Breeding and Feeding Ecology of Pigeon Guillemots (*Cepphus columba*) at Naked Island, Alaska

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INTRODUCTION

The Special Studies division of Ecological Services, U.S. Fish and Wildlife Service was organized to study the effects of the construction and operation of the trans-Alaska pipeline on the environment. Part of the Special Studies program has consisted of obtaining baseline information on marine bird and mammal populations in Prince William Sound where the pipeline terminus is located. This report presents results of fieldwork conducted on the pigeon guillemot (Cepphus columba) at Naked Island in Prince William Sound during the 1979 field season. A description and history of the Naked Island complex are presented by Oakley and Kuletz (1979) in a report on the initial (1978) field season of the pigeon guillemot project. A map of the island complex with colony sites marked is presented in Figures 1 and 2.

METHODS

Breeding Biology and Ecology of the Pigeon Guillemot

Breeding Chronology and Colony Attendance

Five colonies were selected (Fig. 1) for detailed observations of breeding behavior. Nests of 30 pigeon guillemots from the colonies were monitored to determine the range of dates for egg laying, hatching and fledging. All nests were found during the egg stage and followed to completion. Data from these nests were also used to determine production and nesting success on Naked Island. General observations of adults carrying fish, juveniles on the water, plumage condition and measurements of brood patches and gonads of collected birds provided additional information on breeding chronology.

Observations on colony attendance of pigeon guillemots were made from mid-May until mid-August. Colonies were watched periodically for periods of three to 24 hours and the number of birds on rocks or in the water near the colony were recorded every 15 or 30 minutes. Chase flights, copulations and attempted copulations were recorded during this period. Additional data on colony attendance were obtained from time-lapse cameras overviewing one colony. Numbers of birds on the water and on rocks were recorded by frame. The camera was set at 30 or 60 second intervals and functioned from 24 to 48 hours.

Feeding Ecology

Information was collected on forage species, forage areas and feeding rates of adult and juvenile pigeon guillemots using the following methods:

Forage Species - Forage species were determined from 1) stomach contents of collected birds 2) observations of food items carried to the nest and 3) collection of food items found near the nest and 4) limited sampling of benthic food species with minnow traps:

1. Collected birds - Twenty pigeon guillemots were collected for food habits; 10 during late May and 10 during late June. Diving birds were watched for several minutes before collecting. Birds were weighed immediately, then the esophogus and gizzard were injected with 10% formalin. Stomachs were dissected later in the day, and fixed in 10% alcohol after a period of several days. A rough sort of stomach contents was made using a dissecting microscope. Further analysis will be done at a later date.

2. Chick feeding observations - Observations of food brought to young are useful in the study of pigeon guillemot food habits (Slater and Slater 1972). Observation points at four colonies were established to determine the type, size and frequency of fish brought to young. Observations were conducted from blinds or an open boat for four to six hour periods using binoculars or 20-45 power spotting scopes. Fish specie, size of fish as a multiple of bill length, and time of delivery were recorded by individual nest when possible. Often it was difficult to identify fish to the species level but they could easily be placed into one of five general groups: blennies (Stichaeidae, Pholidae), sandlance (Ammodytidae), cod (Gadidae), sculpins (Cottidae), flatfish (Pleuronectidae). Occasionally fish dropped near the nest site by adults or rejected by young birds were collected, identified, measured and weighed. Casual observations of adults carrying fish during other aspects of field work were recorded and treated separately.

3. Sampling of forage fish - Twelve minnow traps were baited with dead fish or food remains and placed at depths of 3 to 10 meters in two bays on three occasions. Collected fish were identified, weighed and measured.

4. Time lapse camera analysis - A super-8 movie camera adapted for time lapse photography was positioned on a nest to determine feeding rates and food species brought to young. Intervals between shots varied from 20 to 23 seconds permitting approximately 24 hours of exposure per roll. Adults were watched from a nearby blind to

insure that this interval allowed a photograph of the adults perched at the nest entrance with a fish in the bill. Fish size and species were determined for each delivery photographed, when possible.

Foraging Areas - During chick feeding observations, foraging areas were determined by mapping locations where pigeon guillemots landed after delivering a fish. Locations were recorded for individual nests when possible. Foraging locations for the colonies were also mapped from vantage points near the colony. At the end of the season, depth profiles were mapped of important foraging areas with a small sonar depth finder.

Feeding Rates - Before chick rearing began, adult feeding activity was monitored to determine foraging areas and feeding behavior. Groups of pigeon guillemots were divided into singles, pairs, and groups of three of more and placed into four distance-from-shore categories: 1-100m, 100-500m, 500-1000m, and more than 1000m. When a pigeon guillemot or group of pigeon guillemots was sighted, the number of dives per bird was recorded during 10 minutes. Observations were made from as far away as possible to minimize disturbance. Feeding rates of adults feeding young were determined from direct observations and time lapse cameras at one nest.

Mensurial Characteristics of Chicks and Adults

Accessible pigeon guillemot chicks were measured for growth every third or sixth day until fledging. Tarsus, culmen, and wing chord were measured to 1.00 mm with venir calipers. Weight was determined from pesola scales of 100, 300 or 1000 g. Chicks weighed within 24 hours of fledging were used to estimate mean fledgling weight and size. The percentage of primaries still sheathed was estimated and the plumage described according to one of eight categories (Table 1). All measurements for a given parameter were averaged to yield a class mean.

Measurements and weights for adult pigeon guillemots were obtained from 20 birds collected for food habits and 20 birds mist-netted for color marking. All birds were weighed, and the tarsus, culmen, wing chord, brood patch, and gonads were measured on all collected birds.

General Seabird and Marine Mammal Surveys

A census of seabirds of the Naked Island complex was conducted from a small boat by circumnavigating each of five islands at a distance of 50-100 m from shore. The island shorelines were divided into segments and all birds were counted and recorded by segments. Counts were conducted between 0700 and 1100 hours. Weather during censusing was clear or overcast with light winds.

In addition to the island census, two inshore transects and one offshore transect (Fig. 2) were surveyed throughout the season. All birds within 200 m of the boat were counted at a speed of about 20 mph. All transects were surveyed during the mornings when sea and light conditions were good.

Counts of birds other than seabirds were recorded during all surveys. Colony location and size were recorded as well as observations on general behavior, ecology, migration, nest success and food habits.

All sightings of marine mammals during surveys and general fieldwork were recorded and mapped. Areas of concentration were noted. General observations on movements, migration and food habits were made.

