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PROGRESS REPORT
SEA CLIFF BIRDS, CAPE THOMPSON and VICINITY

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The sea cliffs currently under investigation begin 1.3 miles W.N.W. of the proposed harbor site at the mouth of Ogotoruk Creek and continue along the coast for slightly over seven miles. They are utilized as nesting sites by large numbers of sea-birds. The biomass involved is large and must be supported almost entirely from the ocean off the cliffs. There is, in addition, some interchange of energy and materials from the sea-cliff community to more clearly terrestrial forms. Hence the bird colonies constitute a biotic link between two biospheres. Both the food supply and the nesting sites are potentially subject to radioactive contamination. The ecosystem including the sea-birds is therefore particularly important not only as it may receive radioactive fallout, but for its purely scientific interest.

The summer field season of 1959 was devoted to satisfying four primary objectives: 1) a general reconnaissance of the area to discover the special problems which are posed by the topography and climate, 2) identification and census of the species comprising the bird-cliff community, 3) establishment of permanent plots to be used throughout the duration of the investigation, and 4) to make preliminary collections and observations to eventually fill out a picture of the breeding biology, local and seasonal movements, food habits, population dynamics, diurnation, and intake and egress of energy and materials for each species and the ecosystem.

Five major bird colonies occupy the cliffs W.N.W. of the mouth of Ogotoruk Creek. These have each been designated by a number beginning with the colony on "Crowbill," and extending to the fifth colony W.N.W. of Cape Thompson. Each is a distinct unit separated from the next by discontinuities in the cliffs, which vary from a short distance up to 1.5 miles in length. They may possess considerable relief but most are of such low height or soft consistency as to be unsuitable for development of colonies. Cliffs supporting bird colonies are largely limestone and range from thirty to more than six hundred feet high. There is an abundance of nesting ledges. The rock is extensively fractured and, except in a very few places, nesting ledges are not safely accessible by man. Small or large rock falls are

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frequent and a more or less continuous shower of stones falls over the cliff faces. A narrow gravel beach separates many of the cliffs from the ocean, but in only one colony (No. 5) is it continuous. In colonies Nos. 1 through 4, one or several headlands project into the ocean rendering much of the study area inaccessible except by boat.

One-hundred-thirty-five photographs were taken during the summer, giving complete coverage of approximately eight miles of coastline. Seventy-two of these are black-and-white and sixty-three are in color. Most of these were taken of specific small areas at close range. Four of these are included to show the characteristics of the cliffs and the bird colonies using them (Plates 1-4). Mr. Reuben Katchadoorian of the U. S. Geological Survey furnished a series of 82 photographs taken of the cliffs at longer range. These were extremely useful in mapping larger census areas.

CENSUS

Objectives:

1. To establish a season total for each species for each study area and for the Ogotoruk Creek-Cape Thompson area as a whole.
2. To detect new settlements and/or the abandonment of old ones.
Is census of "fringe areas" a good way to detect population change?
Population pressure?
3. To detect changes in population density in specific small areas.
Are areas and/or ledges saturated?
4. To determine whether or not birds always return to the same colony, or to the same ledge within a colony.
5. To determine the age structure (and population dynamics) of the population. This objective, more than the others presupposes a study extending over several years.

Methods:

In spite of the efforts of numerous investigators (Portenko, 1931; Krasovski, 1937; Uspenski, 1940; Kaftanovski, 1941; Sdobnikoff, 1938; Belopolski, 1952; Fay and Cade, 1959; and many others) no single method of accurately censusing colonial sea-birds has been evolved. Russian workers

have been particularly active during the past decade in research primarily aimed at increasing the productivity of the large bird colonies along their own northern coasts.

In our census work, we have used several methods separately and in combination:

1. Actual counts of individual birds. This is the method of choice when areas are small, clearly marked off, and the full depth of nesting ledges is visible. These conditions do not usually prevail, and this approach is only applicable in certain "critical" areas. We have, however, made many such counts on cliffs supporting up to 5,000 birds. Such counts demand careful marking off sections of the cliff and consumes sufficient time to cause small errors due to diurnal activity cycles.

2. Estimates of populations on larger areas utilizing the experience of observers gained in counting smaller units. With sufficient practice in counting small groups of birds, it becomes possible to estimate the numbers of birds in large areas by estimating the numbers of groups of one hundred (sometimes one thousand) contained in the larger. In all cases we made independent estimates (a minimum of two observers) and averaged these figures. In controlled circumstances we feel that our error does not exceed eight per cent. This method cannot avoid a certain amount of subjectivity, but with intermittent checking by actual counts, this can be held to a minimum. Checking may take the form of actual counts on the spot or, in favorable situations, by counting the birds in photographs taken at the time of the estimate. Census by photographic means is discussed later.

3. Census of breeding birds may be made during the peak of nesting activity by actual counts of nests or eggs. This method may be very accurate under special circumstances. It normally predicates a clear view from above, a circumstance not often fulfilled in this area. In species which occupy a nest of grass or sticks (e.g., kittiwakes, glaucous gulls, ravens, golden eagles, peregrines, gyrfalcons, and pelagic cormorants) counts can be made with great precision, but with both species of murres which lay their eggs on bare ledges and normally hide them completely with their bodies, it is not a good technique. Murres brood very closely, and unless greatly disturbed do not leave their eggs untended (see method 4). Puffins of both species may be censused by counting them at the mouths of their burrows or nesting crevices in early morning or late evening.

4. The close brooding of murres may be utilized in establishing the size of a breeding population. Normally a murre egg is not left untended -- probably because of the heavy predation pressure exerted on eggs by glaucous gulls, ravens, and occasionally by kittiwakes. A gunshot near a cliff will flush most of the murres not tending an egg. A rapid count or estimate, before flushed birds return, will then yield the number of breeding birds. This method has certain undesirable features, since it is a disrupting influence and does not consider pairs whose nesting may be out of phase.

5. Photographic methods may be employed. A photograph represents an easy, instantaneous sample, unaffected by the movements of birds landing on the cliff or leaving during the census, but the method embodies several disadvantages. Immediate access to the information is not possible in the field unless a Polaroid camera is used, and the advantages of the movements of roosting birds is not exploited. At a given moment, even with excellent visibility, many birds are usually hidden by the bodies of others. With visual census otherwise hidden birds can be seen as birds on a ledge bob their heads and move about. Since the cliff faces are often dark in color, shaded, and the weather frequently rainy or cloudy, good photography is often impossible. Photography may prove to be a useful technique in the analysis of diurnal activity patterns.

Our plans for future seasons include refinements and expansions of present methods to further increase the precision of census figures. It will be possible to determine breeding populations of all the less numerous species to within one or two per cent. For the more common species, the thick-billed murres, common murres, and kittiwakes, small local areas (see method 1) can be censused to within these limits.

