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A

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A STUDY OF THE SUMMER FOOD HABITS

OF THE ARCTIC FOX ON

ST. LAWRENCE ISLAND, ALASKA

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ABSTRACT

The food habits of arctic foxes denning on both lowland tundra and sea cliff habitats on St. Lawrence Island, Alaska, were studied from 9 June to 23 August 1968. Analyses of 1,555 scats and the remains of dozens of prey revealed that, in general, the composition of the diet reflected regional differences in the availability of prey species.

Based on the frequency of occurrence of their remains in scats, about 90% of the diet of foxes denning on lowland tundra consisted of small mammals. Of the five species of small mammals on the island, the tundra vole was by far the most frequently represented in scats. The remains of birds, primarily eider and oldsquaw ducks and emperor geese, occurred in 20-30% of the scats collected on the tundra.

A high frequency of occurrence of avian remains (80-100%) was noted in scats collected on cliffs adjacent to the sea, reflecting the proximity of thousands of nesting seabirds. Species were taken in proportion to the accessibility of their nesting habitat. Crested and parakeet auklets sustained the greatest degree of predation while horned and tufted puffins were taken in moderate numbers. Murres, pigeon guillemots, pelagic cormorants, and larids were taken only rarely.

Though readily available, marine mammal carrion and marine invertebrates were little used.

PREFACE

Financial support for this study was provided by the Alaska Department of Fish and Game through Federal Aid in Wildlife Restoration, Project W-17-1, Work Plan A-9, and administered through the Alaska Cooperative Wildlife Research Unit, University of Alaska, College.

I would like to express my gratitude to the following people: to Dr. David R. Klein, Leader, Alaska Cooperative Wildlife Research Unit, for his aid and encouragement in planning and executing the study and for critically reading the thesis; Dr. Francis H. Fay of the Arctic Health Research Center, for sharing with me his extensive knowledge of St. Lawrence Island and for his patient encouragement and excellent suggestions during every phase of the study; Mr. Samuel J. Harbo of the Department of Wildlife Management, for his aid in planning the study and for critically reading the thesis; and to Dr. L. Gerard Swartz, Head, Department of Biological Sciences, for critically reading the manuscript.

Special thanks go to my long-time friend, Jerry Skulan, for his enthusiastic assistance, keen observations, and entertaining companionship during the field investigation.

The residents of Gambell extended their hospitality in many ways. I am especially indebted to Vernon and Charles Slwooko and their families and to Hugo Apatiki for their lucid discussions of life on St. Lawrence Island and for

providing transportation during the study.

As Walt Whitman observed, ". . . the best is that which must be left unsaid."

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INTRODUCTION

St. Lawrence Island, Alaska, lies in the northern part of the Bering Sea, a region characterized by leaden skies and gale-force winds. Approximately 600 Yupik Eskimos live on the island, with the population almost equally divided between two permanent villages, Gambell and Savoonga. The furs of the arctic fox (<u>Alopex lagopus</u>) provide an important source of income for many of these people.

According to Chesemore (1967), the islands in the Bering Sea produce the highest catch of foxes per unit area of any geographical region of Alaska and St. Lawrence Island accounts for the greatest proportion of the catch on these islands. Catches of 50 and 100 foxes per trapper are not uncommon on St. Lawrence Island (Hughes, 1960).

Initiation of the present study was prompted by the lack of basic information needed for sound management of the arctic fox population on St. Lawrence Island. A unique ecological situation exists on this island in that both tundra and coastal biotopes are present, each supporting abundant prey populations during the summer. My primary objective was to determine the food habits of foxes denning in areas representative of the two major biotopes. Secondarily, I endeavored to secure information on other aspects of the fox's ecology including the physical characteristics of dens, reproduction, distribution, and behavior.

From studies on its morphological characters, Rausch (1953a) concluded that the arctic fox is a single, highly variable species of circumpolar distribution. It became apparent to me, after a perusal of the literature, that the arctic fox is remarkably versatile in its food habits as well. The list of foods utilized by this animal includes a wide variety of plant and animal organisms, both marine and terrestrial in origin. The greatest variability in diet occurs during winter, when these animals roam far and wide, obtaining nourishment from a variety of sources. During the breeding period the foxes are linked to certain biotopes and hence dependent on a food supply of relatively limited variety (Vibe, 1967). Braestrup (1941), in his treatise on the arctic fox in Greenland, indicates that an ecological differentiation exists between foxes dependent on lemmings (Lemmus and Dicrostonyx) and those dependent on products of the sea. He termed the former type "lemming" foxes and the latter "coast" foxes. In a more recent consideration of fox populations in the arctic, Vibe (1967) supported Braestrup's views, adding that the white color phase is characteristic of "lemming" foxes while the blue color phase is predominant in "coast" foxes.

Arctic fox populations inhabiting the arctic tundra in Canada and Alaska have been studied extensively by Macpherson (1969) and Chesemore (1967), respectively. Both authors noted the primacy of lemmings in the fox's summer diet. Shibanoff (1951) described a similar situation on the tundra of northern Russia. On St. Lawrence Island, the tundra vole (*Microtus oeconomus*), rather than the lemming, is the predominant microtine rodent on the island's tundra.

Barabash-Nikiforov (1938), Osgood *et al.* (1915), Braestrup (1941), and Lavrov (1932) have noted the dependence of "coast" foxes on seabirds and marine invertebrates on the Commander Islands, Pribilof Islands, and in Greenland and Russia, respectively.

DESCRIPTION OF THE STUDY AREA

St. Lawrence Island (Fig. 1) is about 100 miles (160 km) long and 10 to 40 miles (16 to 64 km) wide and lies in the Bering Sea about 200 miles (320 km) south of Bering Strait. Fay and Cade (1959) have reviewed the major ecological considerations including physiography, climate, and vegetation. The island is primarily of volcanic origin, mountain ranges occupying about one-fourth of its 2,000 square mile (5,180 sq km) surface area. About two-thirds of the interior land is low, rolling tundra dotted with lakes. The flora is characteristic of the circumpolar tundra biome; the almost complete lack of arborescent forms of shrubby species being the primary distinction between its vegetation and that of the adjacent mainlands.

My assistant and I spent the periods from 9 to 27 July and from 17 to 23 August on the Putgut Plateau study area (Fig. 2). The southern rim of this formation is at an elevation of 100 feet (30.5 km) above sea level and is oriented in a general east-west direction, about 1 mile north of the coast. The south-facing slope of this ancient wave-cut terrace rises 9 to 15 m above the tundra. To the north and south of it lie areas of gently sloping tundra where moss of the genus Sphagnum, forbs including the genera Rumex and Saxifraga, and grasses and sedges of the genera

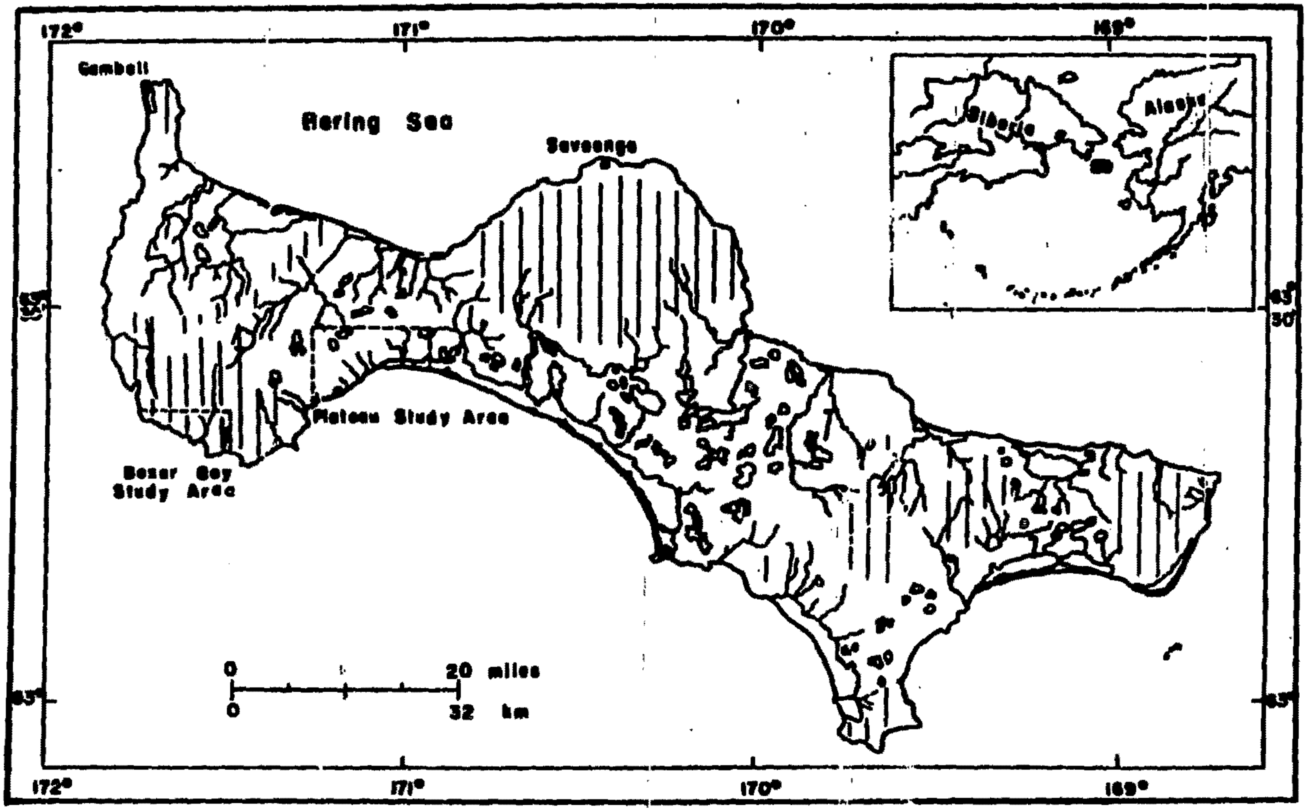

Fig. 1. St. Lawrence Island, Alaska, showing its position relative to the continents (insert) and the location of the study areas (within dashed lines). The vertical lines designate areas of rocky ground with little vegetation other than cryptogams.