Daily records of wind direction, temperature, and precipitation were made and are summarized in Appendix I.

RESULTS AND DISCUSSION

Pigeon Guillemot Breeding Chronology

The median dates and ranges of fledging and laying periods in 1979 are compared to 1978 and presented in Table 2. The breeding condition of birds collected for food habits analysis is shown in Table 3. Observations related to timing of breeding activities are listed below.

Arrival and Pre-laying

Pigeon guillemots were present on the study area upon our arrival on May 9. Pairs were active at colony sites for short periods of time, particularly in the morning. Chasing, billing, and attempted copulations were common by 15 May and frequency increased through May. Length of time on colony rocks or near the colony also increased through May.

Tidal fluctuations appeared to influence colony attendance from mid-May through the season. Pigeon guillemots seemed to concentrate activities at the colony for a several hour period before and after high tide. This phenomenon was also noted by Slater (1976) for Uria algae but Drent (1965) noted no correlation with pigeon guillemot colony activity and tide fluctuations. Data concerning counts of numbers of pigeon guillemots at the colony correlated to the time of day and tide will be statistically analyzed by computer for this study and included as an appendix when computer time is available.

Incubation

The first nest was found on 25 May and it contained two eggs. Thirty more nests were found in June, the last one on 26 June. Ranges and median of laying were identical for each year. Because most of the nests followed in 1979 were returns from 1978, less variability might be expected than from a different set of nests each year.

Chick Period

The first chick in our study nests hatched on 29 June, however, adults in the area were first observed carrying fish on 27 June. Median hatching dates and ranges for 1978 and 1979 are listed in Table 2. Dates were similar for each year.

Fledgling Period and Departure

The first juvenile on the water was seen on 21 July. The first chick from nests followed in this study fledged on 31 July. All of the chicks we followed had fledged by 23 August. However, adults feeding young were observed at other nests until our departure on 27 August. Peak concentrations of juveniles were observed in Cabin Bay on 15 August, when 15 juveniles were counted in close proximity. It appears that juveniles do not remain near the colony but move to coves often considerable distances away. Nest sites and three locations of three fledglings marked with pitric acid are shown in Figure 3.

Sightings of juveniles were less common in late August but occurred until our departure on 27 August. Adult attendance at the colony also decreased markedly in late August.

Pigeon Guillemot Breeding Success

Mean clutch size, hatching and fledging success figures for pigeon guillemots in 1978 and 1979 are presented in Table 4. A comparison of nests common to 1978 and 1979 is also found in Table 4. Clutch size was slightly higher in 1979 than 1978, possibly due to increased nesting experience of the adults involved. Although clutch size was higher, hatching and fledging success were lower in 1979 than 1978. We think the 1979 values may be more typical because results were based on nests found in the egg stage in 1979 where most nests were found in the chick stage in 1978. Results from both years at Naked Island are considerably higher than results from other studies (Moe and Day 1977; Thorenson and Booth 1958). Prey species, particularly sandlance, appeared abundant as in 1978 (Oakley and Kuletz 1979), which may have contributed to high success rates. Predators such as raven (Corvus corax) and river otters (Lutra canadensis) frequented colony sites and caused considerable alarm. However, we do not know the extent of predation by either aerial or land predators. Two egg clutches which produced only one young could usually be attributed to infertile eggs rather than loss of eggs or death of one chick.

Feeding Ecology

Adult Food Habits

Preliminary frequency of occurrence results of esophogi contents of 20 adult pigeon guillemots are listed in Table 5. Fish fragments were the most common item (95%) followed by shrimp remains (70%). Identification of fish species was often difficult but sandlance (Ammodytes hexopterus) remains were identified most often. Percentage values for crab and shrimp differ considerably from 1978 results when only one of 14 stomachs contained shrimp, but this can probably be attributed to the small sample sizes rather than yearly differences. Small organisms such as copepods, ostracads, and amphipods were often found in the gut, but these are probably accidental to other feeding. Some of the nematodes were probably parasitic. We suspect the importance of invertebrate food items has been underestimated in the adult diet and additional work is needed in this area.

Foraging Areas and Feeding Intensities

Observations by Oakley and Kuletz (1979) support the assumption that pigeon guillemots are inshore, primarily benthic feeders. They noted the importance of bays and coves to feeding pigeon guillemots and suggested that most feeding occurs within the 100 m depth contour.

Our observations also indicated that pigeon guillemots are primarily inshore feeders and the majority of feeding occurs within the 50 m contour zone. Although bays were also important to feeding pigeon guillemots in 1979, we should emphasize that the extensive shallow shelf (< than 100 m in depth) surrounding the island complex provided a large feeding area. Pigeon guillemots regularly flew long distances (> 2 km) out in the open oceans to feed, particularly before chicks were hatched. We do not know the maximum depth that a pigeon guillemot will dive but it seems doubtful that they are feeding on the bottom here as some areas were at least 100 m deep.

During June before chicks were hatched, the number of dives of pigeon guillemots feeding at various distances from shore were counted in 10 minute intervals. Water depths ranged from less than 5 m inshore to more than 100 m offshore. Dives were recorded separately for flock sizes of one, two and three or more pigeon guillemots. Results are listed in Table 6. Analysis of variance indicated that there were no significant differences ($p < .01$) in the number of dives among the distance categories and no trends were evident in Table 6. Although analysis of variance indicated no significant differences in the number of dives among groups sizes, regardless of distance, an inverse relationship seemed apparent (Table 6). Correlation of the number of dives/bird with group size was significant ($p < .01$), showing an inverse relationship. However, only 30% of the variability in the number of dives can be explained by group size. Additional factors such as date, time of day and tide cycles may account for some of the variability, as well as sample size.

These results indicate that although pigeon guillemots are inshore feeders, little difference existed in feeding intensity, as measured by the number of dives per minute, within a 2 km distance from shore during June. Later, as foraging for chicks began, pigeon guillemots tended to feed closer to the colonies but we have no quantitative data for analysis. We should emphasize that these data do not analyze numbers of feeding birds by distance category, but number of dives/minute. We suspect that number of feeding birds are higher for the inshore distances categories throughout the season, but increasingly so as it progresses. Additionally, a trend of decreased feeding with increasing flock sizes was evident in June, but not definite. We suspect that increased social interaction with increasing group size may be a factor, and large groups of pigeon guillemots are probably related to a nearby colony and are probably not feeding. Finally, the use of bays and coves by feeding pigeon guillemots was apparent, particularly as chicks were raised, however, our data are insufficient for analysis of open ocean versus bay feeders. We suspect that the use of bays may be a function of prey preference by individual pigeon guillemots, as well as protection from wind and heavy seas.