All sampling techniques are subject to one major source of error which requires consideration, i.e., diurnal and seasonal activity rhythms. In order to compensate for the variations in observed numbers of birds on the cliffs with time of day and progress of breeding, counts of certain small areas were made at fifteen minute, thirty minute, one hour, and two hour intervals for periods ranging up to 37.5 hours in length. Seven of these counts were made between June 20 and September 1. These data were then plotted. Since at all hours of the day when there is sufficient light to permit counting, birds are still seen feeding or resting in the

water offshore, the observed maximum counted on the cliffs does not represent all the birds. Counts of birds on the water indicate that the peaks in the plotted curves represent slightly over 90 per cent of the resident population. Thus at the hour of sampling the per cent of the total resident population represented by the observed birds can be calculated from the curve. Figure I represents the diurnal activity cycle prevailing during parts of three days (August 30-September 1). Diurnal cycles vary with weather as well as with progress of nesting, so care must be taken to match the curve used with the conditions during census.

Census Areas:

A total of sixty-nine permanent census areas were established. These are of two major types: 1) selected "Small Areas" in which actual counts of all species were made, and 2) "Larger Areas" in which estimates were made of murres and kittiwakes and counts of all other (less abundant) species.

The "Small Areas" satisfy several requisites for population analysis. They are small (or if large areas, are subdivided into small units) and hence can be accurately counted. If short term population fluctuations are to be detected, the subjective features of estimation techniques must be eliminated. Many of these areas were chosen at the fringes of large colonies and should therefore be sensitive indicators of change in population pressure. Others, located in the midst of large concentrations, will give indications of saturation.

The "Large Areas," like the small ones, are based on recognizable topographic divisions and serve primarily to fill out complete coverage of the seven miles of study area, yielding totals which can be used in analysis of the entire ecosystem. These areas are largest in colony No. 5 in which close access is most difficult. Colony No. 5 is the most remote from the proposed harbor site and attention during the first study season was focused more intensely on colonies Nos. 1 through 4.

Census Area 1. Colony 1, (Crowbill). This is a relatively small colony located on the wave cut face of a long ridge perpendicular to the shore. As is typical of several of the colony sites, a steep talus slope lies above the sheer cliff. The cliff face is largely limestone of relatively firm consistency up to about 300 feet in height. It rises vertically from

Figure I

Diurnal Cycles August 30 - September 1

Weather conditions: clear, temperature range 30°F-40°F.

the water with no beach except at the extreme ends. The bottom of the E.S.E. end fits Fay and Cade's (1959) "rock-pile" type in which the topography is characterized by heaps of boulders. At St. Lawrence Island these rock-pile cliffs were extensively utilized by several species. In the Ogotoruk Creek-Cape Thompson area only a few pelagic cormorants were found nesting here. The cliff face is dissected at one point by a deep ravine in which horned puffins are found. Census Areas 2, 3, and 4 are included in the totals for Area 1, but hold special status as "Small Areas."

Census Area 2. Area 2 comprises the E.S.E. face of the rock formation jutting farthest into the water. This area is used primarily for roosting since most of the ledges are too shallow to permit egg laying.

Census Area 3. Area 3 is located on the top of Crowbill near the verge of the cliff. Here the talus slope is stabilized by Elymus arenarius. Glaucous gulls are the only species nesting in Area 3 where we found 23 nests. These were heavily preyed upon by red foxes (Vulpes fulva) which reared a litter about 300 yards away. No young gulls were successfully brought off, apparently due entirely to foxes. Egg shells and one downy young were found at the mouth of the den.

Census Area 4. Area 4 represents the W.N.W. terminus of Colony 1. This is a cliff face which is perforated by a wave-cut hole. A pair of peregrines, Falco peregrinus, successfully reared two young in a stick nest located in the midst of a concentration of murre (see photograph No. 1).

Census Area 5. Area 5 extends from the small drainage W.N.W. of Crowbill .95 miles to the mouth of Nusoaruk Creek. These are low shaly bluffs sloping steeply to a gravel beach. The formations are soft and friable, suitable for horned puffins which dig burrows (or nest in crevices when the substratum is firmer). The area is not used extensively by any other species. One pair of roughlegged hawks, Buteo lagopus nested at the W.N.W. end.

Census Areas 6-33. Colony 2 extends from the mouth of Nusoaruk Creek to a point 1.44 miles W.N.W. Steep, often unstable cliffs up to 500 feet high rise abruptly from the water or from a narrow gravel beach. The beach is often broken by headlands. Most of this colony is inaccessible except by boat, though access by foot is possible for short distances at each end. A few nesting ledges may be reached by climbing from below. The W.N.W. end of this colony is the major source of eggs for Eskimo use. It is this colony which supports the most complete avian fauna.

Census Areas 6 through 31 are located along the length of Colony 2 and all show essentially the same physiographic features. Rock strata are very soft and often tilted from 35 to 45 degrees. Fracturing furnishes abundant nesting sites. Areas 32 and 33 are characterized by firmer rock and deep ledges tilted up to 10 degrees.

Census Area 34. Area 34 is a long discontinuity of low bluffs running from the W.N.W. end of Colony 2 to a point 1.74 miles W.N.W. A gravel beach is continuous except during periods of high waves. Most of these bluffs are of weathered rock of a consistency much like soil. A few snowbanks persist at the W.N.W. end which, from the stratification, appear to be several years old.

Census Area 35-44. Colony 3 extends .59 miles W.N.W. from a point .16 miles W.N.W. of the mouth of Emmikroak Creek. This includes "Agate Rock." The characteristics of the rock in Colony 3 vary widely. The E.S.E. portion is composed of soft material dropping off sharply about 550 feet to a gravel beach. Outcrops of harder rock are utilized by nesting birds (Areas 35-38), but much of it is not occupied. The middle portion is of somewhat firmer rock and is extensively used by birds (Area 30). The W.N.W. portion is lower, still more stable, and slopes gradually almost to sea level (Areas 40-44). Little or no beach is present. A pair of peregrines used ledges near the highest point but did not nest successfully.

Census Area 45. Area 45 is very similar to Area 34 and runs from the end of Colony 3 to the mouth of Eegikruttoosook Creek, .4 miles W.N.W.

Census Area 46-55. Colony 4. (Cape Thompson). Colony 4 includes .43 miles of coastline W.N.W. of the mouth of Eegikruttoosook Creek. Areas 46-50 are outcrops of relatively solid rock situated below about 50 feet of very soft strata. The cliff including areas 51-55 is firmer and that portion W.N.W. of Area 50 descends directly into the water. Area 53 is included in the totals for Area 52, but holds special status as a "Small Area" (see Plate No. 3). Most of Area 54 is visible from the top of the Cape Thompson headland; this is also a "Small Area," although it occupies a much greater area and contains many birds (see Plate No. 4). Ledges are tilted at about 20 degrees.

Census Areas 56-69, Colony 5. Colony 5 extends from a short discontinuity W.N.W. of Colony 4 nearly to the end of the sea cliffs. It does not possess talus slopes above the cliffs but drops off abruptly to a continuous gravel beach over 600 feet below. The rock is soft and broken and rock falls are frequent. Colony 5 includes Census Areas 56-69.

Data:

Census data are given in table I. Species which may form a part of the sea cliff community are listed. Abbreviations as used in the table are indicated following the name. Listings as given here and in the table are in approximate order of decreasing abundance.