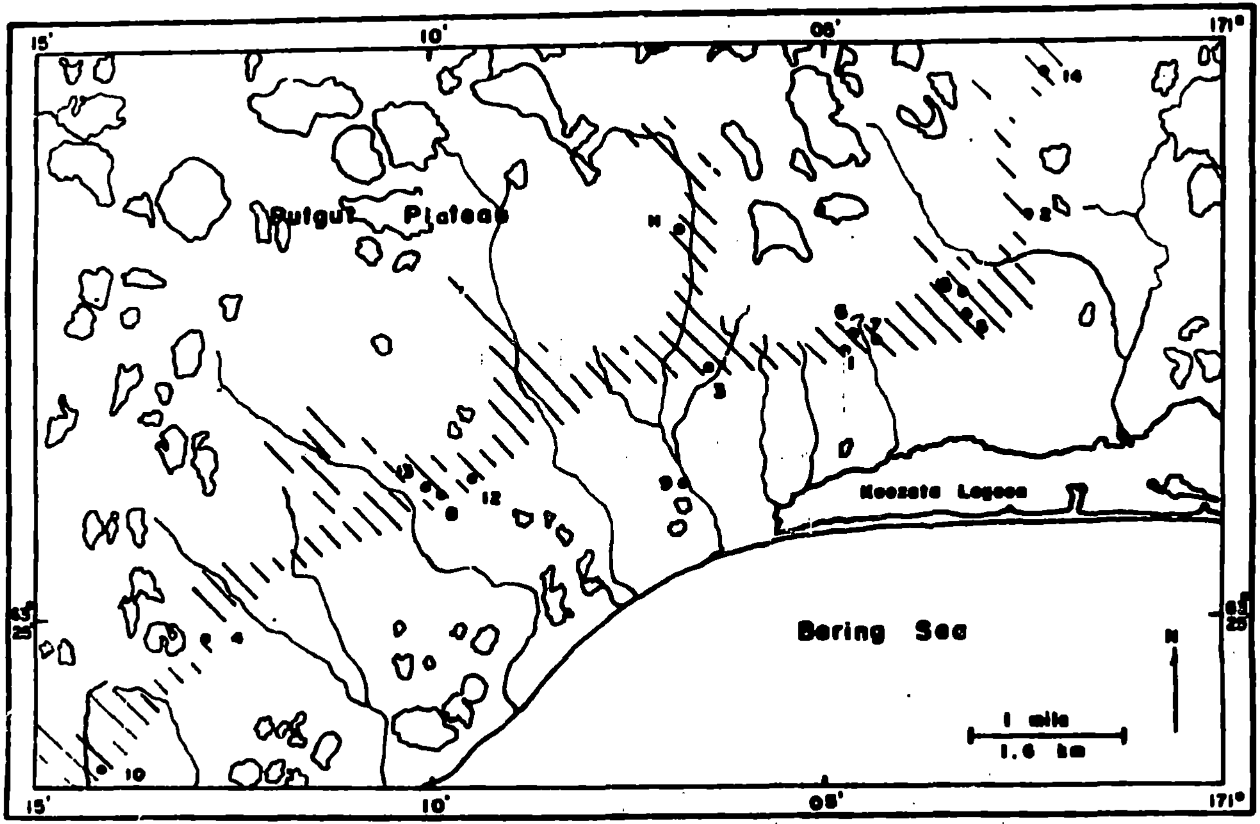

Fig. 2. Putgut Plateau study area, showing the numbered locations of dens and rocky terrain (diagonal lines). The southern rim of the plateau coincides with the lower edge of the rocky area.

Carex, Eriophorum, Calamagrastis, Festuca, Arctogrostis, and Poa are typical (Fay and Cade, 1959). Numerous small streams drain the plateau; their valleys are conspicuous features of the plateau rim. The rim and river valleys are characterized by dry rocky ground covered with lichens, scattered herbs, and some Salix and Dryas.

The period from 28 July to 16 August was spent on the sea cliff study area, located on the southwestern coast in the vicinity of Boxer Bay (Fig. 3). Here, on the southern limits of the Poovoot Range, are located precipitous slopes ranging in height from 50 to more than 1,000 feet (15 to more than 305 m). Fay and Cade (1959) recognized two major types of sea cliffs on St. Lawrence Island. One type they termed "rock-pile" cliffs,

> characterized by great heaps and jumbles of boulders, ranging in size from a few cubic feet to several hundred cubic feet, and occasionally tall pinnacles or columnar shafts jut up from the confusion of smaller boulders. These cliffs are particularly distinguished by the absence of sheer rocky escarpments, though they are in some instances adjacent to them.

The portion of the cliff study area to the west of Boxer Bay is principally of this type. The other type of cliff designated by Fay and Cade is the "sheer-wall" type,

> characterized by high escarpments ranging in height from about 200 to nearly 1,000 feet. These precipices frequently drop directly into the sea with little or no intervening beach but in most instances the sheer-walls are interrupted at intervals by rock-pile cliffs. The most abundant and characteristic plant of the sheer-wall cliffs is Sedum roseum, which occurs principally on the upper levels.

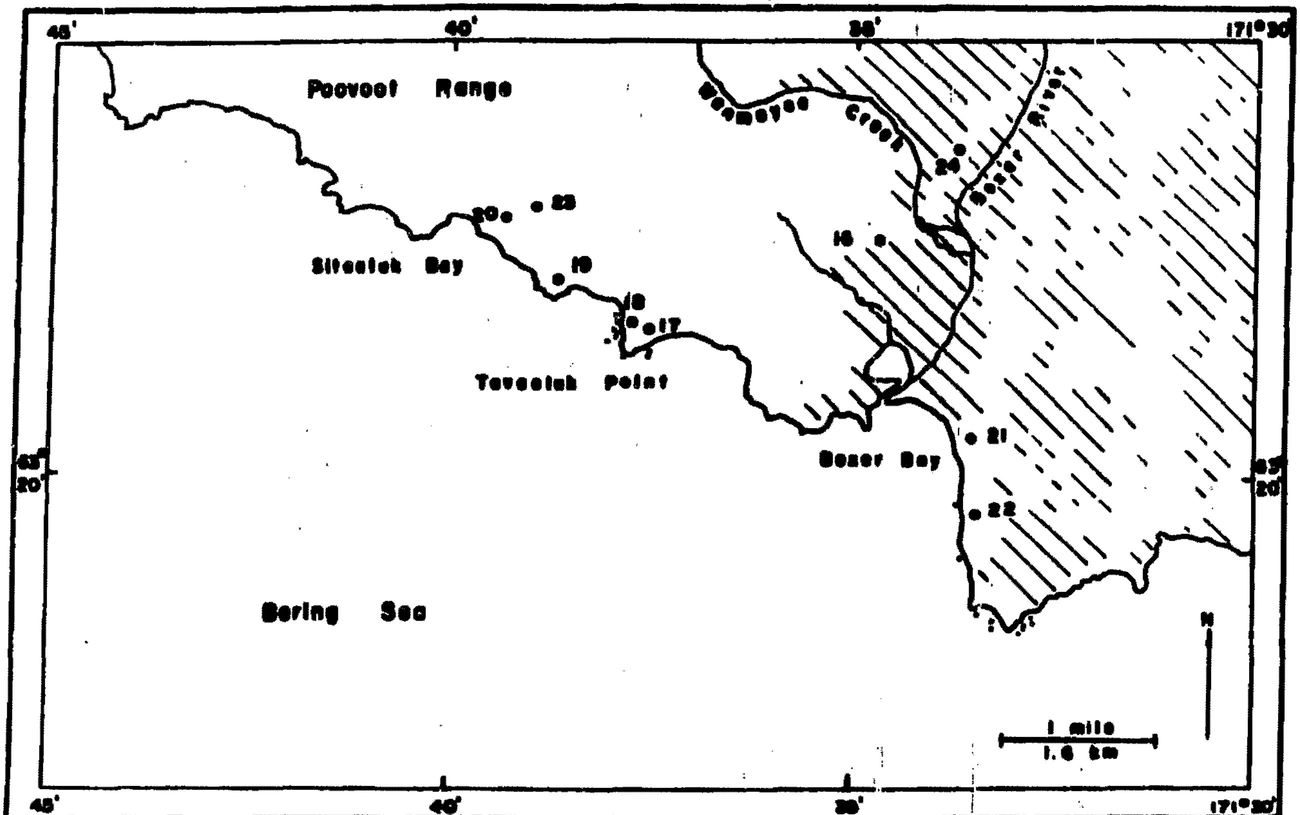

Fig. 3. Boxer Bay study area, showing the numbered locations of dens and the extent of wet and mesic tundra (diagonal lines).

The cliffs on the east side of Boxer Bay are representative of this type. The distinctive associations of birds found on each type of cliff were described by Fay and Cade and will be considered in the following section.

Another distinction between these habitats is the character of the areas inland from them. The uplands adjacent to the rock-pile cliffs are almost entirely rocky barrens while those adjacent to the sheer-wall cliffs support considerable areas of wet and mesic tundra. This is due primarily to the relatively steeper slopes and the different substrata found in the uplands adjacent to the rock-pile cliffs. For comparative purposes I have treated the data from these areas separately.

The Boxer River Valley provided yet another habitat near the cliffs. For a distance of one mile north of the mouth of this river the floor of the valley is about one mile in width, relatively flat, and characterized by wet tundra. The surrounding area is almost entirely barren uplands although some mesic tundra is found to the north in the Boxer and Wanmayee river valleys.

METHODS

Primary sources of data on the summer diet of the arctic fox were scats and food remains collected at den sites. I obtained some additional information by observing the hunting behavior of foxes although frequent fog reduced the effectiveness of this technique.

As originally planned, scats and food remains were to be collected at each den site at intervals of two weeks so that changes in the summer diet related to environmental changes could be detected. The general location of several dens had been obtained from Francis H. Fay (viva voce) and from several people in the village of Gambell. However, the inconspicuous nature of fox dens on the plateau, my lack of familiarity with the study area, and the necessity of conducting field investigations on foot made the initial location of dens more difficult than expected. These factors and the comparatively short period of time I was able to spend in the cliff study area resulted in the data being more heterogeneous, with respect to time and number of collections per den, than was desired.