Chick Food Habits

To determine the type and frequency of food items carried to young, five colonies were watched for more than 150 hours during July and August. The results of 1229 deliveries to the nests are listed in Table 7. Fish were by far the most important food item (99.6%) and all identified fish belonged to one of six families, most of which are considered benthic (Hart 1973). Sandlance were the most commonly delivered fish (53%) followed by blennies, sculpin, cod, and flatfish. Estimated lengths of fish brought to young were converted from multiples of the average bill lengths (33mm) to millimeters. Mean lengths for forage species are presented in Table 8. Fish dropped at the nest site were weighed and measured and these results are presented in Table 8. Various species are represented in each species group indicating that a wide variety of organisms are delivered to the young, although all are primarily benthic. A list of potential forage species obtained in minnow traps is presented in Table 9. These results are similar to the other pigeon guillemot studies listed in Table 8. Although food organisms delivered were similar in the three studies, percentage values for different species differed markedly among studies. Sandlance was the dominant food species at Naked Island, but minor at the other sites. The reverse was true for blennies, and the remaining organisms were roughly similar between sites, except cod which were important at Blair Island. Invertebrates were very minor food items in all studies. We do not know if differences among sites results from annual variation in food supplies or if they reflect differences in prey species available at the different sites. For the two years at Mandarte Island, blennies were dominant each year, although the 1972 value was double that of

1965. This may have been due to differences in methodology and sample sizes.

Individual Feeding Variation

Other studies (Slater and Slater 1972; Drent 1965; Koelinsk 1972) have indicated that individual pigeon guillemots or pairs of pigeon guillemots have specific feeding habits which can vary considerably among individuals of a colony. Although we were only rarely able to distinguish individuals of a pair, we were often able to quantify numbers and species of fish brought to individual nests. To determine if food species varied significantly among nests at a colony, a chi-square analysis of fish species group by nest was conducted. Results of this test were significant ($p < .01$) so an analysis of residuals was applied to individual cells to determine which species group at which nest were significantly different than expected. Results of this analysis are presented in Tables 10 through 13.

Evidence of significant differences in food selection by individual adults or pairs is obvious in each of the three colonies observed at Naked Island, and also by colony for five colonies at Naked Island. At Hook Colony (Table 10), sandlance were delivered significantly more than expected to nests 45, 46, and 34 and nests 14 and H1 approach significant in this direction. Conversely, blennies and sculpins were selected less than expected for these nests, although the difference was significant only for sculpins at nest 45. The remaining nests at Hook Colony indicate a trend opposite of the first five. Nests H2, H3, and H4 had significantly less sandlance delivered than expected, but significantly higher numbers of blennies. Nests H7 and H8 had significantly higher numbers of sculpins and "other" fish delivered, respectively, however samples sizes were small for these nests.

At Row Colony (Table 11) individual variation in food delivered was evident at nests R3, R4, R5, R6, and R7. Nests R3 and R4 indicate increased utilization of sandlance and lower utilization of blennies than expected. Results from nest R5 indicate significantly less than expected use of sandlance and blennies but markedly higher than expected utilization of sculpins and other organisms. Nests R6 and R7 had significantly higher utilization of blennies but lower than expected deliveries of sculpins and other organisms. Differences between nests in the unidentified column can usually be attributed to distance of the nest from the blind.

At Nomad Colony, (Table 12) nests 47, 28, and 39 had higher than expected deliveries of sandlance while use of blennies, sculpins, and other organisms were less than expected, but not at significant levels. Significantly less than expected numbers of sandlance were delivered to nest N1 but deliveries of blennies and sculpins were significantly greater. Nest N2 had significantly higher numbers of "other" organisms than expected, in this case flatfish. Differences in fish delivered to unknown nests were not significant, except for unidentified organisms. Nest 47 had significantly fewer unidentified organisms probably because it was closest to the blind and easy to observe.

By applying the same type of analysis to colony totals, variation in food species delivered to young is evident (Table 13). Hook Colony, the most inland of the five (Fig. 2), had significantly less sculpins delivered and less sandlance at nearly significant levels. Conversely, cod and flatfish were delivered at highly significant levels and the number of blennies approached significance in this direction. Westpoint Colony had significantly higher than expected deliveries of sandlance and significantly less deliveries of sculpins and cod. At Nomad Colony, significantly higher numbers of sculpin were delivered than expected, significantly less flatfish, and less sandlance at near significant levels.

In suggesting reasons for the differences in food items delivered to nests, Slater and Slater (1972) noted that a member of a pair may specialize in unusual food species and thus account for differences at individual nests. They proposed that individual preferences resulted from either 1) each bird foraging consistently in a certain area and catching the fish prevalent there, or 2) each bird may have a specific search image whereby it tends to look for and catch a particular species in preference to others. They felt their evidence supported the first reason. Because markings on our birds faded rapidly, the majority of our data do not distinguish individuals of a pair. However, certain observations support the individual forage area preference theory. On one occasion a marked bird brought in seven consecutive small, red, unidentified fish from almost exactly the same location. On another occasion an adult delivered 15 consecutive sandlances from the same foraging spot. Finally, one banded bird accounted for nearly all the flatfish delivered to one nest during the season. Our mappings of foraging areas by nest also lend support to the theory, although individuals of the pair were not separated. For example, foraging areas for nest 47 at Nomad Colony were distinct from those of nest N1 and fish species delivered were significantly different than expected (Table 12). Similar examples occurred at Row Colony and at Hook Colony. However, these observations are limited and considerably more work needs to be done. Although we have no strong data to indicate that different birds foraging in the same area are selecting different species, we suspect this may also occur.

We have some evidence which indicates that a pigeon guillemot's foraging area during chick feeding may be influenced by its association with a certain colony. Although exceptions occurred regularly, pigeon guillemots from Row and Nomad colonies generally did not mix foraging areas (Fig. 5). This general separation was maintained throughout the chick feeding period. Birds from Nomad Colony generally flew to the north and west around the corner, then east; Row Colony birds flew primarily west and southwest. We do not know if this phenomena is a result of proximity of foraging area or if some social exclusion principal is operating. Another hypothesis suggested by Ward and Zahavi (1973) is that colonies serve as information centers for productive foraging areas and that birds learn from one another. Solitary feeders such as pigeon guillemots may follow successful feeders from the colony should their foraging area become unproductive. Observations from other colonies at Naked Island do not necessarily support the hypothesis of colony segregation, as we saw foraging birds from one colony cross other colonies on their way to feed. However, landing locations of longer flights such as these were hard to observe and we have insufficient observations to determine if any separation was occurring.

