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BREEDING BIOLOGY AND FEEDING HABITS OF SEABIRDS OF SITKALIDAK STRAIT, 1977-1978

by

Patricia A. Baird

and

Martha A. Hatch

U.S. Fish and Wildlife Service
Biological Services Program
1011 E. Tudor Road
Anchorage, Alaska 99503

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Abstract

We studied the breeding biology and food habits of tufted puffins, black-legged kittiwakes, glaucous-winged gulls, arctic and Aleutian terns during the 1977 and 1978 breeding seasons at inner east Sitkalidak Strait. We censused the entire area, including Kiliuda Bay both years.

Breeding chronology for all bird species was essentially the same for 1977 and 1978. The number of breeding kittiwakes, gulls and terns of both species declined in 1978 whereas the number of breeding tufted puffins remained rather constant. Likewise productivity at all stages of breeding: number of eggs laid, number of chicks hatched, number of chicks fledged and chicks fledged per nest attempt declined for all of the above surface and cliff nesters, but not for the tufted puffins. The decline in reproductive output in 1978 was due to a number of factors: fewer breeding birds, fewer eggs laid to begin with, increased predation of eggs and chicks by mew and glaucous-winged gulls, ravens, northwest crows and bald eagles, and perhaps a change in the prey base.

The prey base for all of the species we studied changed radically from 1977 to 1978. In 1977, capelin, Mallotus villosus, was by far the most important prey with respect to numbers and frequency of occurrence. In 1978 capelin was replaced by sandlance, Ammodytes hexapterus as the most important prey and was found in significantly fewer numbers and in significantly fewer of the regurgitations and bill loads of the birds than it was in 1977. This decline of capelin in 1978 may have somehow influenced the decrease in numbers of breeding birds and also their lowered reproductive success.

INTRODUCTION

The purpose of the OCSEAP studies was to define the role of seabirds in the Alaskan marine environment and to identify and evaluate potential impacts to the seabirds from the development of the petroleum reserves on the Alaska Outer Continental Shelf.

The studies in and around Kodiak Island are part of an integrated program to assess the entire ecosystem in the area in anticipation of drilling in lease areas. The program is interdisciplinary and involves biology, geology, chemistry and physical oceanography. These integrated studies were first initiated in 1978 in order to fill in data gaps in our knowledge about the ecosystem in the Kodiak area.

The USFWS has identified 251 seabird colonies in and around Kodiak Island (Bartonek et al., RU 337) and about 130 bird species that are present in the coastal areas of Kodiak. The USFWS has information on the abundance and distribution of seabirds from the pelagic studies we have been conducting off Kodiak from 1976-1978 (RU 337). Sitkalidak Strait with its important colonies on Cathedral Island and the adjacent Boulder Bay was identified as a key site to study.

STUDY AREA

Sitkalidak Strait separates Kodiak and Sitkalidak Islands in the western Gulf of Alaska (Figures 1, 2). It varies in width from about 0.5 km at its center, Sitkalidak Passage, to about 5 km at its eastern and western midpoints and 14.5 km at its eastern and western entrances. The inner part of the strait is fairly shallow (2.5-18.5 m) but near Cathedral Island and Barling Bay the depth increases to about 130 m. Surface water temperatures range from about 6°C in May to near 12°C in August. Summer weather is generally wet and mild. Air temperatures during our 1978 studies ranged from a minimum of 0°C to a maximum of 28°C with highest temperatures occuring in August (Figure 26). Over 711 mm of rain fell between 13 May and 7 August, 1978 averaging about 6.4 mm per day with only about 28 percent of the days being rain free (Figure 27). The biggest storm occurred on 23-24 May when 79 mm of rain fell in a 48 hour period. Winds, generally between 8 and 32 km/hr, were usually from the southeast, northwest and southwest with the former predominating in early summer and the latter occurring mostly in late summer (Figure 28). Numerous bays, fjords and small islands occur within this area and 1,500 mountains surround the strait. These mountains provide shelter from the open ocean to the south. The dominant breeding seabird species in the strait are tufted puffin, black-legged kittiwake, glaucous-winged gull and arctic and Aleutian terns.

Our base camp was located at Cozy Cove (Figure 3) and we concentrated our 1977 and 1978 studies in the inner two-thirds of the eastern arm of Sitkalidak Strait. The islands where our 1977-78 studies were conducted ranged from flat, grassy Sheep Island to the fairly steep, mixed meadow-umbel covered Cathedral Island. All of the islands in this area are easily accessible and the colonies are quite workable. There is some interference by the natives of Old Harbor, 6 mm east of our base camp, not only with their traditional egging of tern and gull nests but also with their use of the islands as recreation areas. The villagers, however, are very interested in the wildlife around Old Harbor, and have a progressive outlook of preserving the area and keeping development at a minimum.

MATERIALS AND METHODS

In 1978 we adhered to most of the methods we used in 1977, culling those which we found to be less important or meaningful, and adding some new ones to answer questions formulated as a result of last year's analysis.

The main thrusts of our investigations in 1978 were to determine: 1) chronology, 2) reproductive success and 3) growth of chicks for black-legged kittiwakes, tufted puffins, and gluacous-winged gulls, and to compare these results with those we found in 1977. We also conducted censuses of all colonies in the immediate study area with less extensive surveys of colonies in adjacent bays and fjords. These latter surveys helped us determine the abundance and distribution of breeding birds in the entire Sitkalidak Strait area. Before our intensive surveys in 1977 and 1978, the only other information we had were brief flyovers by Lensink and Berns (Lensink 1957, Berns 1972) and a survey by boat in 1976 (Sanger et al., 1976).

In conjuntion with our colony-based studies we investigated habitat preferences of all major species for possible correlation of selected habitat parameters with reporductive success. We also gathered feeding data concurrently with our growth studies of the chicks by collecting their regurgitations or their parents' bill loads.

Monthly we conducted a beached-bird survey at Ocean Bay on the ocean side of Sitkalidak Island and at the landing beach on Amee Island (Figure 4).

We also made monthly seawatches at Lagoon Point in Sitkalidak Strait (Figure 3). The purpose of these was to detect possible regular diurnal movements of birds away from and to nearby colony. These data have not yet been analyzed but will be presented in our final report.

We took daily measurements of maximum and minimum tempreatures, precipitation and wind. Incidentally we noted the abundance and distribution of marine mammals and other birds. These notes appear in the species account.

TUFTED PUFFINS

We studied mainly the puffins on Cathedral Island which was by far the most important tufted puffin colony in the inner east Sitkalidak Strait area. We also studied two plots on Amee Island which were chosen as a comparison for reproductive success in less preferred habitat.

We chose all study plots to give equal representation to the different kinds of tufted puffin habitat on Cathedral and Amee Islands, including different slopes, exposures and burrow densities. Table 1 explains the way in which we set up our study plots. In 1978 we studied seven of the nine total puffin plots from 1977. We also set up four new plots (Figure 5). Of the eleven plots studied, three were used for monitoring chick growth, seven were used for habitat analysis, two were used as controls for disturbance during the egg stage and five were used for monitoring reproductive success without disturbance from measuring the chicks. All nests were used for information about chronology. The plots that we did not disturb during the egg stage we called "undisturbed plots" and the burrows in them we only dug up near time of fledging to discover the number of chicks produced per plot. All other burrows we excavated by making window-holes with tufted grass and earth plugs over the nest chamber in order to check for presence of eggs and chicks. It was through these windows that we removed the chicks for the growth studies.

We checked the burrows on "disturbed plots" every three days prior to egg laying. As soon as we discovered an egg in a nest chamber, we did not disturb that burrow again until forty days later--a few days less than the incubation period of tufted puffins. If we found a chick at this point in time, unless the plot was a growth plot, we did not disturb the burrow again until approximately forty days from that date--a time period just less than the normal fledging period. The first time we discovered a chick in the productivity or growth plots we weighed and measured it. We monitored the growth plots every three days, taking the following measurements on all chicks present: weight, lengths of diagonal tarsus, exposed culmen, and wing cord. We weighed the chicks in plastic bags hung from Pesola scales. Near fledging we banded the chicks with green color bands and Fish and Wildlife bands.

At the outset of the study we attempted to use a method others have used in the past to check for burrow occupancy (Wehle 1977, Nysewander 1977). In this method, a fence of toothpicks is placed across the burrow entrance and then checked 24 hours later to see if the toothpicks have been knocked down. Supposedly, the burrows with eggs (or chicks), the nesting burrows, will have the toothpicks knocked down, while those that are inactive will have the toothpicks up. However we found that this method is not valid for determining nesting burrows because many burrows (22%) that had no eggs or chicks in them would have adult puffins using them and they would knock down the toothpicks. The interpretation of the results of the toothpick method is critical. The method should be used to estimate the ratio between burrows entered and burrows with nests, not for estimating the breeding population solely in the number of burrows with toothpicks knocked down.

We took habitat measurements on five of the disturbed plots and both of the undisturbed control plots. Parameters measured were nearest neighbor distance, slope, exposure, burrow depth, and burrow length and slope. The summary of these measurements is in the Addendum.

We collected bill loads that adult tufted puffins were bringing in for the chicks by our method of bill taping (Baird and Moe 1977). We preserved the samples in 10% formalin within an hour after they were collected, and analyzed the specimens months later in the lab, recording species, length, numbers weight, and volume of the prey. For data analysis we used species length, numbers, and frequency of occurrence of prey.

BLACK-LEGGED KITTIWAKES

This year we studied four of the five kittiwake plots that we had set up in 1977 and added one new plot (Figure 6). Three we chose as chronology and growth plots and two were chronology and productivity plots. We used five of the plots for habitat analysis, which will appear in the Addendum.

We chose the plots to obtain a good representation of sizes of colonies, their height above water, exposures, and slopes. We disturbed the productivity plots as little as possible , checking them every three days for number of nests, number of eggs and number of chicks. To check the plots with as little disturbance as possible we had to climb above the colony and look down over the cliff to determine presence of nests, eggs, and chicks. We initially marked individual nests with numbered tongue depressors so that we could relocate them. We reached the growth plots by climbing ropes and checked these plots once every three days. We obtained the habitat parameters for all nests on five of the six plots during the first week in September when most of the chicks had fledged. These observations were taken with the aid again of climbing ropes.

In mid-July we conducted a kittwake census of the entire inner Sitkalidak Strait area, counting every occupied nest and every chick. Two counts by two people were always made for each area censused and these counts usually yielded the same number or were within 5% of each other. If the numbers differed we used the avarage of the two after a second count was made.

On the growth plots we numbered the eggs with red or blue china marker and as soon as the chicks hatched we fitted them with numbered plastic color bands. We weighed chicks every three days using Pesola scales and measured their exposed culmen, diagonal tarsus, and wing cord. On all plots, when the chicks neared fledging, we weighed, measured, and banded them with Fish and Wildlife bands and color bands if they had not previously been banded.

The parameters of the habitat that we measured the first week of September were: height above water, nearest neighbor distance, exposure, slope, ledge width, presence and amount of overhang, presence of adjacent ledge and overhang of adjacent ledge. A summary of these is in the Addendum.

Concurrently with the growth measurements we collected feeding data opportunistically. In our disturbance of the kittwake chicks for growth they would often regurgitate their stomach contents. Immediately we would place this regurgitation in a plastic bag and label it and within four hours we added 10% formalin. We performed the analysis of these regurgitations months later in the lab and recorded the same information on these food samples as we did for the tufted puffins: species, number, weight, length and volume. For analysis, we used length, frequency of occurrence, and percent numbers of prey. Volume is an inadequate measure for soft prey such as fish because of rapid digestion of the tissue. Two birds could eat exactly the same number and kind and length of a certain fish species but due to different amounts of time that the prey remained in the stomach, the volumes could be radically different from each other, depending on when that regurgitation was collected. Thus volume measurements tend to give meaningless if not erroneous results and we did not use this measurement and do not recommend it for food analysis of piscivorous species.

GLAUCOUS-WINGED GULLS

We repeated the same sampling scheme for glaucous-winged gulls that we used last year. We constructed our plots to sample colony types (solitary and grouped). We further divided the solitary-type plots into vertical plots relatively inaccessible to humans and horizontal easily accessible plots in order to test for human disturbance of the nesting gulls. Both of the colonial plots were rather inaccessible, one being on a precipitous sea rock, Lesser Kittiwake Rock, and the other on a sea stack, Amee Rock, reachable only by climbing ropes (figure 7). All plots were the same ones as last year, plus we had six "opportunistic" nests that were at the tops of the kittiwake plots, and we also monitored these.

We used all plots for chronology, habitat analysis, growth and reproductive success. Human disturbance does not seem to be a problem with gulls once the chicks are hatched, so we combined growth and productivity plots due to the low sample sizes.

One of the questions we wanted to answer was if there was a noticeable difference in chronology between the two main kinds of gull colonies: truly colonial and solitary. If there were a difference then it would perhaps indicate a preference in type of nesting situation. In order to determine if there were differences in habitat we measured slope, exposure of, and vegetation height and cover around the nest, and also the nearest neighbor distance.

The plots we chose represented a variety of slopes, exposures and habitat types, and we feel that they were a good sample of the available habitat occupied by the breeding gulls.

We checked the solitary plots and one colonial plot once every three days, and the colonial plot on Amee Rock approximately once every week, depending on weather. We had to ascend this sea stack with a rope and at times the weather was too stormy for a safe ascent.

We numbered every egg with a china marker and when chicks hatched we banded them with numbered color bands. We used the same techniques for weighing and measuring gull chicks as we did for the other species. We also collected regurgitations opportunistically. Just before fledging we banded the chicks with U.S. Fish and Wildlife bands.

We conducted a census of the gulls during their late incubation stage. At this time they are conspicuous and easy to count at the nest site, so we feel our count is fairly accurate. If only one member of the pair were present we counted it as two birds to derive our estimates. Because the count was during incubation we assumed that at least one of the pair of all breeding adults would be on the nest at this time.

RESULTS

TUFTED PUFFINS

Distribution and Abundance

In the entire Sitkalidak Strait area, there are two major tufted puffin colonies, Puffin and Cathedral Islands, with minor colonies on the three islands in Kiliuda Bay and on Amee Island.

We censused the inner east Sitkalidak Strait area by boat on 12 July 1978 and Kiliuda Bay on 22 May 1978, counting birds and also estimating numbers of "nesting burrows" by extrapolation from the densities of our flagged plots (Tables 2,3). We detected no new colonies in this census or in any of our trips in and around the Sitkalidak Strait area.

The tufted puffin population of inner-east Sitkaldiak Strait remained stable from 1977 to 1978, and the tufted puffins occupied the same geographical areas in 1978 as they had in 1977 (Figure 8). The numbers of birds seen during our boat survey, as in 1977, was approximately half that of the estimated number of nesting burrows, probably because one of each pair was at the burrow during our count.

Phenology

When we arrived at Sitkalidak Strait on 8 May the tufted puffins had already established territories and were occupying burrows. They were also in the midst of their pre-egg laying attendance cycles with approximately two days of absence and one day of colony occupation. The first eggs were laid on 27 May, with 59% being laid by 5 June (Figure 9). This is slightly ahead of 1977 when 23% were laid by this date. The four eggs laid between 22 June and 4 July may represent second clutches.

Chicks began to hatch on 8 July, peaking 16-18 July, indicating an incubation period of about 42 days which is similar to what others have found (Baird and Moe 1977, Nysewander 1977, Wehle 1976, 1977). The last chicks hatched on 1 August. Fledging began on 21 August and peaked the 25th of August, yielding a nesting period of about 44 days, corresponding to nesting periods from other studies (Ibid.). Of 32 chicks studied, only two had not fledged by the time we left on 7 September.

Productivity

The productivity of tufted puffins in 1978 was similar to that in 1977 (Table 4). In 1977, for the disturbed plots, 72.0% of all the burrows entered at least once had eggs and in 1978, 67.0% had eggs ($p>0.4$*) The hatching success, or chicks hatched per egg laid, was 61.2% in 1977 and 52.2% in 1978 ($p>0.1$). Fledging success, or chicks fledged per chick hatched was 87.8% and 88.9% in 1977 and 1978 respectively ($p>0.5$). The chicks fledged per burrow with eggs was 0.537 and 0.464 ($p>0.2$) and the number of chicks fledged for all burrows entered at least once was 0.38 and 0.31 ($p>0.1$) respectively. Thus, for each stage in the reproductive cycle, the percent success was very similar between years.

The undisturbed plots also were similar in their productivity between years, in the number of chicks fledged per burrow entered at least once (Table 5). There was a radical difference in number of chicks fledging from disturbed and undisturbed plots (Table 6). Significantly more chicks fledged from the undisturbed plots than from the disturbed. This does not, however, invalidate our estimate of productivity because they must be disturbed in order to study them and this disturbance probably affects them in the same ways from year to year.

* Statistical analysis is based on the equality of two percentages or t-tests with a $p<0.05$ showing a significant difference between years.

Mortality

The proportion of eggs and chicks lost in 1977 and 1978 was similar: 46.7% in 1977 and 49.3% in 1978. Likewise the proportions of mortality in the egg and chick stages were similar (Table 7). However the kinds of mortality differed somewhat between the two years. The greatest mortality in 1977 was simply disappearence of the egg, 19.4% while in 1978 it was abandonment of the egg, 27.5%. Disappearance of the egg in 1977 however may simply reflect abandonment. Few of the eggs (1.5%) in 1978 were infertile, while in 1977 there were many, (9.0%). Total chick mortality was similar for both years: 42.0% in 1978 and 37.3% in 1977. All the chick mortality in 1978 is probably related to inattentiveness by the adult. The disappearance of a chick is most likely due to the parent's not bringing food to the burrow. A hungry chick of any age will, at some level of hunger, leave the burrow. The fate of the chicks that disappeared is unknown but we assume they all died once they left the burrow, unless they were almost ready to fledge.

Because the number of chicks fledged from undisturbed plots was significantly greater than from disturbed, we assumed that human disturbance in the areas where puffins nest is very detrimental to their reproductive success. However, in the disturbed plots, the actual touching of an adult in the burrow while we were checking for eggs did not seem to effect abandonment of the egg. In the disturbed plots we chose three categories to compare the effect of physical contact with a tufted puffin adult or checking of the burrow with the adult still inside it (we call this "disturbed"): burrows disturbed and subsequently abandoned, burrows abandoned but not disturbed, and burrows disturbed but not subsequently abandoned. A chi-square test among these categories revealed no difference, so we can say that the disturbance of a particular burrow does not always result in abandonment--that it probably depends on the individual puffin and also on the stage of incubation (Table 8). However more important, with respect to development of this area, the constant disturbance or perhaps simply presence of humans at the breeding colonies of tufted puffins drastically reduces their reproductive success.

Trophics

Table 9 shows the prey types that tufted puffins took in 1977 and 1978 and includes the percent numbers, frequency of occurrence, and lengths. At this time we do not have prey lengths for the prey that tufted puffins brought their chicks in 1977. The types of prey items taken in both years differed somewhat qualitatively and the frequency in which they were taken was similar except for the two major fish species, capelin and sandlance. Chi-square tests between years respect to percent numbers of prey taken and also to frequency of occurrence of all prey yielded no significant differences between all of the species. However a percentage test between capelin and between sandlance of both years did yield a significant difference in percent numbers for both species and for frequency of occurrence for capelin (Tables 11 and 12). Capelin (Mallotus villosus) and sandlance (Ammodytes hexapterus), the two most important food items for all seabirds in the Kodiak area, occurred in different proportions for 1977 and 1978. In 1977 capelin and sandlance made up 64.9% and 25.8% of the total numbers and occurred in 75.0% and 37.5% of the bill loads respectively. In 1978, capelin and sandlance made up 36.9% and 49.6% of the total numbers and occurred in 34.6% and 46.2% of the bill loads. Thus, if all species are compared together, the similarity of species other than sandlance and capelin override any differences between these two species in the two years. Yet there does seem to be a real difference in numbers and frequency of occurrence. The mean lengths of all food taken by tufted puffins was 94.79 ± 1.97 mm in 1978.

Likewise, diversity, H', of the prey base was similar and the species evenness, J', or the frequency in which they took each prey species was approximately the same for both years (Table 10).

We aged chicks from known dates of hatching and then constructed the growth curves of the chicks using these actual ages and their corresponding weights. The purpose of constructing growth curves is to find the average growth of the chicks in a supposedly stable environment against which other years may be compared. Growth therefore for these purposes is typically defined as weight gained and no wing growth over a certain time period because wing growth is less influenced by environmental changes than is weight.

Figure 10 shows the data points of all the chicks we studied with the best fitting polynomial regression curve drawn through them. Growth is typically sigmoid with a thrid order polynomial best describing the growth pattern (r^2=0.9487 in 1977 and r^2=0.9086 in 1978). Figure 11 compares the ploynomial regression curves between 1977 and 1978. The slopes are almost identical, and the absolute values of the curves are very similar. From this we can say that the growth of tufted puffin chicks was similar in 1977 and 1978.

BLACK-LEGGED KITTIWAKES

Distribution and Abundance

We censused all the kittiwake colonies in east inner Sitkalidak Strait in August, when presence of chicks would be obvious. The number of pairs of kittiwakes found on this census was similar to that of 1977 (Tables 2,3, and Figure 12), except for an increase of about 124 breeding pairs on Ghost Rocks in 1978. Likewise the kittiwakes occupied the same colonies in 1978 as they did in 1977, with the exception of the marginal colony on Amee Rock which they did not use in 1978. We censused the colonies in Kiliuda Bay in May and found similar numbers as Douglas Forsell had found there in 1977 (personal communication).

We also censused the large colony of kittwakes in Boulder Bay, once in June and once in August. The difference in numbers of breeding pairs present in June between years at the Boulder Bay colony was great, with 25,000 pairs in 1977 and 3,500 pairs in 1978. By August 1978 there were only 1,500 pairs remaining at the Boulder Bay colony. The reasons for this drastic decrease in numbers in 1978 are not apparent at this time, but the decrease reflects the overall poor productivity that kittiwakes had in 1978.

Phenology

Upon our arrival the first week in May, we found the kittiwakes already occupying nest sites on the cliffs. The total number of occupied nests reached a peak around the 12th of June and then declined drastically between 1-20 July (Figure 13). The greatest loss of nests occurred the first 2 weeks in July. We defined nest loss as complete disappearance of the nest from the cliff and also disappearance of a major portion of the nest due to non-maintenance and repair. Thus, kittiwakes could still be occupying a nest site but not be considered a breeding pair due to an inadequate nest.

Kittiwakes initiated most of their clutches from 12 June - 17 July with one started 3 August. The commencement of clutch initiation was similar to that of 1977 when the first eggs were laid on 14-17 June. The peak of laying occurred between 22 June and 3 July with the greatest number of eggs present on the colonies on 30 June (Figures 14, 15). There was a peak of egg mortality immediately after the first eggs were laid between 20 June and 7 July. After this, second clutches were initiated by 42.3% of the kittiwakes (Figure 16).

The first chicks hatched between 14 and 19 July, yielding an incubation period of about 27-31 days which agrees with what others have found (Nysewander 1977, Jones and Peterson 1978). The first chicks fledged on 18 August with the peak occurring the first week in September. This gives a brooding period of approximately 30 days which is similar to the brooding times found by others (Ibid).

Of all chicks still living by the time we left on 7 September, 19.0% had not yet fledged. These chicks were all from one plot and they were all from second clutches. The rapid decline in number of chicks present on the colonies (Figure 13) was due mainly to predation by gulls, not to fledging.