Every scat found was collected. Those not associated with a den were analyzed as "random collections"; all others were analyzed according to den number, date, and study area. Scats and food remains were placed in individual paper bags.

Since the foxes on this island frequently harbor adults of the cestode Echinococcus multilocularis (Rausch, 1967), the causative agent of alveolar hydatid disease in man, scats were handled with forceps in the field and analyzed only after being autoclaved at the Arctic Health Research Center in College, Alaska.

Scats were composed primarily of indigestible matter, including hair, claws, bone, teeth, feathers, vegetation, and soil. The scats were pulled apart and their contents identified by comparison with study skins and skeletons of birds and mammals collected on the island. Mammal remains were identified using color and texture of fur and dental, skeletal, and claw characteristics. Avian remains in scats were principally body feathers and were classified using the size, color, and shape of quills. It was always possible to identify mammal remains at the species level but avian remains could usually be identified with certainty only to the family level.

From a study in which captive red foxes (Vulpes vulpes) were fed known quantities of prey and their fecal emissions studied, Scott (1941) concluded that frequency of occurrence provided the best estimate of the relative importance of prey species. He found that, in general, fecal passages are produced approximately in direct proportion to the quantity of food consumed. From a similar study Lockie (1959) concluded that percentage weight is the most accurate way of interpreting the results of fecal analysis. For the purposes of the present study I employed the frequency of occurrence method since the volume of material precluded the use of the latter method. To show the relative frequencies of occurrence of the species of small mammals and families of birds represented in scats, I have presented the data with these segments delineated. However, to obtain an indication of the relative importance of the two major groups (birds and small mammals) in the diet a different treatment was required. As noted above, small mammals were easily identified to species while bird remains could, in most cases, be identified only to the family level. For this reason, as well as the fact that due to their small size a relatively greater variety of small mammals can be ingested in a short period of time by a fox, small mammals are likely to score a greater number of occurrences in a scat than are birds. Because of this I have also presented the data in the "grouped" form suggested by Scott (1941). By this method, each group can score no more than one occurrence in a scat. These computations avoid overemphasizing the importance of small mammals and underemphasizing the importance of birds in the fox's diet.

I collected forty species of birds and the five species of small mammals found on St. Lawrence Island and prepared their skins and skeletons as reference material for the analysis of scats and food remains.

Whenever possible, food remains, as opposed to scats, were analyzed in the field. This treatment was especially effective at dens located in alcid nesting colonies where there was a considerable volume of material, primarily alcid remains, and an accurate and rapid determination of species composition was possible. The data on food remains for each den indicate the minimum number of individuals of each species represented in the remains. Though they are a qualitative indication of species taken by foxes, these data are not a quantitative sample of diet, for they are undoubtedly biased in favor of large birds which are unlikely to be completely consumed. Further, they are not an accurate indication of the number of individuals consumed, for prey are not always consumed at the den. Some remains could have been inside the den; others could have been scattered elsewhere by larids (Bédard, 1967) and other scavengers.

Most of the scats and food remains that I found were fresh and evidently had accumulated in the spring and summer of 1968. For this reason, my data are considered to be indicative of the summer diet only. The late summer collections at dens holding litters of pups provide a good record of pups in adolescence as Lund (1962) suggests. Some of the dens that I visited probably had produced litters of pups during the previous summer, but the small number of old scats collected there, early in the summer of 1968, suggests that many of those that accumulated earlier had disappeared during the winter months. Fay (viva voce) found scats in the stomachs of St. Lawrence Island foxes trapped in the winter months, and he reports that, in late winter and spring, food resources are so limited that any available organic material is likely to be ingested by foxes.

The variation among groups of scats from the different habitats in the frequency of occurrence of small mammals, birds, and egg shells was statistically evaluated with a Chi-square test. The overall frequency of occurrence of each of the above food items in scats, without regard to study areas, was considered to be the "expected" frequency. The frequency of occurrence observed in scats collected on each study area was then tested against the appropriate "expected" frequency to determine any statistically significant difference. The statistical significance of the results will be discussed in conjunction with the data from each habitat.

PREY POPULATIONS--PLATEAU STUDY AREA

Of the three microtine rodents endemic to the island, only the tundra vole (Microtus oeconomus) is abundant (Rausch, 1953a; Fay and Cade, 1959). Burrows and runways of this animal were commonly seen on the tundra above and below the plateau rim. Fay and Cade (1959) indicate that the tundra vole population undergoes periodic fluctuations but without the amplitude observed in lemming populations. A snap-trap census conducted during late August by Francis H. Fay of the Arctic Health Research Center indicated that the tundra vole population was moderately high compared to previous years. Little is known of the status of the red-backed vole (Clethrionomys rutilus) or the collared lemming (Dicrostonyx torquatus) except that both are relatively uncommon (Rausch, 1953a). In other areas of Alaska the red-backed vole has been associated primarily with areas where overhead cover is available (Bee and Hall, 1956; Pruitt, 1967). Apparently, this habitat preference is also characteristic of the red-backed vole on St. Lawrence Island as they are found in the vicinity of boulder fields (Fay, viva voce). Rausch (1953a) indicates that the tundra shrew (Sorex tundrensis) is uncommon; only one was caught in the small mammal census during the present study. The arctic ground squirrel (Citellus undulatus) is common on the well-drained slopes of the plateau while nearly absent from the surrounding wet tundra.

The only passerine birds I saw were the lapland longspur (Calcarius laponicus) and the snow bunting (Plectrophenax nivalis). Longspurs were typical of the mesic tundra while snow buntings were characteristic of rocky areas on the plateau rim. I found several nests of the longspur in late June and early July, and newly fledged young of this species were occasionally seen in early July.

Shorebirds were abundant in this area, the most common being dunlins (Erolia alpina), rock sandpipers (E. ptilocnemis), and red phalaropes (Phalaropus fulicarus). Present though less common were the northern phalarope (Lobipes lobatus), western sandpiper (Ereunetes mauri), long-billed dowitcher (Limnodromus scolopaceus), ruddy turnstone (Arenaria interpres), and golden plover (Pluvialis dominica). Nests of species in the first group were commonly found in June.

Fay (1961) estimates the summering population of waterfowl on this island to be about 9,000 nesting and more than 25,000 non-breeding ducks, geese, and swans. Both breeding and non-breeding segments of the waterfowl population were represented on the plateau study area. Of the four species of eiders present the most abundant was the common eider (Somateria mollissima). I found nests of this species near the beach in late June though most occurred on several small islands in Koozata Lagoon. In general, the greatest number of eiders occurred near the coast. Flocks of up to two hundred immature king and Steller's eiders were frequently seen offshore and along Koozata Lagoon. Oldsquaws (Clangula hyemalis) were common throughout the summer, both near the coast and inland. Pintail ducks (Anas acuta) were fairly common, especially near fresh water.

Emperor geese (Philacte canagica) were among the most common waterfowl in this area. Flocks were seen daily along the coast and near Koozata Lagoon. Fay and Cade (1959) note that ten to twenty thousand non-breeding birds, outnumbering breeders by at least ten to one, spend the summer along the southern coast and larger lagoons on the northern coast and suggest that St. Lawrence Island is the principal summering area for the population of immature emperor geese produced in Alaska and Siberia. Flightless birds were seen along the coast from late June to the end of July; the largest concentrations occurred on the barrier beach between Koozata Lagoon and the sea. The latter area is favored by geese during their molt. Flocks of from two to twenty seven geese were observed on the uplands immediately north of the plateau rim in early July. I found fresh goose droppings in and around entrances to fox dens on several occasions and older droppings indicated utilization of the plateau by geese in previous years.

Whistling swans (Cygnus columbianus) were occasionally seen. A nest containing three eggs was found east of the plateau on June 18 and I observed adults on lakes in the vicinity of the plateau. Fay (1961) estimates the population on the western half of the island to be about twenty.

Three species of loons are found on St. Lawrence Island. These include the yellow-billed loon (Gavia adamsii), arctic loon (G. arctica), and the red-throated loon (G. stellata). These birds were commonly seen carrying small fish from the sea to their nests near the inland lakes.

Of the three species of jaegers on the island the long-tailed jaeger (Stercorarius longicaudus) was most common. A nest of this species containing one egg was found on mesic tundra along a small river valley north of the plateau rim on 6 July. Pomarine jaegers (S. pomarinus) and parasitic jaegers (S. parasiticus) were also observed, the latter species being the least common.

Of the larids found on the island the black-legged kittiwake (Rissa tridactyla) is by far the most abundant. Though it does not nest in the plateau study area this bird was abundant along the nearby coast. The glaucous gull (Larus hyperboreus) and herring gull (L. argentatus) were also common, the latter being the only larid known to nest in the study area. At least fifty nesting pairs have been observed on small islands in Koozata Lagoon (Fay and Cade, 1959). Arctic terns (Sterna paradisaea) were common near the lagoon where they also nest.

Sandhill cranes (Grus canadensis) were occasionally seen and a nest containing two eggs was found on 13 June 200 m south of the plateau rim. Not included in this discussion are rare avian species and those not associated with the terrestrial environment. These have been described by Fay and Cade (1959) and by Fay (1961).

Various types of potential food were available on the beach throughout the summer. Remains of marine invertebrates including decapod crustaceans, mollusks, and coelenterates were abundant. Carrion of avian species such as fulmars (Fulmarus glacialus), murres (Uria sp.), and auklets (Aethia sp. and Cyclorrhynchus psittacula), though often nearly stripped of flesh by marine amphipods, was common, especially after storms. The carcasses of three walrus (Odobenus rosmarus), a sea lion (Eumetopias jubata), and a young ringed seal (Phoca hispida) were present in July and August. The carcass of a harbor seal (P. vitulina) lay for the entire summer on the beach near the base camp.