One phenomena common to all colonies, also reported by Drent (1965) is that pigeon guillemots rarely foraged directly in front of the colony, even though food species were readily available. While other seabirds were actively feeding and catching prey species used by pigeon guillemots, they were almost always ignored in the vicinity of the colony. Perhaps pigeon guillemots attract fewer predators to the colony by minimizing feeding in the immediate vicnity.

Foraging patterns from the various colonies during the pre-chick period appeared more distant, and scattered than during the chick rearing period. Observations of landing sites were much more difficult as adults often flew straight out to sea until lost from view. Attempts to follow in a small boat were unsuccessful, nor could the bird be followed with a spotting scope from shore. Comparison of flight directions from Hook, Nomad and Row colonies before and during the chick rearing period can be seen in Figures 5 to 8. Also, during the pre-chick stage, the segregation of foraging areas noted above (Fig. 5) was not apparent, as demonstrated in Figure 8. Reasons for the difference in foraging strategies between chick and pre-chick stages may be due to the greater availability of prey species inshore during the chick rearing period. Schooling fish and their predators, such as minke whales (Balaenoptera acutorastrata) and porpoises, were seen more commonly inshore as June progressed. Also, as noted earlier, adults may have different feeding habits than chicks, and this may be reflected in foraging areas.

Diurnal Chick Feeding Patterns

The most complete data for one nest on diurnal foraging patterns of adults feeding chicks were obtained by time lapse photography covering 224 daylight hours during the middle third of the 35 day chick rearing period. Observations from a nearby blind indicated that deliveries to the nest were rarely missed by the camera, set on 20-23 second intervals, and we estimate that 95-100% of the deliveries were recorded on film.

Results from the time lapse data are presented in Figure 9. Deliveries averaged 1.18 fish per hour for the 225 hours, but the rate varies considerably through out the day and from day to day. Although the camera did not record at night, previous studies (Drent 1965; Koelnick 1972) have demonstrated the pigeon guillemots do not feed in the dark. As indicated in Figure 97 this pair of pigeon guillemots began feeding at first light and frequencies of deliveries increased rapidly until 0600 hours then fluctuated until noon when a sporadic decline began. From 2000 to 2100 hours, a sharp increase occurred resulting in the highest number of deliveries recorded for the day. This may result from an attempt to fill the chicks for the night. The general trend reported here is similar to that recorded by Koelnick (1972) except no late evening peak occurred in that study.

During observations from blinds of various nests, it became apparent that considerable variation existed in time of deliveries from nest to nest. For that reason, results in Figure 9 can not be applied to the colony in general. A compilation of all deliveries recorded from blind observation for the entire season averaged 1.17 fish per hour per nest for the 157 hours covering more than 50 nests and 1,175 deliveries. This figure is higher than the .99 fish per hour recorded by the time lapse camera. However, there were significantly ($P < 0.01$) fewer fish delivered in the morning ($\overline{X}$ = .94) than the afternoon ($\overline{X}$ = 1.39 fish/hour) which does not support the trend recorded by the time lapse camera. Observation hours from the blind were not as evenly distributed as those of the time lapse camera, as there were fewer early morning and late evening observations. Feeding rates from other studies also show variable diurnal trends. Koelnick (1972) found highest frequencies of deliveries between 0600 and 1000 hours, then a continual decline through the day.

Slater and Slater (1972) also found highest deliveries in the morning. However, Drent (1965) and Thorenson and Booth (1958) found no preferred feeding period during the day. Our results suggest that at Naked Island, although more fish were delivered in the afternoon, no period of the day was markedly favored for chick feeding. However, additional data are required for definite conclusions.

We lack sufficient data to monitor changes in deliveries to one nest from hatching to fledging. Koelnick (1972) determined that fish size varied greatly from nest to nest and weight estimates were more valuable than frequency of deliveries. Weight of fish delivered reached a peak after 10 days and was maintained at about 100 g/chick for 20 days before tapering off (Koelnick 1972). Our observations also indicated that for a few days after hatching, fish delivered are small but afterwards there was no discernable trend in size of fish delivered.

Mensurial Characteristics of Chicks and Adults

Chick Growth

The growth curves for each of the parameters measured are presented in Figures 10 through 13. Results are comparable to those of 1978 (Oakley and Kuletz 1979). Fledging weights were noticeably higher in 1979 than 1978 (Table 14). Increased prey availability and breeding experience of adults may have contributed to the difference. Slight downturns in the curves at fledging time can be attributed to a severe storm during the last few days before fledging, and to small sample sizes for the last two measurement periods.

Adult Measurements

Weights and measurements of adult pigeon guillemots captured and collected in 1979 are compared to 1978 values in Table 14. Adult weights were significantly less than 1978 values but still significantly higher than weights of pigeon guillemots collected elsewhere (Drent 1965; Thorenson and Booth 1958). Adult males weighed more than adult females. Fledging weights approached mean adult weights, particularly adult females. Tarsus, culmen and wing chord measurements were similar for adults in 1978 and 1979.

Island Bird Surveys

Results from 5-6 June complete surveys of Naked and associated islands are presented in Table 15. The pigeon guillemot was the most numerous seabird on the four largest islands and accounted for 58% of all birds surveyed. Alcids together comprised 88% of all birds counted. Gulls, primarily Glaucous-winged (*Larus glaucescens*) and Black-legged Kittiwakes (*Rissa tridactyla*) accounted for 9% of birds surveyed. Waterfowl, principally harlequins (*Histrionicus histrionicus*) and mergansers, (*Mergus* sp.) comprised 2% of all birds observed. Results of surveys for 1978 and 1979 are listed in Table 16 for four major alcid species. Except for horned puffins (*Fratercula corniculata*), numbers were similar on each area for both years indicating stable populations. Differences may be due to timing of the survey and variables such as visibility.