Thick-billed murre. Uria lomvia T.M.
 Common murre. Uria aalge C.M.
 Black-legged kittiwake. Rissa tridactyla B.K.
 Horned puffin. Fratercula corniculata H.P.
 Glaucous gull. Larus hyperboreus G.G.
 Tufted puffin. Lunda cirrhata T.P.
 Pelagic cormorant. Phalacrocorax pelagicus P.C.
 Pigeon guillemot. Cepphus columba P.G.
 Black guillemot. Cepphus grylle B.G.
 Common raven. Corvus corax
 Peregrine falcon. Falco peregrinus P.F.
 Golden eagle. Aquila chrysaetos G.E.
 Gyrfalcon. Falco rusticolus G.

Certain other species play a less important role in the community as occasional visitors, or nest on the cliffs but play no important part in the nutritional dynamics of the sea cliff ecosystem as a whole. These species are as follows:

Rough-legged hawk. Buteo lagopus
 Snowy owl. Nyctea scandiaca
 Short-eared owl. Asio flammeus
 Mew gull. Larus canus
 Sabine's gull. Xema sabini
 Arctic tern. Sterna paradisaea
 Snow bunting. Plectrophenax nivalis
 Gray-crowned rosy finch. Leucosticte tephrocotis
~~Long-tailed jaeger. Stercorarius longicaudus~~
~~Parasitic jaeger. Stercorarius parasiticus~~
~~Pomarine jaeger. Stercorarius pomarinus~~
Discussion:

Table I includes census data obtained during the height of the breeding season (August 11 through September 9, 1959) except in the case of glaucous gulls which had essentially completed their breeding by mid-August. Figures given for glaucous gulls were obtained during June and

TABLE I.

Census of Adult Birds at the Height of Breeding

Census Area		Murres	T.M.	C.M.	B.K.	H.P.	G.G.	T.P.	P.C.	P.G.	B.G.	P.F.	G.E.	G.	R.L.H.
1		2,100	-			60	46	4	2			2			
2	* /		160												
3	* /						46								
4	* /	340										2			
5						<100									2
6	*	14													
7	*	55													
8	*	110				6		6							
9	*	660				6		2							
10	*	6,000			230	50		8							
11	*	500			630	2									
12	*	1,370			250	16									
13		1,200			15	25									
14		1,500			140	20									
15		1,300			290	20									
16		1,040			70	16									
17		750			260	6									
18		1,600			410	16									
19		1,200			550	6									
20		4,800			960	7									
21		7,000			410	35									
22		6,300			680	20									
23		7,700			270	40									
24		2,400			1,200	9									
25		7,700			130	10			2						
26	*	1,100			260										
27		9,900			780	10				6					

[illegible]

Census Area	Murres	T.M.	C.M.	B.K.	H.P.	G.G.	T.P.	P.C.	P.G.	B.G.	P.F.	G.E.	G.	R.L.H.
57	3,000													
58	6,700													
59	18,000													
60	6,700													
61	2,700													
62	3,300													
63	4,900													
64	1,000													
65	12,000													
66	* 130													
67	13,300													
68	2,700													
69	* 130													
Records not included in other areas														
Top Colony 2						about 50			10	10				
Top " 3						" 15								
Top " 4						8								
Colony 4 or 5													2	
Colony 5				5,000	300									
Approx. totals	195,000	117,000	78,000	24,000	1,200	120	18	12	10	10	4	3	2	2

Ranging through entire area (no nests found on cliffs): Ravens --6-10 birds.

*Indicates selected "Small Areas." All others are "Large Areas."

Indicates "Small Areas" the totals of which are included within those of "Large Areas." These numbers are therefore not summed at the end of the table.

In Colony 5 it was not possible to accurately determine the numbers of horned puffins or kittiwakes in individual areas. Estimated totals for Colony 5 are listed at the end of the table.

Numbers listed have been compensated for diurnal activity cycles and are rounded in a manner consistent with the level of accuracy of each sample. At this stage of the investigation no statistical analysis of census data is possible.

July from nest counts. Pigeon guillemots and black guillemots were frequently present off Colony 2 but no nests were found. Their status as breeding birds in this area is uncertain. Ravens undoubtedly nest in the area but no nests were found on the cliffs. Since they clearly function in the sea cliffs ecosystem, they are included in the table (bottom). A single pair of gyrfalcons was frequently seen near Cape Thompson. No nest was found, however, and no immature birds were seen. Rough-legged hawks and golden eagles both frequented large stick nests on the cliffs, but did not successfully breed. All other species successfully bred.

In general it was not practicable to attempt differentiation of the two species of murres during census because of the close similarity of these two species, the distance, and the pitching of the boat from which censusing was often done. In any event, the two species are virtually equivalent ecologically. Only minor differences exist in either their appearance or mode of life. Since close access to much of the cliff area is ruled out by topography we do not have accurate information as to the ratio of thick-billed to common murres over the whole area. Data from spot samples, plus our impressions gathered from examination of the cliffs throughout the summer, lead us to believe the ratio of thick-billed to common murres is about 60:40. Locally these proportions vary through a continuum, with monospecific groups at both extremes.

All "Small Areas" were censused by actual counts. These were specifically selected to permit actual counts, provide representative areas on the fringes, middle, upper and lower parts of the colonies, provide representatives of all ecologically important species, provide samples with varying population densities, and if possible, permit close access. Diurnation curves were obtained from "Small Areas," and photographs were taken. Analyses on "Small Areas" permitted excellent standardization and evaluation of census techniques. Under comparable conditions our census results on "Small Areas" are highly reproducible. Four curves established for Area 2 (thick-billed murres) in late June are very nearly congruent. Roosting peaks during clear weather on Area 53 (August 31 and September 1) are 246 and 250 (both species of murres) and the curves for the two days are very similar in shape. During peak periods birds are still seen arriving and departing and at these times birds can be seen on the water. This would indicate that the peaks do not represent the entire resident population. We were not fully successful during this first

season in devising a satisfactory objective method for judging the actual proportion of the resident population represented by the peaks. An airplane flight over the ocean during a peak period showed many murres at .5 to 2 miles offshore and diminishing numbers to the limit of the flight (10 miles offshore). Other flights were planned but poor weather conditions and the reluctance of pilots to fly low over the ocean prevented this. Estimates of the numbers of birds present on the water indicate that the proportion of birds still absent from the cliffs during peaks is about 10 per cent. This assumption was used to calculate total birds.

Enlargements of photographs taken at the time of census compared with visual counts show that under favorable circumstances photography can be a good census tool. A Polaroid Land Camera which will permit immediate access to a photograph might be useful if the limitations of photograph size and graininess inherent in this method of photography can be transcended.

Estimation techniques were evaluated on "Small Areas" by first estimating and then counting the birds. By periodically doing this we kept our estimates well standardized. Nest counts were also used. Egg counts of murres were abandoned as a census tool because of close brooding (see Census Methods).

"Large Areas" were censused by estimation. Cliffs are normally characterized by cracks, different colored strata, and projections which permit subdivision into blocks of almost any size desired. By sketching the cliff or marking photographs, census areas can be conveniently plotted. Then groups of an estimated 100 birds (or sometimes 1000) can be blocked off to yield a total. All of Colony 5 except Areas 66 and 69 and parts of the other colonies were censused by this means. Photographs were also used on "Large Areas." It was found that distance and lack of contrast between birds and the rock were serious limiting factors in the use of photography in censusing "Large Areas." Nesting sites were often hidden in photographs which also causes significant errors. Censusing by using the technique of flushing non-brooding murres was not extensively used because of inherent errors and the disturbance thus caused in the colony. None of the figures in Table I are based on this method.

