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ECOLOGICAL STUDIES IN THE NORTHERN BERING SEA:
BIRDS OF COASTAL HABITATS ON THE SOUTH SHORE
OF SEWARD PENINSULA, ALASKA

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CONTENTS

I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT 1

II. INTRODUCTION

 A. General Nature and Scope of the Research 4

 B. Specific Objectives 5

 C. Relevance to Problems of Petroleum Development 5

III. CURRENT STATE OF KNOWLEDGE 6

 A. Contrast Between Two Geographic Regions in the Northern Bering Sea 6

 B. Knowledge of the Breeding Biology of Black-legged Kittiwakes in the Waters of the Alaskan Continental Shelf. . . 7

IV. STUDY AREA 9

V. METHODS AND RATIONALE OF DATA COLLECTION. 9

 A. Seabirds 10

 B. Waterfowl 13

VI. RESULTS AND SPECIES DISCUSSION

 A. Seabirds 13

 1. Censure% 13

 2. Reproduction and Variation in Numbers - Bluff Cliffs. . . 14

 a. Black-legged Kittiwakes 14

 Estimates of Numbers 14

 Daily Attendance at the Cliffs 14

 Reproductive Success 15

 Phonological Evenst Relating to Lowered Reproduction 18

 Feeding Behavior and Food Sources 19

 b. Common and Thick-billed Murres 20

 Estimates of Numbers 20

 Daily Activity Patterns 21

 Seasonal Variation in Attendance 22

 Reproductive Schedule 22

 Reproductive Success 25

 Feeding Behavior and Food Sources 28

 c. Other Species

 Pelagic Cormorant and Glaucous Gull 29

 Horned puffin 30

 Tufted Puffin, Pigeon Guillemot, Parakeet Auklet. . . 30

 3. Other Locations in Norton Sound

 a. Sledge Island 31

 b. Topkok Head and Rocky Point. 31

 Pelagic Cormorants. 31

 Glaucous Gulls. 31

B.	Predators	32
	Egg-Chick Predators	
	1. Ravens	32
	2. Glaucous Gulls	39
	3. Other Egg-Chick Predators	40
	Predators on Adults	
	1. Golden Eagle	41
	2. Gyrfalcon	41
	3. Rough-legged Hawk	42
	4. Other Predators	42
c.	Waterfowl	43
	1. Spring Migration	43
	2. Fall Migration	44
	3. Distribution of Waterfowl Gathering Areas Over the Southern Part of the Seward Peninsula	44
VII &		
VIII.	DISCUSSION AND CONCLUSIONS	47
A.	Techniques for Measuring Biological Characteristics	47
	1. Censuring	47
	2. Measuring Reproductive Success	48
	3. Food	49
B.	The General Application of Seabirds to OCSEAP Problems	50
c.	Primary and Secondary Effects of Oil Development	52
	1. Oil Spills and Seabirds	52
	2. Secondary Development	53
IX.	SUMMARY OF FOURTH QUARTER ACTIVITIES	55

LIST OF TABLES

1A.	Comparison of laying dates and clutch sizes of Black-legged Kittiwakes in Alaska.
1B.	Comparison of Kittiwake clutch sizes in England, Russia and Alaska.
1C.	List of study areas at Bluff and data collected at each.
2.	Number of "breeding" birds at Murre map areas (as a percent of the season's high counts).
3.	Counts of Murres at Bluff-comparison of percentage of birds remaining on the cliff during censuses.

4. Bird populations at colonies in Norton Sound, 1977.
5. Comparison of Murre numbers, 1975-1977.
6. Estimates of total numbers of Black-legged Kittiwakes.
7. Reproduction of Black-legged Kittiwakes at Bluff and Square Rock.
8. Reproductive success of Black-legged Kittiwakes as measured in large sample counts of nests and chicks.
9. Summary of Black-legged Kittiwake feeding behavior observed near Bluff Cliffs during the summer of 1977.
10. Estimates of total Murre numbers at Bluff, 1977.
11. Murre censuses - Square Rock and Sledge Island.
12. Number of sites monitored within each Murre map area.
13. Numbers of "breeding" birds present at Murre map areas.
14. Numbers of eggs, chicks hatched and chicks fledged at Murre map areas.
15. Murre reproductive success.
16. Comparison of Murre reproductive success, 1976-1977.
17. Egg loss summary (murre).
18. Murre chick loss summary.
19. Reproduction of Pelagic Cormorants and Glaucous Gulls at Bluff
20. Estimates of reproductive success of cormorants, murre, and kittiwakes at Sledge Island, 1977.
21. Estimates of reproductive success of Pelagic Cormorants and Glaucous Gulls at Rocky Point and Topkok Head, 1977.
22. 1977 Waterfowl censuses.

LIST OF FIGURES

1. Map of the Bering Strait Region.
2. Diagram of the cliffs at Bluff, showing locations of study sites and landmarks used during censuses.
3. Murre remaining on the cliff during censuses.

4. Twenty-four hour counts - Kittiwakes.
5. Nest-building activity in Black-legged Kittiwakes.
6. Egg laying and hatching of Black-legged Kittiwakes; Bluff Cliffs and Square Rock, 1977.
7. Egg laying of Black-legged Kittiwakes; Bluff Cliffs, 1976.
8. Variation in numbers of Black-legged Kittiwakes at the Bluff Cliffs, 1977.
9. Variation in numbers of kittiwakes at Bluff Cliffs, 1976.
10. Attendance at nest sites by kittiwakes.
11. Number of kittiwake eggs present and amount of mortality, Bluff Cliffs and Square Rock, 1977.
12. Number of kittiwake eggs present and amount of mortality, Bluff Cliffs, 1976.
13. Twenty-four hour counts - Murres.
14. Seasonal Variation in Murre Attendance at the Cliffs.
15. Reproductive schedule - Common and Thick-billed Murres.
16. Calculated versus observed laying dates - Common Murres.
17. Dates of egg loss (murres).
18. Breeding phenology of Pelagic Cormorants and Glaucous Gulls at Bluff, 1977.
19. Variation in numbers of Horned Puffins at the cliffs.
20. Location of Bird Predator Nests at Bluff Cliffs, 1977.
21. Number of eggshells found and crushed on the cliff top at Bluff, 1977
22. Numbers of waterfowl in major coastal habitat.

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

The purpose of our work is to identify those aspects of the biology of wildfowl which deserve careful consideration in order to avoid unnecessary damage in the course of development associated with the extraction of oil. Our objectives are to locate major concentrations of seabirds, waterfowl and shorebirds in space and time; to establish the numbers involved and the circumstances under which the gathering areas are important; to learn the relation of selected species of seabirds to the oceanic ecosystems by measuring the birds' reproductive rates and food dependencies; and to investigate the relation of biologically important areas to the geography and ecology of the Northern Bering Sea, such as location of nesting cliffs, feeding grounds at sea, and tundra nesting habitats, as well as those wetlands and mudflats which are used for feeding and escape from hunting pressure.

These studies to date have consisted of, first, a general inventory and, second, analysis of the breeding biology of selected species. The analytical studies are intended to prepare generalizations about the relations of seabirds to their habitats, because there is not enough time or money to make studies of all the species which may be affected or to prepare models which include the necessary environmental parameters to allow prediction of ecosystem effects ahead of time.

In our work at the cliffs at Bluff, Square Rock and Sledge Island, we have concentrated on studies of Pelagic Cormorants, Glaucous Gulls, Ravens, and especially on Black-legged Kittiwakes and Common Murres. The results of these studies, when added to the knowledge of the same species obtained in other parts of Alaska's Outer Continental Shelf and in the North Atlantic, form a basis for interpreting the results of short term observations made where seabird cliffs are inhospitable or remote. They have also provided a set of techniques for making measurements of population size and breeding success of seabirds when only a short time is available.

Our work indicates that both Black-legged Kittiwakes and Common Murres are sensitive to changes in the food supply available in Norton Sound. Thus they offer the possibility of acting as indicator species for negative changes in the trophic structure of the sea. Our work also suggests that Ravens and Glaucous Gulls may act as indicator species, but of a different sort. These two species seem to benefit from organic wastes supplied by humans and thus to benefit from development. The contrast in the effects of development offered by these two pairs of species indicates that it may be dangerous to assign a priori, definite boundaries to the relation between a given species and what we consider to be its habitat or ecosystem. Unfortunately, the way species are 'coupled' to their 'systems' remains one of the major unanswered questions of ecology. For example there is now a good amount of information on the food of murres and kittiwakes in North Atlantic and North Pacific, Bering and Chukchi Seas which indicates that the food used varies considerably between geographic

regions and between years. Yet the form and habitat of the prey remains consistent to a large extent. At this point detailed studies of food can be expected to document this variation in food resources and opportunism in the choice of prey. Hence we conclude that until detailed studies can be run by specialists in fish and crustaceans, closely coordinated with the studies of oceanic structures, sea bird research should concentrate on feeding actions of the birds and the details of their spatial distribution at sea, rather than spending more than passing time on studies of prey items in the sea. We point out below that birds at sea are distributed in patterns that suggest important oceanographic features (see also the Annual Report for R.U. 447). The reported distribution should be confirmed, because it is directly applicable to defining the area of sea which must be included as part of the habitat of the major seabird nesting islands in the Northern Bering Sea.

Work in Alaska and in the North Atlantic indicates that unwanted effects can be anticipated during the process of development. We list three and suggest how knowledge already gained in northwest Alaska can be used to clarify the processes involved and hence to prevent or mitigate the damage. In other parts of the world, economic development has been characteristically accompanied by (a) direct reduction of populations of some native species, by (b) increasing activities of people at breeding sites and the introduction of carnivores that are escaped pets, and by (c) rapid growth of aggressive species (e.g. Glaucous Gulls and Ravens) which benefit by shoddy disposal of wastes and which compete for nest sites or exert increasing predation pressure on vulnerable species.

a) The work of Springer and Roseneau (NOAA, 1978) indicate that the populations of Common and Thick-billed Murres have decreased by half at the cliffs at Cape Lisburne and Cape Thompson since Schwartz (1966) made counts in 1959 - 1961. Our counts at Little Diomed Island (see report for R.U. 447) suggest that there may have been a decrease in the numbers of murres since counts were made by Kenyon in 1958 (Kenyon and Brooks, 1960). This situation offers an opportunity to observe the short term effects of the lowered population and to follow the rate of population recovery. However, our counts of the populations of murres on the cliffs at Bluff suggest that the situation may be complex. In a good year, 1975, we counted almost an order of magnitude more murres than we did at a low count in a poor year, 1976. During other years our counts have varied between 30,000 and 60,000. Some of these differences are due to variations in numbers during the course of the day or the season, but it is clear that many more birds are on the cliffs in a 'good' year than are present when reproduction is poor. Springer and Roseneau have appreciated this and applied corrections for diurnal variation, but reproductive success observed by Schwartz was very much higher in the late 1950s than in the mid 1970s and it may not be possible to make reliable judgements of the changes in population until another 'good year' occurs.

b) King Island offers an opportunity to observe the effects of the presence of people and their pets on a seabird colony, because the natives of Ukivok have not occupied the village except temporarily since the mid-1960s. Furthermore, Arctic Foxes come to the island each spring on the sea ice and breed. Experience in eastern U.S. and elsewhere has shown that foxes and domestic dogs have virtually the same effects on the behavior of breeding seabirds at their colonies.

King Islanders Ed Muktoyuk, John Pullock and Mike Saclamana report that murre and kittiwakes now nest on many ledges which were barren of breeding birds when they were children collecting eggs on the island. The changes should be documented and further changes followed as an experimental case (although in reverse) of the impact of heavy human usage and the rates of recovery.

We have observed that Arctic Foxes have an observable impact on breeding parakeet Auklets and the Eskimos believe that they affect Tufted Puffins even more. The people of Little Diomed believe that the reason there are many times more Tufted Puffins on Fairway Rock than on Little Diomed is the absence of foxes from the Rock which is too small to support a fox over the summer. Arctic Foxes should be removed annually from King Island and the changes in the seabird population monitored.

c) There are good reasons to expect that an increase in human population or further development will be accompanied by an increase in gulls and ravens, both of which benefit from food supplied by wastes and garbage. Studies of the effects of Glaucous Gulls and Common Ravens begun in 1977 at Bluff Cliffs should be expanded to a general study of this problem in several parts of Alaska, because the problem of gulls displacing other seabirds has proven to be serious in Europe, Eastern U.S., Australia and New Zealand.

d) Finally our studies tend to confirm the hypothesis which was offered at the start of Research Unit 237, namely that there are important oceanographic differences between Norton Sound and the Chirikov Basin which are reflected in the action of water masses, primary productivity, the detritus/benthic fauna, the crustacea and fish, nekton/plankton fauna, the marine mammals and the marine birds. The area of the Norton Basin which is approximately the size of the Gulf of Maine supports a population of sea birds in the order of 4,000,000 individuals. This number is at least twice the population of seabirds in the western Atlantic seaboard including Labrador, Newfoundland, the Gulf of Saint Lawrence, Nova Scotia and the Gulf of Maine. Because this area is clearly on the line of transportation of heavy equipment to the oil fields on the north slope and increasing secondary development in the Nome area, we should know more about the basic structure, and the similarities and dissimilarities of the natural geographical and ecological units of Norton Sound and the Chirikov Basin. This requires

that attention be given to the previously little-studied oceanographic zone between 6 meters and 60 meters depth, and that studies be coordinated among experts on organisms at the several "places" to the food chains as well as chemical and physical oceanography. But to understand the biological oceanography, coordinated studies of physical and chemical oceanography should be directed towards answering the questions posed by the distribution of organisms. Although considerable progress has been made in the coordination of oceanographic studies during the Outer Continental Shelf Environmental Assessment Projects, there is still little use made by physical and chemical oceanographers of what is known about the distribution of organisms in order to identify and circumscribe physical problems that need answers.

If, as we understand it, a primary goal of OCSEAP is to develop insight into what factors may be important in order to make ecosystem models that will predict the impacts of development, it would make sense to address some obvious differences already provided by natural conditions or previous human activities.

II. INTRODUCTION

A. General Nature and Scope of the Research. We have discussed the nature and scope of this work in some detail in other reports. We are gathering data to document the distribution in space and time of the seabirds, shorebirds and waterfowl on the south shore of the Seward Peninsula. We are collecting evidence on why the areas where these birds gather are important and how they may be vulnerable to direct and indirect effects of development. We are also working to gain insight on what factors may be important in predicting the impact of development ahead of time. But neither time nor money is available to develop the knowledge of all the ecosystem factors that control bird populations. Also we do not believe that the models of population behavior prepared for terrestrial game species, song birds and insects will necessarily prove instructive in interpreting the ecology of wildfowl. Thus as we pointed out at the symposium on the Conservation of Marine Birds in Seattle in 1975, it is most efficient to pick a few critical aspects of the biology of a few key species and study them in detail in order to make generalizations applicable to other seabirds and waterfowl. In that paper we also sketched out some of the characteristics of seabirds which distinguish them from other birds.

Experience gained in studying the impact of hunting and of chemical pesticides indicates that environmental influences on reproductive rate are more important in the survival of a population than direct massive mortality. Hence it is generally agreed that studies of reproductive biology and breeding success are promising ways to identify the place of individual species in ecosystem models. We have therefore been making detailed studies of promising species of seabirds at a few breeding cliffs, gathering data and formulating our interpretations which

should apply to other places. We have concentrated on Common Murres and Black-legged Kittiwakes studying activities at mapped nests, the foods brought in and the effects of the predators, Arctic Foxes, Ravens and Glaucous Gulls which live at the seabird cliffs.

B. Specific Objectives.

Marine Birds

1. To determine the number and distribution of seabirds relative to periods of the breeding season and to characteristics of available habitat within a colony or study area.
2. To provide estimates of nesting success of principal species.
3. To establish and describe sampling areas which may be used in subsequent years or by other persons for monitoring the status of populations.
4. To determine the amount and kinds of foods used by the principal species, and to determine the foraging patterns, when possible, to determine the relationship of food selected to that available.
5. To describe the chronology and phenology of events in the biology of breeding birds, including changes in population from the beginning of occupation of sites in the spring through departure in the fall.
6. To provide comparisons of current data with recent historical data.

Waterfowl and Shorebirds

1. To determine the number and distribution of principal species at spring arrival, during the breeding season and in fall gatherings, as these are related to characteristics of available habitat within the area.
2. To establish and describe sampling areas which may be used in later years or by others for monitoring the status of populations.
3. To provide a comparison of current data with recent historical data.

c. Relevance to Problems of Petroleum Development.

The primary purpose of this work is to identify those aspects of the biology of wildfowl which deserve careful consideration in order to avoid unnecessary damage in the course of development associated with oil extraction. Furthermore we feel that we should suggest management techniques and political institutions which may function to prevent or to mitigate unwanted effects.

The wildfowl resource has a direct political value which can be measured in terms of the number of people who complain and the intensity of their response if birds are harmed. The birds also have a value, being at the tops of marine food chains, as indicators of changes in the effectiveness of energy transfer from one trophic level to another. An illustration of this sort of phenomenon is supplied by the differences in the seabird fauna between Norton Sound and the adjacent region from Saint Lawrence Island to the Bering Strait. We have discussed these differences in detail in other reports. We review certain aspects of those differences in the next section.

III. CURRENT STATE OF KNOWLEDGE

We reported on the general state of knowledge of seabirds in our report for 1976 (Steele and Drury, NOAA 1978). In this section we will include summaries of: A) what we have observed as to the geographical and faunal differences between Norton Sound and the waters between Saint Lawrence Island and the Bering Strait; and of B) what is known of the breeding biology of Black-legged Kittiwakes in the waters of the Alaskan Continental Shelf.

A. Contrast Between Two Geographic Regions in the Northern Bering Sea.

As one goes west from Cape Nome along the southern shore of the Seward Peninsula, a number of biological changes can be observed. The natives of the region, speakers of Inupiat, traditionally depended primarily on the hunting of marine mammals and seabirds for their food and clothes. At sea, the great whales (Bowhead, Finback, Minke and Grey Whales), smaller whales (Belukhas and porpoises), walrus and Bearded Seals become numerous and are important food items as are the smaller seals (Ringed and Spotted). Migratory seafowl (King Eiders, Oldsquaws and Black Scoters) are numerous in spring. Auklets are a conspicuous element of the seabird fauna and Thick-billed Murres are a major percentage of the murre population. On land, tundra vegetation becomes progressively lower and more scattered and the waterfowl of fresh water and lowland tundra become progressively sparser.

As one goes east from Cape Nome and Safety Lagoon, one finds that the native people are speakers of Yupik who have traditionally depended on fishing and on caribou hunting. Other than small seals, occasional walrus and Belukhas, marine mammals are inconspicuous and most waterfowl migration consists of geese and fresh water ducks. Virtually all murres are Common Murres. They, Black-legged Kittiwakes, Pelagic Cormorants and Horned Puffins make up the seabirds, as auklets are absent. Seabird nesting colonies are smaller and scattered along the coast on small headlands. Instead of nesting in isolated pairs, Arctic Terns gather into a large colony. Aleutian Terns are present as well. Chum and Pink Salmon run the rivers in early summer, and as a consequence Glaucous Gulls gather conspicuously along the rivers and shoreline in

mid and late summer. Whistling Swans, Canada Geese, Pintail, Baldpate and Greater Scaup are numerous in the lower reaches of rivers that flow into salt marshes or send out distributaries onto broad mudflats. These waterfowl congregate in late July and large numbers can be found into late September. On the uplands, the tundra vegetation is wetter and taller as more shrubs, including blueberries, grow, and East of Golovin, White Spruce is found.

The predominance of fish-eating seabirds and virtual absence of crustacean eaters (with the exception of small numbers of Parakeet Auklets, a species of catholic tastes) would appear to be related to the different system of current flow in Norton Sound as compared to the Chirikov Basin. Coastal water, largely maintained by outflow of major Alaskan rivers, enters Norton Sound and forms a counter-clockwise gyre moving out northwest past Nome and Sledge Island. The eastern third of the sound appears to be removed from this flow and it appears to be dominated by flow from local rivers. The lack of zooplankton eaters, suggests a lack of zooplankton, hence a lack of suitable floating green plants for Copepods, Euphausiids and Mysids to feed upon. Some planktonic food must be available to small 'silver fish'. These small fishes, Herring, Rainbow Smelt, Salmon smelt, Saffron Cod and especially Sand Lance provide food for the Common Murres, Horned Puffins and Kittiwakes. This conspicuous difference in seabird species abundance reflecting their differing feeding strategies (which must have extensive ramifications in the biological and physical oceanography of the region) still remains to be studied under the auspices of OCSEAP.

Such conspicuous faunal differences, especially since they are associated with distinct ecological structures, provide a natural basis for categorizing regions of Alaska's Outer Continental Shelf. It would seem efficient to base further development of the environmental assessment program on investigating the similarities and dissimilarities between neighboring systems such as these

B. Knowledge of the Breeding Biology of Black-legged Kittiwakes in the Waters of the Alaskan Continental Shelf.

The following observations result from a workshop on geographical variation in the reproductive success of Black-legged Kittiwakes together with papers on the food, foraging patterns, winter activities and mortality of this species. The reports were part of the Pacific Seabird Group Meetings.

1. Black-legged Kittiwakes have a number of characteristics that make them more easily studied at their breeding sites than other cliff-, burrow-, or rubble-nesting species. They may prove useful as an indicator of indirect effects of oil spills. Because they are relatively insensitive to the direct and catastrophic effects of oil spills, their

numbers remain relatively constant, and they are relatively inexpensive to monitor.

As a result of the studies made in four regions (Cape Lisburne to St. Lawrence Island, the Southern Bering Sea, Southwest Gulf of Alaska and Northeast Gulf of Alaska) over three years, we have identified the following kinds of information, not only as important for understanding the biology of Black-legged Kittiwakes, but also so that kittiwakes can be directly useful for environmental assessment by NOAA and BLM.

a. Reproductive Biology

i. There is a gradient in the date of laying of first egg and the peak of egg-laying that varies from the GOA regions to those of the Bering Straits and Norton Sound, with those in the north being laid later. (Table 1a) There is also apparently an historical change in phenology, at least at Cape Thompson, where, in the 1960's, (Schwartz 1966) clutches were initiated earlier than in the present studies (1975-1977). (Springer and Roseneau 1978)

ii. There are important and regular variations in the size of clutches and the percent of nests in which eggs are laid from one region to another, with smaller clutches being laid and fewer nests receiving eggs in the north than in the GOA. Again, historical information suggests that in the 1950's (Pribilof's Hunt, Squibb and Peterson 1978) and 1960's (Cape Thompson, Schwartz 1966) clutch size may have been larger than at present.

If one lists average clutch sizes from all available data according to date of laying (Tables 1a and 1b) it emerges that there is a trend in clutch size from largest in the earliest laid (the first week of May) to smallest in the latest (the first week of July). The trend appears to be continuous for all Kittiwakes throughout the season if data from the Barents Sea, the North Sea, the Gulf of Alaska and the Bering Sea are all shown together (Table 1b). More data are needed from early and middle June to show whether this apparent trend is in fact continuous.

iii. Important differences exist in the regularity of reproductive success in different geographic regions as well. These differences have, in the past three years, usually been expressed in the number of eggs hatching per nest, either because fewer eggs were laid or because eggs failed to hatch. In some regions there have been years of failure and years of greater success (high productivity) in which some pairs even raise two chicks per nest. In other regions, reproductive success has been consistently moderate and no parents have been able to raise twins.

iv. The reasons for reproductive failure have differed in different regions. In the north, particularly, absence of food has been suggested to be the primary influence, while in the GOA, bird predators, perhaps taking advantage in changes in kittiwake behavior in response to shortages of food, are the proximate cause of reproductive failure.

Kittiwakes in other parts of their circumpolar range, e.g. the Northeast Atlantic, where this species is reproducing very well and the population is increasing, lay earlier and lay larger clutches than in Alaska (Table 1b). One would presume according to theory that (Lack 1954 ~~et seq~~) timing of laying of the clutch, size of the clutch, and the percentage of nests receiving eggs all relate to the availability of food. The above results all suggest that Bering Sea and Bering Strait kittiwake populations are presently subject to stress due to food limitation.

b. The food used by kittiwakes varies in conspicuous ways between regions. In the GOA kittiwakes depend heavily on Capelin, which seems to be consistently available. This resource is augmented by Sand Lance, especially when parents are feeding young.

In the southern Bering Sea kittiwakes use a diverse food supply without heavy dependence on a single species.

In the northern Bering Sea different colonies use different foods, and high levels of success between 1975 and 1977 seem to have depended upon appearance of Sand Lance in the feeding range.

Kittiwakes are evidently opportunists in their feeding. They will become specialists if suitable prey is available. Whether a colony has a consistent or "boom/bust" economy seems to depend upon the kinds and numbers of small fish and crustacea and the phenology of those organisms in the surrounding area, see Discussion.

IV. STUDY AREA

The study areas in Norton Sound (Figure 1) were described and illustrated in our March 1977 report. Our efforts in seabird work this year were concentrated on intensive studies at Bluff, and short-term surveys of the colonies at Sledge Island, Topkok Head, and Rocky Point. Our waterfowl surveys covered from the base of Cape Spencer to the Cape Denhigh and Shaktoolik region.

v. METHODS AND RATIONALE OF DATA COLLECTION

In 1975 and 1976 we developed and tested various field methods for censusing the Bluff colony and sampling reproductive success. This year our emphasis was on applying those methods to intensive studies of the

Table 1A. Comparison of laying dates and clutch sizes of Black-legged Kittiwakes in Alaska.

<u>Place</u>	<u>Approximate date of starting clutch</u>	<u>Peak of laying</u>	<u>Clutch size</u>	
Cape Lisburne	1 July	10-16 July	1.02	Springer G Roseneau (NOAA 1978)
Cape Thompson	2 July	5-13 July	1.1	Springer & Roseneau (NOAA 1978)
Cape Thompson	21-25 June		1.88-1.92	Schwartz (1966)
Sledge Island	20 June		1.53	Drury et. al. (NOAA 1978)
Bluff Cliffs	19-25 June	4-12 July	1.16-1.2	Drury et. al. (NOAA 1978)
Cape Pierce	19 June	20 June		Hunt, Squib & Peterson (1978)
Saint Paul Island	29 June-5 July		1.37-1.46	Hunt, et. al. (NOAA 1978)
Saint George Island	30 June-1 July		1.36-1.46	Hunt, et. al. (NOAA 1978)
Southwest Gulf of Alaska			1.38-1.87	Moe, et. al. (1978)
Kodiak Island Area	5-10 June	12-17 June	1.56-1.96	Nysewander et. al. (1978)
Northeast Gulf of Alaska	1-10 June	19-25 June	1.76	Lehnhausen, et. al. (1978)

Table 1B. Comparison of Kittiwake clutch sizes in England, Russia and Alaska.*

	May				June				July	
	<u>1st wk.</u>	<u>2nd wk.</u>	<u>3rd wk.</u>	<u>4th Wk.</u>	<u>1st wk.</u>	<u>2nd wk.</u>	<u>3rd wk.</u>	<u>4th wk.</u>	<u>1st wk.</u>	<u>2nd wk.</u>
England	2.3-2.8 (2.4) ⁺	2.0-2.4 (2.3) ⁺	1.9-2.3 (2.1) ⁺	1.8-2.0 (1.9) ⁺	1.8-2.0 (1.8) ⁺					
Russia	2.3		2.0	1.5						
Alaska					1.8	1.6-2.0	1.5-1.9	1.4-1.5	1.4-1.5	1.0

* Coulson and White (1961), Belopol'skii (1957), and Uspenski (1956).

⁺ Average clutch size.

Figure 1
Map of the Bering Strait Region



reproductive biology of the seabird species present, especially murre and kittiwakes. Most of these methods are described and discussed in detail in the March 1977 Annual Report for this research unit. Below, we shall briefly describe the methods used this year, and more thoroughly discuss new or modified procedures.

A. SEABIRDS

1. Bluff Cliffs and Square Rock

A party of two visited Bluff on 21-26 May and 3-11 June. From 12 June until 12 September, a permanent party, usually of four, collected data at Bluff Cliffs and Square Rock. Twenty-one study sites were visited roughly every other day beginning 14 June. The sites were illustrated in last year's annual report; in Table 1c we list the data collected at each of these sites in 1977.