Transects

Two inshore transects and one offshore transect were surveyed through the season during mornings and only when the visibility was good. The locations of the transects are presented in Figure 2 and results of the 1979 surveys are compared to 1978 results in Tables 17 and 18 for birds and mammals respectively. Trends observed between transects in 1978 are similar to those of 1979, indicating that individual species maintained area preferences from year to year. Black-legged Kittiwakes were the most common gulls on inshore transects but numbers were similar to Glaucous-winged gulls for the offshore transect. Of alcids, pigeon guillemots increased noticeably on each inshore transect from 1978 to 1979. Offshore densities for 1979 were 10 to 16% of the inshore values indicating a preference by pigeon guillemots for inshore activity. Marbled Murrelet (Brachyramphus marmoratus) numbers increased dramatically from 1978 to 1979 on one inshore transect but not the other. Offshore numbers for murrelets were also approximately 10% of inshore values. Densities and frequency of occurrence of both horned and tufted puffins (Lunda cirrhata) were less in 1979 than in 1978. Since the entire island census also indicated decline in puffin numbers, utilization of Naked Island by puffins may be decreasing. Of waterfowl, higher numbers of harlequins and mergansers were recorded in 1979 than 1978 but fewer white-winged scoters (Melanitta deglandi) were noted. Loon (Gavia sp.) numbers were also higher in 1979 than 1978. Differences in densities for the less numerous species may be a function of sample size. Also, because 1979 surveys were conducted during morning hours and some 1978 surveys were conducted in the afternoon, timing of the surveys could have influenced results for all species.

Marine Mammals

The most noticeable difference in marine mammal sightings between 1978 and 1979 (Table 18) was the increase in sea otter (Enhydra lutris) and harbor seal (Phoca vitulina richardi) numbers on the inshore transects. We do not know if this represents population increases or are functions of sample size and survey timing. Offshore density values were 25-40% of inshore values. The reverse was true for dall (Phocoenides dalli) and harbor porpoise (*Phocoena phocoena*) which were two to three times more numerous offshore. Numbers of other marine mammals were too small for comparison between transects or years.

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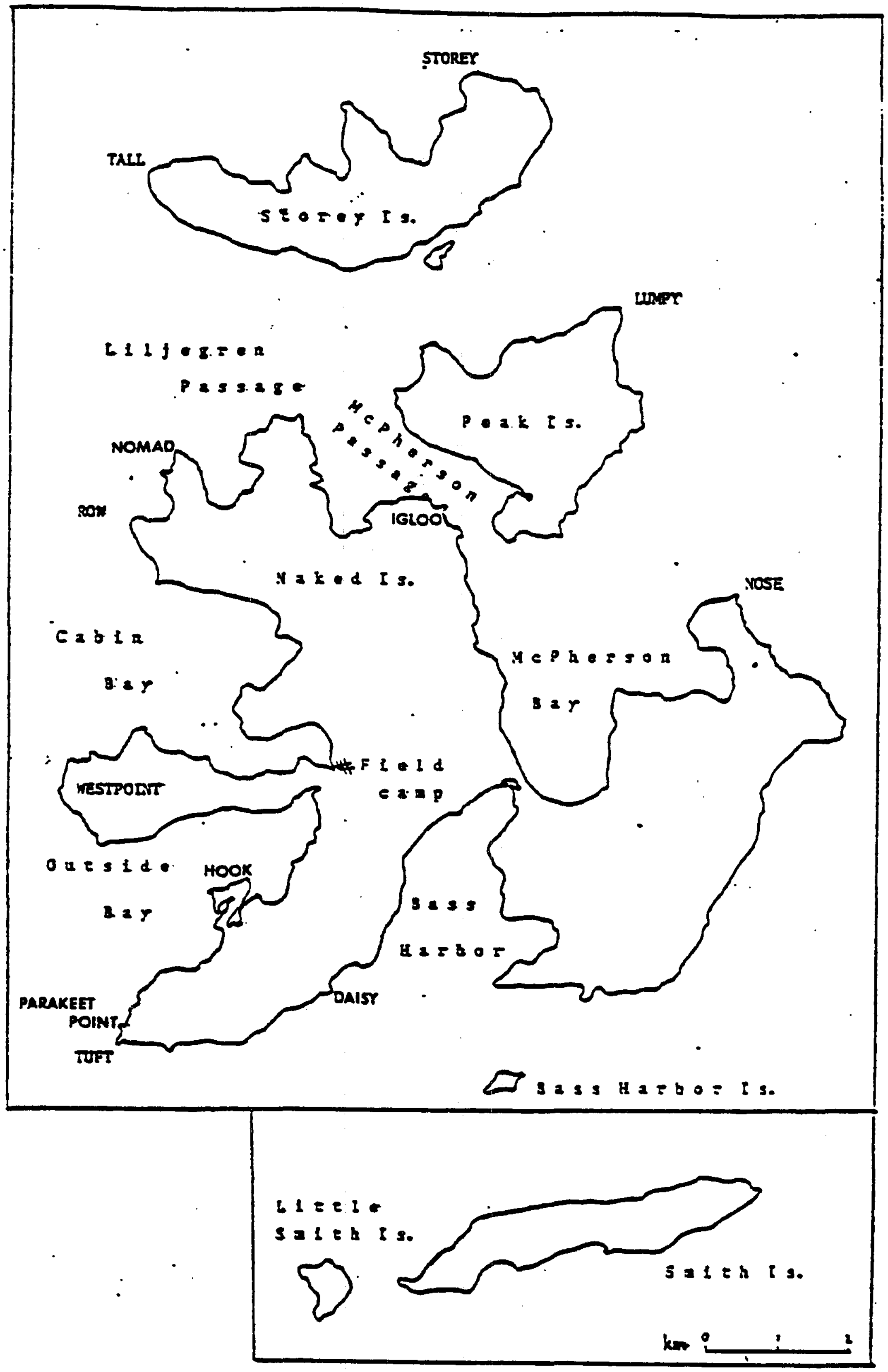

Figure 1. The study area.

