODS

Unless otherwise stated, data were obtained by observing birds from vantage points on the cliffs using a 20-power spotting scope and/or binoculars. Observation sites were marked with rock cairns and/or numbered wooden stakes, then were mapped and photographed as an aid to relocation of the site. Much of the nesting area on Shaiak Island was accessible and on such areas total coverage or sampling with quadrats or line transects was possible. Nesting areas were photographed from observation sites to facilitate observations throughout the field season, and to assist in comparison of data from 1976 with that from other years.

Double-crested Cormorant.

Nests of Double-crested Cormorants (*Phalacrocorax auritus*) were recorded as they were found on the slopes of Shaiak Island. All nests were re-examined weekly from 11 June to 22 August as weather allowed. Information on clutch sizes, numbers of young, and nest status was recorded. Six young were banded using USFWS bands with red streamers attached, and with numbered red leg bands to permit subsequent visual identification of individuals. General fledging dates of the colony were determined by observations of marked young away from nests, as well as from observations of nests.

Pelagic Cormorant.

General features of the Pelagic Cormorant (*Phalacrocorax pelagicus*) nesting habitat and the distances between nests were obtained from photographs of nests and nesting areas. As weather allowed, nesting areas and potential nesting areas were visited twice weekly from the date nests were found until fledging of young. At each visit the number of adults at each nest site, the number of incubating or brooding adults, the number of large young in each nest, and any unusual occurances were noted.

Twenty-seven nests in a 805 meter long cliff area were observed three times daily from 28 April to 8 September to record fluctuations of numbers. Clutch sizes, dates of laying, dates of loss of eggs and young, and fledging dates were also recorded.

Common Eider.

The Common Eider (*Somateria mollissima*) nesting area on Shaiak Island was searched for eider nests weekly 6 June to 22 August when weather permitted. Nests on the peninsula were recorded when found, although no concerted effort was made to search for duck nests.

Glaucous-winged Gull.

Glaucous-winged Gulls (*Larus glaucescens*) were censused on Shaiak Island by using line transects, quadrat samples, and total counts of birds in large colonies as described by Nettleship (1976). One quadrat 30.5 by 30.5 meters was established during early incubation. Territorial birds were observed from a blind to determine the number of incubating birds and failed breeding birds.

Eggs were measured, weighed, and marked with indelible ink when found in nests. Nests in the line transect and quadrat samples containing eggs were marked with numbered tongue depressors pushed almost completely into the ground to facilitate re-finding nests. All marked nests were visited weekly.

Black-legged Kittiwake.

Twenty-four nesting areas of Black-legged Kittiwakes (*Rissa tridactyla*) were censused as soon as melting snow permitted observations from cliff tops. Areas were delineated and photographed as described by Nettleship (1976). Mainland nesting areas were visited twice weekly throughout the field season to determine the number of territories, the number of birds, the number of birds apparently incubating, the number of young, and any unusual occurrences. Similar observations were made of nesting birds on Shaiak Island weekly when weather permitted.

A 805-meter long cliff area containing four distinct nesting areas were visited three times daily from 29 April to 8 September to assess fluctuations in the number of birds using the colony area. More intensive observations of birds on 106 territories were made to determine egg laying dates, clutch sizes, loss of eggs and young, hatching dates, and fledging dates. No attempt was made to follow particular nests due to dense numbers and the apparent turnover of adults which occupied unsuccessful nests.

Common Murre.

Seventeen nesting areas of Common Murres (*Uria aalge*) were observed in the manner described for kittiwakes. Nesting areas on the peninsula were visited twice weekly; and those on Shaiak Island weekly or as weather permitted.

A 805-meter long portion of the cliffs containing three distinct nesting areas were visited three times daily to assess diurnal and seasonal variations in murre numbers. Two areas containing 50 and 75 breeding birds, respectively, were observed to determine egg laying dates, rate of loss of eggs and young, hatching dates, and dates young left the cliff. As murres do not build nests, and brooding birds are difficult to identify, each adult was watched until it moved enough to permit establishing the presence or absence of eggs or young.

Tufted Puffin.

The density and reproductive status of the Tufted Puffin (Lunda cirrhata) on Shaiak Island was estimated from thirty 5 by 5 meter plots. Cairns were built at the beginning of each series of plots to facilitate their relocation. Plots were established weekly from incubation through two weeks into the brood rearing period. Burrows containing adults, eggs, or young as well as those with evidence of fresh digging, a worn entrance, egg shells, or fresh fecal material were considered to be occupied. Occupied burrows were marked near the entrance with numbered tongue depressors. Numbered burrows were visited weekly or as weather permitted to determine the status of eggs and young. Twenty-four eggs and eleven young were weighed and measured. Twelve adults and eight young were banded with USFWS leg bands. Seven of the young were also banded on the left leg with numbered red bands.

Other Alcids.

Pigeon Guillemots (Cepphus columba), Horned Puffins (Fratercula corniculata), Tufted Puffins, and Parakeet Auklets (Cyclorrhynchus psittacula) were noted as pairs were seen on the cliffs, or if concentrations of birds were seen. All crevices where these species nested were inaccessible to observers, and the breeding status of each species was inferred from observations of displays, birds going into cracks, birds carrying food items, and the eventual dissapearance of the species from the breeding area.

RESULTS

Double-crested Cormorant.

Double-crested Cormorants were first observed on the study area on 30 April. No eggs were found when Shaiak Island was visited on 6 June, but two nests found on 11 June, each with two eggs, indicated that laying began by 7 June. Eggs in five nests hatched between 2 and 10 July. Young in 13 nests fledged between 22 and 29 August. After 22 August, dates of fledging of young were estimated from observations of color-marked young. The average number of young fledging per successful nest was 1.62.

M. H. Dick (pers. comm.) estimated the nesting population of Double-crested Cormorants on Shaiak Island to be 125 pair in 1973. Areas with active nests 25 June 1973 (J. C. Bartonek photo) did not have active nests on 11 June 1976. The reduction in numbers of nests in 1976 is attributed to two red foxes (Vulpes fulva) who destroyed all nests located on the slopes of Shaiak Island.

Pelagic Cormorant.

Pelagic Cormorants were on the ledges when Petersen arrived 28 April. At most nest sites, 1 to 3 inches of snow still covered old nest platforms, although nests could be seen beneath the snow. Birds began gathering new nest material as soon as vegetation was exposed by melting snow.

A nest found 21 May with the first three eggs of a four egg clutch, indicated that nesting began 14 May. The peak of egg laying was 24 May, and last nests were not initiated until early July (Table III-1). The size of 28 clutches varied from 2 to 5 eggs (Table III-2). The average clutch size of 3.11 eggs was similar to that of clutches observed in 1970 (3.1) and 1973 (3.2) (M. H. Dick pers. comm.).

Fledging of young began 3 August. Most young fledged by 27 August, although some young remained in nests until September. One to four young fledged at each nest (Table III-2). Of 128 nests observed with eggs and/or young in 1976, young had fledged from 100 nests (73.1%), and 5 nests (3.9%) still had unfledged young on 3 September. Egg laying, hatching, and fledging dates are similar to those observed by M. H. Dick in 1970 and 1973 (pers. comm.).

Successful nests with eggs or small young were attended by at least one adult during all observation sessions. Adults without eggs or young, or with large young, were most prevalent on territories in late afternoon through late evening. Peak numbers of adults on the colonies occurred in the late evening when pairs were commonly found on territories and non-breeding birds were found roosting on cliff faces.

An estimated 350 pairs of Pelagic Cormorants nested on Cape Peirce in 1976. Changes in the total population of Pelagic Cormorants from 1970, 1973 and 1976 were not apparent, although use of nesting areas varied between years. Significantly more young fledged per successful nest in 1976 than in 1970 and 1973 (M. H. Dick pers. comm.).

Common Eider.

One nest scrape with one egg was found 6 June on Shaiak Island, and several nest scrapes with no eggs were found throughout the field season. One nest with abundant down but no eggs was found on the peninsula.

J. C. Bartonek (pers. comm.) estimated 100 eider nests on Shaiak Island 14 July 1973, but no nests with eggs were found in the primary nesting area in 1976. The lack of nests found with eggs was attributed to red foxes taking eggs as they were laid, but data are inconclusive. Possibly, the bulk of the population did not attempt to nest.

Black-legged Kittiwakes.

Black-legged Kittiwakes were first observed 29 April and occupied nesting territories the same day. All birds were intermittently absent from nesting areas until 30 May. Territories were occupied by both successful and unsuccessful nesting birds until all young fledged. All laying was completed between 10 June and 10 July. The last young fledged on 2 September (Table III-3). Loss of eggs to Common Raven (Corvus corax) was continuous throughout the period of laying and incubation. Breeding birds were not marked, but observations of several birds with aberrant plumage and foot color patterns suggest that there was a continual change over of pairs on territories throughout the breeding season.

Of a sample of 1986 nests, eggs in 38.9% (772) hatched and young fledged from 24.6% (489). No pairs produced more than one fledged young. Loss of nests was reduced after hatching and 63.3% of the nests with young survived to fledging. Loss of eggs was not unifirm throughout the Cape Peirce area; no eggs hatched in two areas, eggs in as many as 50% of the nests hatched in 16 areas, and 50 to 80% of nests in 6 areas had eggs hatch. Variation between nesting areas in loss of young was not apparent, although further analysis of the data is needed. Losses of eggs and young were due primarily to predation by Common Ravens.

Numbers of kittiwakes on territories varied both diurnally and seasonally. The maximum number of birds were on territories by sunset each evening; decreasing to minimum numbers in early afternoon. By late incubation, only those birds that were incubating eggs or which had recently lost their eggs were present on territories during early afternoon. Numbers of birds maintaining territories decreased during brood rearing, and were lowest after the young fledged.

Extrapolation of counts from sample areas of known density to other parts of the Cape Peirce area indicated that the total population numbered about 100,000 pairs.

Glaucous-winged Gulls.

Glaucous-winged gulls were present on 28 April. Most gulls nested in a dense colony on the slopes and plateau of Shaiak Island, but a few nested on the peninsula cliffs as scattered pairs. Laying on Shaiak Island had begun by 6 June when 84.8% (39 nests) of 46 nests contained one egg, 1.3% (2 nests) contained two eggs, and 2.2% (1 nest) contained 3 eggs. Egg loss to Eskimo egg gathering activities and to two red foxes occurred throughout the egg laying period. Red foxes continued taking eggs throughout incubation and eliminated all eggs prior to hatching.

A density of 1 nest per 12.9 sq. meters was found in a sample area of 930 sq. meters in apparent optimal habitat. Nests were empty and nest material blown away before other plots could be established. Renesting attempts were not observed. Counts of territorial pairs from the blind on 11 June indicated 508 birds and 60 nests were present. Comparative counts of birds from photographs taken 25 June 1973 (J. C. Bartonek photo) showed 668 birds in the same area. In that year, foxes were not present, and gulls successfully hatched eggs (J. C. Bartonek pers. comm., M. H. Dick pers. comm.). Thus, numbers of pairs attempting to nest probably were similar in both years. Our observations indicated that about 5,000 birds attempted to nest on Shaiak Island in 1976.

Common Murre.

Common Murres were observed on the cliffs when Petersen arrived 28 April. Murres irregularly occupied the cliff nesting areas until 12 June (Table III-4). Because it is difficult to identify eggs or young on ledges, our sample sizes are small, but data are believed to be representative of the population.

Losses of eggs to predation by Common Ravens were high. Ledges on which laying was synchronized and which were crowded with murres appeared to be more successful than when laying was not synchronized or when fewer than 20 birds were present.

Periodic influxes of breeding plumage birds were noted during July and August. A total population of 500,000 birds, and a breeding population of 200,000 birds was estimated from counts of 9,000 birds in sample areas. Our limited data indicated that about 20% of the pairs successfully raised young. Data are insufficient for more accurate estimates.

Tufted Puffin.

The first Tufted Puffin were observed in the study area on 17 May, and birds were regularly observed beginning 19 May. Tufted Puffins nested on Shaiak Island in crowded colonies, and on the Cape Peirce peninsula as scattered pairs. Egg laying was not observed. One egg pipped on 17 July, and the peak of hatching (16 eggs) was 4 August. Two eggs were still present on 22 August when the burrows were last visited. Fledging was not observed.

Of 59 nests, 35.6% were known to be unsuccessful. Five burrows were obviously destroyed by red foxes, eggs disappeared from 11 burrows, and 5 eggs were apparently deserted. Loss caused by investigators could not be estimated because of disturbance by Eskimo egging parties on the island 10, 11, and 12 June, and the continual disturbance by red foxes. There were no obvious differences in the timing of egg-laying and breeding success among plots of different physical characteristics or nesting densities.

An average of 0.40 active burrows per sq. meter was found in thirty 5 by 5 meter plots. Plots with the highest densities contained 1.25 burrows per meter^2. Extrapolation of sample densities to the total area used for nesting indicated that the breeding population of Shaiak Island was about 39,600 pairs.

Other Alcids.

Approximately 150 pairs of Pigeon Guillemots, 450 pairs of Horned Puffins, and 50 pairs of Parakeet Auklets nested in the cliffs on the peninsula and Shaiak Island. The cracks and crevices birds used were inaccessible. One Horned Puffin egg was observed 7 July in a crack on the cliffs, but had disappeared by 12 July. Three adult Parakeet Auklets collected on 14 July had brood patches, indicating they were breeding birds. Parakeet Auklets were last observed 11 August, and Pigeon Guillemots on 3 September. Horned Puffins were still present on 9 September.

DISCUSSION

Factors influencing nest site establishment.

Although snow was present on nesting areas when birds arrived in 1976, it did not prevent birds from landing on nesting areas and establishing territories. On the peninsula, no birds attempted to nest on slopes with drifted snow. Birds on Shaiak Island were observed evenly dispersed on the snow covered slopes, and were apparently on nest sites. However, laying did not begin until nesting areas were free of ice and snow. In general, cliff ledges preceeded slopes in becoming ice and snow free. Although the effect of snow was minor in 1976, it seems likely that deep snow or late melting may prevent some birds from nesting in some years.

In general, all species arrived before their species specific nesting areas were free of snow, but the sequence of arrival was correlated with the sequence of snow melt of their specific type of nesting site.

Factors influencing reproductive success.

Of those birds attempting to nest in 1976, success seemed to be most influenced by loss of clutches and broods to predation by Common Ravens and red foxes. Losses to Common Raven were apparently minimized by Common Murres by synchronization of laying on crowded ledges. Kittiwakes apparently minimized losses to Common Ravens by nesting on small inaccessible ledges. Losses to red foxes were apparently minimized by all species by nesting in inaccessible areas. Behavioral defensive reactions to predators resulted in no apparent reduction of egg or young losses, except by Pelagic Cormorants which could successfully defend their nests from ravens.

Because of continuous loss of eggs to predators, the actual number of eggs laid by Black-legged Kittiwakes could not be accurately determined. Only one young fledged in each successful nest; and those initially with two young loosing one young within a week of hatching. Reasons for partial loss of broods could not be determined, but may reflect the availability of food as well as partial predation.

Pelagic Cormorants raised significantly more young per brood to fledging in 1976 than in 1970 or 1973 (M. H. Dick pers. comm.). Broods of four young fledged in 1976, whereas none were observed in 1970 or 1973 (M. H. Dick pers. comm.). Clutch sizes did not differ between years, and apparently more young per brood survived to fledging. Reasons for the higher survival in 1976 are obscure, but may reflect an increased food availability during the chick stage.

Population estimates.

Estimates of the number of Black-legged Kittiwakes and Common Murres nesting or seen in nesting areas during the field season are probably low. The total number of murres at Cape Peirce may be as many as 1,000,000, but no fewer than 500,000. There may be as many as 200,000 pairs of kittiwakes, but no less than 100,000 pairs. No observations were made from boats or airplanes to determine the percent of the nesting area used that was censused from cliff edges, thus, more accurate estimates are not possible at this time. Numbers of Pelagic Cormorants are probably accurate to within a few pairs, since most of the known nesting areas could be observed. The size of the nesting population of Tufted Puffins and Glaucous-winged Gulls were estimated by using sampling techniques which are relatively free of biases affecting estimates for other species, thus, our estimates may be relatively accurate. Exact counts were obtained for nests of Double-crested Cormorants.

Table III-1

Breeding Chronology of Pelagic Cormorants.

Event	Date	Sample Size
Egg laying		110 nests
First egg laid	14 May	
Modal egg laying	24 May	
Last egg laid	3-7 July	
Hatching		25 nests
First hatched young	16 June	
Modal hatching	21 June	
Last hatched young	26 July	
Fledging		103 nests
First fledged young	3 August	
Modal fledging	10 August	
Last fledged young	? September	

Table III-2.

Size of Clutches and Broods of Pelagic Cormorants.

	No. of eggs or young per nest					
	1	2	3	4	5	Average
Clutches	0	4	18	5	1	3.11
	(0%)	(14.3%)	(64.3%)	(17.9%)	(3.6%)	
Broods	14	38	48	3	0	2.39
	(13.6%)	(36.9%)	(46.6%)	(2.9%)	(0%)	

Table III-3.

Breeding Chronology of Black-legged Kittiwakes.

Event	Date	Sample Size
Egg laying		48 nests
First egg laid	10 June	
Modal egg laying	20 June	
Last egg laid	2 July	
Hatching		45 nests
First hatched young	9 July	
Modal hatching	15 July	
Last hatched young	27 July	
Fledging		34 nests
First fledged young	18 August	
Modal fledging	28 August	
Last fledged young	2 September	

Table III-4.

Breeding Chronology of Common Murres

Event	Date	Sample Size
24 hour ledge occupancy		3 areas
First birds seen on nesting areas at 2200 hrs.	1 June	
50% of birds on nesting areas at 2200 hrs.	12 June	
Egg laying		12 eggs
First egg laying	7 June	
Modal egg laying	15 June	
Last egg laid	18 June	
Hatching		8 young
First hatched young	18 July	
Modal hatching	21 July	
Last hatched young	22 July	
Young jumping from ledges		15 young
First young in water	10 August	
Modal young dissappearance	17 August	
Last young off cliffs	4 September	

IV. Predation on Seabirds.

Colonial nesting seabirds are believed to be in part restricted to island nesting areas by mammalian predators (Lack 1954 and 1968, Murie 1959). Furthermore, foxes are believed to determine nesting locations of seabirds (Fay and Cade 1959). Selection pressure by avian predators is believed to have selected for synchronization of egg laying within ledges (Belopol'skii 1957) and within colonies (Lack 1968). Further suggesting that birds have nested on cliffs over an extended period of time, are studies on adaptations of birds to cliff nesting (Cullen 1957, Tschanz and Hirsbrunner-Scharf 1975).

Norman (1971) documented the impact of an invasion of red foxes (Vulpes vulpes) on Short-tailed Shearwaters (Puffinus tenuirostris) nesting in Australia, but no studies prior to ours have been conducted where foxes had no other prey species available. A recent invasion of the mammal-free Shaiak Island by two red foxes (Vulpes fulva) provided an opportunity to evaluate predation by foxes on six species of seabirds including: Double-crested Cormorant (Phalacrocorax auritus), Pelagic Cormorant (P. pelagicus), Common Eider (Somateria mollissima), Glaucous-winged Gull (Larus glaucescens), Black-legged Kittiwake (Rissa tridactyla), Common Murre (Uria aalge), and Tufted Puffin (Lunda cirrhata). The nearby nesting colonies at Cape Peirce provide comparisons of nest sites selected in an area of historic red fox activity. Our observations of foraging techniques used by both avian and mammalian predators, means by which birds avoid predators, and our observations of nesting success provides further insite of the value of nest site selection in minimizing losses to predators.

METHODS

Birds and mammals potentially utilizing seabirds were recorded when encountered to determine their relative abundance. Den sites of four pair of red foxes, and nest areas of three pair of Common Ravens (Corvus corax), two pair of Rough-legged Hawks (Buteo lagopus), and one pair of Bald Eagles (Haliaeetul leucocephalus) were located. Incidental observations of foraging behavior of all species were made when they were encountered. Den sites of red foxes were examined for food remains when found; then checked intermitantly throughout the field season. All prey items were removed from the den site at each visit to facilitate identification of new items and to permit evaluation of seasonal differences in prey.

The abundance and nesting phenology of passerines and shore birds which were alternate prey were determined by censuses of linear transects. Numbers of hoary marmots (Marmota caligata) and arctic ground squirrels (Citellus undulatus) seen daily were recorded. Abundance of small mammals was determined by trapping (2000 trap nights) between 2 May to 6 September. Traps were set in the dune area and near the cliffs where small mammals were thought to occur.

An 804-meter long area along the beach was searched for dead birds at 2 to 3 day intervals between 21 May to 5 September. Dead birds were removed from the beach after checking for the presence or absence of oil on the plumage, and determination of age and sex.

RESULTS

Buteoninae.

One Bald Eagle nest and two Rough-legged Hawk nesting areas were found (Fig. IV-1). One Bald Eagle fledged between 8 and 16 August, and one Rough-legged Hawk fledged 30 July.

Rough-legged Hawks and Bald Eagles were never observed attempting to capture sea birds. Each species was observed flying past nesting Black-legged Kittiwakes and Common Murres once. All birds immediately flew from the nests until the raptor was past the nesting area, but no eggs or young seabirds were present. M. H. Dick (pers. comm.) found kittiwake and Tufted Puffin remains at the nest of the Bald Eagle in 1973, indicating they may take seabirds.

Falconidae.

Gyrfalcons (*Falco rusticolus*) were observed 12 times between 2 May and 4 September. No nests or suspected nesting areas were found on Cape Peirce, although Gyrfalcons have been reported nesting at nearby Cape Newenham (Fyfe, et. al. 1976). All observations in 1976 were of a pair of gray-phase birds which suggests that they were nearby residents. One Gyrfalcon made three unsuccessful attempes to capture a Green-winged Teal (*Anas crecca carolinensis*) on a small pond. Interactions with nesting seabirds were not observed.

Peregrine Falcons (*Falco peregrinus*) were observed only twice (20 May and 16 August), and are not known to nest in the area (Fyfe, et. al. 1976). Peregrine falcons probably had no impact on the seabird colonies in the area.

Glaucous-winged Gull.

A few pair of Glaucous-winged Gulls nested on the cliffs of Cape Peirce, and an estimated 5,000 birds nested on Shaiak Island. Adult gulls frequently flew near the cliffs, and toward the primary foraging area, a nearby salmon stream. Sub-adult gulls primarily scavaged along the beach and in the harbor seal (*Phoca vitulina*) pupping area. Loss of nests to Glaucous-winged Gulls was apparently restricted to unattended nests, and no gulls were observed taking eggs or young from undisturbed seabird nests. However, opportunistic predation on eggs or young may be common when colonies are disturbed by other predators or human activity. Gulls took eggs of murres and kittiwakes when Eskimos disturbed nesting colonies during egging activities, and loss of two Glaucous-winged Gull nests to gulls was attributed to observed activity.

Common Raven.

Three pairs of Common Ravens were found nesting on the cliffs (Fig. III-1), and four young fledged at each nest between 29 and 30 June. Adults and young ravens frequently harassed nesting kittiwakes and murres, and successfully took adult seabirds, eggs, and young from nests

(Table IV-1). Raven preceed the taking of eggs and young by flying close to adult birds on nest sites. Tufted Puffins, Common Murres, and Black-legged Kittiwakes that did not have eggs or young immediately flew from the area. A raven then landed on the cliff or ledge near an incubating bird. Most kittiwakes defended the nest by pecking at the raven, but of little avail, and ravens removed them by grasping a wing with the bill and pulling them from the nest, then seized and flew off with an egg or young. Common Murres were similarly removed from eggs after ravens landed on the ledge near the incubating adults. Sigman observed an immature raven killing an adult kittiwake in flight near a colony. Common Ravens were not observed harassing Pelagic Cormorants, and the cormorant egg (Table IV-1) was probably from an unattended nest. One Pelagic Cormorant young was scavanged near a cormorant colony, apparently after it had fallen from a nest.

Loss of eggs from Black-legged Kittiwake nests in discrete nesting areas was not uniform throughout the Cape Peirce area; no eggs hatched in two areas, eggs in as many as 50% of the nests hatched in 16 areas, and 50 to 80% of nests in 6 areas had eggs hatch. Nesting areas were noted to be desimated between twice weekly observations. Loss probably occurred during one day, but data are insufficient to support that conclusion. Common Raven families were observed foraging together and six Common Ravens could conceivably destroy 50 nests during one foraging effort.

Losses of nests to Common Ravens decreased in mid-July after eggs of kittiwakes hatched. However, this reduced predation on kittiwake chicks may have been a result of the increased availability of young passerines which were beginning to emerge from nests. Populations of small mammals were low, and during 2,000 trap nights, only 12 _Sorex obscurus_ and two _Microtus oeconomus_ were captured. Thus, rodents did not provide an important alternate food source, although they may in other years. Common Ravens collected by M. H. Dick (pers. comm.) in 1976 had eaten _Empetrum_ and _Vaccinium_ berries which would also provide an alternate food source in some seasons.

Red Fox.

Four territories of red foxes were found on the Cape Peirce peninsula, and two red foxes were present on Shaiak Island. Of six den sites found on the peninsula (Fig. IV-1), five were freshly excavated. Individual foxes were recognized by pellage and body conformation differences. At least one red fox was seen each day, and the individual could usually be determined. One pair successfully raised five pups, and all food items recorded were from that family.

Remains of avian food items at den sites occurred in the same proportions as birds found dead on the beach within the foxes' territory ($X^2 = 11.42$, $df = 9$, $p < 0.1$; Table IV-2), suggesting that scavaging may provide an important source of food. Foxes were observed taking an adult kittiwake from a colony on one occassion, and an egg of a murre on one occasion.

Remains of arctic ground squirrels, haory marmots, and least weasels (Mustela rixosa) were also found at den sites (Table IV-2). Arctic ground squirrels and hoary marmots were eaten, but the least weasles were not. Adults and pups were observed hunting squirrels, and adults were observed capturing them. Small rodent remains were not found.

Two red foxes were observed on Shaiak Island 2 May, and were present throughout the field season. There were no small mammals on the island, and the foxes were apparently dependent on seabirds and their eggs and young for food, although invertebrates may have provided an alternate food source.

On Shaiak Island, Common Eiders, murres, Glaucous-winged Gulls, and Double-crested Cormorants nested on level or sloping terraine areas that were accessible to foxes. All nests initiated in such habitat by these species were destroyed by foxes or by gulls after disturbance by foxes. Nests of kittiwakes on accessible portions of cliffs were also destroyed and only nests in areas inaccessible to foxes survived (Table IV-3).

Burrow nesting provided some protection to Tufted Puffins. Of 59 Tufted Puffin nests observed, only 35.6% were destroyed by two weeks into brood rearing. Direct loss to foxes accounted for 76.2% of the unsuccessful nests. Five marked burrows were dug out by red foxes, but in most instances eggs or young were taken from short burrows. Adult puffins were also taken, as carcasses were commonly found. Our samples indicated that the total loss of adults was approximately 5,000 birds (4 metric tons).