Estimates of Populations

We made censuses from a small boat passing in front of the cliffs in the same way as in 1976. Our counts of the Bluff Cliffs (Figure 2) were on 28 June (murre only), 7 and 29 July, and 19 August; and of Square Rock and adjacent cliffs on 19 August.

Twenty-four Hour Counts (To determine Daily Activity Patterns)

Many investigators have noted that the number of birds occupying the cliffs varies over the course of a day. Thus, a single count may only reflect a percentage of the total birds actually occupying the cliff that day. In 1976 we used counts taken at different times of the day over the entire season to arrive at a curve for daily attendance. However, that method does not allow for possible changes in the attendance pattern over the course of the season. In 1977 we made hourly counts of murre and kittiwakes for 24 or 25 consecutive hours in delineated count areas at Bluff Cliffs (Study area 14-15) and Square Rock simultaneously. These counts were taken on 14 June, 30 June-1 July, 9, 19, and 29-30 July, and 8-9 August. Increasing amounts of darkness forced us to interrupt the late July and August counts in the early hours. Also, we felt that the accuracy of the counts declined during dusk hours on the counts of 19 July and after, as the birds became difficult to see.

From these counts we calculated a correction factor relating the number of birds present on the cliff at each hour to the highest count of birds from that 24 hour cycle. This correction factor was then applied to censuses or counts at study sites to correct for differences which result from the daily activity pattern, and thus to determine the actual population totals. Cliff counts were generally made on a day adjacent to a 24-hour count.

Table 1C. List of study areas at Bluff and data collected at each.

<u>study Site</u>	Kittiwake		Murre		Puffin
	<u>count</u>	<u>map</u>	<u>count</u>	<u>map</u>	<u>count</u>
1	x		x		
1B			x	x	x
2				x*	x
3	x				x
4				x	x
4B		x	x	x	
5		x	x		x
6			x		x
7	x		x		x
8		x	x		x
9	x		x		x
10		x		x	x
11	x		x		x
12				x	x
13		x			
14		x			
15	x		x	x*	
16 (not used)					
17		x			
18					x
19		x	x	x	
Square Rock		x	x	x	

*Thick-billed Murre maps (all others are of Common Murres).

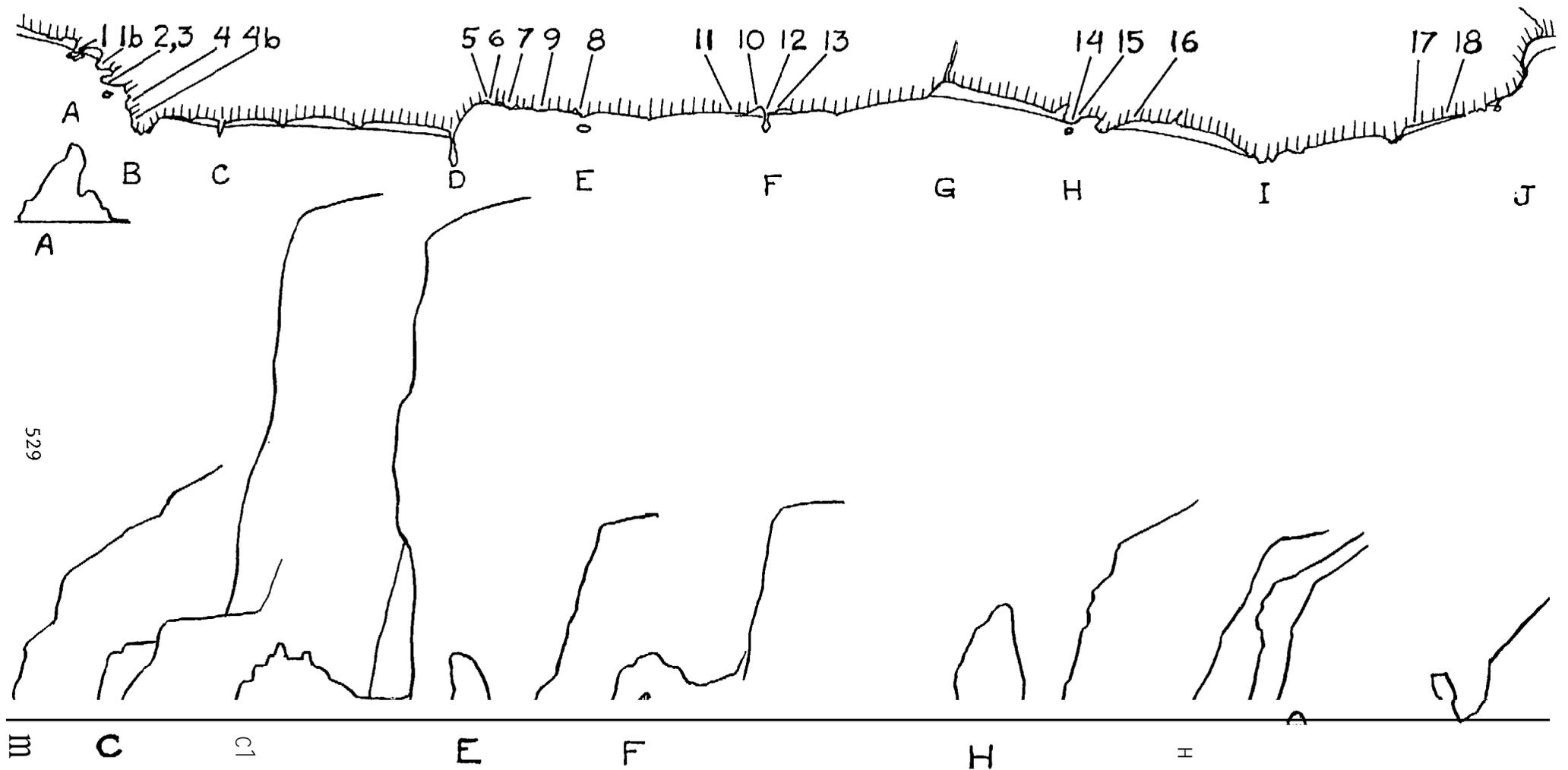


Figure 2. Diagram of the cliffs at Bluff, showing locations of study sites and landmarks used during censuses.

Reproductive Schedule and Success

a. Black-legged Kittiwakes

We established kittiwake map areas in the same way as last year. In addition to noting on each visit the number of adults, eggs and chicks at individual nests, we also recorded the physical status of the nest site and the amount of material added to it. We established three statuses: a "rock roost" or bare rock ledge with no material on it; an "old pad" of material remaining from the previous year; and a "cup" capable of holding an egg.

b. Common and Thick-billed Murres

i. Maps - The data and hence the estimates of breeding schedule and reproductive success are relatively imprecise when compared to the kittiwake data due to the difficulties in seeing which birds have eggs or chicks, and to the varying number of nonbreeding and unsuccessfully breeding birds. We have found that the best method of following the progress of the breeding season and determining reproductive success is by selecting a ledge which is visible from the top of the cliff, and noting on a sketch map or photograph the locations of all eggs and chicks seen. The situation at each of these sites is checked roughly every other day. If an adult murre does not move so that we can see under it, the status noted at the previous visit is presumed to still exist. Chicks are more easily seen than eggs, especially after they have grown larger and begun to move around. Using this method, we were able to determine the laying, hatching and departure periods and the peak of each; and to obtain relatively accurate figures for the number of eggs laid, chicks hatched, and chicks fledged for each mapped ledge.

ii. Estimates of the breeding population - This is a difficult number to determine, due to varying numbers of apparently nonbreeding birds. (See definition and description of "breeding birds" under the section on murre reproductive success.)

1) One way of estimating the breeding population of murres is to use counts of birds which are strongly attached to the cliffs, as these are the birds that are probably trying to lay an egg, or are protecting an egg or chick. The counts of birds remaining on the cliffs during the disturbance caused by the cliff counts, made at or after the peak of laying, were used to get an estimate of the total number of breeding birds. This was also done in 1976. In 1977, the peak of laying occurred from 7-10 July. The cliff census of 7 July yielded 44,736 birds of which 40,000 were "persistent". One estimate of the numbers of breeding pairs therefore is approximately 20,000 (half the number of breeding birds).

2) A second way of estimating the total breeding population, (also used in 1976, see p.30 *op.cit.*), is to figure a percentage of breeding birds to total birds present at study sites and relate this figure to a cliff count. Table 2 shows the probable number of breeding birds at each of the six map sites. (See also the discussion under Reproductive Success on the determination of breeding birds.) These figures taken as a percent of the season's high counts gives an average figure of 71%. If we apply this percent to the highest cliff count figure of 62,000 we get 44,000 breeding birds, again about 20,000 pairs.

3) Breeding birds, i.e. those with eggs or chicks to protect or strong territorial attachments, are likely, as mentioned before, to remain on the cliffs longer when faced with a disturbance (such as a small boat passing the cliffs), than are non-breeding birds. Note that in 1976, (see Table 3 and Figure 3) the percentage of birds remaining on the cliffs varied from 50-68%; while in 1977 the percent varied from 69-96%. In 1977 the highest percentages of persistent birds occurred during the incubation period, which is as expected. In 1976, the highest percentages did not occur until August, and there was a dip around 9-11 July which was when the breeding schedule was apparently interrupted. These findings suggest that the number of birds remaining on the cliffs, i.e. the persistent birds, may correlate with reproductive success. Note that this number was much higher in 1977 than in 1976,

c. Horned Puffins

We made regular counts of puffins to determine their variation in numbers at the cliff. It is relatively difficult to obtain reproductive data on puffins, because they nest in crevices in the cliff face. We obtained limited data about their reproduction from a few nest holes visible from the top of the cliffs.

d. Pelagic Cormorants and Glaucous Gulls

We located and monitored individual nests of these species that were visible from the tops of the cliffs.

Trophic Studies

Throughout the season, we kept notes on feeding aggregations that we could see from land, and on fish that we saw murre and kittiwakes bring to the cliffs. These notes are summarized under the appropriate bird species. We lacked the logistics to collect birds for stomach contents.

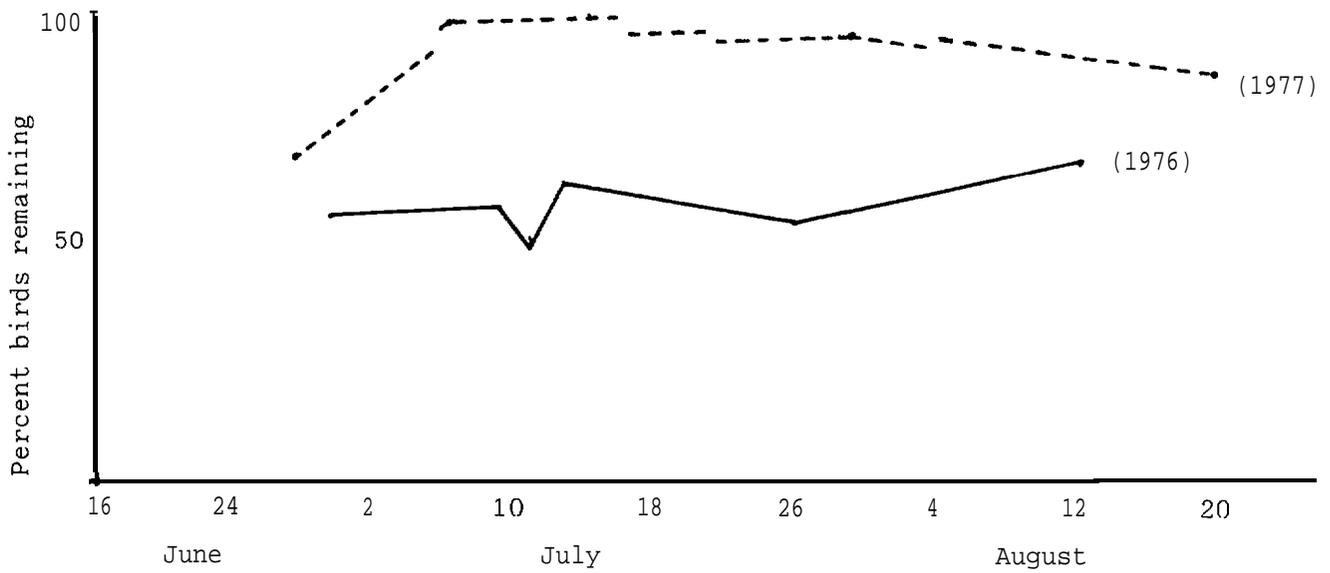
Table 2. Number of "breeding" birds at Murre map areas (as a percent of the season's high counts) .

Map Area	Probable Number of "Breeding" Birds	Seasons High Count	Percent "Breeding" Birds
1B	45	63	71%
4	35	58	60%
4B left	47	55	85%
4B inside	53	74	71%
10	139	201	69%
12	51	70	72%

Table 3. Counts of Murres at Bluff - comparison of percentage of birds remaining on the cliff during censuses.

1976		1977	
Date	<u>Percent remaining</u>	Date	<u>Percent remaining</u>
June 16	58%	June 28	69%
June 30	57%	July 7	93%
July 9	58%	July 29	96%
July 11	50%	August 19	86%
July 13	62%		
July 26	55%		
August 12	68%		

Figure 3. Murres remaining on the cliff during censuses.



Predators

At the October 1976 meeting of OCSEAP Principal Investigators working on birds, there was general consensus that Ravens played a major role and Glaucous Gulls a significant role in egg and chick mortality of kittiwakes and murre. In order to examine the impact of these predators, we kept detailed notes on the species, especially of Ravens, throughout the 1977 season. We kept notes on the predatory behavior of the species and all instances in which we saw them carrying seabird eggs. We also recorded the "caches" of egg shells that we found on the tundra. In addition, we kept notes on the other raptors of the area: Golden Eagle, Rough-legged Hawk, Marsh Hawk and Gyrfalcon.

2. "Sledge Island"

We visited Sledge Island by boat on 22-24 June and 23 August. On each visit we circled the island in a boat and counted all species, and also visited the two study sites established in 1975 to sample reproductive success of pelagic cormorants, murre and kittiwakes.

3. Topkok Head was visited by boat on 17 July and 22 August and Rocky Point on 22 July and 20 August. On those trips, we counted all species and sampled reproductive success of Pelagic Cormorants and Glaucous Gulls.

B. WATERFOWL

The method of waterfowl transects in 1977 was the same as in 1976. We made flights in late May and early June over the small sections of open water at the mouths of rivers and in temporary ponds. In late August we flew over the major areas of coastal wetland on the south side of Seward Peninsula.

These flights were not straight-line transects, but were in the form of "reconnaissance" surveys to locate the major concentrations of waterfowl, and their critical gathering areas.

We are confident that we know where the important waterfowl gathering places are in our area in the fall. Using the maps we have prepared it will be possible to establish fixed transects if annual monitoring of the populations in sample is required.

VI. RESULTS AND SPECIES DISCUSSIONS

A. SEABIRDS

1. Censuses

Table 4 presents the rounded maximum and minimum counts of adult birds at the five colonies we monitored in Norton Sound.

Table 4. Bird populations at colonies in Norton Sound, 1977.

Maximum and minimum censuses and estimates shown for five localities.

	<u>Sledge Island</u>	<u>Topkok Head</u>	<u>Bluff Cliffs</u>	<u>Square Rock</u>	<u>Rocky Point</u>
Pelagic Cormorant	310 - 500 70 nests	292 - 331 140 nests	108 - 170 70 nests		650 - 920 250 nests
Glaucous Gull	ii 2 nests	130 22 nests	97 - 185 30 nests	18 - 24 9 nests	250
Black-legged Kittiwake	400 - 750		6000 - 8700	1210	
Murres	2750 - 6300		28,400 - 48,900	7600	
% Common	85%		99%	100% (?)	
Pigeon Guillemot	7	13	2		
Horned Puffin	53	115 - 230	813 - 1312	400	130 - 210
Tufted Puffin	3	11 - 31	6		4

Table 5. Comparison of Murre numbers, 1975-1977.

	1975	1976	1977
<u>Bluff</u> high count	90,000	56,000	62,000
breeding pairs	25,000	13,000	20,000
<u>Square Rock</u>	6200	4000	7600
<u>Sledge Island</u>	2300	2900	2800 - 6000

Significance of year-to-year variation in murre numbers

Table 5 shows a comparison between estimates of the numbers of murrens at Bluff, Square Rock and at Sledge Island for 1975, 1976 and 1977. An increase in numbers is indicated from 1976 to 1977 at all three places, ranging from 10-52% more birds. This change is interesting in that it suggests that total numbers may correlate with reproductive success. The highest numbers and figures of reproductive success occurred in 1975. Both were much lower in 1976, and in 1977 both increased again, although not to the levels seen in 1975.

2. Reproduction and Variation in Numbers

Bluff Cliffs

a. Black-legged Kittiwakes

Estimates of Numbers

Table 6 shows the results of our three boat censuses of kittiwakes at Bluff and the correction for the daily variation in numbers to show the possible maximum number of birds. The number present in 1977 was about the same as 1976. We presume the increase in the August count (which occurred in counts at study sites as well) reflects an influx of younger birds coming to the colony (cf. Coulson & White 1958).

Daily Attendance at the Cliffs

The results of our 24-hour counts are shown in Figure 4. We conclude from these data that the daily schedule of kittiwakes varied over the course of the season, and that the schedule was different **between** Square Rock and the Bluff Cliffs. We should test in future seasons whether the variation is the same from year-to-year. However, we have indications, discussed below, that some of the changes in the kittiwakes' attendance pattern are correlated with events surrounding the poor reproductive success.

The percent fluctuation in the number of birds present over the course of a day was lower during egg-laying but increased again in mid and late July, to reflect departure of a large percentage of the birds during the night hours. There is some effect of the increasing amount of darkness on the ability of an observer to count all of the birds on the cliff, which might make the number lower, but nevertheless the drop in kittiwake numbers at nighttime was dramatic, especially on 29-30 July. During that count, only 10% of the highest count at study site 15 was present at 01:00. We checked the kittiwake map area at study site 14 at the same time, and found that only three

Table 6. Estimates of total numbers of Black-legged Kittiwakes, Bluff 1977.

(counts made from a boat passing in front of the cliffs)

Section of Cliff	7 July		29 July		19 August	
	max.	min.	max.	min.	max.	min.
A to C	1440	1270	1800	1080	1775	1600
C to D	1370	1300	1700	1500	1670	1575
D to E	550	540	800	790	1310	930
E to F	950	890	980	760	1420	1300
F to G	520	440	650	610	740	690
G to H	300	280	210	160	440	360
H to I	750	571	966	856	950	870
I to J	150	120	280	270	280	260
TOTAL (A to J)	6030	6011	7386	6026	8585	7555
Percent on cliff*		100%		86%		99%
CORRECTED TOTAL	6030	6011	8588	7007	8672	7631

* at same time during nearest 24-hour count

Figure 4. Twenty-four hour counts = Kittiwakes

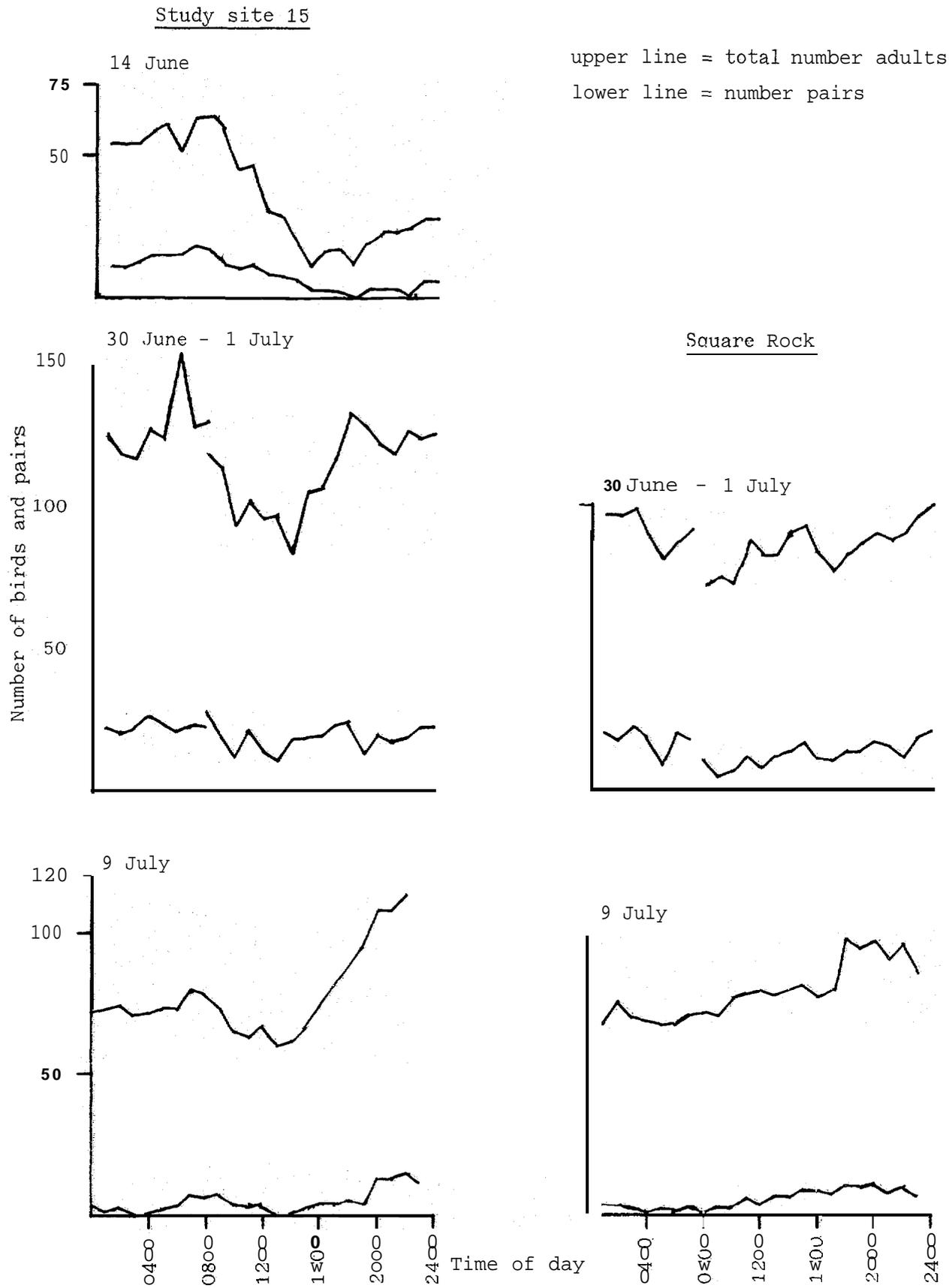
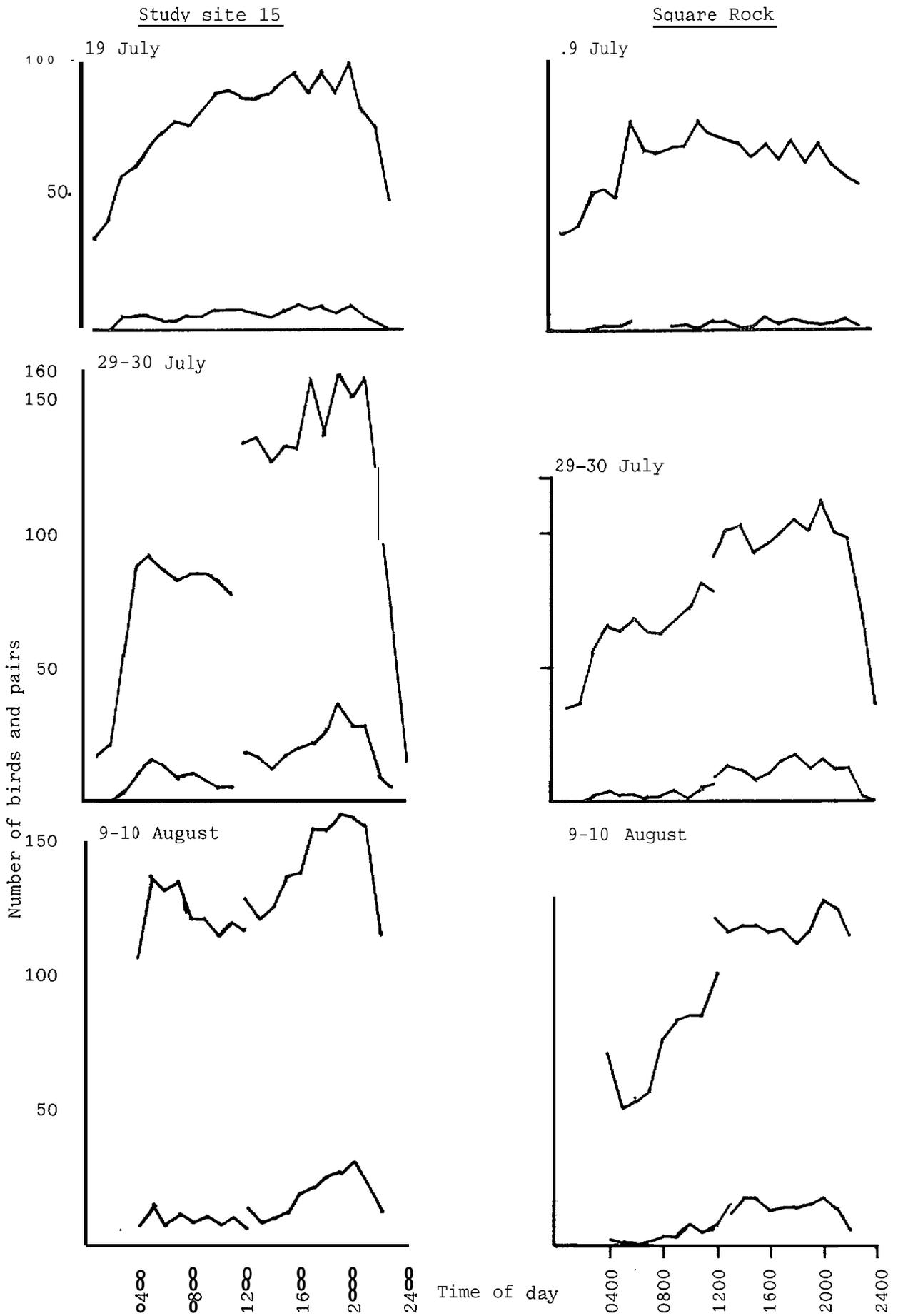


Figure 4 (cont.). Twenty-four hour counts - Kittiwakes



birds were present out of a normal count of 40. By 02:30 there was a visible stream of kittiwakes coming in to the cliffs from all directions. By 05:00 numbers had built to a *first* peak, yet the maximum number of birds present at the end of the count at 11:00 was only 60% of the number at the beginning of the count.