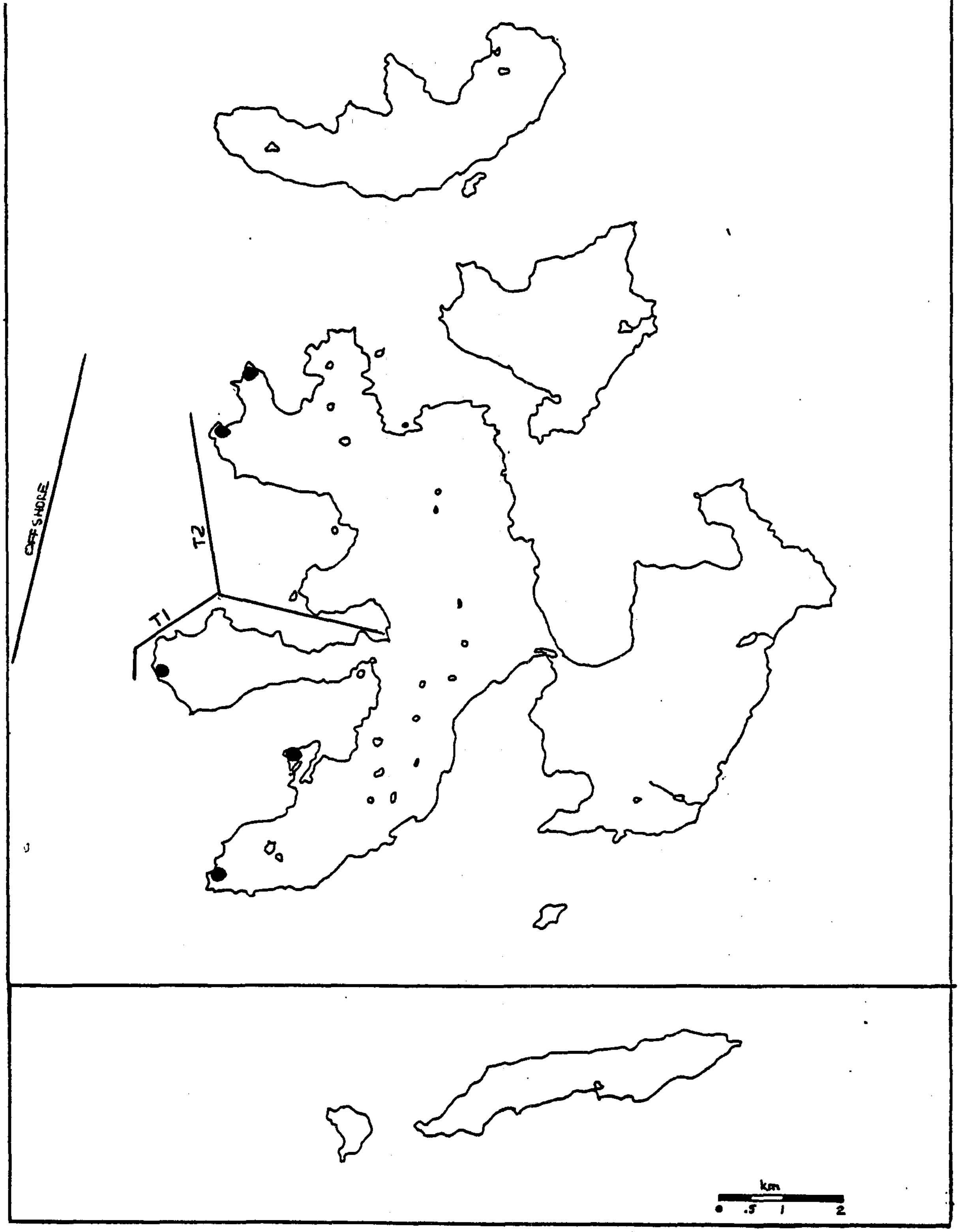

Figure 2. Primary colony study sites and transect locations.

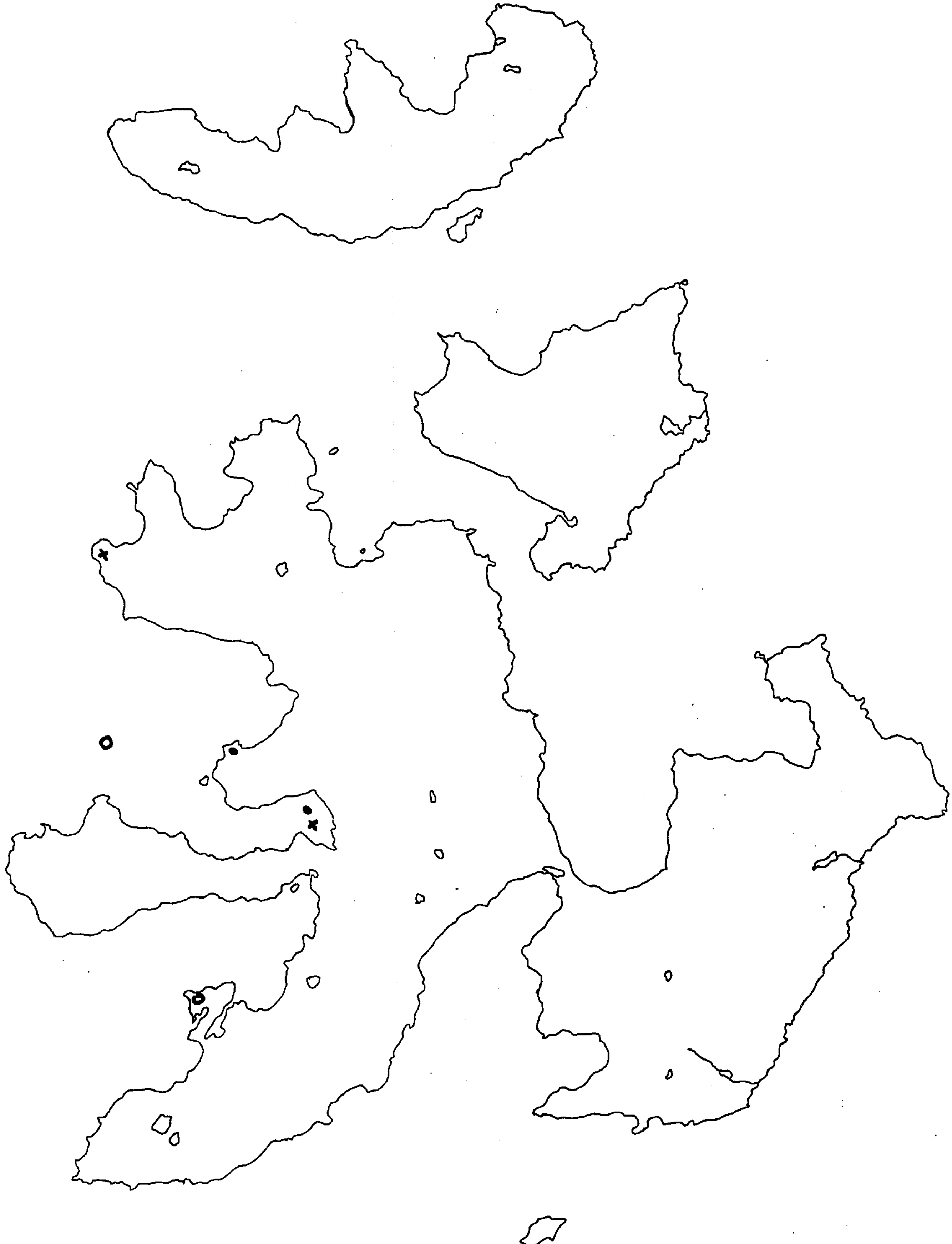

Figure 3. Locations of marked fledglings and their respective nests.