Productivity

The productivity of black-legged kittiwakes in 1978 was minimal and drastically reduced from that of 1977 (Table 14). Clutch size ($\bar{x}$ = 1.26) was significantly decreased from last year ($\bar{x}$ = 1.68) with only 14.1% of the nests with 2-egg clutches this year, compared with 55.2% in 1977 ($p<0.05$) (Table 13). The number of nests with eggs per all nests built was also lower in 1978: 53.7% versus 83.8% in 1977 ($p<0.001$). The number of chicks hatched per egg laid was likewise significantly lower in 1978 than in 1977: 35.9% and 74.2% ($p<0.001$), with the mean brood size at hatching also lower: 1.25 and 1.57 respectively ($p<0.0001$). The similarity of clutch size and brood size at hatching indicates that the one and two-egg clutches were preyed on equally. Clutch size thus may have no effect on egg loss. The number of chicks fledged per chick hatched (fledging success) was also low compared to 1977: 52.6% versus 76.5 ($p<0.05$). The mean brood size at fledging was significantly different between the two years: 1.15 and 1.34. The young fledged per nest with eggs differed radically between the two years with 0.89 fledging in 1977 and only 0.31 in 1978 ($p<0.05$), as did the young fledged per nest attempt 0.74 in 1977 and 0.17 in 1978), (both $p<0.001$).

Mortality

The combined mortality of eggs and chicks of black-legged kittiwakes was significantly higher in 1978 than in 1977 (Table 13, $p<0.05$) but of this the percentage of chicks dying was approximately the same for both years while the number of eggs dying was much higher in 1978 (62.7%) than in 1977 (30.9%). The majority of the egg deaths (88.5%), and all chick deaths in 1978 were presumably from predation. We assumed that disappearance of an egg or chick was due to predation.

Most of the predation was by glaucous-winged gulls with additional predation by crows and ravens. The chicks they ate were sometimes quite old—over four weeks, almost ready to fledge. In 1977, predation of eggs and chicks accounted for only 58.9% of all mortality while in 1978 it accounted for 90.6%.

* a p value less than 0.05 means there was no significant difference between years, and is derived from either a t-test or a difference in percentages test.

In 1978 the greatest mortality (64.1%) took place the last two weeks of June (Figure 16). This was immediately after the first eggs were laid. The time of the next highest peak of mortality was the week before and the week of the first fledglings when there was 17.6% mortality.

Trophics

The differences between the food base for kittiwakes in 1977 and 1978 is evident in Table 16. In 1977, sandlance, Ammodytes hexapterus and capelin, Mallotus villosus occurred in 50.0% and 59.3% respectively of the regurgitations and together made up 85.5% of the total numbers of all food items ingested. In 1978, Ammodytes and Mallotus respectively were in 75.9% and 6.9% of all the regurgitations. Together they made up 79.3% of the total number of food items ingested and of these numbers, Ammodytes comprised 90.5%. Contingency chi-square tests between the two years with respect to percent numbers and frequency of occurrence yielded significant differences ($p<0.0001$. $X^2 = 22.4332$ and $p<0.0180$, $X^2 = 10.0691$ respectively Tables 11 and 12). The mean lengths of the food items kittiwakes preyed on in 1978 was 103.19 ± 2.79. We do not yet have this information for kittiwakes in 1977.

If 1977 and 1978 are compared with respect to diversity, the kittiwakes were eating a more diverse diet in 1977 ($H' = 0.5509$) than in 1978 (H' 0.3402) and the species eveness was also different, with the kittiwakes in 1977 taking more even proportions of all food items ($J' = 0.7080$) than they did in the inbalanced situation in 1978 ($J' = 0.5651$, Table 17).

In summary, 1978 was a very different year, food-wise for kittiwakes than was 1977. The kinds of food taken changed both qualitatively and quantitavely. The food base was somewhat more diverse in 1977 and the frequency of occurrence and percent numbers of food items taken differed greatly. Kittiwakes relied heavily on Mallotus villosus in 1977, and in 1978 they did not. In fact, this species was almost nonexistent in the regurgitations of the chicks in 1978.

Chick Growth

We aged chicks from known dates of hatching and then constructed the growth curves of the chicks using these actual ages and their corresponding weights (Figure 17), as we had with tufted puffins. The growth of kittiwakes followed the typical sigmoid pattern. When growth from hatching to fledging is compared for both years (Figure 18) it is apparent that there is no difference in growth between the two years. The curves themselves are very similar and are the best fit of polynomials through the paired values of age and weight. The polynomials best describing the growth for both years are third order polynomials with r^2s of 0.936 and 0.954 for 1977 and 1978 respectively.

GLAUCOUS-WINGED GULLS

Distribution and Abundance

The population of breeding adult glaucous winged gulls declined by 49.0% in 1978 (Table 2). In 1977 there were 940 gulls breeding in the area and in 1978 there were 480. Even with the decrease in numbers, they used the same areas as last year in which to nest (Figure 19), but these areas were not as heavily populated as in 1977. The populations around Kiliuda Bay increased somewhat from 1977 (Table 3) but not enough to account for the decline in the gull population in the inner part of Sitkalidak Strait. There were always quite a few non-breeders especially later on in the season when many second and third year gulls were roosting on the beaches and rocks adjacent to the colonies.

Phenology

When we arrived in the Sitkalidak Strait area the 8th of May, the glaucous-winged gulls had already established territories. They were constructing nests but had not yet laid eggs. They initiated the first clutches on 5 June and continued egg laying until 19 July (Figure 20). The peak of total nests was the first week in June as was the peak of total eggs (Figure 21). There was much egg mortality the first two weeks after laying and there were a few renestings but most of the adults whose eggs were preyed on, or whose eggs were otherwise lost, abandoned the nest site. The bimodal graph in Figure 21 reflects the second clutches that some gulls started due to loss of their first clutch.

The first chicks hatched on 3 July with the peak of hatching on 11 July. The greatest number of chicks present on the colony was on 17 July (Figure 22), and the last chicks hatched 4 August. This gives an incubation time of 28 days. Fledging took place from 12 August to 5 September, with two chicks not having fledged by the time we left on 7 September. This yields a brood period of approximately 40 days.

Productivity

At all stages, the productivity was less in 1978 than it was in 1977. There were fewer nests with eggs per nest built, 45.3% (1978) and 64.3% (1977, p 0.001*), fewer chicks hatched per egg laid, 48.0% and 75.4% ($p<0.001$) and fewer chicks fledged per chicks hatched, 74.6% and 89.1% ($p<0.001$), (Table 18).

The mean clutch size of glaucous-winged gulls was 2.2 (Table 18) and only 45.3% of all nests had clutches. The initial and final brood sizes likewise were fairly high 2.1 and 1.9, yet there was only a 48.0% hatching success (chicks hatched/egg laid) and a 74.6% fledging success (chicks fledged/chicks hatched).

We found no difference between colonial and solitary nesting gulls with respect to clutch size ($p>0.16$) brood size ($p>0.07$), or number of fledglings ($p>0.47$). Likewise we found no differneces between the inaccessible and the accessible plots with respect to all phases of productivity, ($p>0.05$.) as we had found in 1977. This may reflect less egging. Perhaps the similarities between these inaccessible and accessible plots this year were in part due to egging not being a mortality factor for eggs.

Mortality

Avian predation at the egg stage was the major cause of reporductive failure in glaucous-winged gulls at Sitkalidak in 1978 (Table 19). Egg and chick mortality were 40.7% and 9.8% respectively. The next highest and only other cause of mortality at the egg stage was exposure 9.8%. In 1977 the number % eggs lost was approximately three times the number of chicks lost while in 1978 that number is approximately 4. Predation by other birds was not very important in 1977 (3.0%).

Most of the mortality, 56.7% occurred from 15-21 June during the peak of the egg stage (Figure 23). Many chicks died while pipping, apparently a very vulnerable time. The next peak of mortailty was 16 between 6 and 12 July.

Trophics

The glaucous-winged gulls, like the black-legged kittiwakes, had a significant change in diet from 1977 to 1978, both qualitatively and quantitatively. In comparing individual prey species in the regurgitations of the chicks, we found a significant difference (p 0.003, X^2 = 29.5841, Table 20) in the frequency of occurrence between 1977 and 1978. The same difference was true for changes in percent numbers ($p=0.0005$, $X^2=40.0354$, Table 8).

The diversity in both years was fairly high, (H' = 0.8877 for 1977 and H' = 0.9166 for 1978, Table 21) which is common for a generalist species like a gull. Species eveness was also fairly high for both years, J' = .7372 in 1977 and 0.7997 in 1978.

From Table 20 it is apparent that in 1978, *Ammodytes hexapterus* was the most important food item for glaucous-winged gulls with respect to numbers and frequency of occurrence in the regurgitations, 46.4% and 24.0% respectively, with *Mallotus villosus* being the next important; 16.4% and 16.0%. The rest of the species are of minor importance in the gulls diet although together they occur in 47.0% of the chicks' regurgitations unlike in other species that are not so much generalists. In 1977, *M. villosus* was the most important with respect to numbers and frequency of occurrence (56.8% and 48.5%), followed by *A. hexapterus* (20.3% and 20.0%) with again, the other species having little importance in the diet. It therefore seems that these two species of fish are the most heavily used food item of glaucous-winged gulls and that if one of them is not taken in great quantities one year, the other will be. These data of course are based only on two years but we believe they reflect an interesting trend in feeding strategies which should be pursued.

Chick Growth

We compared growth rates of chicks by fitting a ploynomial regression line through a set of points of age and weight of chicks as in the tufted puffin and black-legged kittwake data. Again, we found that a sigmoid curve yielded the best fit (r^2 = 0.9569, 1978 and r^2 = 0.9749, 1977, Figure 24). We then compared the growth curves of 1977 and 1978 with respect to slope and shape and found great similarity between the two (r^2 = 0.9749, 1977 Figure 25).

ARTCIC+ALEUTIAN TERNS

Data from 1978 have yet to be analyzed for these two species. However, we feel that their failure on one major breeding colony should be addressed here. In April, shortly before the terns arrived, natives from Old Harbor burned an island which constituted one of the terns' major colonies, Amee Island. The vegetation was 70-80% destroyed on this island. The terns however attempted to nest there, but due to the lack of vegetation, their nests were very conspicuous. Egging of the nests was quite heavy and about 80% of the nests on our plots were abandoned. The ckicks that hatched on our plots were all from second clutches. Their hatching coincided with a series of violent storms in early July and these storms were responsible for killing 82% of the chicks. At this time also there was increased avian predation of the terns. On our plots, 18% of the hatchlings were taken by mew gulls, and there were 0% of fledglings.

Where humans interfere as they did with terns in 1978 on Amee Island, it can mean the failure of an entire colony. If terns are indicative of the true situation caused by human disturbance, and, if this disturbance were to continue for many years, major shifts in the abundance and distribution of seabirds could occur.

DISCUSSION

The breeding season of 1978 at Sitkalidak Strait was quite different from that of 1977. The breeding populations of tufted puffins and black-legged kittiwakes in inner east Sitkalidak Strait did not change in numbers between the 1977 and 1978 seasons, but there was a 49% decrease in glaucous-winged gull breeding populations and a 75.0% decrease in the large kittiwake population at Boulder Bay. The same nesting areas were used by all species except cormorants in both years. Perhaps with an increase in population, other habitats that may be marginal would be used. The breeding chronology seemed to be rather fixed, varying only a few days between years for all species.

The most outstanding differences between the two breeding seasons of 1977 and 1978 were those of reproductive success and those of the prey items taken by all species. Both the kittiwakes and glaucous-winged gulls had drastically reduced reproductive success in 1978 from what they had in 1977 while the reproductive success of tufted puffins was similar for the two years. Another major difference was the proportions in which the frequences and numbers of the two major prey species, capelin and sandlance, changed between 1977 and 1978.

For glaucous-winged gulls and kittiwakes in 1978, the percent of nests with eggs decreased and the clutch sizes were smaller. The number of chicks fledged per breeding pair was much less for both species in 1978 than in 1977, and the number of fledglings per nest attempt was drastically reduced. This compares with no differences between years for tufted puffin productivity. The percent of nesting burrows in 1977 and 1978 was similar as was the number of chicks fledging per breeding pair and per nest attempt.

For kittiwakes and gulls, the decrease in number of eggs hatching and in number of chicks fledging was accentuated by increased avian predation in 1978. This predation was much greater than in 1977, yet predation was not a mortality factor for tufted puffins. Many more adult glaucous-winged gulls and black-legged kittiwakes abandoned their nests and more eggs and chicks were preyed on this year than were last year. Glaucous-winged gulls were the most conspicuous predator, but ravens, northwest crows, mew gulls and immature bald eagles were more highly abundant around the colonies this year and we observed them preying on eggs and chicks. We observed mew gulls taking tern chicks, ravens taking eggs, and we saw signs of eagle predation on adult puffins, glaucous-winged gulls, black-legged kittiwakes and both species of terns. The avain predators are all generalists and opportunists and probably take the easiest and most available prey which is often eggs and chicks of other or their own species. This increased predation pressure may be augmented by decreased nest attentiveness by the prey species in inferior food years. These two factors probably act synergistically in increasing the mortality of the eggs and chicks and together with decreased numbers of nests with eggs and smaller clutch sizes they severely depress the reproductive success.

A great amount of predation of the kittiwakes and gulls took place shortly after or during peak laying between 15 and 28 June, and again, at hatching and shortly thereafter, from 6-26 July. At this time 15.6% of the kittiwake and 30.0% of the gull chicks died. This is mainly due to predation but some of it is from the high winds accompanied by temperatures that plunged into the 30's and low 40's. Instead of directly affecting the chicks, the elements may have affected the amount of food brought to them perhaps either by cooling down the water and thereby suppressing the upward magration of some prey, or by disturbing the water surface so much that the adults had a hard time locating prey. Likewise increased avian predation may in part be due to pressure from lack of an adequate food base.

This year, the arctic and aleutian tern populations were also down from those of 1977. The terns were probably affected in the same ways as were the gulls and kittiwakes with the human disturbance they experienced adding to the decrease in numbers of breeders and in the number of eggs hatched. The burning of one of their nesting islands so soon before their arrival altered the habitat so completely that a nesting failure was almost a foregone conclusion. Even if the nests had not been egged so readily, due to low vegetation cover, we believe that avian predation or exposure would have decimated the chick and egg population just as much. Predation by humans simply speeded up the process which had already been set in motion by the general "failure phenonmenon" that was happening throughout the Sitkalidak Strait area.

Accompanying this reduction in productivity and probably related to it was a radical shift in food habits of the seabirds both qualitatively and quantitatively. The proportions of the frequencies and number of the major prey s species, capelin and sandlance, changed from 1977 to 1978. The most important food item in 1977 was the capelin, Mallotus villosus and the second was the sandlance, Ammodytes hexapterus. In 1978 this order of importance changed. Sandlance and capelin still comprised the majority of the total numbers of prey and occurred in more of the regurgitations than any other food items. However, sandlance became the most important food item with capelin taken in significantly fewer numbers and occurring in significantly fewer regurgitation or bill loads. The shift from capelin to sandlance was much more radical for the glaucous-winged gulls and kittiwakes than for the puffins. Tufted puffins were still able to obtain capelin 36% of the time while gulls and kittiwakes only obtained capelin 16% and 5.3% of the time respectively. Capelin likewise comprised 36.0% of the total food items for puffins and only 16.4% and 6.4% for glaucous-winged gulls and kittiwakes. So despite an overall decrease in available capelin, puffins still managed to obtain a rather large proportion even though it was less than in 1977.

We may speculate on this difference in food between the two years. Capelin have a circadian migration to the surface at night and may also stratify themselves in the water column in part with respect to temperature. However, if the conditions are not right, they may remain at greater depths. Kittiwakes and gulls are surface feeders while puffins are divers. Carscadden (personnal communication) states that the capelin in the nearshore waters are the fish most important to marine birds and in the northwest Atlantic they may be the most important fish fodder in that ecosystem. He continues that in daylight, the schools are stratified from the bottom to midwater but at night the schools break up with individuals dispersing to surface waters (0-40m). Light seems to be the environmental trigger for diurnal migration. Perhaps the difference in light was such this year that the capelin did not make their migration upward or if they did, they may have remained mainly at depths unavailable to the surface-feeders. It is interesting to note that, perhaps following this upward migration of capelin, the kittiwakes did feed at night, while the puffins, who were able to procure capelin at greater depths during the day when the capelin were deep, did not feed at night. This then may be one of the reasons that the percent numbers and frequency of occurrence of capelin were greater for tufted puffins in 1978 than they were for kittiwakes and gulls. Puffins may have been able to reach the depths at which the capelin were schooled whereas the kittiwakes and glaucous-winged gulls could not.

Lack of adequate food or nutrients at the outset of the breeding season may cause reproductive failure in many birds. The causes for this failure either may be due to a lack of food during the pre-laying period which predicts trends in the low abundance of food later on in the season when the chicks are hatched, or else may be due to simply a lack of the right nutrients or amounts thereof in the diet to provide the ingredients necessary for egg formation. Either or both of these factors may be operating on the birds when they first arrive on the breeding grounds and will begin to have effects immediately.

The decrease in the breeding population of glaucous-winged gulls in inner east Sitkalidak Strait and of black-legged kittiwakes at Boulder Bay in 1978, and the general reproductive failure of both species may be a response to this decrease in abundance or availability of capelin. The behavior of the prey may be important with respect to catchability. Perhaps one species is harder to catch than another and the birds would have to spend more time searching and catching this prey. Capelin may be a more nutritious fish than sandlance and because they were not attainable in great numbers in 1978, even though sandlance may have been, the surface surface feeders, gulls and kittiwakes, may have responded to this with a decrease in productivity, while puffins which could reach the available capelin did not respond in this way. This decrease was reflected in all stages of the breeding cycle from reduced adult breeding populations to fewer nests with eggs, smaller clutch sizes, and fewer fledglings per nest attempt and per breeding pair, as well as increased predation by other avian species as the season progressed. The lack must still have been present during the egg and chick stages because other birds, especially gulls, ravens and crows chose to utilize one of the more easily available food sources at that time: eggs and chicks of surface nesters. Thus the lack of food that precipitated smaller clutches and fewer nests with eggs continued throughout the breeding season affecting the populations at all stages of the cycle and further decreasing the final overall productivity.

Chick growth is intended to be a measure of the environmental influence on the chick population. The assumption is that if the food base is inadequate the chicks will no grow as rapidly as in a good food year. However, during 1978, it was apparent that the food base was different and probably not as good as in 1977, but that the the chicks were growing as rapidly as they did in 1977. It therefore seems that the response to an inadequate food supply is not to deliver less or worse quality food to chicks, thus depressing their growth rate, but rather to depress the productivity rate. There were less chicks produced per nest but of those that made it grew equally as well as chicks produced in a bad year.

CONCLUSIONS

Reproductive success of seabirds is not constant from year to year but varies perhaps in accordance with fluctuations in the ecosystem. We believe that one of the variables in the ecosystem which may influence reproductive success is food availability. In the food base, the factor that changed the most drastically between the 1977 and 1978 breeding season was the availability of capelin. Capelin seems to be one of the critical components in the prey base for all seabirds in the Sitkalidak Strait area, such that a decrease in their supply or their availability to seabirds may be reflected in drastic reduction in reproductive success of the seabirds. It seems that reduction in prey below a certain level with respect to numbers or frequency of occurrence of the prey may decrease reproductive output in the birds. Even though the numbers and frequency of occurrence of capelin were significantly reduced from 1977 for tufted puffins, the reductions weren't as much as those for black-legged kittiwakes and glaucous-winged gulls. Correspondingly, the tufted puffins had as good reproductive success in 1978 as in 1977 whereas the other two species did not. Perhaps the level to which the capelin were reduced for puffins was above the critical level so that it did not affect puffin productivity, while the low levels of capelin for kittiwakes and gulls were below this level and their productivity reflected this.

Growth of chicks seems to be rather constant from year to year and independent of the reproductive success. The chicks of glaucous-winged gulls, tufted puffins and black-legged kittiwakes in 1978 grew at similar rates and reached similar asymptotes at fledging as did the chicks in 1977 even though the productivity for gulls and kittiwakes was below that of 1977.

Tufted puffins and arctic and Aleutian terns seemed to be most sensitive to human disturbance. Comparisons of disturbed and undisturbed plots of tufted puffins yielded higher reproductive success in plots where puffins were not disturbed during the egg or early chick stage.

Disturbance of the habitat for Arctic and Aleutian terns combined with egging produced very little reproductive output in the colony where this disturbance occurred. Presence of humans and their pets and any major habitat disturbance or destruction at the time before egg laying, and during the egg and chick stages tend to be detrimental to the productivity of the seabirds.

In 1977 heavy egging on accessible glaucous-winged gull plots severely decreased the reproductive output of the birds on these plots versus the output of birds on plots relatively inaccessible to humans. In 1978 however the glaucous-winged gulls were not egged as heavily as they were in 1977 and this showed up in equal productivity between plots accessible and inaccessible to humans.

NEEDS FOR FURTHER STUDY

If capelin are indeed important for high reproductive success it would be interesting to identify what the critical numbers and frequency of occurrence of capelin in the environment are. The identification then of these levels would help pinpoint potentially bad food years which tend to produce low reproductive success for some or all the seabird species. In conjunction with this it would be good to be able to predict low food years based on some physical parameter which might somehow influence the abundance or distribution of capelin.

It would be wise to test the theory of the relationship of food availability and reproductive success by monitoring the colonies yet another year. Two years have produced opposite outcomes and a third year should give credence to a testing of the theory of this relationship.

Table 1. Kinds of Studies Conducted on the Different Puffin Plots, 1978

	Cathedral Island									Amee Island	
	2	3	4	5	6	7	8	9	10	1	2
Chronology	X	X	X	X	X	X	X	X	X	X	X
Productivity											
Disturbed					X		X	X	X		X
Undisturbed	X			X							
Chick Growth		X				X				X	
Habitat Measurements	X	X	X	X	X	X				X	

Table 2. Number of Breeding Birds in the Sitkalidak Strait Area, 1977-1978.

<table>
<tr><th>Species</th><th>Numbers 1977</th><th>Numbers 1978</th></tr>
<tr><td>Tufted Puffin</td><td>13,584</td><td>10,714</td></tr>
<tr><td>Black-legged Kittiwake</td><td>4,766</td><td>5,032</td></tr>
<tr><td>Glaucous-winged Gull</td><td>940</td><td>482</td></tr>
<tr><td>Arctic Tern</td><td>1,275</td><td rowspan="2">544</td></tr>
<tr><td>Aleutian Tern</td><td>1,065</td></tr>
<tr><td>Pelagic Cormorant</td><td>252</td><td>226</td></tr>
<tr><td>Red-faced Cormorant</td><td>137</td><td>262</td></tr>
<tr><td>Horned Puffin</td><td>184</td><td>104</td></tr>
<tr><td>Pigeon Guillemot</td><td>520</td><td>232</td></tr>
<tr><td>Mew Gull</td><td>20</td><td>24</td></tr>
<tr><td>Northwest Crow</td><td>8</td><td>12</td></tr>
<tr><td>Bald Eagle</td><td>4</td><td>4</td></tr>
</table>

Table 3. Census of the Kiliuda Bay Area.[1]

Species	Boulder Bay 1977[3]	Boulder Bay 1978[5]	Duck Is. 1977[2]	Duck Is. 1978[4]	Nest Is. 1977[2]	Nest Is. 1978[4]	Ladder Is. 1978[4]
Tufted Puffin			1,500	400[6]	400	1,400	300[7]
Black-legged Kittiwake	40,000	7,000	828	1,400	380	360	250
Glaucous-winged Gull			50	200		180	350
Pigeon buillemot						20	25
Pelafic Cormorant							10

1. Blank means no census taken

2. Census by D. Forsell

3. Census by P. Baird, D. Forsell, A. Moe

4. Census by P. Baird, V. Hironaka

5. Census by P. Baird, M. Hatch, D. Nysewander

6. Density = $2.0/m^2$

7. Density = $2.2/m^2$

Table 4. Reproductive Success of Tufted Puffins at Sitkalidak Strait in 1977 and 1978.