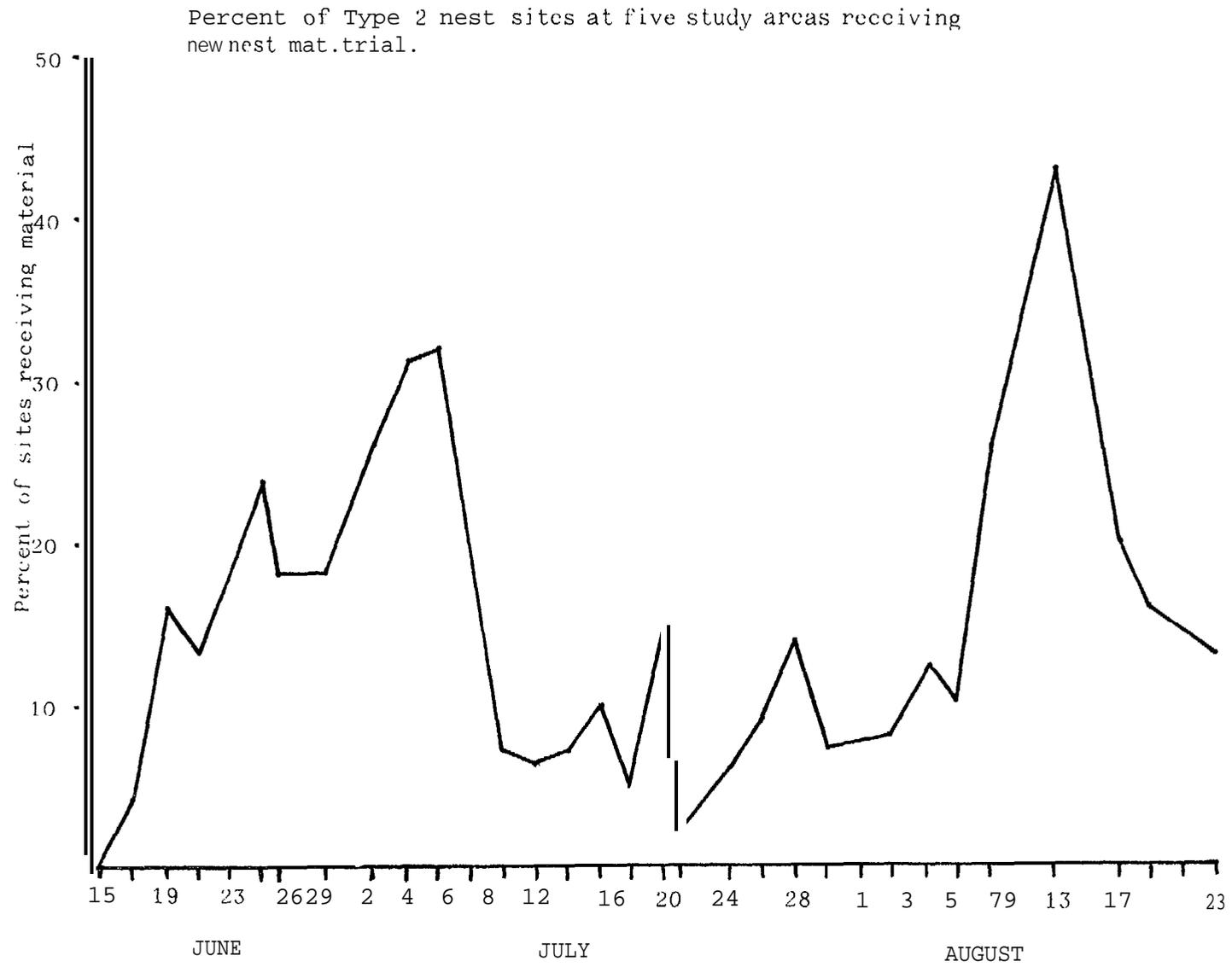
Reproductive Success

The 1977 season was another poor one for Black-legged Kittiwakes at Bluff, although not as poor as the near total failure in 1976. We have analysed the events surrounding the reproductive season, and believe we have identified a period of stress similar to, but less severe than the one that evidently occurred in 1976.

The reproductive season consists of a series of events during any of which a disruption may depress total breeding success. The events that we consider are: how many birds come to the cliffs and how many build nests in time for them to be productive; how many eggs are laid and when, how many hatch, when are eggs lost; and, finally, how many chicks fledge. In our detailed study we are able to show when a disruption occurred and to speculate as to what environmental event at sea might have affected the kittiwakes. These' data ultimately are useful in determining what changes in kittiwake population size and reproductive success mean as indicators of events in the marine ecosystem.

(i) Significance of Nest Site "Status"

This year, part of our data are on nest-building and the physical status of a nest site, which we use as indirect indicators of the level of reproductive effort. We have given special attention to territorial establishment and nest-building because a large percentage of the birds we have studied have not "progressed" beyond that stage of the reproductive cycle. We know from our own observations, from other kittiwake studies (cf. Coulson & White 1956), and from studies of other gulls, that nest-building occurs late in the courtship sequence, primarily after copulation (we have seen pairs copulating on bare rock ledges before any nest material was placed on the site). Building activity then indicates at least that the site has a pair on it. The largest burst of building on a site generally occurs just before an egg is laid: therefore, building activity is an indication of a high level of motivation on the part of the occupants to reproduce. Figure 5 shows the percent of all sites that were improved during the season. The first peak in building occurred just before the peak of laying. The second peak, in August, occurred following the occupation of new sites and reoccupation of sites that had been attended earlier in the season and then abandoned.

Figure 5. Nest-building activity in Black-leoped Kittiwakes.

At the beginning of the season, some kittiwake sites are bare rock roosts, while others have old pads of nest material from a previous season. We found that only nine of the 55 sites that received eggs (17%) originated as rock roosts. There are two possible reasons: an old pad may indicate that the site is physically stable, by virtue of the persistence of material on it; and/or, old pads may be occupied by older, more experienced birds. Some rock roosts are obviously inferior sites (e.g., on seaward-sloping ledges, or loose dirt or unstable boulders) and many are not built on until late in the season.

For the purpose of a detailed estimate of degrees of reproductive success, we have defined three types of sites we think indicate three parts of the breeding population. This analysis can be used only when observations are made throughout the season. Future investigators may want to see if the percentage of each type of site is different in years when kittiwakes are more or less productive. We have excluded from this analysis sites that we saw occupied infrequently. These sites may have been used by loafing birds or birds prospecting for a site.

Type 1. Sites improved on or before the peak of laying should indicate all those pairs that were both highly motivated and on schedule so as to have a chance at being productive.

Type 2. All improved sites includes those developed late in the season. This number is biologically significant, in that it includes all those sites occupied by birds that were definitely paired, and where the pair was highly enough motivated as to build or begin building a nest even though they may not succeed in reproducing. Additionally, this number should be close to the number of "nests" that one would count when sampling reproductive success from the top of the cliff or from a boat in late August or early September.

Type 3. All regularly attended sites includes the sites that were attended on at least half of our visits, but not improved, including those seen occupied only by single birds. Few other studies of seabird reproduction try to include these birds, but we feel the persistent attenders at the cliff should be noted.

Our main argument for this analysis is that there is no single figure for reproductive success; and that the figure arrived at is affected by how we define what we are measuring and with what part of the population we are concerned.

(ii) Reproductive Data

Table 7 shows data for reproductive success as obtained at seven study sites along the Bluff Cliffs, study site 19 on the cliffs opposite Square Rock, and a section of the north side of Square Rock.

Table 7. Reproduction of Black-legged Kittiwakes at Bluff and Square Rock, 1977.

	<u>Bluff Cliffs</u>	<u>Study Area 19</u>	<u>Square Rock</u>	<u>All Sites</u>
Type 1. Sites improved on or before peak of laying	152	20	27	199
Type 2. All improved sites.	215	32	32	279
Type 3. All regularly attended sites.	234	34	32	300
eggs	64	13	26	103
clutches	55	10	21	86
chicks	18	1	15	34
broods	17	1	14	32
fledglings*	12	0	15	27
broods	11	0	14	25
<hr/>				
eggs/clutches per				
1.	.42/.36	.65/.50	.96/.78	.52/.53
2.	.30/.26	.41/.31	.81/.66	.37/.31
3.	.27/.24	.38/.29	.81/.66	.34/.29
chicks/broods per				
1.	.12/.11	.05	.56/.52	.17/.16
2.	.08/.08	.03	.47/.44	.12/.11
3.	.05/.05	.03	.47/.44	.11/.11
fledglings				
broods	per 1. .08/.07	0	56/.52	14/.13
	2† .06/.05	0	.47/.44	.10/.09
	3. .05/.05	0	.47/.44	.09/.08
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chicks per egg	.28	.08	.58	.33
fledglings per egg	.18	0	.58	.26
fledglings per chick	.67	0	1.0	.79
avg. clutch size	1.16	1.30	1.24	1.20
avg. brood size (at hatching)	1.06	1.00	1.07	1.06

+ fledglings per Type 2 site is figure comparable with usual "chicks per nest"
 * number of fledglings is the number of chicks known to have fledged or still in their nests as of 11 September.

Table 8. Reproductive success of Black-legged Kittiwakes as measured in large sample counts of nests and chicks, 3 September 1977.

	<u>Bluff Cliffs</u>		<u>Square Rock and study area 19</u>	<u>All areas</u>
	<u>between D and G</u>	<u>between H and J</u>		
no. nests* sampled	705	514	138	1357
no. chicks, broods	72	61	32	165
	72	60	31	163
chicks/broods per nest	.10	.12	.23/.22	.12

On 3 September we walked most of the length of the cliff at the crest. At each place where we could see a sample of 25 or more nests we stopped and counted the "nests" and nestlings visible. Table 8 shows the results of this sample.

In 1975, we estimated .48 chicks produced per nest at Bluff, and in 1976, .02 chicks per nest. In 1977, .08 chicks were produced per improved kittiwake site at Bluff Cliffs, and .12 at Bluff and Square Rock combined. Thus the 1977 season was about four or five times more productive than 1976, but still only one fourth or one fifth as productive as 1975.

The difference in success between Square Rock and Bluff Cliffs is conspicuous and apparently inexplicable. Egg laying and hatching success per nest at Square Rock were about twice that at Bluff, and fledging success three to four times higher. Study site 19, on the cliffs next to Square Rock, had egg production higher than did Bluff Cliffs. However, high egg mortality caused total reproductive failure.

In Table 8, the fledging figure is lower than in Table 7 because the sample includes sites outside of those that were followed during the season, but the total figure for Square Rock and site 19 combined is the same as that obtained over the season for Type 2 sites. The north-facing side of Square Rock that we studied is presumably sheltered from the effects of bad weather, which comes primarily from the southeast. However, two sheltered north-facing areas at Bluff, the "Rope Stack" and "Thumb Stack", produced .07 and .10 chicks per nest respectively, so it does not seem that shelter was the main factor that increased success at Square Rock.

The productivity figure for Bluff Cliffs from our larger sample in Table 8 is higher than the one obtained at study sites over the season, and the difference is not ascribable to chick mortality (recorded at study sites) after the sweep sample of the entire cliff was taken. However, the figure for Square Rock and site 19 was the same as that for Type 2 sites over the season, and the figure for Bluff Cliffs and Square Rock combined is between the figures obtained for Types 1 and 2 sites. We conclude that samples taken from the top of the cliff at the end of the season will yield estimates of reproductive success which are probably as representative of the cliff as a whole as are study sites,

Although egg production at Bluff was lower than it must have been in 1975, it was considerably higher than in 1976. The major cause of failure appears not to have been in egg production, but in egg mortality, as only one third of all eggs laid ever hatched. In the next section, we present the data on phenology of the season, and following that we postulate a mechanism and a cause of the lowered reproduction.

Phonological Events Relating to Lowered Reproduction

(i) Laying and Hatching.

The number of eggs laid and the number of chicks hatched at Bluff and Square Rock are graphed for four-day periods in Figure 6.

In cases where we could not obtain an exact laying date, and the egg eventually hatched, we extrapolated a laying date by calculating back from the hatching date. We used 27 days as the standard incubation period. On several eggs that we followed from laying to hatching, the period was 26 to 28 days (the variation may be because we visit the sites every other day), and Coulson and White (1958) reported an average incubation period of 27.3 days.

The shapes of the curves reflect the normal distribution we would expect, which is in distinct contrast to the laying curve obtained in 1976 at Bluff Cliffs, which peaked normally but then plummeted abruptly (Figure 7). Too few chicks hatched in 1976 to make a useful graph.

(ii) Changes in Numbers-of Adults in the Course of the Season.

In Figure 8 we have graphed the totals of adults at five study sites as a percentage of the sum of the high counts for the season at those sites, over four-day periods. This technique enables us to show general trends in the mean number of kittiwakes present without the inevitable "noise" in the raw data, and allows us to use data for days when not all the study sites were counted.

There was a first peak in attendance at about the peak of laying, but then a gradual decline to a low point between 18 and 25 July. Attendance then increased to a new high point in early to mid-August, when renewed nest-building occurred. In Figure 9 we show the same information for 1976. A similar drop in attendance occurred then, only the decline in numbers was earlier, more rapid and deeper. This correlates with the rapid drop in egg-laying that occurred in 1976.

(iii) Occupation of Nest Sites Over the Season.

In Figure 10 we show the percentage of kittiwake nest sites in our map areas that were occupied by days during the 1977 season. These data have been corrected to reflect the maximum percentage of attendance recorded in the closest 24-hour count. In some cases the correction factor resulted in a figure greater than all the sites we know to have been occupied at the study area: such cases are shown as 100% attendance. The graph shows a conspicuous period of abandonment between 18 and 26 July at Bluff Cliffs and study site 19, but at

Figure 6 Egg laying and hatching of Black-legged Kittiwakes;
Bluff Cliffs and Square Rock, 1977.

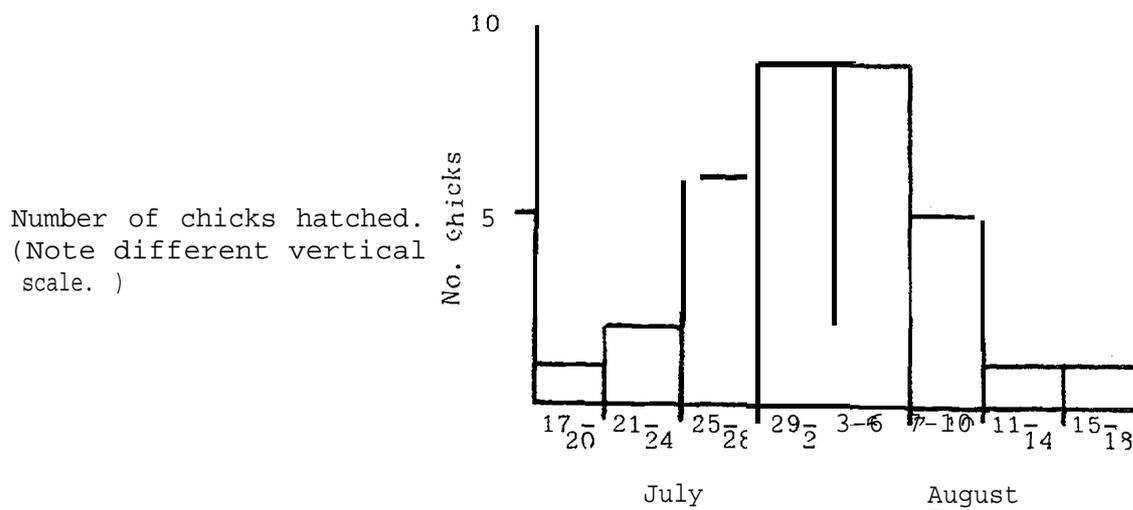
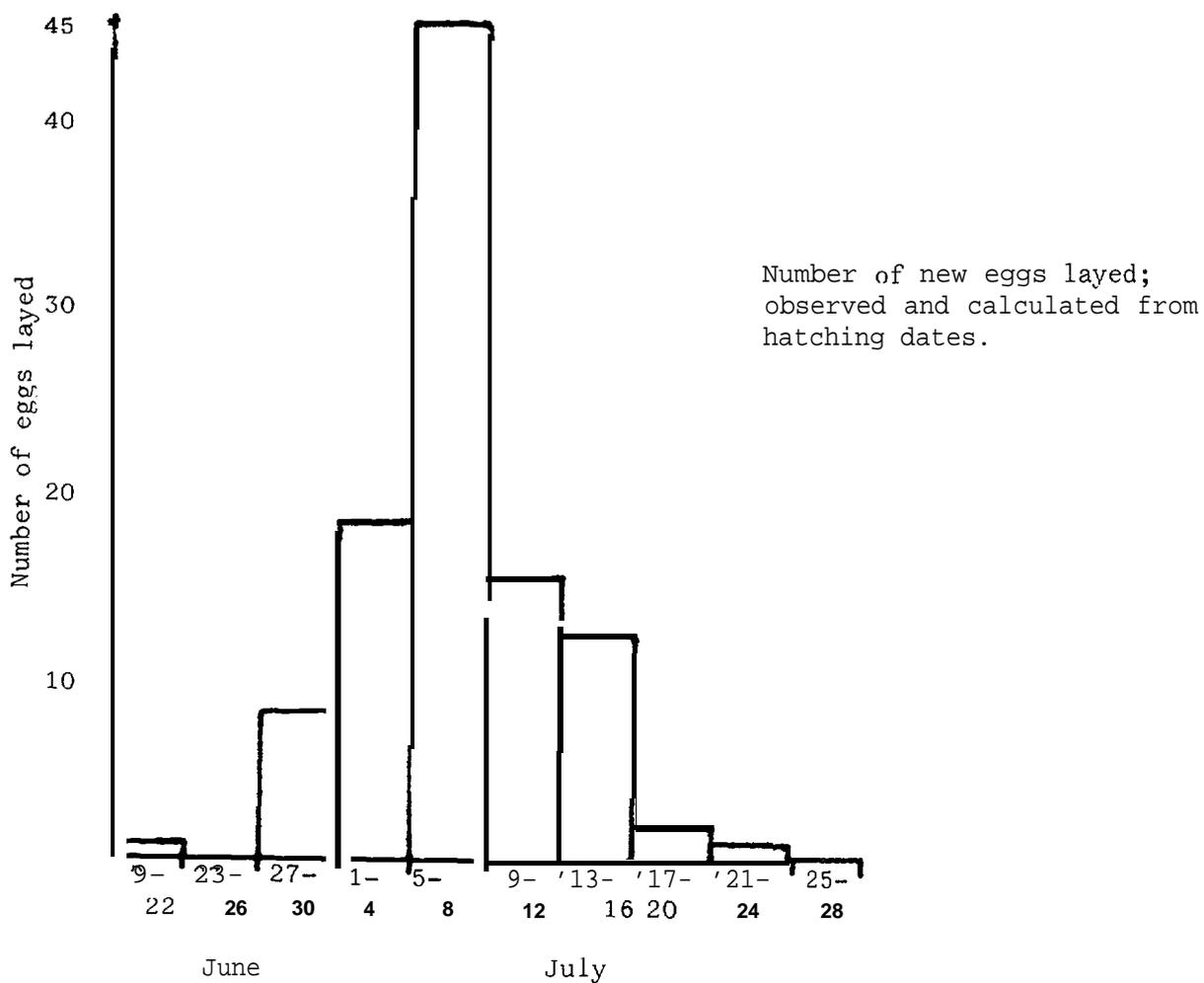


Figure 7. Egglaying of Black-legged Kittiwakes; Bluff Cliffs, 1976.

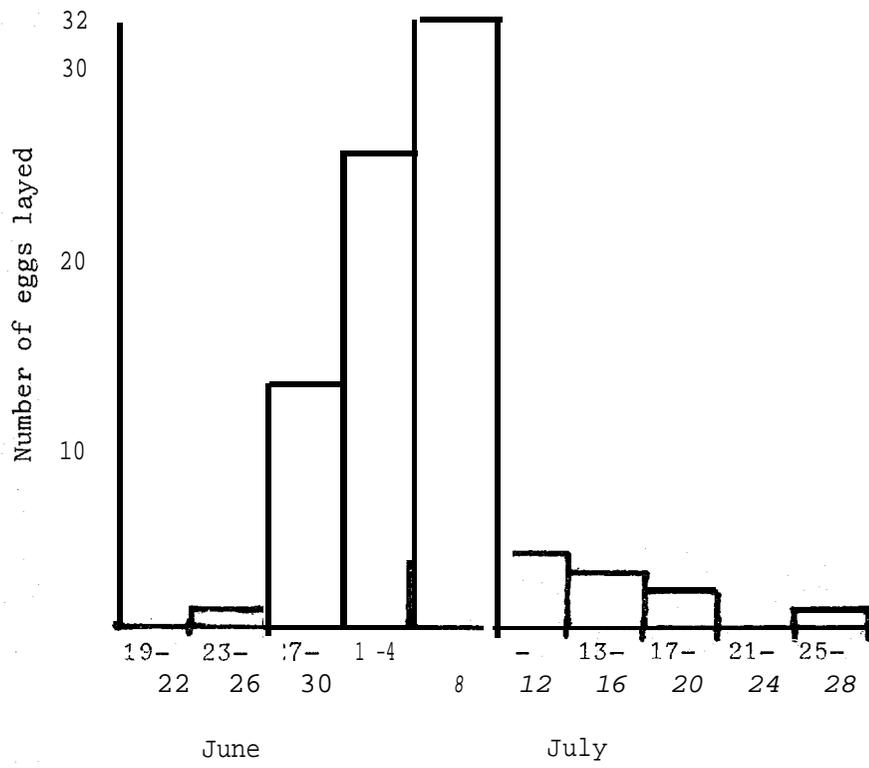


Figure 8. Variation in numbers of Black-legged Kittiwakes at the Bluff Cliffs, 1977.

Mean numbers of adult kittiwakes at five study areas, shown as a percentage of the season's highest counts.

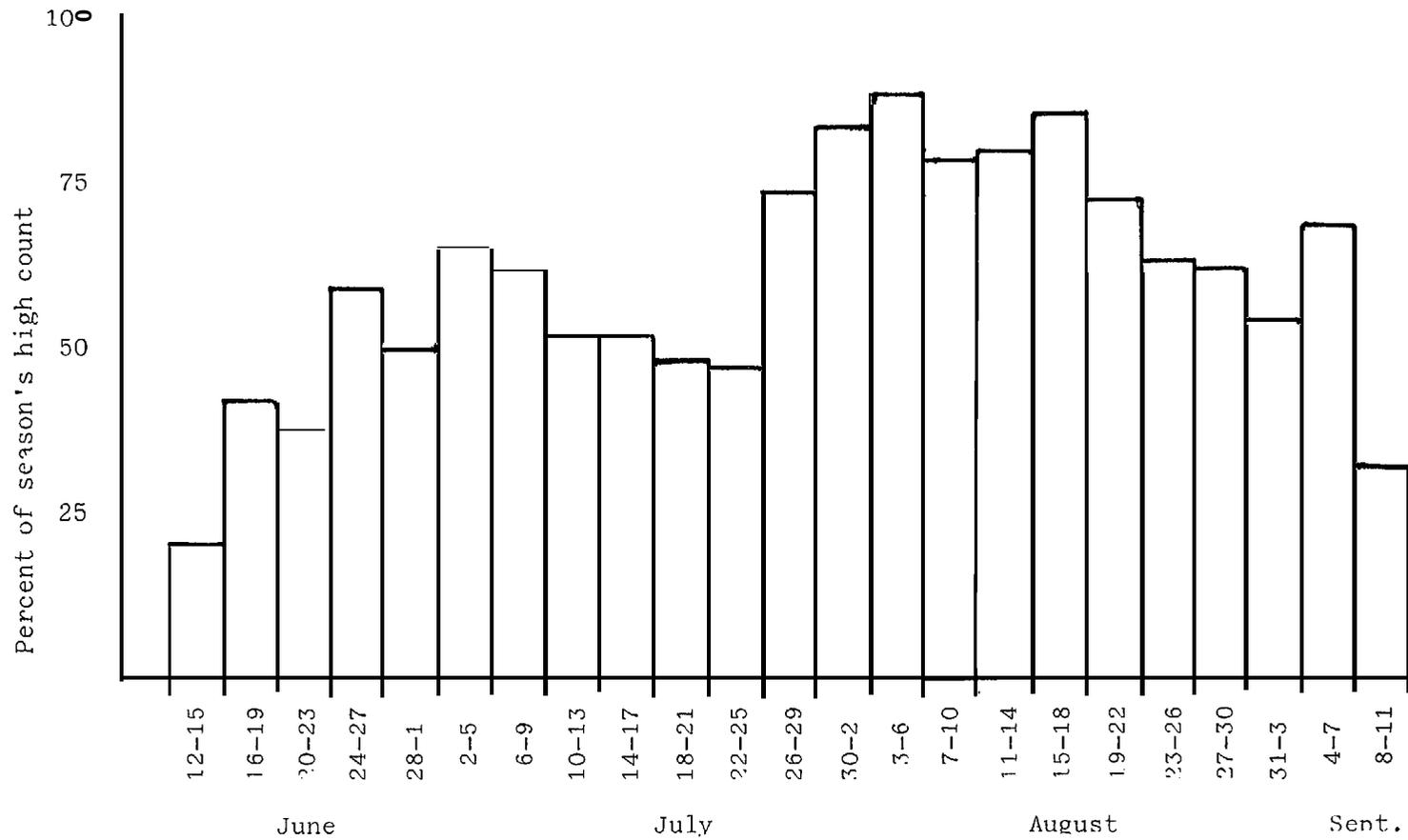


Figure 9. Variation in numbers of kittiwakes at Bluff Cliffs 1976

Data shown as in Figure 8.

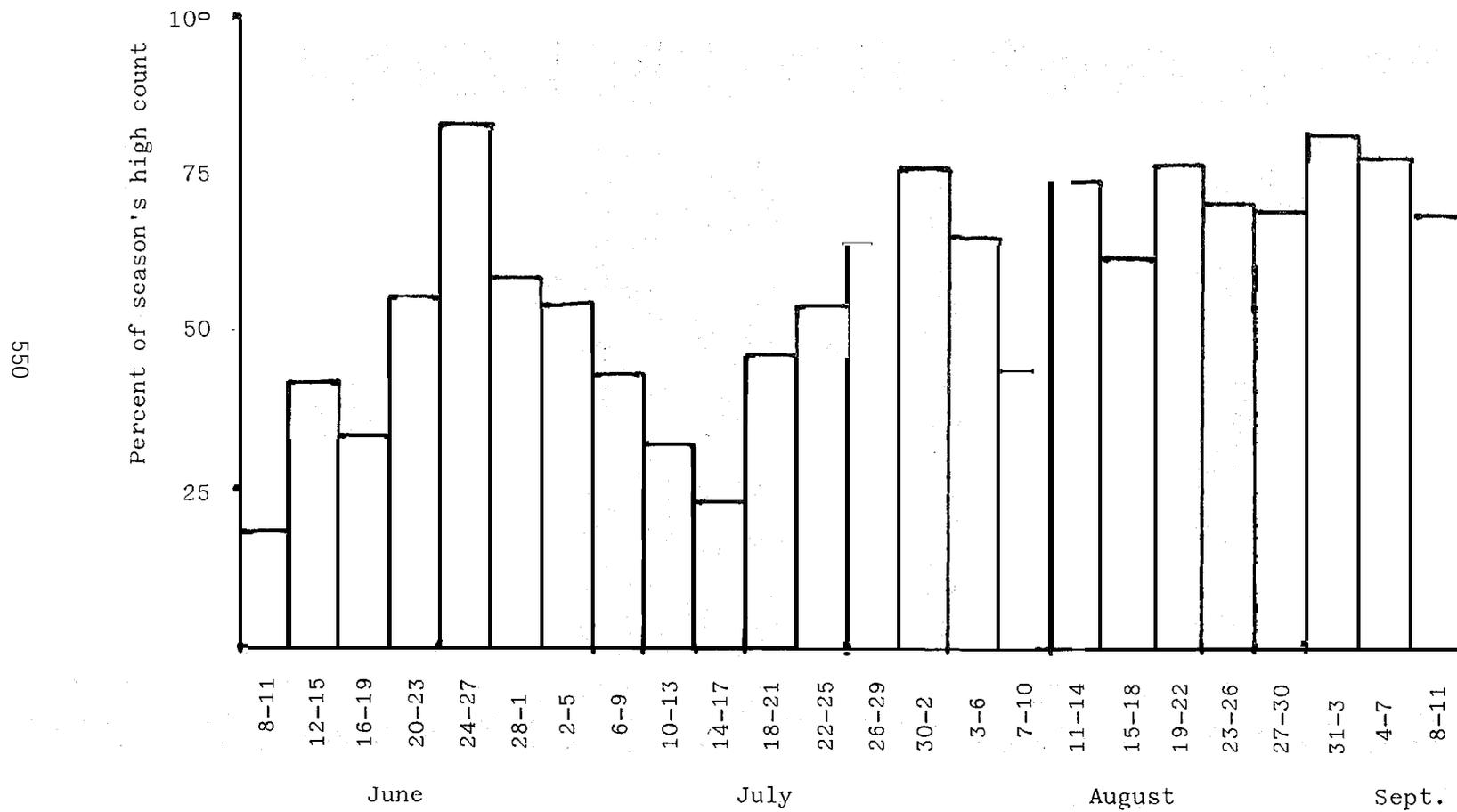
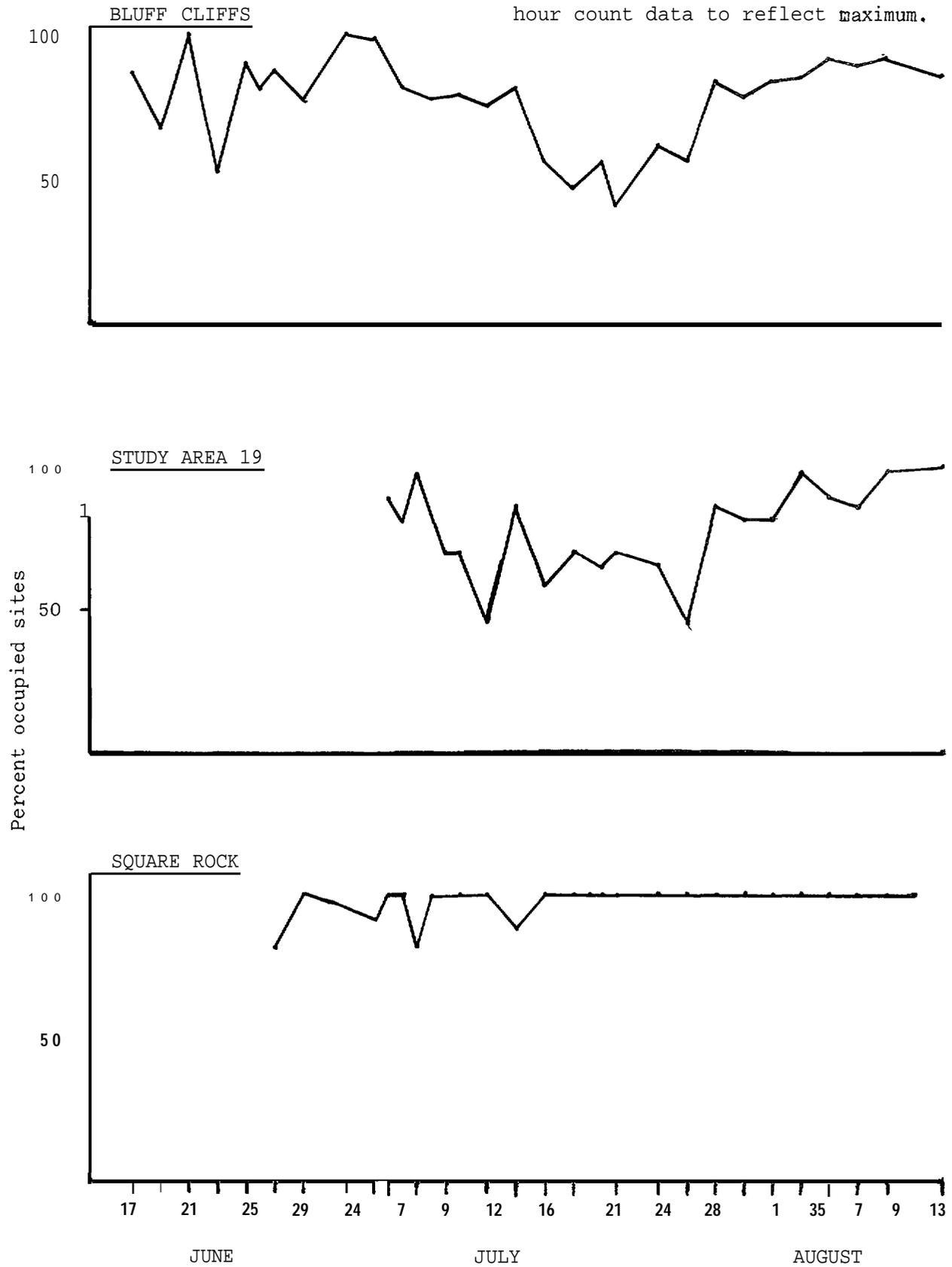


Figure 10. Attendance at nest sites by kittiwakes.