Arctic Ground Squirrels.

Arctic ground squirrels were commonly found along cliff edges and ridges of the Cape Peircr peninsula. None were found on Shaiak Island. Squirrels were never observed at nests of kittiwakes, murres, or Pelagic Cormorants.

Hoary Marmots.

Hoary marmots were restricted to rocky cliff edges and were commonly seen in cracks on cliff faces. No seabird-marmot interactions were observed.

DISCUSSION

Tuck (1970) has observed Rough-legged Hawks and Gyrfalcons taking murres at colonies, but we did not observe raptors preying on any seabirds. Although Bald Eagles, Rough-legged Hawks, and Gyrfalcons resided in the area, they had minor impact on the nesting success of seabirds at Cape Peirce.

Remains of arctic ground squirrels, haory marmots, and least weasels (Mustela rixosa) were also found at den sites (Table IV-2). Arctic ground squirrels and hoary marmots were eaten, but the least weasles were not. Adults and pups were observed hunting squirrels, and adults were observed capturing them. Small rodent remains were not found.

Two red foxes were observed on Shaiak Island 2 May, and were present throughout the field season. There were no small mammals on the island, and the foxes were apparently dependent on seabirds and their eggs and young for food, although invertebrates may have provided an alternate food source.

On Shaiak Island, Common Eiders, murres, Glaucous-winged Gulls, and Double-crested Cormorants nested on level or sloping terraine areas that were accessible to foxes. All nests initiated in such habitat by these species were destroyed by foxes or by gulls after disturbance by foxes. Nests of kittiwakes on accessible portions of cliffs were also destroyed and only nests in areas inaccessible to foxes survived (Table IV-3).

Burrow nesting provided some protection to Tufted Puffins. Of 59 Tufted Puffin nests observed, only 35.6% were destroyed by two weeks into brood rearing. Direct loss to foxes accounted for 76.2% of the unsuccessful nests. Five marked burrows were dug out by red foxes, but in most instances eggs or young were taken from short burrows. Adult puffins were also taken, as carcasses were commonly found. Our samples indicated that the total loss of adults was approximately 5,000 birds (4 metric tons).

Arctic Ground Squirrels.

Arctic ground squirrels were commonly found along cliff edges and ridges of the Cape Peircr peninsula. None were found on Shaiak Island. Squirrels were never observed at nests of kittiwakes, murres, or Pelagic Cormorants.

Hoary Marmots.

Hoary marmots were restricted to rocky cliff edges and were commonly seen in cracks on cliff faces. No seabird-marmot interactions were observed.

DISCUSSION

Tuck (1970) has observed Rough-legged Hawks and Gyrfalcons taking murres at colonies, but we did not observe raptors preying on any seabirds. Although Bald Eagles, Rough-legged Hawks, and Gyrfalcons resided in the area, they had minor impact on the nesting success of seabirds at Cape Peirce.

Glaucous-winged Gulls appeared to be effective as opportunistic predators when disturbance of colonies caused incubating or brooding birds to leave their nests, thus exposing eggs and young to predation. Although losses caused by gulls were of relatively minor importance at Cape Peirce, it could be significant in areas where colonies are subjected to additional disturbance as may be caused by increased human activity.

Common Ravens were clearly the most persistant and effective avian predator on both kittiwakes and murres, taking large numbers of eggs and young. Ravens were least effective when kittiwakes or murres nested on ledges that prevented ravens from landing near the nesting site. Synchronization of laying and crowding on ledges by murres also tended to exclude ravens and increased nesting success. The differences in nesting success on different ledges provides a strong selective pressure for use of a particular habitat and for synchronization of laying in crowded conditions. As murres are known to return to the same ledges to breed in successive years (Tuck 1960), crowding probably reflects an increased survival of chicks on particular ledges and the return of chicks and adults to the ledges they were born or nested successfully.

Red foxes were the primary mammalian predator within the study area. Foxes are historically abundant at the Cape Peirce peninsula, and with few exceptions, seabirds utilized only areas that were inaccessible to them. Thus, the effect of predation by foxes was negligible. At Shaiak Island, however, foxes have not been present in recent years, and seabirds traditionally nested in areas that included areas that were easily accessible to the two foxes that invaded the island in 1976. In those accessible areas, all nests of cormorants, eiders, murres, gulls, and kittiwakes were destroyed, and productivity of Tufted Puffins was reduced. In addition, foxes killed about 6% of the adult puffins.

The foxes' devastating effect on the seabirds of Shaiak Island indicates that nesting in vulnerable areas could not persist where foxes are present, and that the distribution of seabirds in mainland areas is limited by mammalian predators.

We consider it significant that seabirds attempted to nest in vulnerable areas on Shaiak Island in normal numbers despite the presence of foxes, although few attempted to nest in similarly vulnerable habitat in mainland colonies. Possible causes for this persistance include the imprinting of young to the area of their origin, an unusually strong tendency of adults to occupy sites they have used previously, or the inability of birds to recognize foxes as predators of eggs and young and immediately change nest sites to inaccessible areas.

Table IV-1.

Numbers of seabird prey observed taken by Common Ravens.

Species	Adults	Eggs	Young
Pelagic Cormorant	0	1	0
Black-legged Kittiwake	1	6	1
Common Murre	0	7	0

Table IV-2.

Species potentially available and used by one red fox family.

Species	No. of individuals found:	
	Beached birds	Den site Prey items
Pelagic Cormorant (Phalacrocorax pelagicus)	1	0
American Wigeon (Anas americana)	0	1
Pintail (Anas acuta)	1	0
Harlequin (Histrionicus histrionicus)	3	1
Eider (Somateria sp.)	1	0
Black Scoter (Melanitta nigra)	1	0
Glaucous-winged Gull (Larus glaucescens)	2	1
Black-legged Kittiwake (Rissa tridactyla)	10	23
Common Murre (Uria aalge)	12	23
Horned Puffin (Fratercula corniculata)	0	2
Tufted Puffin (Lunda cirrhata)	0	2
Least weasel (Mustela rixosa)	-	4
Hoary marmot (Marmota caligata)	-	3
Arctic ground squirrel (Citellus undualtus)	-	3

Table IV-3.

Chronology of seabird nest loss on Shaiak Island.

Species	No. Pair	Egg Laying Dates	Fox Exploitation Dates	Nesting Habitat
Double-crested cormorant	300	1-11/6	1-19/6 2-10/7	Plateau Slopes
Pelagic Cormorant	50	14/5-1/7[1/]	none	Cliff faces
Glaucous-winged Gull	2,500	4-17/6	4/6-2/7	Plateau
Black-legged Kittiwake	10,000	10/6-2/7	10/7-15/8 none	Rock faces Cliff faces
Common Murre	25,000	7-18/6	7/6-15/8 none	Slopes Cliff faces
Tufted Puffin	39,590	4/6-17/7	17/7-22/8	Sod slopes

1/ Estimated from size of young.

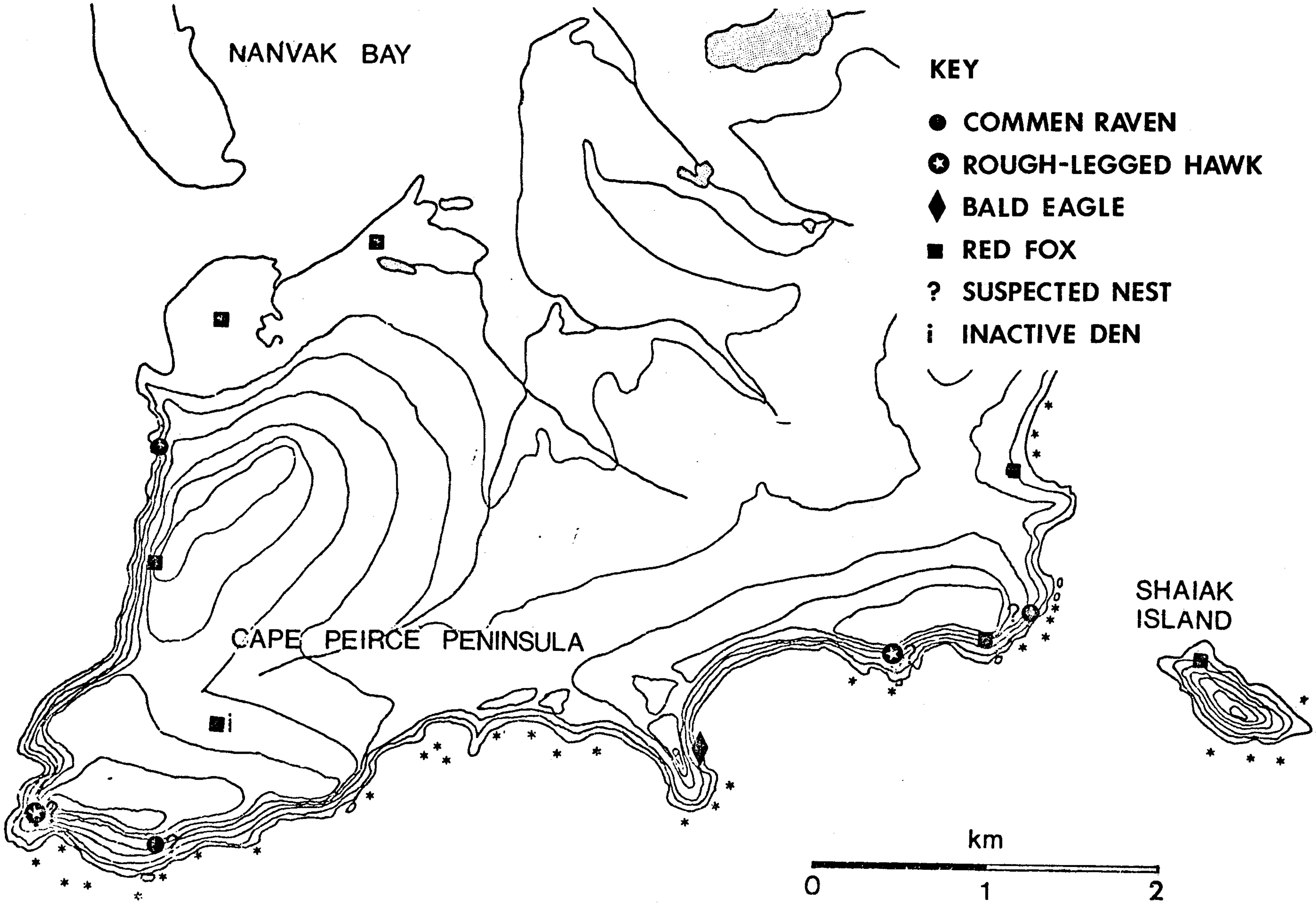


FIG. IV-1. LOCATION OF AVIAN PREDATOR NEST SITES AND RED FOX DEN SITES.

V. Spring migration, molt, and foraging areas of loons and waterfowl.

Migrant loons, waterfowl, and cormorants may be easily observed from the cliffs of Cape Peirce; some species proceeding northward and others stopping at Nanvak Bay (King 1966, M. H. Dick pers. comm.). Observations at Cape Peirce, thus permit evaluation of the timing of migration and the importance of the coastal route from Bristol Bay to more northern breeding, feeding, or molting areas. Additionally, large numbers of waterfowl are present in the Nanvak Bay-Cape Peirce area from early April to October (King and Monson 1968, Hout 1971). These include many seaducks (eiders, Harlequin, and scoters), none of which have been studied in the Bering Sea region and only limited information is available from other areas (Bellrose 1976). Habitat use of wintering seaducks have been conducted on the east coast of the U.S. (Stott and Olson 1973), and South Sweden (Nilsson 1972), and habatat use of molting birds have been conducted in Denmark (Joensen 1973).

Thus, our observations which document the chronology of spring migration, and characterize the populations in the Nanvak Bay-Cape Peirce area are of interest both for evaluation the importance of the study area and to the overall understanding of populations and ecology of the seaducks of the Bering Sea.

METHODS

Migration and general movements of loons, cormorants, waterfowl, and alcids were observed from three seawatch sites and 12 bay observation sites (Fig. V-1). The Nanvak Bay site was in the dunes overlooking the bay, Obs. II seawatch site was on a cliff 30 meters above the water, and the Cape Peirce VABM seawatch site was from a rock windbreak near the VABM marker 115 meters above the water. Bays and inlets below the cliffs were censused from marked observation sites on the cliffs.

Birds using Nanvak Bay and the water along the cliffs were censused by making sweeps with a 20 power spotting scope. Species, age, sex, plumage, molt stage, group size and composition, and activity data for each individual was recorded. Age and sex determination of waterfowl were based on plumage characteristics described in Palmer (1976). Counts of two hours in duration of all birds and mammals moving up or down the coast were made from the VABM seawatch site, with the same type of data collected as during the sweeps. In addition, birds flying with food in their bills were recorded. From 19 April to 1 June, seawatches were conducted as weather permitted three times daily from Nanvak Bay and Obs. II. Sweeps were conducted twice daily, and two hour watches once daily on alternate days from 29 April to 1 June from the VABM seawatch site. Seawatches were conducted at all sites weekly from 1 August to 1 August, then twice weekly from 1 August to 5 September. Bays and inlets were censused twice weekly throughout the field season as weather allowed.

Areas utilized by birds (Fig. V-2) were delineated by noting where birds foraged or roosted.

RESULTS

Spring Migration.

Gaviiformes - Red-throated Loons (*Gavia stellata*) and Arctic Loons (*G. arctica*) migrated past Cape Peirce 3 May until 1 June, with peak migration of Red-throated Loons occuring 14 days earlier than Arctic Loons (Table V-1). Both species were seen in numbers ranging from single individuals to flocks of 14. Flocks of Red-throated Loons (Table V-2) did not vary significantly in size throughout spring migration, with an average flock size of 1.93. Arctic Loons migrated predominantly as flocks until after peak migration when singles predominanted (X^2 = 43.88, *df* = 9, *p* > 0.005; Table V-2). All migrating loons observed were in breeding plumage, and none stopped along the cliffs of Cape Peirce.

Anserinae - Black Brant (*Branta bernicla nigricans*) and Emperor Geese (*Anser canagica*) were observed flying overland across the Cape Peirce peninsula as well as around the Cape from May to June (Table V-1). On the one clear day during peak Black Brant migration, some flocks were observed landing at Nanvak Bay, and others continued up the coast. A sum of 4,400 Black Brant were observed from the Nanvak Bay seawatch site at one count. Some brant fed in the windrowed eelgrass on the shore, but most roosted on the ice. Emperor Geese were similarly observed, but in smaller numbers. Sex of individuals was not determined; all geese observed at close range during migration were in adult plumage.

Anatinae - Most ducks migrated as pairs or in flocks of nearly equal sex ratios (Table V-1). Exceptions were Pintail (*Anas acuta*), White-winged Scoters (*Melanitta deglandi*), and Oldsquaw (*Clangula hyemalis*). Pintail and White-winged Scoter flocks were all or nearly all male, with only the occasional female seen. Flocks of Oldsquaw were predominantly females with an occasional pair observed. Both male and female Oldsquaw were in either alternate plumage or in the prebasic molt early in migration, then during the latter part of migration birds in the basic plumage were observed.

Analysis of age-sex ratios, and flock composition as they changed through the season has not been completed.

Most yearling and some two-year old male, and some yearling female eiders and scoters could be identified. It was apparent that sub-adults migrated after the peak migration of adults, and stopped and fed more frequently than adults.

The King Eider (*Somateria spectabilis*) was the dominant species observed, with 10,798 birds observed during a 2.6 hour observation period at peak migration. Flocks of up to 650 birds were recorded, and flocks of 200-300 birds were common in early migration. Flocks of greater than 100 birds were not observed after 12 May when sub-adult birds predominated.

Alcidae - Local movements of Common Murres (Uria aalge) could not be seperated from possible migration past Cape Peirce to other areas. Pigeon Guillemots (Cepphus columba), Horned Puffins (Fratercula corniculata), Tufted Puffins (Lunda cirrhata), and Parakeet Auklets (Cyclorrhynchus psittacula) had no discernable migration past Cape Peirce, but "appeared" off the cliffs and apparently remained in the study area.

Phalacorcoracidae - Both Pelagic Cormorants (Phalacrocorax pelagicus) (and/or Red-faced Cormorants [P. urile]) and Double-crested Cormorants (P. auritus) were observed flying up and down the coast throughout the field season. There was no obvious migration as reported by M. H. Dick (pers. comm.) in 1973. Cormorants were generally flying in groups of one or two individuals and were occasionally seen landing on nearby cliffs, indicating that all birds we saw were a part of the local population.

Molting and foraging areas of seaducks.

Harlequin - Pairs of Harlequin (Histrionicus histrionicus) were observed daily during migration, until 31 May when unpaired birds predominated. Males were the predominant sex molting in the area, with females comprising only 12.4% of the total molting birds. Molting Harlequin were usually found in flocks of 3 to 15 individuals, with all individuals in a similar stage of molt. Birds began the pre-basic molt 8 to 15 July, became flightless 16 to 23 July, and had regained flight by 23 August (Table V-3).

The area immediately adjacent to the outer coast was the principle habitat utilized by Harlequin, and flocks commonly foraged close to shore (Fig. V-2), and roosted on rocks exposed at low tide.

Common Eider - Flocks of adult Common Eiders (Somateria mollissima) were observed during migration, and sub-adults were observed in small flocks (5 to 20 individuals) during the molt. Some adults were in the area throughout the field season, and we found them nesting on both the mainland and Shaiak Island. However, no broods were observed. Flightless birds were found beginning 28 July, and were still present on 9 September (Table V-3). Full winged birds were not encountered regularly in the fall.

Common eiders used Nanvak Bay during both the spring and summer seasons (Fig. V-2) and foraged in the shallow water where we observed them eating Mya arenaria.

King Eider - Although the King Eider was the predominant species observed on migration, few birds remained in the area to molt; molting birds being observed only as scattered individuals. Birds which remained on the study area were mostly sub-adults. They became flightless beginning 30 July (Table V-3); and flightless birds were still present 9 September when we left the study area. Birds in the pre-alternate molt were not observed.

Both migrant and resident King Eiders foraged primarily off the tip of Cape Peirce, and between Shaiak Island and the peninsula (Fig. V-2);

with migrating birds in flocks of several 1,000, and molting birds in flocks containing 1 to 21 birds. Molting birds occassionaly roosted on the rocky shores near the foraging areas.

Steller' Eider - Flocks of adult Steller's Eiders (Polysticta stelleri) were observed while on migration until 8 July (Table V-3). Flocks observed in July, August, and September consisted of birds in basic plumage. It could not be determined if birds in this plumage were sub-adult males, adult females, or sub-adult females. Only a few adult males were identified in flocks, which contained from 9 to 350 individuals. All birds within individual flocks were in identical molt stages, although flocks differed. The first flightless birds were observed 27 August (Table V-3), and flocks were still moving into the area to become flightless when we left 9 September.

Both migrating and molting flocks foraged in areas adjacent to cliffs, along the peninsula (Fig. V-2). Flocks roosted near foraging areas on rocks exposed during low tide.

Black Scoter - Black Scoters (Melanitta nigra) were not common molting birds, and most observations were of migration birds. Molting birds were flightless by 15 August (Table V-3), and presumably were still flightless when we lift the study area 9 September.

Migrant scoters foraged in Nanvak Bay (Fig. V-2), in flocks of mixed age and sex. Although Common Eiders foraged in Nanvak Bay at the same time, mixed species flocks were not observed.

White-winged Scoter - White-winged Scoters were observed only as scattered individuals along the cliffs. Flightless birds were first noted 20 July, and were still in the study area 9 Septemver (Table V-3). Those we observed were predominantly males of undetermined age, and birds could be found in almost any stage of molt from July through September.

White-winged Scoters foraged up to 1 km or more from the cliff area (Fig. V-2), and were never observed near shore.

Surf Scoter - Surf Scoters (Melanitta perspicillata) were observed as scattered individuals along the cliffs. Migrants were not observed feeding in the study area. Molting birds were predominantly adult and sub-adult males. As with White-winged Scoters, birds in almost any plumage or molt stage could be found throughout the flightless period (Table V-3).

Surf Scoters foraged in the surf along the western portion of the Cape Peirce peninsula, and in one area along the southern portion of the peninsula (Fig. V-2).

Red-breasted Mergansers - A few pair of Red-breasted Mergansers (Mergus serrator) were observed on migration in early May. Most birds observed were in a single molting flock of 163 adult males. All individuals observed 8 July were in the prebasic molt, and were flightless by 30 July (Table V-3). Flightless birds were still observed 7 September.

DISCUSSION

Spring migration.

Probably most of the west coast populations of Arctic Loons, Red-throated Loons, Black Brant, Emperor Geese, King Eiders, and Stellers Eiders migrate through the Cape Peirce-Nanvak Bay area. Also migrating through the area were significant numbers of Common Eiders, Harlequin, and Black Scoters that breed further north, as well as smaller segments of the breeding populations of Common Goldeneye (Bucephala clangula), Greater Scaup (Aythya marila), American Green-winged Teal (Anas crecca carolinensis), American Wigeon (A. americana), Oldsquaw, Pintail, and Red-breasted Mergansers. During the later part of spring migration, sub-adults and non-breeding birds of many species were observed migrating to more northerly feeding areas, and some stayed in the Cape Peirce-Nanvak Bay area to molt.

Loons did not migrate as obvious pairs, although pairs could have migrated together in flocks. Similarly, Black Brant and Emperor Geese may have migrated as pairs. Ducks probably were paired, since flocks of adults invariably had a 50:50 sex ratio. Notable exceptions were flocks of male Pintail, and male White-winged Scoters, and female Oldsquaw. Possibly the male White-winged Scoters were non-breeding birds summering along the west coast of Alaska, unpaired adults going to breeding areas inland, or males that have abandonded nesting females and are on a molt migration. Pintail and Oldsquaw may have been migrating to more northern breeding areas, and only a small disproportionate segment of each population was observed.

The timing of migration for each species varied (Table V-1); with peak migration of Red-throated Loons, Anatinae, goldeneyes, King Eiders, and Oldsquaw occuring in early-May, and most other species migration by 18 May. Surf Scoter migration peaked 20 June. No information from Cape Peirce is available to cpmpare peak migration dates of waterfowl from other years.

Foraging areas.

Nanvak Bay is obviously an important feeding area for migrant Black Brant, Emperor Geese, Common Eiders, Black Scoters, Greater Scaup, Common Goldeneye, Oldsquaw, and Red-breaseted Mergansers. As much as 50% of the world's population of Black Brant foraged or roosted on Nanvak Bay during spring migration. Until the ice began to melt in the marsh areas, all puddle ducks foraged or roosted in Nanvak Bay. Harlequin, Steller's Eiders, and King Eiders migrating in the spring foraged along the cliffs, as well as throughout the rest of the field season. Arctic and Red-throated Loons were the only species not observed foraging during spring migration.

Seaducks found foraging in the Cape Peirce-Nanvak Bay areas showed spatial and temporal segregation of the use of feeding areas (Fig. V-2). White-winged Scoters were found furthest from the cliffs, and Surf Scoters were found in surf near the cliffs. Steller's Eiders and Harlequin were found the closest to the cliffs, but at different times. King Eiders generally restricted activity to two areas off the cliffs not utilized by other species. Red-breasted Mergansers, Common Eiders, and Black Scoters foraged in Nanvak Bay, but not in the same area or in mixed species flocks.

Food items taken by seaducks at Cape Peirce were not determined. Information of food habits of Harlequin, scoters, eiders, and mergansers during May to Septmeber are fragmatory; but in general, scoters, Harlequin and eiders take similar types of benthic organisms, and Red-breasted Mergansers take fish (Preble and McAtee 1923, Cottam 1939, McGilvrey 1967, Pethon 1967, Bengtson 1971, Nelsson 1972, Stott and Olson 1973). More data on food preferences, substrate types, water depth, food availability, and foraging ability of each species is needed before conclusions regarding habit separation by species at Cape Peirce can be made.

Molt chronology.

Common Eiders and Redbreasted Mergansers became flightless during the same time of year as individuals of the same age and sex classes in Denmark (Joensen 1973). Steller's Eiders are flightless during August and September both at Cape Peirce and Izembek Bay, Alaska (Jones 1965). Observations of subadult flightless King Eiders from areas other than Cape Peirce are lacking, but flightless dates are similar to Common Eiders. Male Harlequin were flightless 16 July to 23 August at Cape Peirce, but comparative information on flightless male Harlequin from other areas are lacking (Bellrose 1976). Flightless White-winged Scoters, Black Scoters, and Surf Scoters can be found at Cape Peirce late-July through September; however, information on the flightless period of these scoters from other areas is lacking. The general consensus is that scoters are flightless August and September, and molt at sea (Joensen 1973, Palmer 1976, Bellrose 1976). Observations beyound 1 km from shore at Cape Peirce should be made since flightless birds have been found 4 to 10 km from shore (Joensen 1973).

Table V-1

Spring migration dates of common species

Species	Peak Migration Date	Dates of Migration 1/
Red-throated Loon	6 May	3 May - 1 June
Arctic Loon	20 May	5 May - 1 June
Pelagic Cormorant	12 May	5 May - 9 June
Black Brant	12 May	3 May - 1 June
Emperor Goose	16 May	2 May - 9 June
Pintail	2 May	28 April - 17 May
American Wigeon	1 May	29 April - 14 May
American Green-winged Teal	1 May	1 May - 19 May
Greater Scaup	10 May	30 April - 31 May
Common Goldeneye	7 May	30 April - 13 May
Harlequin	16 May	30 April - 7 June
Common Eider	18 May	5 May - 8 June
King Eider	5 May	30 April - 30 June
Steller's Eider	13 May	28 April - 14 June
Oldsquaw	3 May	28 April - 26 May
Black Scoter	12 May	30 April - 20 June
White-winged Scoter	12 May	30 April - 30 June
Surf Scoter	20 June	21 May - 13 July
Red-breasted Merganser	none	28 April - 31 May

1/ Observer present 28 April to 9 September.

Table V-2

Flock sizes of loons during spring migration.

	Flock Size										
	1	2	3	4	5	6	7	8	10	13	14
Red-throated loon											
3 May - 1 June	46	21	9	5	1	0	1	0	1	1	0
Arctic loon											
3 May - 20 May	46	24	16	10	6	6	2	4	2	0	1
22 May - 1 June	80	14	4	1	1	0	0	0	0	0	0

Table V-3

Molting dates of non-breeding water fowl.