Kittiwakes proved easier to census than murres because of their lesser abundance, conspicuous nests, lighter coloring, and the greater spacing maintained between roosting birds. In Colonies 2 through 4 (no kittiwakes were present in Colony 1) census figures are more reliable than

are those for murres. On Colony 5 the same topographical limitations hamper census of both murres and kittiwakes.

All other species were individually counted throughout the area (except horned puffins in Colony 5) and precision is therefore greatly improved.

ANNOTATED LIST OF SPECIES

The following list includes only those species relating to the sea cliff community. It should be noted that although birds clearly independent of the sea cliff ecosystem were not our primary concern, sight records (as well as occasional collections) were made of all avian species wherever possible. A total of 68 species were recorded by the bird cliffs party. All specimens taken are in the University of Alaska Museum with the exception of one horned puffin which was sent to Dr. Max Brewer at the Arctic Research Laboratory at Point Barrow. Two thick-billed murres, one common murre and two kittiwakes were preserved entire and sent to Dr. Jared Davis for radiochemical analysis. A few mammals enter the ecosystem but since these are considered in Dr. Pruitt's report they are not included in our annotated list except when pertinent. Mammals are further considered in this report in the section on the ecosystem.

Annotations are drawn largely from our field notes but material from the literature is included when pertinent. In some cases the observations are so indicated.

The species below are listed in taxonomic order as given in the Fifth Edition of the American Ornithologists' Union Check-List of North American Birds.

Pelagic cormorant, Phalacrocorax pelagicus.

This species was present on June 16, and groups of up to five were often seen perched on ice floes. A nest containing 2 eggs was found on July 20. These birds incubated until August 11 when the nest was seen to be empty. On August 28 one egg had been laid and was being incubated. A nest in Colony 2 contained two nearly fledged young on August 17. These young were seen on the water soon after and remained in the area at least until September 7.

Rough-legged hawk, Buteo lagopus.

One pair of rough-legged hawks was seen on a large stick nest on June 19. The nest was empty and remained so throughout the season. This pair was often seen along cliffs during the first half of the summer and less frequently after mid-July. The birds were not seen feeding and their possible position in the sea-cliffs ecosystem is at present speculative.

Golden eagle, Aquila chrysaetos.

Two adult and at least one immature golden eagles were seen, but apparently successful nesting was not accomplished. A pair was flushed from a large stick nest in Area 3 on June 24, but no eggs or young were observed during the summer.

An adult was seen eating an adult murre, and it is likely that golden eagles derive a significant portion of their food from the bird colonies.

Gyr Falcon, Falco rusticolus.

A single pair of gyrfalcons frequented the cliffs near Cape Thompson and was seen repeatedly. No nest was discovered, however, and they apparently did not breed successfully.

No predation on the sea-birds was observed, but the falcons undoubtedly subsist to a certain extent on the colonial cliff-nesters.

Peregrine falcon, Falco peregrinus.

Two pairs of peregrines were regularly sighted. Two downy young were found in a stick nest on June 27. On August 9 the immature birds were seen flying. They were adept fliers at this time and had no doubt been on the wing for at least 3 weeks. The other pair did not nest successfully but were seen regularly throughout the summer.

Peregrines prey on the cliff birds. Partly eaten adult murre which can be attributed to falcons were occasionally found.

Long-tailed jaeger, Stercorarius longicaudus; Parasitic jaeger, S. parasiticus and Pomarine jaeger, S. pomarinus.

All three species of jaegers were seen but the long-tailed jaeger was most common. Several nests of the long-tailed jaeger containing eggs were found between June 16 and June 30. Two downy young of the parasitic jaeger in the company of adults were found by the botanical party on July 14.

Glaucous gull, Larus hyperboreus.

Although not great in number, glaucous gulls are conspicuous and important members of the sea cliffs ecosystem. They are found in the Ogotoruk Creek-Cape Thompson area for a longer period than any other sea cliff nester. Nests with 1 to 3 eggs were present on June 19 and one newly hatched young was found on this date. The first flight of a fledgling was observed on August 8 at Cape Thompson. Glaucous gulls nested in locations which were accessible to foxes and were heavily preyed upon. Re-nesting after fox predation was observed and a "first flight" of another fledgling on August 28 probably represents the product of a second laying. Five fledglings were banded.

At last report (November 16) glaucous gulls were still in the area. The sea ice had moved in and out several times and the glaucous gulls left when the ice was in and returned when open water was again available.

Predation by this gull on other species is intense. Nests of glaucous gulls are usually surrounded by murre egg shells, as well as those of kittiwakes. Concentrations of egg shells are also found on cliff tops and other roosting spots. These gulls were often seen in flight carrying eggs, and their attacks on murre chicks are frequent. During most of the summer when eggs and young of other species are available, glaucous gulls seem to live on them almost exclusively. This species is probably the most important predator on the bird colonies.

Two adults were taken by our party and another was picked up dead on the beach. One downy young was found partly eaten in the mouth of a red fox den. Measurements of another were provided by the terrestrial birds party. The stomach of this last specimen contained a murre embryo. The skin of one specimen and the skeleton of the other were placed in the University of Alaska Museum.

Mew Gull, Larus canus.

A single adult was collected by Max Thompson of the terrestrial birds project between Ogotoruk Creek and Cape Seppings on August 5. During early and mid-August numerous immature mew gulls were seen along the coast in the Cape Thompson region. This species is not common in the far North (Bailey, 1948) but immature birds and occasional adults have been recorded as far north as Point Barrow. While they do temporarily utilize the feeding grounds of the Cape Thompson bird colonies, they are of slight importance in the community dynamics.

Black-legged kittiwake, Rissa tridactyla.

This is the most common gull in the area and ranks second in abundance only to the murres. Kittiwakes began actively nesting during the middle of June and on June 18 eleven nests were observed in Colony 2, two of which had eggs (one egg each). On June 25 about 1,500 kittiwakes were observed flying about a mile up and down the valley of Eegikruttoosook Creek to a wet grassy area beneath a large snowbank where they were gathering nesting material. Counts showed birds passing up the valley and returning at a rate of about 60 per minute during three hours of observation. These birds were all building nests in Colony 4. No eggs were visible in 12 nests examined on this date. The first hatched chick was seen in Colony 4 on July 20, and by July 27 20 to 30 per cent of the visible nests contained chicks. Fledglings were seen leaving the nest on August 30 and by September 7 many young had permanently left the nest. Kittiwakes left the cliffs between September 25 and 29.

One case of predation on a murre chick was observed but kittiwakes do not extensively prey on eggs and/or young of other species. They do occasionally steal fish from murres.

Ten specimens were taken. Six were adult males and the rest were young from four days old to nearly fledged. The average weight of 5 adults was 504 grams, range 465 gms. to 526 gms. One male taken on June 27 had enlarged testes, the rest taken from July 21 through September 7 had regressing gonads. Four skins (one adult and three young) and one skeleton were placed in the University of Alaska Museum.

Sabine's Gull, Xema sabini.

An immature male was taken off Colony 4 on August 18. During the two weeks following our first record, several additional sight records of Sabine's gull were made.