Percent of Type 2 sites occupied by one or two birds each day, corrected to 24-hour count data to reflect maximum.



Square Rock, the most productive of our sites, attendance never dropped below 80% and stayed at 100% during the times when other sites were being abandoned. It appears that not only did birds leave the cliffs whose reproductive efforts had already failed, but some birds which still had eggs also did so. This does not help us to explain -why the Square Rock site was not disrupted as the others were.

(iv) Egg Mortality and Events Surrounding Failed Eggs.

Egg mortality at Bluff and Square Rock is shown in Figure 11 as a proportion of all the eggs present at the study sites. The daily percent mortality is greatest between 13 and 24 July. The data for 1976 (Figure 12) also shows a peak of mortality in this period, but also severe early mortality and even more severe mortality at the peak. The times of mortality coincide with the times of lower attendance at the cliffs in both years.

These data indicate that many nests with eggs apparently were abandoned. Abandonment of a nest also gave Glaucous Gulls and Ravens opportunities to take the eggs. Of 51 nests that lost eggs, 15% were seen unattended before the egg was lost, 27% were unattended at the time the loss was noted, and 35% were unattended on at least two of our next four visits to the site and frequently for several visits afterward. Fifty-five percent of nests that lost eggs were seen to be physically deteriorated whether or not they were seen unattended.

Physical deterioration of a site suggests that material has been stolen from it, which occurs to most sites when they are not occupied. We have observed a kittiwake stealing material from a nest with an egg in it while the nest was not attended. The kittiwake doing the pilfering repeatedly stepped on the egg and occasionally bumped it. The egg was missing at our next visit, but the pilfering continued. On the visit after that, all material was gone from the site.

The data indicate that there was a period (presumably of stress) during mid to late July which caused the kittiwakes temporarily to abandon their sites, including some with eggs. High egg mortality in this period appears to have depressed reproductive success in a major way. We do not know why birds on the north side of Square Rock were not affected similarly.

Feeding Behavior and Food Sources

The following data are what we observed from land, and are preliminary, because we did not make observations of birds at sea.

Throughout the season we saw *mélées* of feeding kittiwakes. During these observations, we were able to define three types of feeding behavior: 1) one in which the birds swim on the surface of the water and peck at the surface shallowly; a second in which they land gently on their breasts and upper bellies in the water and peck below the surface, sometimes submerging their entire head, then flutter up out of the water and repeat the action; and a third, in which they make tern-like dives below the surface from six or more feet above the surface of the water.

Figure 11. Number of kittiwake eggs present and amount of mortality, Bluff Cliffs and Square Rock, 1977.

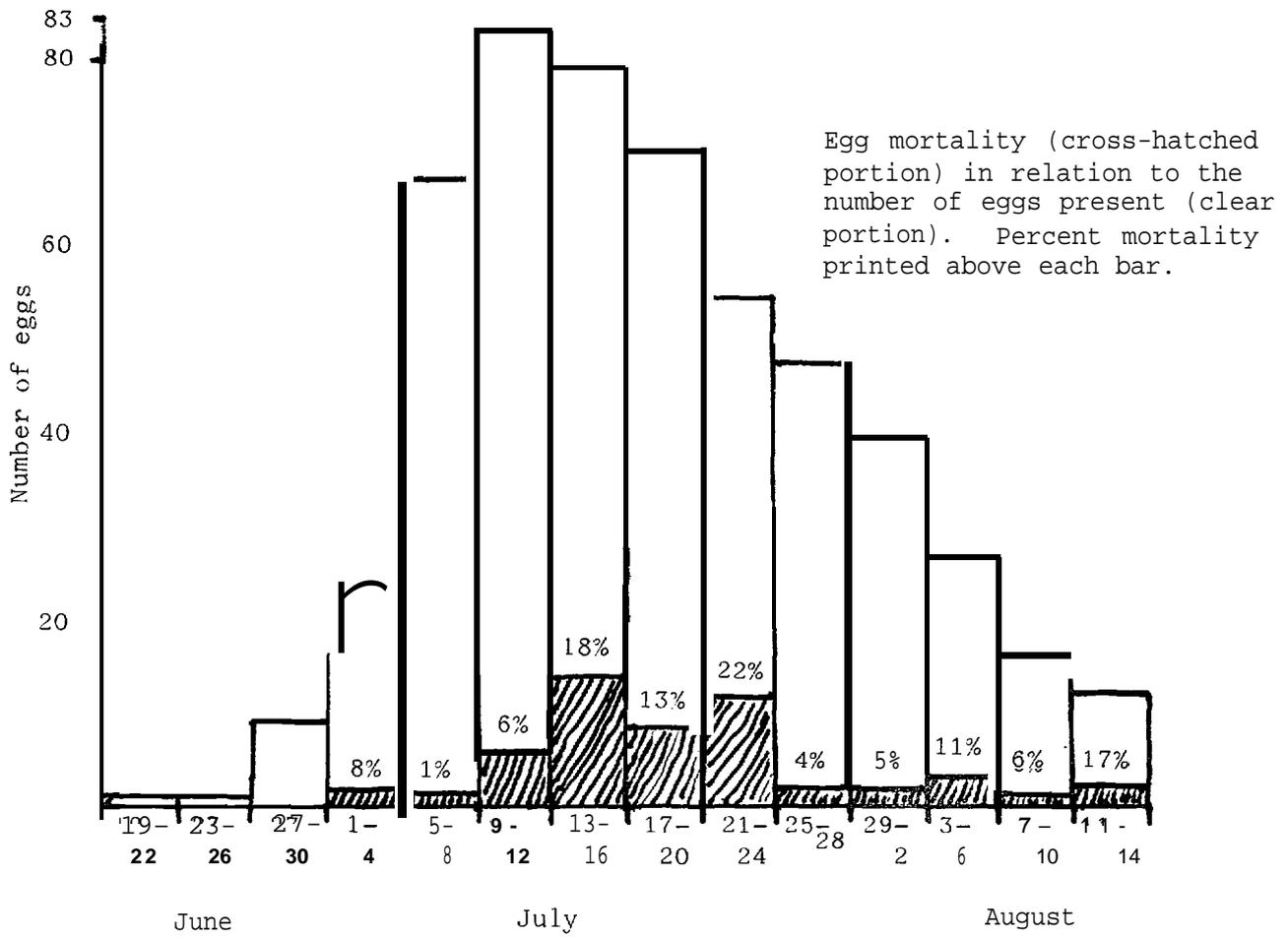


Figure 12. Number of kittiwake eggs present and amount of mortality, Bluff Cliffs, 1976.

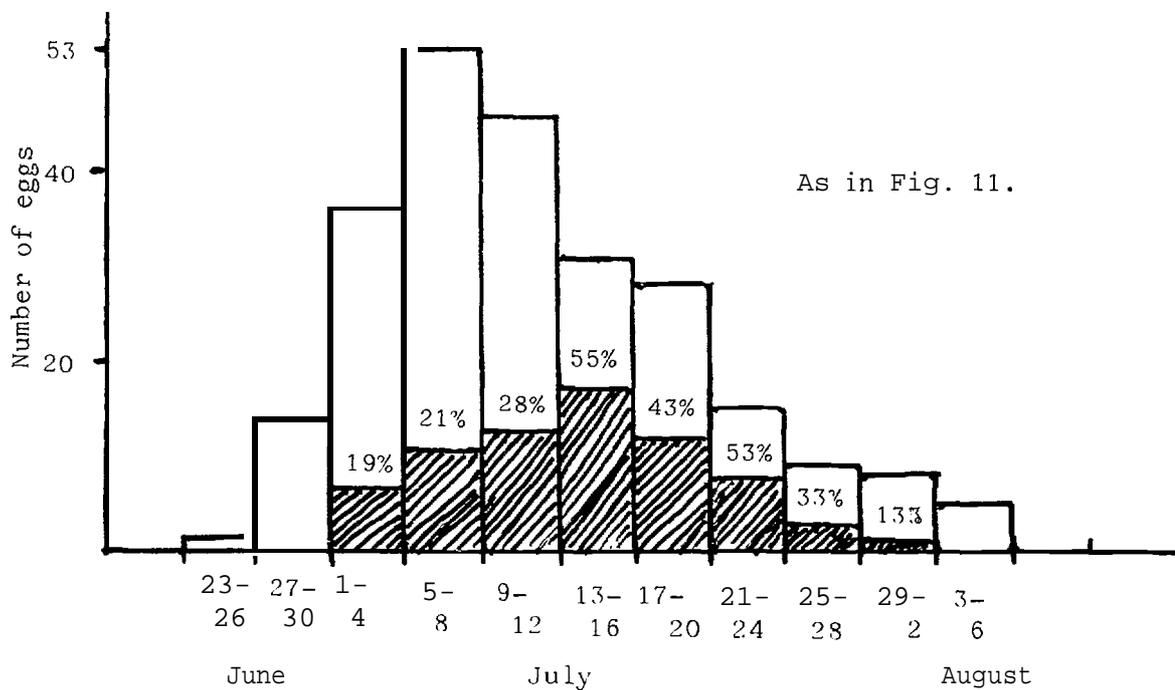


Table 9. Summary of Black-legged Kittiwake feeding behavior observed near Bluff Cliffs during the summer of 1977.

	First Week	Second Week	Third Week	Fourth Week
JUNE		Infreq. in groups of 50-100 with Glaucous Gulls, taking 2 to 8 in. fish, some <u>Eleginus</u> . Dive from air.	Infreq. in mixed groups. Dive from air.	Groups 100-300 feed on surface or make shallow dunks - food too small to see (small crustacea?)
JULY	one melee of 400 birds with Glaucous Gulls, take 4 in. fish.	Groups 100-200 feed using shallow dabs at surface.		Continued infrequent melees taking indiscernible food by shallow dabs.
AUGUST	Chicks fed <u>AMMO-dytes</u> . Group of 100 adults seen making shallow dives	Frequent melees 100-500 birds making shallow and deep dives. Schools of <u>Ammodytes</u> apparently moving into vicinity.	Massive schools of <u>Ammodytes</u> visible close to cliffs. Schools often close to surface allowing kittiwakes to catch multiple fish at surface. Frequent simultaneous melees of 100 birds each along entire length of cliffs.	Melees over <u>Ammodytes</u> schools continue, become smaller, fewer, more dispersed.
SEPT.	One melee of 75 kittiwakes making deep dives.			

Our observation of feeding mélées are summarized in Table 9. Almost all of these feeding bouts occurred within a mile of the shore. Apparently, the mixed aggregations we saw in early and mid-June were feeding on schools possibly of Saffron Cod (Eleginus), small trout, and young salmon. In July, the food used was crustaceans judging from the feeding behavior used (predominantly the first method described above and occasionally the second).

Our watches indicated that rates of feeding varied widely during the season. On 29 July, concurrent with a 24-hour count, we observed a chick in a nest at study site 14 for about 45 minutes out of every hour. We did not see it fed once during the entire day, even though an adult was present most of the time, and there were several changes of adults. However, on 2 and 4 August we observed three nests with chicks at study site 17, and saw them fed several times.

At all times when the food exchanged has been identifiable, it consisted of small Sand Lance (Ammodytes). Apparently, Ammodytes began to move into the waters off Bluff Cliffs in early August. We saw groups of diving kittiwakes mixed with ruffins and murrees on 5 August. On 13 August there were large mélées visible "everywhere". This period of abundant food reached its peak between 21 and 24 August, when schools of Ammodytes of 10 m² or greater in surface size were swimming within a quarter of a mile of the cliffs, and some along the base of the cliffs. Murrees and puffins attacked these schools from underneath, which may have driven some of the fish close to the surface, as the kittiwakes frequently caught more than one fish in single shallow stabs. These Ammodytes were mostly one and one half inches long.

We believe as we have said before that the phenology and abundance of Ammodytes may be critical to the reproduction of kittiwakes in the northern Bering Sea area, but there is an unfortunate dearth of information on the biology of this major marine resource.

b. Common and Thick-billed Murrees

Estimates of Numbers

Table 10 shows the results of the four cliff counts made at Bluff in 1977. A correction factor derived from the nearest 24 hour count (see Methods) was applied to the cliff counts to get an estimate of the total population. Table 11 shows the results of the three censuses done at Square Rock, and those done at Sledge Island. The first estimate at Sledge is probably high; the second is closer to, although still higher than, the 1976 estimates which were about 1500 birds. The count made at Sledge in August of about 3000 birds, is close to the estimates made before 1975 by members of the Alaska Department of Fish and Game.

Table 10. Estimates of total Murre numbers at Bluff, 1977.

(counts made from a boat passing in front of the cliffs)

Section of Cliff	June 28th		July 7th		July 29th		August 19th
	max.	min.	max.	min.	max.	min.	
A	1150	890	1570	940	1050	1020	1950
A to C	5200	4460	7760	4170	6800	5050	5000
C to D	14,600	9750	14,830	7670	15,600	10,600	11,875
D to E	4340	3180	3688	2890	4580	4200	4220
E to F	5660	4820	5320	4900	7260	5380	6040
F to G	2360	1530	1965	1635	2670	1960	1355
G to H	2090	1510	2480	1930	2490	1750	2060
H to I	5480	2720	4290	3830	4300	2820	3240
I to J"	485	450	560	430	495	554	370
TOTAL (A to J)	41,365	29,400	42,500	28,400	45,250	33,250	36,100
Percent on cliff *		87%		95%		88%	100%
CORRECTED TOTAL	47,545	33,800	44,736	29,900	62,132	48,900	36,100

* at same time during nearest 24-hour count

Table 11. Murre censuses - Square Rock and Sledge Island.

Square Rock*

May 22	3,330
June 4	4,800
August 19	7,600

Sledge Island

June 21-24	6000 ⁺
August 23	2800 ^{**}

* Direct counts

⁺ High count rounded off

^{**} Direct count

The highest counts of murrelets occurred twice during the 1977 season. On 21 May 61,900 murrelets were counted in the leads in front of the Bluff Cliffs. Again on 29 July a cliff count yielded 62,000 birds. These figures support the observation also made in 1976 (see p.40 of the report for the '76 field season), that most of the birds associated with the colony arrive early, and that many leave before the breeding season starts, to return later in the season.

We have no data on the total numbers of Thick-billed Murrelets at the Bluff Cliffs as they are impossible to distinguish from Common Murrelets when counting from the base of the cliff in a small boat. The percentage of Thick-bills is very small, however; it is probably less than 1%.

Daily Activity Patterns

The changing patterns of daily attendance at the cliffs were observed in the course of the 24 hour counts. These were done six times during the 1977 season at 10 day to two week intervals. Two different sites were used, Sites 14/15 at the Bluff Cliffs, and Site 19 and Square Rock. Fading light made it impractical to continue these counts past early August. The graphed results of the 24 hour counts of murrelets at Study Sites 14-15 and Square Rock are shown in Figure 13.

Early in the season (mid-June), the attendance patterns at Sites 14/15 and contrasted sharply with those at Site 19 and Square Rock. At 14/15, murrelets were present on the cliffs all night and in the very early morning and late evening (peaking at 0400 and 2300), and were all gone in the middle of the day (from 1100 to 1700). At Square Rock, murrelets were present on the cliffs most of the day but were all gone in the very early morning (0100 - 0500). At this early part of the season the changes in numbers occurred rapidly, and during certain portions of the day, all the birds left the cliff. Fighting and territorial defense behavior occurred when the birds were on the cliff, but this was apparently not yet a full-time commitment.

After egg-laying began, complete desertion of the cliff no longer occurred. The variation in numbers dropped to 40-60% in late June and early July. Presumably the birds were remaining to protect their territories and eggs. Also, the patterns of attendance at the two count areas became similar with a majority of birds present on the cliff in the early morning [from 0400 to 0800), and evening (0800-1200). The birds left the cliff at night, (with numbers decreasing after 2000, and increasing after 0100), and again at midday.

Figure 13. Twenty-four hour counts - Murres.

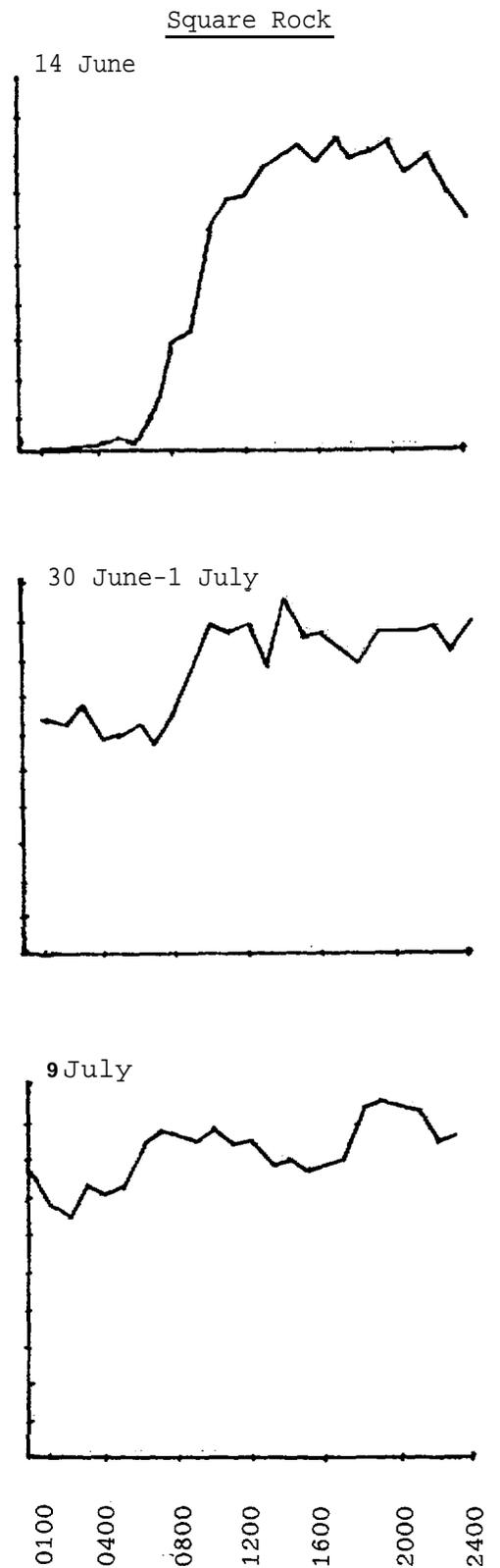
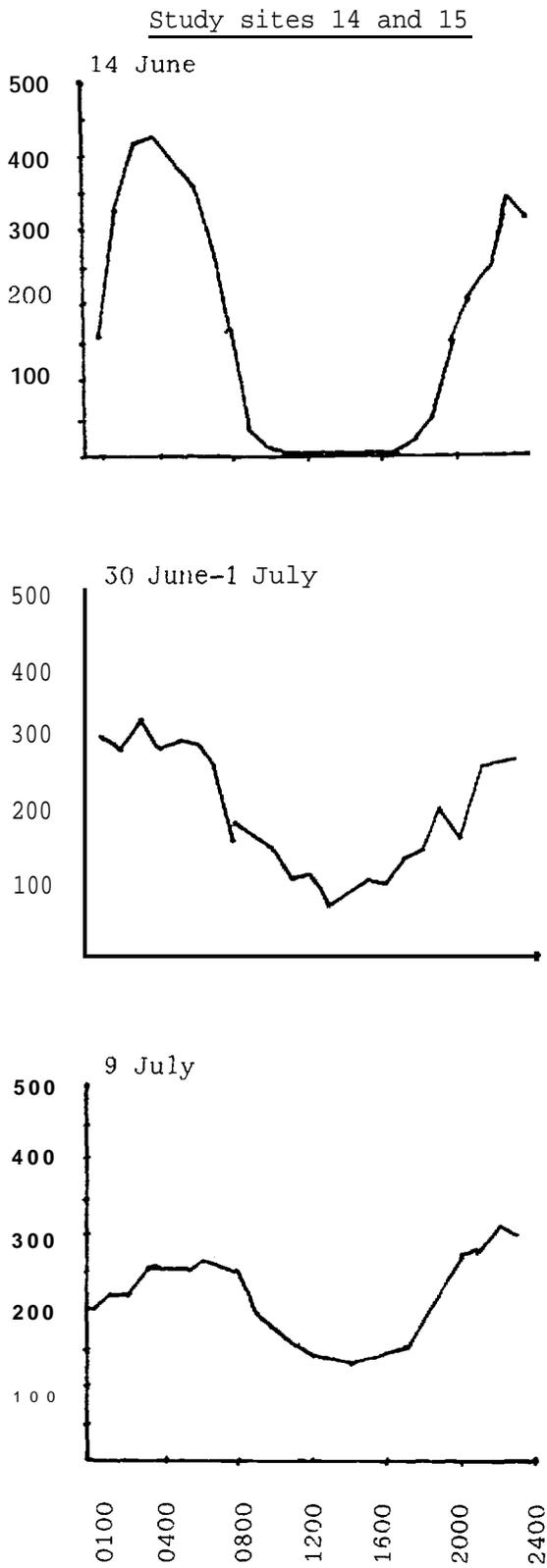
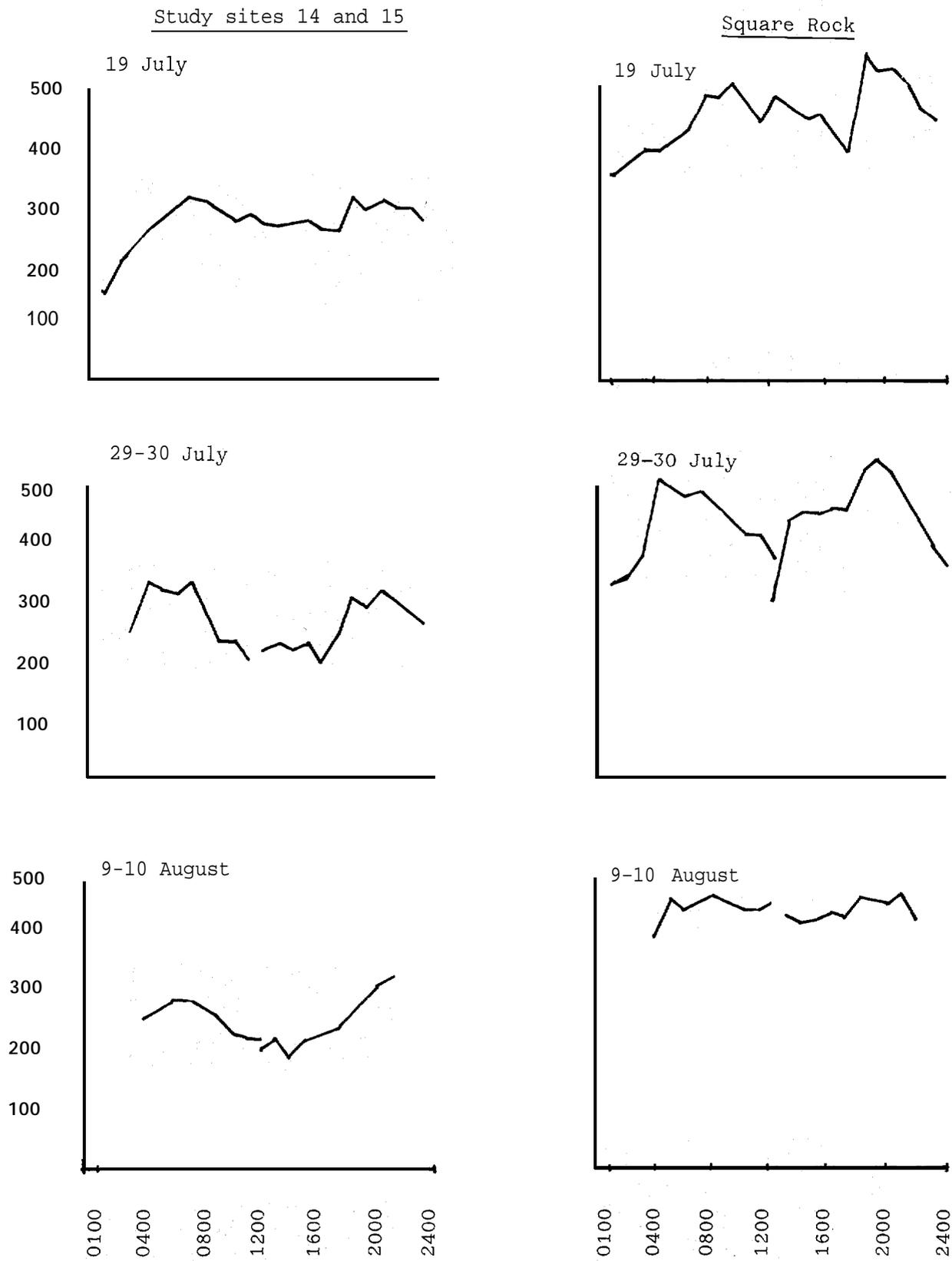


Figure 13 (cont.). Twenty-four-hour counts - Murres



The changes in numbers did not occur as abruptly as they did earlier in the season. The variation in numbers remained near 40-50% in mid and late July, but decreased to 15-30% in early August. This may be due to an influx of young birds "prospecting" for future nesting sites.