Species	Dates present1/	Dates flightless	Predominant age-sex class molting
Harlequin	31 May - 8 Sept.	16 July - 23 Aug.	male
Common Eider	6 May - 9 Sept.	28 July - 9 Sept.	subad. male & subad. female
King Eider	6 May - 9 Sept.	30 July - 9 Sept.	subad. male & subad. female
Steller's Eider	8 July - 9 Sept.	27 Aug. - 9 Sept.	subadult (?)
White-winged Scoter	1 May - 9 Sept.	20 July - 9 Sept.	male (adult?)
Surf Scoter	21 May - 9 Sept.	30 July - 9 Sept.	subad. male & ad. male
Red-breasted Merganser	29 June - 9 Sept.	30 July - 9 Sept.	adult male

1/ Observer present 28 April to 9 Sept.

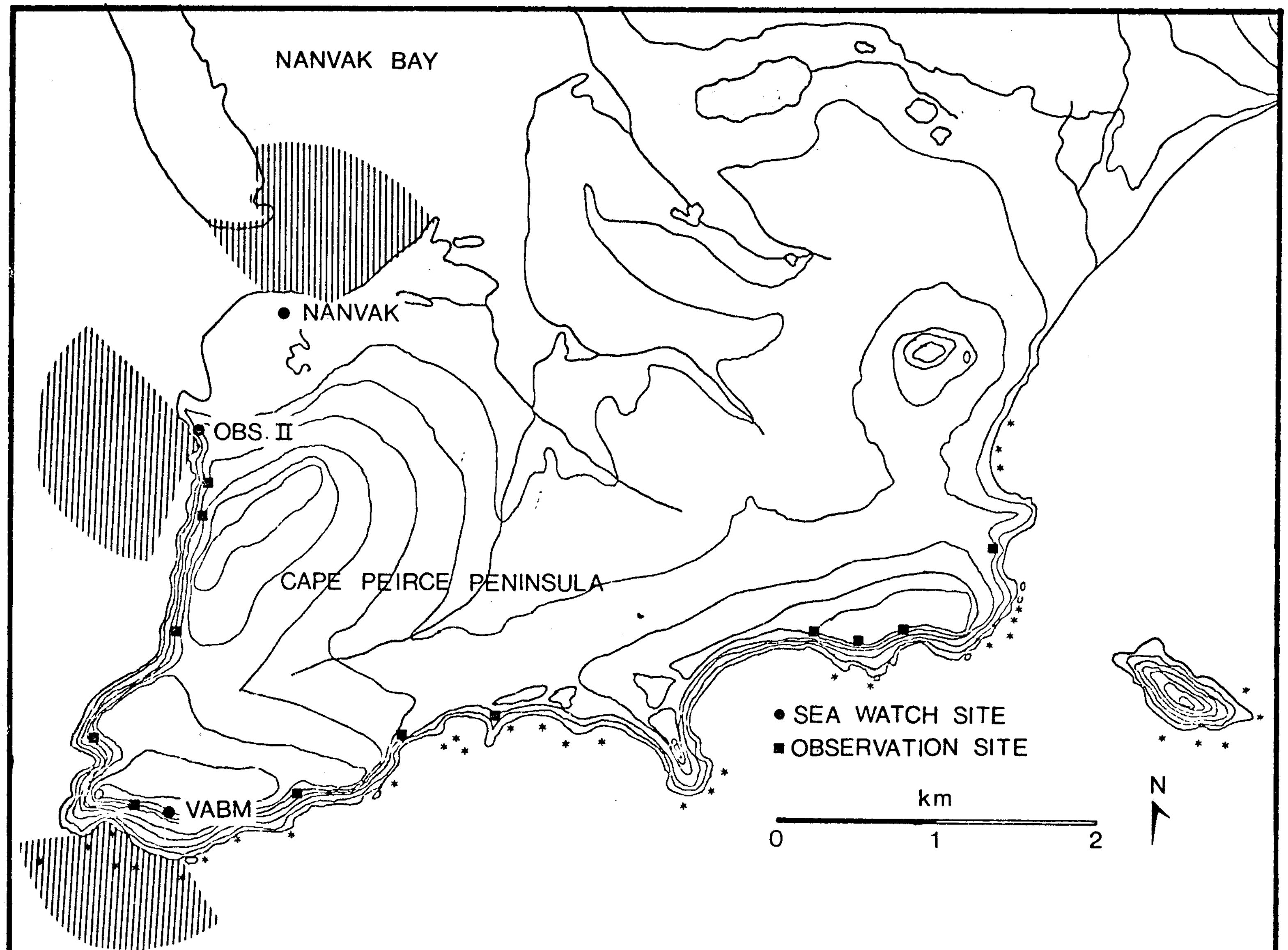
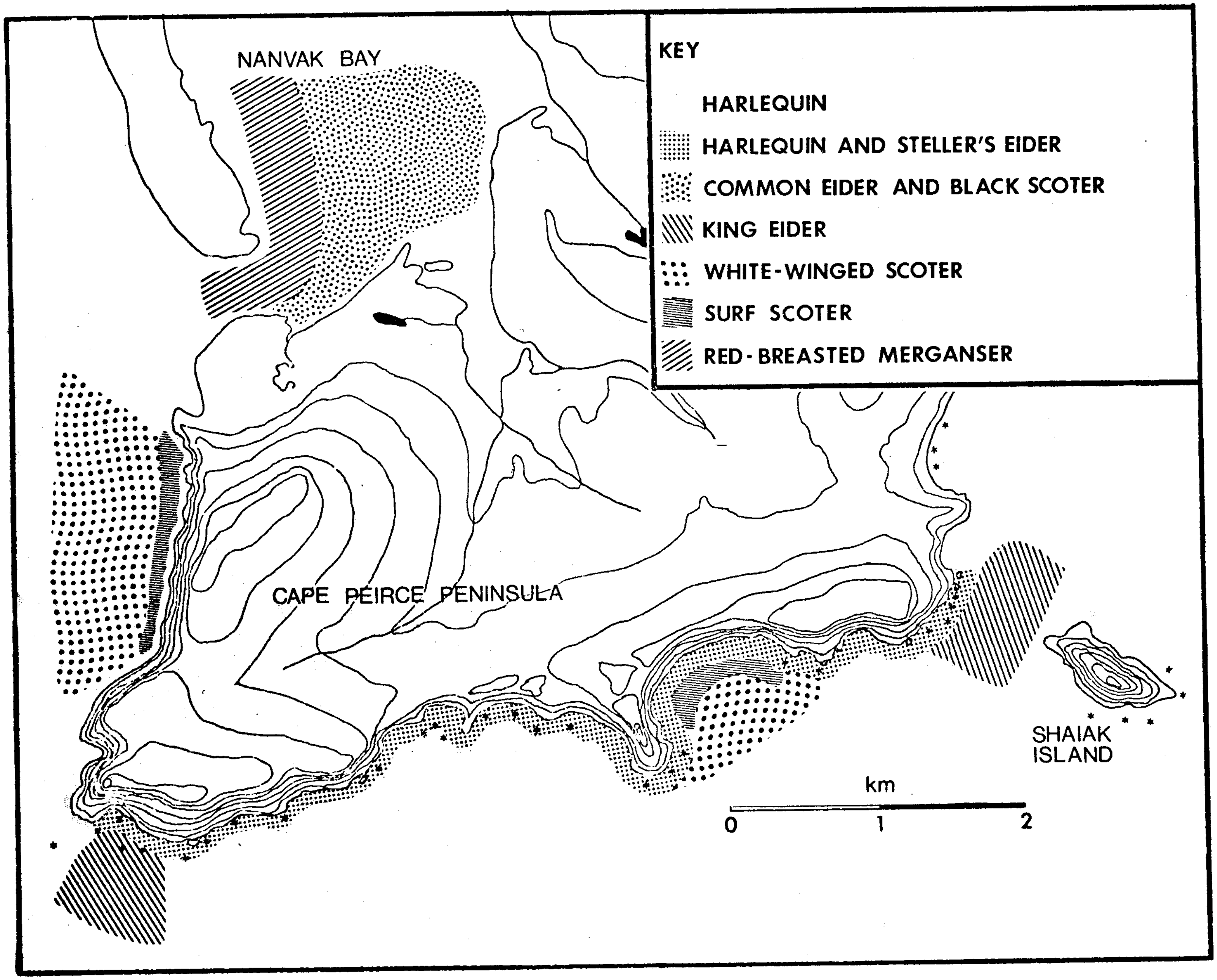


FIG. V-1. LOCATION OF SEAWATCH SITES AND OBSERVATION SITES

FIG. V-2. FEEDING AREAS OF SEADUCKS



Literature Cited

Bellrose, F. C. 1976. Ducks, geese, and swans of North America. Stockpole Books, Harrisburg, PA

Belopol'skii, L. O. 1957. Ecology of sea colony birds of the Barents Sea. Natl. Sci. Found., Washington, D.C. (Transl. from Russian). Israel Program for Sci. Transl., Jerusalem.

Bengtson, S-A. 1971. Food and feeding of diving ducks breeding at Lake Myvatn, Iceland. Ornis Fennica 48:72-92.

Coast and Geodetic Survey. 1954. U.S. Costal Pilot 9, Alaska. Cape Spencer to Arctic Ocean, 6th ed. U.S. Dept. of Commerce.

Cottam, C. 1939. Food habits of North American diving ducks. Tech. Bull. No. 643, U.S. Dept. Agri., Washington, D.C.

Cullen, E. 1957. Adaptations in the kittiwake to cliff-nesting. Ibis 99:275-302.

Dick, M. H. and L. S. Dick. 1971. The natural history of Cape Peirce and Nanvak Bay, Cape Newenham National Wildlife Refuge, Alaska. Unpubl. report. U.S. Fish Wildl. Serv.

Fay, F. H. and T. J. Cade. 1959. An ecological analysis of the aviafauna of St. Lawrence Island, Alaska. Univ. Calif. Publ. in Zool. 63:73-150.

Fyfe, E. F., S. A. Temple, and T. J. Cade. 1976. The 1975 North American peregrine falcon survey. Can. Field Nat. 90:228-273.

Hoare, J. M. and W. L. Coonrad. 1961. Geologic map of the Hagemeister Island quadrangle, Alaska. Misc. Geologic Invest., Map I-321, U.S. Geol. Surv., Washington, D.C.

Hout, J. L. 1969. Cape Newenham National Wildlife Refuge, Narrative Report. U.S. Fish Wildl. Serv. Loose-leaf publ. n. p.

Hout, J. L. 1970. Cape Newenham National Wildlife Refuge, Narrative Report. U.S. Fish Wildl. Serv. Loose-leaf publ. n. p.

Hout, J. L. 1971. Cape Newenham National Wildlife Refuge, Narrative Report. U.S. Fish Wildl. Serv. Loose-leafe publ. n. p.

Joensen, A. H. 1973. Molt migration and wing-feather molt of seaducks in Denmark. Danish Rev. Game Bio. 8:1-42.

Jones, R. D., Jr. 1965. Returns from Steller's eiders banded in Izembek Bay, Alaska. Wildlfowl Trust 16:83-85.

King, J. G. 1966. Cape Newenham, Alaska. A wildlife metropolis. U.S. Fish Wildl. Serv. Loose-leaf publ. n. p.

King, J. G., and M. A. Monson. 1968. Report of field inspection trip of bird resources of Bristol Bay, April 22-23, 1968. U.S. Fish Wildl. Serv. Unpubl. report n. p.

King, W. B. 1967. Seabirds of the tropical Pacific Ocean. Smithson. Inst., Washington, D. C.

Lack, D. 1954. The natural regulation of animal numbers. Oxford Univ. Press, London.

Lack, D. 1968. Ecological adaptations for breeding in birds. Chapman and Hall, London.

McGilvrey, F. B. 1967. Food habits of sea ducks from the Northeastern United States. Wildfowl Trust 18:142-145.

Murie, O. J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. North Amer. Fauna No. 61.

Nettleship, D. N. 1976. Census techniques for seabirds of Arctic and Eastern Canada. Occ. Paper No. 25, Can. Wildl. Serv.

Nilsson, L. 1972. Habitat selection, food choice, and feeding habits of diving ducks in coastal waters of South Sweden during the non-breeding season. Ornis Scandinavica 3:55-78.

Norman, F. I. 1971. Predation by the fox (Vulpes vulpes L.) on colonies of the short-tailed shearwater (Puffinus tenuirostris) (Temminck)) in Victoria, Australia. J. appl. Ecol. 8:21-32.

Palmer, R. S. (ed.). 1976. Handbook of North American Birds, Vol. 3. Waterfowl (Part 2). Yale Univ. Press, New Haven.

Pethon, P. 1968. Food and feeding habits of the common eider (Somateria mollissima). Nytt Magasin for Zoologi 15:97-111.

Preble, E. A. and W. L. McAtee. 1923 A biological survey of the Pribilof Islands, Alaska. North Amer. Fauna No. 46.

Stott, R. S. and D. P. Olson. 1973. Food-habitat relationship of sea ducks on the New Hampshire coastline. Ecology 54:996-1007.

Tschanz, B. and M. Hirsbrunner-Scharf. 1975. Adaptations of colony life on cliff ledges: a comparative study of guillemot and razorbill chicks. In Functions and Evolution in Behavior. Faerends, Beer, and Manning (Eds.). Clarendon Press, Oxford. 358-380.

Tuck, L. M. 1960. The murres. Can. Wildl. Series 1:1-260.

APPENDEX I. Birds and Mammals Observed at Cape Peirce and Nanvak Bay.

Several lists of birds and mammals seen in the area have been compiled (King 1966, Hout 1969 & 1971, Dick and Dick 1971), and notes on each reported. Table 1 includes species recorded at Cape Peirce-Nanvak Bay from 1963 to 1976, and all observations were between 2 April and 1 October. Notes on species included in this report include species not observed previously to 1976, or those that changed status in 1976.

SPECIES NOTES

Birds

Yellow-billed Loon (Gavia adamsii). One adult in basic plumage was observed flying south across the Cape Peirce peninsula 3 September 1976.

Red-throated Loon (Gavia stellata). This species has been recorded previously (Table 1), but breeding was not recorded until 1976. A pair hatched one egg 23 June in a small pond, and the young fledged 13 to 19 August. Red-throated Loons were also common spring migrants.

Frigatebird (Fregata sp.). One bird in immature plumage was observed soaring and stalling 20 May 1976 above the dune area, then soared west out to sea. The individual had the typical immature plumage of white breast, neck, and head. The individual could have been a F. minor, F. ariel, or F. magnificens based on descriptions of subadults in King (1967) and Palmer (1962).

Red-faced Cormorant (Phalacrocorax urile). Red-faced Cormorants were previously observed nesting on the cliffs of Cape Peirce in 1970 and 1973 (Dick and Dick 1971, M. H. Dick pers. comm.). Birds were only observed on 12 occasions from 7 May to 21 August 1976, and no birds attempted to nest.

Snow Goose (Anser hyperborea). Flocks of an estimated 150, 75, and 100 Snow Geese were observed 1 May 1976 along the cliffs of Cape Peirce. Age rations could not be determined.

Baikal Teal (Anas formosa). A single alternate plumage male was observed 1 May 1976 in a small melt water pond. The bird flew from the pond and landed in Nanvak Bay as I approached within 10 meters. The bird had a black rump, scapulars, and head stripes similar to a male Pintail, but was teal size with a green speculum and green head patches. The cream colored patches before and behind the eye were obvious.

American Kestrel (Felco sparverius). A male was observed 27 August 1976 flying down the coast along the cliff edge.

Solitary Sandpiper (Tringa solitaria). An individual in alternate plumage fed along the edge of a fresh water pond with Western Sandpipers 19 May 1976.

Spotted Sandpiper (Actitus macularia). A group of two birds in alternate plumage were seen 26 and 30 May 1976 on the upland tundra.

Lesser Yellowlegs (Totanus flavipes). Lesser Yellowlegs foraged in the tidal marsh on six days between 10 June and 12 July. One male (MRP 194, OBS-CE No. FW 602339007) was collected 10 June 1976, and had the following measurements; culmen - 34.9mm, tarsus - 50.5mm, weight - 85 gms. In 1973, M. H. Dick (pers. comm.) tentatively identified a bird as a Lesser Yellowlegs.

Skua (Catharacta skua). A skua was observed in the marsh 29 July 1976 after a mild storm. The attempt to secure the specimen was unsuccessful. The individual was very dark, and the characteristic white "patches" at the base of the primaries were conspicuous. The skua was "mobbed" by an adult parasitic jaeger when leaving the marsh area.

Red-legged Kittiwake (Rissa brevirostris). Four adult Red-legged Kittiwakes in alternate plumage were observed roosting with two Black-legged Kittiwakes on fast ice in Nanvak Bay 30 April 1976. One immature Red-legged Kittiwake roosted on a rock beneath a Black-legged Kittiwake colony on 25 September 1976.

Sabine's Gull (Xema sabini). Sabine's Gulls were observed 5 July 1964 by King (1966) (Table 1), but none were observed again until 1976 when birds were observed on five days from 12 May to 31 May. All individuals were in alternate plumage and were either feeding in shallow water or roosting on the beach of Nanvak Bay.

Cliff Swallow (Petrochelidon pyrrhonota). One Cliff Swallow foraged over a small pond with eight Tree Swallows and six Bank Swallows 9 June 1976.

Arctic Warbler (Phylloscopus borealis). A group of eight Arctic Warblers foraged briefly in a snow-free area of the marsh 1 May 1976.

Myrtle Warbler (Dendroica coronata coronata). A single male Myrtle Warbler was observed along the cliff edge 19 May 1976.

Slate-colored Junco (Junco hyemalis hyemalis). Slate-colored Juncos were observed in the dune area and nearby cliffs 29 August (one individual), 2 September (one individual), and 4 September (one group of four). One individual was captured and banded.

Mammals

Dusky shrew (Sorex obscurus). Twelve specimens tentatively identified as Dusky shrews were trapped during 2,000 trap nights 1 May to 5 September. All specimens were captured in heath-grass areas.

Ribbon seal (Histriophoca fasciata). A single Ribbon seal was observed 22 May 1976 on the sand of Nanvak Bay with Harbor seals.

Harbor porpoise (Phocoena vomeria). One individual was observed 1/2 mile off shore 28 June 1976 apparently feeding.

Gray whale (Eschrichtius robustus). Gray whales have previously been observed (Dick and Dick 1971), and an attempt to monitor northward migration during sea watches (see part V for sea watch description) was made in 1976. Whales were observed moving up the coast 5 May to 21 July, with no feeding activity observed. The first apparent cow-calf group was observed 20 May and such groups were observed until 13 July. Observations of 141 groups of Gray whales averaged 1.73 individuals per group. The largest group observed contained six individuals, but most groups had three or less individuals. One marked Gray whale, later identified by the description as "Gigi" (J. Hall pers. comm.), was observed 30 June in a group of four whales.

Minke whale (Balaenoptera acutorostrata). One individual tentatively identified as a Minke whale was observed diving one mile off the cliff area 13 July 1976.

Table 1.

Checklist of birds observed at Cape Peirce-Nanvak Bay - 1963 to 1976.

Species	1963-69[1/]	1970[2/]	1971[3/]	1973[4/]	1976[5/]
Common Loon (*Gavia immer*)	x	x		x	x
Yellow-billed Loon (*Gavia adamsii*)					x
Arctic Loon (*Gavia arctica*)	x	x		x	x
Red-throated Loon (*Gavia stallata*)	x	x	x	x	x
Red-Necked Grebe (*Podiceps grisegena*)	x	x	x	x	x
Horned Grebe (*Podiceps auritus*)				x	x
Short-tailed Shearwater (*Puffinus tenuirostris*)				x	
Double-crested Cormorant (*Phalacrocorax auritus*)	x	x		x	x
Pelagic Cormorant (*Phalacrocorax pelagicus*)	x	x	x	x	x
Red-faced Cormorant (*Phalacrocorax urile*)		x		x	x
Whistling Swan (*Olor columbianus*)		x		x	x
Canada Goose (*Branta canadensis*)	x	x		x	-
(*B. c. minima*)					x
(*B. c. taverneri*)					x
Black Brant (*Branta bernicla nigricans*)	x	x	x	x	x
Emperor Goose (*Anser canagica*)	x	x	x	x	x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
White-fronted Goose (*Anser albifrons*)		x	x	x	x
Snow Goose (*Anser caerulescens*)					x
Mallard (*Anas platyrhynchos*)	x	x		x	x
Pintail (*Anas acuta*)	x	x	x	x	x
Shoveler (*Anas clypeata*)	x	x		x	x
Common teal					
(*Anas crecca crecca*)				x	x
(*A. c. carolinensis*)	x	x	x	x	x
Baikal Teal (*Anas formosa*)					x
American Widgeon (*Anas americana*)				x	x
Greater Scaup (*Aythya marila*)	x	x		x	x
Common Goldeneye (*Bucephala clangula*)	x	x		x	x
Barrow's Goldeneye (*Buchphala islandica*)	x				
Bufflehead (*Bucephala albeola*)				x	x
Oldsquaw (*Clangula hyemalis*)	x	x	x	x	x
Harlequin Duck (*Histrionicus histrionicus*)	x	x		x	x
Steller's Eider (*Polysticta stelleri*)	x	x		x	x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
Common Eider (*Somateria mollissima*)	x	x		x	x
King Eider (*Somateria spectabilis*)	x	x		x	x
White-winged Scoter (*Melanitta deglandi*)	x	x		x	x
Surf Scoter (*Melanitta perspicillata*)	x	x		x	x
Black Scoter (*Melanitta nigra*)	x	x		x	x
Red-breasted Merganser (*Mergus serrator*)	x	x		x	x
Bald Eagle (*Haliaeetus leucocephalus*)		x		x	x
Gyrfalcon (*Falco peregrinus*)	x	x		x	x
Peregrine Falcon (*Falco peregrinus*)		x	x	x	x
Goshawk (*Accipiter gentilis*)		x			x
Marsh Hawk (*Circus cyaneus*)				x	x
Rough-legged Hawk (*Buteo lagopus*)		x		x	x
Swainson's Hawk (*Buteo swainsoni*)		x		x	
Osprey (*Pandoin haliaetus*)		x		x	x
Golden Eagle (*Aquila chrysaetos*)		x	x	x	

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
American Kestrel (Falco sparverius)					x
Willow Ptarmigan (Lagopus lagopus)		x		x	x
Rock Ptarmigan (Lagopus mutus)		x		x	x
Lesser Sandhill Crane (Grus canadensis)	x	x		x	x
Golden Plover (Pluvialis dominica)		x		x	x
Black-bellied Plover (Pluvialis squatarola)		x		x	x
Semipalmated Plover (Charadrius semipalmatus)	x	x		x	x
Mongolian Plover (Charadrius mongolus)				x	
Whimbrel (Numenius phaeopus)		x		x	x
Bristle-thighed Curlew (Numenius tahitiensis)				x	
Hudsonian Godwit (Limosa haemastica)				x	x
Bar-tailed Godwit (Limosa lapponica)		x		x	
Solitary Sandpiper (Tringa solitaria)					x
Spotted Sandpiper (Actitis macularia)					x
Wandering Tattler (Heteroscelus incanum)	x	x		x	x
Greater Yellowlegs (Tringa melanoleucus)		x		x	x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
Lesser Yellowlegs (*Tringa flavipes*)				x	x
Short-billed Dowitcher (*Limnodromus griseus*)		x		x	
Long-billed Dowitcher (*Limnodromus scolopaceus*)				x	
Unknown Dowitcher (*Limnodromus* sp.)					x
Surfbird (*Aphriza virgata*)				x	x
Ruddy Turnstone (*Arenaria interpres*)		x		x	x
Black Turnstone (*Arenaria melanocephala*)		x		x	x
Rock Sandpiper (*Calidris ptilocnemis*)	x	x		x	x
Pectoral Sandpiper (*Calidris melantos*)				x	x
Sharp-tailed Sandpiper (*Calidris acuminata*)		x		x	
Dunlin (*Calidris alpina*)	x	x		x	x
Sanderling (*Calidris alba*)	x	x	x	x	x
Baird's Sandpiper (*Calidris bairdii*)		x		x	
Least Sandpiper (*Calidris minutilla*)	x	x		x	x
Western Sandpiper (*Calidris mauri*)	x	x	x	x	x
Terek Sandpiper (*Xenus cinereus*)				x	x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
Red Phalarope ((*Phalaropus fulicarius*)	x	x		x	x
Northern Phalarope (*Phalaropus lobatus*)	x	x		x	x
Common Snipe (*Capella gallinago*)	x	x		x	x
Parasitic Jaeger (*Stercorarius parasiticus*)	x	x		x	x
Pomarine Jaeger (*Sterocorarius pomarinus*)				x	x
Long-tailed Jaeger (*Stercorarius longicaudus*)	x	x		x	x
Skua (*Catharacta skua*)					x
Glaucous Gull (*Larus hyperboreus*)				x	x
Glaucous-winged Gull (*Larus glaucescens*)	x	x	x	x	x
Mew Gull (*Larus canus*)	x	x		x	x
Bonaparte's Gull (*Larus philadelphia*)	x	x		x	x
Black-legged Kittiwake (*Rissa tridactyla*)	x	x	x	x	x
Red-legged Kittiwake (*Rissa brevirostris*)					x
Sabine's Gull (*Xema sabini*)	x				x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
Arctic Tern (*Sterna paradisaea*)	x	x		x	x
Aleutian Tern (*Sterna aleutia*)				x	x
Common Murre (*Uria aalge*)	x	x	x	x	x
Pigeon Guillemot (*Cepphus columba*)	x	x	x	x	x
Horned Puffin (*Fratercula corniculata*)	x	x		x	x
Tufted Puffin (*Lunda cirrhata*)	x	x		x	x
Marbled Murrelet (*Brachyramphus marmoratum*)		x	x		
Parakeet Auklet (*Cyclorrhynchus psittacula*)	x	x		x	x
Short-eared Owl (*Asio flammeus*)	x	x		x	x
Say's Phoebe (*Sayornis saya*)		x			
Barn Swallow (*Hirundo rustica*)				x	
Cliff Swallow (*Petrochelido pyrrhonota*)					x
Tree Swallow (*Iridoprocne bicolor*)	x	x		x	x
Bank Swallow (*Riparia riparia*)		x		x	x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
Black-billed Magpie (*Pica pica*)				x	
Common Raven (*Corvus corax*)	x	x	x	x	x
American Robin (*Turdus migratorius*)				x	
Varied Thrush (*Ixoreus naevius*)				x	
Hermit Thrush (*Catharus guttata*)		x		x	
Gray-cheeked Thrush (*Catharus minima*)	x	x		x	x
Arctic Warbler (*Phylloscopus borealis*)					x
Water Pipit (*Anthus spinoletta*)		x		x	x
White Wagtail (*Motacilla alaba*)				x	
Yellow Wagtail (*Motacilla flava*)	x	x		x	x
Orange-crowned Warbler (*Verminora celata*)		x		x	
Yellow Warbler (*Dendroica petechia*)	x	x		x	x
Myrtle Warbler (*Dendroica coronata*)					x
Blackpoll Warbler (*Dendroica triata*)				x	
Northern Waterthrush (*Seiurus noveboracenisis*)				x	
Wilson's Warbler (*Wilsonia pusilla*)	x	x		x	x

Table 1. Continued

Species	1963-69	1970	1971	1973	1976
Red-winged Blackbird (*Agelaius phoeniceus*)				x	
Rusty Blackbird (*Euphagus carolinus*)				x	x
Gray-crowned Rosy Finch (*Leucosticte tephrocotis*)	x	x		x	x
Redpoll (*Carduelis sp.*)		x		x	x
Savannah Sparrow (*Passerculus sandwichensis*)	x	x		x	x
Slate-colored Junco (*Junco hyemalis*)					x
Tree Sparrow (*Spizella arborea*)		x		x	x
White-crowned Sparrow (*Zonotrichia leucophrys*)		x		x	x
Golden-crowned Sparrow (*Zonotrichia atricapilla*)	x	x		x	x
Fox Sparrow (*Passerella iliaca*)		x		x	x
Lapland Longspur (*Calcarius lapponicus*)	x	x	x	x	x
Snow Bunting (*Plectrophenax nivalis*)	x	x	x	x	x

1 King (1966) - 12 days April to September 1963 and 1964; Hout (1969) - 3 to 12 June, 21 to 29 July, and 18 September 1969.