Most of the larger lakes and lagoons on the island contain arctic char (Salvelinus alpinus). Koozata Lagoon also holds arctic grayling (Thymallus arcticus) and lake herring (Coregonus sardinella), and red salmon (Oncorhynchus nerka) are reported to spawn here. Blackfish (Dallia pectoralis) and nine-spined sticklebacks (Pungitus pungitus) are common in most lakes and streams.

PREY POPULATIONS--CLIFF STUDY AREA

The two major types of sea cliffs on the island each support distinct associations of nesting birds. The rock-pile cliffs (Fig. 8) characteristically are the habitat of pigeon guillemots (Cepphus columba), crested auklets (Aethia cristatella), least auklets (A. pusilla), parakeet auklets, and snow buntings. The parakeet auklet nests primarily on the upper slopes, using crevices in the shafts and pinnacles jutting above the surrounding boulders. Crested and least auklets nest below in the interstices in boulder fields and talus formations. The lowest slopes are used primarily by pigeon guillemots.

The avifauna of the sheer-wall cliffs is characterized by the pelagic cormorant (Phalacrocorax pelagicus), black-legged kittiwake, glaucous gull, common murre (Uria salge), thick-billed murre (U. lomvia), horned puffin (Fratercula corniculata), tufted puffin (Lunda cirrhata), parakeet auklet, and raven (Corvus corax). Murres, kittiwakes, and cormorants are restricted in their nesting to narrow ledges on the escarpments. Glaucous gulls nest primarily on pinnacles, especially offshore, and on the seaward ends of ridges extending out into the sea. The upper limits of these cliffs are utilized by parakeet auklets, horned puffins, and tufted puffins.

Anatids were relatively uncommon in this study area though occasionally pintail, oldsquaw, eider ducks, and emperor geese were observed in the Boxer River valley. Harlequin ducks (Histrionicus histrionicus) were seen along the coast.

Shorebird and passerine populations appeared to be comparable in species composition and numbers to those in the plateau study area but with lower numbers on the rocky, barren areas west of Boxer Bay.

The areas of wet tundra in the Boxer River valley and to the east of Boxer Bay supported tundra voles. Isolated populations of tundra voles were also found in grassy swales on the cliffs west of Boxer Bay. Red-backed voles were seen on several occasions in rocky areas near the cliffs west of Boxer Bay and collared lemmings could also be expected in those areas, though none was seen.

Nine-spined sticklebacks were common in the small lagoon at Boxer Bay and in August a few silver, pink, and chum salmon (Oncorhynchus kisutch, O. gorbusha, and O. keta, respectively) and Dolly Varden trout spawned in this lagoon and in the Boxer River.

RESULTS

A total of 24 dens was found during the study; 15 of these were located in the plateau study area (Fig. 2) and nine in the Boxer Bay area (Fig. 3).

St. Lawrence Island is known for its relatively high population density of foxes and during the field investigation sightings were of almost daily occurrence. The many foxes that I observed exhibited a variety of responses to my presence, ranging from indifference and close approach to avoidance at a distance of several hundred meters. Almost without exception, however, the foxes became quite vocal when I approached them.

Fox pups were first seen outside of a den on 8 July at den 14 and sightings here and elsewhere increased as the summer progressed. Though first seen only near the den entrance, by mid-August pups were observed traveling up to 100 m from the den in the course of play activities. This increase in pup activity is reflected in the sudden appearance of large numbers of scats at these dens after mid-July. Pups were often seen during relatively fair weather and during late afternoon and evening.

With the following exceptions all of the foxes that I observed on the island were of the white color phase. The one adult blue phase arctic fox seen during the summer was one parent of a litter of at least five pups at den 22. Three of these pups were blue phase and two were white phase. In addition, two of the six pups that my assistant observed at den 13 on 21 August were of the blue color phase. The entire coat of both pup and adult blue foxes was sooty brown to almost black in color. In summer, the adult white fox is dark brown on the face, neck, back, legs, and the dorsal surface of the tail, and greyish white on the sides and underparts (Figs. 9 and 12). The white phase pups I saw in July were almost entirely brown while the coloration of pups seen in August closely resembled that of the adults. This change from natal to adult-like pelage has been described by Chesemore (1970).

I collected and analyzed a total of 1,555 scats and the remains of dozens of birds. The results from each den, with a brief description of the den site, the activity of foxes in the vicinity, and the general condition of food remains, are presented in the following pages.

Plateau Study Area

Five dens on the plateau had litters of pups at some time during the summer, though in one and possibly two cases pups were moved from one den to another. These dens, with one exception, were relatively extensive in construction having from five to 13 entrances. Only one den was discovered in a wet tundra situation though others could have been present. This den (den 9) was on a 2 m elevation along a small stream. All other dens in the plateau area were associated with either mesic tundra or rocky barrens on the slopes of the plateau and river valleys (Fig. 5). The burrowing of ground squirrels appeared to exert a direct influence in determining the location of dens. The burrows of these animals were almost always present among those of foxes and three of the single entrance fox dens that I excavated in late August were enlarged ground squirrel burrows, the upper 1 to 2 m being used by foxes. The plant communities around dens were noticeably altered in that the dry tundra community was replaced by relatively lush stands of grasses and sedges. This change is due primarily to disturbance and the addition of organic compounds to the soil.

In the middle of June, during the spring thaw, I found three caches of small mammals along the plateau rim. The first cache, found on 13 June at den 1, contained five tundra voles (Fig. 6). On 16 June another cache was found at den 4 containing 27 tundra voles, a red-backed vole, and a collared lemming. The third cache, containing 16 tundra voles and a collared lemming, was found 50 m from den 1 on 18 June. Of the tundra voles in these caches, 73.6% were males. The five voles in den 1 were piled 50 cm inside the entrance while at the other two sites the prey were partially buried. The condition of the prey in these caches indicated that they had been taken in the previous few days. The animals were intact but showed evidence of having been chewed. The shallow and apparently hurried construction of these caches indicates that they were of a temporary nature. I visited the cache at den 1 the day after discovering it and found only one vole. The other caches were visited within a week after their discovery and were found empty, again indicating that the caches were of a temporary nature. However, the disappearance of the cache contents may have been prompted by the author's interference or may have been caused by other foxes. Other orifices that might have harbored a cache were probed, including many not constructed by foxes, but no other caches of small mammals were found.

The relatively small number of scats collected at den 1 indicates that this site was not used intensively (Table 1). Excavation of this den revealed that it was 1.5 m in depth. The birds identified in the food remains were each represented by a sternum and scattered wing bones, all in a weathered condition.

Den 2 had been constructed in the midst of a ground squirrel colony and had three entrances. No scats were found after the initial collection (Table 2) and foxes were not seen in the immediate area. This was the only instance where I identified fish parts (arctic grayling) in a scat or in food remains. The remains of a phalarope were fresh,

Table 1. Results from den 1.

Date:	6-15-68		7-3-68		7-22-68		8-22-68	
No. scats:	38		9		1		7	
Item	No.	%	No.	%	No.	%	No.	%
Microtus	21	55.3	6	66.7	1	100.00	5	71.4
Clethrionomys	1	2.6	-	--	-	--	-	--
Dicrostonyx	1	2.6	-	--	-	--	-	--
Citellus	2	5.3	-	--	-	--	-	--
Waterfowl	25	65.8	6	66.7	-	--	2	28.6
Shorebird	2	5.3	-	--	-	--	1	14.3
Unidentified bird	1	2.6	-	--	-	--	-	--
Odobenus	2	5.3	-	--	-	--	-	--
Decapod Crustacean	1	2.6	-	--	-	--	-	--
Insect	1	2.6	1	16.7	-	--	-	--
Vegetation	2	5.3	1	16.7	-	--	-	--
Soil	4	10.5	1	16.7	-	--	-	--

Grouped Data
No. scats = 55

	No.	%
Small mammals	36	65.5
Birds	36	65.5

Food Remains

Date:	6-15-68
Item	No.
Murre	1
Eider duck	1
Emperor goose	1

Table 2. Results from den 2.

Date:	6-18-68	
No. scats:	26	
Item	No.	%
Microtus	15	57.7
Clethrionomys	1	3.8
Citellus	1	3.8
Alopex	6	23.1
Waterfowl	6	23.1
Shorebird	1	3.8
Egg shells	1	3.8
Grayling	1	3.8
Insect	4	15.4
Vegetation	3	11.5

Grouped Data

No. scats = 26

	No.	%
Small mammals	17	65.4
Birds	7	26.9

Food Remains

Date: 6-18-68

Item	No.
Murre	1
Crested auklet	1
Emperor goose	1
Red phalarope	1

Fig. 4. Looking southeast from the rim of the Putgut Plateau in mid-June. Part of the ice-covered Koozata Lagoon (light area) is visible in the center of the picture.

Fig. 5. Den 13, a site representative of the dens along the river valleys draining the plateau. Note relatively lush vegetation around the den entrances to the right of assistant.

Fig. 6. Den 1 and cache of 5 tundra voles found on 13 June. Note molted winter hair clinging to top and sides of entrance. The prey were found piled 50 cm inside the den.

Fig. 7. Cache of 16 tundra voles and one collared lemming (bottom) that was found 50 m from den 1 on 18 June.

consisting of a wing and scattered feathers, but the bones of other species showed signs of weathering and appeared to have been deposited in previous years.

Den 3 was located in a small area of rocky barrens and had three entrances. Though it was evident from the amount of food remains that this site had been used by foxes in previous years, no signs of use were found after early July (Table 3). A scat collected at this site provided the only evidence during the summer of a fox consuming a tundra shrew. The food remains were all in a dry and weathered condition. The birds were represented by their sterna and a few scattered bones; a seal was represented by a pelvic bone. The eggs were those of a duck-sized bird.

Some of the dens on the plateau appeared to be used relatively little during the summer and yielded little in the way of food remains or scats. Dens 4, 5, 6, and 7 were of this type. The data from these dens are presented in Table 4. However, the largest cache of small mammals found was at den 4. Dens 9, 10, and 12 showed no signs of recent use and no scats or food remains were found. All of the above dens had but one entrance.