Arctic tern, Sterna paradisaea.

Arctic terns were seen at intervals from June 17 through September 9 but were at no time present in large numbers.

Common murre. Uria aalge.

Phenological data for the common murre appear identical with that for the thick-billed murre (see below). Data from the six specimens collected are not significantly different from that taken from thick-billed murre. The discussion of thick-billed murre below applies equally to the common murre.

The common murre is frequently found in monospecific groups surrounded by thick-billed murre. When groups of common murre are found in an area, thick-billed murre ordinarily occur singly or in small numbers at the periphery of these groups, occupying more precarious nesting sites. Observations of behavior as well, supports the conclusion that common murre are able to displace thick-billed murre. The colonies near Cape Thompson and those at Cape Lisburne are close to the known northern limit of the range of the common murre. Uspenski (1956) speculates that common murre may be extending their range northward on Novaya Zemlya. It is possible that this is taking place in Alaska, too. It will be interesting to observe any changes which may take place in the Cape Thompson colonies during future years.

Thick-billed murre, Uria lomvia.

This species is easily the most abundant in the area. When we arrived on June 16, thick-billed murre were present in great numbers feeding in open leads and roosting on the cliffs. Their arrival date at any nesting locality is largely a function of ice conditions in the ocean off the cliffs (Uspenski, 1956). Thus, the problem of predicting arrival dates hinges not so much on the seasonal adjustments of the birds as on accurate, long term records of the ice conditions in this specific area of the northwest Alaska coast. Our own observations of ice conditions from the air would seem to indicate that the ice near the Ogotoruk Creek-Cape Thompson area may behave differently from that farther down the coast. Unfortunately no reliable long term records of either ice conditions or bird arrivals exist for this area. There are no permanent local inhabitants and the impressions of the pilots who fly regular mail runs past the cliffs have thus far proved unsatisfactory.

Due to the late beginning of this contract, no definite statement can yet be made regarding the arrival date of murre. However, it is our opinion that if open leads are present during late winter or early spring at least some birds will be present. It seems unlikely, however, that

large concentrations of murres will be found before mid-April. As part of the present research contract we plan to have a man on the study area continuously beginning in February, 1960. In addition, the writer will make three visits during March, April, and May primarily to gather data on the spring migration of colonial sea birds. We should, therefore, have accurate data for the coming spring.

Almost all murres were in summer plumage by June 16. However, occasional birds in winter plumage were seen as late as July 14. A specimen in winter plumage was taken by Max Thompson on this date.

Copulation was frequent during June and continued throughout the summer, but diminished in frequency after the middle of July. Egg laying is closely associated with sunlight (Uspenski, 1956), and July 9 and 10 were the first partly clear days following a stormy period. It is likely that the sunshine stimulated active egg laying during these days. The first chicks were observed on August 11 (about 5 per cent of the eggs on ledges at Cape Thompson were hatched at this time) which corresponds with published incubation times of 30 to 35 days. The majority of eggs were hatched by August 17, but a few eggs were still hatching on September 8. These late hatching eggs probably represent re-laying after egg losses. Several murres were observed to re-lay at least once.

Young murres are reported to leave the nesting ledge between the 17th and 25th days (Uspenski, 1956). We first observed murre chicks in the water on August 25, fifteen days after the first hatched young were seen. During the two weeks following August 25, increasing numbers were seen in the ocean being tended by adult birds. We witnessed many chicks leaving the nesting ledges. When the chick leaves the nesting ledge, no wing quills are yet present and the chick falls nearly straight down while rapidly beating its undeveloped wings. The force of its leap from the ledge may carry it a short way from the cliff but violent contact with rocks at the base of the cliff are frequent. In no case did we observe injuries when chicks were of normal age at departure. Thick body feathers have developed by normal departure time. This padding and the low specific gravity of the chicks effectively prevents injuries from falls. Premature departure does often seem to result in injuries and death. Young chicks were frequently found dead on gravel beaches and rocks below the colonies.

Adults and young of the year remained at the cliffs through September 25. Harry Spencer, who is spending the winter at Chariot base-camp, reports that no murres were left on September 29, and states that their

departure was coincident with a cold windy period.

Mortality among both species of murres may be divided into three categories: egg mortality, chick mortality, and adult mortality. Predation may account for a large fraction of eggs lost. Glaucous gulls and ravens were seen carrying murre eggs and both species regularly patrolled the nesting ledges. Large numbers of murre eggshells were collected from the tops of the colonies where they were left by predators. Red foxes apparently take eggs whenever the nesting ledges can be reached. Fox dens were observed with murre egg shells scattered about. Eskimos take eggs regularly in considerable numbers. In 1959 a party of Eskimos took 12 to 16 five-gallon tins of eggs. Loss of eggs by breaking on the ledge is slight, but eggs fall from the cliffs frequently. Losses by falling are greatest during disturbance of the colonies when large numbers of murres are flushed. Storms sometimes destroy eggs when pools of water form around the eggs, and violent winds may cause some to be dislodged. Some loss by high waves may occur, but murres ordinarily do not nest less than 30 feet above sea level so such losses are minimized.

Chicks may be lost by predation to glaucous gulls, ravens, and foxes. Falls, chilling, and starvation also cause death.

Adults are preyed upon by man, gyrfalcons, peregrines, golden eagles, and probably at times by snowy owls. The greatest single cause of death among adult murres seems to be rock falls. Almost every day crippled murres were seen on the beaches. Mr. R. Campbell, U. S. Geological Survey, reported 44 murres killed at Colony 5 by a single rock slide. We observed similar cases in which up to ten murres were killed. Injuries to these birds seen in slides were similar to those continually observed in crippled or dead birds found on the beaches. Apparently in response to the danger from rock falls, murres are very sensitive to the sound of falling rocks, particularly before breeding begins. They are more responsive to rocks heard above them than they are to those at the side or below. During breeding when rocks are thrown in their vicinity they usually do not fly when the sound is below them or to the side, even if very close, but if the rock strikes the cliff above them they fly quickly.

There is little evidence of regular migration movements in either species of murre except in the northern portion of the range. Gabrielson (1959) discusses the status of knowledge of migratory movements in Alaska. Observers seldom travel out on the ice in winter so knowledge of their occurrence in open leads in the pack ice is virtually nil. It is likely

that birds from the Cape Thompson-Cape Lisburne region drift south at least into the Bering Sea as the pack ice forms. Overland flights have been reported by several authors (Freuchen and Salomonsen, 1958; Uspenski, 1956; Bent, 1919; Bianki, 1922; Hartert, 1921-22; Twitchell, 1914; and others) and often attributed to storms. The significance of such reports, however, is unknown. Eastward flights of murres along the northern coast of Alaska are reported by Freuchen and Salomonsen (1958) and it is possible that murres from the Cape Thompson area may be involved.

Fifty-three murres including both species were banded this summer (seven adults of which were all thick-billed murres). The banding program will be expanded in subsequent years with the hope of acquiring sound knowledge of migration and population dynamics. Corrosion of aluminum bands in sea water and the remoteness of the area militate against complete success.