2. Dick and Dick (1971) - 23 May to 28 August 1970.

3. Hout (1971) - 2 to 9 April, 18 September to 1 October 1971.

4. Dick (pers. comm.) - 27 April to 19 May, 26 May to 24 June, 14 August to 27 September 1973.

5. This study - 28 April to 9 September 1976.

Table 2.

Checklist of mammals observed at Cape Peirce-Nanvak Bay - 1963 to 1976.

Species	1963-69 1/	1970 2/	1971 3/	1973 4/	1976 5/
Dusky Shrew (*Sorex obscurus*)					?
Least Weasel (*Mustela rixosa*)				x	x
River Otter (*Lutra canadensis*)		x			(tracks)
Red Fox (*Vulpes fulva*)	x	x	x	x	x
Northern Sea Lion (*Eumetopias jubata*)	x				x
Walrus (*Odobenus rosmarus*)	x	x			x
Harbor Seal (*Phoca vitulina*)	x	x	x	x	x
Ribbon Seal (*Phoca fasciata*)					x
Hoary Marmot (*Marmota caligata*)	x	x		x	x
Arctic Ground Squirrel (*Citellus undulatus*)	x	x		x	x
Tundra Redback Vole (*Clethrionomys ratilus*)				?	?

Table 2. Continued

Species	1963-69	1970	1971	1973	1976
Tundra Vole (*Microtus oeconomus*)					?
Grizzly Bear (*Ursus horribilis*)	x	(tracks)		(tracks)	(tracks)
Muskrat (*Ondatra zibethica*)		x			
False Killer Whale (*Pseudorca crassidens*)		x			
Harbor Porpoise (*Phocoena phocoena*)					x
Gray Whale (*Eschrichtius robustus*)		x		x	x
Minke Whale (*Balaenoptera acutorostrata*)					?

1. King (1966) - 12 days April to September 1963 and 1964; Hout (1969) - 3 to 12 June, 21 to 29 July, and 18 September 1969.

2. Dick and Dick (1971) - 23 May to 28 August 1970.

3. Hout (1971) - 2 to 9 April, 18 September to 1 October 1971.

4. Dick (pers. comm.) - 27 April to 19 May, 26 May to 24 June, 14 August to 27 September 1973.

5. This study - 28 April to 9 September 1976.

APPENDEX II. Possible Aging Technique for Common Murres in Breeding Plumage.

The age determination of a species by observations of a relatively conspicuous morphological characteristic can be a useful tool to help determine demographic information of a population. Common Murres (*Uria aalga*) in breeding plumage have been described with "feet and swimming webs black, but lighter (brownish or yellowish) on anterior side of tarsometatarsus and external surface of toes" (Dement'ev and Gladkov 1951).

Common Murres in breeding plumage were noted to have a variable shade of orange coloration on their toes and tarsus. Four distinct color variations were separated into bright orange, moderate orange, light orange, or dark (no observable orange) color catagories. Associated with the variations in foot and tarsus color were differences in breeding success. Birds with young 11 August 1976 were predominantly birds with bright or moderate foot and tarsus colors, and those without young had dark or light orange feet and tarsus colors (X^2 = 16.22, *df* = 3, *p* > 0.005; Table 1). Data suggest that slight and dark foot-tarsus individuals were the last to have young jump from the cliffs.

Birds collected in the area for food habit studies were examined for a brood patch, foot and tarsus color, and bursa. All birds were in the alternate plumage, and no young of the year were collected. Data (Table 2) suggest a correlation with age and foot-tarsus color.

Further examination of a larger sample size of breeding plumage birds at colonies, and examination of known age individuals is needed to access the validity of the hypothesis that foot and tarsus color is age-related, and to more accurately describe the color variations.

Literature Cited

Dement'ev, G. P. and N. A. Gladkov (eds.). 1951. Birds of the Soviet Union, Vol. 2. (Trans. from Russian). Israel Program for Sci. Transl., Jerusalem.

Palmer, R. S. (ed.). 1962. Handbook of North American Birds, Vol. 1. Yale Univ. Press, New Haven.

Table 1.

Foot-tarsus colors of Common Murres on one ledge.

Date1/	Status of birds	Number of birds observed with: dark foot-tarsus	slight orange foot-tarsus	moderate orange foot-tarsus	bright orange foot-tarsus
11 August	Without young	9	4	3	2
	With young	0	0	7	6
17 August	Without young	8	1	0	0
	With young	0	1	0	0
23 August	Without young	1	0	0	0
	With young	1	1	0	0
28 August	Without young	5	2	4	0
	With young	1	1	0	0

1/ First young jumped 10 August; model young dissappearance 17 August; all young jumped by 3 September.

Table 2.

Specimen data of Common Murres collected in 1976.

USFWS Acc. no.	Date coll.	Sex	Foot-tarsus color	Burse length (mm)	Brood patch	Plumage
522	19 June	F	bright	none	present	alternate
524	19 June	M	moderate	none	present	alternate
528	19 June	M	moderate	none	absent	alternate
523	19 June	F	light	15	absent	alternate
532	14 July	F	light	14	absent	alternate
533	14 July	F	light	19	absent	alternate

APPENDEX III. 1976 Weather Data from Cape Peirce.

	April[1/]	May	June	July	Aug.	Sept.[2/]	Total
Ave. daily max. (C)	3.0	5.1	10.6	14.4	13.8	11.5	
Ave. daily min. (C)	-3.0	-0.6	3.7	7.1	9.0	6.0	
Max. for mo. (C)	6.0	11.0	21.0	20.0	18.0	14.0	
Min. for mo. (C)	-3.0	-3.0	0.0	2.0	7.0	4.0	
Total ppt. (mm)	0	14.2	21.8	23.6	96.0	27.7	183.3
Days of < 5% cloud	1	1	4	2	2	0	10
No. days with snow	0	10	0	0	0	0	10
No. days with rain	0	10	11	11	20	3	55
No. days with fog	1	9	17	17	7	0	51
No. days w/winds ≤ 5 kts	0	11	14	18	15	5	63
No. days w/winds 6-25 kts	2	14	15	12	14	2	59
No. days w/winds 26-35 kts.	0	1	1	0	1	0	3
No. days ≥ 36 kts.	0	5	0	0	1	0	4

1/ April 29-30

2/ Sept. 1-7

Annual Report

NOAA-OCSEAP Contract: 01-022-2538
Research Unit: RU-341/342
Study Task: A6
Reporting Period: October 1, 1976 to March 31, 1977
Pages: i-vi + 57

THE TROPHIC RELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA AND THE SOUTHERN BERING SEA

by

Gerald A. Sanger

and

Patricia A. Baird

Part XIV

of

POPULATION DYNAMICS AND TROPHIC RELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA AND SOUTHERN BERING SEA

J.C. Bartonek, C.J. Lensink, P.J. Gould,
R.E. Gill, and G.A. Sanger
Co-principal Investigators

U.S. Fish and Wildlife Service
Office of Biological Services - Coastal Ecosystems
800 A Street - Suite 110
Anchorage, AK 99501

April 1, 1977

TABLE OF CONTENTS

List of Tables — Page Number

List of Figures

ABSTRACT

About 740 bird specimens for feeding studies, or other marine bird food samples were collected in 1976 at colony study sites, or at sea aboard NOAA vessels. Five-hundred-fifty of these were accessioned into the OBS collections. More specimens were collected from the Kodiak Basin study area (153) and the NEGOA area (132) than elsewhere.

A total of 798 food samples from 41 species of birds have been accessioned into the OBS collections to date; 87 (11%) of these were empty. Most (655) were specimens of Northern Fulmars, Sooty and Short-tailed Shearwaters, Glaucous-winged Gulls, Black-legged Kittiwakes, Arctic Terns, Common and Thick-billed Murres, Horned and Tufted Puffins, and Marbled Murrelets. An additional 30 species were represented in the other 143 samples.

The frequency of occurrence of fish, squid, and nektonic crustacea in the stomachs of 14 species of birds was determined on samples pooled from all areas and seasons. Fish predominated in Sooty Shearwaters, Common Murres, Horned Puffins and Black-legged Kittiwakes. Squid predominated in Thick-billed Murres, and crustaceans predominated in Crested and Cassin's Auklets and Ancient Murrelets. All three prey categories were well represented in a few species, including Northern Fulmars, Short- tailed Shearwater, Thick-billed Murres and Tufted Puffins. Preliminary data from prey samples identified to species suggest that Capelin, Sand Lance, juvenile Walleye Pollock, Thysanoessa spp euphausiids and the large hyperiid amphipod Parathemisto libellula are important in the diets of several species of marine birds.

More effort is needed in collecting seasonal series of bird food samples. Similarly, the integration of bird feeding studies with those on zooplankton, nekton and benthic fauna is needed.

INTRODUCTION

The portion of Research Unit 341/342 dealing with studies of the feeding ecology of marine birds was designed to help satisfy the objectives of Task A6 of OCSEAP, to "...describe the dynamics and trophic relationships of selected species at offshore and coastal study sites." We concentrated our studies on seven key species because of their large biomass: Northern Fulmars, Sooty and Short-tailed Shearwaters, Black-legged Kittiwakes, Tufted Puffins, and Common and Thick-billed Murres. Several other species have also received attention.

Our specific objectives are:

1. To determine the feeding rates of the birds, i.e., the amount of food the birds consume per unit of time.
2. To determine the species composition of the prey.
3. To characterize the prey trophically and ecologically.
4. To develop and improve methods of studying the feeding ecology of marine birds in the field, and to develop and improve methods of analyzing food samples in the laboratory.
5. To determine temporal changes in food intake rates and in species-trophic composition of the prey throughout the year.
6. To determine the effects of geographical area, age, and sex on the feeding ecology and trophic relationships of the birds.
7. To determine inter- and intraspecific relationships of the feeding habits of the various bird species.
8. To estimate the total intake of prey species over time, by using population data from RU's 337 and 342 in combination with the feeding data from RU 341 and thus estimating the quantitative roleof birds in marine ecosystems.

This report is a summary of the progress made on RU 341/342 for the past year, and includes recommendations for improving the quality and pertinence to OCS development of studies of the feeding ecology of marine birds.

Relevance to Problems of Petroleum Development

An evaluation of the impact of petroleum development on the ecosystem requires an understanding of the structure (food web pathway) and dynamics (energy flow through the food web) of that ecosystem. In the case of birds, for example, if oil pollution caused a decline of an important prey species, the effect on the bird populations could then be better understood, if not predicted. Similarly, if a population of birds were destroyed by a catastrophic oil spill, the consequences to the ecosystem could be understood. Again, if the productivity of a particular bird colony were reduced or eliminated due to peripheral activities associated with petroleum development (e.g. aircraft harassment of birds on colonies) the consequences to the ecosystem of the birds not gathering food for their chicks could be predicted.

CURRENT STATE OF KNOWLEDGE

Ainley and Sanger (in press) summarized all the literature on the feeding ecology and diets of marine birds in the eastern North Pacific Ocean and the Bering Sea. They characterized broad taxonomic groups of prey into a simple scheme of trophic levels. These need much refinement to reflect more accurately prey size as well as type, but they at least give a point of departure for more sophisticated studies. Much of the feeding information (e.g. Bent 1921, Preble and McAtee 1923) consists only of anecdotal lists of prey species or types (e.g. "fish", "squid") without reference to sizes.

There have been very few studies which even begin to provide the detailed kind of species identification and size information needed to characterize prey at trophic levels. Particularly scarce are feeding studies which give information on temporal changes in feeding habits or which attempt to relate the birds' prey consumed to prey available. Notable examples of such studies are those of Bedard (1969) on Crested, Least, and Parakeet Auklets in the eastern Bering Sea, and those of Sealy (1975) on the Ancient and Marbled Murrelet off British Columbia. Each of these studies was repeated over a number of years, and gave data on the changes in prey species and size composition at regular intervals throughout the breeding season. These studies, however, do not contain a trophic characterization of the prey eaten.

Information generally is lacking on the winter diet of marine birds and on the characterization of trophic levels of prey regardless of season, and on information on the nutritional quality of their prey. Bedard's (1969) study touched briefly on the last point by demonstrating that equal biomass of different prey species does not necessarily mean nutritional equality.

STUDY AREA

Food samples from marine birds came from two kinds of field situations: bird specimens collected at sea from ships of opportunity, mostly NOAA research vessels, (Table 1), and food samples collected at the bird colonies. Collections at sea were widely scattered over the Bering Sea and Gulf of Alaska and were usually in areas away from colony study sites. Specimens were often but not always, collected from feeding concentrations of birds. The colony study sites (Figure 1) were selected because of the large numbers or the importance of birds present, and the uniqueness of the area or its potential vulnerability to impact from petroleum development.

METHODS

Field Methods

Birds were usually collected at sea by shotgun, from a skiff which had been put over the side from a research vessel, or occasionally collected from the research vessel itself. The former method was preferred because the skiff did not cause the birds to flush as far away and it was much faster and more maneuverable than the larger vessel.

Collecting from research vessels was strictly opportunistic, depending largely on the weather and to a lesser extent on the nature of the other scientific work and the cooperation of the cruise's chief scientist. Problems related to this are discussed in the summary of fourth quarter activities.

Food samples from the colony study sites were generally collected more systematically. In a few cases the collections were frequent enough so that inferences on changes in diet and prey availability through time will be possible when the samples have been analyzed.

As soon as a bird was collected, its stomach was injected with 10% formalin or 50% isopropanol to stop digestion and to preserve stomach contents. The bird was then weighed and measured and either its stomach was removed and preserved in 10% formalin or 50% isopropanol. Other food samples were collected by intercepting parent birds carrying prey in their bills or by picking up food samples which had been dropped or regurgitated by parent birds at the nest sites. These food samples were all labeled and preserved as above.

Laboratory Methods

Stomachs were opened longitudinally, and the state of digestion and location in the digestive tract of general categories of prey were determined. This work may yield clues to the frequency of feeding and rates of digestion, but is largely experimental at present. The following basic information was then determined:

1. The drained, wet weight of the preserved stomach contents, measured to the nearest 0.1 g.
2. The displacement volume of the drained stomach contents, measured to the nearest ml.

The information collected to this point constitutes what we term a "rough sort," and can be generated by most technicians with minimum training.

As our time and available trained personnel has allowed, we then have collected additional information from the stomach samples, including:

1. The identity of each prey item to the lowest possible taxon.
2. The character of each such prey item (e.g. whole animal, kind of identifiable remaining part).

3. The lengths of whole prey animals, or their identifiable remains from which original lengths can often be extrapolated.
4. The weights of individual whole prey items for larger prey, or the aggregate weights of known numbers of smaller prey.
5. The identity and size (straight line length of greatest dimension) of all non-food material (rocks, gravel, plastic particles, wood chips, etc.).

Since very little information exists on relationships between whole prey and their parts, an ongoing task of our laboratory work has been to accumulate data on such relationships. The parasphenoid bone in the head of fishes has shown promise of being easily recognized and measured. Preliminary data on the relationship of this bone to total length of Capelin is presented in the Results section. Another ongoing laboratory task is to accumulate and expand a reference collection of prey species. This too is discussed under Results.

The personnel involved in the laboratory work were G. Sanger, P. Baird, C. Vita, P. Gould, S. Fullerton, A. Moe, V. Hironaka, and A. Fukuyama.

Automatic Data Processing Forms

A significant part of our laboratory work has been spent in improving our field and laboratory data forms. Sanger proposed the idea of a comprehensive data coding format for feeding studies at the "Bird PI Meeting" in Anchorage in October 1976. A number of OCSEAP bird investigators, particularly Stan Senner, have contributed ideas and suggestions since then. With the guidance and coordinating efforts of Michael L. Crane, EDS Liason Officer, the coding forms shown in Figures 2 and 3 are the latest and best available forms for feeding studies of marine birds. They are sufficiently flexible to allow entry of data on pelagic birds and shorebirds, and they allow complete documentation, identification, and measurements of lengths and weights of prey.

RESULTS

Food Samples Collected in 1976

About 740 bird specimens and other food samples were collected in 1976 at colony study sites or at sea. Of these, about 550 have been accessioned into the collections of the OBS (Office of Biological Services). More specimens were accessioned from the Kodiak Basin (153) and the Northeast Gulf of Alaska (132) than from any other OBS area. Relatively few collections (47) were made in the Bristol Bay area (Figures 4 through 15).

As noted in Figure 4, only four Short-tailed Shearwaters were collected in the eastern Bering Sea, and no Sooty Shearwaters were collected there. The record is a little better in the Gulf of Alaska for both of these species. The distribution of Black-legged Kittiwake collections (Figure 10) was fairly even over all areas except in the

Northeastern Gulf of Alaska where the number collected (28) was relatively high. Both species of murres were well represented in the collections around Kodiak Island (Figure]2). The Kodiak Basin was well represented with puffin samples (Figure 15) due to intensive collecting in the Semidi Islands and on Ugaiushak.

Tables 2 through 14 summarize the OBS study areas from which collections were made, and the numbers of these accesssioned, rough sorted, and final sorted. About 50 food samples have been final sorted, including 19 Arctic and Aleutian Terns which were analyzed as a special project.

Preliminary Analyses of Feeding Habits of Marine Birds

A total of 798 food samples from 41 species have been accessioned into the OBS collection since the start of the OCSEAP; 87 of these (11%) were empty. Most of the samples (655) have been from the following 11 species:

Northern Fulmar	28	Common Murre	80
Sooty Shearwater	41	Thick-billed Murre	58
Short-tailed Shearwater	31	Horned Puffin	43
Glaucous-winged Gull	43	Tufted Puffin	114
Black-legged Kittiwake	76	Marbled Murrelet	35
Arctic Tern	19		

An additional 30 species are represented in the other 143 samples.

The analysis of frequency of occurrence of major prey categories in the samples rough sorted so far shows that fish, squid and nektonic crustacea are important. This is summarized in Table 15. There is sufficient data for comparison of the relative importance of these prey categories for 14 of the bird species; these data are integrated for all areas, seasons and years (Figure 16). A more detailed presentation of the data will be possible when the samples are completely sorted and identified, and the results analyzed by computer.

Analysis of fragmentary data on the frequency of occurrence (not numbers) of three species each of fish and nektonic crustacea in 14 species of birds indicates that these six species are important in the diet of marine birds (Table 16). Much additional data will be needed before drawing conclusions, but this summary at least gives a glimpse of relationships.

The other sections of this RU 341/342 report, on the individual studies at the bird colonies, contain much information on the feeding ecology of birds observed during the 1976 season. Data on feeding habits as determined from observations on bill loads (fish in the bills of parent birds being carried to young) is included. All of this information will be analyzed further, intergrated, and presented in subsequent reports.

Synopsis of Shearwater Feeding Habits

We summarized the feeding data from all the shearwaters first because the two species occur in the greatest numbers of all other birds off the coast of Alaska, and therefore they probably have the greatest impact on the ecosystem of all birds present. We identified all prey species as far as possible, usually to species, and measured all prey taken by the two shearwater species. We also determined what percent of body weight the stomach contents were, to try to specify maximum and average stomach loads.

Foods of Sooty and Short-tailed Shearwaters

Food samples were obtained from the stomachs of 22 Sooty and 11 Short-tailed Shearwaters in the Gulf of Alaska, and from 12 stomachs of Short-tailed Shearwaters in the Bering Sea. The distribution of the samples of the two species between the Gulf and the Bering Sea reflects their distribution in nature. Fish, squid, and crustaceans predominated in these samples (Table 17). Sooty Shearwater samples contained mainly fish by volume, while those of Short-tailed Shearwaters contained mainly euphausiids. Squid beaks occurred in the digestive tracts of both species, with 82% of the Sooty and 43% of the Short-tailed Shearwaters containing them (Table 18).

Table 17

Percent Occurrence of Major Prey Items in Sooty and Short-tailed Shearwater Stomachs

SPECIES	NUMBER IN: GULF	BERING	TOTAL	% FISH	% SQUID	% CRUSTACEA
Sooty	22	0	22	73	82	14
Short-tailed	11	12	23	22	43	56

Table 18

Numbers of Prey Items Found in Digestive Tracts of Sooty and Short-tailed Shearwaters

PREY ITEMS	SOOTY (N=32) Gulf	Bering	SHORT-TAILED (N=18) Gulf	Bering
Fish	147	-	4	0
Squid	166	-	13	0
Euphausiid				
Unident.	4	-	138	1
T. inermis	0	-	93	1
T. raschii	0	-	622	30
Crustacea	0	-	16	11
Amphipod	0	-	1	0
Gastropod	0	-	2	0

Prey length is also an important component of any discussion on trophic relationships within a food web. Differences in prey length preferences between Sooty and Short-tailed Shearwaters may reflect or perhaps be influenced by differences in the prey type they select. Sooty Shearwaters preyed on fish of 80-137 mm, while Short-tailed Shearwaters preyed on euphausiids of 14-32 mm (Table 19).

Table 19

Lengths (mm) of Major Prey of Shearwaters

SPECIES	PREY	N	X%	$S_{\bar{x}}$	S_x	RANGE
Sooty	Fish	94	120.7	13.4	1.4	80-137
Short-tailed	Euphausiid	44	24.6	5.0	0.8	14-32.2

Prey weight is the third parameter which we are using in our analysis of food webs. We can indirectly determine biomass consumption by measuring the weight of stomach contents. The weight of the stomach contents is expressed as a percent of body weight and this is then expressed as a percent of the maximum observed weight of stomach contents for a particular bird species. This latter percent is called the Index of Filling, and will become more valuable as the data base expands. Short-tailed Shearwaters, averaging 685 g body weight, carried a maximum of 12.3% of their weight as food. Sooty Shearwaters, averaging 927 g body weight, carried a maximum of 13.9% of their weight as food. A larger sample size for both species is needed before we can establish an average load for each.

Preliminary Data on Tern Feeding Habits

Figure 17 compares the frequencies of lengths of euphausiids in the stomachs of 17 Arctic and 2 Aleutian Terns collected together in Icy Bay, Alaska. No significant difference in prey lengths was observed Much additional information will be needed to make firm conclusions about feeding relationships between these congeneric, sympatric species.

Prey Reference Collection

An ongoing objective of our laboratory work has been to build up a reference collection of prey species and their identifiable parts. Table 20 is a list of the species and identifiable parts now present in the OBS collection.

Certain identifiable parts may remain in bird stomachs for relatively long periods and because of this it is often hard to extrapolate the original length of the prey item as well as to identify prey types and species. Among the most important of these parts are fish otoliths and parasphenoid bones, and squid beaks.

We compared the total lengths of Capelin to the lengths of their parasphenoid bones in an initial attempt to determine how well this bone could be used to predict fish length (Figure 18). There was little correlation between the two lengths; T^2 (r^2=0.14,r=0.37). The total length measurements, however, were made on preserved specimens, which may have distorted the actual total length. We anticipate that this data will be refined when we are able to compare measurements on fresh fish.

Input to Eastern Bering Sea Ecosystem Modeling

The authors spent about 65 person-days preparing a report on the birds of the eastern Bering Sea under a subcontract to OCSEAP RU-77 (Ecosystem Dynamics-Birds and Mammals). The pertinent literature was reviewed on ten species of marine birds which are important in that area either because of their large biomass, or as representatives of the diversity of the pelagic bird community (Table 21). We must emphasize that these data are historical, and are probably gross underestimates.

Dramatic seasonal changes occur in the abundance of birds in the eastern Bering Sea. Peak abundance occurs in early spring with the influx of Sooty and Short-tailed Shearwaters from their breeding grounds in the southern hemisphere, and with the staging of Alaskan breeding species prior to nesting.

Table 21

Abundance of Selected Marine Bird Species in the Eastern Bering Sea

SPECIES	ESTIMATED NUMBER OF BIRDS*
Northern Fulmar	5,000,000
Shearwaters(both species)	10,000,000
Glaucous-winged Gull	170,000
Black-legged Kittiwake	750,000
Murres (both species)	5,000,000
Least Auklet	2,000,000
Crested Auklet	1,500,000
Parakeet Auklet	500,000

* = based on an area of one million km^2

During the Alaskan birds' breeding season, the distribution of all species except the shearwaters is strongly oriented toward colonies. Little is known about the diets of the birds, but the abundant shearwaters and murres appear to consume large quantities of euphausiids, and schooling pelagic and demersal fishes. Prey items range in size from copepods of 7 mm or less (eaten by Least Auklets) to fish of at least 25 cm (eaten by Murres). Glaucous-winged Gulls, Black-legged Kittiwakes, and Northern Fulmars probably benefit greatly from offal produced by Walleye Pollock fisheries. The fisheries have possibly created an imbalance in the ecosystem which has benefited planktivorous birds.

Recommendations to further refine ecosystem data on marine birds include: 1) more intensive studies on population sizes and the diets of the shearwaters; 2) better estimates of colony population sizes, and the relationships between numbers of birds on the colonies and numbers at sea; 3) many more food samples collected systematically throughout the year; 4) inclusion of meroplankton (including ichtyoplankton), copepods, euphausiids, small pelagic fishes, epibenthic macroplankton, and fisheries offal in the model of the ecosystem.

DISCUSSION

Some generalizations are possible on the frequency of occurrence of major prey, particularly when sympatric pairs of related species are compared (Figure 16). Fish predominated among food selected by Sooty Shearwaters, while Short-tailed Shearwaters tended to consume more invertebrates. Fish were markedly more prevalent in Common Murres than in Thick-billed Murres with the latter having a high consumption (75%) of squid. This may reflect the fact that many of the Thick-billed Murres came from more oceanic areas than the Common Murres, but it also bears out Spring's (1971) observations on the probable feeding preferences of these species.