Seasonal Variation in Attendance

Seasonal variation in attendance of Common and Thick-billed Murres at the cliffs is shown in Figure 14. The variation is shown as a percent of the season's high counts at several study sites. The pattern of variation is similar in the two species. There was a first, low peak in numbers in mid-June, when 40-55% of the maximum population of birds were on the cliffs. In late June numbers decreased and only 20-30% of the birds were present. At the peak of laying, about 7-11 July, 70% of the population was present. This figure probably represents those birds most highly motivated to a reproductive effort, i.e. the "breeding population". Total numbers increased slightly after the laying peak until maximum numbers were reached in mid to late August. These late season increases were due to the arrival of young birds breeding for the first time, and then due to the arrival of nonbreeding young birds prospecting for future sites. Numbers declined after the third week in August as chicks began to depart along with the breeding and nonbreeding adults. By the time we left Bluff on 12 September, the cliffs were 99% empty of Murres.

Reproductive Schedule

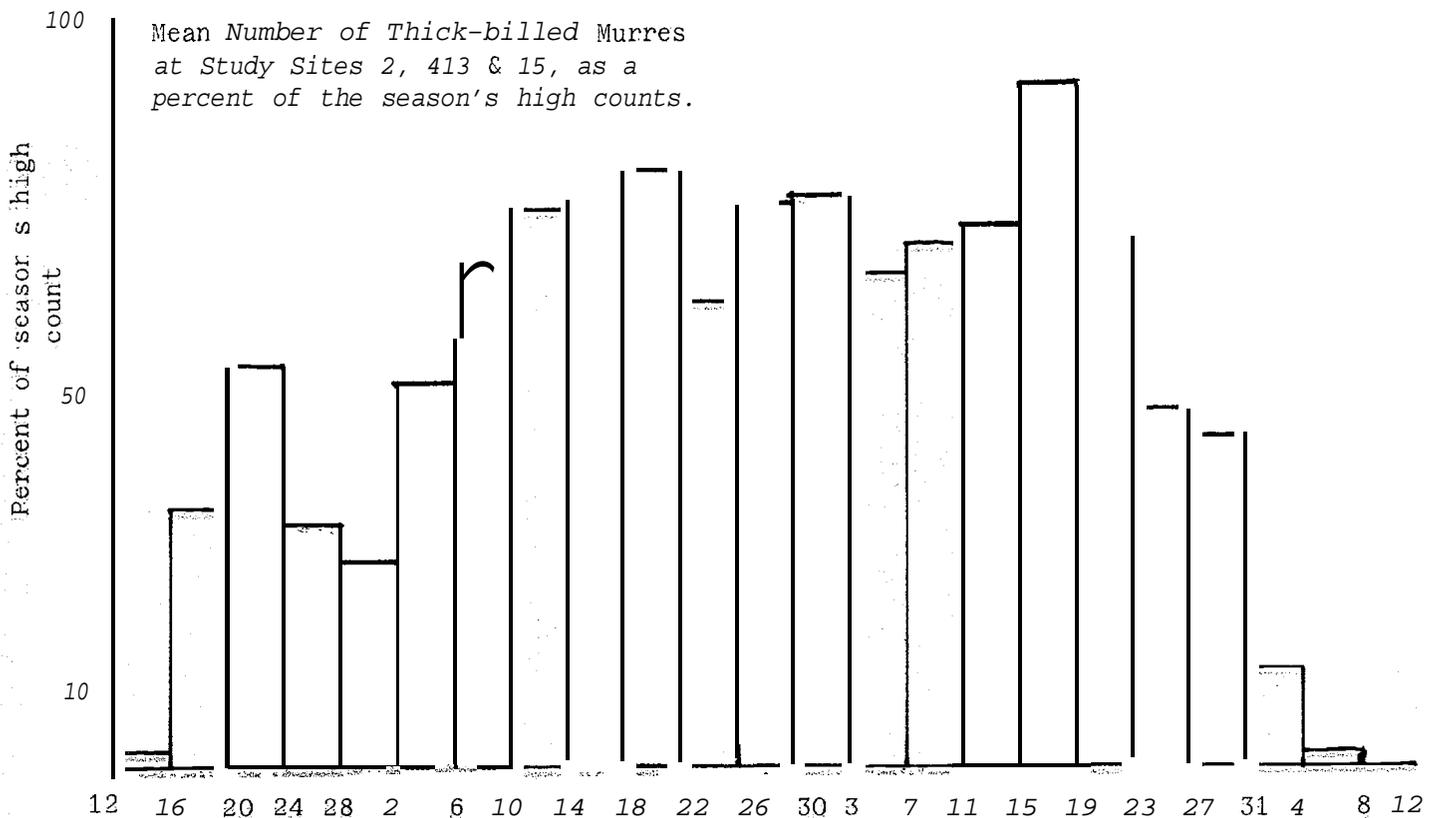
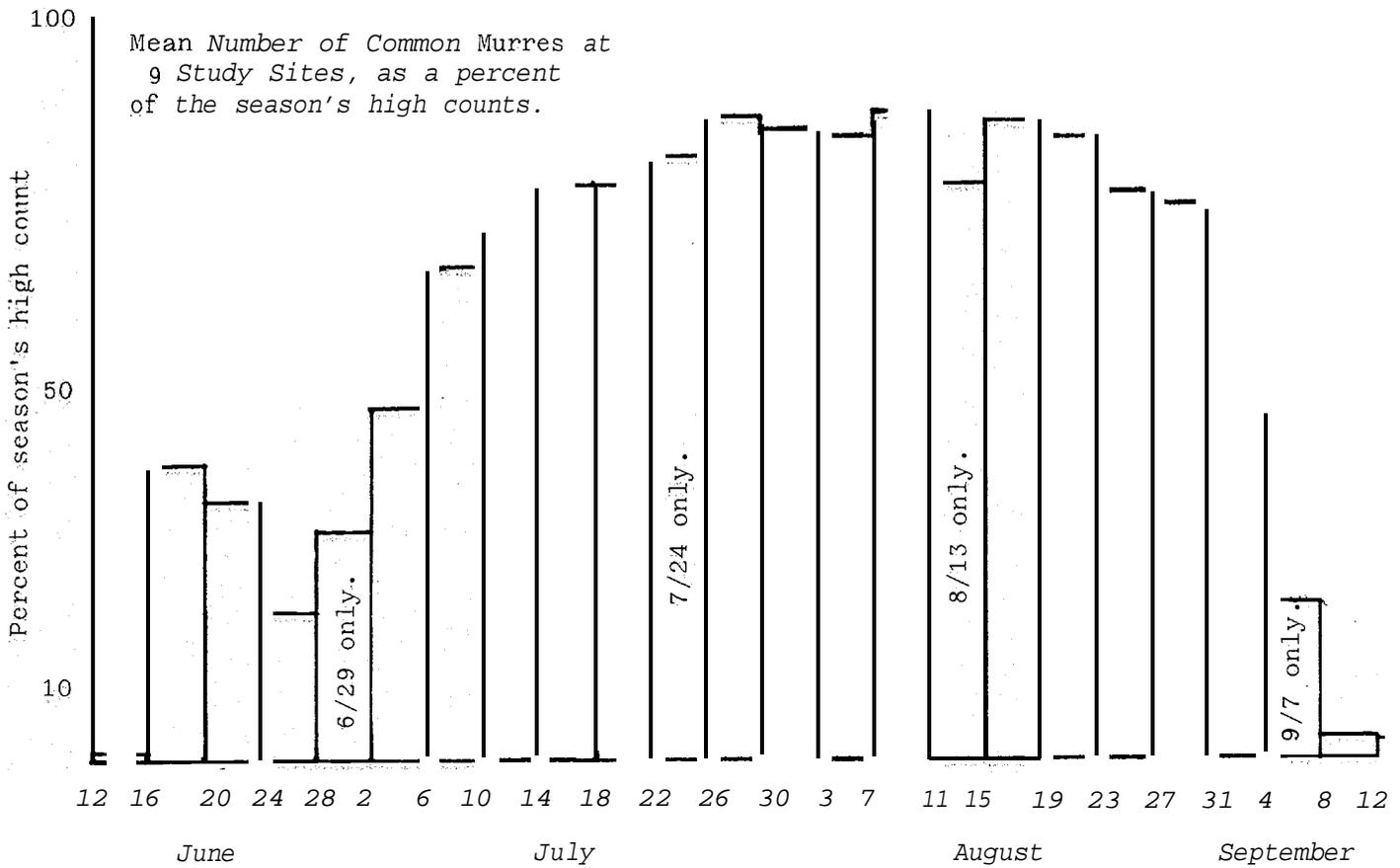
Arrival and Early Occupation of the Cliffs - When we flew in to Bluff on 21 May, we counted 30-40,000 murres on the water. A count from the top of the cliff yielded a total of 62,000 murres on the water. The birds were flocking at the base of the cliffs; some were flying to and from the cliffs, however those that landed did not remain long and were very easily scared off. Some fighting and copulations were noted among birds on the cliff.

At 1600 on 22 May, murres were seen flying en masse to Square Rock which they occupied until 2100, when all left. These changes approximate the pattern of daily activity shown by the 24 hour count made in the middle of June.

On 23 May no murres were seen at Bluff or at Square Rock all day, which suggests that their ties to the cliffs were still rather loose.

On 24 May at 1045 murres were present in the lead in front of the cliffs, but were not hugging the inshore edge. At 1930 a count was made of 2600 murres on the water in front of the Bluff Cliffs.

Figure 14. Seasonal Variation in Murre Attendance at the Cliffs



Birds started "flying in thousands" to the Bluff Cliffs at about 2000, (which is approximately when they were seen leaving Square Rock on 22 May). A total count of 12,000 birds on the water was made at this time,

A count at 0645 on 25 May showed about 17,000 birds present on the water near the Bluff Cliffs. Very few birds were actually on the cliffs at this time. A count made from the air on 2 June at 1820 yielded the similar figure of 19,000 birds.

The high count of 21 May was not repeated until the end of July, suggesting that many (nonbreeding) birds arrive early along with those that are going to breed, and that the nonbreeders leave before egg laying begins and return later in the summer.

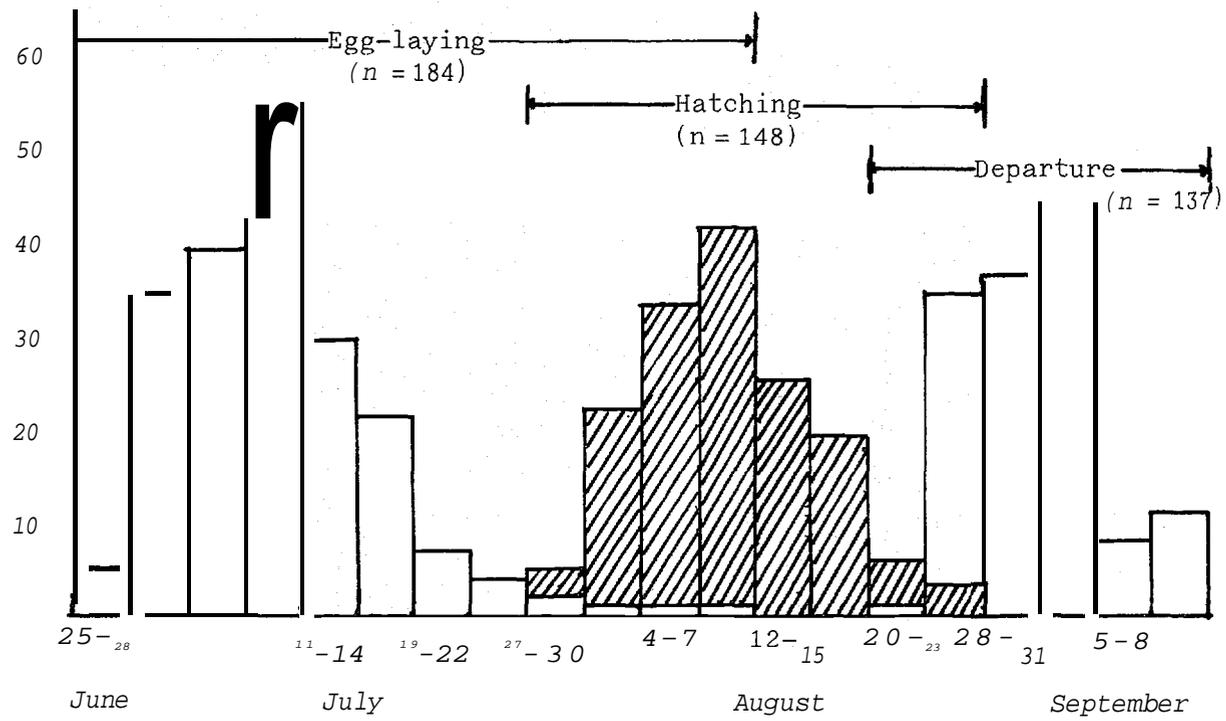
These early observations, and the 24 hour count of 14 June show that the patterns of attendance at the Bluff Cliffs and at Square Rock were, at this time, nearly opposite even though they are within three miles of one another. This suggests that they exist (to some extent) as separate colonies.

Laying and Hatching - Figure 15 shows the reproductive schedules of Common and Thick-billed Murres. These data come from the ledges at which murres were individually mapped. Since it often takes many hours of observation to determine whether a murre in an incubating posture actually has an egg, the first sightings of eggs were usually later than the actual laying dates. Our data on hatching and departure dates is much more reliable. We therefore calculated the laying curve from these, using Tuck's (1960) figure of 33 days as the length of the average incubation period. The calculated laying curve corresponded closely to the curve derived from observed laying dates which were known to be accurate. (See figure 16)

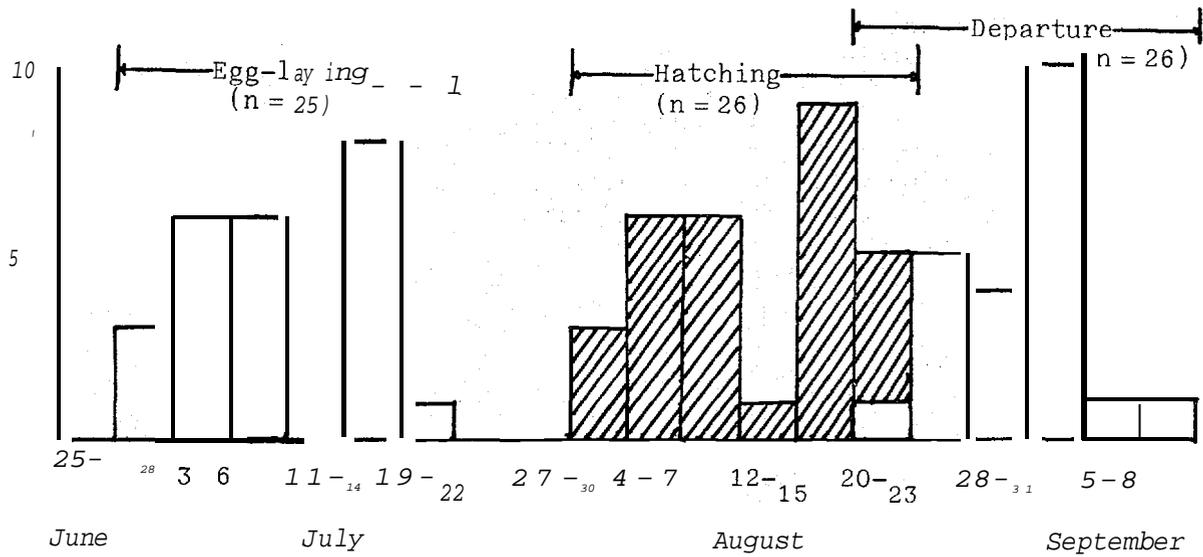
The first egg shells were seen on 21 June near a Raven's nest. Eggs were seen on the top of Square Rock on 22 June. These were heavily preyed upon by Glaucous Gulls and Ravens. The earliest eggs are particularly vulnerable to predation because the majority of birds without eggs were easy to flush from the ledges, leaving the few with eggs more open to attack. The peak of laying occurred from 7-10 July for Common Murres.

Our sample size for the laying period of Thick-billed Murres was small (a total of 33 eggs were mapped at two sites), but within this sample the laying peak occurred from 15-18 July. We saw new eggs until the middle of August; however these late eggs almost certainly failed to hatch.

Figure 15. Reproductive schedule - Common and Thick-billed Murres.

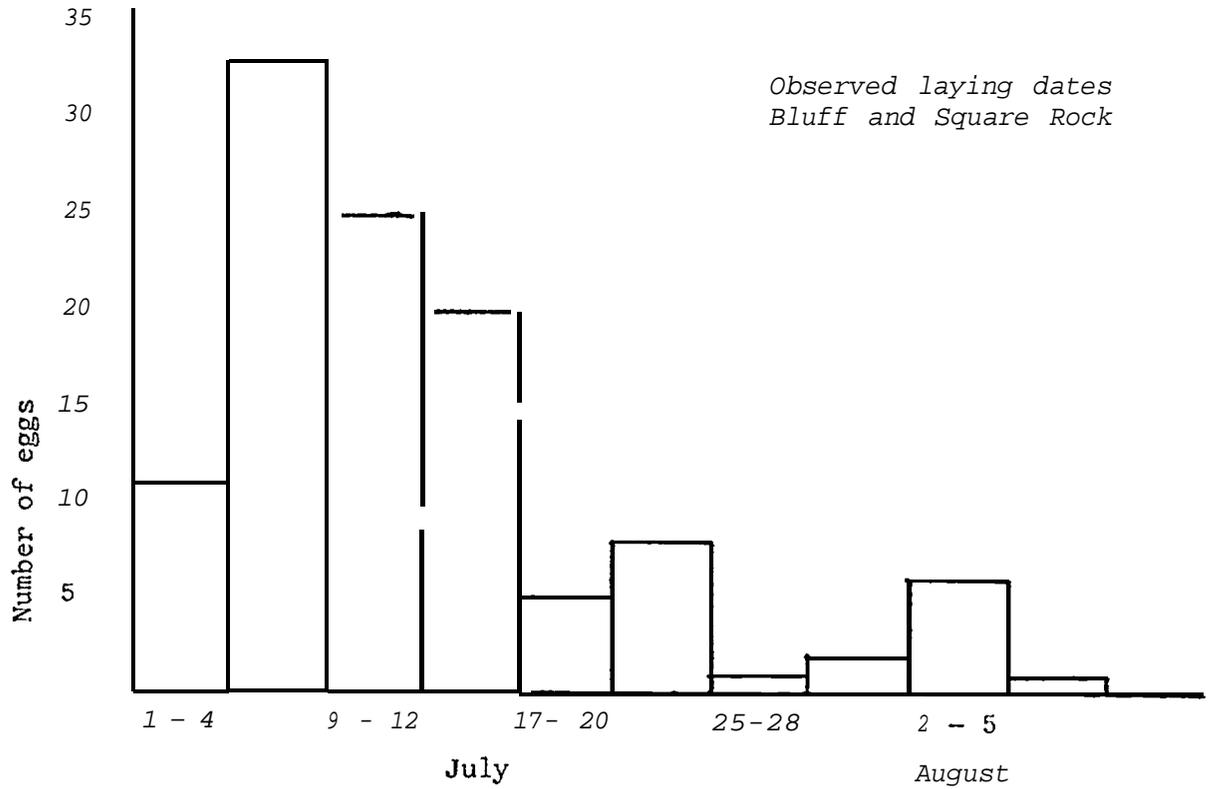
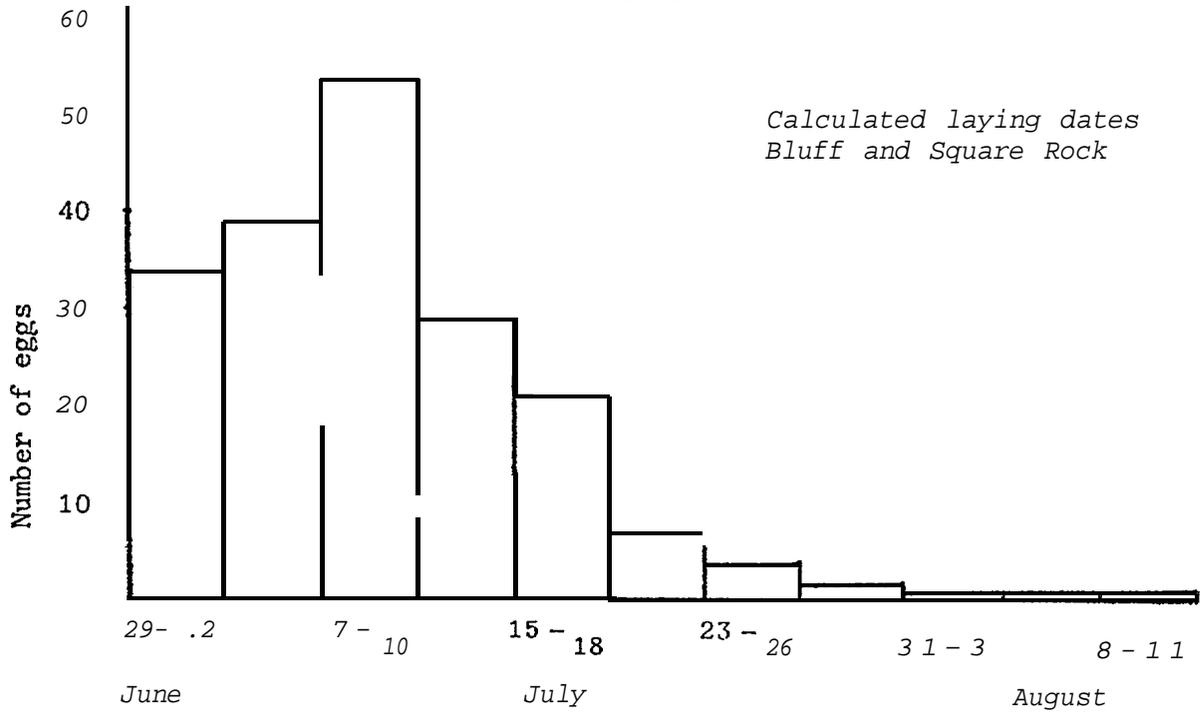


Common Murres



Thick-billed Murres

Figure 16. Calculated versus observed laying dates - Common Murre.



The first chicks were seen on 30 July at Square Rock, and on 3 August in the map areas at the Bluff Cliffs. The reproductive schedule of the murre at Square Rock seemed to be consistently a few days ahead of the birds at the Bluff Cliffs; further evidence that they exist as separate colonies. The peak of hatching occurred from 8-12 August for Common Murres, and (in our small sample) from 16-20 August for Thick-billed Murres. Hatching continued until 28 August, with the exception of one or two very late chicks (which failed to survive) that didn't hatch until the first week of September.

Fledging of Chicks - Departure dates are probably the most reliable data we have for the murre breeding schedules, because as the chicks get larger and nearer to jumping age, they move around more and often stand away from the parent making them easier to keep track of. On the map areas, we usually knew to within a day or so when each chick disappeared, and whether it was old enough to have jumped. We used Tuck's (1960) estimate of 18-25 days as the average age of chicks old enough to leave the cliffs. Chicks that were known to be less than 18 days or which still looked very small and immature when they disappeared were assumed to have been lost. Those older than 18 days were assumed to have fledged successfully.

The first Common Murre chicks jumped on 20 August, and the peak of jumping occurred from 1-5 September; most of the chicks jumped after 24 August. The first Thick-billed Murre chick also jumped on 20 August, and their peak also occurred from 1-5 September. These data on departure dates suggest that the Common Murre and Thick-billed Murre schedules corresponded rather more closely than the data on laying and hatching would indicate, but the sample may be too small to be truly representative.

A few days prior to jumping from the cliff, chicks would begin to stand apart from their parents. Jumping usually started just after dusk and would continue into the darkness. The chicks are very vulnerable to predation at this time; the darkness affords them some measure of protection.

Large groups of adults congregate at the base of the cliffs when the chicks are ready to jump. One adult usually accompanies each chick as it makes its jump, and it is surrounded by many adults after it hits the water, presumably providing more protection from predators. The chick and a group of adults then begin to move directly out to sea. Chicks were sometimes seen in the water at the base of the cliffs surrounded by adults during the daytime; they apparently also jump in the daylight although they are much more vulnerable then.

\ We left Bluff on 12 September in 1977, and by this date, 99% of the adults and chicks had left the cliffs.

Identifiable Stages of Chick Development - We have recorded the following stages in the development of murre chicks. At first the young do not raise their heads and are a uniformly leaden color with speckles of white on the head and neck. Next the young birds raise their heads and stand up. At this time the head and neck are covered with characteristically pointed feathers speckled with white at the tip resembling "pepper and salt". Next the bird is much larger, just less than half the length of the adult's white belly, and shows a white chin, but the cheeks are still dark or "pepper and salt". At the last stage before jumping, the chick has a white chin and "halfmoon" white cheeks. It stands for hours at a time beside its parent and often can be heard peeping when fed. Occasionally it gives the ringing double note associated with a chick which is just about to, or has, jumped from the ledge. Our observations indicate that the first two stages occupy 8 or 9 days and so do the last two. The last stage may be quite prolonged in the case of some chicks.

Late Season Territorial Activity - The amount of fighting among murre appeared to decline after egg laying and incubation began. As new birds began to arrive in early August however, there seemed to be a resurgence of fighting. These incoming birds were often seen loitering on the cliffs, yet some were seen in the incubation posture. Toward the end of August, fights were sometimes seen at reoccupied sites after chicks had left.

Reproductive Success - Reproductive Success, for both Common and Thick-billed Murres, was much higher in 1977 than in 1976. While the determination of the reproductive success of murres is difficult, by expanding our use of detailed mapping of murre ledges (see description of this method under "Methods") this year we were able to get much more complete data than we have had in the past. All of the calculations of murre reproduction came from mapped areas.

We had eight murre map areas at the Bluff Cliffs in 1977, two of which (at Study Sites 2 and 15) were only Thick-billed Murres. There was a total of 184 Common Murre "sites" (places at which an egg was seen on a ledge) and 33 Thick-billed Murre sites. (See Table 12). The map areas were chosen, and their boundaries determined mainly by their visibility from the top of the cliff. The most reliable data come from the small, narrow ledges where it is much easier for the observer to keep track of each bird, hence to check whether it has an egg or chick. The wider and more crowded the ledge, the more difficult the area is to map accurately. Our results therefore, do not reflect differences in reproductive success that may be caused by differences in ledge type. We suspect that such differences may exist.

Table 12. Number of sites monitored within each Murre map area.

<u>Study area</u>	(Common Murres)	<u>Number of sites</u>
1B		15
4		9
4B left		20
4B inside		26
10		82
12		32
Total		<u>184</u>
	(Thick-billed Murres)	
2		16
15		17
Total		<u>33</u>

Table 13. Numbers of "breeding" birds present at Murre map areas.

<u>Study area</u>	<u>July 6-10 counts</u>	<u>average</u>	(probable number of "breeding" birds)	<u>highest number of , incubators recorded</u>
1B	35, 43, 56	45		40
4	27, 34, 44	35		17
4B left	40, 54	47		26
4B inside	48, 53, 59	53		32
10	136,135,2.41,144	139		75
12	52, 51, 49	51		22
2	17, 15, 24	19		17
15	15,17,17,13	16		17

The map areas at Stakes 2 and 15 were chosen for their high concentration of Thick-billed murrelets. Common murrelets were not included in these maps although they were interspersed with the Thick-bills. Thick-billed murrelets nest on small and narrow ledges, which makes them relatively easy to map. So, although our sample is small, it is probably characteristic and fairly precise. We mapped and counted Thick-billed murrelets only where they were concentrated; thus our data are not useful in determining the total population of Thick-bills.

The biological meaning of "incubating murrelets" is not yet clear. We have found no very consistent relation between the number of "incubators" and the number of eggs actually present on the ledge. Therefore, estimates of reproductive success for 1977 were not based on the numbers of birds in incubation posture (see discussion pp. 26-27, 57 of report for 1976 field season) present in murre count areas, as was done in 1976.