	1977	1978	P*
Number of nests built	93	103	
Number of nests with eggs	67	69	
Mean clutch size	1.0	1.0	
Number of eggs laid	67	69	
Number of chicks hatched	41	36	
Mean brood size at hatching	1.0	1.0	
Number of chicks fledged	35	32	
Laying success (Nests with eggs/nest built)	72.0%	67.0%	> 0.4
Hatching success (Chicks hatched/egg laid)	61.2%	52.2%	> 0.1
Fledging success	87.8%	88.9%	> 0.5
Chicks fledged/nest w eggs	0.537	0.464	> 0.2
Chicks fledged/nest attempt	0.38	0.31	> 0.1
Percent nests hatching one or more eggs	61.2%	52.2%	

* Statistical analysis is based on the equality of two percentages test with a $p < 0.05$ reflecting a significant difference between years.

Table 5. Productivity of burrows in undisturbed plots of tufted puffins, 1977, 1978.

	1977	1978
Fledglings	23	16
Burrows entered at least once [a]	54	33
Eggs [b] (extrapolated from disturbed plots)	39 (72.0%)	22 (67.0%)
Fledglings per eggs laid	0.59	0.73
Fledglings per nest attempt	0.43	0.49

(a). evidenced from toothpicking the entrances

(b). percents applied to all burrows to find # of eggs, are obtained from disturbed plots.

Table 6. Comparison of Productivity in the Disturbed and Undisturbed Tufted Puffin Plots, 1978.

	Disturbed (N = 103)		Undisturbed (N = 33)	
	N	% of Total	N	% of Total
# Chicks fledged	32	31.1	16	48.5
# eggs laid	69	67.0	22 (67%x33)	assume 67.0
# chicks fledged per # eggs laid	46.4		-	72.4

Table 7. Mortality of Tufted Puffins

Egg Stage	(N = 67) 1977 N	%	(N = 69) 1978 N	%
Eggs rolled out of nest	0	0	6	8.7
Eggs abandoned	6	9.0	19	27.5
Eggs infertile	6	9.0	1	1.5
Fate unknown (eggs disappeared)	13	19.4	3	4.4
Total egg	25	37.3	29	42.0
Chick Stage				
Chicks starved	3	4.5	3	4.4
Chicks flooded out	1	1.5	0	0
Fate unknown (chick disappeared)	2	3.0	2	2.9
Total chick	6	9.0	5	7.3
Total mortality	31	46.7	34	49.3

Table 8. Chi-square analysis of disturbance on tufted puffins: egg stage only.

Disturbed and abandoned........12
Disturbed, not abandoned.......16
Not disturbed but abandoned....15

$X^2 = 0.31818$ $p < 0.0005$

Table 9. Prey items of tufted puffin chicks. Sitkalidak Strait 1977 and 1978

Species	1977 % Frequency of occurrence	1977 % Total Numbers	1978 % Frequency* of occurrence	1978 % Total* Numbers	$\bar{X}$ Length ± SE
Mallotus villosus	75.0	64.9	31.0 (34.6)	36.0 (36.9)	94.87 ±3.64
Ammodytes hexapterus	37.5	25.8	41.4 (96.2)	48.3 (49.6)	97.02 ±2.19
Trichodon trichodon	14.2	3.1	--	--	--
Onchorhynchos nerka	8.9	1.6	--	--	--
Theragra chalcogramma and *Gadidae*	14.3	3.7	10.3 (11.5)	10.5 (10.8)	71.0 ±2.53
Salmonida and *Osmeridae*	--	--	3.5 (3.9)	1.8 (1.8)	137.0 ±5.5
Unidentified fish	--	--	10.3	2.6	--
Cephalopoda	1.8	0.3	--	--	
Octopoda	1.8	0.6	3.5 (3.9)	0.9 (0.9)	

* parentheses are percentages not including unidentified fish.

Table 10. Prey species diversity and evenness, tufted puffins, 1977 and 1978.

	1977	1978
Species diversity H'	0.6509	0.5316
Species evenness J'	0.7702	0.7605

Table 11. Changes in percent numbers of food items between 1977 and 1978.

	Black-legged Kittitwake	Tufted Puffin	Glaucous-winged Gull
Contingency x^2	$X^2 = 22.4332$	$X^2 = 5.3516$	$X^2 = 40.0359$
	p = 0.0001	p = 0.1478	p = 0.00001

Table 12. Changes in percent frequency occurrence of food items between 1977 and 1978.

	Black-legged Kittiwake	Tufted Puffin	Glaucous-winged Gull
Contingency X^2	$X^2 = 10.0641$	$X^2 = 8.1170$	$X^2 = 29.5841$
	p = 0.0180	p = 0.0874	p = 0.0003

Table 13. Distribution of frequencies for clutches, nestlings, and fledglings: black-legged kittiwakes, 1977 and 1978.

Clutch	Number of eggs		Number of chicks		Number of fledglings	
Size	1977	1978	1977	1978	1977	1978
1	38	49	36	21	51	17
2	75	17	48	7	26	3
3	1	—	—	—	—	—

Table 14. Reproductive Success of black-legged kittiwakes at Sitkalidak Strait in 1977 and 1978.

	1977	1978	p
Number of nests built	136	121	
Number of nests with eggs	114	65	
Mean clutch size	1.68	1.26	
Number of eggs laid	178 (83.8%)	78 (53.7%)	
Number of chicks hatched	132 (74.2%)	28 (35.9%)	
Mean brood size at hatching	1.57	1.25	
Mean brood size at fledgling	1.34	1.15	
Number of chicks fledged	101	20	
Laying success (nests with eggs/nest built)	83.8%	53.7%	< 0.001
Hatching success (chicks hatched/egg laid)	74.2%	35.9%	< 0.001
Fledging success (chicks fledged/chick hatched)	76.5%	52.6%	< 0.05
Chicks fledged/nest w eggs	0.886	0.308	< 0.001
Chicks fledged/nest attempt	0.743	0.165	< 0.001
Percent nests hatching one or more eggs	56.6%	43.1%	

Table 15. Mortality of black-legged kittiwakes

Egg stage	(N = 191) 1977 N	%	(N = 83) 1978 N	%
Egg rolled out			2	2.41
Egg abandoned			4	4.82
Egg disappeared probably predation	39	20.42	46	55.42
Egg infertile	11	5.76		
Exposure	9	4.71		
Total egg	59	30.89	52	62.65
Chick stage				
Predation	1	0.52	12	14.46
Starved	2	1.05		
Exposure	15	7.85		
Chick disappeared	13	6.81		
Total chick	31	16.23	12	14.46
Total all mortality	90	47.12	64	77.11

Table 16. Prey items of black-legged kittiwake chicks, Sitkalidak Strait, 1977 and 1978.

Species	1977 % Frequency of occurrence	1977 % Total Numbers	1978 % Frequency* of occurrence	1978 % Total* Numbers	$\bar{X}$ Length ± SE
Mallotus villosus	59.3	42.2	5.3 (6.9)	6.4 (7.6)	94.87 ±3.64
Ammodytes hexapteres	50.0	43.6	57.9 (75.9)	60.3 (71.7)	104.04 ±2.36
Trichodon trichodon	2.8	1.0	10.5 (13.8)	12.7 (15.1)	112.43 ±4.20
Onchorhynlos nerka	7.4	4.3	--	--	
Theragra chalcogramma	4.6	3.8	--	--	
Unidentified fish	--	--	21.1	14.3	
Pandalopsis (shrimp)	6.5	5.2	--	--	
Katharina tunicata	--	--	2.6 (3.5)	4.7 (5.7)	

* parentheses are percentages not including unidentified fish.

Table 17. Prey species diversity and evenness, black-legged kittiwakes, 1977 and 1978, Sitkalidak Strait.

	1977	1978
Species Diversity H'	0.5509	0.3402
Species Evenness J'	0.7080	0.5651

Table 18. Reproductive success of glaucous-winged gulls at Sitkalidak Strait in 1977 and 1978.

	1977	1978	p
Number of nests built	84	117	
Number of nests with eggs	54	53	
Mean clutch size	2.48	2.28	
Number of eggs laid	134	123	
Number of chicks hatched	101	59	
Mean brood size at hatching	1.87	2.10	
Mean brood size at fledging	1.67	1.91	
Number of chicks fledged	90	44	
Laying success (Nests with eggs/nest built) = Breeding pairs/nest built	64.3%	45.3%	< 0.001
Hatching success (Chicks hatched/egg laid)	75.4%	48.0%	< 0.001
Feldging success (Chicks fledged/chicks hatched)	89.1%	74.6%	< 0.001
Chicks fledged/ness w eggs	1.67	0.83	< 0.001
Chicks fledged/nest attempt	1.07	0.376	< 0.001
Percent nests hatching one or more eggs	NA	54.7	

Table 19. Mortality of glaucous-winged gulls at Sitkalidak, 1977 and 1978.

	1977 N = 134		1978 N = 123	
Egg stage	N	%	N	%
Exposure	1	0.7	12	9.8
Predation	4	3.0	38	30.9
Infertile	5	3.7		
Shell damage	2	1.5		
Rolled out	2	1.5		
Disappeared	3	2.2		
Total Egg	17	12.7	50	40.7
Chick Stage				
Exposure			2.	1.6
Predation			10	8.1
Starved	1	0.7		
Died pipping	3	2.2		
Disappeared	2	1.5		
Total chick	6	4.5	12	9.8
Total	23	17.2%	62	50.4

Table 20. Prey items of glaucous-winged gull chicks, Sitkalidak Strait, 1977 and 1978.

Species	1977 % frequency of occurrence	1977 % total[a] numbers	1977 $\bar{X}$ length ± SE	1978 % frequency of occurrence	1978 % total numbers	1978 $\bar{X}$ length ± SE
Mallotus villosus	31.5(39.5)	$56.8_b(63.8_b)$	89.86 ±1.24	16.0(22.2)	$16.4_b(19.4_b)$	107.0 ±15.5
Ammodytes hexapterus	14.8(18.6)	$20.3_b(22.8_b)$	101.75 ±2.37	24.0(33.3)	$46.4_b(54.8_b)$	118.33 ±7.27
Theragra chalcogramma	0.9(1.2)	$0.6_b(0.7_b)$		2.0(2.8)	$0.9_b(1.1_b)$	83.0 ±0
Trichodon trichodon	0.9(1.2)	$0.3_b(0.4_b)$		6.0(8.3)	$11.8_b(14.0_b)$	121.33 ±4.61
Hemilepidotus hemilepidotus	---	---	---	2.0(2.8)	$0.9_b(1.1_b)$	167.0 ±0
Osmeridae	2.8(3.5)	$3.0_b(3.6_b)$	64.67 ±0.27	---	---	
Cottidae	0.9(1.2)	$0.3_b(0.36_b)$	274.0 ±0	---	---	
Pholididae	---	---		2.0(2.8)	$0.9_b(1.1_b)$	
Ophiidae	---	---		2.0(2.8)	$0.9_b(1.1_b)$	
Unidentified fish	20.4 (--)	11.0_b --		28.0	15.5_b --	
Diptera adults and larvae	0.9(1.2)	$1.9_b(2.2_b)$		2.0(2.8)	33.5(34.5)	1.0

Table 20. Prey items of glaucous-winged gull chicks, Sitkalidak Strait, 1977 and 1978. (cont'd)

Species	1977 % frequency of occurrence	1977 % total[a] numbers	1977 $\bar{X}$ length $\pm$ SE	1978 % frequency of occurrence	1978 % total numbers	1978 $\bar{X}$ length $\pm$ SE
<u>Isopoda</u> (<u>Siduria</u> <u>entoma</u>)	---	---		2.0(2.8)	$0.9_b(1.1_b)$	
<u>Brachy</u> & <u>Telmessus</u> crabs	0.9(1.2)	$0.3_b(0.4_b)$		2.0(2.8)	$0.9_b(1.1_b)$	77.0
<u>Lepasterius</u> <u>hexactus</u>	0.9(1.2)	$0.6_b(0.7_b)$	52.5 $\pm$8.84	---	---	
<u>Stronglescentratis</u> sp.	3.7(4.7)	$1.3_b(1.5_b)$		2.0(2.8)	$0.9_b(1.1_b)$	
<u>Mytilus</u> <u>edulis</u>	5.6(7.0)	$1.9_b(2.2_b)$		6.0(8.3)	$2.7_b(3.2_b)$	46.0
Tube worm	5.6(7.0)	---		---	---	
Fish eggs	4.6(5.8)	55.3(58.1)	0.2	2.0(2.8)	48.6(50.0)	0.2
<u>Pelecypoda</u>	0.9(1.2)	$0.3_b(0.4_b)$		2.0(2.8)	$0.9_b(1.1_b)$	
<u>Katharina</u> <u>tunicata</u>	2.8(3.5)	$1.0_b(1.1_b)$		---	---	
Plant material	1.9(2.3)	---		---	---	

a parentheses are percentages not including unidentified fish

b percent does not include fish eggs and insect larvae

Table 21. Prey species diversity and evenness, glaucous-winged gulls, Sitkalidak Strait, 1977 and 1978.

	1977	1978
Species Diversity	0.8877	0.9166
Species Evenness	0.7372	0.7997

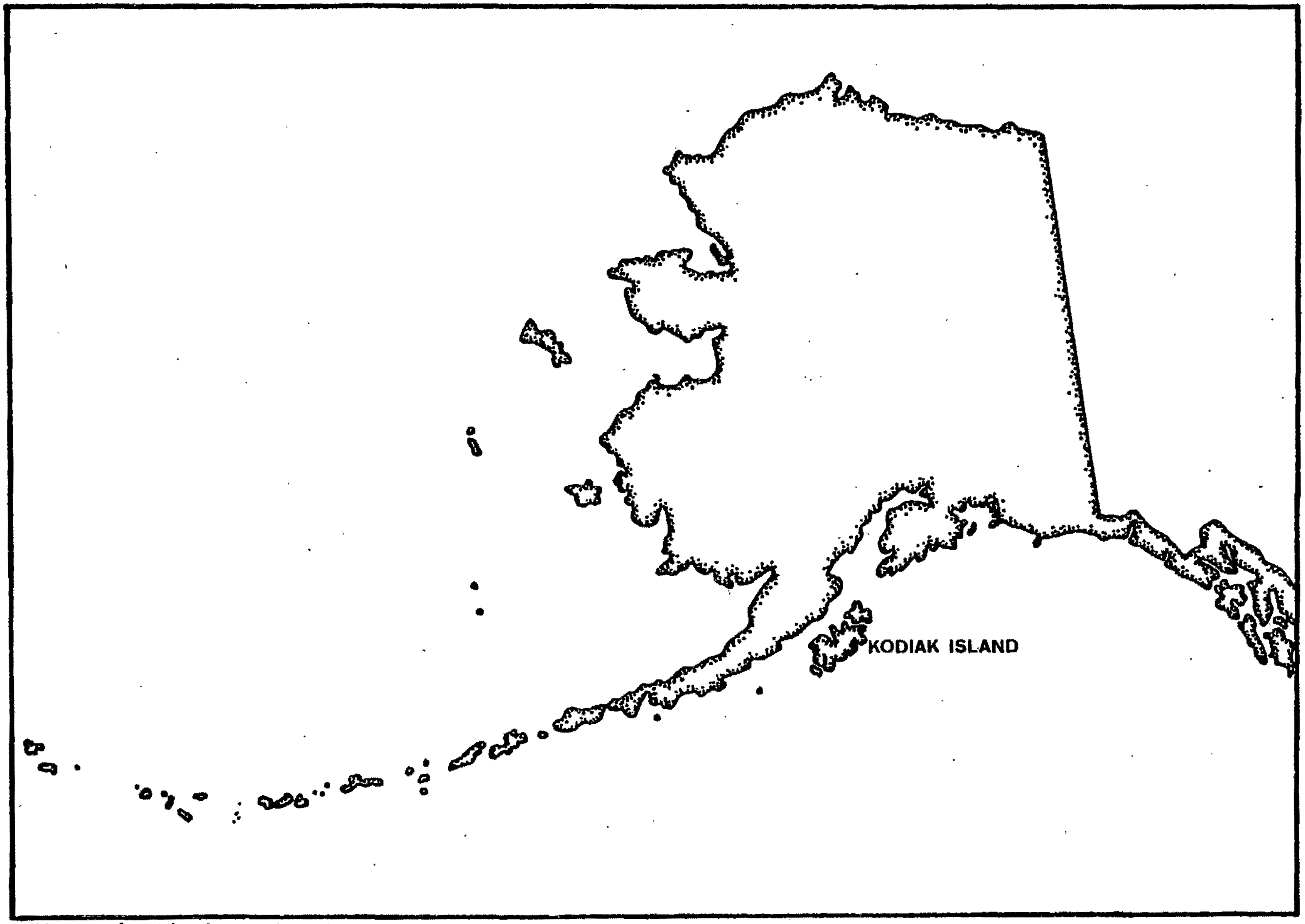

Figure 1. Alaska and Kodiak Island.

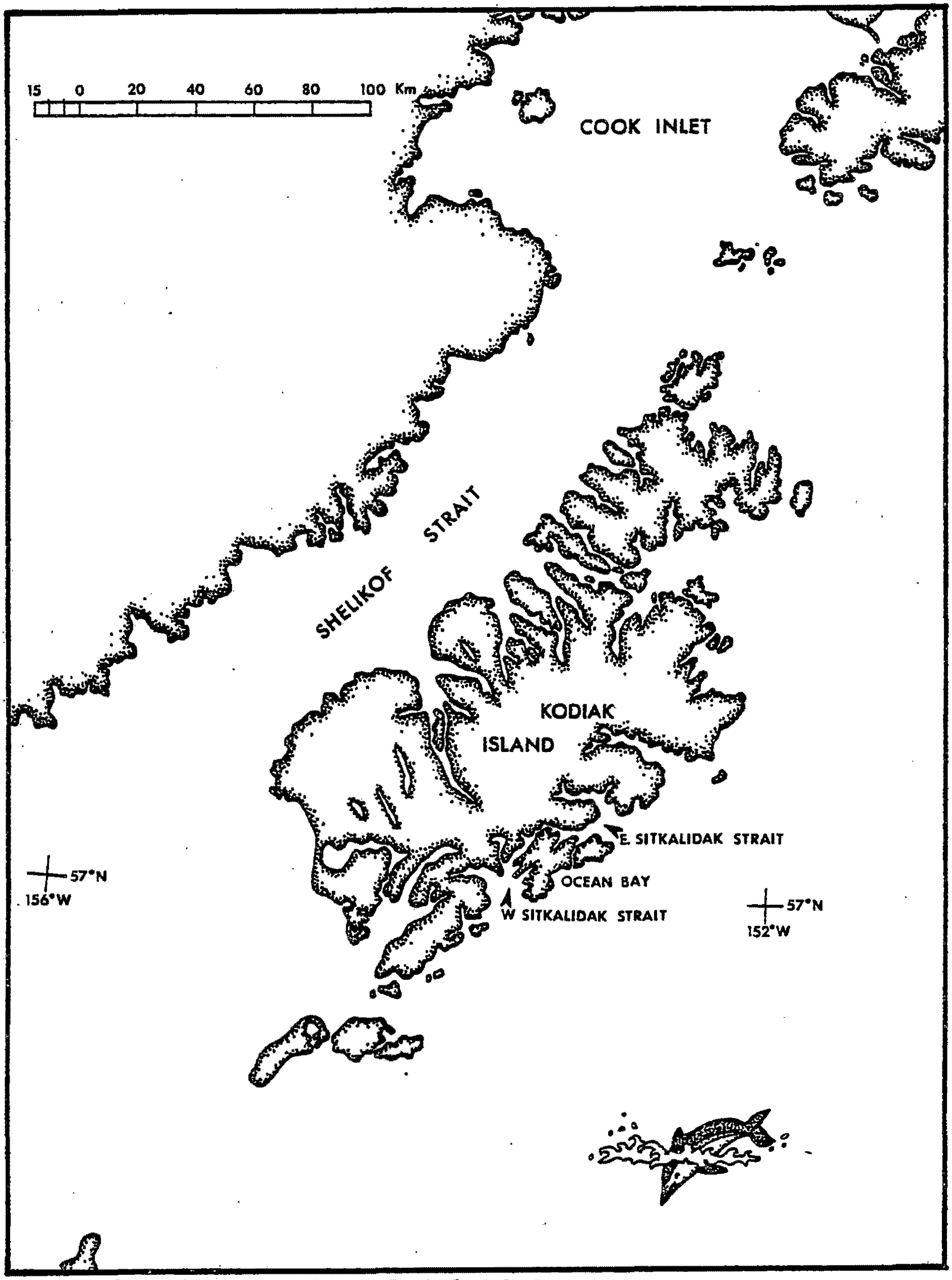

Figure 2. Kodiak Island and Sitkalidak Strait.

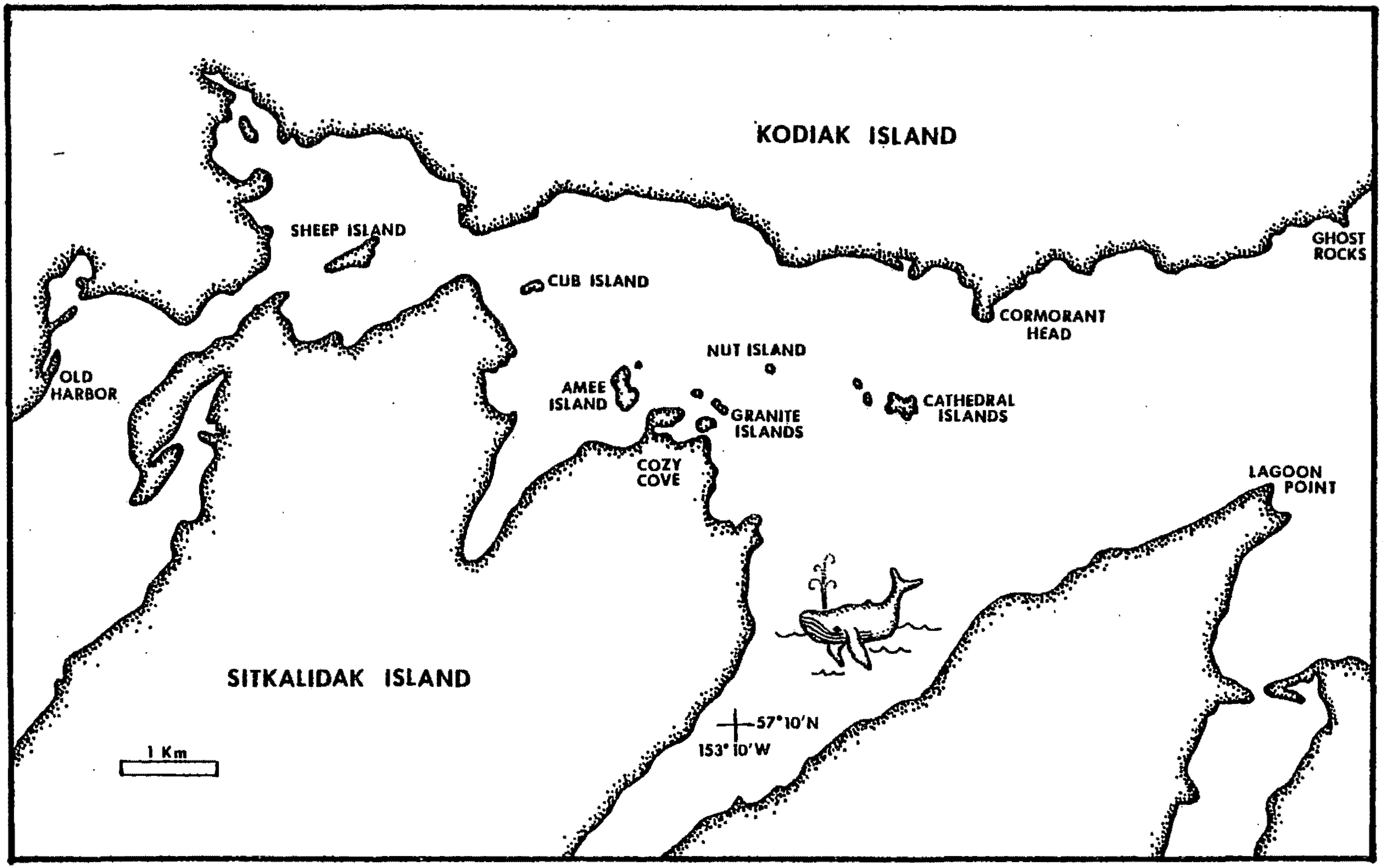

Figure 3. Inner east Sitkalidak Strait.