Horned Puffins consumed more fish and crustaceans than did Tufted Puffins, which in turn consumed more squid than the Horned Puffins (55% vs. 15%). This is perhaps a reflection of the higher tendency of Tufted Puffins to forage in pelagic rather than nearshore areas. Black-legged Kittiwakes had a high incidence of fish (75%), and a low incidence of squid (5%) and of crustaceans (ca. 20%). The data on the two terns is admittedly misleading. The apparent lack of fish in the diet of Arctic Terns is an artifact of the particular samples examined; all were collected from a relatively restricted area in the Northeast Gulf of Alaska, where they had been feeding heavily on euphausiid crustaceans. When all of our food samples of Arctic Terns have been examined, data will no doubt reflect the piscivorous habits of the species.

The 100% incidence of crustaceans in the diets of Crested and Cassin's Auklets is to be expected in light of Bedard's (1969) data on Crested Auklets, and Manuwal's (1974) findings for Cassin's Auklets. Similarly, our data on Marbled and Ancient Murrelets corroborate Sealy's (1975) discovery that Marbled Murrelets eat relatively more fish than crustaceans, and vice versa for Ancient Murrelets.

The frequent occurrence of Sand Lance (*Ammodytes hexapterus*) and Capelin (*Mallotus villosus*) in our preliminary data (Table 16) suggests that these prey species are important in food webs of Alaskan marine birds. Similarly, the two *Thysanoessa* euphausiids and the large hyperiid amphipod *Parathemisto libellula* bear continued observation as species important to birds.

The closely related Sooty and Short-tailed Shearwaters occupy different positons in the food web as shown by differences in prey type and prey size selection. This is a common occurrence in closely related bird species which differ in size. In this case, the two species differ in size by factors of 1.33 in bill length and 1.35 in body weight with Sooty Shearwaters being largest in both respects. Last year's report did not show this difference, but that was probably due to the small sample size that had been analyzed.

Squid seems to be a common food item for both species, judging from the number of beaks found in the digestive tracts. We do not know, however, how long squid beaks are retained nor how fast squid bodies are digested. We thus cannot, at this time, say much more than that squid are important in the diets of both species.

RECOMMENDATIONS

Our recommendations fall into two broad categories: 1) how the bird studies *per se* can be improved and 2) how the bird studies could be integrated with other types of studies.

More effort should be directed toward collecting food samples from birds throughout the year at regular intervals, and particularly during the breeding season. Figures 4 through 15 reflect how widely scattered the samples are, as well as the disproportionate numbers of birds collected from the various OBS Regions. More effort should be directed toward locating and collecting birds that are actively feeding as well as toward coordinated collections and observations between colony study sites and work from vessels. Data on colony and at-sea population sizes need much refinement.

There needs to be more integration and coordination of bird studies with other disciplines on the research vessels. Work integrating studies on zooplankton, nekton and benthos, with studies on bird feeding and distribution would reveal much about relationships among birds and their prey. In particular, bird studies would benefit by integration with other studies that are gathering information on the distribution and abundance of Capelin, Sand Lance, juvenile Pollock (G. Hunt, personal communication), euphausiids, and benthic and epibenthic fauna such as *Mytilis* and juvenile shrimp, Tanner, and King Crabs.

SUMMARY OF FOURTH QUARTER OPERATIONS

Laboratory Activities

Much of the quarter was spent preparing the final report for the RU 77 subcontract, revising (with Mike Crane) and finalizing our ADP data codes and forms, and in preparing this report.

Two biological technicians, Mr. Allan Fukuyama and Ms. Valerie Hironaka, joined the project on 28 February, 1977, to assist Sanger and Baird in the analysis of the large backlog of stomach samples. Hironaka and Fukuyama have both had experience and training in marine biology, including sorting and identification of marine invertebrates, so we anticipate much faster progress in the months ahead than in the past.

About 20 stomach samples of birds were rough sorted during the quarter. Due to a heavy load of report writing and other paperwork, and to problems associated with finalizing our ADP coding and data formats, we are behind schedule on all aspects of sample analysis and data entry and submission. We anticipate that the first batch of feeding data of marine birds (for shearwaters, Taxonomic Groups "A": see letter of 1 October 1976, from J. Bartonek to H. Bruce) will be submitted for keypunching by early May. Other taxonomic groups will follow at regular intervals, and by July we anticipate being back on schedule.

Sanger and Baird were both on NOAA research vessels during this quarter and attempted to collect winter samples of birds. However, due to rough weather, equipment, and other problems, they collected only two White-winged Scoters for RU 341/342.

Problems Encountered

The delays in sample analysis, data formatting, and subsequent data submission will be rectified with the addition of help in the laboratory and the finalizing of our ADP coding and formatting system.

There were also problems with the collections from shipboard. The time and geographical location of the collections from shipboard were opportunistic, as mentioned before, whereas at the field camps it was more systematic. For instance, we could not always determine the exact stage of the breeding cycle of the birds, or the colonies they came from in the shipboard collections, nor could we cover all the important pelagic areas equally by season due to the work schedule of the vessels. In the field camps, the personnel tried to obtain a good sampling of prey throughout the breeding cycle by collecting during the pre-egg, incubation, chick-feeding, and post-fledging stages at the colony sites.

Another problem is in the actual collecting from the large research vessels. Often the weather is too rough to take the skiff out from the ship so that collections must be made from 30 feet above the water. On a basis of time-cost-effort, the large ships are not suitable for bird collections.

1977 Field Season

The 1977 sites for field camps have been selected during this quarter. Three major considerations in their selection, in addition to the selection factors for 1976, were the timing of the oil leases, the logistics of transporting personnel in order to obtain the most data with the least expenditure of time and effort and the availability of Kodiak as the only suitable area for a year-round research effort. Therefore, Kodiak Island was chosen to have the greatest research effort by OBS this field season because the leases off Kodiak are the first to come up, and the logistics are best for this area.

At Sitkalidak Strait there will be a main field camp which will be a base out of which the surrounding area will be studied. There will be a minimum of two investigators there with probably a third present off and on throughout the season. At Long Island there will be two cooperators. The charter vessel will operate in Sitkalidak Strait and Chiniak, Kiliuda, and Ugak Bays the majority of the summer and these areas are where heavy collecting effort will be expended. The charter vessel will supply the outlying field camps once, and the rest of the time the personnel on board will be collecting birds and making radial transects off of Kodiak. There will also be temporary OBS camps at areas not on Kodiak: St. Matthews, Chamisso, Nunivak, Hazy, St. Lazaria, Chowiet, Ugaiushak, and Middleton Islands, and the Yukon Delta (Figure 19). Cooperators will be at a camp in the Barren Islands.

LITERATURE CITED

Ainley, D.G. and G.A. Sanger. In Press. Seabird trophic relationships in the northeastern Pacific Ocean and the Bering Sea, In: Proceedings of "Conservation of marine birds in northern North America - An international symposium.": U.S. Fish Wildl. Serv., Wildl. Res. Report, in press.

Bedard, Jean 1969. Feeding of the Least, Crested, and Parakeet Auklets around St. Lawrence Island, Alaska. Canad. J. Zool. 47(5):1025-1050.

Bent, Arthur C. 1919. Life Histories of North American Diving Birds. Dover, 239pp.

Manuwal, David A. 1974. The natural history of Cassin's Auklet (Ptychoramphus aleuticus). Condor 76(4):421431.

Preble, E.A. and W.L. McAtee 1923. Biological survey of the Pribilof Islands, Part I, Birds and Mammals. No. Amer. Fauna No. 46, 128pp.

Sealy, Spencer G. 1975. Feeding of the Ancient and Marbled Murrelets near Langara Island, British Columbia. Canad. J. Zool. 53(4):418-433.

Spring, Lowell 1971. A comparison of functional and morphological adaptation in the Common Murre (Uria aalge) and Thick-billed Murre (Uria lomvia). Condor 73(1):1-27.

TABLE 1. O.B.S. Shipboard Field Operations in 1976-1977.

OPERATION NUMBER	DATES	OBSERVERS	OBS REGIONS*	NUMBER OF TRANSECTS	KM^2 SURVEYED	NUMBER OF STATIONS
FW6-002	15 Feb. to 20 Feb.	M. Phillips G. Sanger M. Kirchhoff D. Hardy	NEGOA,BCS, NWGOA,SEAS	72	193.9	0
FW6-004	23 Feb. to 04 Mar.	M. Kirchhoff	NEGOA,PWS, NWGOA	53	71.2	60
FW6-005	23 Feb. to 27 Feb.	D. Frazer D. Hardy	BCS, OBS, OGOA,KB	119	162.4	0
FW6-007	01 Mar. to 11 Mar.	D. Frazer	NEGOA,KB, NWGOA	110	115.9	118
FW6-008	09 Mar. to 12 Mar.	C. Handel	BCS,OBC, OGOA	47	77.7	0
FW6-009	08 Mar. to 25 Mar.	M. Phillips	KB,APS,BB, SGB	81	117.3	35
FW6-010	17 Mar. to 21 Mar.	G. Sanger S. Bates C. Handel M. Rauzon T. Schad	BCS,SEAS, NEGOA,KB	149	181.4	0
FW6-011	16 Mar. to 29 Mar.	M. Kirchhoff	NWGOA,PWS, NEGOA	85	128.5	44
FW6-012	24 Mar. to 21 Apr.	M. Rauzon	NWGOA,KB,BB, APS,SGB,SCB	92	101.5	52

TABLE 1. Continued.

OPERATION NUMBER	DATES	OBSERVERS	OBS REGIONS*	NUMBER OF TRANSECTS	KM^2 SURVEYED	NUMBER OF STATIONS
FW6-013	30 Mar. to 15 Apr.	D. Frazer	NWGOA,LCI, UCI	113	107.9	115
FW6-016	06 Apr. to 13 Apr.	C. Harrison	NWGOA,KB, LCI,UCI, NEGOA,PWS	91	114.6	0
FW6-018	14 Apr. to 30 Apr.	T. Schad	NWGOA,SEAS, NEGOA	57	61.5	4
FW6-019	21 Apr. to 01 May	A. DeGange	NEGOA,PWS, NWGOA,KB, OGOA	63	72.3	23
FW6-021	25 Apr. to 13 May	D. Forsell	OA,SCB, NAV,SGB	100	113.9	14
FW6-025	01 May to 11 May	A. Moe	NWGOA,KB	14	11.5	0
FW6-026	18 May to 20 May	C. Harrison	NWGOA,PWS NEGOA	25	22.5	0
FW6-027	22 May to 08 Jun.	J. Bartonek A. Sowls G. Sanger	NWGOA,KB,SS, APS,BB,SGB	130	136.4	0
FW6-028	17 Jun.	C. Handel	PWS	3	2.5	0
FW6-029	18 Jun. to 26 Jun.	C. Handel G. Sanger	NWGOA,KB	20	15.3	0

TABLE 1. Continued.

OPERATION NUMBER	DATES	OBSERVERS	OBS REGIONS*	NUMBER OF TRANSECTS	KM^2 SURVEYED	NUMBER OF STATIONS
FW6-050	04 May to 05 May	P. Gould M. Rauzon	NEGOA,KB	42	54.7	0
FW6-051	06 May to 08 May	P. Gould M. Rauzon	NWGOA,LCI	46	54.6	5
FW6-052	12 May to 20 May	P. Gould	NEGOA,KB, NWGOA	110	129.4	1
FW6-057	18 May to 03 Jun.	D. Forsell	OA,SCB,UMB, SCB,BB,NAV, APS,SS,NWGOA	113	126.6	11
FW6-058	07 May to 21 May	A. DeGange	NWGOA,SS,KB, LCI,APS	88	77.4	24
FW6-064	25 May to 03 Jun.	P. Gould C. Larson	NWGOA,KB, NEGOA	35	34.1	0
FW6-066	26 May to 05 Jun.	K. Metzner	KB,APS,BB, SGB,ECB	59	58.6	0
FW6-067	06 Jun. to 20 Jun.	K. Metzner	SGB,BB,ECB, APS,KB	99	101.5	15
FW6-068	30 May to 16 Jun.	M. Rauzon	BCS,SEAS,PWS, NEGOA,KB,SS, NWGOA,APS,SCB, OGOA	37	43.1	0

TABLE 1. Continued.

OPERATION NUMBER	DATES	OBSERVERS	OBS REGIONS*	NUMBER OF TRANSECTS	KM^2 SURVEYED	NUMBER OF STATIONS
FW6-070 FW6-071	07 Jun. to 23 Jun.	P. Baird	KB,APS,UMB, BB,SGB,OAP, OSK,OBC	110	139.4	4
FW6-074	26 Jun. to 16 Jul.	D. Forsell	KB,SCB,APS, ECB,BB,UMB	170	166.9	0
FW6-077	16 Jul. to 19 Jul.	K. Metzner	BCS,OBC,KB, OGOA	49	65.1	1
FW6-078	20 Jul. to 31 Jul.	K. Metzner	NEGOA,KB	26	31.6	0
FW6-082	08 Jul. to 29 Jul.	S. Bates C. Handel	NEGOA,SEAS, ECB,HB,NAV, BWR	33	46.5	0
FW6-083	22 Jul. to 31 Jul.	C. Harrison	NWGOA,SS,KB, APS,OAP,OGOA	94	96.5	0
FW6-085	04 Aug. to 14 Aug.	K. Metzner	KB,APS,SGB, ECB,NB,HB	60	75.2	0
FW6-084 FW6-087	25 Aug. to 02 Sep.	P. Baird	BCS,OBC,OSK, KB,APS,SGB, ECB	76	88.7	1
FW6-088	01 Sep. to 16 Sep.	P. Gould	KB,APS,SGB, ECB,NB,WCS,HB	182	175.4	0
FW6-089	20 Sep. to 01 Oct.	P. Gould	KB,APS,BB, SGB,ECB	77	71.8	0

TABLE 1. Continued.

OPERATION NUMBER	DATES	OBSERVERS	OBS REGIONS*	NUMBER OF TRANSECTS	KM^2 SURVEYED	NUMBER OF STATIONS
FW6-092	18 Oct. to 29 Oct.	A. Sowls	LCI, SS, NWGOA	70	80.6	0
FW6-094	23 Oct. to 31 Oct.	P. Gould	KB, APS, OAP	46	40.0	0
FW6-095	04 Nov. to 23 Nov.	P. Baird	NWGOA, OGOA, NEGOA, KB, LCI, SS	71	83.2	0
FW7-026	20 Jan. to 08 Feb.	P. Baird	BCS, SEAS, NWGOA, KB	90	88.1	3
FW7-027	15 Feb. to 20 Feb.	G. Sanger M. Peterson	BCS, OBC, OGOA	109	146.9	0
TOTALS						
45	15 Feb. to 20 Feb.	20	25	3,316	3884.1	530

* = Refer to Figure 1 for area definitions

Table 2. State of analysis of birds collected in 1976 in Hope Basin.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater			
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull		1	
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake	1	2	
Arctic Tern			
Aleutian Tern			
Common Murre			
Thick-billed Murre			
Pigeon Guillemot			
Marbled Murrelet			
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin			
	1	3	

Table 3. State of analysis of birds collected in 1976 in Norton Basin.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater			
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake		1	
Arctic Tern			
Aleutian Tern			
Common Murre			
Thick-billed Murre			
Pigeon Guillemot			
Marbled Murrelet			
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet	1		
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin		2	
	1	3	

Table 4. State of analysis of birds collected in 1976 in Navarin Basin.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar	2		
Sooty Shearwater			
Short-tailed Shearwater			
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper	1		
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake	2		
Arctic Tern			
Aleutian Tern			
Common Murre			
Thick-billed Murre	3		2
Pigeon Guillemot			
Marbled Murrelet			
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin			
	8		2

Table 5. State of analysis of birds collected in 1976 in St. George Basin.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar		1	
Sooty Shearwater			
Short-tailed Shearwater		1	
Fork-tailed Petrel	2		
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant		1	
Oldsquaw	1		
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake		4	
Arctic Tern			
Aleutian Tern			
Common Murre			
Thick-billed Murre		1	
Pigeon Guillemot	1		
Marbled Murrelet			
Kittlitz's Murrelet	3		
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet	2	1	
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin		2	
	9	11	

Table 6. State of analysis of birds collected in 1976 in Bristol Bay.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater		1	2
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant	1		
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw	1		
White-winged Scoter			
Semipalmated Plover	1		
Wandering Tattler	1		
Lesser Yellowlegs	1		
Wood Sandpiper			
Northern Phalarope	3		
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull	2		
Black-legged Kittiwake	3	1	
Arctic Tern			
Aleutian Tern		2	3
Common Murre	8		
Thick-billed Murre			
Pigeon Guillemot	1		
Marbled Murrelet			
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet	3		
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin	5	1	
Tufted Puffin	7		
	37	5	5

Table 7. State of analysis of birds colleceted in 1976 in the Oceanic Aleutians.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater			
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake		1	
Arctic Tern			
Aleutian Tern			
Common Murre		3	1
Thick-billed Murre	1	3	
Pigeon Guillemot			
Marbled Murrelet			
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet	1		
Least Auklet			
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin	1		
	3	7	1

Table 8. State of anlaysis of birds collected in 1976 in Alaska Peninsula South.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater		1	4
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake	3		
Arctic Tern			
Aleutian Tern			
Common Murre			
Thick-billed Murre			
Pigeon Guillemot	1		
Marbled Murrelet	6		
Kittlitz's Murrelet	1		
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin			
	11	1	4

Table 9. State of analysis of birds collected in 1976 in Kodiak Basin.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar	2		
Sooty Shearwater			
Short-tailed Shearwater		2	1
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull	22		
Glaucous-winged x Herring			
Mew Gull	1		
Bonaparte's Gull			
Black-legged Kittiwake	9	2	
Arctic Tern			
Aleutian Tern			
Common Murre	12		
Thick-billed Murre	9		
Pigeon Guillemot	2		
Marbled Murrelet	5	3	
Kittlitz's Murrelet			
Ancient Murrelet	3		
Cassin's Auklet			
Parakeet Auklet	9		
Crested Auklet	1		
Least Auklet			
Rhinoceros Auklet	2		
Horned Puffin	26	1	
Tufted Puffin	41		
	144	8	1

Table 10. State of analysis of birds collected in 1976 in Northwest Gulf of Alaska.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater		1	2
Short-tailed Shearwater		3	1
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake		5	
Arctic Tern			
Aleutian Tern			
Common Murre		5	1
Thick-billed Murre		1	1
Pigeon Guillemot			
Marbled Murrelet			
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin		2	
		17	5

Table 11. State of analysis of birds collected in 1976 in Shelikof Strait.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			1
Short-tailed Shearwater			
Fork-tailed Petrel			
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake	3		
Arctic Tern			
Aleutian Tern			
Common Murre	32		
Thick-billed Murre	10		
Pigeon Guillemot	1		
Marbled Murrelet	5		
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin	1		
Tufted Puffin			
	52		1

Table 12. State of analysis of birds collected in 1976 in Lower Cook Inlet.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater			
Fork-tailed Petrel		1	1
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull			
Glaucous-winged x Herring			
Mew Gull		4	
Bonaparte's Gull			
Black-legged Kittiwake	1	3	
Arctic Tern			
Aleutian Tern			
Common Murre	3	1	
Thick-billed Murre			
Pigeon Guillemot			
Marbled Murrelet		2	1
Kittlitz's Murrelet			
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet			
Horned Puffin			
Tufted Puffin			
	4	11	2

Table 13. State of analysis of birds collected in 1976 in Northeast Gulf of Alaska.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar	1	1	1
Sooty Shearwater		13	7
Short-tailed Shearwater			
Fork-tailed Petrel	3		
Leach's Petrel	2		
Double-crested Cormorant			
Pelagic Cormorant	4		
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter	1		
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull	10		
Glaucous-winged x Herring			
Mew Gull		2	
Bonaparte's Gull			
Black-legged Kittiwake	27	1	
Arctic Tern		3	16
Aleutian Tern			3
Common Murre	1	2	1
Thick-billed Murre			
Pigeon Guillemot			
Marbled Murrelet	11		
Kittlitz's Murrelet	3		
Ancient Murrelet			
Cassin's Auklet			
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet	5		
Horned Puffin			
Tufted Puffin	12	1	1
	80	23	29

Table 14. State of analysis of birds collected in 1976 in British Columbia Shelf.

Species	# Accessioned	# Rough Sorted	# Final Sorted
Northern Fulmar			
Sooty Shearwater			
Short-tailed Shearwater			
Fork-tailed Petrel	1		
Leach's Petrel			
Double-crested Cormorant			
Pelagic Cormorant			
Red-faced Cormorant			
Oldsquaw			
White-winged Scoter			
Semipalmated Plover			
Wandering Tattler			
Lesser Yellowlegs			
Wood Sandpiper			
Northern Phalarope			
Glaucous Gull			
Glaucous-winged Gull	6		
Glaucous-winged x Herring	1		
Mew Gull			
Bonaparte's Gull			
Black-legged Kittiwake			
Arctic Tern			
Aleutian Tern			
Common Murre	8		
Thick-billed Murre			
Pigeon Guillemot			
Marbled Murrelet	3		
Kittlitz's Murrelet			
Ancient Murrelet	4		
Cassin's Auklet	5		
Parakeet Auklet			
Crested Auklet			
Least Auklet			
Rhinoceros Auklet	17		
Horned Puffin	2		
Tufted Puffin	12		

Table 15. Frequency of occurrence of major food items in the stomachs of marine birds collected in Alaskan waters between 1969 and 1976. % = % of number sorted. Page 1 of 4.

Species	Number		Prey item present							
			Fish		Squid		Crustacea		Other, Unidentified	
	Acc.	Sorted	#	%	#	%	#	%	#	%
Laysan Albatross	1	1							1	100
Northern Fulmar	28	10	7	70	7	70	2	20	1	10
Sooty Shearwater	41	41	25	61	19	46	4	10	2	5
Short-tailed Shearwater	31	28	11	39	16	57	4	14	5	18
Fork-tailed Storm Petrel	9	4			2	50	1	25		
Leach's Petrel	3	0								
Double-crested Cormorant	1	1					1	100		
Pelagic Cormorant	2	0								
Red-faced Cormorant	1	1	1	100			1	100		
Harlequin Duck	1	0								
Oldsquaw	1	0								
White-winged Scoter	1	0								
Semipalmated Plover	1	0								

Table 15. Frequency of occurrence of major food items in the stomachs of marine birds collected in Alaskan waters between 1969 and 1976. % = % of number sorted. Page 2 of 4.

Species	Number		Prey item present							
			Fish		Squid		Crustacea		Other, Unidentified	
	Acc.	Sorted	#	%	#	%	#	%	#	%
Wandering Tattler	1	0								
Lesser Yellowlegs	1	0								
Northern Phalerope	4	0								
Pomarine Jaeger	1	0								
Ivory Gull	1	0								
Glaucous Gull	2	1							1	100
Glaucous-winged Gull	43	3	1	33					2	66
Herring Gull	4	0								
Mew Gull	7	6	1	17			5	83	2	33
Black-legged Kittiwake	76	21	16	76	1	5	4	19	2	10
Red-legged Kittiwake	1	1	1	100	1	100	1	100		
Bonaparte's Gull	2	0								
Sabine's Gull	1	0								

Table 15. Frequency of occurrence of major food items in the stomachs of marine birds collected in Alaskan waters between 1969 and 1976. % = % of number sorted. Page 3 of 4.

Species	Number		Prey item present: Fish		Squid		Crustacea		Other, Unidentified	
	Acc.	Sorted	#	%	#	%	#	%	#	%
Arctic Tern	19	16					16	100		
Aleutian Tern	9	9	6	27			3	33	1	11
Common Murre	80	13	10	77			2	15	2	15
Thick-billed Murre	58	32	9	28	24	75	7	22	14	44
Pigeon Guillomot	9	3	3	100			3	100	2	67
Horned Puffin	43	14	11	78	2	14	4	28		
Tufted Puffin	114	34	20	59	18	53	4	12		
Rhinoceros Auklet	20	4	4	100						
Crested Auklet	14	6					6	100		
Cassin's Auklet	5	5					5	100		
Least Auklet	4	1					1	100		
Parakeet Auklet	13	0								
Marbled Murrelet	35	6	4	67			2	33	1	17

Table 15. Frequency of occurrence of major food items in the stomachs of marine birds collected in Alaskan waters between 1969 and 1976. % = % of number sorted. Page 4 of 4.

Species	Number		Prey item present: Fish		Squid		Crustacea		Other, Unidentified	
	Acc.	Sorted	#	%	#	%	#	%	#	%
Kittlitz's Murrelet	7	1					1	100		
Ancient Murrelet	16	9	1	11			5	56	3	33

Table 16. Frequency of occurrence of three fish and three crustacean prey species in the stomachs of marine birds collected in Alaskan waters between 1969 and 1976.

Species, No.	Prey item present: Fish						Crustacea					
	Ammodytes hexapterus		*Mallotus villosus*		*Clupea harengus pallasi*		*Thysanoessa inermis*		*Thysanoessa raschii*		*Parathemisto libellula*	
	#	%	#	%	#	%	#	%	#	%	#	%
Glaucous-winged Gull 1			1	100								
Black-legged Kittiwake 7	3	43			1	14			1	14	2	29
Common Murre 1	1	100										
Pigeon Guillomot 1							1	100				
Horned Puffin 6	4	67	2	33			1	17				
Tufted Puffin 3	3	100										
Rhinoceros Auklet 3	3	100										
Crested Auklet 3							3	100				
Ancient Murrelet 5							5	100				

Table 20. Species present in the OBS-CE reference collection, as of March 1977. Each species is represented by at least one whole specimen, plus parts as indicated: O = otolith; P = parasphenoid bone; V = vertebral column.

FISHES

Gaddus macrocephalus
Tarletonbeania crenularis
Triglops sp.
Trichodon trichodon
Clupea harengus pallasi O
Ammodytes hexapterus P, V
Mallotus villosus O, P, V
Pholis laeta
Triglops pingeli
Hemilepidotus hemilepidotus
Plerogrammus monopterygius

EUPHAUSIDS

Thysanoessa inermis
Thysanoessa raschii
Thysanoessa longipes

ISOPODA

Saduria entomon

DECAPODA

Pandalus goniurus
Pandalus borealis

GASTROPODA

Lymnaea sp.
Aplexa sp.

BRANCHIPODA
Anostracan sp.

AMPHIPODA

Caprellid
Caprella californica

AMPHIPODA

Gammarids
Anonyx nugax
Calliopius laeviusculus
Cyphocaris anonyx
Cyphocaris challengeri
Eusirid sp.(?)
Eusiridae sp. (?)
Gammaridea sp. B
Gammaridea spp.
Halice sp. (?)
Haustoriid sp. A; sp. B
Melphidippa sp.
Paraphoxus sp.
Hyperiids
Cranocephalus scleroticus
Hyperia medusarum f. hystrix
Hyperietta stephenseni
Hyperoche mediterranea
Hyperoche medusarum
Lanceola clausi
Lanceola loveni
Lanceola sayana
Lycaea pulex
Oxycephalus clausi
Paraphronima crassipes
Paraphronima gracilis
Parathemisto libellula
Parathemisto pacifica
Phronima sedentaria
Primno macropa
Proscina sp. (?)
Scina borealis
Scina rattrayi
Scina stebbini
Scypholanceola vanhoeffeni
Streetsia challengeri
Syrrhoe crenulata
Tryphaena malmii
Vibilia australis
Vibilia caeca
Vibilia sp.