Den 8 had one large entrance and was used by a family of foxes which also occupied den 13, located about 200 m to the northwest. I saw an adult male and a lactating female fox near these dens on several occasions. Seven pups were observed at den 8 on 14 July. On 21 August six pups were

Table 3. Results from den 3.

Date:	6-24-68		7-6-68	
No. scats:	11		6	
Item	No.	%	No.	%
Microtus	4	36.4	4	66.7
Clethrionomys	1	9.1	-	--
Sorex	-	--	1	16.7
Waterfowl	6	54.5	-	--
Shorebird	3	27.3	1	16.7
Egg shells	1	9.0	-	--
Soil	-	--	1	16.7

Grouped Data

No. scats = 17

	No.	%
Small mammals	10	58.8
Birds	10	58.8

Food Remains

Date: 6-24-68

Item	No.
Murre	5
Crested auklet	3
Common eider	1
Egg shells	3
Phoca sp.	1

Table 4. Results from dens 4, 5, 6, and 7.

Den	Date	No. scats	Contents
4	6-24-68	1	*Microtus* & Vegetation
5	6-18-68	2	1. *Microtus* 2. *Microtus* & Sipunculid
6	7-22-68	1	*Microtus*
7	6-18-68	1	Waterfowl

playing near den 13. When alerted, four of these went into den 13 while the other two ran directly to den 8. After these pups had disappeared another approached the area indicating that at least seven pups were still using these dens. A fox skeleton found at den 8 was weathered, while the other remains were fresh. A female oldsquaw, intact and lying 0.5 m inside the entrance, appeared to have died and stiffened in a sleeping position a few days prior to my finding it. Its plumage was undisturbed and it is likely that it had succumbed to disease rather than having been killed by a fox. The pups were in the den at the time this bird was found and I saw the parent foxes in the vicinity. One tundra vole, 3 or 4 days of age and evidently taken from a nest, was found intact. Remains of a ground squirrel comprised only the tail and a few tufts of hair.

Den 13 had five entrances and appeared to be at an old well-established den site. The food remains found there were of birds, each species being represented by a sternum and other bones. The remains of the eider and jaeger were old while those of the kittiwake indicated it had been taken a few weeks previously. The data from dens 8 and 13 are combined in Table 5, since these two dens were simultaneously occupied by only one family group.

Den 11 was located 1.4 km north of the plateau rim on the steep slope of a river valley. I heard pups in this den at the first visit and the number of scats collected in August indicates that a litter of pups was reared there (Table 6). The bird remains consisted of sterna and were devoid of flesh, indicating that they were quite old. I saw an adult fox in the vicinity on the first visit.

Den 14 had 11 entrances and seemed to be a well used site. Striking, however, was the relative scarcity of scats and remains found on the first visit (Table 7). At least four pups were seen entering this den on 9 July and two adult foxes, including a lactating female, were seen at that time. The great number of scats that accumulated there during the 42 days between the first and second collections, and similar accumulations at dens 11, 14, and 15 are undoubtedly due to the increasing activity of pups outside the dens. No foxes were seen or heard on the second visit and it may be that this litter was the one found at den 15 on 22 August. The food remains at den 14 were all old and weathered. An

Table 5. Results from dens 8 and 13.

Date:	7-7-68		7-14-68		8-21-68	
No. scats:	73		138		127	
Item	No.	%	No.	%	No.	%
Microtus	50	68.5	132	95.7	117	92.1
Dicrostonyx	9	12.3	-	—	1	0.7
Citellus	4	5.5	1	0.7	4	3.1
Waterfowl	33	45.2	48	34.8	15	11.8
Shorebird	1	1.4	2	1.4	12	9.4
Passerine	-	—	4	2.9	-	—
Egg shells	-	--	1	0.7	1	0.7
Unidentified bird	2	2.7	-	—	8	6.2
Vegetation	2	2.7	4	2.9	6	4.7
Soil	1	1.4	2	1.4	4	3.1

Grouped Data

No. scats = 338

	No.	%
Small mammals	311	92.0
Birds	125	37.0

Food Remains

Date: 7-14-68

Item	No.
Microtus	1
Citellus	1
Alopex	1
Oldsquaw (female)	1

Date: 8-21-68

Item	No.
Eider	1
Jaeger	1
Black-legged kittiwake	1

Table 6. Results from den 11.

Date:	7-6-68		8-20-68	
No. scats:	8		71	
Item	No.	%	No.	%
Microtus	5	62.5	67	94.4
Dicrostonyx	-	--	4	5.6
Citellus	-	--	3	4.2
Alopex	3	37.5	-	--
Waterfowl	1	12.5	-	--
Shorebird	1	12.5	1	1.4
Passerine	1	12.5	1	1.4
Egg shells	-	--	1	1.4
Vegetation	-	--	2	2.8
Soil	-	--	1	1.4

Grouped Data

No. scats = 79

	No.	%
Small mammals	77	97.5
Birds	5	6.3

Food Remains

Date: 8-20-68

Item	No.
Tufted puffin	1
Emperor goose	1

Table 7. Results from den 14.

Date:	7-9-68		8-20-68	
No. scats:	15		128	
Item	No.	%	No.	%
Microtus	14	93.3	127	99.2
Clethrionomys	-	--	1	0.8
Citellus	-	--	8	6.3
Waterfowl	-	--	6	4.7
Egg shells	1	6.7	2	1.7
Unidentified bird	-	--	5	3.9
Insect	-	--	1	0.8
Vegetation	4	26.7	9	7.0
Soil	-	--	2	1.6

Grouped Data

No. scats = 143

	No.	%
Small mammals	142	99.3
Birds	11	7.7

Food Remains

Date: 7-9-68

Item	No.
Emperor goose	1
Alopex	1
Microtus	6

emperor goose was represented by a sternum and other bones, and scattered feathers. The remains of a fox included the maxillae and portions of the appendicular skeleton.

Den 15 was the only den found on the plateau associated with large boulders. These boulders were in two formations about 50 m apart. Each formation had three entrances. This site was visited early in the summer, but evidence of foxes using it was not found until 22 August, when I saw six pups. All food remains and scats found at that time appeared to be fresh (Table 8). Each bird was represented by a sternum, one or both wings, other bones, and feathers. The condition of some of the primary feathers from the geese indicated that at least three of these birds were completing a molt when killed.

The combined results of analyses of scats and food remains from all dens in the plateau study area are shown in Table 17. The scats collected on the plateau indicate that the summer diet of young foxes in this area is composed primarily of small mammals and that the tundra vole is the predominant prey. The frequency of occurrence of this species was consistently 95% or more in the collection of scats deposited by fox pups. The overall frequency of occurrence for this vole is slightly over 90%. Of the remaining small mammal species the tundra shrew occurred least often (one scat) while the red-backed vole, collared lemming, and ground squirrel occurred generally in less

Table 8. Results from den 15.

Date:	8-24-68	
No. scats:	134	
Item	**No.**	**%**
Microtus	107	79.9
Clethrionomys	1	0.7
Dicrostonyx	1	0.7
Citellus	34	25.4
Alopex	2	1.5
Waterfowl	39	29.1
Passerine	4	3.0
Egg shells	3	2.2
Vegetation	2	1.5
Soil	8	6.0

Grouped Data

No. scats = 134

	No.	%
Small mammals	125	93.3
Birds	43	32.1

Food Remains

Date: 8-20-68

Item	No.
Common eider	1
Emperor goose	5

than 10% of the scats. I considered the presence of fox hair, vegetation, or soil in scats to be due to accidental ingestion. The occurrence of marine carrion (pinnipeds and invertebrates) is surprisingly low (6 scats) in view of the available supply of this type of food. The significance of this will be discussed in the next section.

The avian material in these scats was primarily of waterfowl and occurred in a considerable proportion of them (29.9%). Items occurring in less than 5% of the scats from the plateau include egg shells, fishes, insects, vegetation, and soil. The possible origin and significance of the alcid remains found near dens on the plateau will be considered in the following section.

The results from random collections of scats, not associated with dens, are shown in Table 17. In general, these scats appeared more weathered than those collected around the dens. They are presumed to be scats of adult foxes. The frequency of occurrence of small mammals and birds is similar to that in scats collected near dens on the plateau. The hair of a seal pup (lanugo) was identified in one of these scats.

Boxer Bay Study Area

The physical characteristics of dens in the Boxer Bay area showed a marked contrast with those on the plateau. All nine dens in the cliff area were located under large boulders (Figs. 10 and 11) while only one den on the plateau was associated with a large rock formation. The number of entrances to the dens in the cliff area varied from three to eight. At least four of these dens contained litters of pups in August.

On the plateau, hunting by foxes was not observed due to the relatively level topography which precluded the observer's remaining undetected by a fox for any length of time. However, the following observations were made in the cliff area with the aid of a 20X spotting scope. On 11 August a fox carrying a crested auklet was seen. The bird was dropped and upon examination proved to be freshly killed by a bite through the neck. On 14 August a female fox carrying a parakeet auklet returned to its den after an absence of 40 minutes. This bird was freshly taken and killed in the same manner as the crested auklet. On the same day a fox was observed stalking a group of horned puffins and a few minutes later a crested auklet. In both instances, this fox crawled to within 3 m of its intended prey but then abandoned the stalk, probably because of its awareness of the observer's presence. Neither their movement nor the vocalization of foxes caused any widespread alarm among the nesting alcids.

The data from scats collected at dens west of Boxer Bay is presented below. Den 17 was located on the east side of Taveeluk Point at the top of a steep rock-pile cliff and was situated under large boulders. The adjacent slopes were used primarily by large numbers of crested and parakeet auklets and by horned puffins. The high frequency of occurrence of alcids in the scats and their dominance in the remains about the den reflect the ready availability of these birds (Table 9). The alcids identified in these remains and in those found at other dens along the cliffs were almost invariably represented by the sternum and wings, with the wings sometimes attached to the sternum and with varying amounts of feathers and flesh clinging to the bones. Occasionally the feet or bill of a bird was found. It is interesting to note that at three dens the head of a recently killed horned puffin was found neatly separated from the body just posterior to the occipital bones. A puffin egg was found 0.5 m inside one of the entrances to the den. The shell was unbroken. Except for the puffin egg, the food remains found here on my first visit appeared to have been deposited prior to 1968. On the second visit I found the remains indicated in Table 9. No foxes were observed in the immediate vicinity of this den.