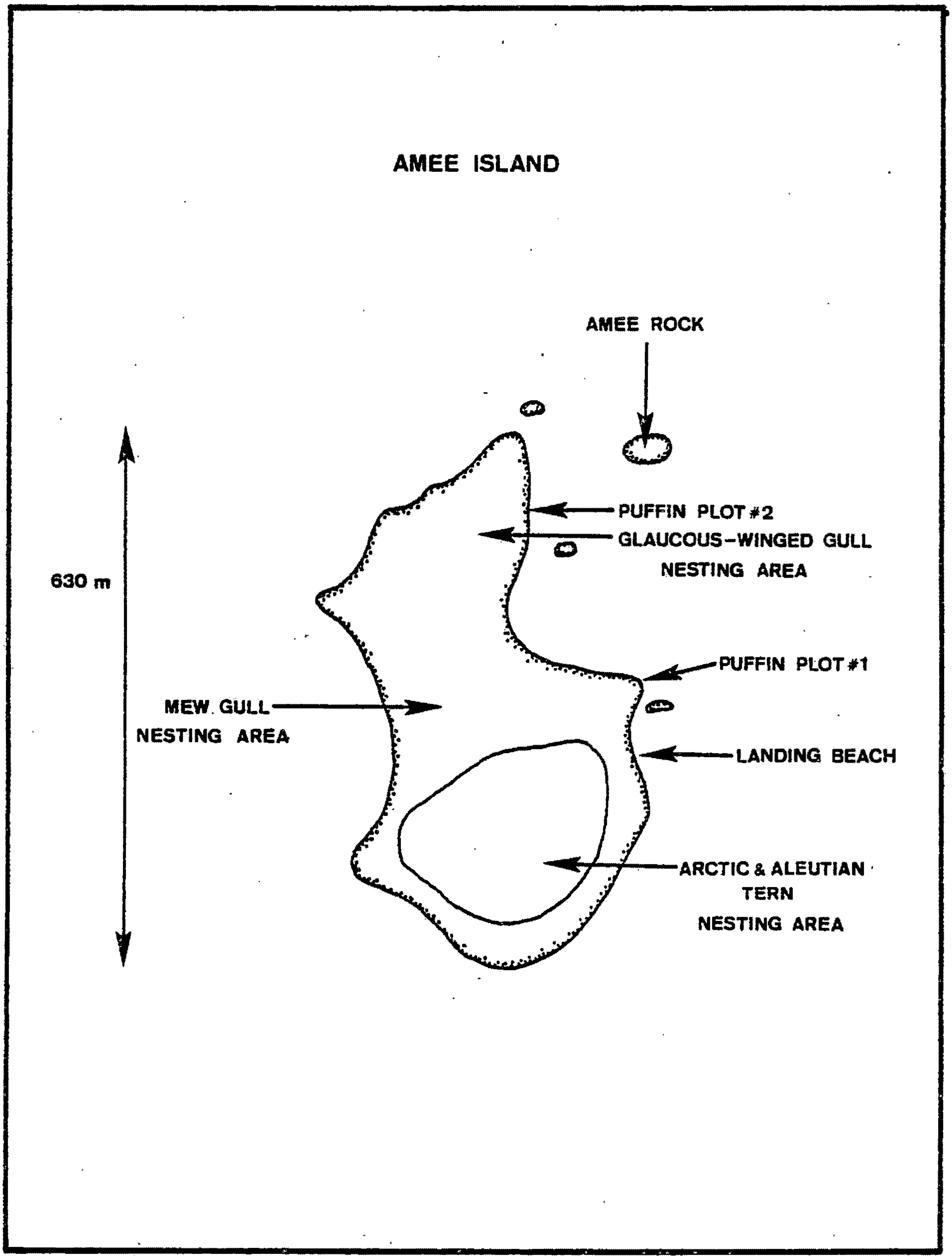

Figure 4. Amee Island: tufted puffin plots and landing beach.

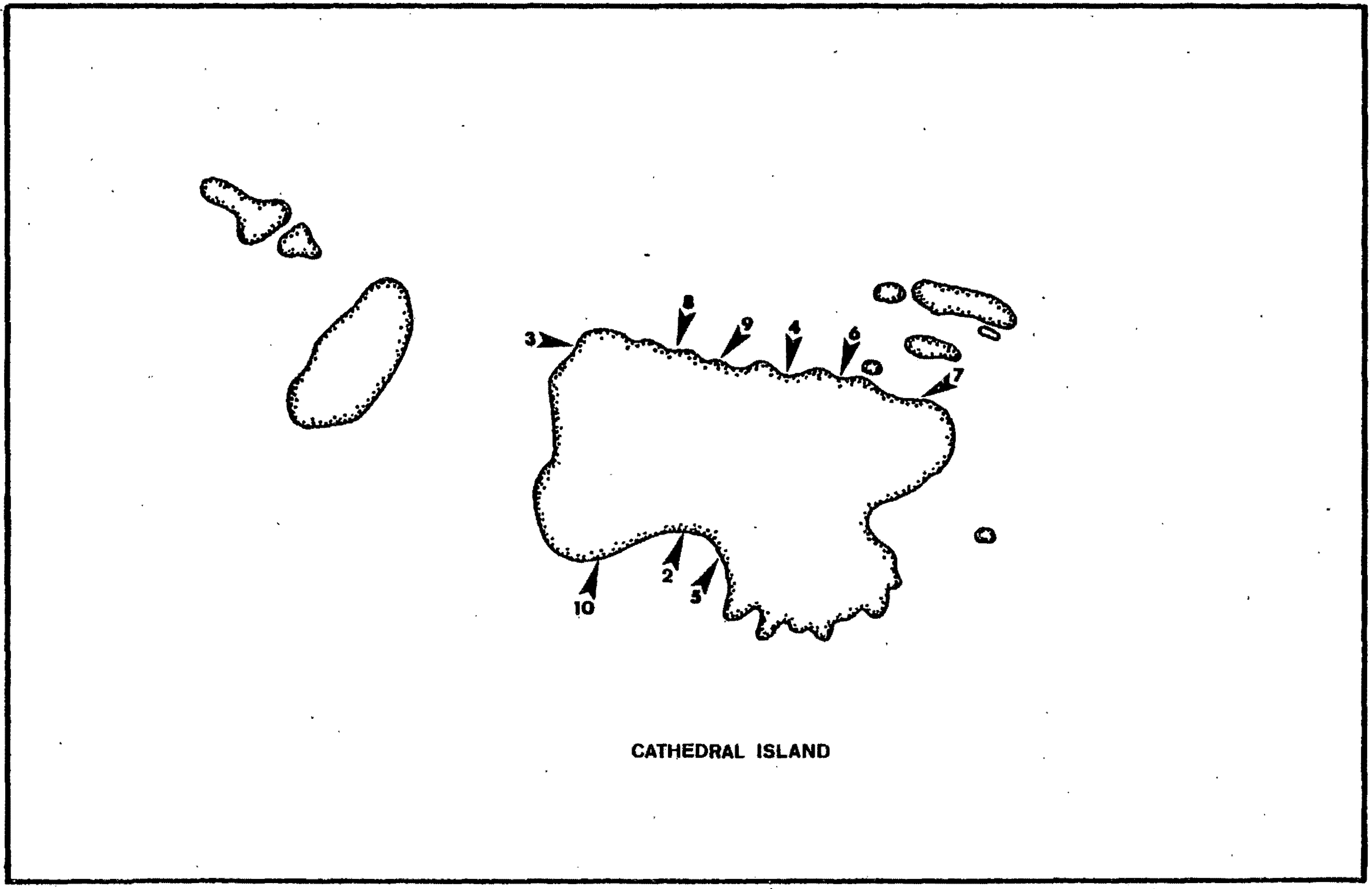

Figure 5. Cathedral Island:tufted puffin plots.

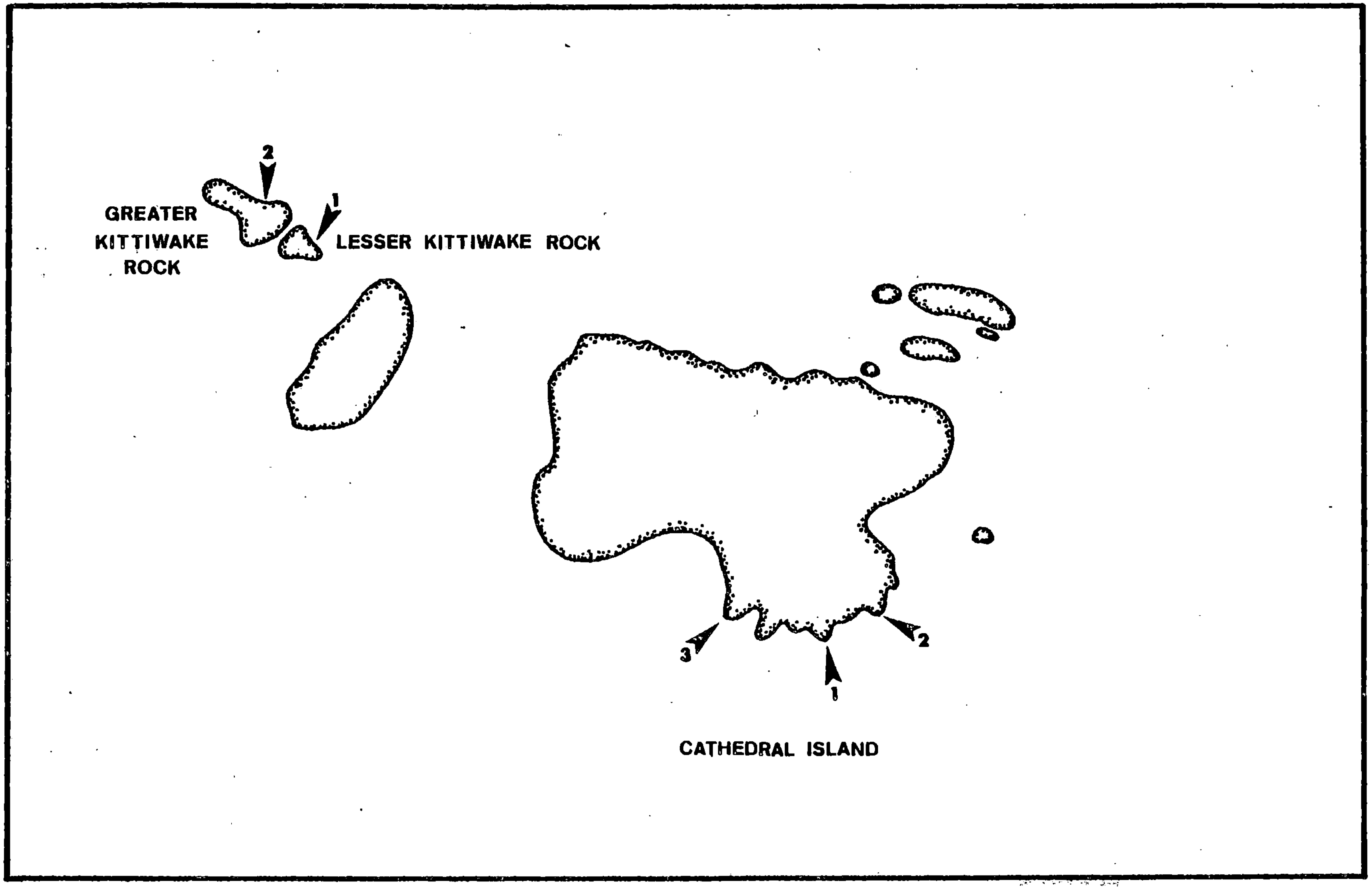

Figure 6. Cathedral Island: black-legged kittiwake plots.

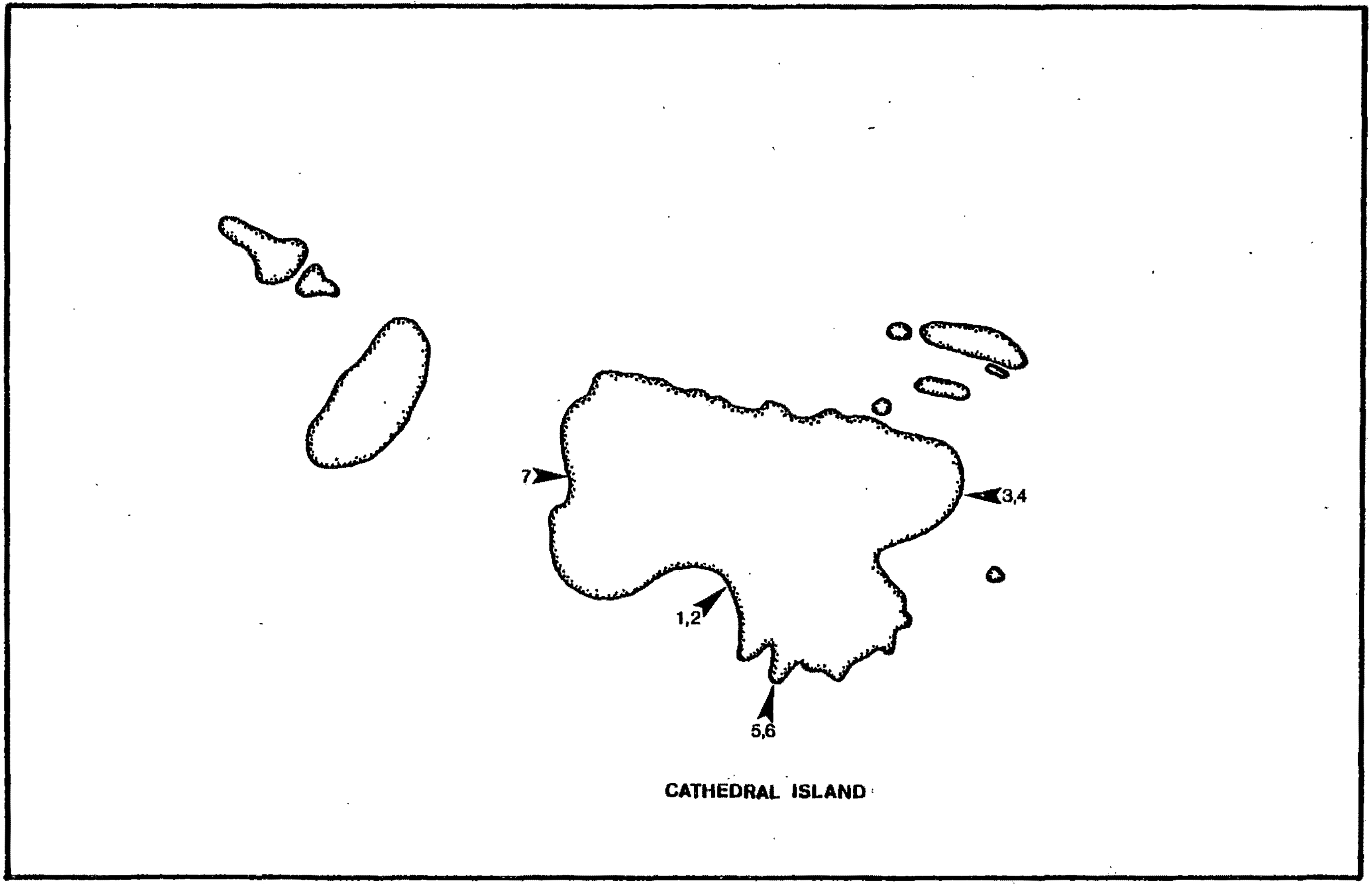

Figure 7. Cathedral Island: glaucous-winged gull plots.

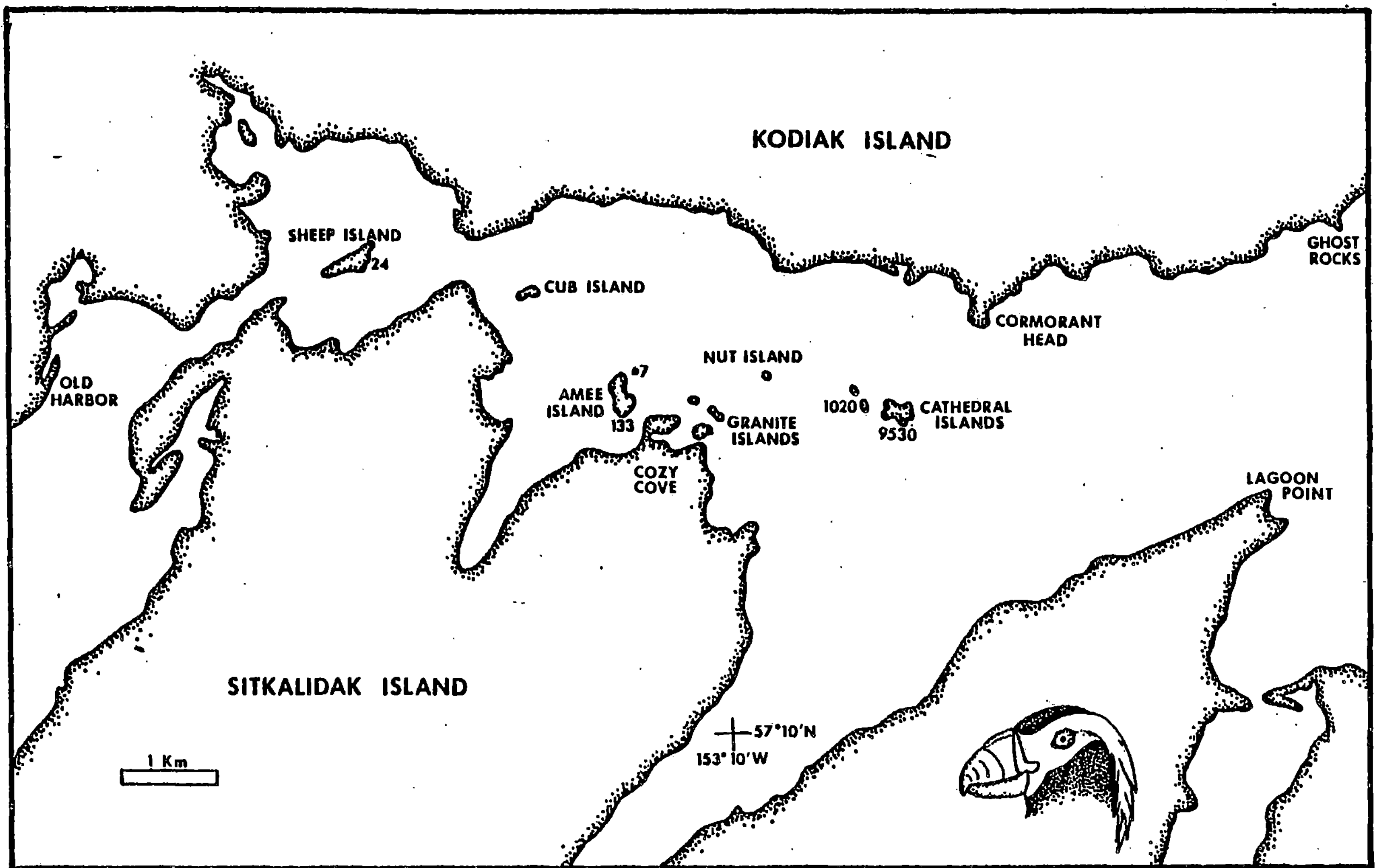

Figure 8. Distribution of tufted puffins.

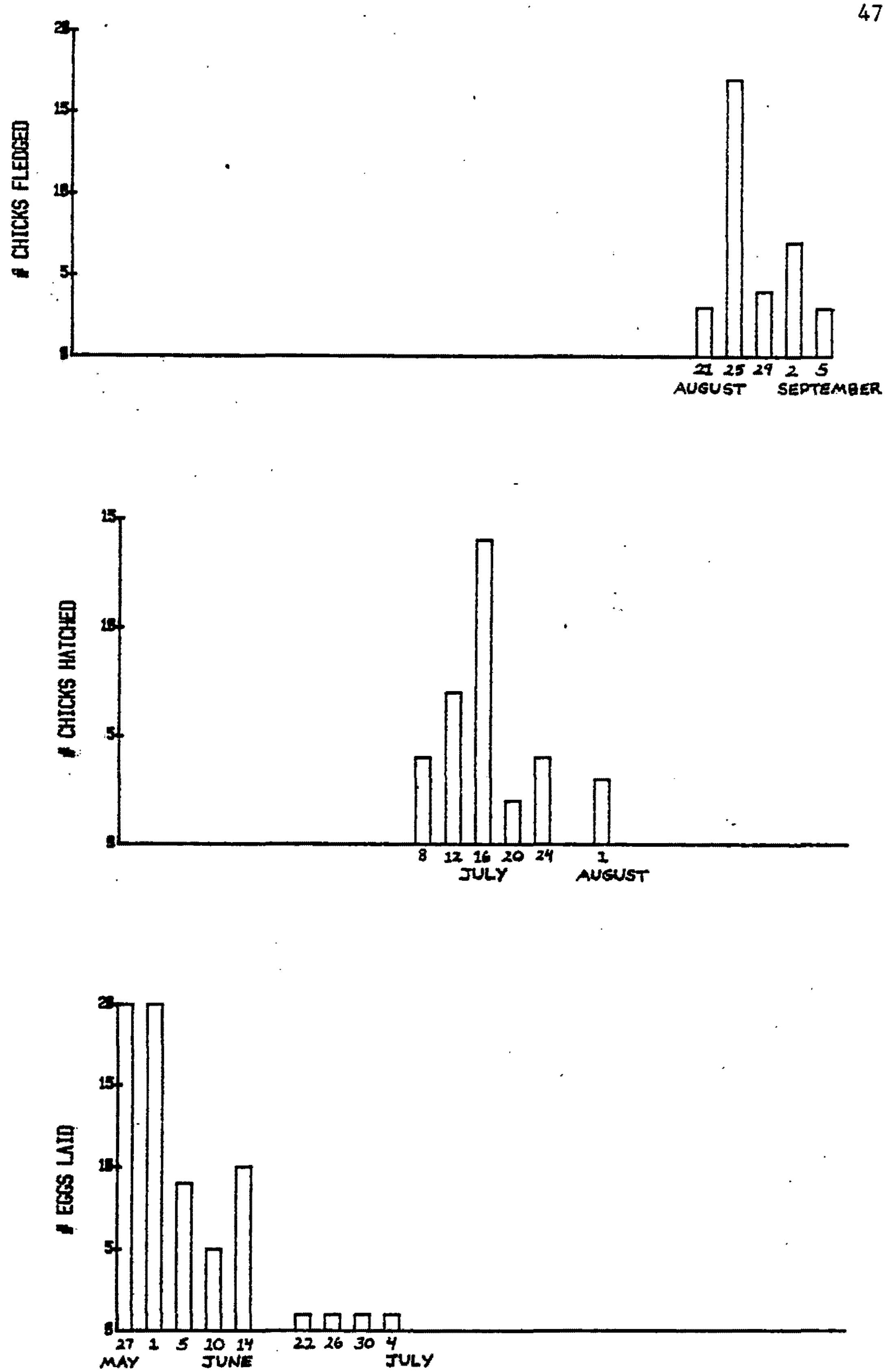

Figure 9. Chronology of tufted puffins.