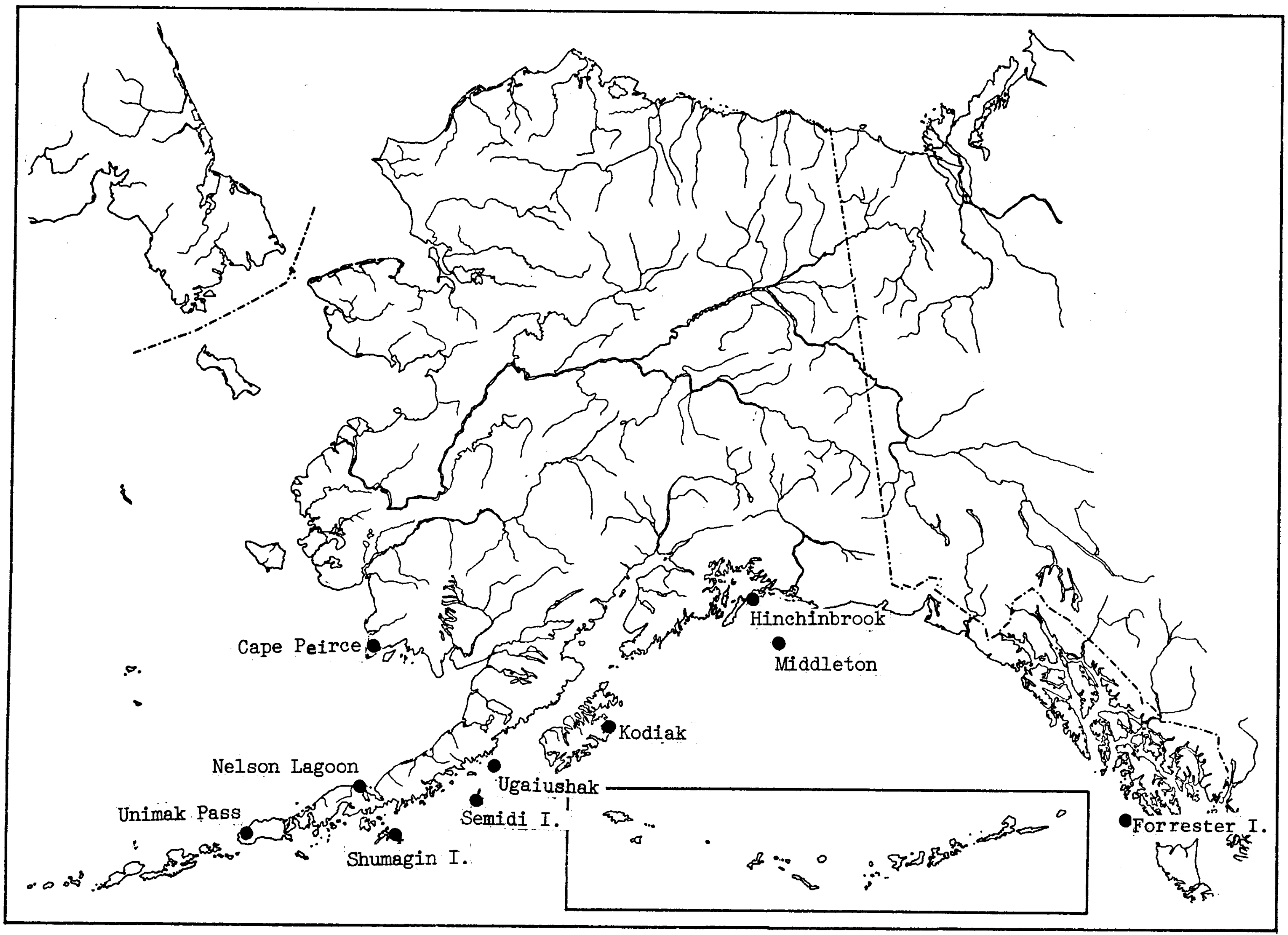
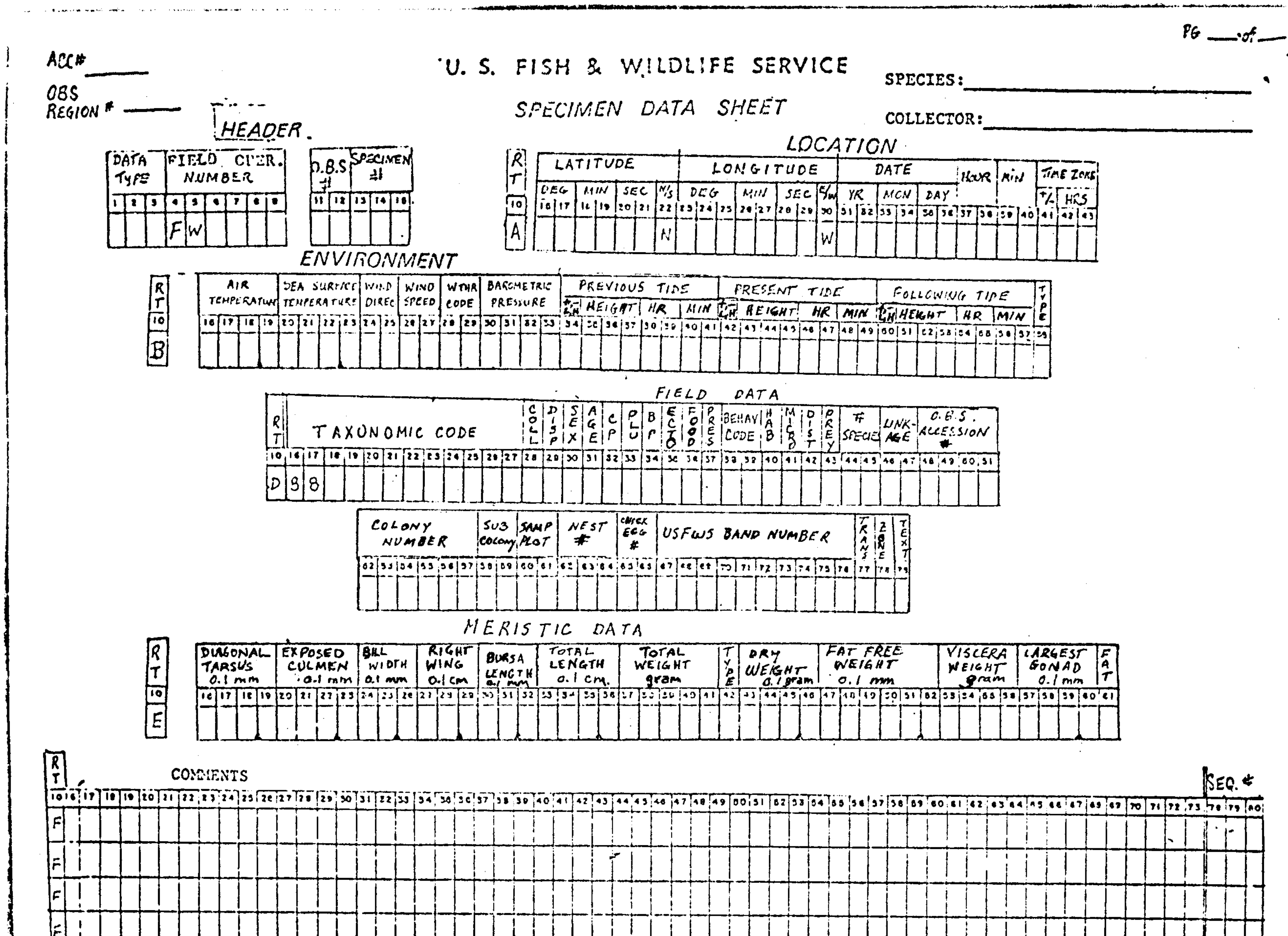


Figure 1. Locations of OBS colony study sites where marine birds were collected for feeding studies in 1976.


PG ___ of ___

ACC# ______

OBS

REGION # ______

U. S. FISH & WILDLIFE SERVICE

SPECIMEN DATA SHEET

SPECIES: ______

COLLECTOR: ______

HEADER

DATA TYPE | FIELD OPER. NUMBER (1 2 3 4 5 6 7 8 9) F W

O.B.S. # | SPECIMEN # (11 12 13 14 15)

LOCATION

RT 10 A

LATITUDE: DEG, MIN, SEC, N/S (N)

LONGITUDE: DEG, MIN, SEC, E/W (W)

DATE: YR, MON, DAY

HOUR, MIN

TIME ZONE: +/-, HRS

ENVIRONMENT

RT 10 B

AIR TEMPERATURE | SEA SURFACE TEMPERATURE | WIND DIREC | WIND SPEED | WTHR CODE | BAROMETRIC PRESSURE

PREVIOUS TIDE: HEIGHT, HR, MIN

PRESENT TIDE: HEIGHT, HR, MIN

FOLLOWING TIDE: HEIGHT, HR, MIN

TYPE

FIELD DATA

RT 10 D 8 8

TAXONOMIC CODE | COLL | DISP | SEX | AGE | CP | PLU | BP | ECTO | FOOD | PRES | BEHAV CODE | HAB | MICRO | DIST | PREY | # SPECIES | LINKAGE | O.B.S. ACCESSION #

COLONY NUMBER | SUB COLONY | SAMP PLOT | NEST # | CHECK EGG # | USFWS BAND NUMBER | TRANS | ZONE | TEXT

MERISTIC DATA

RT 10 E

DIAGONAL TARSUS 0.1 mm | EXPOSED CULMEN 0.1 mm | BILL WIDTH 0.1 mm | RIGHT WING 0.1 cm | BURSA LENGTH 0.1 mm | TOTAL LENGTH 0.1 cm | TOTAL WEIGHT gram | TYPE | DRY WEIGHT 0.1 gram | FAT FREE WEIGHT 0.1 mm | VISCERA WEIGHT gram | LARGEST GONAD 0.1 mm | FAT

RT

COMMENTS

SEQ. #

F

F

F

F

Figure 2. O.B.S. specimen data form used to record information pertinent to marine bird feeding studies.

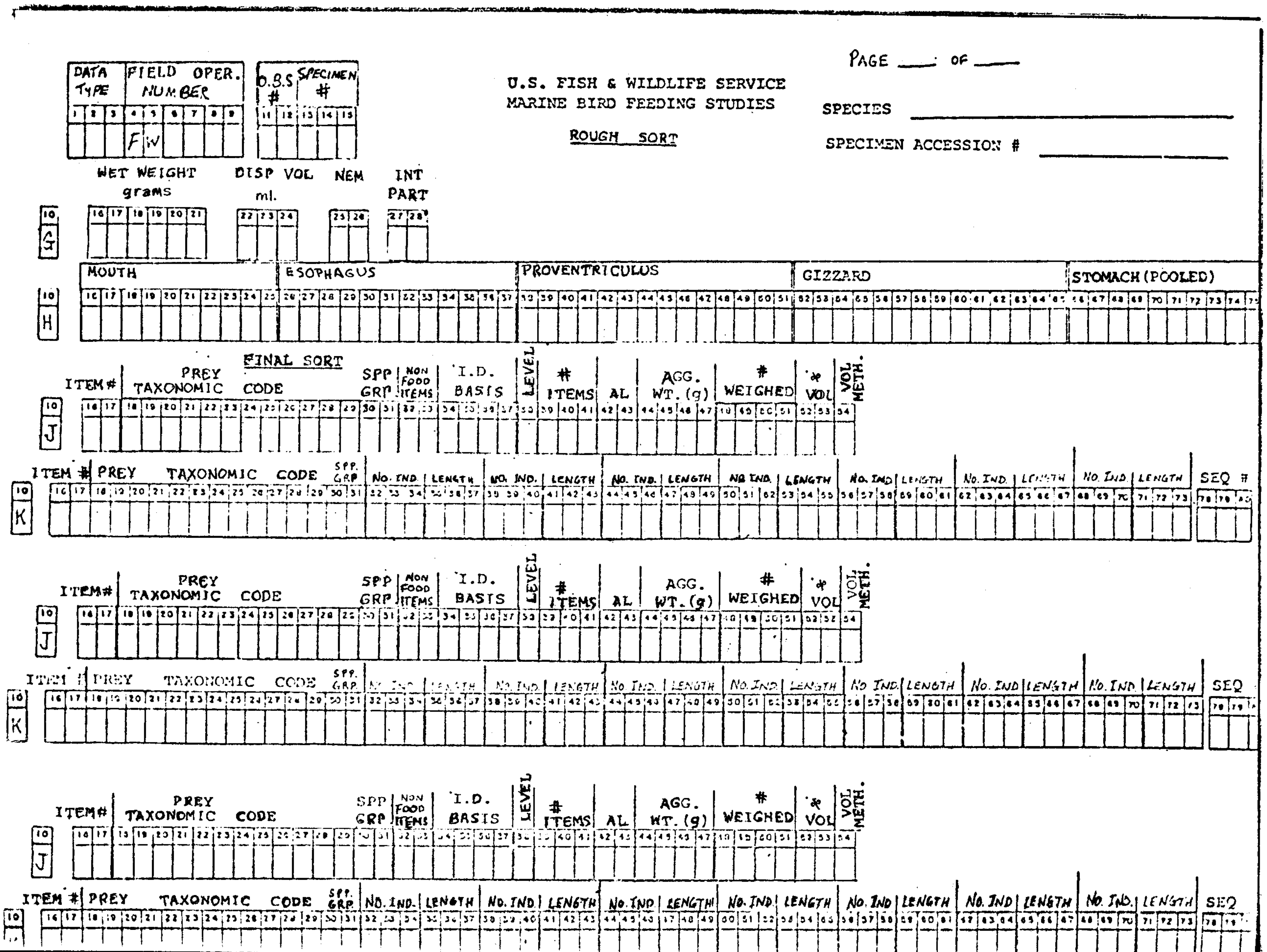


Figure 3. OBS marine bird feeding studies data form used to record stomach contents and other information generated in the laboratory.

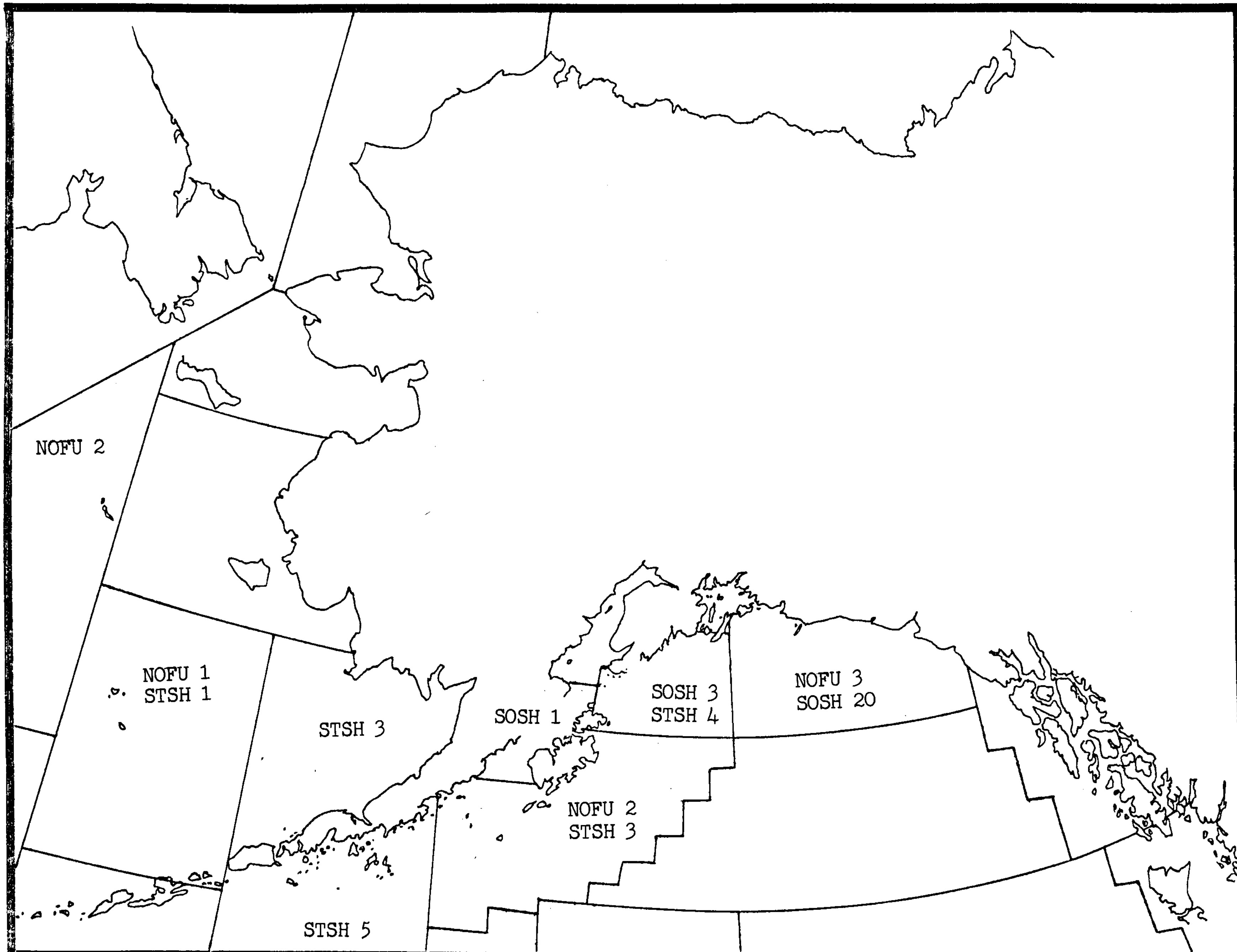


Figure 4 . Numbers of Northern Fulmars (NOFU), Sooty Shearwaters (SOSH) and Short-tailed Shearwaters (STSH) collected, by OBS Region.

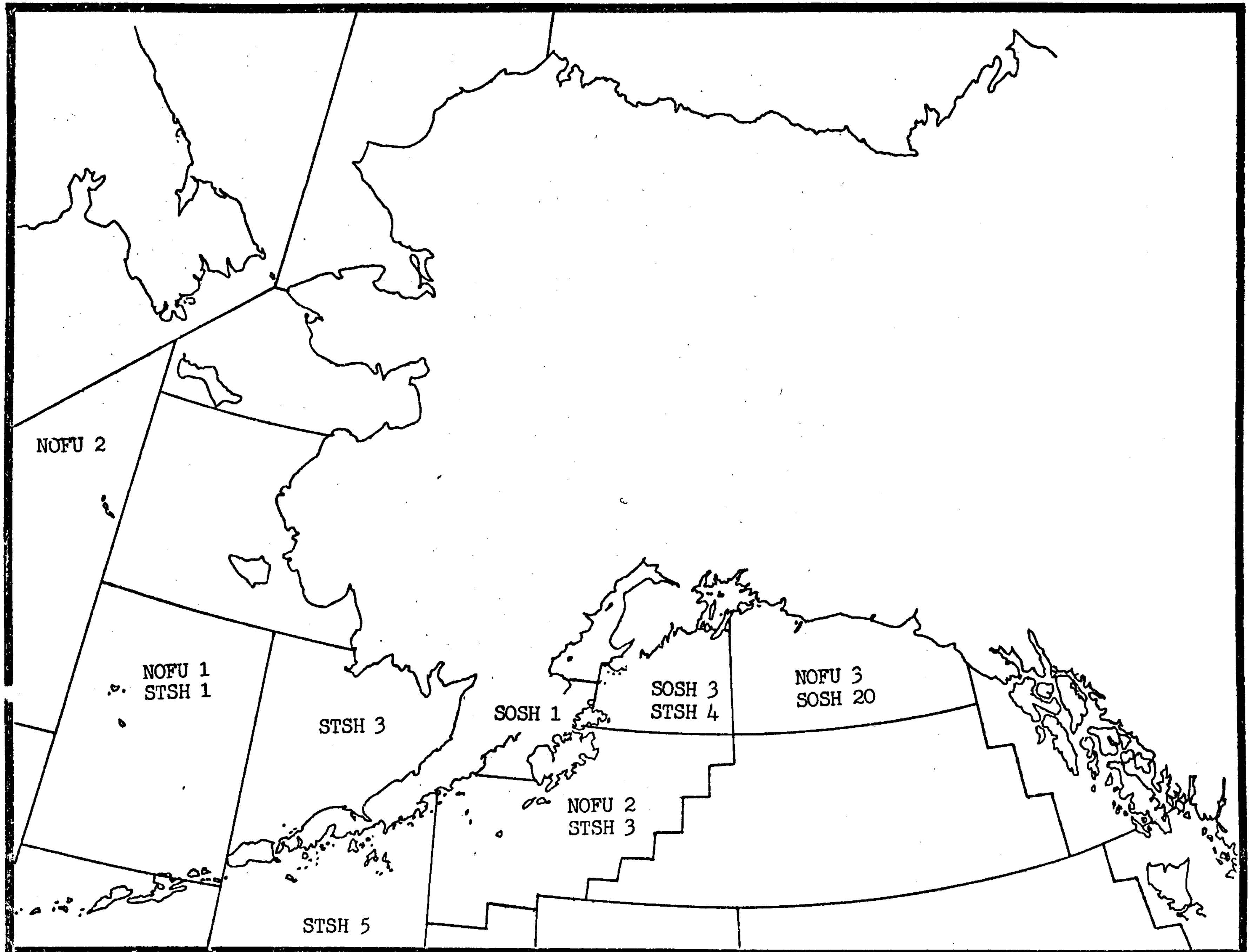


Figure 4 . Numbers of Northern Fulmars (NOFU), Sooty Shearwaters (SOSH) and Short-tailed Shearwaters (STSH) collected, by OBS Region.

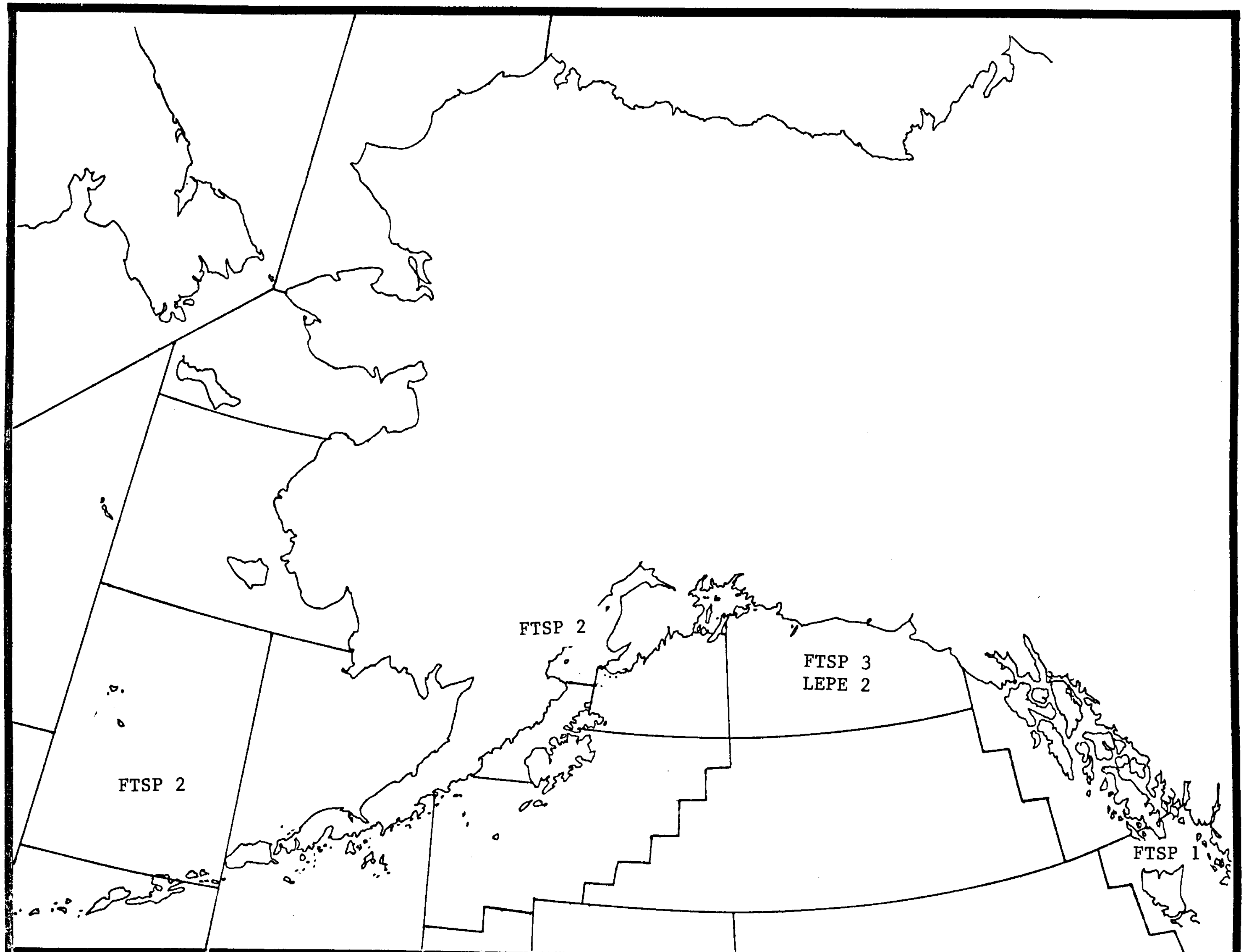


Figure 5 . Numbers of Fork-tailed Storm Petrels (FTSP) and Leach's Petrels (LEPE) collected, by OBS Region.