Den 18 was located under a conspicuous heap of boulders on the west side of Taveeluk Point (Figs. 10 and 11). An adult male and an adult female fox and three pups were identified here on several occasions. With the exception of the fox remains (a few lumbar vertebrae) the remains found were quite fresh and included partly consumed carcasses of

Table 9. Results from den 17.

Date:	8-1-68	
No. scats:	44	
Item	**No.**	**%**
Microtus	6	13.6
Clethrionomys	1	2.3
Dicrostonyx	2	4.5
Citellus	1	2.3
Alopex	1	2.3
Alcids	41	93.2
Egg shells	8	18.2
Soil	1	2.3

Grouped Data

No. scats = 44

	No.	%
Small mammals	10	22.7
Birds	41	93.2

Food Remains

Date: 8-1-68

Item	No.
Horned puffin	2
Puffin egg	1
Murre	2
Crested auklet	5
Parakeet auklet	4

Date: 8-9-68

Item	No.
Horned puffin	1
Crested auklet	1
Parakeet auklet	2

crested and parakeet auklets and an intact parakeet auklet (Table 10). No signs of recent use were found at den 19.

Den 20 was located under a large overhanging rock on the rim of a steep slope a few hundred meters east of Siteeluk Bay. Though I observed adult foxes in the vicinity, the quantity of scats and food remains found was relatively meager, indicating intermittent use or at least that no pups were in the den (Table 11).

Den 23 was situated 300 m north of the rim of the cliffs in the midst of a boulder field. An adult fox was seen here on several occasions. Most of the remains collected appeared to be from birds taken in recent months. The great preponderance of parakeet auklets in the food remains (Table 12) is striking and not readily attributable to a local abundance of this species. In addition, the food remains collected at this den and at den 18 are the only remains in which the least auklet is represented. Although none of the major nesting colonies of this bird are located in the study area, the species is present in numbers comparable to the crested auklet, especially in the Siteeluk Bay area a few hundred meters west of this den site. The possible significance of the low occurrence of the least auklet in food remains will be considered in the following section.

The results from dens 21 and 22, near the cliffs east of Boxer Bay, are presented below. Den 21 exhibited the most striking physical characteristics of any den I found.

Table 10. Results from den 18.

Date:	8-1-68		8-9-68	
No. scats:	75		36	
Item	No.	%	No.	%
Microtus	15	20.0	6	16.7
Clethrionomys	1	1.3	1	2.8
Dicrostonyx	4	5.3	-	--
Citellus	1	1.3	-	--
Alopex	2	2.7	2	5.6
Alcids	73	97.3	35	97.2
Egg shells	15	20.0	12	33.3
Vegetation	4	5.3	2	5.6
Soil	2	2.7	-	--

Grouped Data

No. scats = 111

	No.	%
Small mammals	28	25.2
Birds	108	97.3

Food Remains

Date: 8-1-68		Date: 8-9-68	
Item	No.	Item	No.
Horned puffin	4	Pigeon guillemot	1
Tufted puffin	3	Least auklet	5
Murre	1	Parakeet auklet	2
Crested auklet	8		
Parakeet auklet	4		
Alopex	1		

Table 11. Results from den 20.

Date:	8-9-68	
No. scats:	27	

Item	No.	%
Microtus	6	22.2
Clethrionomys	1	3.7
Citellus	1	3.7
Alcids	25	92.6
Egg shells	6	22.2
Vegetation	2	7.4
Soil	2	7.4

Grouped Data

No. scats = 27

	No.	%
Small mammals	8	29.6
Birds	25	92.6

Food Remains

Date: 8-9-68

Item	No.
Crested auklet	6
Parakeet auklet	4

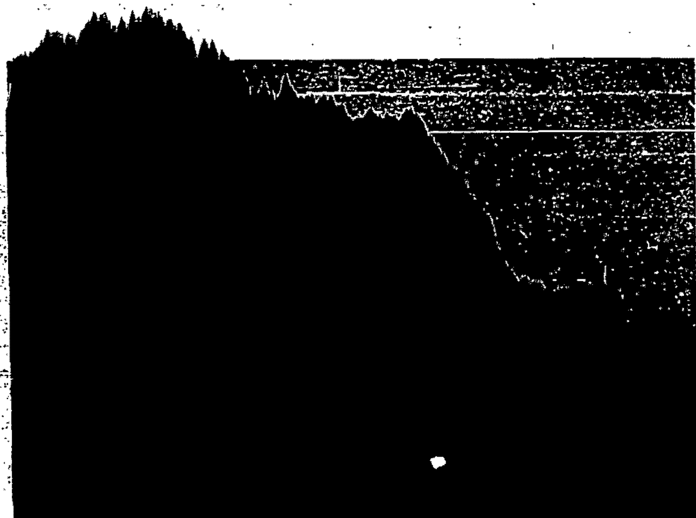

Fig. 8. Sea cliffs of the Poovoot Range on the southwest coast of the island. The upper slopes characterize the rock-pile cliff while the lower cliffs are typical of the sheer-wall type.

Fig. 9. An adult arctic fox moving along the plateau rim in late June. The completely white tail and long white hairs on the neck and shoulders indicate that this individual is in the latter stages of the spring molt.

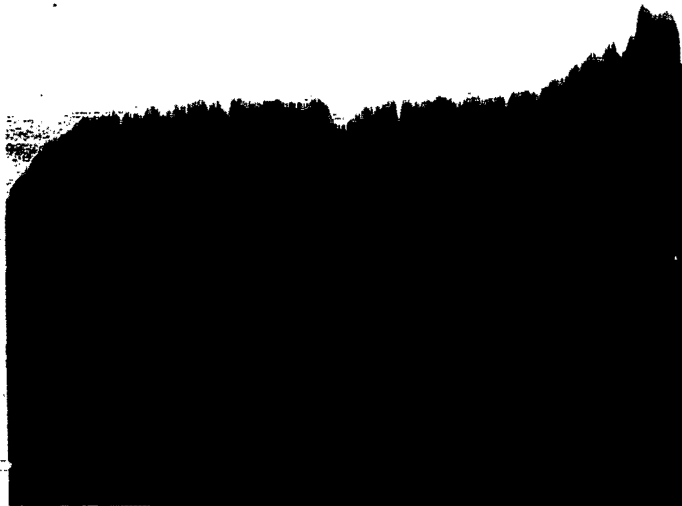

Fig. 10. Large boulders on Taveeluk Point where den 18 was located. Rock-pile cliffs of the type seen here are predominant along the coast west of Boxer Bay.

Fig. 11. Another view of den 18 showing, in front of assistant, one of the entrances.

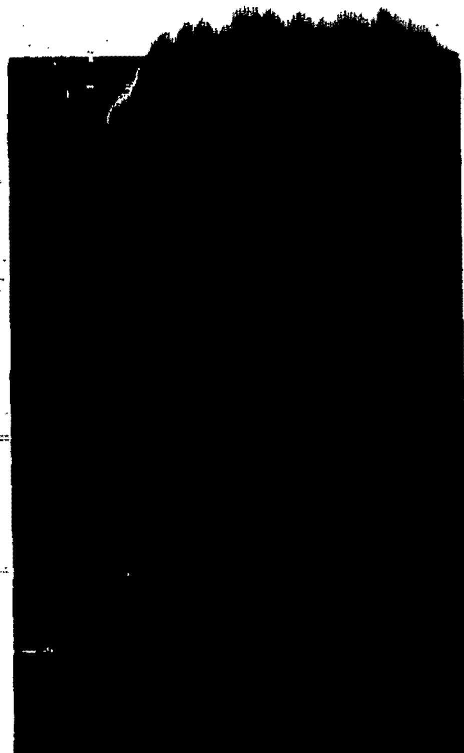

Fig. 12. One of the adult arctic foxes inhabiting den 18. The coat of this individual is typical of the summer pelage.

Table 12. Results from den 23.

Date:	8-16-68	
No. scats:	47	
Item	**No.**	**%**
Microtus	3	6.4
Dicrostonyx	1	2.1
Alopex	1	2.1
Alcids	47	100.0
Egg shells	9	19.1
Vegetation	1	2.1

Grouped Data

No. scats = 47

	No.	%
Small mammals	4	17.4
Birds	47	100.0

Food Remains

Date: 8-16-68

Item	No.
Crested auklet	1
Parakeet auklet	36
Least auklet	5

It was located in an area of rocky, mesic tundra and under a heap of large boulders ranging in size from about 50 to 100 m^3. An adult fox was heard in this den on the first visit, but other activity was not noted. None of the food remains collected here were fresh, though a few had flesh still clinging to them. At least one of the horned puffins found her was a fledgling (Table 13).

Den 22 was in an area of rocky mesic tundra and was situated under partially buried boulders 75 m from the rim of the sheer-wall cliffs. The litter of five pups inhabiting the den was observed playing within a 50 m radius of the den on two evenings in mid-August and an adult blue phase fox was seen here on these and other occasions. The food remains found here were in varying stages of decomposition and were scattered over a wide area (Table 14).

The statistical comparison of the results from scats collected on the cliffs west of Boxer Bay (dens 17, 18, 20, and 23) (Table 17) with those from scats collected east of Boxer Bay (dens 21 and 22) (Table 17) revealed significant differences in the occurrence of small mammals and egg shells. The frequency of occurrence of small mammals (predominantly the tundra vole) is significantly higher ($P < .005$) and the occurrence of egg shells significantly lower ($P < .05$) in scats collected east of Boxer Bay near the sheer-wall cliffs.

The data from scats collected at the six dens near

Table 13. Results from den 21.