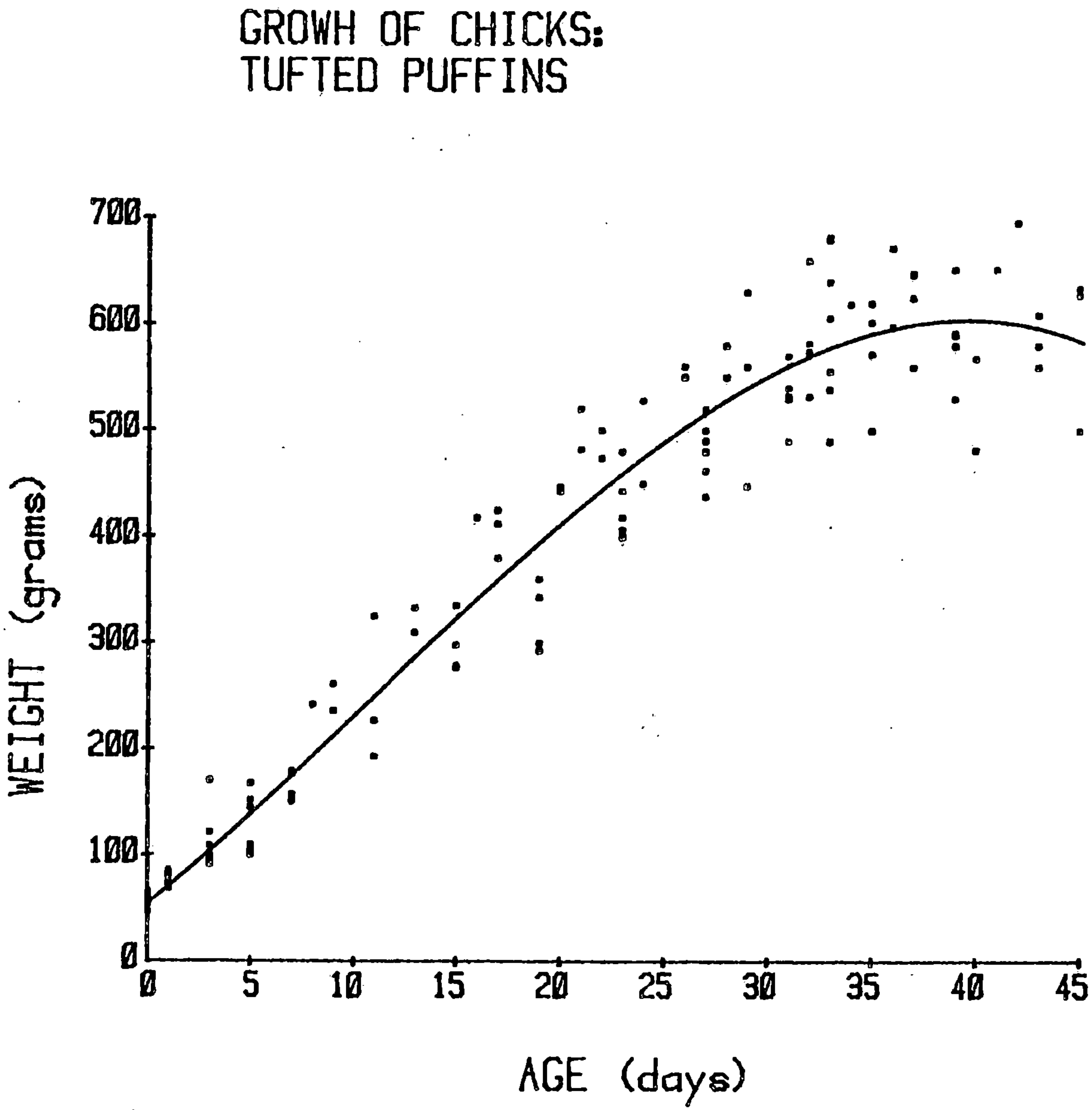

Figure 10. Growth of tufted puffin chicks, 1978.

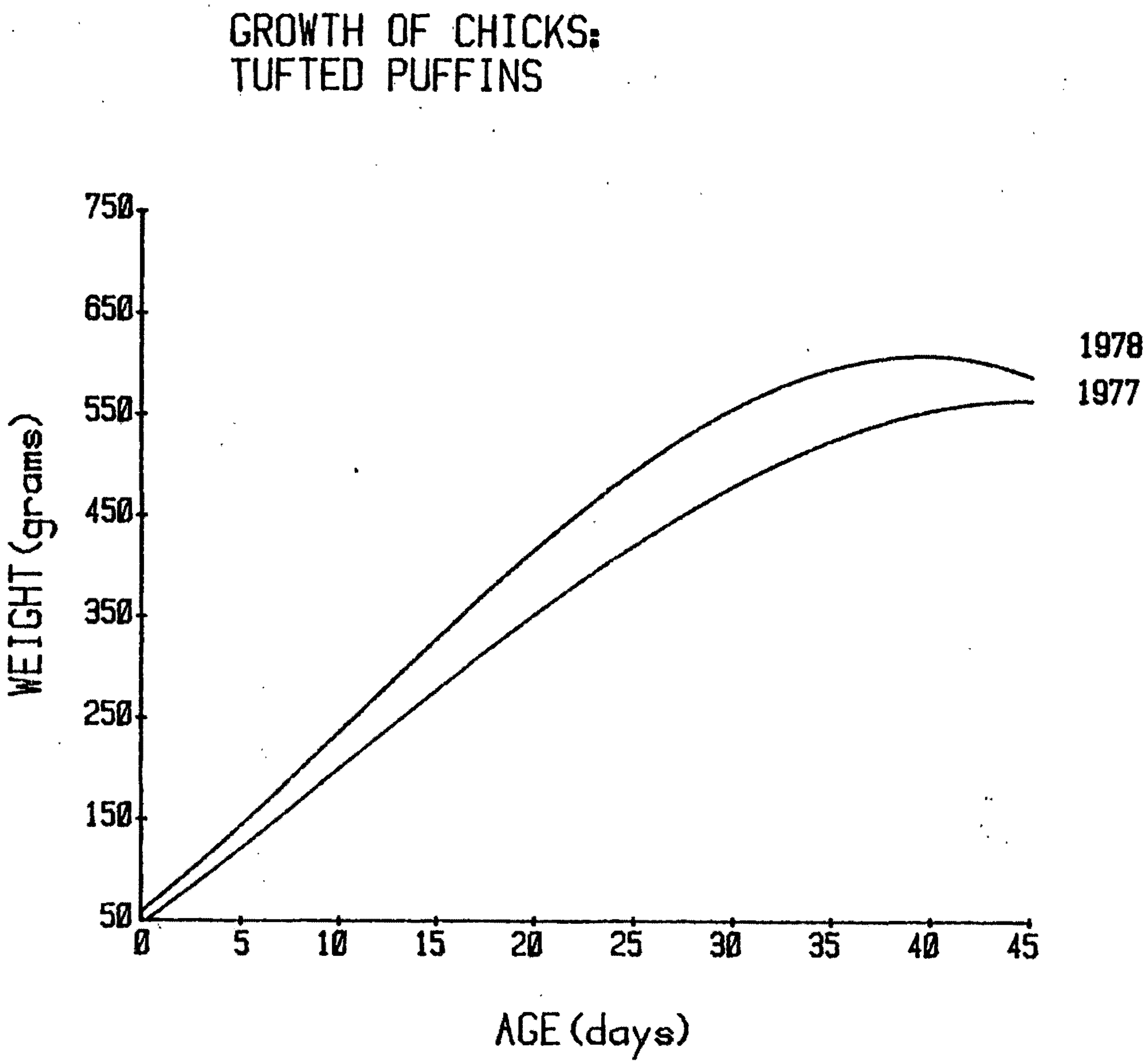

Figure 11. Growth of tufted puffin chicks, 1977 and 1978.

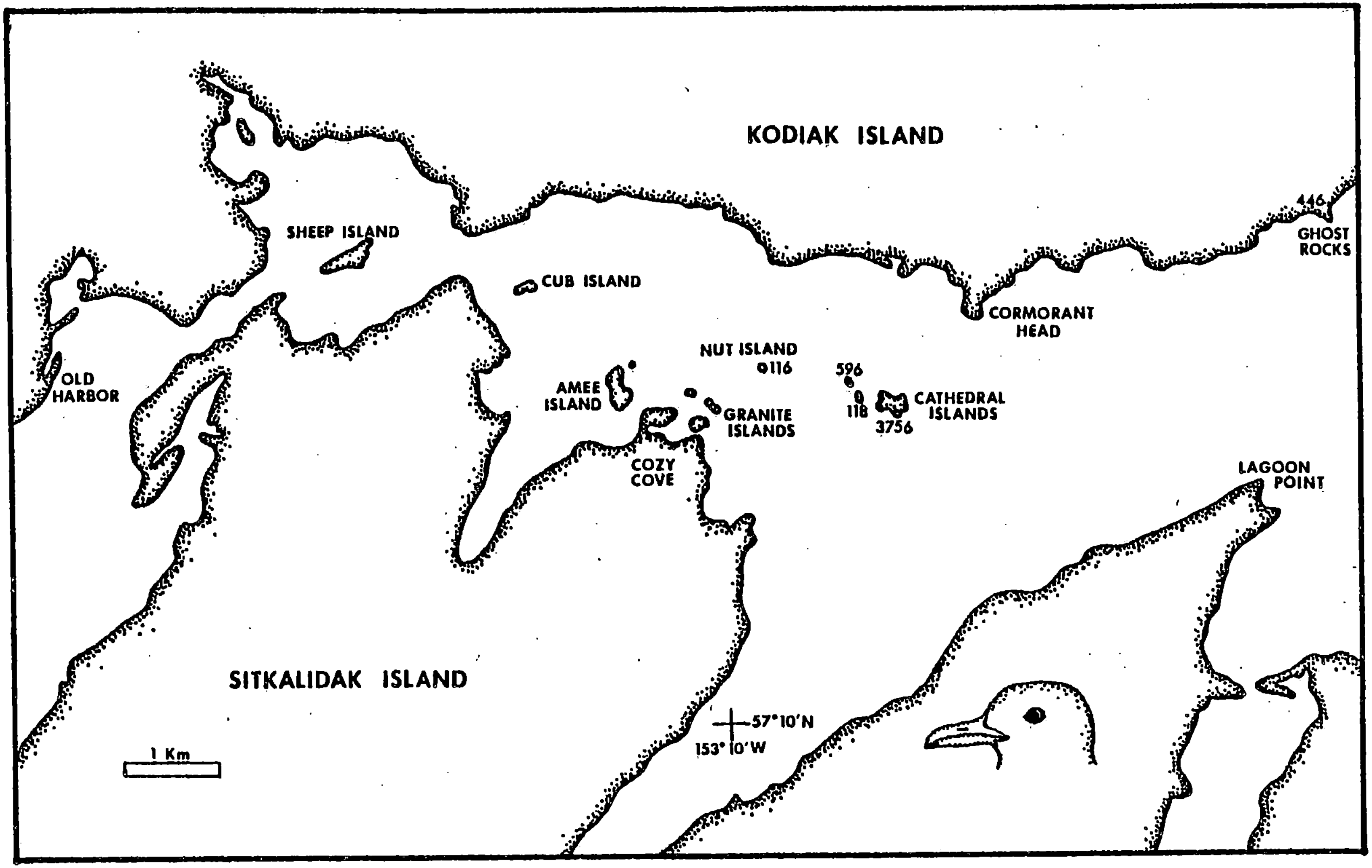

Figure 12. Distribution of black-legged kittiwakes.

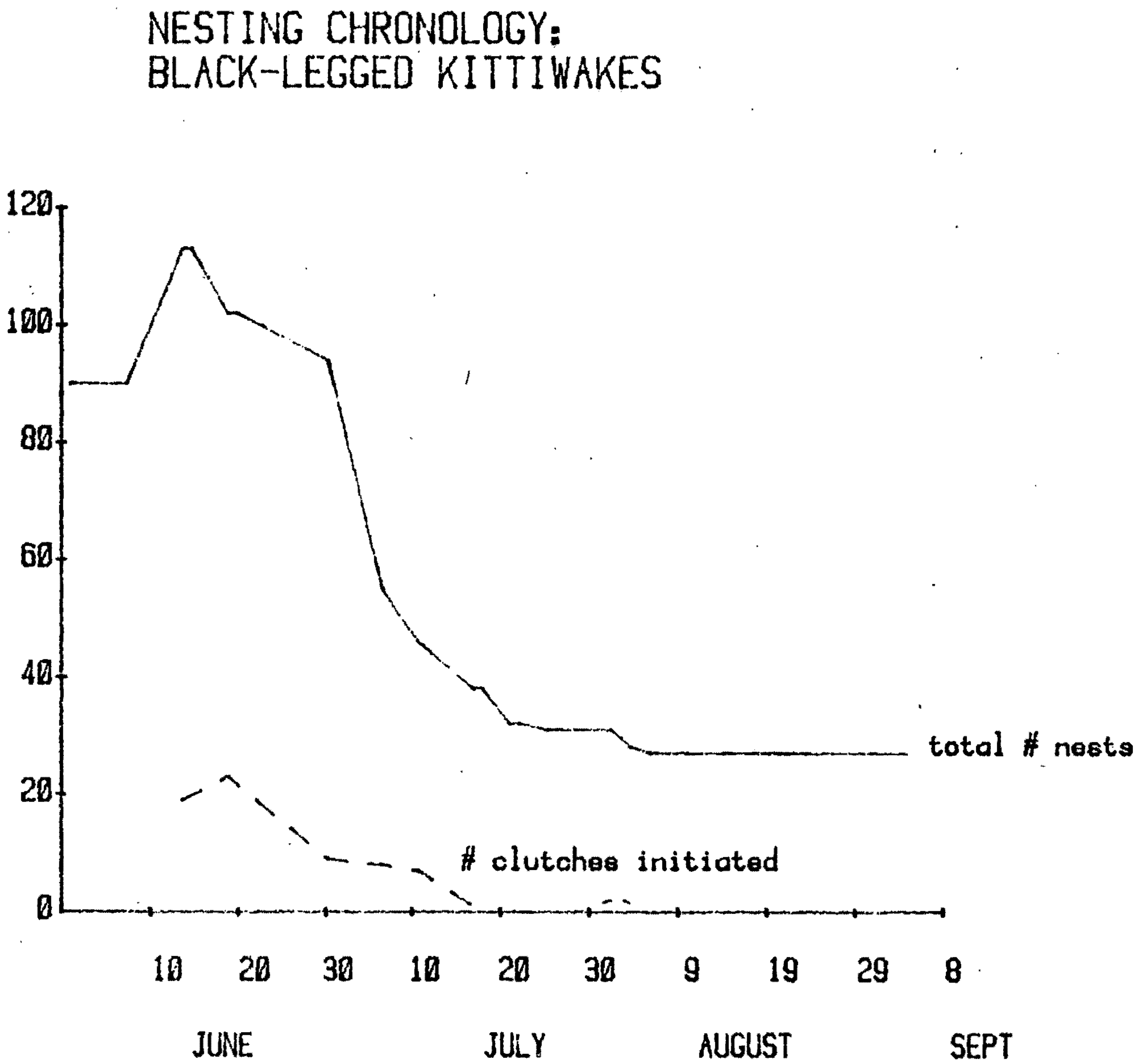

Figure 13. Nesting chronology of black-legged kittiwakes.

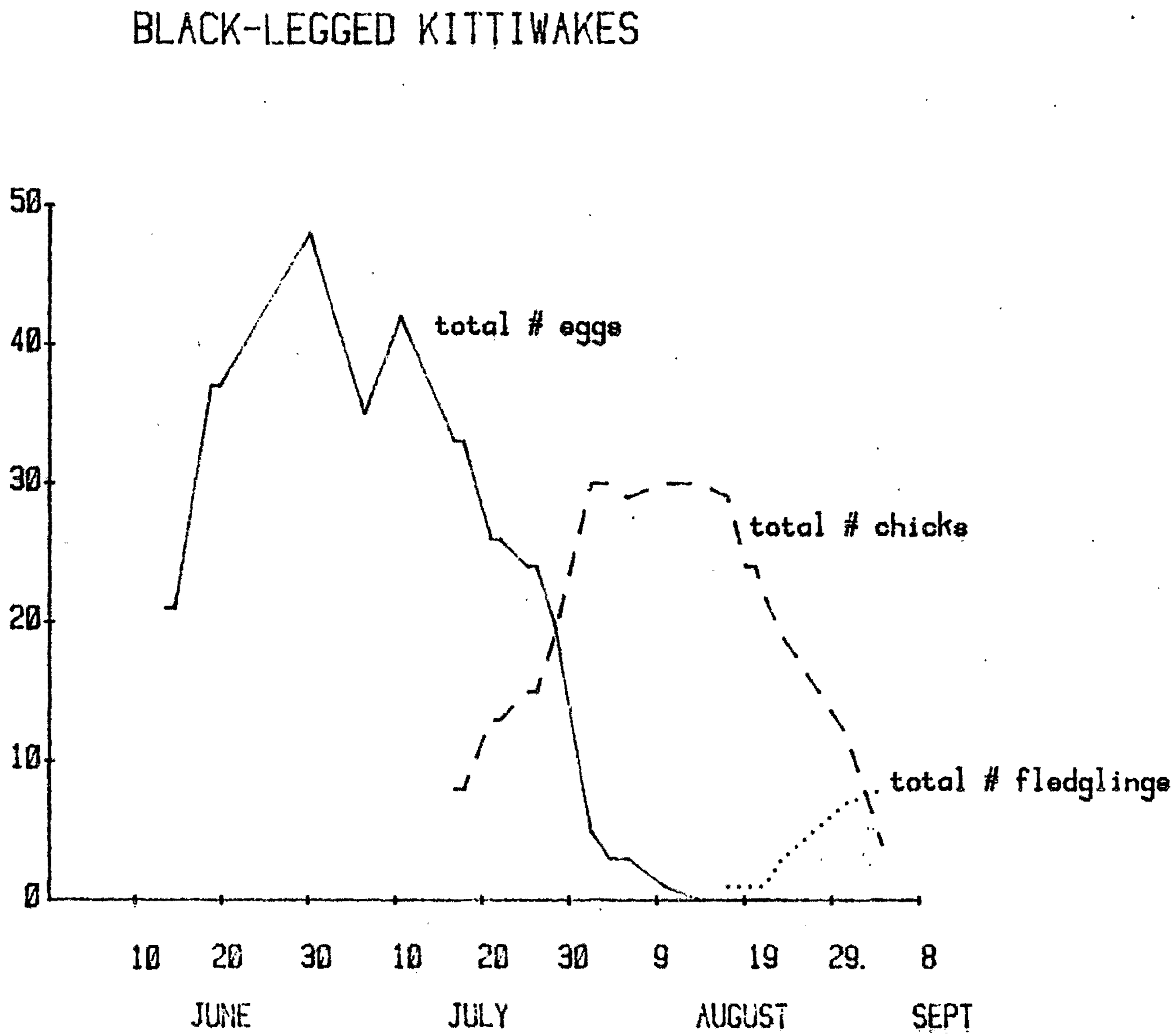

Figure 14. Numbers of eggs, chicks, and fledglings, black-legged kittiwakes.

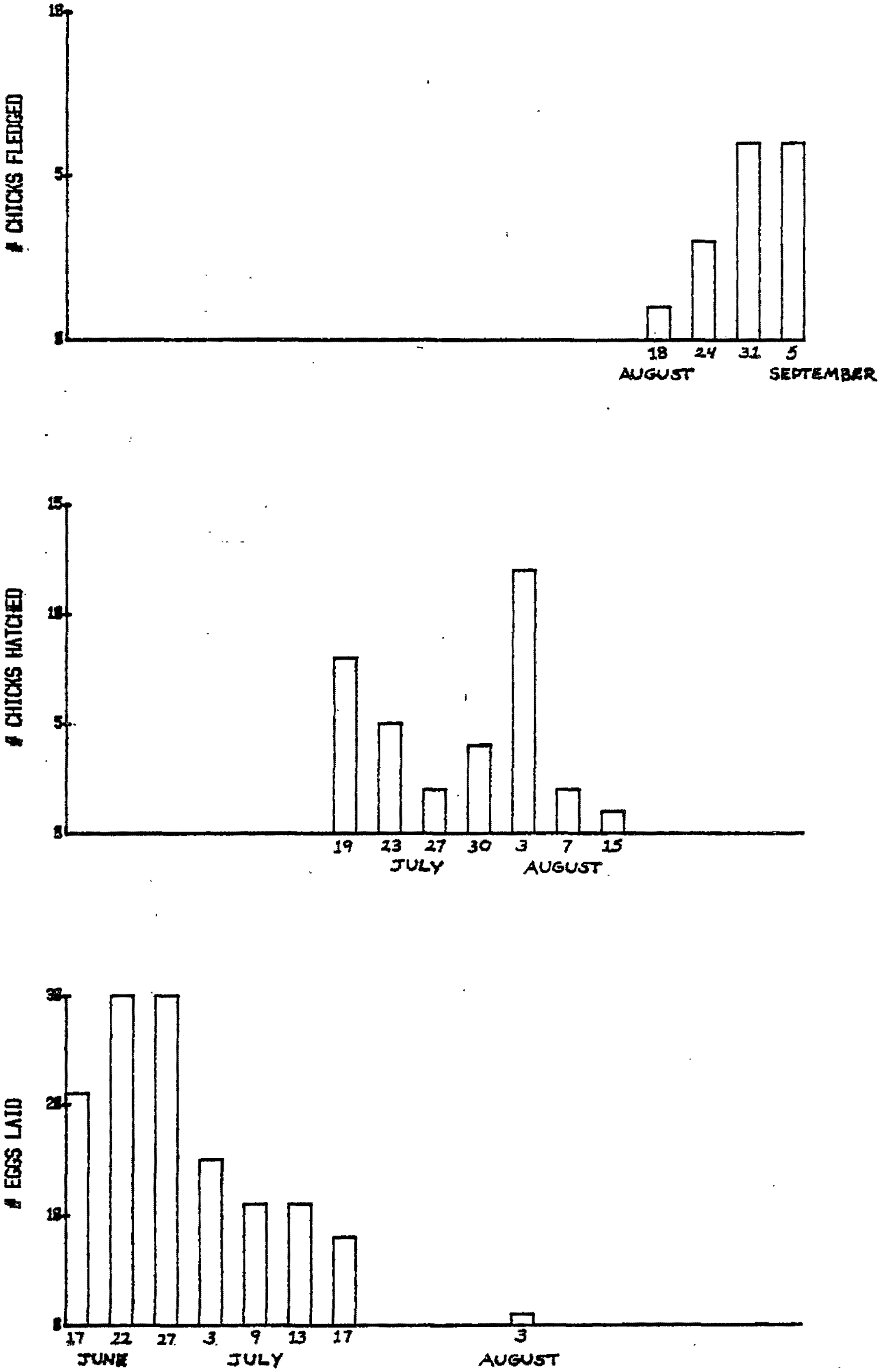

Figure 15. Chronology of black-legged kittiwakes, 1978.