The number of "breeding birds" at the cliffs is difficult to determine due to the presence at various times of "loafing" birds who do not seem to be involved in a breeding attempt. We believe that the level of commitment of birds to a breeding effort is reflected in the strength of their attachment to the cliffs, as shown by their defense of territories, maintenance of the incubating posture, and, of course, production of eggs and chicks. By "breeding birds" we refer to those birds which have the highest level of attachment to a specific site on a ledge at the cliff. The reasoning is recognizably circular.

In 1976, three possible measures of the number of breeding pairs were compared and found to be in good agreement with each other. These were 1) the average number of birds present on the cliffs in late June (representing the birds attempting to breed); 2) the number of birds present at the peak of laying in late July; and 3) the highest numbers of incubators recorded.

It seems reasonable to assume that birds highly motivated to lay eggs will be present at the cliffs around the peak of laying. In 1976, although egg-laying began in late June, the actual peak of laying did not occur until late July due to an interruption of the breeding season (which happened around 8-11 July). The laying peak occurred from 7-10 July in 1977. An average of the counts made at the map areas during this period gives a figure which we believe approximates the number of breeding birds, and which is comparable to the 1976 figures. Our estimates of the numbers of breeding birds present at each site are shown in Table 13. In five of the eight map areas, the highest count of birds in an incubating position is approximately 50% of the average of the July 6-10 counts. This makes sense as only one of a pair of murrelets can incubate at a time, and the 6-10 July counts are of numbers of "breeding" "birds" (not pairs).

Table 14 shows the probable number of "breeding" birds at each site, and the number of eggs observed, chicks hatched and chicks fledged. Table 15 shows murre reproductive success for 1977. Common Murre reproductive success (chicks fledged per breeding pair) varied from .14 to .53 according to the study site. It is difficult to tell how much of the variation in success is due to the differences in ledge type and its suitability as a breeding ledge, or to differences in our ability to measure reproductive success on these ledges. The low figure of .14 occurred at Stake 4 where the mapped ledge was wide and crowded, making it difficult to keep track of individual birds, eggs and chicks. (See disc. on p. 60 of report for 76 field season)

Our figures for eggs produced per breeding pair are probably low because on the more crowded ledges some of the eggs were most likely never seen. We have little data on egg loss and replacement. ,

Comparisons of Reproductive Success in 1976 and 1977 are shown in Table 16. Although our data from 1976 are much less precise some general comparisons between the years are possible. Our estimates of eggs produced per breeding pair are similar for 1976 and 1977, however there is a large difference in the figures of eggs hatched/eggs laid, and of chicks fledged/breeding pair between the years. The low figure of reproductive success in 1976 was therefore not due to a failure to lay eggs. Our data show that the interruption of egg-laying in 1976 resulted in lower hatching success. Although similar numbers of eggs were laid many of the eggs were laid much later in 1976. These late eggs had a lower rate of hatching.

In 1977, 65-100% of the common murre eggs that were laid, hatched successfully at the different sites, average being 85%. This figure is probably high, as it is certain that we missed some eggs that were lost or replaced. Of those chicks that hatched 82-100% fledged successfully, averaging 87%.

Of the Thick-billed murre eggs laid, 69-91% (of those monitored) hatched. Of these Thick-billed murre chicks .91-100% fledged successfully.

As mentioned earlier, it is probable that we never saw a number of eggs that were laid and lost or replaced. Table 17 summarizes our egg loss data. Our figure for percent of eggs lost is undoubtedly low. The data we have are useful to some extent though, in showing the degree to which egg-loss can be attributed to various factors. Those eggs lost whose "fates" we did not know were most likely lost through either falling off the ledges or by predation. By "sterile" eggs we mean those which continued to be incubated, but which did not hatch until the adult finally gave up late in the season. Some eggs were not incubated; most of these were eventually taken by Glaucous.

Table 14. Numbers of Eggs, chicks hatched and chicks fledged at Murre map areas.

Common Murres

<u>Study area</u>	<u>Number of eggs seen</u>	<u>Number of chicks hatched</u>	<u>Number of chicks fledged</u>
1B	15	14	14
4	9	6	5
4B left	20	20	20
4B inside	26	20	20
10	82	71	58
12	(32*)	32	27
<i>Total</i>	184	157	137

Thick-billed Murres

2	16	11	10
15	17	15	15
<i>Totals</i>	33	26	25

	<u>Common Murres</u>	<u>Thick-billed Murres</u>
<i>Total eggs</i>	184	33
<i>Total chicks hatched</i>	157	26
<i>Total chicks fledged</i>	137	25

* Eggs were not noted in this map area, chicks only were noted. This figure represents the minimum number of eggs present.

Table 15. Murre reproductive success.

Common Murres

<u>Study area</u>	<u>Number of "breeding" birds</u>	<u>Eggs/ breeding pair</u>	<u>Chicks hatched/ breeding pair</u>	<u>Chicks fledged/ breeding pair</u>
1B	45	.33	.31	.31
4	35	.26	.17	.14
4B left	47	.43	.30	.28
4B inside	53	.49	.38	.38
10	139	.59	.51	.42
12	51	(*)	.63	.53
<i>Total</i>	370	.48	.42	.37

Thick-billed Murres

2	19	.84	.58	.53
15	16	1.06	.94	.94
<i>Total</i>	35	.94	.72	.69

	<u>Common Murres</u>	<u>Thick-billed Murres</u>
<i>Hatched/laid</i>	.85	.76
<i>Fledged/laid</i>	.74	.74
<i>Fledged/hatched</i>	.87	.96

* Eggs were not noted in this map area, chicks only were noted. This means that the figures for hatched/laid, and fledged/ laid may be slightly high.

Table 16, Comparison of Murre reproductive success, 1976-1977.*

<u>Common Murres</u>	1976	1977
Eggs/breeding pair	.45-.47	.48
Chicks fledged/breeding pair	.06-.09	.37
Eggs hatched/eggs laid	.29-.48	.85
 <u>Thick-billed Murres</u>		
Eggs/breeding pair	1.05-1.13 [†]	.94
Chicks fledged/breeding pair	.29-.40	.69
Eggs hatched/eggs laid	.26-.37	.76

* Comparisons cannot be exact as the methods and results from 1976 are less precise than in 1977.

[†] See p.61-62 in 1976 report on egg replacement for explanation of these figures.

Table 17. Egg loss summary.*

Total eggs observed (at map areas)	217	Fate unknown	9 (26%)
Total eggs known lost	34	Never hatched (sterile)	5 (15%)
Percent egg loss	16%	Unincubated	6 (18%)
		Preyed upon	2 (6%)
		Crushed (no chick seen)	2 (6%)

* Data from Murre maps only.

Figure 17. Dates of egg loss.

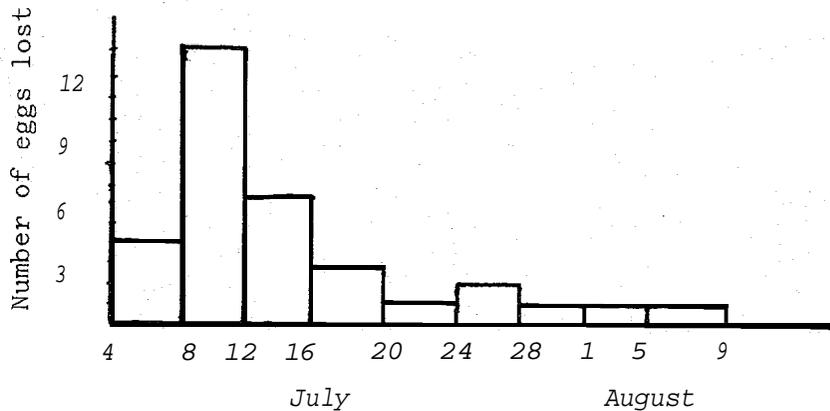


Table 18. Murre chick loss summary.*

Total chicks hatched	183	Age of "lost" chicks	
Total chicks lost	21	1-6 days	7
Percent chicks lost	11%	7-12 days	8
		13-18 days**	6

* Data from Murre map areas only.

** Chicks over 18 days assumed to have fledged successfully.

Gulls or Ravens. Some apparently rolled into places which were inaccessible for incubation by the adult, such as in a crack or behind a rock.

By far the heaviest egg loss occurred during the peak laying period, from 6-11 July. (See Figure 17) The data we have shows that 5 of the 12 eggs whose 'ages' when lost are known, (42%) were less than 10 days old when they disappeared. Tuck's (1960:153) findings agree that egg loss is apt to be highest soon after the eggs are laid. He states that this is because eggs are often laid in precarious positions, and because eggs stabilize as incubation progresses due to movement of the embryo towards the small end of the egg. This causes the radius of the circle in which the egg will roll if disturbed to decrease.

Data on loss of chicks are summarized in Table 18. We assumed that chicks which reached 18 days of age fledged successfully. Chick losses are mainly due to exposure, predation and falling off the ledges. Of the 183 chicks we monitored in our map areas, 21 were lost (or 11%). We know the fate of only 3 of these 21. Two were seen dead on the ledge, possibly due to exposure or disease. These chicks were both 18 days old. One chick was seen taken by a Glaucous Gull. Seven, or 33%, of the chicks lost were less than 6 days old. According to Tuck (1960), chicks are most vulnerable to exposure during their first 6 days. Of the chicks which died 38% were 7-12 days old, and 29% were 13-18 days old. After 30 August, the number of birds left on the cliffs began to decline, leaving the remaining chicks without the protection of many other birds. Chicks remaining late in the season are more vulnerable to predation. Six chicks which were not from a mapped area, were seen (dead) on the beach above the high tide mark on 29 August. They were eventually taken by Glaucous Gulls.

If 50% of the breeding pairs produced eggs, and there were approximately 20,000 breeding pairs at the Bluff Cliffs in 1977, then about 10,000 eggs could have been laid at the cliffs. According to our data about 42% of these eggs hatched, maybe 4,200 chicks, and of these maybe 3,700 fledged.

Feeding Behavior and Food Sources

Our data on food sources of murrelets is again limited but it indicates that prickleback (Lumpenus) is by far the primary food brought to chicks on the ledges. Murrelets are seen also with Sand Lance (Ammodytes), with a fish that was probably Saffron Cod, and with a species of Herring.

We often saw adult murrelets bringing fish to the cliffs in their bills. They would either swallow these fish or feed them to a mate or chick after a long period of standing beside their mate, bowing and looking away. Often the fish were left lying on the ledges. Murrelets bringing in a fish would sometimes be attacked by another murrelet attempting to steal it.

Several times adults were seen attempting to feed a chick that we knew had been lost. The adult would poke the fish down in front of another bird in an incubation posture, but would sooner or later usually drop the fish. This suggests that the parent had fed itself fully before bringing food to the young.

We saw murrelets, usually in small numbers, feeding in association with kittiwakes and puffins in "feeding mêlées". It was usually not possible to tell what sort of small fish the birds were feeding on, though they were probably Sand Lance (Ammodytes). These "mêlées" were observed at the base of the cliffs and as far as 1 or 2 miles offshore.

c. Other Species

Pelagic Cormorant and Glaucous Gull

The reproductive success of these two species is summarized in Table 19. Their approximate breeding phenology at Bluff is shown in Figure 18.

We followed five of 22 nests of cormorants to positive fledging. The others were checked until the chicks were well developed. The figure for fledgings in the first column of Table 19 is for those that positively fledged; the figure in the second column, is for the number of chicks seen at the last visit; we are assuming that these chicks fledged.

In the case of Glaucous Gulls, it was impossible to see some clutches because of obscured vision. The figure for eggs per nest is determined from known clutches and by assuming that the number of chicks that hatched in the other nests was equal to the number of eggs. In the second column, the fledging rate is calculated for all nests, including those that did not hatch, for which clutch sizes aren't known.

The impact of Glaucous Gulls as predators is discussed in the section on predators below.

Table 19. Reproduction of Pelagic Cormorants and Glaucous Gulls at Bluff Cliffs, 1977.

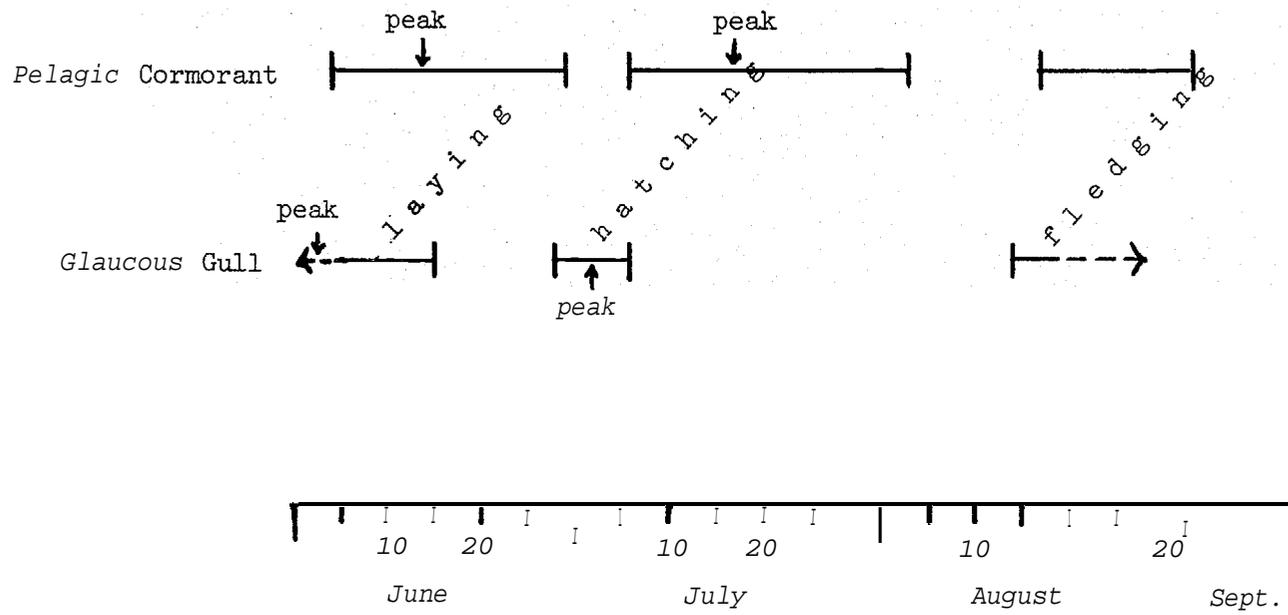
	<u>Pelagic Cormorant</u>	<u>Glaucous Gull*</u>					
		<u>Bluff</u>		<u>Square Rock</u>		<u>All</u>	
		<u>prod.</u>	<u>all</u>	<u>prod.</u>	<u>all</u>	<u>prod.</u>	<u>all</u>
no. nests monitored	22	6	13	5	9	11	21
eggs/nest	3.55	1.30					
chicks/egg	.78	.77					
chicks/nest	2.77	1.66	.92	2.2	1.22	1.91	1.05
fledge/egg	.67	.54					
fledge/chick	.86	.70	.66	.72	.73	.71	.70
fledge/nest	2.41	1.16	.62	1.6	.89	1.36	.73

*Data for Glaucous Gulls is separated by the nests that produced chicks and all nests that produced eggs for which clutch sizes are not known. Eggs per nest and chicks and fledglings per egg are shown for those nests whose clutch sizes are known, and assuming. the number hatched = clutch size.

<u>Clutch Size</u>	<u>no. nests with clutch</u>	
	<u>Pelagic Cormorant</u>	<u>Glaucous Gull</u>
1	0	2
2	3	8
3	9	6
4	7	
5	1	
6	1	

NOTE : The assumption that the number of chicks hatched = clutch size is arbitrary but may be misleading. Among Herring Gulls approximately 50% mortality occurs during a ten day period centered around hatching.

Figure 18. Breeding phenology of Pelagic Cormorants and Glaucous Gulls at Bluff, 1977.



Horned Puffin

Figure 19 shows the number of puffins counted from day to day at five study sites as a percent of the highest number counted at those stakes. It has been our experience at every colony we have worked in that the number of puffins from day to day and between weeks fluctuates widely. We have found that in general an on-shore wind will bring more puffins to the cliffs, but this is not always the case. We believe that most of these birds are nonbreeders, since they have no particular persistence at the cliff, and since many occupy ledges or boulders that do not have burrows near them.

Because of the inaccessibility of their nests, we have limited information on puffin reproduction. At Study Site 18 the five burrows in which eggs were visible from the top of the cliff were first seen to contain eggs on 1 July. Only two of these eggs hatched; the other three were noted missing on 9, 16 and 27 July respectively.

The chicks had hatched by 31 July. On that date, we removed one from its burrow. It still had its egg tooth, weighed roughly 60 grams, and its exposed culmen was 18mm long. Both chicks were noted gone from their burrows on 9 September.

Tufted Puffin, Pigeon Guillemot, and Parakeet Auklet are present in low numbers at Bluff. Tufted Puffins are seen in suitable holes in the cliff, so we suspect that they do breed here. On 29 August an apparently flightless juvenile guillemot was found dying on the beach; this constitutes the first breeding record of the species inside Norton Sound. We counted a maximum of 36 Parakeet Auklets at Study Site 18 on 26 June and 40 on 10 August; a group of auklets was usually present at this site in the morning throughout the season, generally numbering around 20. They were most frequently seen in the water, but a few were occasionally perched at two places, one near the top of the cliff and another about one third of the way up, where there is dirt and broken rock. We do not know if they nested.

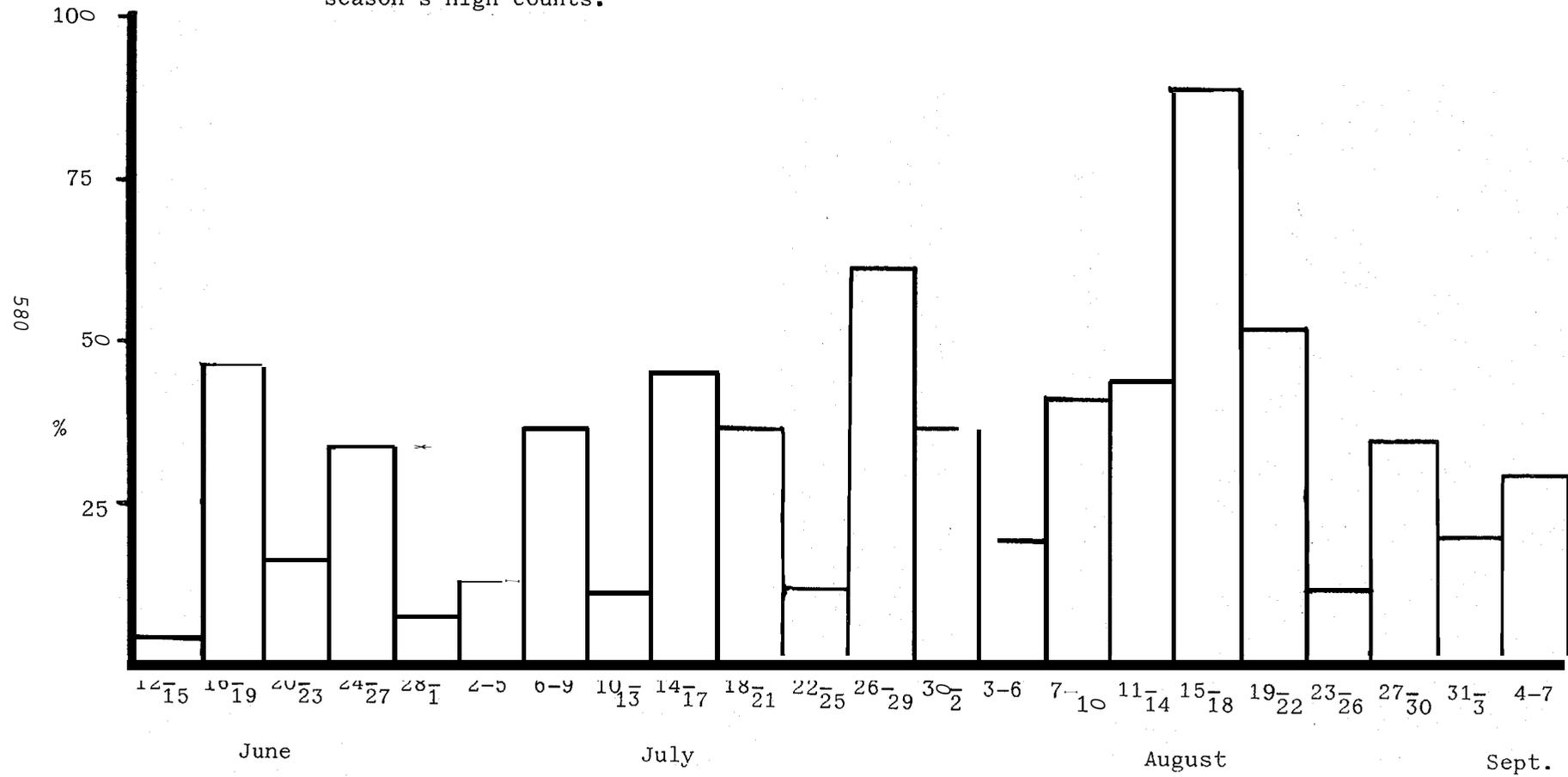
3. Other Localities in Norton Sound

a. Sledge Island

Sledge Island, is accessible in our small boats only on calm days. The owner of the one large boat for hire that we found in Nome would not go except on days when we could go just as easily in our small boat. Thus, Sledge continues to be a relatively difficult place to work. We had a party of two on the island on 21 to

Figure 19. Variation in numbers of Horned Puffins at the cliffs; Bluff, 1977.

Mean number of Horned Puffins at five study sites, shown as a percent of the season's high counts.



24 June, and another party of two visited the island for one day on 23 August. The infrequency of our visits gives us limited data on reproductive success. We have used the data we have to calculate reproductive success in ways that will be comparable to data obtained on future short visits.

Table 20 summarizes reproductive success for murre, kittiwakes, and cormorants in 1977, and the method by which the figures were obtained.

Black-legged Kittiwakes reproduced about as well as they did at Bluff Cliffs. The data for murre do not allow us to make comparisons; however, our party counted more murre at Sledge in June of this year than we had ever counted there before. The figure for cormorants is made without knowing the number of chicks that had already fledged and left the nest. However, the second number provides a rough estimate for cormorant reproduction. In either case it is lower than the productivity at Topkok Head and Bluff, but possibly the same as or higher than productivity at Rocky Point.

b. Topkok Head and Rocky Point

We visited each of these colonies by boat twice.

Pelagic Cormorants - The best time to sample cormorant reproduction from the water is when the chicks are old enough to be upright and visible, but are not yet fledged. Stormy weather during two weeks in the middle of August kept us from visiting the colonies at the ideal time; by late August many juvenile cormorants were already in the water. It is difficult to distinguish fledged juveniles from adults when they fly away together at some distance from the boat. The figures for reproductive success (Table 21) are our best estimates. We have counts from late July, when not all chicks were visible, and counts from late August, when many chicks had fledged.

The higher estimate for reproductive success of the Topkok Head cormorants is close to that obtained at Bluff, but at Rocky Point our estimate shows productivity of only about half that at Bluff or Topkok. This may be an artifact of the data.

Glaucous Gulls - We were not able to see gull nests from the water at either locality, but we did census adults on both visits, and we counted airborne birds of the year on our August visits. We were able to count adults incubating in nests at Topkok during an airplane flight in late June. These data are summarized in Table 21.

Table 20. Estimates of reproductive success of cormorants, murres, and kittiwakes at Sledge Island, 1977.

Species	Estimated Reproductive Success chicks/nest	Data Used
Pelagic Cormorant	.76	counts at study sites: 42 chicks (August), 54 nests (June) (does not include fledged chicks that had left nests)
	1.6	censuses around island: roughly 160 birds of the year (August) roughly 100 nests (June)
Black-legged Kittiwake	.05	counts at study sites in August: 6 chicks, 122 nests
	.10-.15	count from boat of nests, chicks, and birds in brooding posture in August: 317 nests, 31 chicks, 17 "brooders"
Common Murre	.22	counts at study sites in August: 100 chicks, 450 pairs (900 adults)
	.18	study site 1: 425 pairs (max.adult count in June = 850) 75 chicks (max.count August)
Thick-billed Murre	.33	count at study site 2 in August: 7 chicks, 11 adults

Table 21. Estimates of reproductive success of Pelagic Cormorants and Glaucous Gulls at Rocky Point and Topkok Head, 1977.

	<u>reproductive success</u> <u>chicks/nest</u>		<u>average brood size</u>	
	<u>Rocky Pt.</u>	<u>Topkok</u>	<u>Rocky Pt.</u>	<u>Topkok</u>
Pelagic Cormorant	.81 - 1.2	1.04 - 2.4	2.1	1.6 (17 July)
Glaucous Gull	15 juveniles on 20 August - no nests seen	1.4*		

*31 birds of the year (22 August), 22 incubating adults counted from an airplane 15 June.

B. PREDATORS

There are two classes of predators at Bluff based on what they take; egg-chick predators, and predators of the adult birds. The egg-chick predators include the raven (Corvus corax principalis), Glaucous Gulls (Larus hyperboreus), and perhaps the Red Fox (Vulpes fulva), the Arctic Ground Squirrel (Citellus parvii) and the Short-tailed Weasel (Mustela ermines). The predators on adults are the Golden Eagle (Aquila chrysaetos), the Peregrine Falcon (Falco peregrinus), the Gyrfalcon (F. rusticolus), and the Rough-legged Hawk (Buteo lagopus). These-predators have varying effects on the murre and other seabirds depending on the extent and the timing of their predation.