Data from 30 adult thick-billed murre specimens are available. About half of these were collected in cooperation with Max Thompson and John Hines of the terrestrial birds project. In general, determinations on all species examined included weight, wing, culmen, bill length from external naris to tip, sex, gonad condition, approximate age, fat condition, brood patch, plumage, parasites, and stomach contents. The average weight of males is 922 grams, range 695 gms. to 1,081 gms.; of females 929 gms., range 823 gms. to 1,132 gms. The sex ratio is 15 males:14 females. The birds remained fat throughout the season.

Analysis of food habits from stomach contents presents serious problems. The extremely rapid digestion by murres has been observed by our own party and by other observers. Digestion proceeds so rapidly that the great majority of stomachs were empty of intact food organisms. The otoliths of fish do remain in relatively good condition for periods up to 24 hours. These can be identified and are now being sorted out of the stomach washings. These will be sent to Dr. Norman Wilimovsky of the U. S. Fish and Wildlife Service, Juneau, Alaska. Most of the food of murres is fish, but invertebrate remains are common. Crustaceans were occasionally found, the most numerous being amphipods. Polychaete fragments are often found and occasional gastropod shells. The latter may represent mechanical admixture rather than a food item. Mechanical admixtures were common and included pebbles, pieces of eggshell, down, feathers, and bits of mollusc shell. From the apparent weathered condition, these pieces of mollusc shell probably do not represent evidence of a food source. Analysis of stomach contents is incomplete, but indications at present show that murres feed

primarily on littoral species.

One hundred twenty-eight vials of parasite specimens were recovered; these data have not yet been analyzed.

Pigeon guillemot, Cepphus columba and Black guillemot, Cepphus grylle.

Both species of guillemots were seen throughout the summer, usually on the water of Colony 2 and Colony 5. There were probably not more than 10 individuals of each species. On one occasion a black guillemot landed on the cliff at Colony 2, but no nests of either species were found. The pigeon guillemot is not known to breed north of Bering Strait.

The presence of these species in the Ogotoruk Creek-Cape Thompson area was not reported by Spencer on November 16, but they are likely to be found during the winter in small numbers wherever open water exists. Bailey (1948) reports that seal hunters found black guillemots in open leads far offshore in the winter. It is regularly found wintering off Point Barrow. It is possible that pigeon guillemots (and perhaps black guillemots) may move south during the winter.

One male specimen of pigeon guillemot was taken only July 20. The testes were regressing and the bird was in heavy molt. A brood patch was present but was regressing.

Horned puffin. Fratercula corniculata.

Horned puffins were abundant all along the cliffs on June 16. One was seen entering a burrow on June 20 but it was not possible to determine the date of egg laying. This probably occurred during the first and second week of July. A downy chick was seen within a nesting burrow on August 31, but hatching dates were not determined. Spencer reports that horned puffins left the cliffs during the same period as the murre and kittiwakes -- September 25 to 29.

Seven specimens were taken. Two skins are in the University of Alaska Museum and one was sent to the Arctic Research Laboratory at Point Barrow. The skeletons of the remaining four were sent to the University of Kansas Museum by M. C. Thompson. The average weight of three males was 596 grams, range 488 gms. to 675 gms.; of 5 females (partial data provided by M.C.T. for two specimens) 560 gms., range 538 gms. to 602 gms. The testes of a male taken June 24 were enlarged. All others (taken after July 23) were regressing. The oviducts of females taken from August 1 through September 7 were regressing; the oviduct of one taken July 14 was enlarged. All were fat.

Tufted puffin, Lunda cirrhata.

This species was not abundant but was regularly seen throughout the season. About 18 nesting pairs were scattered from Colony 1 to Colony 4. No nests were accessible and no nesting data were obtained. Two female specimens were taken. One skin was placed in the University of Alaska Museum. Measurements were provided for a male by the terrestrial birds party. Two were females; their average weights were 773 gms., range 762 to 783 gms. The oviducts of both were regressing (one female taken July 20, others on August 25). The weights of the male specimen taken by the terrestrial birds party is not known.

Snowy owl, Nyctea scandiaca.

No nests of this species were found within 3 miles of the coast, but occasional adult birds were seen near the cliffs. Snowy owls are known to feed on sea birds (Uspenski, 1956) but no such predation was observed by us. Exploitation of the potential food supply in the bird colonies may occur if the present high level of microtine abundance drops.

Short-eared owl, Asio flammeus.

Short-eared owls were frequently observed flying off the coast, particularly during courtship in June. Later in the season they were more often seen flying over the tundra, and 2 nests were found by the botanical party. One nest found on July 21 held one downy young, another on July 26 held three downy young. No indications of predation on the cliff birds were seen but as in the case of the snowy owls, a shift in food may occur with a crash in the microtine cycle.

Common raven, Corvus corax.

Ravens are probably permanent residents in the area. They were observed on June 16 and on November 16 were still present. No nests were found but ravens probably do nest on the sea cliffs at times. Inland sites are no doubt regularly utilized as well. Single individuals and small groups of ravens, up to six birds, were often seen flying along the cliffs. They were observed carrying eggs in flight and no doubt regularly prey on the eggs and chicks of the sea bird colonies. A raven was seen picking up a murre egg. Many authors report predation on microtine rodents. Fay and Cade (1959) feel that microtine abundance is not correlated with abundance of ravens on St. Lawrence Island. Is it possible that the abundant supply

of food from the bird colonies on the island during the summer may act as a buffer? It will be interesting to determine whether a shift in raven food occurs in the Cape Thompson area if the expected crash (Pruitt, personal communication) occurs in Microtus.

Snow bunting, Plectrophenax nivalis.

This species is common in the area and several nested on the cliffs. It is obviously of little importance in the sea cliff ecosystem.

Gray-crowned rosy finch, Leucosticte tephrocotis.

Several nesting pairs used the cliffs. Its importance in the ecosystem, however, is slight.

THE BIRD CLIFFS ECOSYSTEM

The diagram of the sea cliffs ecosystem, Figure II, illustrates the general framework into which data from this and succeeding years will be fitted. It is hoped that numerical expressions of intake and egress of energy and materials can be progressively refined through each study season and that shifts in the flow of energy and materials with environmental changes can be clearly shown. The figures included in Table II and in the diagram are approximations based on our own work and that of other writers (Uspenski, 1956; Coulson and White, 1957). In some cases data are not now available and figures presented are our own estimates. Much of the material presented is tentative in that the figures will no doubt undergo considerable revision as more adequate numbers of samples are gathered. It is unlikely, however, that major changes in the concept of the basic structure of the ecosystem will be necessary.

For the purposes of discussion, the organisms in the sea cliffs ecosystem are divided into "Primary Consumers" and "Secondary Consumers." Actually, of course, the organisms used as food by our "Primary Consumers" are themselves consumers at various levels in the oceanic food web. It is not possible to discuss the marine food web and for clarity we will use these admittedly imprecise terms.

It is clear that in several substances the organisms involved belong at one time to one level and at other times to another. Glaucous gulls, for example, may on the same day derive live food directly from the ocean, eat eggs and young birds from the colonies, and act as scavengers. There

Figure II. The Bird Cliffs Ecosystem

21 a

Secondary Consumers

Parasites

Peregrine: 2-4 kg. / day
Gyrfalcons: 1-2 kg. / day
Golden eagle: < 1 kg. / day
Man : < 1 kg. / day
Snowy owl (?)
Foxes (?)