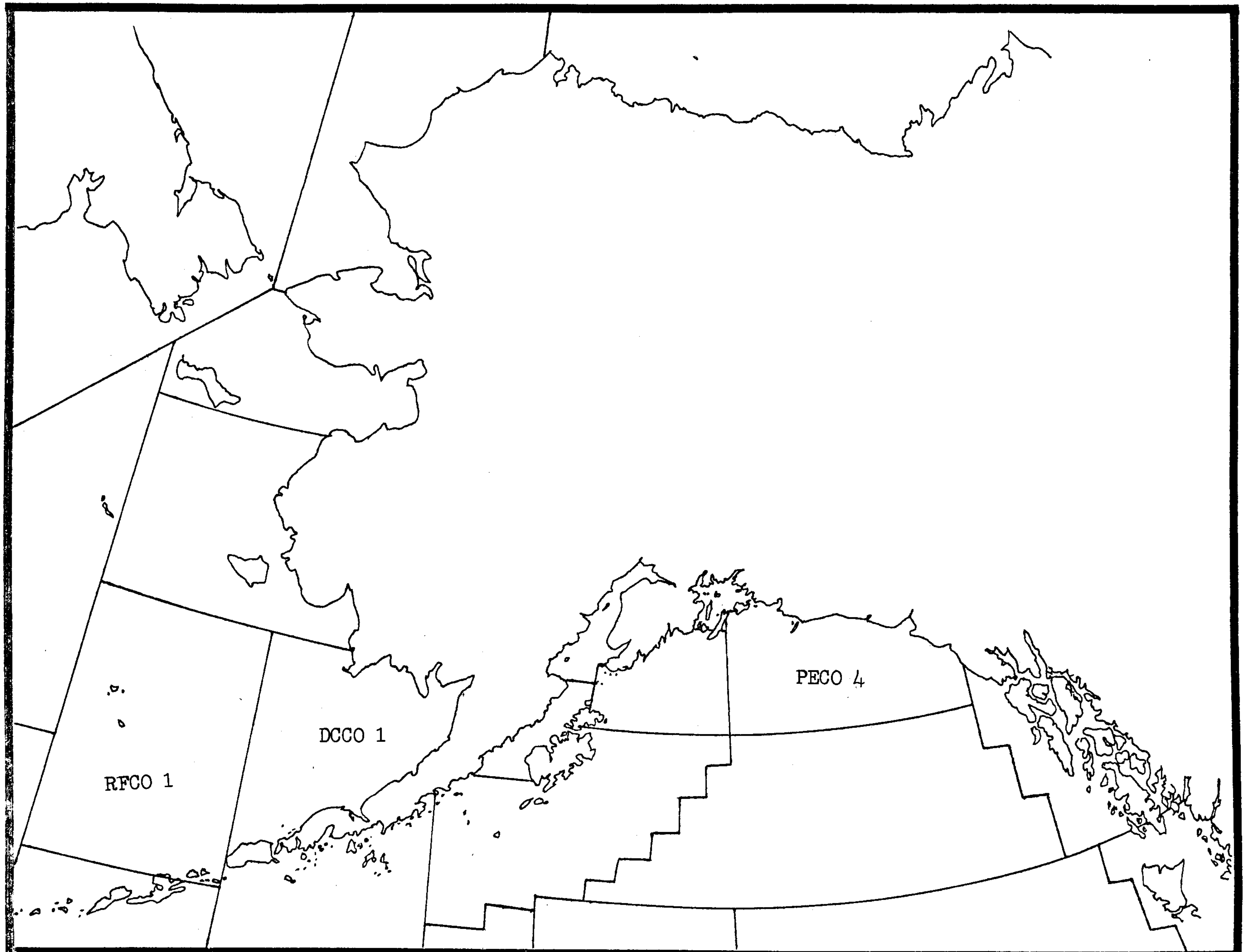


Figure 6 . Numbers of Double-crested Cormorants (DCCO), Pelagic Cormorants (PECO) and Red-faced Cormorants (RFCO) collected, by OBS Region.

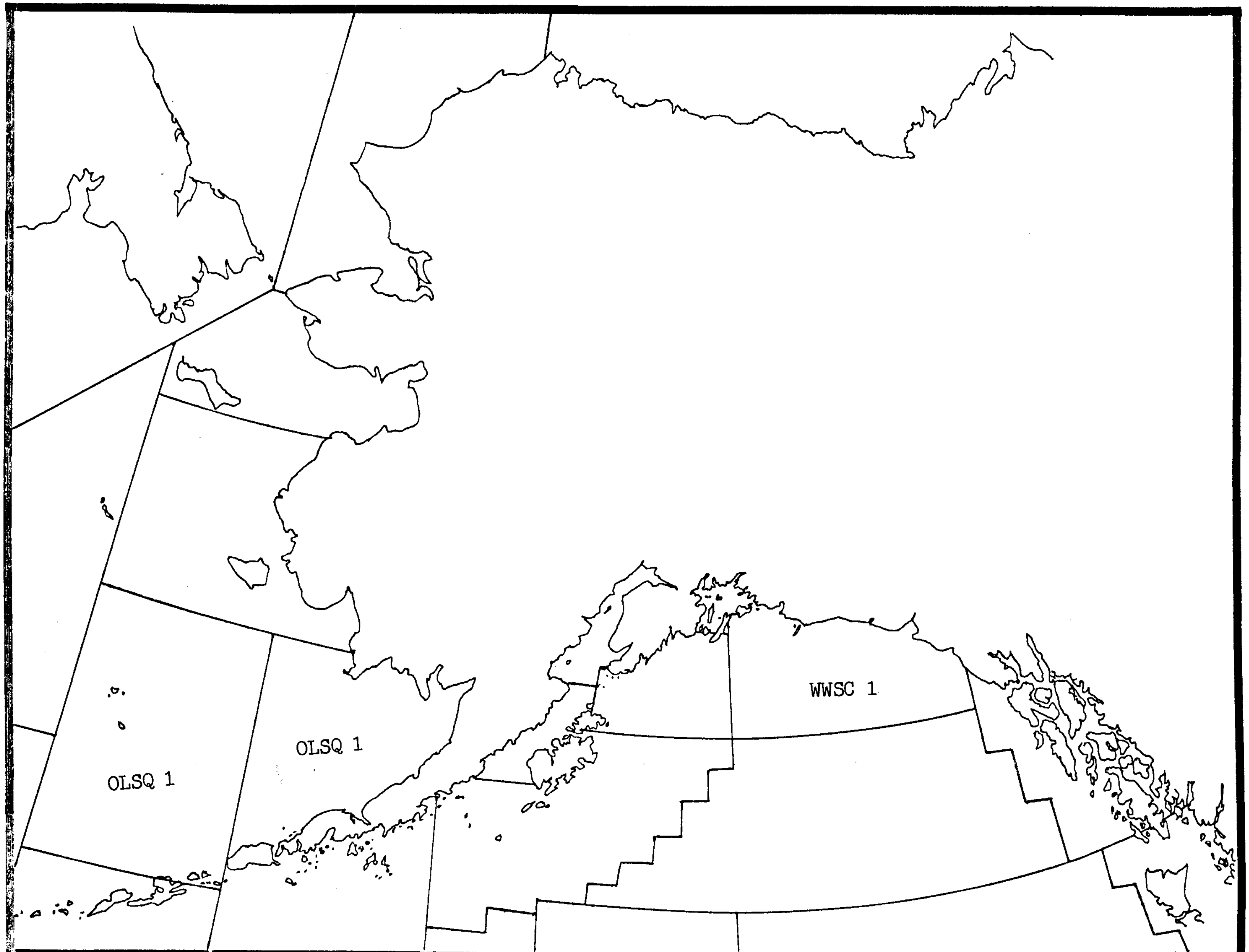


Figure 7 . Numbers of Oldsquaws (OLSQ) and White-winged Scoters (WWSC) collected, by OBS Region.

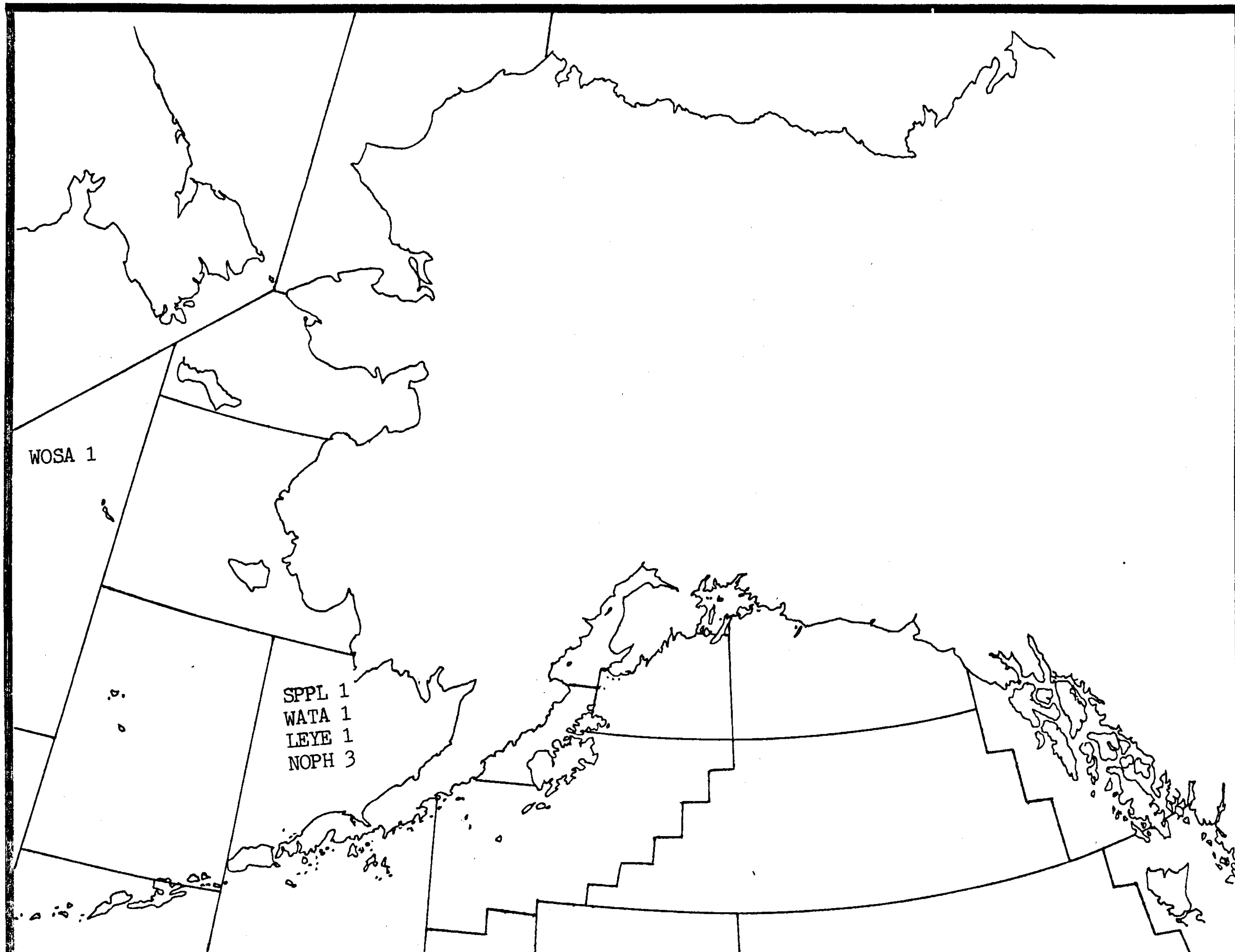


Figure 8 . Numbers of Semipalmated Plovers (SPPL), Wandering Tattlers (WATA), Lesser Yellowlegs (LEYE), Wood Sandpipers (WOSA) and Northern Phalaropes (NOPH) collected, by OBS Region.

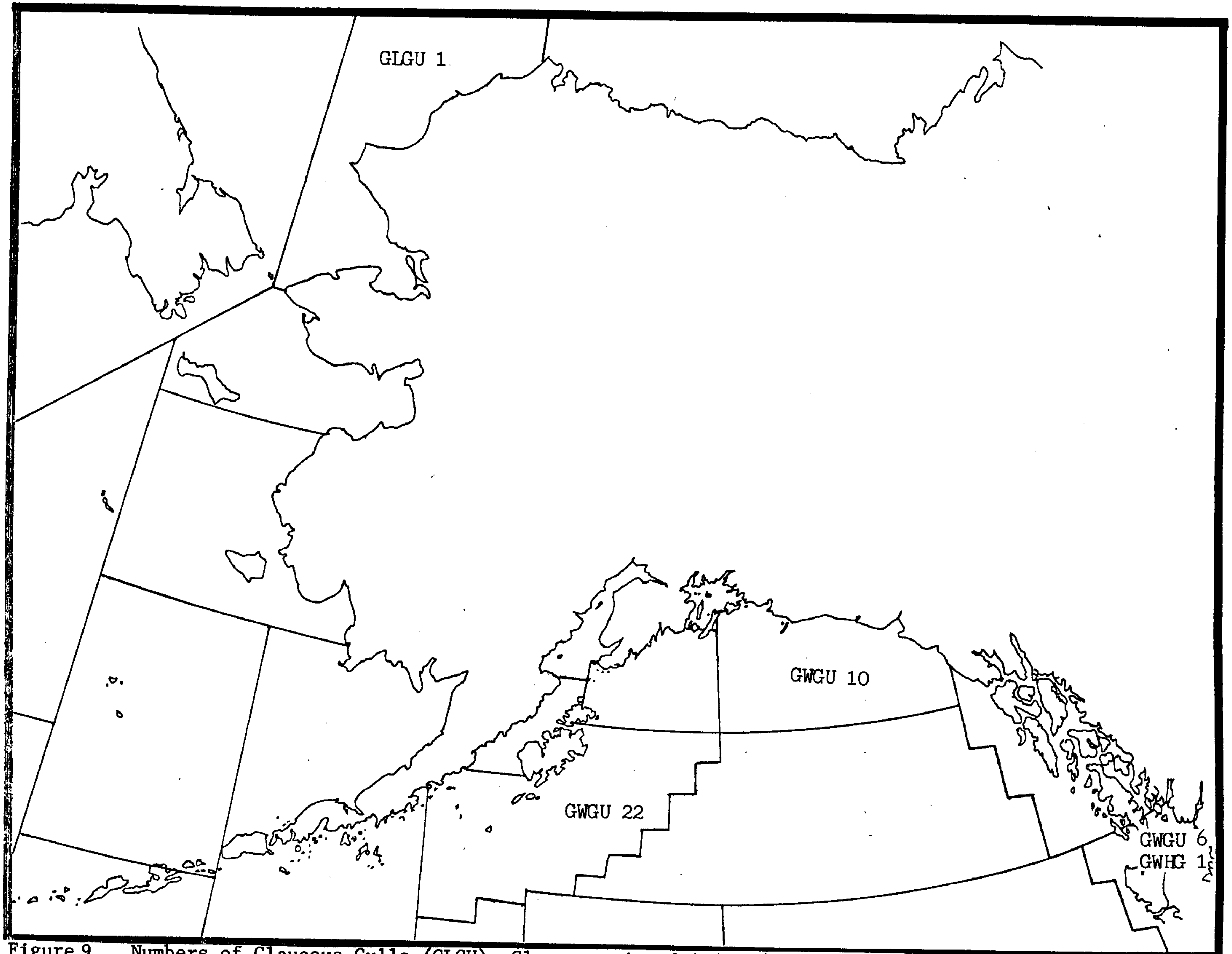


Figure 9 . Numbers of Glaucous Gulls (GLGU), Glaucous-winged Gulls (GWGU) and Glaucous-winged x Herring Gulls (GWHG) collected, by OBS Region.

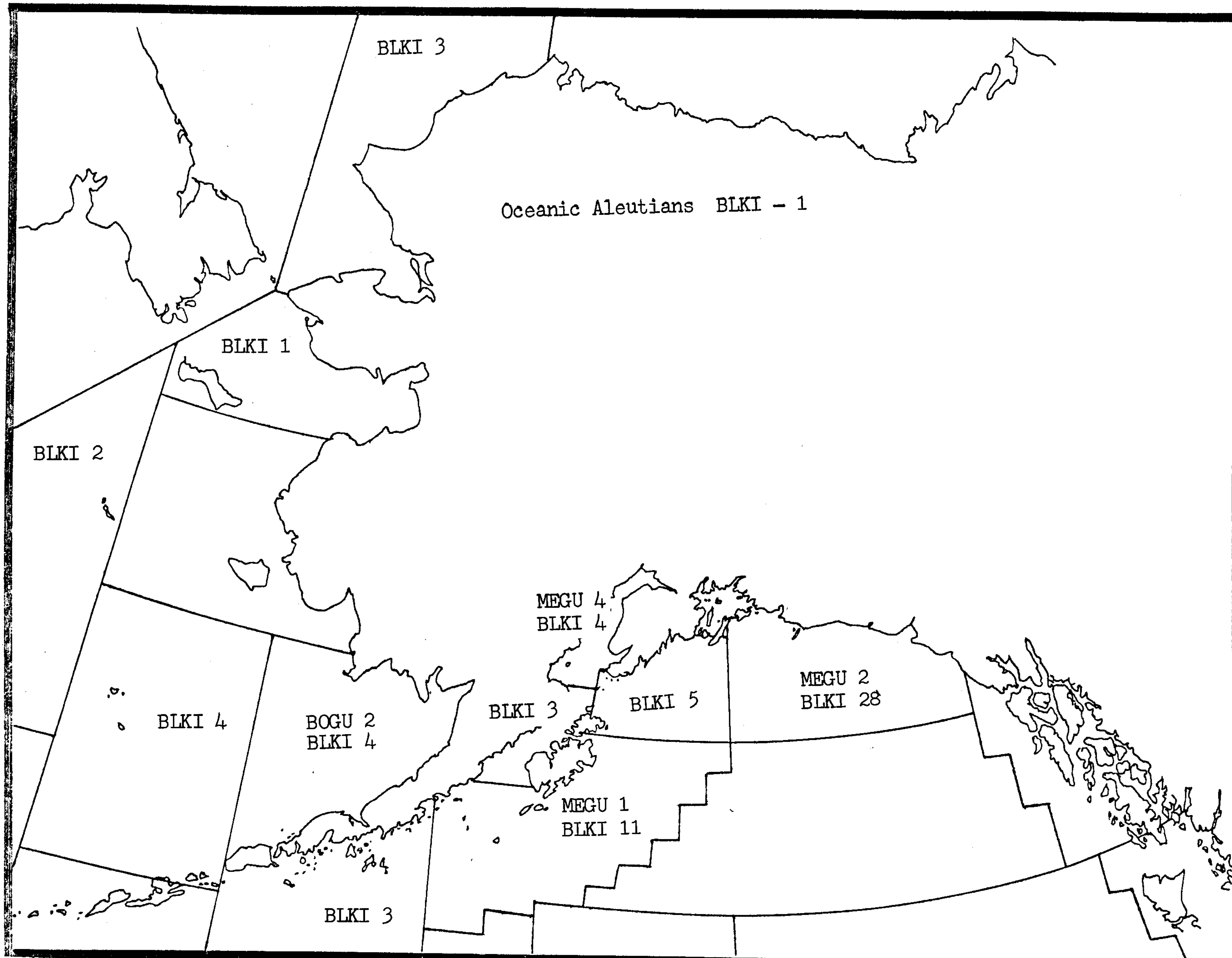


Figure 10. Numbers of Mew Gulls (MEGU), Bonaparte's Gulls (BOGU) and Black-legged Kittiwakes (BLKI) collected, by OBS Region.

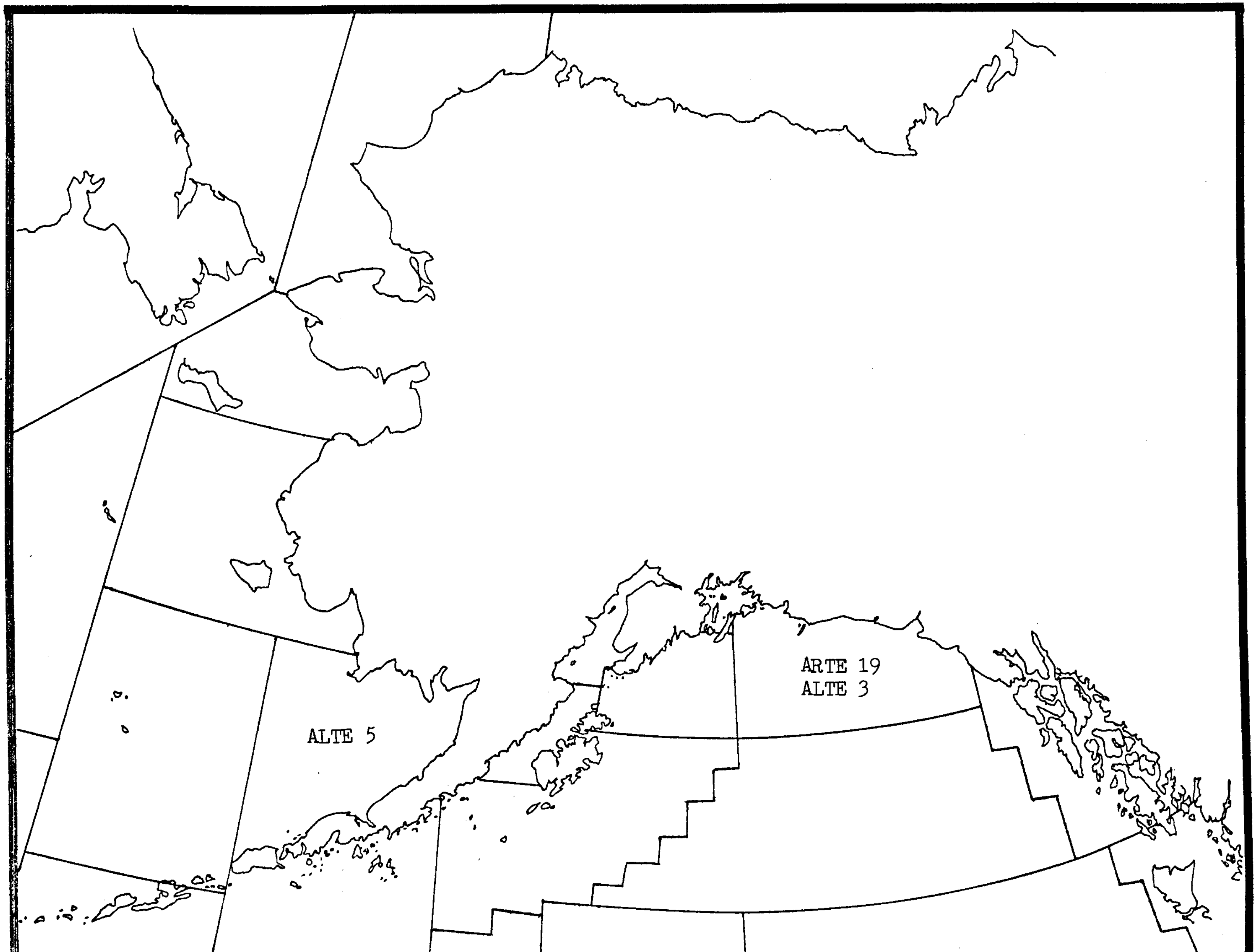


Figure 11. Numbers of Arctic Terns (ARTE) and Aleutian Terns (ALTE) collected, by OBS Region.

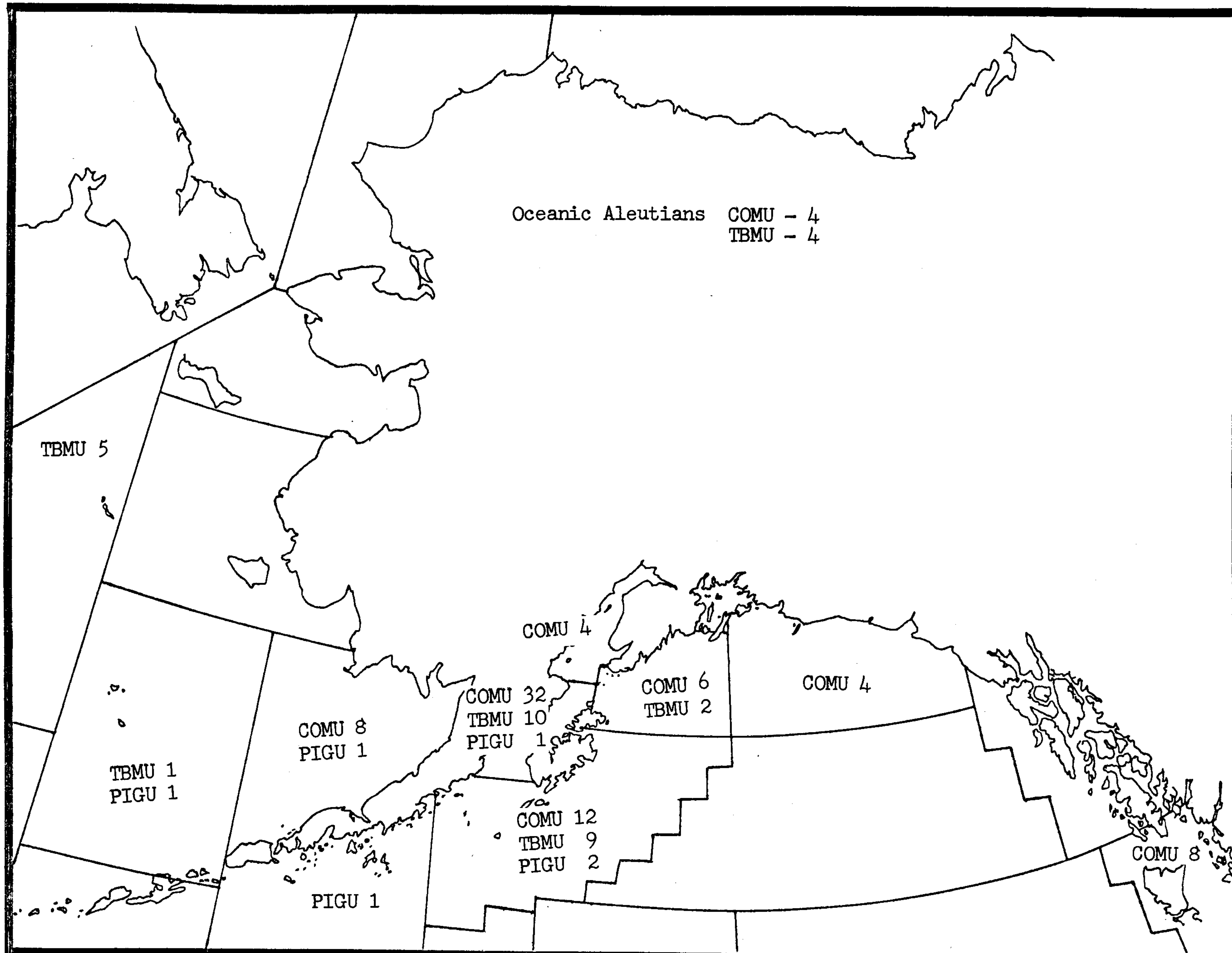


Figure 12. Numbers of Common Murres (COMU), Thick-billed Murres (TBMU) and Pigeon Guillemots (PIGU) collected, by OBS Region.