MORTALITY:
BLACK-LEGGED KITTIWAKES

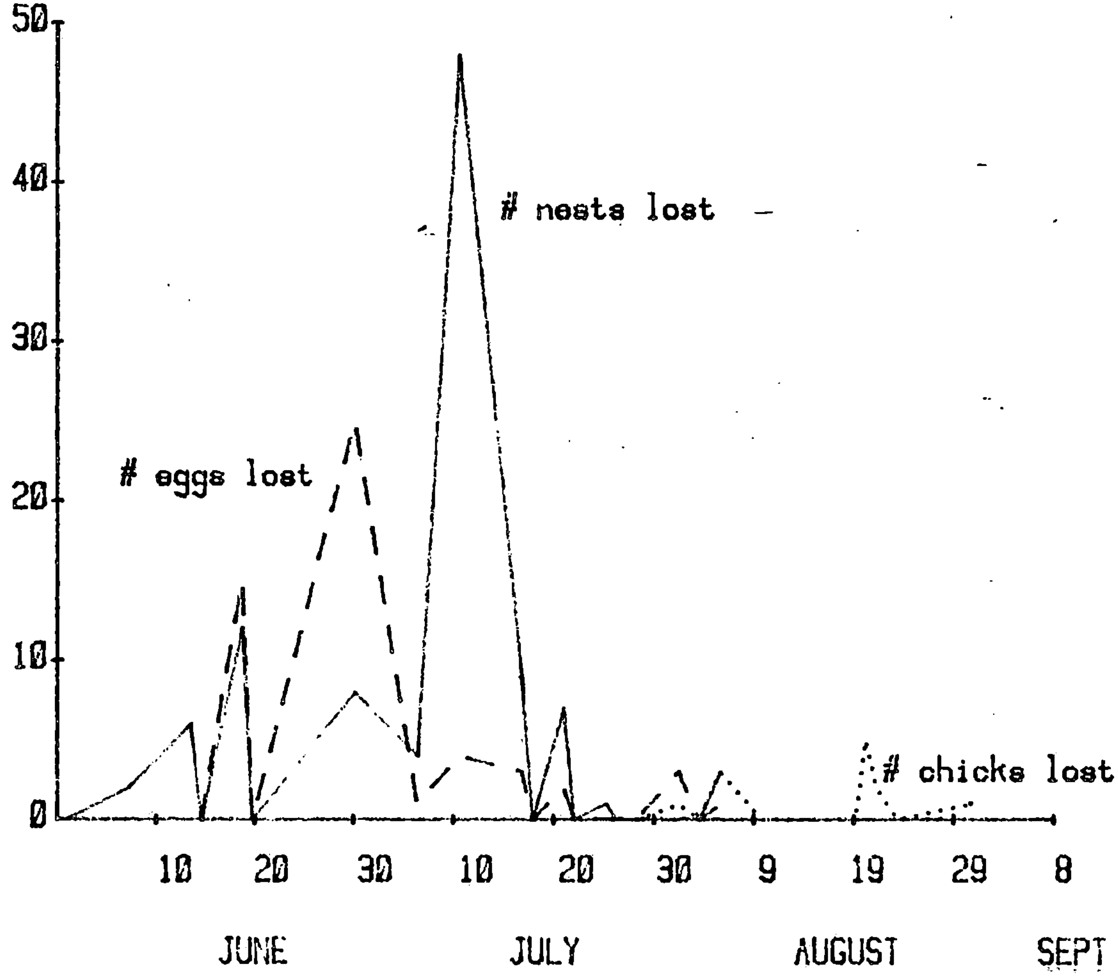

Figure 16. Mortality of black-legged kittiwakes.

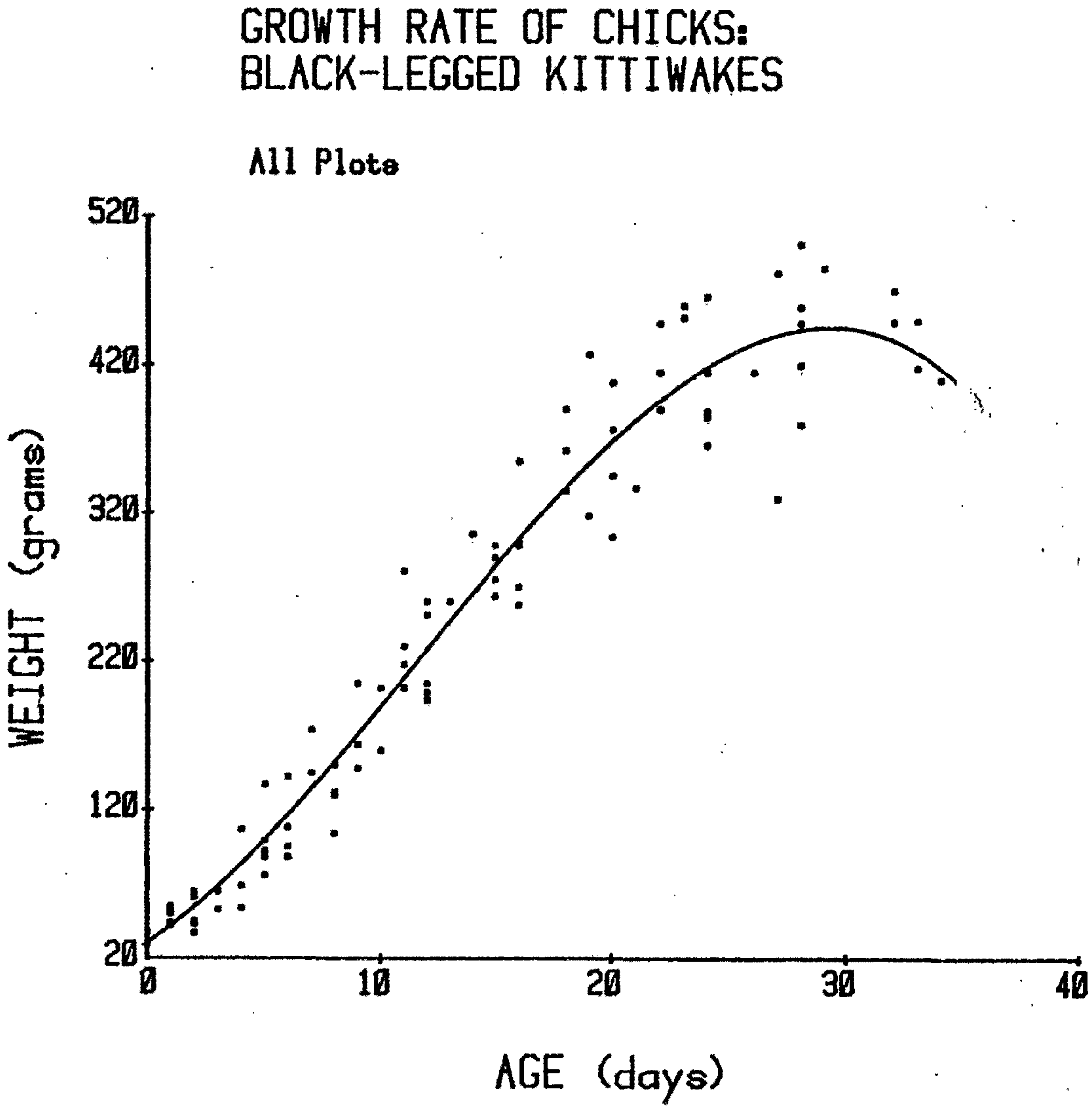

Figure 17. Growth of black-legged kittiwake chicks, 1978.

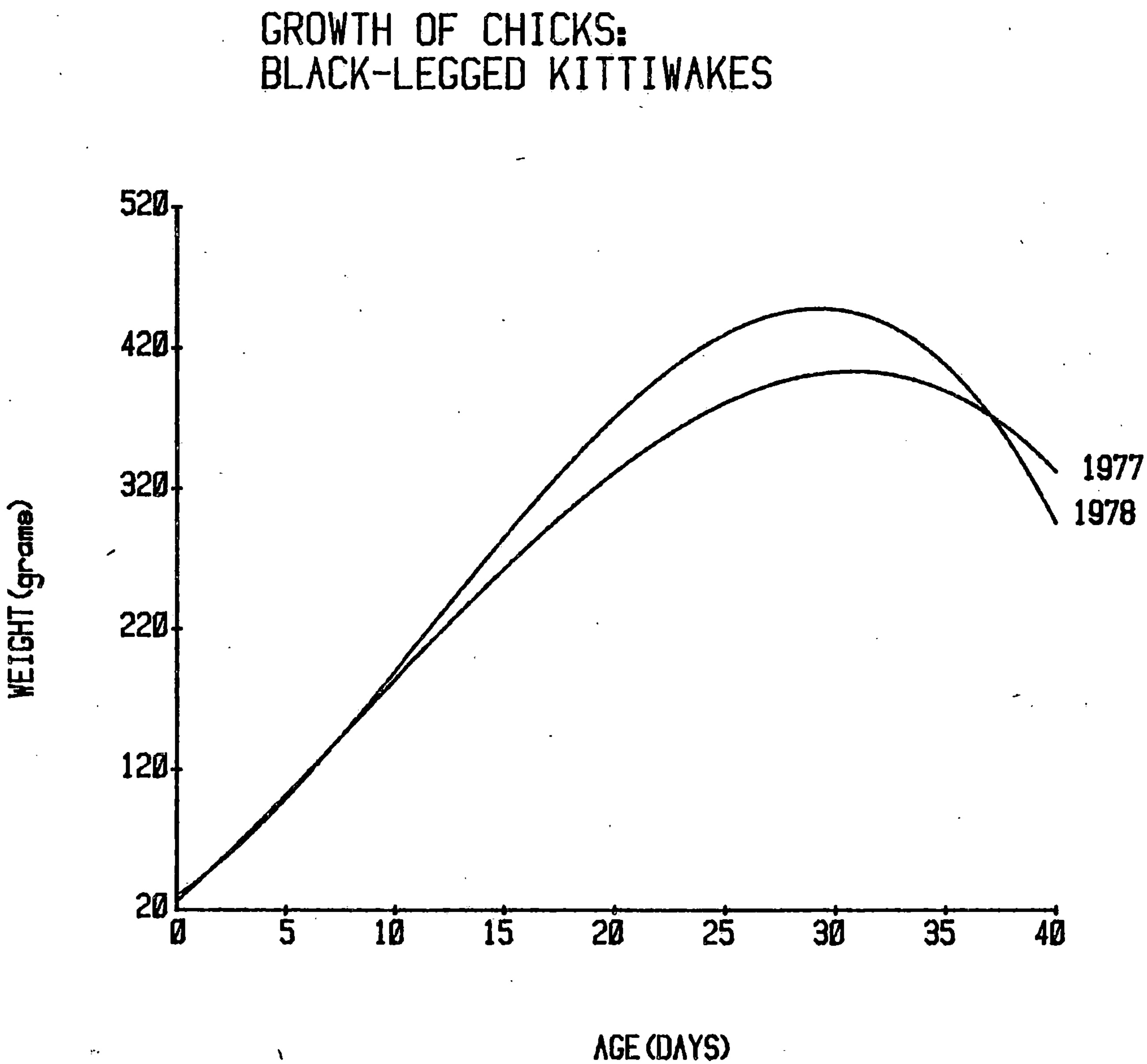

Figure 18. Growth of black-legged kittiwake chicks, 1977 and 1978.

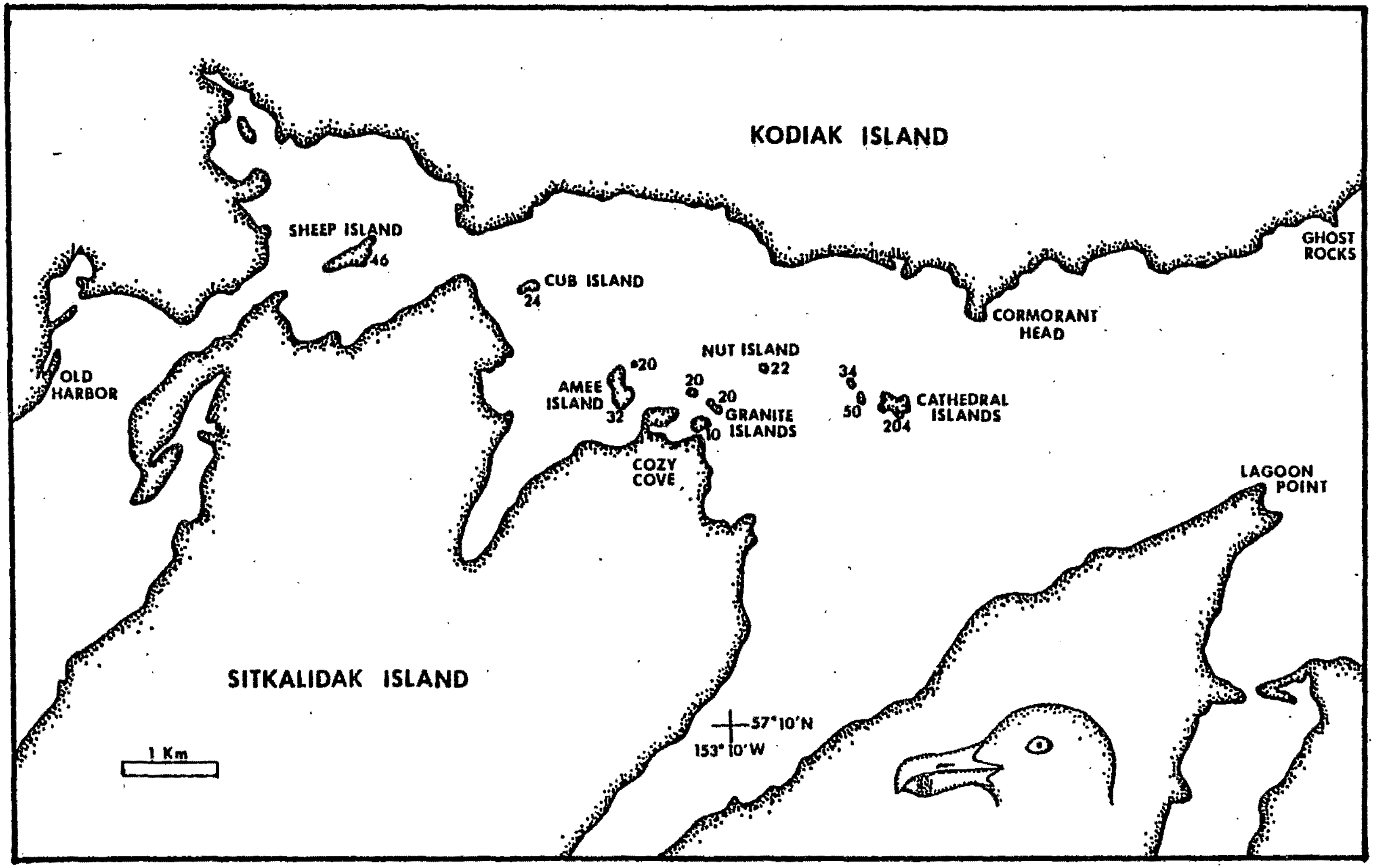

Figure 19. Distribution of glaucous-winged gulls.

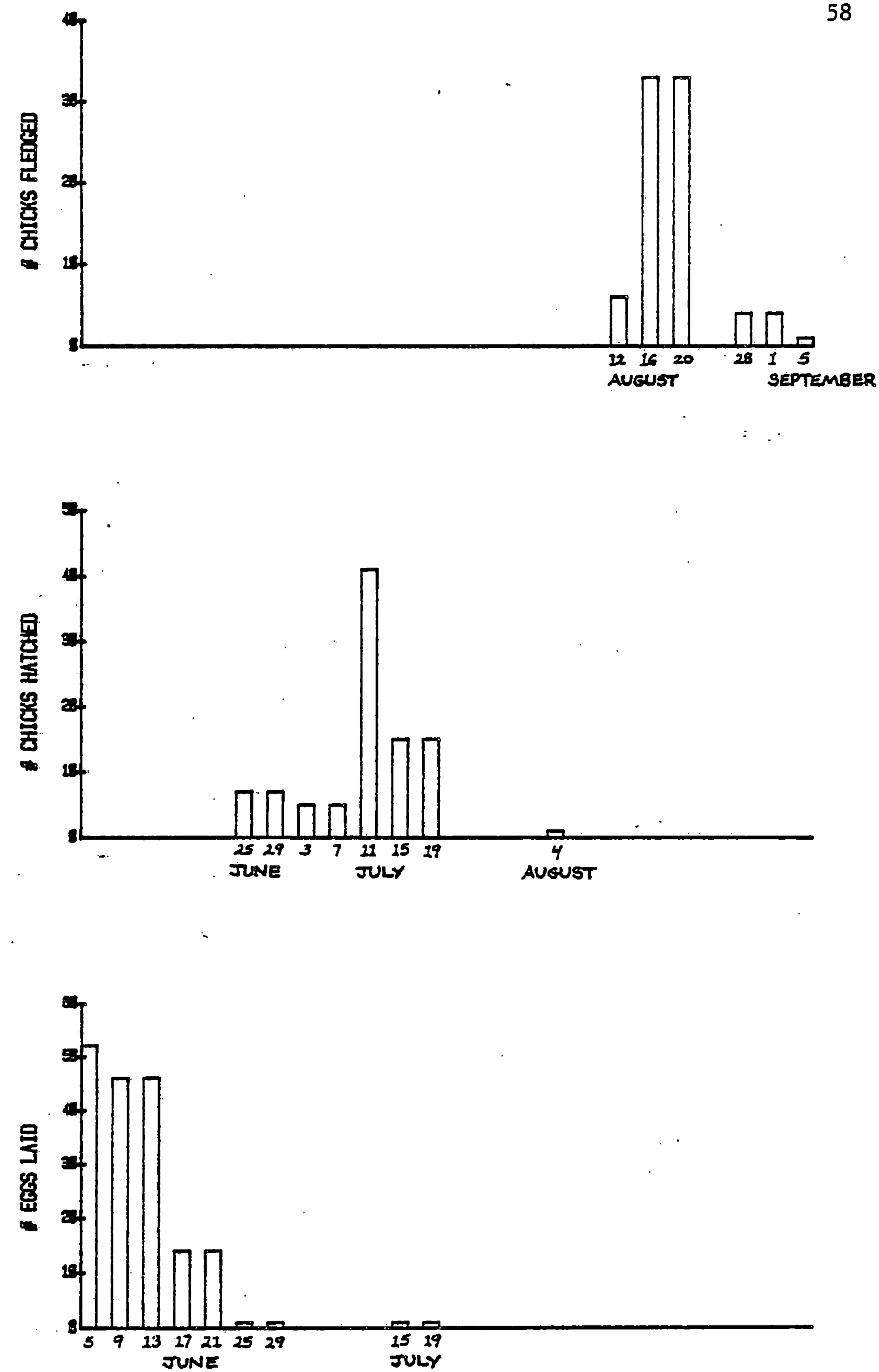

Figure 20. Chronology of glaucous-winged gulls.

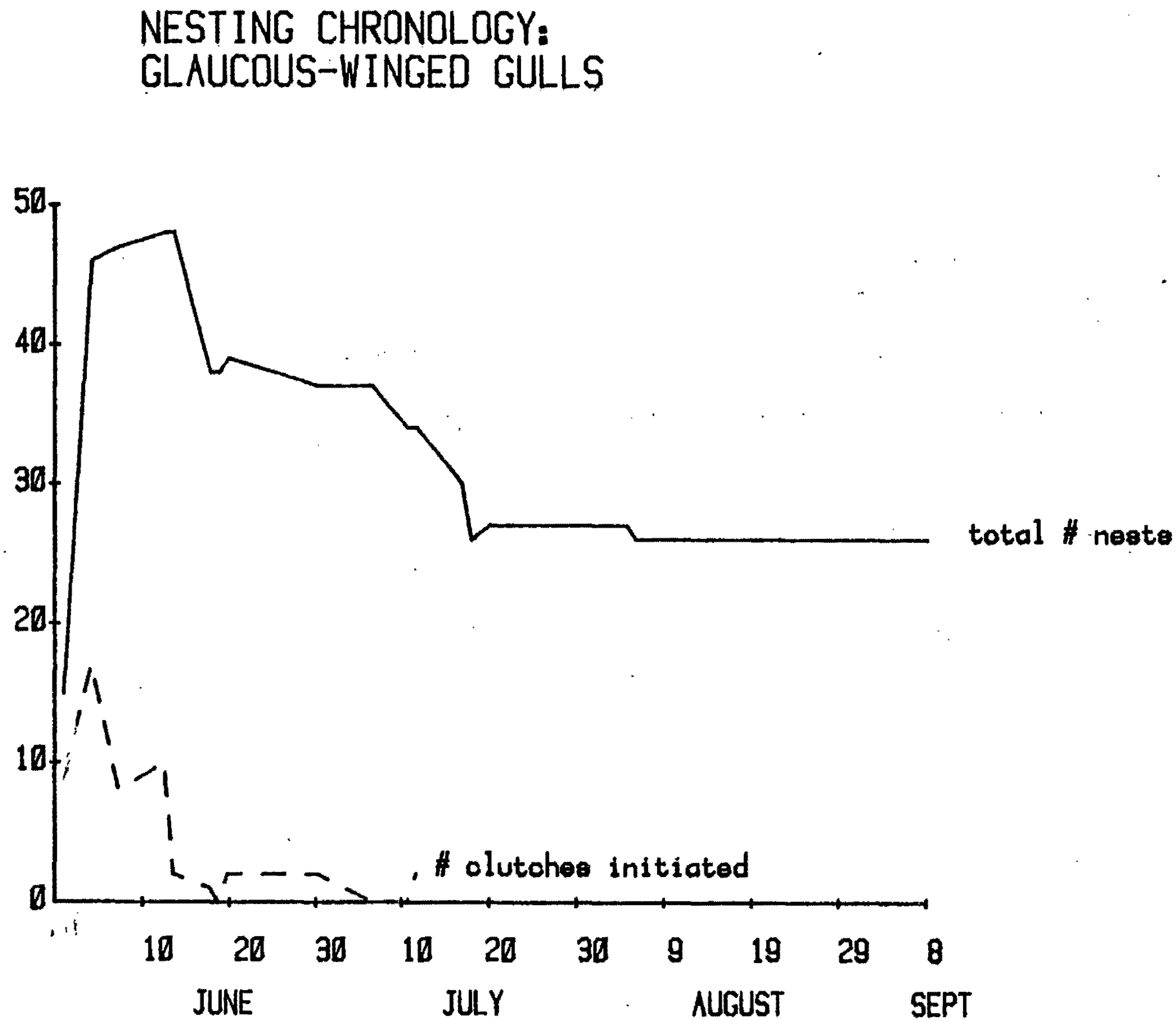

Figure 21. Nesting chronology of glaucous-winged gulls.