Glaucous gull: 40 kg. / day
Foxes : $\pm$ 4 kg. / day
Ravens : < 1 kg. / day
Kittiwakes: < 1 kg. / day
Snowy owl (?)
Short-eared owl (?)
Rough-legged hawk (?)
Golden eagle (?)
Jaegers (?)

Glaucous gull: 40 kg. / day
Raven : < 1 kg. / day
Foxes : $\pm$ 4 kg. / day
Man : ?
Kittiwake : occasional?

Scavengers

Glaucous gulls
Ravens
Foxes
Kittiwakes

Approx. biomass secondary consumers: 250 kg.

Feces, death & decay:

*The maximum biomass of eggs and young will not occur at the same time. Both are included for illustrated purposes. The maximum biomass in the system occurs during the last week of August when both kittiwake and murre young are still at the nest. Both species leave during the last week of August and the first week of Sept. the kittiwakes preceding the murres by about a week.

Primary Consumers

Thick-billed murre
Common murre
Black-legged kittiwake
Horned puffin
Glaucous gull
Tufted puffin
Pelagic cormorant
Black guillemot
Pigeon guillemot

Fish and invertebrates
Ocean

24,000 kg/day (adults)
or
4,000 kg/day (chicks)

GUANO

Approx. biomass adults: 190,000 kg.
" " chicks: 12,000 kg.
" " eggs : 10,000 kg.

"ACCIDENTAL" LOSS
OF EGGS, YOUNG, OR ADULTS

DECAY

washed back into ocean

Terrestrial
Communities

APPROX. 50 KG/DAY
BY AVIAN SECONDARY
CONSUMERS

ADULTS AND
IMMATURE

YOUNG

OR

* EGGS

TABLE II Biomass and Food Intake

21 b

Species (Adults)	Number on Cliffs	Approx Average Wt.(kg)	Approx Biomass in kg	Approx Average weight food/day/ individual	Approx Biomass Seed/day kg
Murres	196,000	0.9	176,400	.100	17,640
Kittiwakes	24,000	0.5	12,000	.055	6,600
Horned Puffins	1,000	0.5	500	.055	28
Glaucous gulls	150	1.5	225	.170	38
Tufted Puffins	18	0.8	14	.080	1
Pelagic Cormorants	12	2.0	34	.220	5
Black guillemot	± 10	0.4	4	.040	.2
Pigeon	± 10	0.5	5	.055	.3
Raven	± 10	1.2	12	.110	1.3
Peregrine	4	0.9	4	1.0	4.0
Golden eagle	2	3.0	6	1.0	2.0
Gyrfalcon	2	1.0	2	1.0	2.0

Approx. total biomass of adult primary consumers 190,000 kg.

Approx. total biomass of chicks 12,000 kg.

Approx. total biomass of eggs 10,000 kg.

Approx. total biomass of food of adult primary consumers 24,000 kg/day

Approx. total biomass of food of young primary consumers 4,000 kg/day

Approx. biomass of adult avian secondary consumers 250 kg

Approx. biomass of young avian secondary consumers 70 kg

Approx. biomass of food of adult secondary consumers 44 kg/day

Approx. biomass of food of young secondary consumers 10 kg/day

are seasonal shifts in food habits also. During the summer glaucous gulls satisfy almost all their nutritional requirements by eating eggs and young of other species, but in other seasons must feed directly on oceanic production or act as scavengers. Their food may at times be derived from terrestrial sources (e.g., mice).

Other species are of doubtful or unproved position. The choice of food of at least eight species of birds may depend on cycles of abundance in microtine rodents. Rough-legged hawks, snowy owls, and short-eared owls frequented the area of the cliffs, but none was observed to prey on the sea-birds. These species are primarily microtine feeders, though they might at times feed on the colonial cliff birds. The snowy owl has been reported by several authors to kill and eat adult murres, and it is possible that the rough-leg does likewise. During the past summer microtines were abundant; possibly these raptores utilize the sea-bird colonies more extensively during "lows" in the microtine cycles. The food habits of jaegers are correlated with microtine fluctuations (Pitelka, Tomich and Treichel, 1955) and a shift toward sea-birds might be expected during microtine "lows." Long-tailed jaegers were seen on two occasions harassing adult glaucous gulls. Jaegers commonly steal food from other birds, though they were not observed doing so at the cliffs in 1959, nor were they seen to prey on eggs or chicks. Ravens, while predators on microtine rodents, were often seen preying on the bird colonies. The part played by simple food preference is not clear nor are the possible implications in the behavior of this species on the food habits of the foregoing species. If ravens utilize both microtine rodents and the eggs and young of sea-birds, why do the other species not do likewise?

Kittiwakes appear to function as Primary Consumers, but occasionally they prey on other species. Such predation primarily takes the form of stealing the food of murres. Successful theft of fish from both adult and young murres was observed on several occasions. Kittiwakes are thus directly eating the production of the ocean but through the efforts of the murres. A kittiwake was observed to eat a very young murre chick, but only once; it is doubtful that murre eggs are eaten regularly. Murres are able to displace kittiwakes even to the point of usurping established kittiwake nests so regular predation of defended murre eggs or young is unlikely.

Red foxes were repeatedly observed preying on murre chicks, and egg shells of murres, kittiwakes and glaucous gulls were found at fox dens. As mentioned earlier, red foxes often find the eggs and young of glaucous gulls easy prey since the gulls invariably nested in flat areas at the tops of the cliffs. No arctic foxes (Alopex lagopus) were seen in the Cape Thompson region during the summer and their status as predators on the bird colonies is unknown.

The role of man in the ecosystem is temporary. During the past summer a party of nineteen Eskimos visited the cliffs during the beginning of murre egg laying. The exact number of eggs taken is not known (12 to 16 five-gallon tins). Predation on eggs was localized to a few accessible ledges and probably nearly all murres re-laid. During this period some adult murres were shot, probably fewer than thirty. Occasional predation by man takes place throughout the summer. Eskimos passing by the cliffs at sea frequently shoot adults for food. Apparently the only birds utilized are murres. None of our Eskimo informants had ever eaten the eggs or adults of other species.

Peregrine falcons, gyrfalcons, and golden eagles all prey on adult sea-birds. We have assumed a daily kill of one bird (assumed 1 kilogram) which is probably too high since avian raptors often go several days without a kill (Craighead and Craighead, 1956). The kill is not entirely eaten and the remains are either utilized by scavengers or may decay.

In establishing food consumption for other species, we have used the calculations of Uspenski (1956) for murres. No accurate data are presently available for the remaining species and the figures listed in Table II and in the diagram represent calculations based on per cent body weight of food ingested per day by murres. It is assumed until such information can be gathered that the food requirements of all sea birds found at Cape Thompson are similar.

The weather and topography of the Cape Thompson bird colonies is such that most of the dead material and fecal matter returns to the sea. Large deposits of guano do not develop because of frequent rains which wash the cliffs. Dead birds and broken eggs either fall into the water or on beaches which are intermittently washed by waves. Whether the minerals and organic matter re-entering the ocean in this manner are important in the economy of the marine life offshore is not known. It is hoped that data gathered by other groups may help illuminate this point.

The intake of food by the colonies is large and verbal statements by the ichthyological party that the fish fauna is poor are puzzling. It is hoped that this seeming paradox will be resolved when their data are presented.