Figure 4. Contour lines of heavily used pigeon guillemot foraging areas.

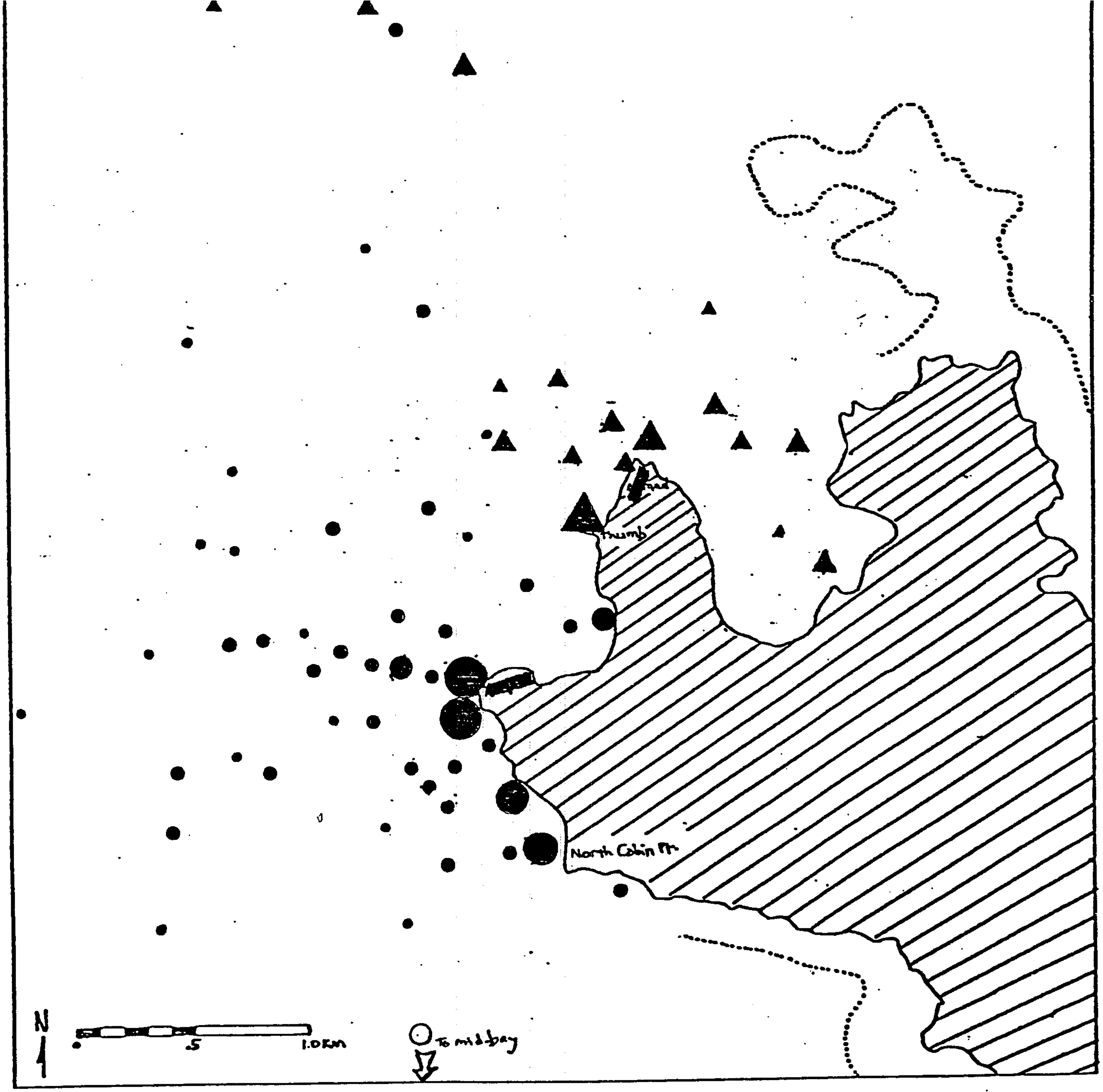

Figure 5. Foraging areas of pigeon guillemots from Row colony (circles) and Nomad colonies (triangles) during the chick rearing period.