Egg-chick predators

1. Ravens
 - a. Bluff birds

There were three active raven nests on and around the cliffs at Bluff (see Figure 20) and three inactive nests. Going from east to west, there was one nest at Square Rock that fledged three young. The next nest was on the Bluff Cliffs and was inactive. This nest was not noticed until July 24 and never showed any signs of use while we were there. It may have been used for a short time early in the season before we arrived at the cliffs. Ravens are known to have multiple nest sites that are used in successive years on a territory (Ratcliffe, 1962). This nest, however, looked new and was probably built this year. The next nest to the west was located near an old mine shaft, and was occupied by a pair that fledged four young. This nest was only 100 yards from a site used last year. Judging from this, and from the reports of the fidelity of ravens to their territories (Ratcliffe, 1962, Coombes, 1948), this is probably the same pair that nested nearby last year. Most of our 1977 data on ravens comes from the pair at this nest. Moving west to Study Site 7, there was a nest that had five eggs in it on May 24. On our next visit on 12 June, a raven flushed off the nest noisily and scolded us from a perch on the cliffs. We did not check the nest for eggs on that visit but the raven appeared to be incubating. When we returned again on the 15th of June, the nest had been abandoned and the eggs were gone. A fox or some other predator (another raven) may have stolen the eggs. However, even if the birds had eggs on 12 June, they may have been sterile since the other two nests had hatched their young almost three weeks before. Alternatively, this may have been a young pair that nested late, and were driven out by the more experienced pair from the east at the mine shaft. There was

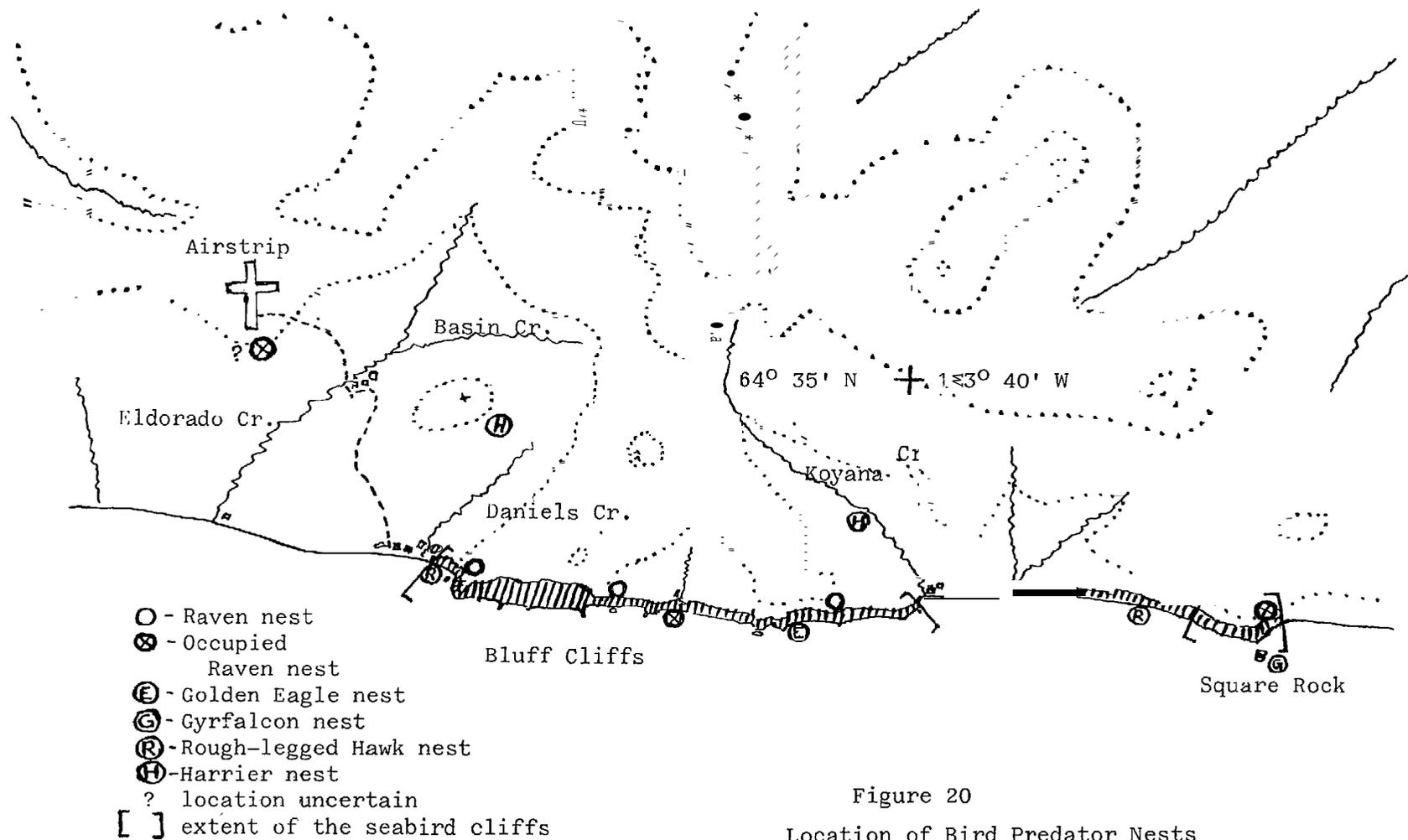


Figure 20
Location of Bird Predator Nests
at Bluff Cliffs, 1977

one other nest built on the cliff near stake 2. On 24 May, melt water was dripping into the nest and adults were never seen to occupy this nest. Presumably it was abandoned when the snow started to melt. The third active nest was never found, but we deduced its presence from, one, the persistent attendance of a pair of ravens at the west end of the cliff who regularly flew northwest carrying murre eggs, and two, the presence of a family of seven (5 chicks) later in the season in this same area of cliff and west along the beach beyond the cliffs. In 1975 a pair of ravens raised a brood of 4 young in a large wooden structure at the mouth of Daniels Creek, the western edge of the cliffs.

If we tentatively locate this undiscovered nest near the air-strip northwest of the mine camp at the west end of Bluff, the three active raven nests space out at about 3 mile intervals. Ravens are very territorial (Goodwin, 1976) and we saw frequent aerial "dog fights" between pairs of ravens on the east side of the high Bluff near stake 5. These were never injurious to either party, but both pairs eventually retreated in opposite directions. The evidence of regular spacing and territorial aggression both support the presence of another nest to the west. Ratcliffe (1962) has seen both boundary clashes and regular spacing in his British ravens.

There is also evidence from Britain that ravens nest in trees (Holyoak and Ratcliffe, 1968). Our unlocated nest is probably in a tree. The other nests are on the cliff and usually built underneath an overhang. The nest with melt dripping into it is an exception. This suggests that one function of an overhanging ledge as a nest site is to protect against the melting snow. The ravens build their nests and lay eggs before the snow has melted (see b. below).

The ravens at Bluff molted during the summer. Later in the season, this was a convenient way to tell adults from the fledged, fully feathered young. The primaries molted first starting with #1 and proceeding out to the end of the wing; the tail molted next and then the secondaries. The ravens were completing the molt of their secondaries through August.

b. Breeding season events

Period of eggs and nestlings

Goodwin (1976) reports an incubation period of 18-20 days for ravens in Germany. The mine shaft raven nest had small young on 24 May, and using Goodwin's incubation period, this means the eggs were laid during the end of April or the first week in May. Allowing one week for the construction of the nest, the fact that nests are completed one week before eggs are laid (Goodwin, op. cit.) , means

that the ravens were on their territories by early to middle April. These are approximate dates but illustrate the fact that the ravens start their breeding season at a time when the weather is foul; when blizzards and high winds are common.

Although we did not see the ravens hatch, we can infer from the 24 May observation of very new young in the nest hatching is around the end of the third week in May. The mine shaft raven chicks climbed out of their nests and up to the top of the cliff (25'-30' up) five to six weeks after hatching, on 28-29 June. They could not fly more than a couple of feet at this point but did use their wings for balance. A week later however, they were flying in earnest. This schedule is in rough agreement with Gwinner's (in Goodwin 1976) German birds who fledge at 6 weeks of age. The four young seen at Daniels Creed in 1975 were climbing but not yet flying on 3 July. An additional 2-3 weeks is needed to perfect their coordination in the air, and especially landing. They are very ungainly at first and seem prone to predation at this point (see below, for interaction with fox). The few days after the chicks climb out of the nest and walk around flightless at the cliff edge offers a good chance to net and band them. We managed to get only one this year before they could escape us.

Period immediately following fledging

We sat in a blind, and later in the open on the tundra, to watch feeding and daily habits of the raven family. The chicks could be told apart by the different patterns of black and flesh tones on the bill. The bill became solid black as the season progressed so the birds must be seen every two days or so to keep them straight over long periods. On June 21 the chicks were fed 28 times in 5 hours (5.8 feedings/hour) and each chick was fed about the same number of times. (The amount given each chick may have been different however. On 29 June, a four hour watch revealed a feeding rate of only 1.25 feedings/hour. One chick was not fed on either of those two days and was noticeably smaller than his three siblings. He was also the last one to leave the nest. The first three left the nest on July 29 and were on the cliff top on the 30, but the small one spent 3-4 days climbing to the top. One reason he was not fed was that the more active chicks were always higher on the cliff and begged louder and longer than he did. By mid-afternoon on the 30th, the bird stopped begging altogether and was apparently going to die. However, on 4 July, he had joined the others at the top and he subsequently progressed normally.

It may be evolutionarily expedient for the ravens to protect themselves against a season of sparse food supply by hatching their young asynchronously. Theoretically, in a poor season, the youngest, smallest chick, will die off first, leaving a family of more manageable size to rear. If the food supply is plentiful, all of the chicks may survive. Other factors besides food supply, such as the experience of the adults, may be compensated for in this way. This may be the situation for the ravens at Bluff. There are many reasons why the small chick was not being fed at the same rate as the others including size, amount of begging, position on the cliff, etc. "but ultimately it may be because it is younger, having hatched later than all the others. There are conflicting reports on asynchronous hatching in ravens in the literature. Lockie (1955) states that ravens in Britain start incubating with egg-laying and the young hatch asynchronously; But Gwinner (in Goodwin, 1976) reports that the female raven sinks the eggs into the nest lining until incubation begins.

All four chicks survived however, and rapidly began to increase the area along the cliff edge that they used. By July 9, the chicks were very persistent in their begging and began to follow the adults as they left after a feed. The chicks began to fly down to the cliff ledges and land beside the adults as they take murre eggs, and even eat the eggs directly from the shells after the adult has broken them open. Also, the adults were observed to fly low over the chicks with food in their bill and fly off inland. The chicks responded by begging loudly and taking off after the adult, but following it for only about 20 feet and then landing. By the 16th of July, the family abandoned the cliff edge as the center of activity and ranged inland over the tundra. They now spend nights away from the cliff also. It is difficult to tell whether the chicks initiate this change with eager begging or the adults do so by encouraging them to follow. Both of these behavior patterns occur together and lead to the expansion of the chick's range. During this stage, the chicks' voices change. They develop a hoarse "crawl", deeper in tone than their juvenile screams.

Period of free flying young, flocking.

Around the first of August, the chicks are seen hunting alone, or in pairs, on the-cliff. This is the time that we saw the family of seven (5 chicks, 2 adults) come in from the west, confirming our hunch that there was a nesting pair west of the seabird cliffs. At this same date, strange ravens begin to move through the area, most of them coming from the east. At first they were just additions to the two families making flocks of 8 to 10 which would shortly split up presumably into the family group and the interlopers. These intruders were mostly chicks, identified by their new set of feathers and were not treated with any aggression by the residents. As the

month progressed, the size of the flocks became larger, culminating with a flock of 40-50 seen in early September. After the first week in August the mine shaft family was not seen together, or at least could not be identified as such though it may have been part of a larger group. Loose flocks of 8-15 were the rule during most of August at Bluff. During any one short observation of these flocks, pairs are apparent; but if a pair is followed for a length of time (\sim 15 min.), it may not remain together. Perhaps the ravens tend to interact in a pairwise fashion within the flock. Coombes (1948) reports that some birds within his nonbreeding flocks "seem to be paired".

Several ravens were seen carrying both murre and kittiwake chicks during August. In 1975, a flock of 25--30 was seen around a walrus carcass. Thus, these late season flocks we see may congregate at the concentration of food found at the cliffs. However, none of the flocks that we saw appeared to be hunting; they were playing in the updrafts created by the high cliffs. Again, we did not see territorial aggression against these birds by the resident breeders, as we did between pairs of breeders.

Coombes (op. cit.) reports the existence of "floating flocks" of ravens during the breeding season in Britain. These flocks are nonbreeders that wander about the hills loafing for the most part, but hunting occasionally and roosting together at night. Coombes postulates that these birds are breeding surplus that stay in a flock for a few years before breeding. Ratcliffe (1962) also postulates a breeding surplus based on the rapidity with which birds that lose their mates find a new one. The flocks we see may also be breeding surplus. Our identification of most of them as birds of the year based on plumage could be faulty since nonbreeding adults may have a different molt schedule than breeders. We never saw signs of these flocks earlier in the season than August at the cliff, or on our few excursions inland, and we have seen them every year at the same time. This suggests that they may be juveniles who are dispersing away from their nests. However, Goodwin (1976) states that chicks "remain more or less under parental care for 5½-6 months". The evidence we have does not support this, but we could not follow the mine shaft family beyond the first week in August.

c. Diet

Ravens are ravenous omnivores. They eat Arctic Ground Squirrel, Tundra Hare (Lepus othus), small passerine, and the eggs of all the seabirds on the cliff; puffins, murre, kittiwakes, Pelagic Cormorants, and even Glaucous Gulls. They will eat carrion including dead walrus and seals, and murre that the Golden Eagle has killed. Blueberries

and probably other plant materials are eaten as well. The ravens carry food in their beak or in their feet and sometimes switch from foot to beak to opposite foot while flying. They also have a gular pouch that they use to carry food to their young.

Early in the breeding season the ravens hunt on the tundra and take mostly Tundra Hares and ground squirrels. They are known to cache food (Goodwin, 1976) and they may do so at Bluff. Often the adult raven was observed to fly to specific spots on the tundra in between feeding the chicks. No food cache was ever found however. In the middle of the breeding season, starting around the first of July, murre eggs become a large percentage of their diet. As we walked along the cliff top, we recorded and then crushed egg shells each time we passed and from this can calculate a rough histogram of frequency of egg predation through the summer (see Figure 21). The ravens ate most of their eggs within 50' of the cliff edge usually on an exposed patch of tundra. They also frequently flew inland with eggs, thus the histograms not a full measure of predation. Egg predation dropped off around the time when the raven family moved away from the cliff to hunt inland, as would be expected. This curve also roughly follows the egg-laying curve for the murre. Later in the season, the cliff was still being exploited, but to a smaller extent than during mid-season.

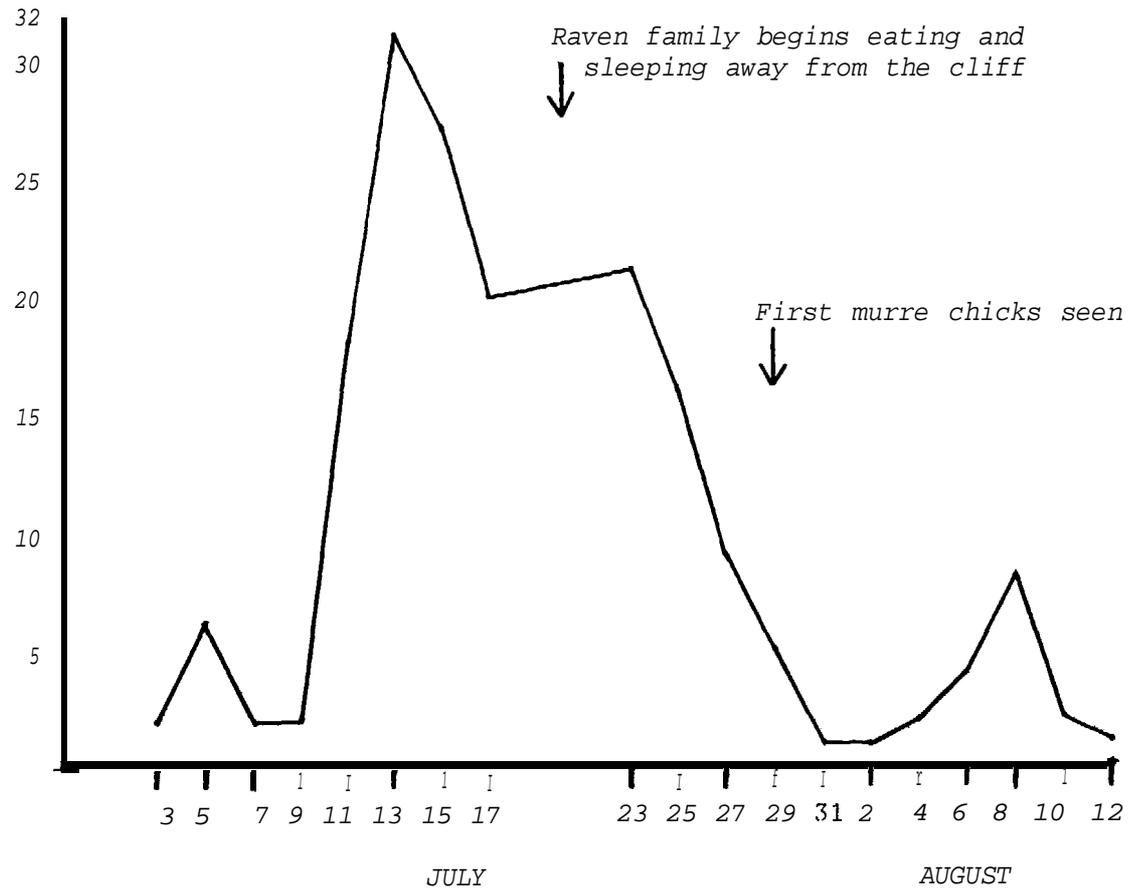
d. *Effect on murre*

The total egg production for the murre this season was on the order of 10,000. We crushed a total of 275 eggshells and assuming that this figure is about half of the total number of eggs taken by ravens, then the ravens took 5-6% of the murre egg production. However, the ravens are the first ones to find murre eggs. We usually see a raven carrying a murre egg 3-4 days before we see eggs on the cliff. Thus, because they are looking hard for the eggs to appear they trim off the ones laid early. This may constitute a pressure on the murre for synchrony of egg production within the colony of murre. The female murre has a very loud "pa-daahh!" call that is given during copulation, and this advertisement may be a mechanism for colony breeding synchrony. More evidence is needed to substantiate the function of this call and the effect of raven predation on the eggs. Also, the raven takes some murre chicks in August but this was observed very infrequently relative to egg predation.

Eggs and chicks are most often taken from lone murre. The raven's strategy is to land on a ledge with a lone murre and try to push it off its egg. Usually both birds go tumbling off the cliff and the more agile raven can turn right back and grab the egg while the murre is taking 400 yards to circle back. Murre are hefty and

Figure 21. Number of eggshells found and crushed on the cliff top at Bluff, 1977

591



have sharp beaks and they can defend the egg if they hold their ground, but often they fall off the cliff trying to do so. Some egg loss occurs when eggs are knocked off the cliff during these fights. It is interesting and probably significant that when even a single murre chick remains on a ledge in September, 10-20 adult murre cluster on the ledge or near to it. If a late nester still had a chick after his neighbor's chicks had jumped and all the "associated" birds had left also, the chick would be especially vulnerable. Even so, late nesters are more likely to be preyed upon than early nesters so ravens may exert some pressure on the timing of the breeding season at the end as well as at the beginning.

e. Interactions with other seabird predators

One of the most conspicuous of events at Bluff were the aerial "dog fights" between the raven and the Golden Eagle. Both birds were seen to initiate these fights and neither was consistently the victor. Most fights seemed to dissipate without a winner being established. The eagle and the raven overlap in diet (Arctic Ground Squirrel, Tundra Hares and carrion) and may compete in this way. The adult ravens stole from the eagle chick after it fledged and was being fed on the tundra (see below). One day, even the raven chicks tried to move the eaglet off a dead murre. The adult eagle protected the eaglet by diving at the ravens.

The eagle-raven antagonism may also reflect the fact that the eagle is a casual predator of the raven. A raven chick was found killed above the eagle nest and eviscerated in typical eagle fashion on 11 August. This was probably one of the ravens from the flocks moving through, since the resident ravens were very aware of the eagle's presence. Eagles are said to be "dominant competitors" of ravens in Britain where they have been observed to displace ravens from their breeding cliffs (Holyoak and Ratcliffe, 1968).

Ravens also had occasional encounters with foxes. A pair of Red Fox was very visible all summer at Bluff. They were seen walking along the edge of the cliff on June 30 the day after the raven chicks climbed out of the nest. The adult ravens stood their ground while the chicks climbed down the cliff. The adult erected every feather on its body, the tail was spread and held up and the wrists were held down and out, with the tips of the primaries on the ground - an impressive show of force. The fox came within 6 feet of this raven and hacked off as the raven made short lunges at him. The raven bounced around and often pecked at the ground, reminiscent of grass-pulling in gulls, during this display. The fox may have taken the eggs from the raven nest at Study Site 7.

There were only rare antagonistic encounters with Glaucous Gulls. Gulls chased raven chicks a few times when the chick was first starting to hunt the cliff alone. Glaucous Gulls were also somewhat parasitic on hunting ravens. A Glaucous Gull is not able to move a murre off its egg and often waited until a raven had done so and then stole the murre egg. The ravens were seen eating a Glaucous Gull egg early in the season; their relationship is not a simple one. The Gyrfalcons at Square Rock (see below) sometimes harassed the Square Rock ravens. A raven was once seen to chase a Peregrine at the Bluff Cliffs.

The raven's diet overlapped with other raptors somewhat depending on the predator and the season. But the most aggressive interactions were with the Golden Eagle who is a sometimes predator of the raven.

2. Glaucous Gulls

a. Bluff birds

There are three age classes of gulls at Bluff that are easily distinguishable early in the season; 1st year birds (pink-beige plumage), 2nd year birds (all white plumage), and adults. As birds in subadult plumages both molt they become harder to distinguish as the season progresses.

There are around 20 breeding pairs at Bluff. When we arrived in late May, they had set up and were defending territories. Eggs were laid around the 10th of June and they hatched between the 8th-12th of July. We had a mixed Herring Gull-Glaucous pair at the Bluff Cliffs which produced offspring this year. At the west side of Rocky Point, we observed a Slatybacked Gull (Larus shistisagus) apparently holding a territory, but no nest was seen.

b. Diet and effect on murre

Glaucous Gulls are omnivorous. They eat fish, (commonly robbing kittiwakes in t'ceding m'lees), carrion from dead seals and walrus washed up on the beach, blueberries, kittiwake chicks, and murre eggs and chicks,

In general, they are unable to move a murre off its egg so they rely on disturbances at the cliff that scare the murre away and then they steal eggs. Their habit of parasitizing a raven's hunting efforts was described above. They also take eggs when an airplane flies close to the cliff or when we go close to the cliff in our outboard. The gulls follow our boat along the cliff during a cliff census, taking eggs from each newly disturbed section of cliff. Thus, Glaucous Gulls

are opportunistic hunters of the cliff. Their standard hunting strategy is to soar along the edge of the cliff until they spot an unattended egg and then swoop down on it. They take the egg off to another ledge on the cliff (rarely up to the cliff edge) and either swallow it whole or peck a hole in it and scoop up the contents.

The amount of predation that the Glaucous Gulls do on murre eggs and brooded chicks is dependent on the amount of disturbance of the murre and the number of gulls around the cliff. (Gulls from Rocky Point may come this far west to hunt the Bluff Cliffs.) Glaucous Gulls do consistent damage to the murre's reproductive effort at the time when the chicks jump off the cliff into the water. If a chick lands in the water and is not immediately joined by an adult, the chick stands a good chance of being eaten by a glaucous gull. An adult murre can defend the chick in the water against Glaucous Gulls. It is very difficult to see the jumping murre chicks since they prefer to jump at dusk. Thus, an estimate of the rate of predation by gulls on jumping chicks is difficult to get.

We made some observations on the jumping of murre chicks on six nights in September of 1975. During that period our set of observations recorded 38 chicks jumping and four taken by Glaucous Gulls. We saw gulls carrying three other chicks in the same cove in the same period. It is dangerous to generalize from this small sample, but at the time we suggested that very few murre chicks jumped unaccompanied by an adult, perhaps one in 10-15. We estimated that gulls took about one in three of the chicks which jumped alone, which includes those we saw on the water. According to our observations at that time, even the chicks which jump off the ledge alone are soon joined by an adult from the groups of adults which loiter at the foot of the cliffs. We have described the behavior of those birds elsewhere.

The Glaucous Gulls which were hunting murre chicks defended sections of the water at the foot of the cliffs, each occupying a shallow cove. In this way the gulls spaced themselves out so that fewer than thirty gulls were effectively hunting chicks. We estimated in 1975 that gulls might take 2000 chicks a year under conditions favorable to the gulls.

3. Other "Egg-chick Predators

Foxes can reach only a few of the ledges that murre nest on by climbing down from the top since the cliff is generally sheer. A fox has been seen only once down on the cliff so he is surely not a heavy egg-chick predator. Arctic Ground Squirrels and Short-tailed Weasels will eat eggs but no evidence of predation on murre by these

animals has been observed. In 1976 we saw an Arctic Ground Squirrel (Sik-sik) working up and down a steep slope close to where a Horned Puffin carried food to a crevice at Study Site 7. It may be that ground squirrels destroy eggs in puffin burrows near the tops of the cliffs.

Predators on adults

1. Golden Eagle

The most spectacular predator at the cliff is the eagle when he folds his wings and plummets with amazing acceleration into a flock of kittiwakes which scatter in all directions. There was one pair nesting at Bluff, another at Rocky Point and perhaps a third at Topkok, making 3 pairs in about 30 miles of coastline.

The Bluff pair were very mottled, both male and female, and we were able to tell them apart by their white markings. Their nest was 100' or so from last year's and, about halfway up a 150' cliff. The nest, a huge bunch of twigs, was apparently built this year. The eagles hatched two chicks but only fledged one. The first one died fairly early in its life. The surviving chick was well feathered on the 27th of June, with only a few tufts of down left on its head. The eagles were very wary of us at this time of the year so we were reluctant to disturb them. On the 17th of July, the chick, now fully feathered, was seen in the nest but he was probably already flying. On July 24, he had definitely fledged. After the time of fledging, the adults became more tame but the chick was very wary.

The Golden Eagles at Bluff took many different kinds of prey. One day's walk along the cliff edge passing all of the eagles' eating perches revealed the carcasses of 3 Tundra Hares, 1 ground squirrel, 14 murrelets and 1 kittiwake. There were also twelve spots of feathers on the tundra indicating twelve murrelets had been recently eaten. This tally can suggest only the range of food items taken and a crude relative frequency. If the eagles took five birds per day per bird for three months, the total is 1350 murrelets taken by eagles in a season. This is an inconsequential 2% of the population of 50,000 to 60,000 murrelets. The predation rate was nowhere near as high as 15 birds per day, (Eagles also take an occasional raven, (see above), and may take ptarmigan.)

II. Gyrfalcon

The other major predator on the adult murrelets at Bluff was the resident pair of Gyrfalcons. Their nest was at Square Rock and hatched two chicks but only fledged one this year. The adults were very wary

and were not often seen. The nest was inaccessible so we could not inspect the remains of prey there. We did find one or two feeding perches where ptarmigan remains were always evident. One day, we saw the Gyrfalcon below the main cliffs at Bluff standing on a freshly killed murre on the beach. It is difficult to measure the rate of the Gyrfalcon predation on the murre. They do take some but we only rarely saw them at the cliffs and we most often saw the adults flying north towards the interior or coming from that direction. This gyr pair probably takes about half murre and half inland species, especially ptarmigan. Cade (1960) reports that the gyr population in Alaska is divided into two groups with the coastal group taking seabirds and waterfowl almost exclusively, and supplementing their diet with inland prey (ptarmigan and ground squirrels) if they are locally abundant.

Cade also reports that the Golden Eagle and Gyrfalcon are competitors and the gyrs "fear and hate Golden Eagle with equal intensity". We never saw any interactions between the gyr and the eagle. The Gyrfalcon was observed diving at the ravens, however, that were "nesting not more than 100 yards from the gyr nest."

3. Rough-legged hawk

There were two breeding pairs of rough-legs at Bluff. One at the west end of the cliff laid 3 eggs, hatched 2 young, but fledged only one. The second young was almost certainly eaten by another family member judging from the presence of the talons and leg bones of the chick in the nest on the 19th of July. The same eating of a younger by an older chick happened in 1975. The second nest was on the cliffs near Square Rock. This pair hatched and fledged two chicks on August 7.

The rough-legs were eating small rodents and Tundra Hare for the most part judging from the remains visible in the nest. The Square Rock pair also took puffins. We often saw one or two pairs of red feet and some colored bills lying around the nest. The nest was placed on a section of cliff where there was a large number of nesting puffins. Puffin remains were not seen at the nest-on the west end of Bluff, although that area also has a large population of puffins.

4. Other predators

A Peregrine Falcon was seen occasionally, roving along the edge of the cliff. He probably took a few murre but did not nest at Bluff this year. The pair of Red Foxes probably could not catch adult murre but may be able to get puffins as they come out of their burrow.

There were 2 families of harriers, one in Koyana Creek and one in Daniels Creek, fledging 4 and 5 young respectively. Also, a long-tailed Jaeger nested on the tundra nearby. This pair fledged one chick. These two predator species did not take seabirds, but may have competed for rodents with the seabird predators who took rodents: i.e. the ravens, Gyrfalcons, and Rough-legged Hawks.

c. WATERFOWL

1. Spring migration.

We arrived in the field in spring of 1977 while most of the southern Seward Peninsula was still under snow, and made flights between Nome and Point Spencer, and between Nome and Bluff. Waterfowl gathered in the first pieces of open water, usually the mouths of rivers whether they were emptying into the sea or into a lagoon. These were the Woolley Lagoons, lagoons between Nome and Cape Nome, the lower reaches of the Flambeau and Eldorado Rivers, and where Pine Creek empties into the lagoons between Bonanza River and Taylor Lagoon. In addition water collected in a number of temporary ponds where creeks or rivers in spring freshet overwhelmed the capacity of the road culverts.

While most of the sea was frozen, ducks such as Oldsquaws, Red-breasted Mergansers, and Black Scoters were to be found in the fresh water lagoons behind the sea beaches. Harlequin Ducks and Common and King Eiders were not seen on such fresh water.

By early June it was clear that 1977 was an unusual year for waterfowl on the southern shore of the Seward Peninsula. Species seldom seen in the area such as Lesser Scaup were seen in small ponds east of Nome, and Mallards and Redheads were seen in the rivers and lagoons around Safety Lagoon. By the middle of the month exceptionally large numbers of Pintails and Shovelers appeared in the lower reaches of Flambeau River, at Bonanza and Taylor Lagoon and at the head of Golovin Bay. The numbers of Canvasbacks did not seem to be unusually large. We saw one bird that appeared to be a Trumpeter Swan.