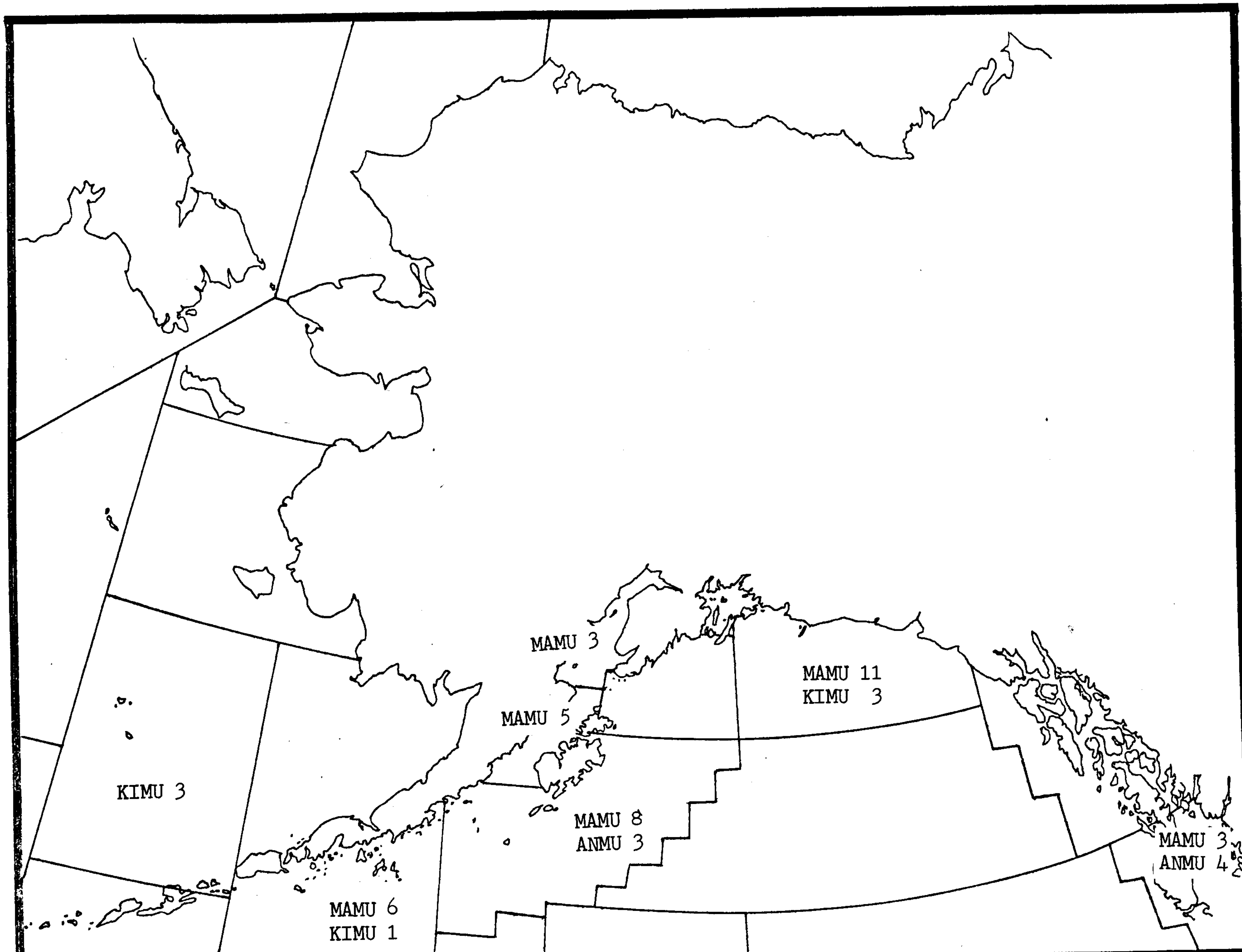


Figure 13. Numbers of Marbled Murrelets (MAMU), Kittlitz's Murrelets (KIMU) and Ancient Murrelets (ANMU) collected, by OBS Region.

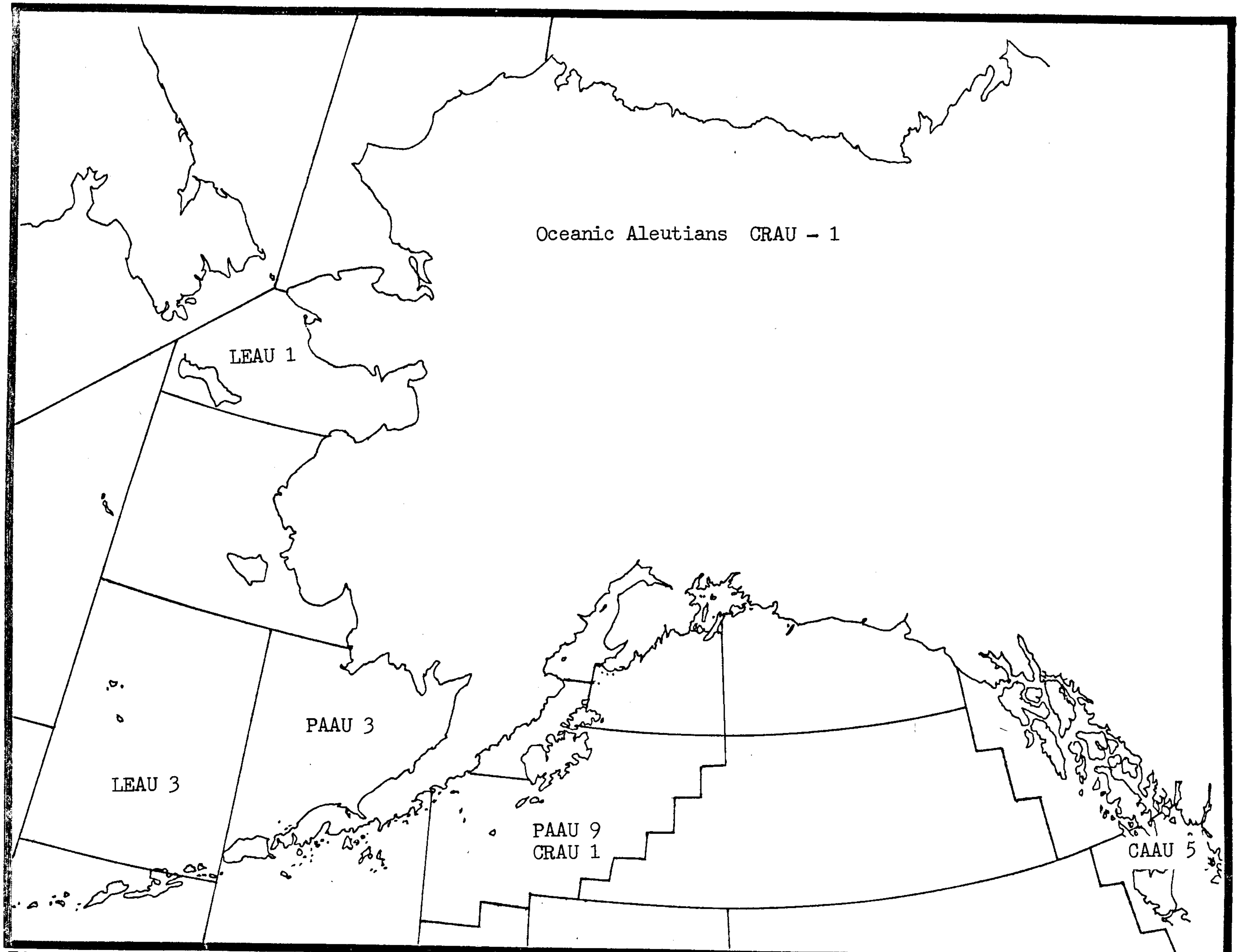


Figure 14 . Numbers of Cassin's Auklets (CAAU), Parakeet Auklets (PAAU), Crested Auklets (CRAU) and Least Auklets (LEAU) collected, by OBS Region.

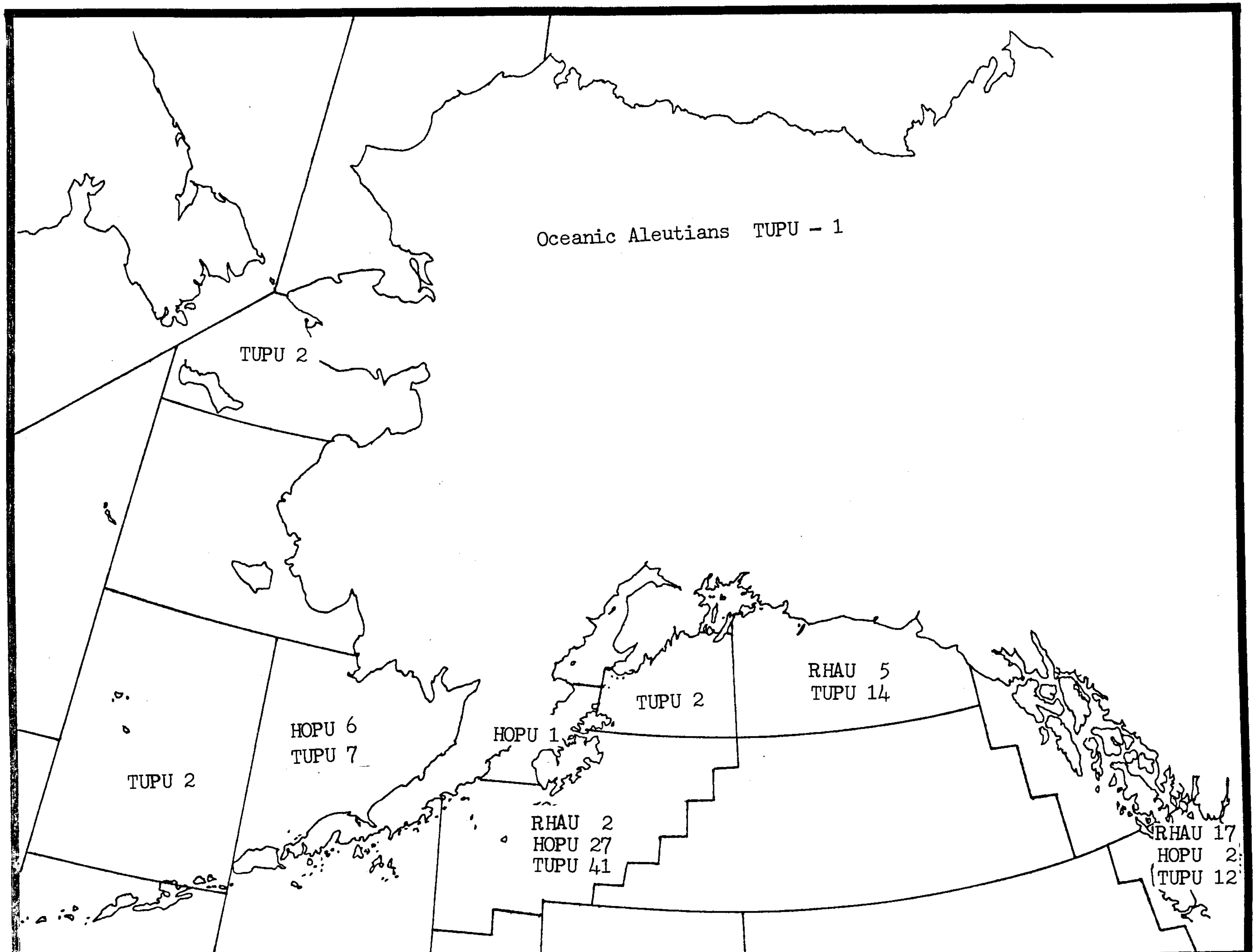


Figure 15. Numbers of Rhinocerus Auklets (RHAU), Horned Puffins (HOPU) and Tufted Puffins (TUPU) collected, by OBS Region.

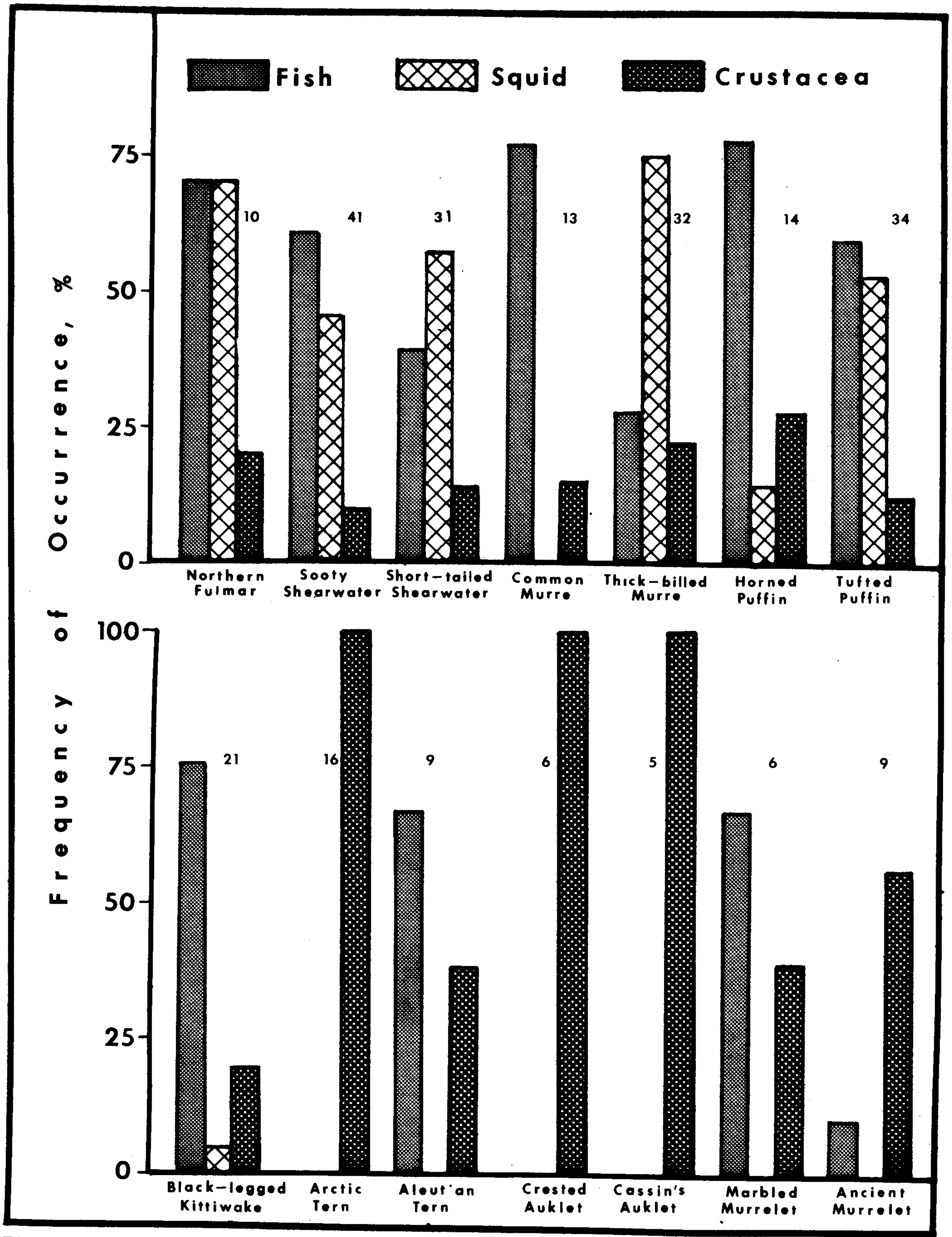


Figure 16. Frequency of occurrence of fish, squid and nektonic crustacea in the stomachs of 14 species of marine birds collected in Alaskan waters between 1969 and 1976. Sample sizes indicated above graph of each species.

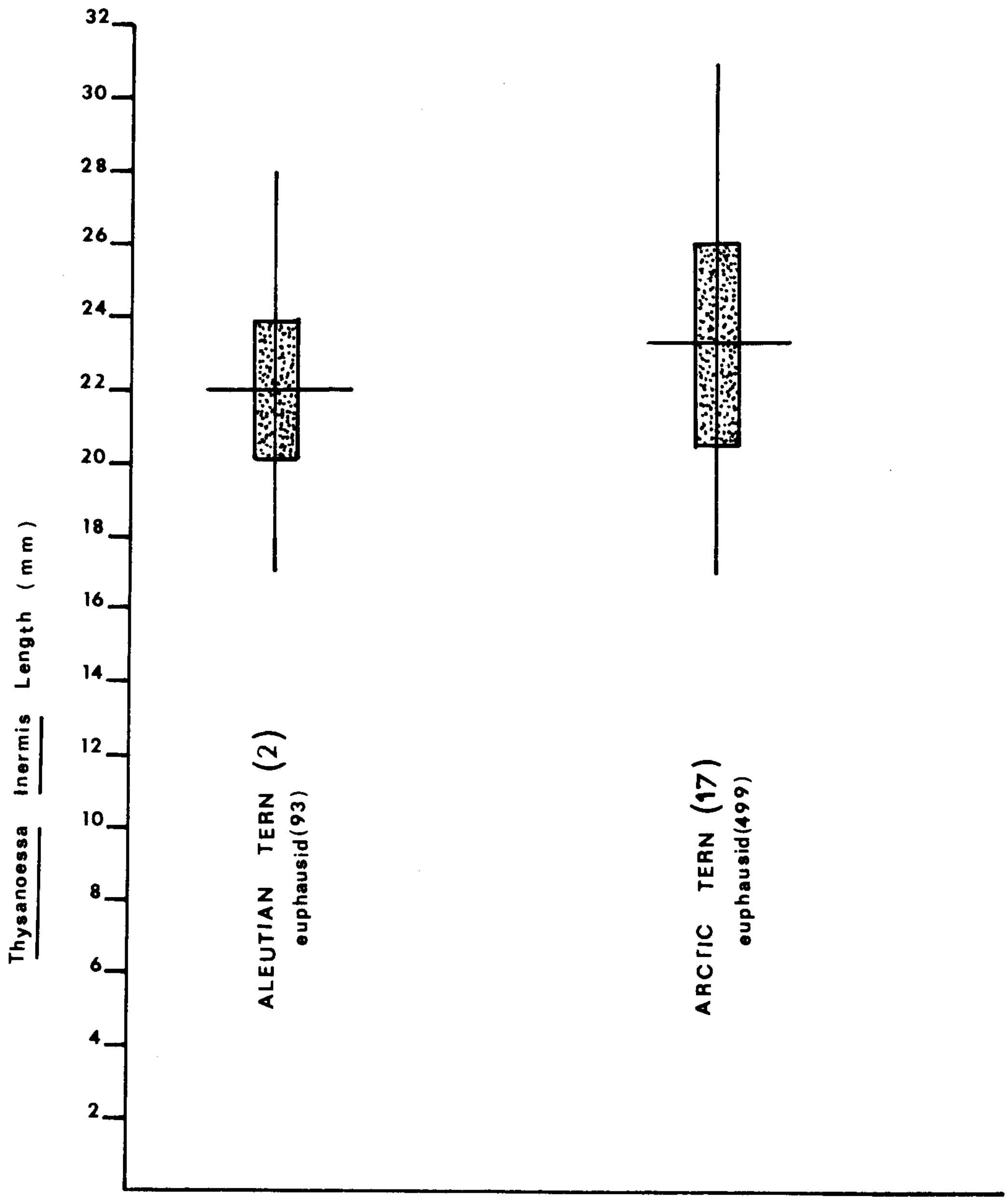


Figure 17. Range, mean and one standard deviation of length of euphausiids found in stomachs of Arctic and Aleutian Terns, collected in Icy Bay, Alaska, May 1976.

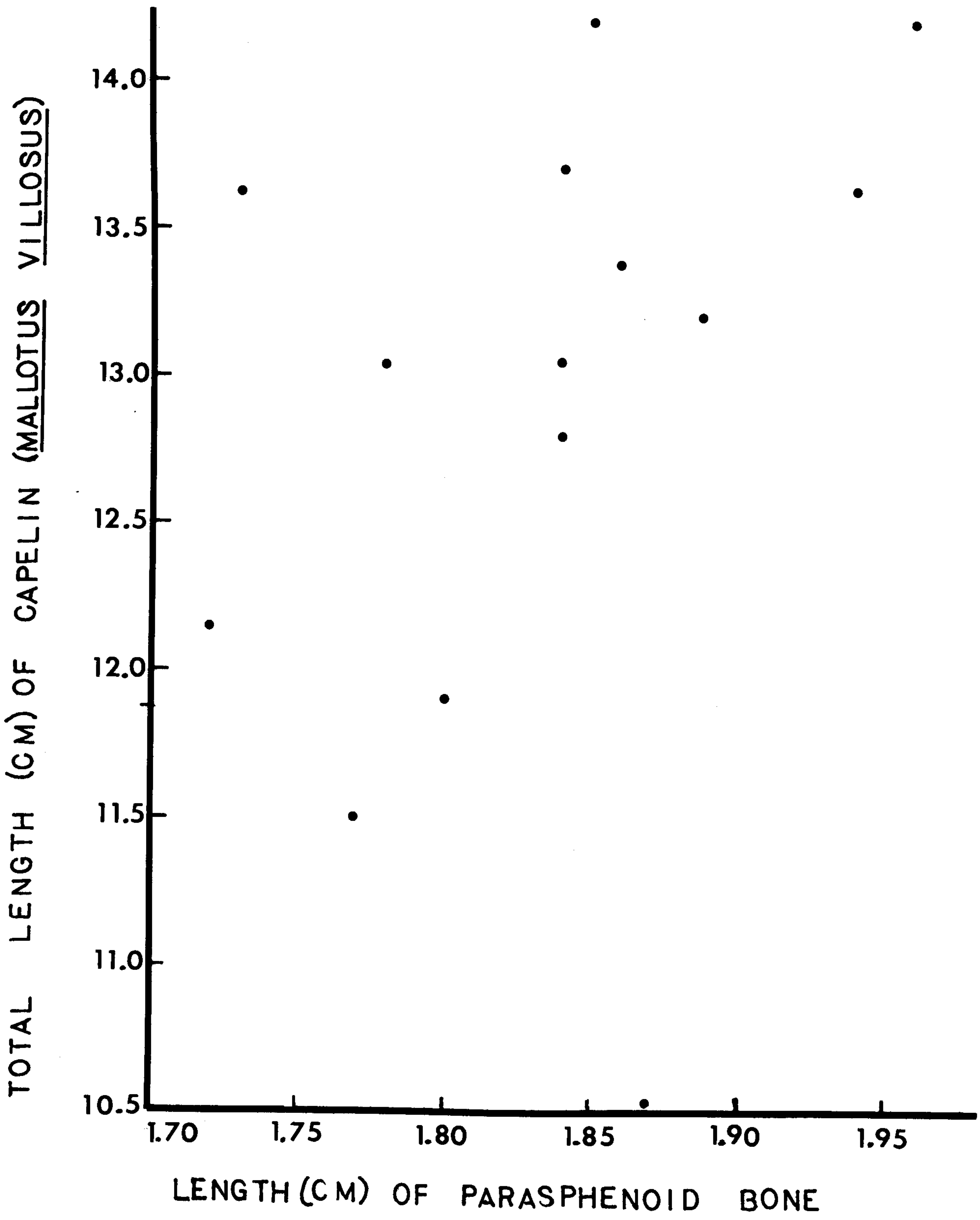


Figure 18. Relationship of total length to length of parasphenoid bone in Capelin, *Mallotus villosus*.

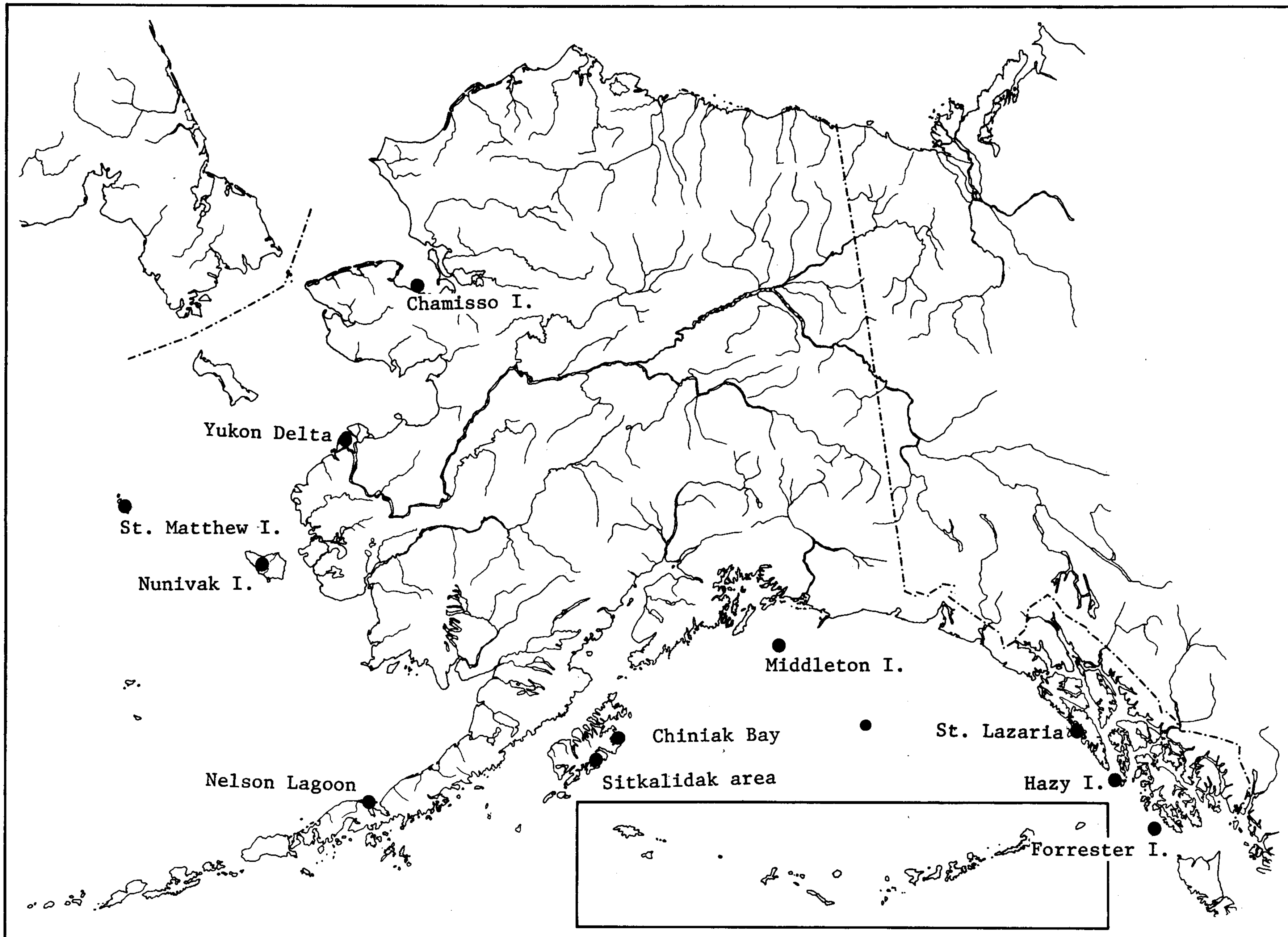


Figure 19. Locations of colony study sites in 1977.

☆U.S. Government Printing Office: 1977-781-773/167 Region 8