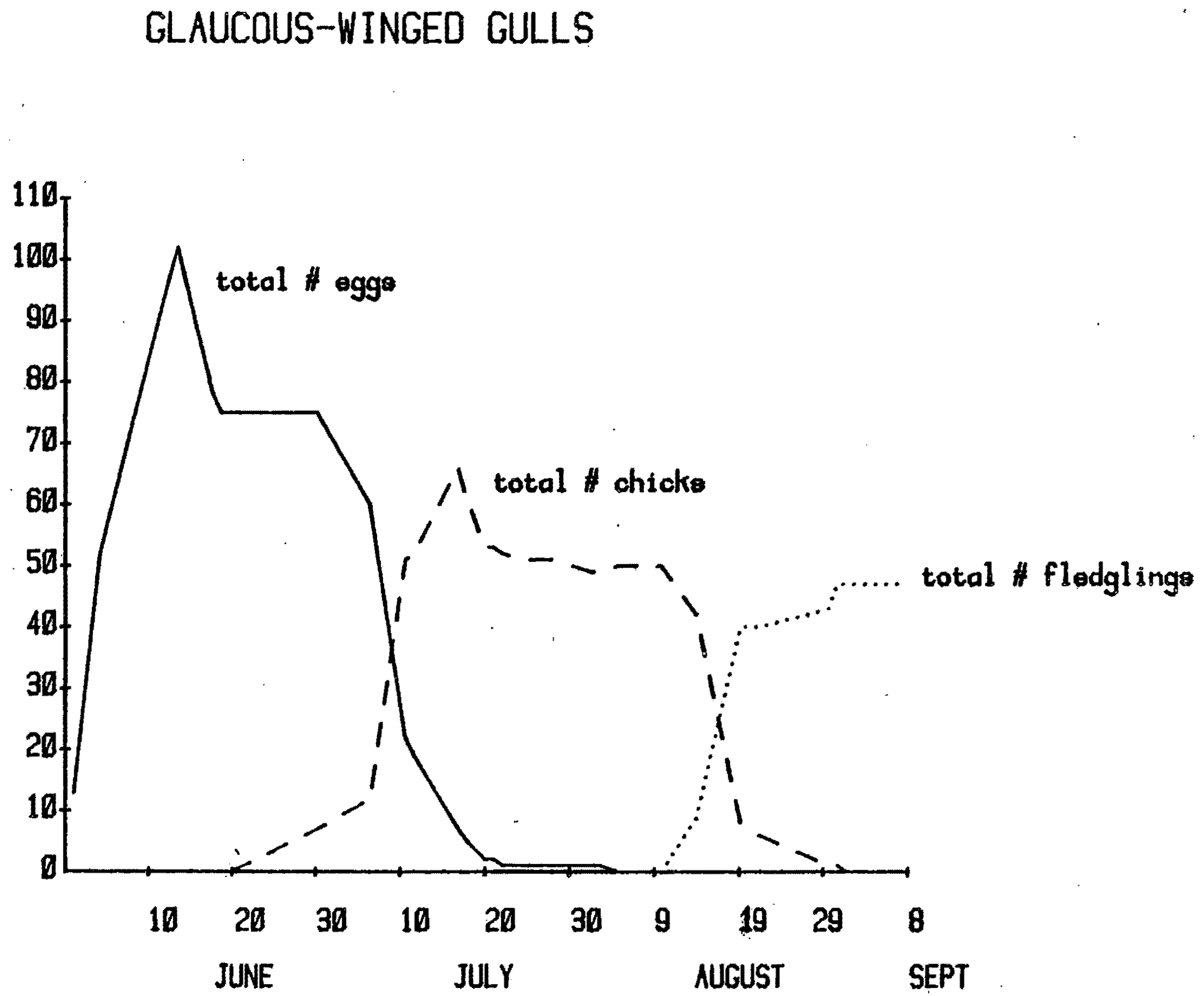

Figure 22. Numbers of glaucous-winged gull eggs, chicks and fledglings.

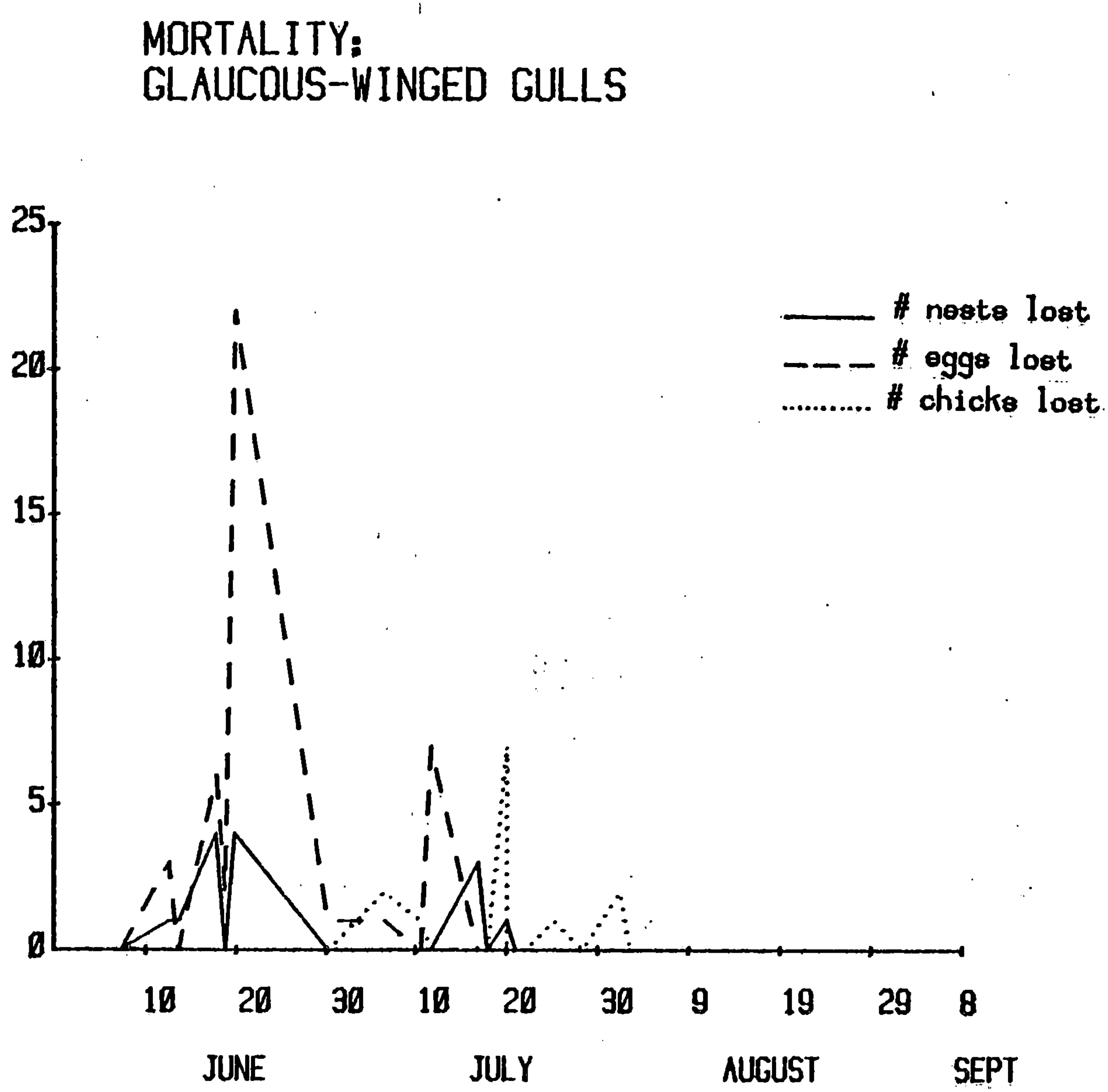

Figure 23. Mortality of glaucous-winged gulls.

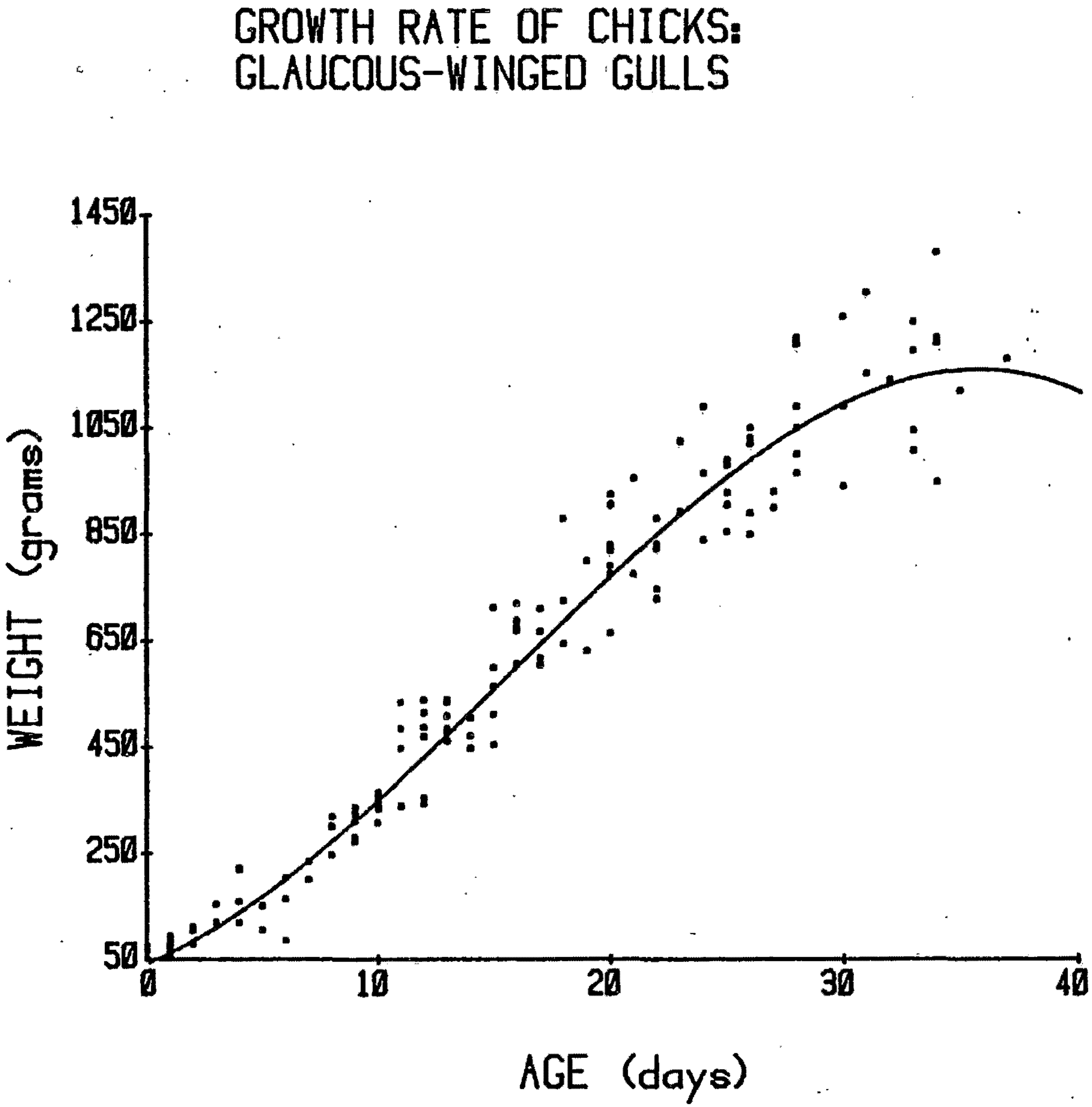

Figure 24. Growth rate of glaucous-winged gull chicks, 1978.

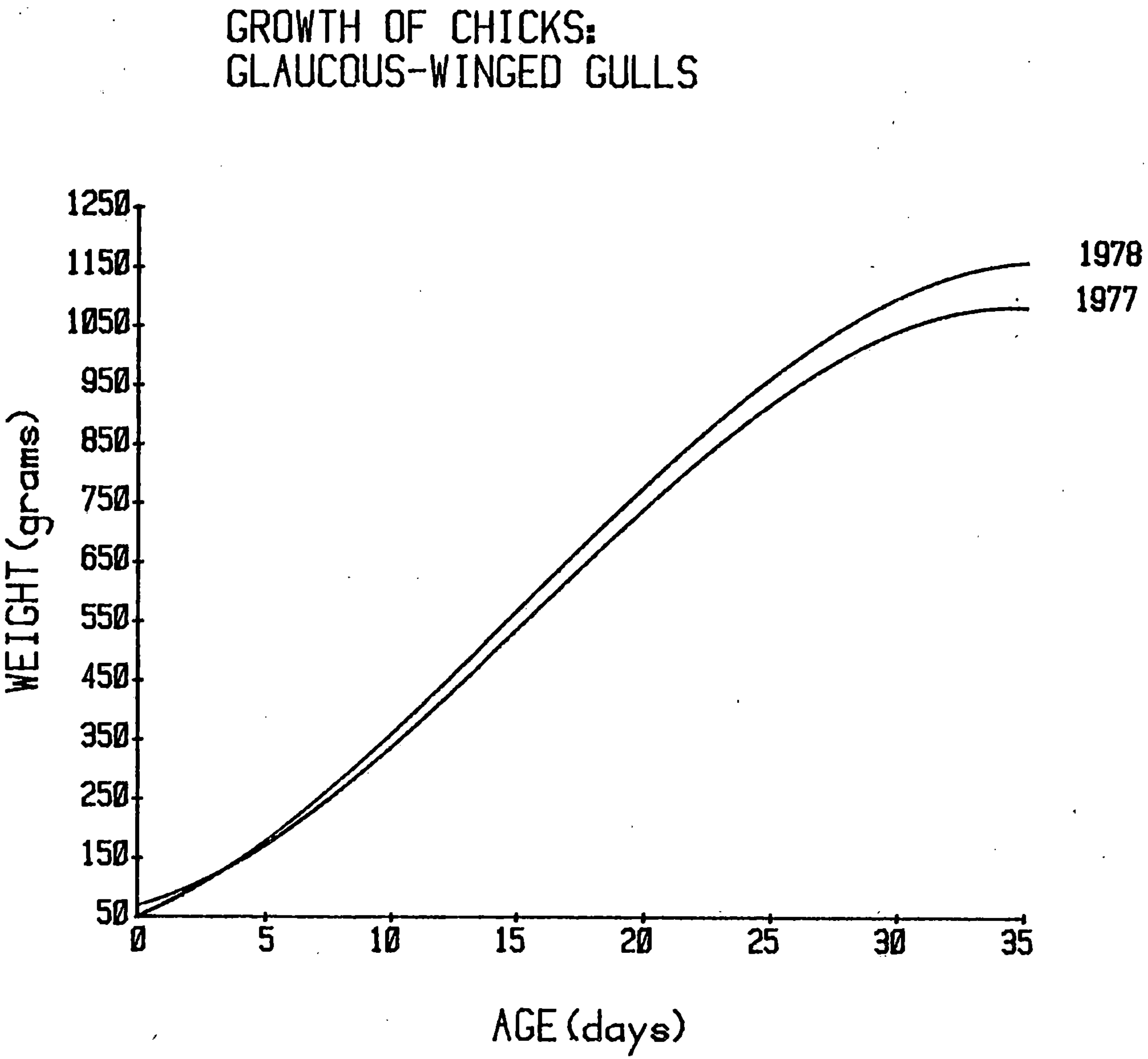

Figure 25. Growth rates of glaucous-winged gull chicks, 1977 and 1978.

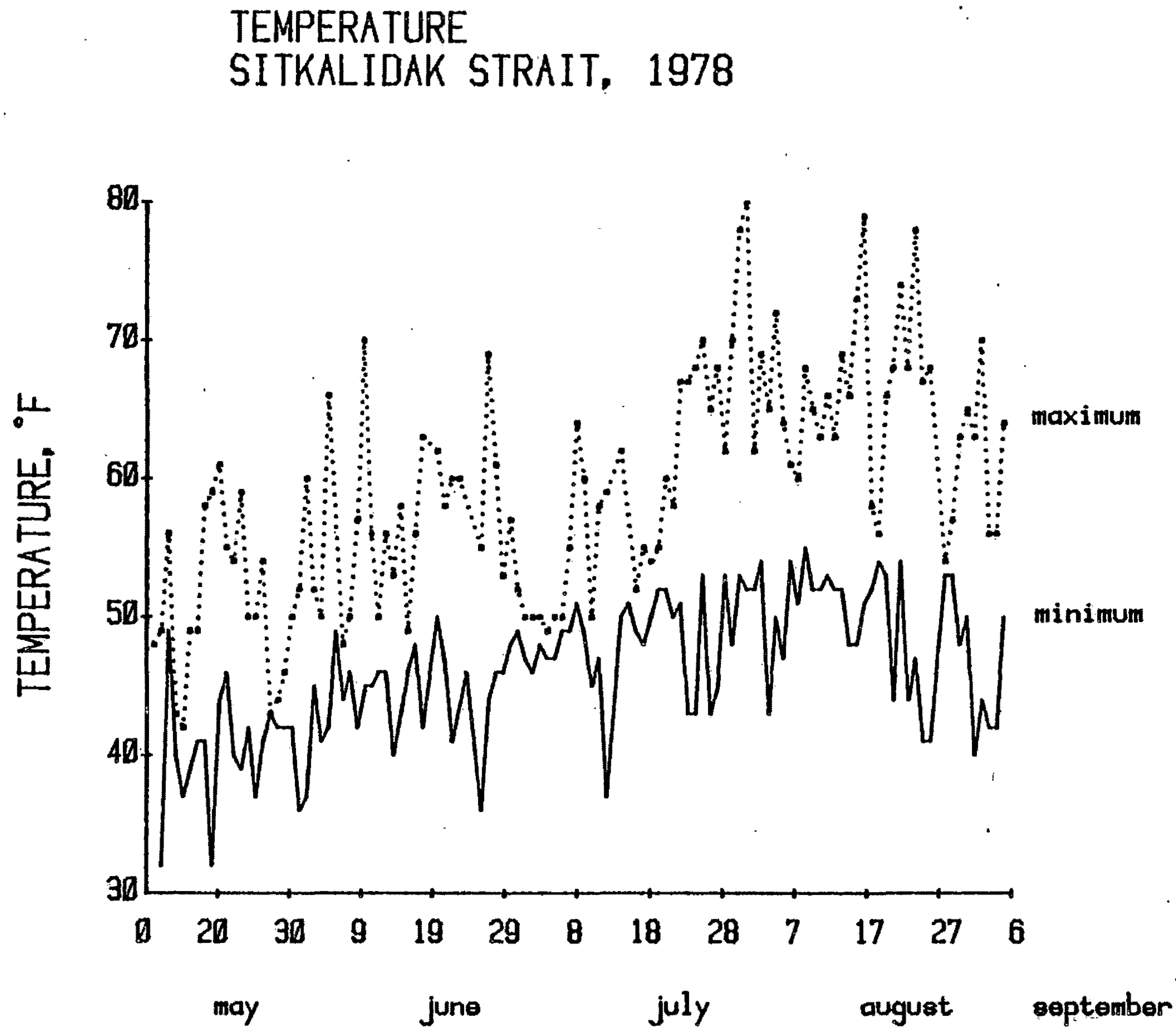

Figure 26. Temperature at Sitkalidak Strait, 1978.

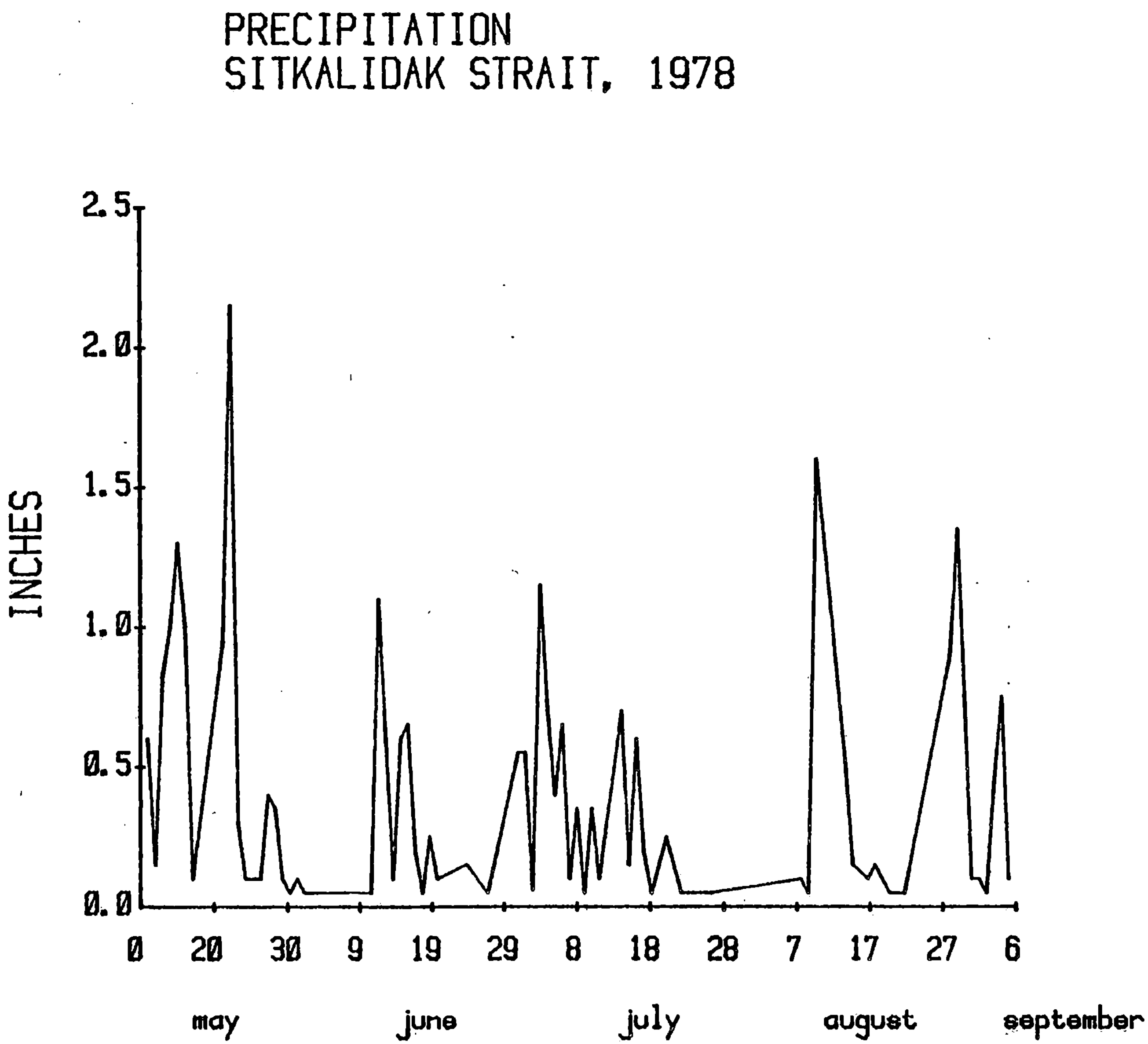

Figure 27. Precipitation at Sitkalidak Strait, 1978.