After talking with R. Jones on the Yukon Delta who reported an influx of Pintail there and remarked that the birds did not seem to be breeding, we surveyed the 'prairie ducks' to see whether this was also true in our area, in the course of air travel planned for other purposes. Our observations indicated that the 'extra' ducks were virtually all still in mixed flocks of males and females on the open water where ducks gather on migration. The Pintails on smaller ponds away from the coast were nearly all single males, and this observation

applied all the way to the north end of the Kougarok Road. In late June we did see 3 broods of Pintails on ponds in mine tailings. Each brood had 5 ducklings. The Shovelers, Mallards and Redheads seemed to follow the same generalization as did the Canvasbacks in Taylor Lagoon, although the Canvasbacks in the flats west of the Flambeau River seemed to be breeding. We interpret these observations as being consistent with the idea that the 'prairie waterfowl', which had extended their spring migration to the northwest because of drought in the northern prairies, did not breed in our area.

2. Fall migration

The fall migration is usually first indicated by the gathering of waterfowl in the salt marshes at the lower reaches of rivers such as the Bonanza on the east end of Safety Lagoon. Martin Olson commented that the 'Sprigs' (Pintail) gathered there unusually early and in especially large numbers in 1977. Martin has lived near the Bonanza River for more than thirty years. We did not have sufficiently regular flights over the area to be confident, but our experience suggests that a movement of Pintails began in late July, built up to a peak in middle August and moved out about August 20-25. This movement may have been local, however, because we found large numbers of Pintails on the mudflats at the mouths of the Fish River, Kwik River and Koyuk-Inglutalik Rivers at 'low tide' between August 26 and 31. Furthermore we noticed that if we surveyed a large-group of ducks closely on our way to Nome, when we came back three hours later the ducks had dispersed. Our surveys were made over several days and we do not think that this effect has influenced our counts.

3. Distribution of waterfowl gathering areas over the southern part of the Seward Peninsula

Between August 26 and August 31 we flew waterfowl census flights over the area between Point Spencer in the northwest and Shaktoolik in the southeast. In 1977 we flew census flights over the flats north of Imuruk Basin, up river past Mary's Igloo and across the divide and down the Niukliuk River, over the Fish River flats and (as in previous years) over the flats around the lower Fish River south of White Mountain. The distribution of waterfowl was as follows:

Sparse numbers (most ponds empty, few birds on ponds and small lakes) : on the coastal tundra west and northwest of Nome; over most of the flats east of the Imuruk Basin, in the tundra ponds back of the coast southwest of White Mountain; in the tundra ponds in back of the coast along the Kwik River, Koyuk River and between the Ing-lutalik River and-Cape Denbigh.

Moderate numbers (several ponds with flocks of tens of waterfowl, most ponds empty): at the base of Cape Spencer, around the Wooley Lagoons near to the Kuzitrin River (in the lower flats east of the Imuruk Basin); in the tundra ponds along the coast from Cape Wooley to Sinuk and along Safety and Taylor Lagoons.

Large numbers (flocks of hundreds or thousands): in the lower Flambeau River; the lower Bonanza River; at Golovin Lagoon and on the mudflats at the mouth of the Fish River; at the mouth of the Kwik River and behind Moses Point; at the mouths of the Kovuk River and the Inglutalik River.

The areas inland and those to the northwest of Nome were censused in the course of a general survey. The coastal areas including Safety Lagoon and the coast to the east were censused in detail. In this entire area during the period of August 26-31 we counted, in order of frequency:

Pintail	28,000
Canada Goose	15,000
Baldpate	2,500
Whistling Swan	1,350
Greater Scaup	1,050
Green-winged Teal	210
Mallard	150
Lesser Scaup	30
Shoveller	8
Canvasbacks	8
Redhead	4
Sandhill Crane	400
Long-billed Dowitcher	1,300
Whimbrel	1,800

These same areas, except for the inland areas along Imuruk River, Kuzutrín River and Niukluk River, were flown looking for waterfowl in 1976. Our experience in both years is consistent with what Jim King of the U.S. Fish and Wildlife Service told us in 1975, that in general, productive waterfowl habitat decreases progressively as one goes northwest from Safety Lagoon. (See Figure 22)

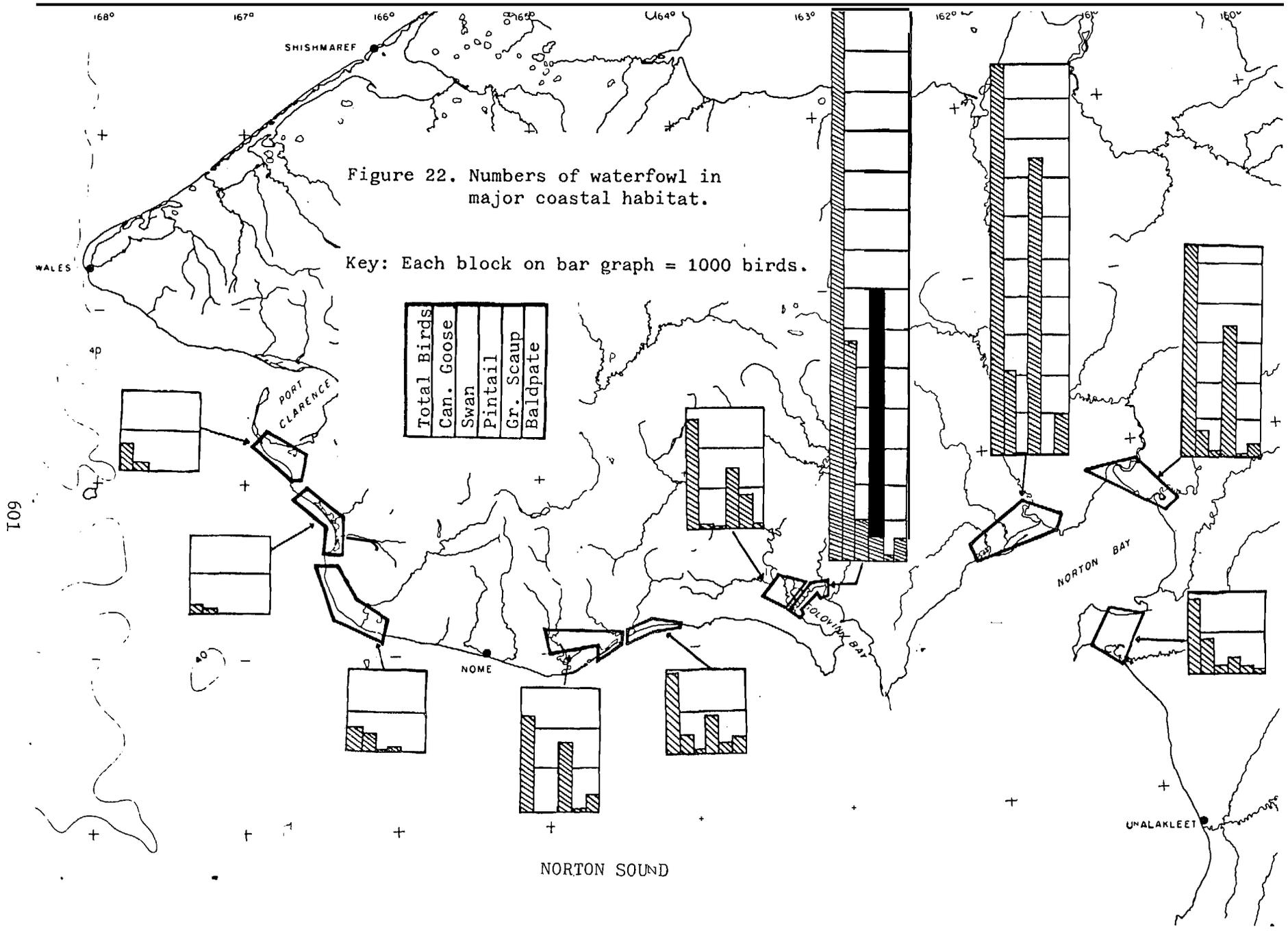
The techniques used in taking these censuses, the areas censused and graphs of the relative frequencies of species within areas are shown in the 1976 report. The graphs on Figure 22 represent our best estimates of total numbers of birds within the designated areas. (As opposed to number of birds seen per minute of transect as was done in 1976.) Other than the noticeably high numbers, our observations for 1977 agree with those of 1976. Table 22 shows the August 1977 data in tabular form.



Figure 22. (On next page) Major coastal waterfowl habitat areas.

From right to left (east to west) on the following map, the outlined areas of major waterfowl habitat are:

- the base of Cape Spencer
- the Wooley Lagoons
- Cape Wooley to Sinuk
- Flambeau River to Bonanza River
- Bonanza River to Taylor Lagoon
- the Fish River flats
- Golovin Lagoon
- Moses Point to the Kwik River
- Koyuk River to the Inglutalik River
- the flats behind Cape Denbigh and Shaktoolik



109

Table 22. 1977 Waterfowl censuses.

<u>Area</u>	<u>All Species</u>	<u>Canada Goose</u>	<u>Whistling Swan</u>	<u>Pintail</u>	<u>Greater Scaup</u>	<u>Baldpate</u>
Base of Cape Spencer	650	200	6			
Wooley Lagoons	132	106				
Cape Wooley to Sinuk	570	347	16	56		
Flambeau River to Bonanza River	2351	2		1808	40	314
Bonanza River to Taylor Lagoon	1950	375	57	905	245	380
Fish River Flats	2753	87	35	1430	880	140
Golovin Lagoon	14,000	5620	1050	6940	105	573
Moses Point	9 0 2 1	1630	25	7516	2	1093
Koyuk to Inglutalik River	5475	719	149	3415	256	302
Cape Denbigh Flats, Shaktoolik River Flats	1758	854	118	343	73	60
Totals	38,660	9940	1456	22413	1601	2862

4. Reproductive success of Whistling Swans

Young cygnets stay with their parents until they fledge. The young can be identified by their brown or usually gray plumage. During aerial surveys we counted the numbers of swans in flocks and recorded each single or pair of adults on the tundra ponds. For each family group we recorded the number of adults and young.

Flocks of swans which we regularly saw at the same place, such as the western part of Taylor Lagoon, were not included in our estimates of reproductive success. For the sake of our calculations, we assumed that all single birds or pairs seen on tundra ponds represented breeding pairs that had failed and that all groups of three or more without young were nonbreeding individuals.

The total reproductive success for 1977 between Teller and Shaktoolik was 1.4 young per pair. This compares to total success of 1.5 in 1976.

In 1975 we censused only the area northwest of Nome and found a reproductive success of 0.9 for 49 pairs and 43 young. In 1977 in this area we found only 15 pairs, but they had 8 young for a success of 0.5. In 1977, east of Nome we found 39 pairs of swans and 69 young, for a rate of success of 1.8.

VII & VIII. DISCUSSION AND CONCLUSIONS

The bird cliffs at Bluff have special advantages for detailed study of seabird biology. These advantages include convenient logistical support; comfortable, though primitive, living facilities; ease of access to study sites, excellent visibility of sections of the cliff from the cliff top; and, dependably good weather. Although there appears to be a conflict between the Native Land Claims and Federal requests under 'd-2' lands, the political situation appears to be very favorable for continued study. The cliffs are less ideal for other aspects of OCSEAP work. The seabirds nesting at the Bluff Cliffs are not typical of the northern Bering Sea in that the murrelets are more than 99% Common Murrelets whereas the general proportion is 50% or more Thick-billed Murrelets. Moreover virtually no auklets nest at Bluff and auklets are a major component of the northern Bering Seabird fauna. The cliffs are high and precipitous and because of the effect of storm waves, few birds nest near the base of the cliffs. This makes it hard to get access to nests in order to weigh nestlings or to band adults or young.

We have used our time at Bluff first to record the species using the area, their comings and goings and the breeding biology of those species accessible to continuous studies. These studies have turned into a systematic search for techniques which will be useable for gathering key biological data at colonies which are less accessible and to which students will be able to pay only short visits. With this in mind we have concentrated on detailed studies of the breeding biology of murres and kittiwakes in order to determine when and how to estimate the numbers of birds nesting on cliffs as well as when and how to measure reproductive success.

A. Techniques for measuring biological characteristics

1. Censusing. It is necessary to recognize that the numbers of the birds at the cliffs are in flux. Numbers vary widely according to the hour of the day and the day of the year. At the Bluff Cliffs we have counted 10,400 murres and 92,000 murres, almost an order of magnitude difference. An additional problem is that it is not clear which counts represent "the population". Apparently competition for nesting sites is intense and as a result many birds which come to the cliff are not able to establish a breeding territory. Moreover, some birds that are able to assert themselves and establish a site do not succeed in laying eggs. It is not clear at any given seabird cliff without detailed study what proportion of the birds present are in these two categories, which are excluded from traditional systems of measuring reproductive success.

It appears however that there are ways by which one can identify the main element of breeding birds. When the birds first come back in the spring, most of the population, including 'nonbreeders' arrive at the cliffs; in the weeks just before laying of eggs, many birds may leave and spend the time at sea. During the height of the egg-laying period only the highly motivated birds are present. That seems to be the time when one can make the most direct counts of the breeding population. Toward the end of the incubation period and when the young are in the nest an increase of birds at the cliffs becomes evident and another peak in counts occurs.

The numbers of birds at the cliffs also varies with time of day. The high and low counts vary between regions and may show marked contrast even between cliffs that are near to each other as our comparisons of numbers of murres between Bluff (Study Site 14/15) and Square Rock (Study Site 19/ Sq.Rk.) showed during June in 1977. Once eggs have been laid the peak numbers usually are present in the late evening.

Optimal times for censusing breeding adults:

There is ample evidence for murre and kittiwakes at Bluff, that the number of birds present at the peak of laying is closest to the number of birds attempting to breed. However, our three years of study have shown that the peak of laying may shift between "good" years for reproduction (1975) and poorer years (1976, 1977). The delay presumably reflects the environmental stress to which the birds are subject that causes their poor reproduction. Springer and Roseneau (NOAA 1978) found the laying peak of kittiwakes in the Cape Thomson area, where the birds have been experiencing similar low reproductive success, to be later than during the prosperous years of the late 1950's (Schwartz 1960). However, counts taken in the first week of July should be close to the laying peak for both murre and kittiwakes.

There does not seem to be any suitable single time for counting Horned Puffins because their numbers at the cliffs are so erratic (Figure 19). Even a count at the peak of laying may not deal with true breeding birds because the breeders may for the most part be inside their nest hole.

Counts of Glaucous Gulls and Pelagic Cormorants are best made when clutches have been completed and the birds are incubating. In the case of cormorants, late June is ideal; for Glaucous Gulls, most clutches are complete in early to mid-June.

Any single count of cliff-nesting seabirds will be affected by the circadian variation in attendance at the cliff, which evidently shifts over the course of the season, and by the seasonal variation in numbers of birds at the cliff, which apparently changes depending on the relative breeding success the birds are experiencing. It is necessary to make studies comparing variations within and between years in order to establish the range of variation within which single censuses fall. Studies made in England show that it is advisable to make several (a minimum of five) counts to encompass unpredicted variation. (Lloyd 1975)

2. Measuring reproductive success. We have found that the number of birds regularly resorting to the cliffs during the egg-laying period is a good indication of the total of breeding birds among murre and kittiwakes.

It is possible to make some additional tests with murre: a) a certain number of birds take on an 'incubating posture' (illustrated in report for 1976). Although this number of birds is much

higher than the number of eggs laid, the number appears to be close to the number of breeding birds i.e. twice the number of pairs.

b) During counts of the bird cliffs in July made from a boat, a certain proportion of birds fly off the cliffs as a boat approaches. If these "fliers" are omitted and only the birds which persist on the cliff are counted one gets a number which, again, is close to the total number of all breeding birds. It is worthwhile noting that during the years 1975-1977, there was an approximate correlation between the percent of "fliers" vs. "persistent" birds and the degree of reproductive success.

Among kittiwakes there is an arbitrary standard for inclusion of a pair of birds among the breeding population; which is those birds who build a nest which contains a substantial amount of material. Even though as many as 60% of these birds may not lay eggs in such nests, and as high as 20% may 'incubate' empty nests or eggs that have failed to hatch, this count gives a figure that can be used to make comparisons between areas and between years.

Our studies suggest that the best time for counting the number of murre and kittiwake chicks on sample areas of the cliffs is in the last two weeks of August. At this time kittiwake chicks are large and stand apart from their parents as do those of murre. The kittiwake chicks are large and distinctive enough to be counted from a boat before the cliffs, but the murre chicks must be counted from sites at which a detailed examination of each bird on the length of a study ledge can be made. The best time to count chicks of Cormorants and Glaucous Gulls is between 10 and 20 August.

We have identified age classes for chicks, which will allow the observer to establish within approximately 4 days the date of hatching, even on only one visit, provided a good sample of chicks is seen.

Our studies also suggest that it may be possible to predict whether a reproductive catastrophe is in progress by counts of the numbers of birds which stay at the ledges during the midnight or midday hours in the middle of July. During the years when reproductive success has been low many birds left the cliffs in the early hours of the morning even though they had eggs.

3. Food. The reproductive success of kittiwakes and murre has varied in similar ways between the three years of our study, and the birds seem to be affected similarly by an apparent shortage of food in Norton Sound even though the food which the two species use appears to be different. The items which Common Murre bring to the cliffs are almost entirely Prickle-backs even when there are large schools of Sand Lance close in front of the cliffs. Kittiwakes do not seem to use Prickle-backs presumably because they are bottom fish.

When a large school of Sand Launce is found, kittiwakes gather in a feeding *mélée* and puffins rush to join; some murrelets are occasionally attracted too. One seldom sees murrelets bringing Sand Launce to their chicks, however.

Kittiwake reproductive performance, as noted in the section on Current State of Knowledge, seems to be closely correlated with the appearance of Sand Launce in the area and hence in their diet. Sanger, Gill and Moe suggested that Sand Launce is important in the Kodiak area even though kittiwakes there feed consistently on Capelin. Springer and Roseneau's (NOM 1978) observations at Cape Lisburne and Cape Thompson most closely resemble ours. They saw almost no Sand Launce in the year of reproductive disaster, 1976. During 1977, when kittiwakes in their area did moderately well, they saw kittiwakes commuting many miles to feed on Sand Launce, found Sand Launce to be conspicuous in the stomachs of birds they collected, and saw the black masses of Sand Launce move southward past the cliffs followed by the feeding flocks of kittiwakes. In our own experience in 1975, which was a good year for kittiwakes, we saw feeding *mélées* of kittiwakes and puffins first off Sledge Island in late June then, further east off Safety Lagoon in mid-July, then off the Bluff Cliffs in August. Kittiwakes commuted to the *mélées* and brought Sand Launce back to regurgitate to their chicks. Nearly all the fish left on ledges near nests or regurgitated by kittiwake chicks which we handled were Sand Launce.

B. The general application of studies of seabirds to OCSEAP problems

Dr. George Hunt has prepared a short paper on the use of seabirds for interpreting conditions of the sea as part of the assessment of Alaska's Outer Continental Shelf. We subscribe to the conclusions which he presented, and will develop some ideas which apply to studies to be made at seabird colonies.

The main reason for pursuing the study of seabirds is their accessibility for study. It has been this characteristic which has allowed bird biologists to examine in detail the actual behavior of specific species and thus to test whether the ecological functions assigned to them by general theorists are valid. In fact in many cases it has been students of birds who have offered new and important insights into the operation of biological systems because of the directness of their studies and the rigor of analysis which that close contact allows.

Certain species and certain colonies are well qualified by their characteristics to be used for continued monitoring or continued study to clarify the meaning of general phenomena observed at less hospitable sites. The kittiwakes in the northern Bering Sea are

a convenient group for the study of interactions with their prey and the mechanisms involved in reproductive disasters. Their part in the ecological system seems to be comparatively simple and straight forward. It is important, of course, to acknowledge that each colony of seabirds has its own peculiar characteristics in the way that individual animals do. The birds at some colonies reproduce consistently well each year, as seems to be the case at the Pribilof Islands. Some colonies occasionally do very well. Others consistently do poorly and one presumes that the individuals occupying these colonies do not reproduce well enough to replace themselves by young, hence that the colony must be maintained by immigration from other colonies which have a surplus of young. We have noted elsewhere that this is the case for Herring Gulls (Drury and Nisbet, 1972). This well known observation is the basis for the classical "Fraser-Darling Effect".

It is important for future monitoring of populations, measuring impacts and predicting effects on populations, to know which colonies produce young at a rate higher than annual adult mortality so that they, in effect, export young. It is also important to identify those colonies which do not produce enough young to maintain the population, hence, those colonies which depend upon immigration of young. This information is needed to determine what colonies are critical and at what rate a population is able to increase. Future work should identify (1) which colonies produce an excess of young and whether the fledging weights of those young are high enough to ensure post-fledging survival. We also need to determine (2) the degree of exchange of kittiwake chicks among colonies and regions, and (3) the life-expectancy and total life-long production of young per kittiwake pair.

In order to make a predictive model of population structure locally and regionally a banding program should be undertaken at several colonies which are dispersed among the regions. The purposes of a banding program are:

1. To measure life expectancy and winter mortality by age groups in order to prepare a life table and hence predict rates and directions of population changes.
2. To identify site tenacity and performance of individual birds and pairs.
3. To establish whether low rates of production of young are associated with lengthened adult lifespan (Presumably reflecting lack of stress from competition for resources).

4. To identify the rates, directions and distance of movement among colonies.

Detailed studies of breeding biology are not needed every year once an intensive study has first been made to establish the baseline, but these should be repeated often enough to detect systematic shifts in breeding biology and populations.

1. The studies should include close attention to details of phenology, clutch size, hatching rate, fledging rate, growth rate, and weight of chicks at fledging.

2. The studies should also include foods used, patterns of foraging, and feeding behavior.

Some studies of basic biological questions can profitably accompany these studies of direct application to OCSEAP. Such studies include: What are the behavioral implications of nesting failure when coupled with the heavy competition for nesting sites? why, in terms both of natural selection and in terms of hormonal (physiological) effects, do birds persist so actively on the ledges after failing? What age groups are represented among the birds that occupy sites without building nests? What are their ages and weights relative to the weights of the birds which lay eggs and to those which build nests but do not lay eggs?

This information should contribute answers to some additional important questions such as: Does the especially heavy competition for nest sites among kittiwakes indicate that sites would remain occupied even if an important percent of the population died? How readily would kittiwakes recover from a decline to resttain present or maximum n'umbers? What studies should be undertaken on the distribution, numbers, behavior, food, foraging patterns and feeding behavior of these birds on the wintering grounds? (The birds spend 2/3 of their lives away from the breeding grounds where our efforts are concentrated.)

c. Primary and secondary effects of oil development

1. Oil spills and seabirds

The special characteristics and problems of oil spilled on the sea have been discussed by many authors in many places. The problem was recognized as serious in the North Atlantic and especially in the Eastern North Atlantic many years before Americans took notice. The meetings of the International Committee for the Protection of Birds gave special attention to problems of oil at the annual meetings at Helsinki, Finland in 1958. At that time Tuck emphasized the

serious impact of oil spills from tanker and general sea-going traffic on the seabirds of the Newfoundland and Labrador coasts. Recently Hunt in these annual reports has discussed the hazards to seabirds; and Paul Adamus of the Center for Natural Areas has prepared a table of relative vulnerability of seabirds on the Atlantic coast for BLM as part of the studies for the Outer Continental Shelf Environmental Assessment on the East Coast of the United States. Vermeer and Vermeer(1974) have also published a review.

The special vulnerability of some species of birds to oil, the predictable disaster which oiling causes and the special circumstances which makes oil spilled onto the sea virtually uncontrollable has convinced most of those concerned with both oil traffic and seabirds that extraordinary steps should be taken to avoid the transport of oil at sea if transport on land is practical..

2. Secondary development

The waters off Bluff have been suggested for a deep water port to serve the Seward Peninsula. The seabird cliffs at Bluff are critical to the population of murrens and kittiwakes in Norton Sound, but are not critical to the populations of Pelagic Cormorants, Horned Puffins or Glaucous Gulls. The cliffs at Bluff have populations of murrens and kitti-wakes comparable to those in the Saint Lawrence Island waters, but lack auklets. Thus one could say that the cliffs at Bluff were less serious a loss than the others if one set of cliffs had to be expended. On the other hand the cliffs at Bluff are unique in the nearly pure population of Common Murrens at a very high latitude. If one includes the cliffs at Topkok Head and Rocky Point the Bluff area supplies breeding sites for most of the birds of Norton Sound,

The effects of secondary development at Bluff would doubtless have an important effect on the towns of White Mountain and Golovin. In this way development would have a large effect on the mudflats at the mouth of the Fish River at the head of Golovin Bay. These are especially important waterfowl flats, probably the most important areas for waterfowl in all of the Seward peninsula.

If development were to occur at Bluff, roads for transportation of heavy goods would be required between there and Nome. A highway system would make the area accessible and therefore much more heavily used than it is now. Such access would have an important effect on the public use of the area, increasing the hunting pressure on waterfowl, and presumably eliminating the thriving population of Grizzly Bears between Bonanza and Golovin.

We have commented in our report for R.U. 447 that future traffic of heavy equipment through the Bering Strait will have an inescapable impact on that area. It would seem to make sense that some facilities will be established in Port Clarence for large ships waiting for the sea ice to clear Point Barrow. Port Clarence appears to provide much better protection for ships and seems to be a more suitable place for port facilities than Bluff. Development in Port Clarence-Grantley Harbor would affect relatively small populations of Pelagic Cormorants and Horned Puffins. The thaw ponds and salt marsh pans at the base of Point Spencer are used by comparatively small numbers of waterfowl and moderate numbers of Geese on fall migration. The serious implications of development in the Teller-Port Clarence area is the danger of contamination of the really important seabird colonies at King Island and the two Diomed Islands, and the effect on the rich fauna of marine mammals which occupy the waters that flow north of Saint Lawrence Island through the Bering Strait and into the southern Chukchi Sea.

IX. SUMMARY OF FOURTH QUARTER ACTIVITIES

A. Ship or Laboratory activities

1. Ship or field-trip schedule. Not applicable.
2. Scientific party.

William H. Drury, Principal Investigator College of the Atlantic
Bar Harbor, ME

John O. Biderman, Research Assistant
Sarah Hinckley, Research Assistant
John B. French, Jr., Project Assistant, University of Wisconsin

3. Field sampling or laboratory analysis. N/A

4. Sample localities. N/A

5. Data analyzed or collected.

Data analyzed were collected during the field season of 1977.

6. Milestone chart and digital data submission schedules.

A meeting was held in Boulder, Colorado on 20-22 March 1978 to discuss the digitizing of data for the NOAA OCSEAP archives. Those at the meeting agreed upon the kinds of data and the formats for entering data collected at seabird colonies. Following the meeting at Boulder, other meetings were held in California to arrange for getting equipment for direct entry of digital data and for having suitable programs prepared for the direct entry process.

Entering our data will be greatly facilitated by use of this equipment, but the submission will be delayed until the equipment and programs become available during the summer (May - September).

7. Meetings.

- a. Drury attended the meetings at the Pacific Seabird Group at Victoria, British Columbia, in January, and took part in a workshop on the breeding biology and variations in reproductive success of Black-legged Kittiwakes. There was also a workshop on the breeding biology of puffins.

- b. Drury also attended a synthesis meeting for OCSEAP studies of the Beaufort Sea and north coast of Alaska, in Point Barrow, AK.

B. Problems Encountered

The lease of a vessel which we had arranged for the summer of 1978 was cancelled in January by the owner of the vessel. We have sought other transportation and have tentatively arranged to use a NARL vessel during August.

The lease was arranged so as to study seabirds feeding away from their colonies. This study requires close cooperation of research from several areas of biology, such as studies of crustacea, fish, and primary productivity, as well as oceanographic structures, to be carried out properly. Such cooperation seems to be of highest priority in the OCSEAP now. Because seabirds are readily visible, it would seem obvious that seeking their concentrations is an effective way to find structures within the ocean which deserve study because of their biological importance. So far in NOAA OCSEAP in the northern Bering Sea, neither the cooperative studies nor suitable vessels have been available.