Date:	8-11-68		8-14-68	
No. scats:	9		25	
Item	No.	%	No.	%
Microtus	6	66.7	14	56.0
Clethrionomys	1	11.1	3	12.0
Dicrostonyx	-	--	4	16.0
Citellus	-	--	2	8.0
Alopex	-	--	1	4.0
Alcids	9	100.0	21	84.0
Egg shells	1	11.1	-	--
Vegetation	-	--	5	20.0

Grouped Data

No. scats = 34

	No.	%
Small mammals	29	85.3
Birds	30	88.2

Food Remains

Date: 8-11-68

Item	No.
Horned puffin	6
Tufted puffin	1
Murre	3
Pigeon guillemot	5
Pelagic cormorant	1
Black-legged kittiwake	1
Crested auklet	15
Parakeet auklet	9

Table 14. Results from den 22.

Date:	8-14-68	
No. scats:	42	
Item	No.	%
Microtus	23	54.8
Dicrostonyx	2	4.8
Citellus	3	7.1
Alcids	34	81.0
Egg shells	4	9.5
Vegetation	3	7.1

Grouped Data

No. scats = 42

	No.	%
Small mammals	27	64.3
Birds	34	81.0

Food Remains

Date: 8-14-68

Item	No.
Horned puffin	8
Tufted puffin	2
Murre	3
Pigeon guillemot	2
Crested auklet	13
Parakeet auklet	11

alcid nesting colonies indicate that in summer the foxes inhabiting these areas prey mainly on alcids. The occurrence of both alcids and egg shells is significantly higher ($P < .005$) than in the other habitats studied while small mammals occurred at a significantly lower ($P < .005$) frequency. The frequencies of occurrence of fox hair, vegetation, and soil are similar to those in scats collected in other habitats. Food remains collected near these dens also indicate a preponderance of alcids in the diet.

Boxer River Valley

Den 16 was located under a conspicuous formation of large boulders 1.4 km north of the coast. Six pups were seen playing near this den on several occasions in August. The only recently deposited prey remains were those of a pintail duck and of a vole. The primary feathers of the pintail indicated that it was molting when killed. The vole, an immature, was intact, though it showed signs of having been chewed. Another vole was represented by its skull. The quantity of scats collected here indicates that this den was used during the entire summer by a family of foxes (Table 15).

Den 24 was situated under a formation of large boulders on a hill between the Boxer and Wanmayee rivers 2.8 km north of the coast. Though six pups were seen here, scats were relatively scarce and no food remains were found (Table 16).

Table 15. Results from den 16.

Date:	7-30-68		8-15-68	
No. scats:	212		66	
Item	No.	%	No.	%
Microtus	183	86.3	63	95.5
Clethrionomys	13	6.1	-	—
Dicrostcnyx	5	2.4	1	1.5
Citellus	9	4.2	14	21.2
Alcids	47	22.2	5	7.6
Waterfowl	2	0.9	5	7.6
Shorebird	1	0.5	-	—
Egg shells	2	0.9	2	3.0
Unidentified bird	1	0.5	1	1.5
Insect	4	1.9	11	16.7
Vegetation	19	9.0	13	19.7

Grouped Data

No. scats = 278

	No.	%
Small mammals	262	94.2
Birds	62	22.3

Food Remains

Date: 7-30-68

Item	No.
Crested auklet	2
Black-legged kittiwake	1
Herring or glaucous gull	1
Emperor goose	1
Pintail	1
Microtus	2
Alopex	1

Table 16. Results from den 24.

Date:	8-15-68	
No. scats:	56	
Item	No.	%
Microtus	44	78.6
Dicrostonyx	5	8.9
Citellus	8	14.3
Alcids	9	16.1
Waterfowl	1	1.8
Egg shells	2	3.8
Vegetation	3	5.4

Grouped Data

No. scats = 56

	No.	%
Small mammals	48	85.7
Birds	10	17.9

This probably indicates that the foxes had moved to this site only a few weeks prior to the collection date.

The data presented in Table 17 indicate that the diet of the foxes inhabiting the Boxer River valley consists primarily of small mammals. The frequency of occurrence of this type of prey is similar to that found in scats from the plateau study area. Avian material, primarily alcids, occurred at a significantly lower ($P < .05$) frequency in scats collected in this valley than in scats collected along the nearby cliffs. Insects and vegetation occurred at frequencies similar to those observed in scats from the other habitats studied.

Table 17. Combined results from scats collected on the respective study areas and results from random collections on the plateau.

	Random Collec-tions		Plateau		Cliffs West of Boxer Bay		Cliffs East of Boxer Bay		Boxer River Valley	
No. scats	119		797		229		76		334	
Item	No.	%	No.	%	No.	%	No.	%	No.	%
Small mammals	95	79.8	722	90.6	50	21.8	56	73.7	310	92.8
Microtus	93	78.2	679	85.2	36	15.7	43	56.6	290	86.8
Clethrionomys	4	3.4	5	0.6	4	1.8	4	5.3	13	3.9
Dicrostonyx	6	5.0	16	2.0	7	3.1	6	7.9	11	3.3
Citellus	3	2.5	57	7.1	3	1.3	5	6.6	31	9.3
Sorex	2	1.7	1	0.1	-	--	-	--	-	--
Birds	36	30.0	238	29.9	221	96.5	64	84.2	72	21.6
Anseriformes	20	16.8	188	23.5	-	--	-	--	8	2.4
Charadriiformes	7	5.9	25	3.1	221	96.5	64	84.2	62	18.6
Passeriformes	6	5.0	10	1.2	-	--	-	--	-	--
Unidentified	3	2.5	16	2.0	-	--	-	--	-	--
Egg shells	3	2.5	11	1.4	50	21.8	5	6.6	6	1.8
Fishes (*Thymallus*)	-	--	1	0.1	-	--	-	--	-	--
Insects	-	--	7	0.9	-	--	-	--	15	4.5
Marine Invertebrates	-	--	2	0.3	-	--	-	--	-	--
Decapod crustacean	-	--	1	0.1	-	--	-	--	-	--
Sipunculid	-	--	1	0.1	-	--	-	--	-	--
Marine mammals	1	0.8	2	0.3	-	--	-	--	-	--
(*Odobenus*)	-	--	2	0.3	-	--	-	--	-	--
(*Phoca*)	1	0.8	-	--	-	--	-	--	-	--
Incidental	3	2.5	58	7.3	18	7.9	8	10.5	35	10.5
Fox hair	-	--	11	1.4	6	2.6	1	1.3	-	--
Vegetation	-	--	26	3.3	9	3.9	8	10.5	35	10.5
Soil	3	2.5	24	3.0	5	2.2	-	--	-	--

DISCUSSION

The arctic fox's preference for denning in elevated, well-drained soils has been noted by several authors. Tsetsevinski (1940) found most of the arctic fox dens on the Yamal Peninsula to be situated on the banks of rivers and streams. In the lower reaches of the Kara and Sibirchayalka Rivers in Russia, Danilov (1958) found 37 of 41 dens built on the main valley sides indicating a marked tendency to use elevated locations. Danilov also demonstrated that areas having a comparatively deep active frost layer and high soil temperatures are favored by foxes for denning. Chesemore (1967) described similar characteristics in arctic Alaska, as has Macpherson (1969) in arctic Canada.

The rocky, sloping ground along the rim and river valleys of the Putgut Plateau is relatively well drained and could be expected to have a deeper active frost layer than the surrounding areas of comparatively level tundra. The above conditions cause the soil on these slopes to be relatively drier and more stable and thus account for the fox's preference for denning in these areas. In addition, ground squirrels favor similar soil conditions for burrowing and their burrows are often enlarged and used by foxes. Fecal deposits of ground squirrels were commonly found in entrances to fox dens and on several occasions ground squirrels were seen in dens known to have been used by foxes only a few days previously. This apparently close association of predator and prey deserves further study. Macpherson (1969) reports that foxes often utilize dens throughout the winter and various trappers on St. Lawrence Island reported similar observations. The use of an elevated location, such as the plateau rim, for denning is thus a further advantage in that such areas are kept relatively free of snow by wind, allowing easy access to dens in winter.

In the more rocky habitat around Boxer Bay the location, arrangement, and extent of each den site depends on the position of large boulders. This situation resembles that found on the Commander Islands by Barabash-Nikiforov (1933).

The influence that territorialism has in determining the density of occupied dens and the home range of foxes is not known, but it may well be an important factor. One instance of territorial behavior was observed in mid-June on the plateau. This involved one fox sporadically chasing another for a distance of about 200 m along the plateau rim. Both foxes vocalized frequently during the 10-minute chase. Bédard (1967) noted that the periphery of the Kongkok basin, a large cirque located several kilometers west of Boxer Bay, was divided among five or six foxes, and he observed territorial clashes among them.

The caches found during the present study indicate that the foxes inhabiting lowland areas may take advantage of a temporary increase in the vulnerability of microtine rodents due to loss of snow cover and concurrent flooding of burrows during the spring thaw. The fact that these caches were located well away from the more extensive dens where pups were found may indicate that they were deliberately established where pups could not interfere with them.

Though no caches were found in the Boxer Bay study area, Mr. Charles Slwooko, an elderly resident of the island, reported that he and other men had found caches of "little auklets and other birds" in this area in previous years. Considering the overwhelming abundance of alcids, it seems that gathering a surplus of these birds would be quite easy for the foxes.

There is evidence indicating that the foxes on the island depend on prey cached in the summer months for part of their winter diet. The scarcity of prey species in the winter months is as striking as the abundance in summer. Except for a few ravens, terrestrial birds are absent from the island in winter, though maritime birds, primarily old-squaw and eider ducks, are found offshore in considerable numbers. Ground squirrels, of course, hibernate during the winter and other small mammals are largely unavailable because of snow cover. Nevertheless, the stomachs of a considerable number of foxes trapped in winter contained remains of birds that do not winter in this region as well as an abundance of small mammals of limited availability

(Fay, unpublished data). Further research is needed to adequately describe the caching activities of the foxes on St. Lawrence Island. Though evidence is in most cases fragmentary, there seems to be a consensus among investigators that have worked in other regions that the arctic fox often caches various food items in summer when food is most plentiful (Fielden, 1877; Beddard, 1902; Osgood et al., 1913; Gibson, 1922; Seton, 1929; Freuchen, 1935; Dubrovskii, 1937; Braestrup, 1941; Soper, 1944; Tuck, 1960; and Barry, 1967).