SUMMARY

The avifauna of the sea cliffs ecosystem in the Ogotoruk Creek-Cape Thompson region has been analyzed insofar as present progress of the investigation permits. We wish to emphasize that this is a progress report, and that some conclusions are tentative. We believe, however, that the basic concepts as outlined are unlikely to undergo major changes.

Thirteen cliff nesting species are of established importance in the sea cliffs ecosystem and make up about 220,000 individuals. Thick-billed murre, common murre, and kittiwakes make up over 95 per cent of this number and comprise about the same proportion of the biomass. Sixty-nine permanent census areas were established and 135 photographs were taken including all census areas. These areas are of two types: 1) "Small Areas" chosen to fulfill specific requirements in the analysis of population dynamics and, 2) "Large Areas" which primarily serve to establish population totals to be used in analysis of the ecosystem. Eighteen "Small Areas" were established, four of which are included within the boundaries of "Large Areas." These two types of census areas give complete coverage of the coastline from Crowbill to the end of the cliffs, approximately 8 miles W.N.W. Census techniques are described.

The avian species nesting on the cliffs or otherwise involved in the sea cliffs ecosystem are listed with annotations. Included in the annotations and of special interest to the planning of Project Chariot is the importance of ice conditions offshore in determining the spring arrival date of the cliff nesting birds. The problem of predicting arrival dates ultimately hinges not on the seasonal adjustments of the birds, but on accurate long term records of the ice conditions on this specific small area of the north west Alaska coast. At this stage of the investigation, we are of the opinion that if open water exists in mid-April, sea-birds may be expected to be present.

The alcids and kittiwakes using the cliffs are true sea birds and consequently migration data are sparse. There is little evidence of regular migration movements. Banding operations were begun in the hope

of establishing such patterns as may exist.

The basic structure of the ecosystem is diagrammed and tentative figures on biomass and the flow of energy and material are presented. The food intake from the ocean during the period of maximum feeding of young is conservatively calculated at about 28,000 kilograms per day, all of which is potentially subject to radioactive contamination.

FUTURE PLANS

In order to lay a firm foundation for the evaluation of the effects of radioactive material entering the highly compact and labile sea cliffs ecosystem, a sufficient number of breeding seasons must be intensively investigated to permit the establishment of general trends. The necessary number of study seasons cannot be predicted but at least one more field season is needed.

During the coming year we plan to have a man in the field continuously beginning in February, 1960. He will function within the framework of both the mammal project and the bird cliffs project. His function in the bird cliffs project will be early season collecting and observation, particularly of arrival dates and their correlations with sea ice and weather conditions. The senior scientist hopes to make short trips to the cliffs during March, April, and May as seems necessary as the season progresses. At least one member of the summer field crew will be in the area before mass arrivals begin and will remain until after the bird colonies break up in the fall.

Major aspects of the study which will be emphasized during the coming season are as follows:

1. Complete censuses will be repeated on all established census areas at intervals throughout the season. Correlated with the censuses will be studies of diurnation as the season progresses, studies of population dynamics and structure, and of ecological distribution.

2. Studies of the breeding biology, especially of murres and kittiwakes will be intensified.

3. Local and seasonal movements will be intensively studied. Marking and banding operations will be greatly expanded as one means to this end.

4. The strongest emphasis will be focused on the ecosystem with complete quantitative expression of all relationships as the goal.

LITERATURE CITED

- Bianki, V. L.
1922. Distribution of birds in the northwestern part of European Russia. Acad. of Sc. Zool. Museum Annual, vol. xxiii, no. 2
- Hartert, E.
1921-22. Die Vögel der palaäarktischen Fauna. Berlin
- Bailey, A. M.
1948. Birds of arctic Alaska. Popular series, number 8, Colorado Mus. Nat. Hist.
- Belopolski, L. O.
1952. A method of counting the number of sea-birds in a colony of northern sea-birds. St. Petersburg. Acad. Imp. Sci. Inst. Geogr.: 307-315, 2 figs.
- Bent, A. C.
1921. Life histories of North American gulls and terns. U.S. Nat. Mus. Bull. 113.
- Coulson, J. C. and E. White
1957. Observations on the breeding of the kittiwake. Bird Study, 5(2): 74-83.
- Fay, F. H. and T. J. Cade
1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. Univ. of Cal. Pub. in Zool., 63 (no. 2):73-150.
- Freuchen, P. and F. Salomonsen
1958. The arctic year. New York: G. P. Putnam's Sons.
- Gabrielson, I. N. and F. C. Lincoln
1959. Birds of Alaska. Harrisburg, Pa.: The Stackpole Co., and Wash. D. C.: The Wildl. Manag. Inst.
- Kaftanovski, Yu. M.
1941. Winter birds of Seven Islands. Tr. of the Seven Islands Sanctuary, vol. 1.
- Krasovski, S. K.
1937. Studies on the biology of Brünnich's murre. Tr. of the Arctic Inst. vol. xxvii.

- Pitelka, F. A., Tomich, P. Q. and G. W. Treichel.
1955. Ecological relationships of jaegers and owls as lemming predators near Barrow, Alaska. Ecol. Monog., 25:85-117.
- Portenko, L. A.
1931. Productive potentialities of the bird fauna of Novaya Zemlya. Tr. of the Biogeochem. Lab. of the Acad. of Sc., Appendix II.
- Sdobnikoff, V. M.
1938. Methods of economic-biological surveying in the arctic. Tr. of the Scientific Research Inst. of Arctic Geography, Animal Husbandry, and Industrial Economy.
- Uspenski, V. S.
1940. Method of biological survey in the Seven Islands Sanctuary. Sc. -Method Notes of the Chief Directorate of Preserves., vol. 7.

1958. The bird bazaars of Novaya Zemlya. Transl. by J. M. Mac Lennan, Can. Wilds. Serv., Transl. Russian Game Rep., vol. 4, 3 figs.

Plate 1. Census Area 4, W.N.W. end of Colony 1.
The black line indicates the E.S.E. limit of the
area. Birds found nesting here are thick-billed
murres, common murres, and peregrine falcon.

Plate 2. Census Areas 38 and 39, Colony 3.

Black lines delineate Area 39 which is of "Small" status. Birds shown in the photograph include glaucous gulls (arrow), thick-billed murres, common murres, kittiwakes (extreme left). Horned puffins are present but not visible in the photograph.

Plate 3. Part of Area 53 ("Small Area").

Some of these ledges are accessible. Note talus.

This was formerly a smooth fan which was undercut by a storm July 7 and 8. Black vertical line indicates approximate height of a man. Birds present include thick-billed murres, common murres, kittiwakes, and horned puffins. Arrow indicates a horned puffin perched above and to the left of its nesting crevice.

Plate 4. Census Area 54, Colony 4.

This face is clearly visible from a headland just out of the picture to the left. This is the largest area censused by actual counts and includes both species of murre, kittiwakes, and horned puffins. Glaucous gulls successfully nested on the headland to the left.

Legend
 sea cliffs (dotted line)
 scale 1:50,000
 contour interval 50 ft
 Redrawn from U.S. Geological Survey maps
 T-1126 and T-1127
 Numbers along the coast indicate "all water areas"