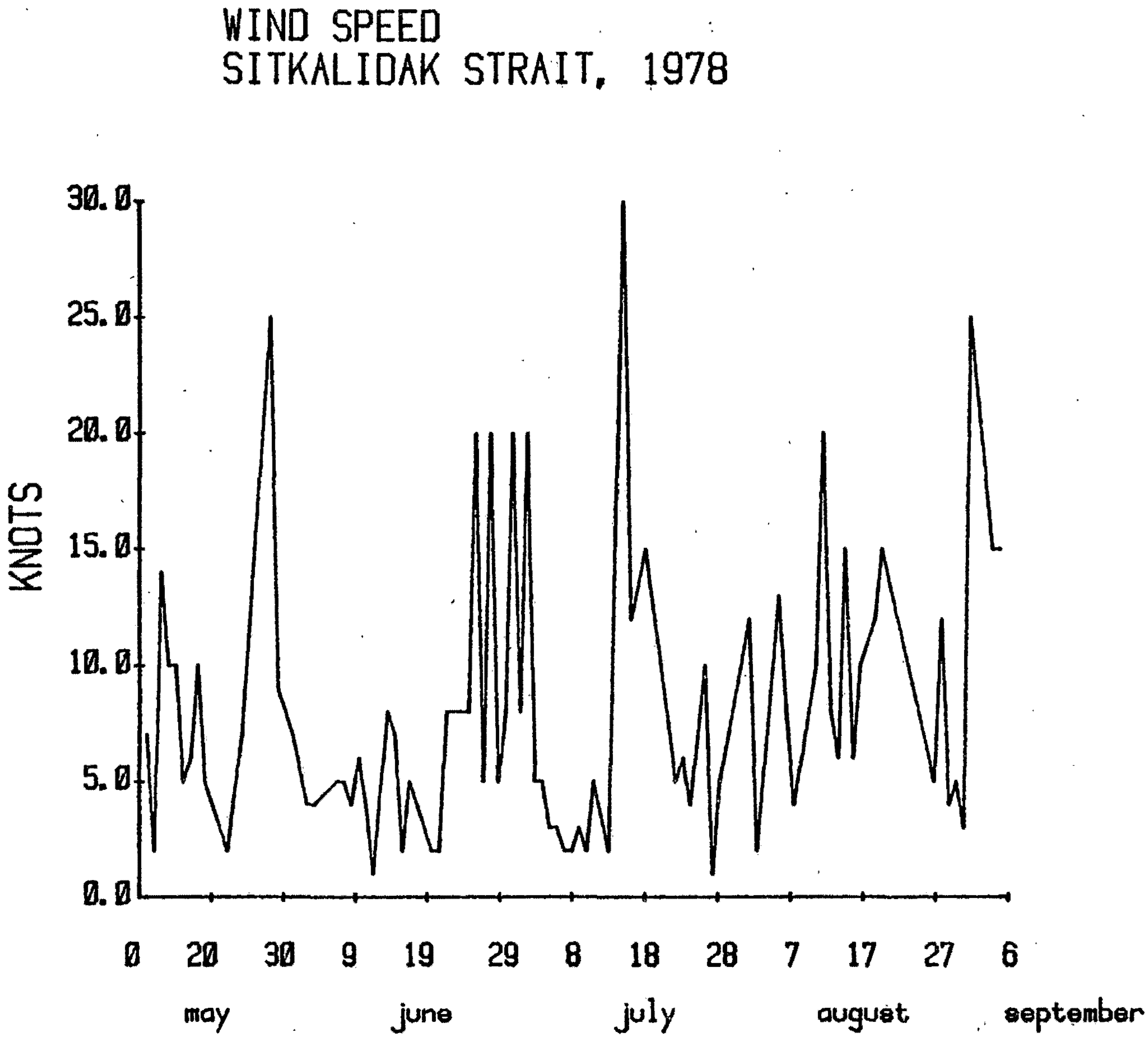

Figure 28. Wind speed at Sitkalidak Strait, 1978.

ADDENDUM

Species Account

Aves

Red-throated loon (Gavia stellata) One was seen in May off our camp beach.

Eared grebe (Podiceps caspicus) On 22 August two were near the Outer Granite islands.

Fulmar (Fulmarus glacialis) On 17 July and 9 August, during storms we saw one near Cathedral Island.

Shearwater (Puffinus spp.) During a storm on 17 July shearwaters were off Lagoon Point and on 9 August one was in a mixed feeding flock off Inner Granite Island.

Trumpeter Swan (Olor buccinator) A pair was in the lakes along the road to Ocean Bay on 24 August.

Mallard (Anas platyrhynchos) Mallards nested in small numbers on Sheep Island.

Pintail (Anas acuta) Thirty pintails were in the lakes along the road to Ocean Bay on 25 August. On 24 August at the head of Amee Bay there were 76 and on 3 September a flock of 10 was seen heading South.

Green-winged teal (Anas carolinensus) On 25 August there were 26 teal on the lakes near the road to Ocean Bay.

American widgeon (Mareca americana) Two females were on the lakes on the way to Ocean Bay on 20 June.

Scaup (Aythya spp.) On 20 June there were 20 scaup on the lakes along the road to Ocean Bay.

Harlequin duck (Histrionicus histrionicus) Harlequin ducks were common throughout the breeding season and were found in flocks of 6 - 30 from Sheep Island to Lagoon Point.

Red-breasted merganser (Mergus serrator) Red-breasted mergansers nested on Sheep, Cub, Amee, and Cathedral islands. They were not present in large numbers, but we saw them almost every day. The average clutch size of the four nests we found was 10.0 eggs. The first merganser chick fledged 14 July. Mergansers were also present on the lakes on the way to Ocean Bay.

Bald eagle (Haliaeetus leucocephalus) Bald eagles, both adult and immature were present throughout the breeding season. They stayed around the colonies during the early laying period of the seabirds and preyed on the adults. There were three aeries from Kiliuda Bay to Ocean Bay to Sheep Island.

Ptarmigan (Lajopies spp.) We found a dead ptarmigan chick on Dusk Island in Kiliuda Bay on 20 July.

Black oystercatcher (Haematopus bachmani) Black oystercatchers nested in small numbers on Sheep, Cub, and Amee islands.

Semipalmated plover (Charadrius semipalmatus) Semipalmated plovers nested on Sitkalidak Island. We saw a pair on the road to Ocean Bay on 20 June, and another pair with a one-to-two-day old chick at Port Hobron on 27 June.

Ruddy turnstone (Arenaria interpres) We saw one in breeding plumage in Amee Bay on 24 July.

Black turnstone (Arenaria melanocephala) We saw black turnstones off Cathedral Island 7-11 August and on Sitkalidak Island on 19 August.

Wandering tattler (Heteroscelus incanum) Wandering tattlers were observed occasionally throughout the breeding season - on 8 and 20 July on the Cub Island spit and on 20 July along the coast near Boulder Bay. On 28 August we saw one in winter plumage off the camp beach.

Lesser yellowlegs (Totanus flavipes) On 24 July in Amee Bay we saw one lesser yellowlegs and on 25 August we saw two on the Ocean Bay beach.

Western sandpiper (Ereuneks mauri) We observed 60 at Ocean Bay on 7 July and ten in Amee Bay on 24 July.

Mew gull (Larus canus). Mew gulls rested on Amee Island this year as they had in 1977, but in fewer numbers. The first chick fledged on 18 July.

Pigeon guillemot (Cepphus columba) Pigeon guillemots were nowhere abundant but were observed every day throughout the breeding season. They nested in low numbers on Sheep, Amee, Cub, Cathedral and the Granite islands.

Marbled murrelet (Brachyramphus marmoratum). Marbled murrelets were seen more often this year than in 1977, possibly indicating that they are increasing in numbers in the Sitkalidak Strait area. We saw the first fledglings on 25 August.

Ancient murrelet (Synthilbor amphus antiquum) An ancient murrelet was observed off Lagoon Point on 17 July during a severe storm.

Horned puffin (Fratercula corniculata) Horned puffins were not observed until 14 May. About 25 pairs nested on Cathedral Island and perhaps another 10 pairs were scattered among Sheep, Cub, and Amee islands.

Short-eared owl (Asio flammus) One flew over camp on 1 September at 2100 - approximately the same date we saw one last year.

Belted kingfisher (Megaceryle alcyon) On 12 July we found a pair of belted kingfishers nesting near our camp above Cozy Cave. A pair had nested nearby there in 1977.

Violet-green swallow (Tachycireta thalassina) Violet-green swallows were observed over a marsh on mainland Kodiak near upper Kiliuda Bay/ Shearwater Cove on 22 May.

Black-billed Magpie (Pica pica) Magpies nested on Amee and Sitkalidak Island and were seen constantly throughout the breeding season.

Common raven* (Corvus corax) Ravens were present throughout the breeding season but were observed most commonly in May and early June.

Northwestern crow (Corvus caurinus) Northwestern crows nested on small islands throughout the Sitkalidak Strait area and were much more abundant this year than last.

Winter wren (Troglodytes troglodytes) Winter wrens nested on Sitkalidak Island.

Golden crowned sparrow (Zonotrichia atricapilla) Golden crowned sparrows nested on Sitkalidak Island.

Fox sparrow (Passerella iliaca) Fox sparrows nested on Sitkalidak, Sheep, Caub, Amee, and Cathedral islands.

Song sparrow (Melospiza melodia) Song sparrows nested on Sitkalidak and Cathedral Islands.

Mammalia

Brown bear (Ursus arctus) Kodiak brown bears were present on Sitkalidak Island and Kodiak Island but we never observed them. In the spring and early summer they remained near a cattle ranch on Sitkalidak and later on they were at the salmon streams.

Shorttail weasel (Mustela erminea) As in 1977, shorttail weasels raised a litter near our camp on Cozy Cove.

River/land otter (Lutra canadensis) We observed otter sign on Dusk Island on 20 July and we saw an adult with two pups near our camp in early August.

Red Fox (Vulpes fulva) Red foxes were occasionally observed on the beaches of Sitkalidak Island and they always ran from us, unlike some of the foxes on the Aleutians.

Northern sea lion (Eumetopias jubatus) We observed a female sea lion in late August. Her bevavior was aberrant and we believe she was injured or sick.

Harbor seal (Phoca vibilium) We saw harbor seals throughout the season, usually basking on the rocks from Cub to Cathedral Islands.

Beaver (Castor Canadensis) On 7 June one beaver swarm past our camp - about the same date one swam by in 1977. On 22 August we saw four in a lake near our camp.

Tundra redback vole (Clethrnonomys rutilus) Voles were present on all the islands in the area.

Sitka white-tailed deer (Odocoileus virginianus) Sitka deer, an introduced species, were observed near camp on 3 and 7 June and 11 and 21 July. All were females. The deer on 21 July was being chased by people in an outboard motor boat.

Killer whale (Orcinus orca) We saw a pod of killer whales once on 23 July when we observed eight off Cathedral Island in Port Hobron Straits.

Harbor porpose (Phocoena phocoena) Harbor porpoises were sighted almost daily and often joined the seabird feeding flocks in Inner East Sitkalidak Strait. We saw them May through September.

Dall porpoise (Phocoenoides dalli) We often saw dall porpoises on the seaward side of Cathedral Island off the Lagoon Point seawatch site.

Minke or Piked whale (Balaenoptera acutorostrata) We observed minke whales from May through September and they were often seen in mixed feeding flocks of seabirds.

HABITAT PARAMETERS : BLACK-LEGGED KITTIWAKES

Plot #	Nest #	Nest Width (cm)	Dist. to water (cm)	Nest overhang presence *	Nest overhang %	Adjacent ledge presence *	Adjacent ledge % ovrhg.	Exposure	Dist. from top(cm)	Slope	Nearest Neighbor Distance
1	1	27	1151	0	0	1	0	170	70	70	20(#2)
1	2	22	1151	1	25	0	0	170	70	70	20(#1)
1	3	32	1001	1	25	1	0	173	100	40	60(#13)
1	4	20	891	1	25	1	75	145	210	75	45(#13)
1	5	25	841	0	0	1	0	145	260	90	30(#6)
1	6	20	841	0	0	1	0	145	260	90	30(#5)
1	7	17	791	0	0	1	0	155	310	85	30(#8)
1	8	22	794	0	0	1	0	155	307	85	30(#7)
1	9	23	751	0	0	1	0	205	350	65	71(#14)
1	10	18	491	0	0	1	0	191	610	65	15(#11)
1	11	21	421	0	0	1	0	195	680	85	60(#12)
1	12	23	446	0	0	1	0	195	655	85	60(#11)
1	13	16	882	1	75	1	25	173	219	90	45(#4)
1	14	20	491	0	0	1	0	205	310	60	55(#8)
2	1	20	395	0	0	0	0	185	140	50	80(#2)
2	2	21	445	0	0	1	0	185	90	55	80(#1)
2	3	20	530	0	0	1	0	180	5	60	90(#4)
2	4	25	395	0	0	0	0	130	140	90	40(#5)
2	5	20	438	0	0	0	0	130	97	90	40(#4)
2	6	31	310	0	0	0	0	155	225	90	33(#14)
2	7	25	325	1	25	1	0	120	210	85	28(#14)
2	8	25	286	0	0	0	0	145	244	80	26(#6)
2	9	23	226	0	0	0	0	195	309	75	25(#10)
2	10	28	271	0	0	0	0	195	264	85	25(#9)
2	11	22	335	0	0	1	0	175	200	65	53(#15)
2	12	20	325	0	0	0	0	175	210	75	55(#11)
2	13	20	415	0	0	0	0	175	120	75	27(#15)
2	14	20	325	0	0	0	0	120	210	85	28(#7)
2	15	21	410	1	25	1	0	175	125	80	37(#13)

* 0=no, 1=yes

HABITAT PARAMETERS ; BLACK-LEGGED KITTIWAKES

Plot #	Nest #	Nest Width (cm)	Dist. to water (cm)	Nest overhang presence *	%	Adjacent ledge presence *	% ovrhg.	Exposure	Dist. from top (cm)	Slope	Nearest Neighbor Distance
3	1	37	355	1	100	0	0	164	222	55	155(#12)
3	2	23	265	1	25	1	0	186	312	80	45(#13)
3	3	20	225	0	0	1	0	181	352	75	20(#13)
3	4	16	335	0	0	0	0	215	242	70	135(#15)
3	5	23	265	1	25	1	0	216	312	85	110(#3)
3	6	28	235	1	50	0	0	220	320	75	30(#9)
3	8	22	242	0	0	0	0	220	313	70	62(#6)
3	9	25	290	1	25	1	0	220	265	85	30(#6)
3	10	26	175	1	25	1	75	213	380	80	30(#11)
3	11	26	235	0	25	1	0	213	320	80	30(#10)
3	12	19	250	0	0	0	0	223	305	85	70(#9)
3	13	20	225	0	0	1	0	186	352	75	20(#3)
3	14	27	336	0	0	0	0	220	219	80	67(#5)
LKWR	1	16	1459	0	0	1	0	45	145	80	26(#41)
LKWR	2	25	1454	0	0	1	0	45	150	80	27(#14)
LKWR	3	23	1404	1	75	1	0	0	200	80	38(#46)
LKWR	4	20	720	0	0	1	0	40	780	90	100
LKWR	5	18	1275	1	75	0	0	40	225	90	178(#6)
LKWR	6	22	1453	0	0	0	0	40	47	90	55(#46)
LKWR	7	22	830	0	0	1	0	63	70	90	32(#9)
LKWR	8	20	805	0	0	1	25	62	95	90	88(#65)
LKWR	9	20	782	0	0	1	0	63	118	90	32(#7)
LKWR	10	17	813	1	50	1	50	62	87	90	66(#11)
LKWR	11	21	820	1	50	1	50	62	80	90	30(#48)
LKWR	12	27	850	1	50	1	25	30	50	90	46(#48)
LKWR	14	24	750	1	25	1	0	350	150	30	62(#52)
LKWR	15	20	855	1	25	1	0	15	45	80	31(#16)

*0=no, 1=yes

HABITAT PARAMETERS : BLACK-LEGGED KITTIWAKES

Plot #	Nest #	Nest Width (cm)	Dist. to Water (cm)	Nest overhang presence *	%	Adjacent ledge presence *	% ovrhg.	Exposure	Dist. from top (cm)	Slope	Nearest Neighbor Distance
LKWR	16	25	853	0	0	1	0	15	47	80	31(#15)
LKWR	17	25	865	1	25	0	0	80	35	90	55(#51)
LKWR	18	20	870	0	0	1	0	345	30	85	54(#16)
LKWR	19	28	735	0	0	0	0	50	110	90	35(#20)
LKWR	20	26	771	0	0	1	0	48	74	90	35(#19)
LKWR	21	26	784	0	0	1	0	48	70	90	38(#22)
LKWR	22	--	799	0	0	0	0	48	46	90	38(#21)
LKWR	23	20	772	0	0	1	0	48	73	90	30(#24)
LKWR	24	17	666	0	0	1	**	55	44	85	30(#23)
LKWR	25	24	592	0	0	1	0	55	118	90	35(#23)
LKWR	26	18	680	0	0	1	**	100	30	90	55(#25)
LKWR	27	--	245	0	0	0	0	40	465	80	15
LKWR	28	22	465	0	0	0	0	40	245	80	128
LKWR	29	20	585	0	0	0	0	55	125	80	70(#32)
LKWR	30	26	678	0	0	1	0	55	32	80	60(#25)
LKWR	31	38	490	0	0	1	50	40	220	90	43(#32)
LKWR	32	23	490	1	50	1	0	40	220	90	43(#31)
LKWR	33	18	302	0	0	1	0	55	38	85	42(#30)
LKWR	34	36	235	0	0	0	0	80	105	85	105(#36)
LKWR	35	18	350	0	0	0	0	40	360	80	15(#27)
LKWR	36	--	628	1	50	1	25	118	--	90	105(#34)
LKWR	37	20	1060	0	0	0	0	62	440	90	345(#8)
LKWR	38	21	1415	0	0	1	0	63	85	90	34(#7)
LKWR	40	30	655	0	0	1	0	50	90	90	35(#19)
LKWR	41	24	1404	0	0	1	0	45	200	80	26(#1)
LKWR	42	21	1434	0	0	1	0	45	170	80	33(#43)
LKWR	43	35	1399	0	0	1	0	45	205	80	33(#42)
LKWR	44	20	1480	0	0	1	0	45	124	80	27(#2)

* 0=no, 1=yes

** nest at top of cliff

HABITAT PARAMETERS : BLACK-LEGGED KITTIWAKES

Plot #	Nest #	Nest Width (cm)	Dist. to Water (cm)	Nest overhang presence *	Nest overhang %	Adjacent ledge presence *	Adjacent ledge % ovrhg.	Exposure	Dist. from top(cm)	Slope	Nearest Neighbor Distance (cm)
LKWR	45	15	1434	1	50	0	0	45	170	80	36(#3)
LKWR	46	15	1109	1	50	0	0	45	150	80	38(#3)
LKWR	47	17	1534	1	75	1	0	10	70	90	34(#38)
LKWR	48	32	715	1	25	0	0	62	100	85	30(#11)
LKWR	49	30	725	0	0	0	0	30	90	85	50(#13)
LKWR	50	26	803	1	25	1	0	40	97	80	35(#51)
LKWR	51	20	803	0	0	1	25	40	97	80	35(#50)
LKWR	52	26	680	0	0	1	25	350	220	70	62(#14)
LKWR	65	20	820	1	75	1	50	62	80	85	35(#11)

* o=no, 1=yes

HABITAT PARAMETERS : TUFTED PUFFINS

Plot #	Nest #	Dist. along transect (m)	Dist. from transect (cm)	Nearest Neighbor Distance (cm)	Slope	Soil Depth (cm)	Window Location (cm)
Cathedral Island							
2	1	8.45	L 125	130(#2)	22	26	R 90
2	2	7.55	L 106	* (#6)		in rock(connected #6)	
2	3	7.25	R 56	70	28	8	U 35,R 22
2	4	6.65	R 115	75	38	19	U 45
2	5	7.06	R 128	false burrow			
2	6	6.77	L 103	100	25	in rock	U 58 L 40
2	7	5.30	R 167	105	22	68	no chamber(conn. #10)
2	8	5.95	L 10	70(#3)	38	45	U 51,L 35
2	9	4.65	0	103(#7)	17	61	U 48
2	10	5.35	R 90	82	20	47	no chamber(conn.#7)
2	11	4.34	R 131	103(#8)	29	31	U40,L 60
2	12	0.50	l 90	70(#22)	40	18	U 56,R 20
2	13	2.05	L 10	60(#27)	28	35	U 60,R 23(conn.#27)
2	14	3.35	L 70	63(#13)	24	39	L 72
2	15	2.37	L 60	63(#14)	27	32	U 60 R 23
2	16	3.50	L 136	90(#14)	30	19	U 20,L 90
2	17	2.04	R 26	55	18	42	U 60
2	18	1.30	R 8	45(#20)	26	15	U 20(conn.#21)
2	19	1.85	L 94	60	22	41	U 30,R 20
2	20	1.00	L 63	45(#18)	28	40	U 48,L 15
2	21	0.95	R 34	68(#20)	27	20	U 20(conn.#18)
2	22	0.80	L 160	45	34	32	U 55, L 24
2	23	1.60	L 190	56	22	43	U 10,R 38
2	24	2.65	L 177	70(#23)	25	32	U 45,L 42
2	25	5.95	L 10	70(#3)	38	45	(conn.#8 at entrance)
2	26	8.44	R 35	92(#3)			
2	27	2.85	R50	60(#13)	23	40	U 53,R 25(conn.#13)
3	1	0.70	L 35	90	24	20	U 32
3	2	4.69	R 90	65	29	75	R 36
3	3	5.00	L 18	43	28	24	U 55,R 63
3	4	5.65	L86	60	29	28	U 43,R 53
3	5	6.85	0	106	25	36	R 65
3	6	6.70	R 39	100	26	23	U 55 L 59
3	7	8.85	R 40	65	28	25	U 45, L 24
3	8	9.50	L 5	65	27	32	R 44
3	9	10.02	R 100	175	26	18	L 63
3	10	14.35	R 15	93	25	17	U 26,R 26

* connected (no nearest neighbor distance)

HABITAT PARAMETERS : TUFTED PUFFINS

Plot #	Nest #	Dist. along transect (m)	Dist. from transect (cm)	Nearest Neighbor Distance (cm)	Slope	Soil Depth (cm)	Window Location (cm)
4	1	0	R 24	92(*2)	41	23	U 61,L 22
4	2	1.43	L 19	66	41	39	U 40,L 55
4	3	1.30	L 100	80	18	56	R 82
4	4	1.55	R 100	80	33	70	U 88
4	5	3.40	L 14	80	23	81	L 38
4	6	7.07	L 24	160	32	66	U 65
4	7	12.34	R 23	74	38	23	U 26,L 49
4	8	12.08	L 70	90(#9)	18	35	U 36,L 20
4	9	14.94	L 86	90(#8)	18	42	U 36,L 20
5	1	3.23	L 63	130(#2)	19	35	U 75,R 63
5	2	2.09	L 33	92(#5)	14	18	U 50,L 36 & D 42,R 20
5	3	2.09	R 47	50(#6)	18	46	no chamber
5	4	2.84	R 89	103(#9)	9	12	U 80,R 43
5	5	1.39	L 94	45(#8)	17	12	U 44,R 25
5	6	1.51	R 40	50(#3)	22	23	reachable
5	7	1.43	L 176	76(#8)	14	33	U 77
5	8	1.39	L 133	45(#5)	19	24	U 55,L 25
5	9	1.77	R 114	69(#6)	90	0	in #6
5	10	0.87	L 65	60(#11)	27	30	U 56
5	11	0.50	L 35	50(#8)	31	33	U 52
5	12	0.90	R 160	110	35	33	reachable
5	13	0.25	R 15	65(#10)	36	14	in #10
5	14	0	L 35	62(#15)	31	0	reachable: in rocks
6	1	1.9	L 7	60(#2)	18	40	U 45, R 20
6	2	2.8	R 25	60(#1)	18	20	U 60,R 36
6	3	3.75	L 30	56(#4)	30	51	U 70,L 33
6	4	3.75	L 70	56(#3)	26	51	U30,R 5
6	5	4.10	L 106	80(#4)	10	53	U 55,R 34
6	7	4.65	R 43	61	30	54	U 52,R 25
6	8	6.90	R 10	148(#9)	14	63	U 60,R 40
6	9	7.05	L 32	148(#8)	12	52	R 75 & U 60,R 75
7	1	0	R 34	66(#2)	24	19	U 83 (*#3)
7	2	0.9	L 13	66(#1)	24	22	U 58,L15(in#3)
7	3	1.41	0	60(#2)	24	46	U 83 (* #1)
7	4	2.00	L 43	46	24	10	a)L 63 b) U 69
7	5	1.92	R 78	53	24	40	reachable
7	6	2.75	R 58	70	30	42	U 90
7	7	2.99	L 42	80(#4)	30	33	U 53
7	8	4.17	R 47	50	22	12	U 45
7	9	4.00	R 95	78	22	57	U 50
7	10	3.95	L 82	50(#11)	48	22	U 48 (*#7)

* connected to