The frequency of occurrence of small mammal remains in scats collected on the plateau in summer indicates that these animals are the predominant item in the diet of foxes inhabiting the island's vast areas of tundra. Similar results have been obtained in comparable habitats by Braestrup (1941), Elton (1942), Mineyev (1946), Pitelka et al. (1955), Macpherson (1969), and Chesemore (1967). From his observations on St. Lawrence Island, Rausch (1958) stated that voles are an important food resource for young foxes while in the den. This view is substantiated by the results from the plateau and Boxer River valley study areas. The litters reared in dens near the cliffs, however, were dependent primarily on alcids for food.

The frequencies of occurrence of the three microtine rodents, the tundra shrew, and the ground squirrel correspond in a general way to the relative population levels of these species. However, as Englund (1965) has suggested, differences in catchability may exist among the species and the fox may show a preference for certain species. The tundra voles habit of living mainly in the open tundra may render it more vulnerable than, for instance, the red-backed vole which is found in rocky habitats. From studies done on the food habits of the red fox, Errington (1935), Scott (1943), Scott and Klimstra (1955), Lockie (1957), and Lund (1962) have suggested that this species has a preference for *Microtus* over other small mammals. The extremely low occurrence of tundra shrews in scats may also be influenced by the predilection of the foxes for voles. Scott and Klimstra (1955) and Lund (1962) have shown that insectivores are killed but often left uneaten by the red fox.

Of the avian remains identified in scats from the plateau, members of the Order Anseriformes were represented most frequently. The food remains indicated that the principal species involved were the oldsquaw, common eider, and emperor goose. The condition of some of the remains of the latter species indicated that these individuals were molting, and hence flightless, when captured. Residents of the island reported other cases of foxes preying on molting geese and it is likely that a major portion of the geese taken by foxes are in this condition. Mineyev (1946) describes a similar situation on Wrangel Island.

The arctic fox has been shown to be a highly efficient predator on the eggs and young of waterfowl (Lewis, 1923 and 1942; Kenyon, 1961; Ryder, 1967; Barry, 1967). In a study of waterfowl nesting on the Anderson River Delta, Northwest Territories, Barry (1967) found that species larger than Pacific brant (Branta bernicla nigricans) were capable of driving foxes away from nests while brant and smaller birds could not do so effectively and thus required island habitat for successful nesting. Barry regularly observed a pair of whistling swans harassing nearby foxes. It appears that this general principle is operative on St. Lawrence Island as well since nesting eiders and smaller waterfowl favor island locations while larger birds, notably the whistling swan and sandhill crane, nest on the inland tundra. On the plateau study area nests of the latter two species were found within a few hundred meters of occupied fox dens.

The occurrence of passerines and shorebirds in scats and remains was relatively low in all of the habitats studied. Though the fox is capable of capturing these birds (Jones, viva voce) and they are abundant, it appears that other prey are more easily obtained and the foxes capture small birds only occasionally.

It is probable that the alcids identified in the bird remains collected on the plateau were picked up as carrion on the beach. Murres and other cliff nesting birds are often killed by falling rocks and there is sometimes considerable mortality among young alcids, especially when they are leaving the nesting colonies in large numbers during late summer and fall (Bédard, 1967). The carcasses of these birds may wash ashore at distant beaches. Thus, each alcid nesting colony in the arctic is, directly or indirectly, important to foxes as Tuck (1960) has suggested.

Descriptions of the arctic fox's predatory habits in alcid nesting areas are common in the literature but vary widely with the species of alcid and the type of nesting habitat involved. In general, the arctic fox has been shown to be the primary factor governing the nest location of seabirds (Turner, 1886; Nelson, 1887; Manniche, 1912; Kirpichnikov, 1937; Bertram and Lack, 1938; Braestrup, 1941; McEwen, 1958; Fay and Cade, 1959; Tuck, 1960). Alcids nesting under rock-piles thus require interstices of a size permitting their entry while offering protection against foxes and other predators. In like manner, puffins and guillemots utilize burrows or crevices and the murres, cormorants, and larids are restricted to the most precipitous cliffs due to their habit of nesting above ground.

Though the vulnerability of the various nesting seabirds needs to be more fully documented, some general statements can be made concerning this aspect with relation to the Boxer Bay study area. Bédard (1967) has described the ecological relationships of the three species of auklets found on the island. The majority of nesting least and crested auklets are concentrated in a few well-defined colonies whereas parakeet auklets are more widely distributed along the cliffs but occur at lower densities than the least and crested auklets. The latter two species, and especially the crested auklet, were present in considerable numbers west of Boxer Bay even though the study area did not encompass any of the major nesting areas. A few crested auklets were seen east of Boxer Bay but least auklets were rare. Parakeet auklets were abundant on the eastern cliffs but only moderately so on the cliffs to the west of Boxer Bay.

The least and crested auklets are undoubtedly the most vulnerable of the cliff nesting birds. The vulnerability of the former species, however, is not reflected in the food remains. The presence of entire wings of the least auklet in some scats indicates that due to its small size, the entire carcass of this species may be consumed by the fox. From his observations of food remains in the large auklet colonies on the island, Bédard (1967) concluded that the crested auklet is the main object of fox predation in these areas. This view is supported by the results of my study. In terms of numbers and probably in terms of biomass, the crested auklet sustains a higher level of predation than any other cliff nesting bird.

The characteristically precipitous habitat of the parakeet auklet would appear to render it much less susceptible to predation than the other auklets. Nevertheless, the food remains indicate that this bird is taken in considerable numbers. The overwhelming preponderance of parakeet auklet remains at den 23 could be attributed in part to a highly efficient method of capturing these birds used by the foxes inhabiting the site or perhaps to a predominance of this species in the hunting territory of these foxes.

The horned puffin and tufted puffins are less vulnerable to predation than the auklets due to their comparatively inaccessible nest sites and also to their different behavioral characteristics. In general, these species occupy more precipitous cliffs and seem more alert to intruders. The number of puffins represented in the food remains reflects their lesser vulnerability. The reason for the greater number of horned puffins versus the number of tufted puffins in the remains is not known.

The cliff-nesting birds most inaccessible to the foxes are undoubtedly the murres, cormorants, and larids. Despite the fox's tremendous agility, it would be difficult indeed for them to capture these birds on the sheer escarpments where these species typically nest. Though some adults and young are eaten by the foxes, many of these probably die from other causes such as rock-falls or are fallen nestlings that have been picked up on the rocks below.

The comparison of data from the dens east of Boxer Bay with that from dens west of this bay revealed that the character of the uplands adjacent to cliffs has a significant influence on the diet of foxes inhabiting areas near the alcid nesting colonies. The proximity of wet and mesic tundra east of the bay and the resultant greater availability of small mammals was reflected by the significantly greater occurrence of small mammal remains in scats collected here as compared to those collected to the west where the inland areas are predominantly rocky barrens. The nature of the cliffs themselves also influences the occurrence of food items in the diet. The significantly lower occurrence of egg shells in scats collected east of Boxer Bay is probably due to the smaller number of auklet nests on the area and to the more inaccessible nature of the seabird nests that are present.

In spite of the almost total dependence on alcid populations for summer food by foxes denning near the nesting colonies, predation is probably nowhere significant in terms of the proportion of the alcid population affected. The number of birds taken probably varies with the relative population levels of alcids and foxes. Higher alcid populations would probably cause a greater number of relatively accessible nest sites to be used.

Shibanoff (1951) noted that the greater the abundance of food, the more restricted is the daily range of the arctic fox. Thus, it is significant that the tremendous avian biomass found on the cliffs was used only lightly by foxes denning in the nearby Boxer River valley. The data indicate, rather, that the foxes in this valley relied almost entirely on small mammals, especially the tundra vole, as their summer food resource. Though the prey community of the tundra was not as spectacular, in terms of apparent activity, as the prey community of the sea cliffs, it was of sufficient availability to support a summer fox population comparable in density to that found along the cliffs.

The remains of various species of fish and marine invertebrates have been noted in the diet of island foxes and in some instances are used extensively (Lavrov, 1932; Barabash-Nikiforov, 1941; Braestrup, 1941). Jones (viva voce) reports that marine invertebrates, particularly amphipods, are an essential component of the diet on some of the Aleutian Islands. The above items occur only rarely, however, in the summer diet on St. Lawrence Island. Insects occurred at a similarly low frequency. Vegetation, soil, and fox hair were considered to be items ingested incidental to feeding activities and occurred only in trace amounts. Similar occurrences have been noted by numerous other workers.

Beach carrion appears to be a minor item in the summer diet. Carcasses of marine mammals were present on the beach during the summer but remains of these food resources were found in only a few scats. Further, little fox activity or "sign" was observed along the beach and there was no evidence of foxes feeding on carcasses of seal, sea lion, or walrus. Apparently, the summer availability of small mammals and birds is such that foxes are not required to utilize carrion at this time. Trappers on the island report that the meat of marine mammals that is set out as bait in the fall attracts foxes during and after November but not before, and Schiller (1954) found abundant evidence of foxes feeding on a number of dead walruses along the northeast coast of the island in winter. Thus, carrion is probably an important food resource only in mid-to-late winter.

The data indicate that, in general, the summer diet of arctic foxes on St. Lawrence Island clearly reflects regional differences in the composition of the prey population. Foxes living along the cliffs feed mainly on alcids while tundra foxes feed mainly on voles. The arctic fox has often been described as an "opportunistic" predator and scavenger (Mineyev, 1946; Braestrup, 1941; Chesemore, 1967) and this term may well apply to the winter food habits of the foxes on St. Lawrence Island. Though the summer diet does indicate a strong response to availability, the foxes are not entirely opportunistic in their food habits during this season of food abundance. The results of my study indicate that during the summer of 1968, the foxes relied almost entirely on recently captured prey despite a plentiful supply of marine mammal carrion. Further, the abundant passerines and shorebirds were little utilized and the tundra shrew was nearly absent from the diet, indicating that the fox expends little hunting effort on these items when other, larger prey are available. The fact that the foxes can afford the luxury of predilection suggests that the summer food supply on the island is more than adequate for the population of foxes.

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