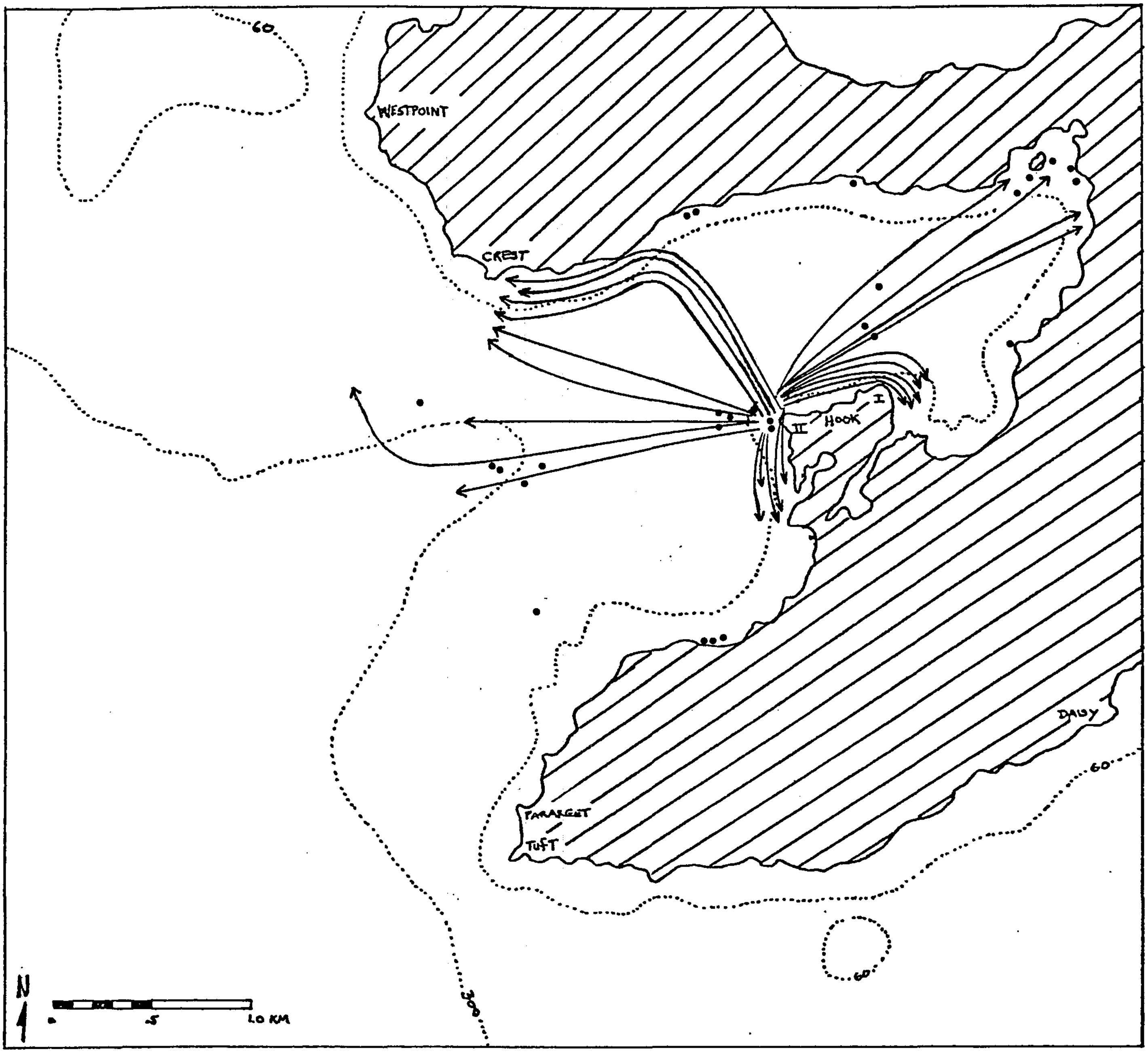

Figure 6. Foraging flight directions (arrows) and landings (dots) of pigeon guillemots from Hook colony during the chick feeding period.

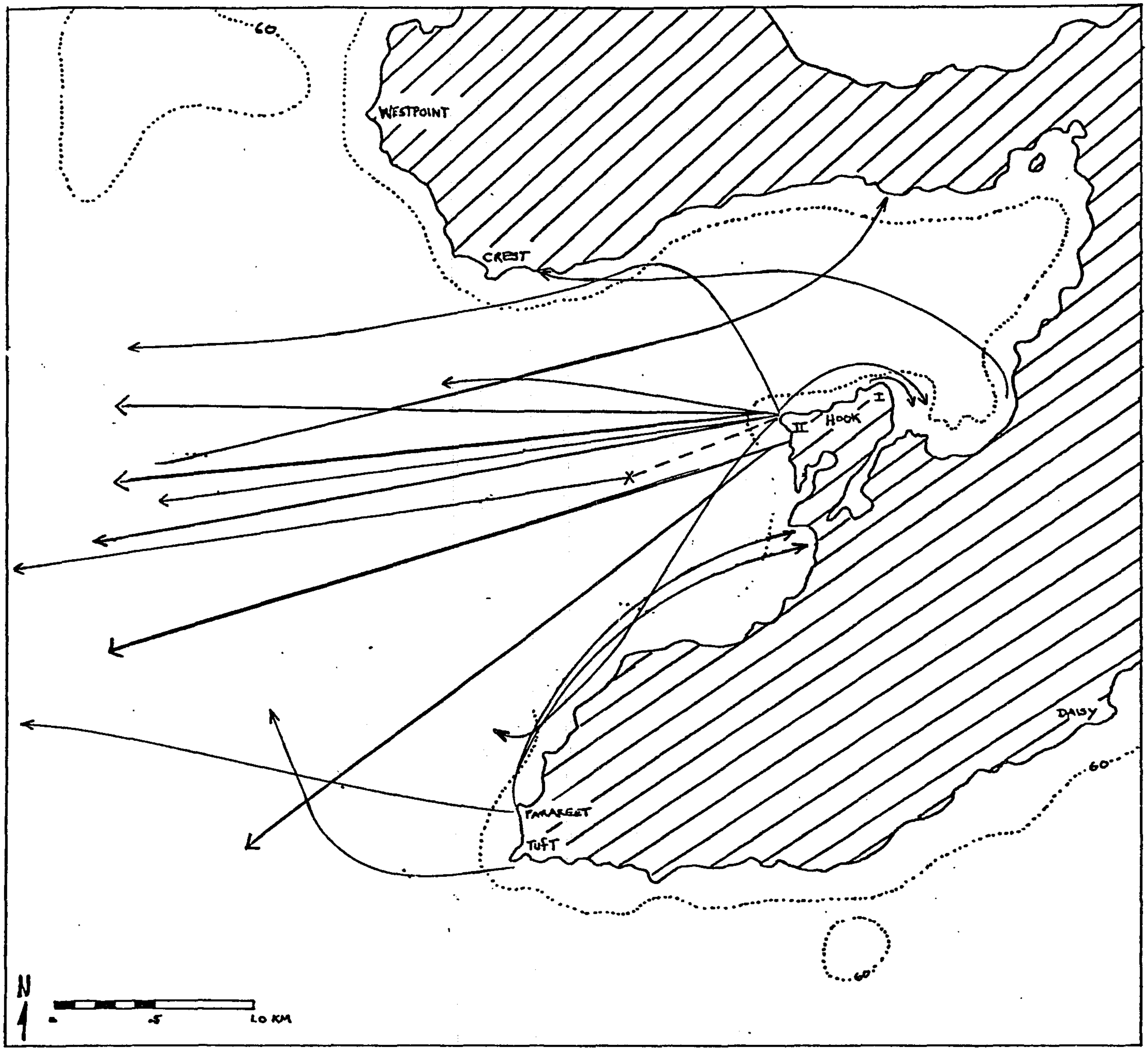

Figure 7. Foraging flight directions of pigeon guillemots from Hook colony before the chick feeding period.

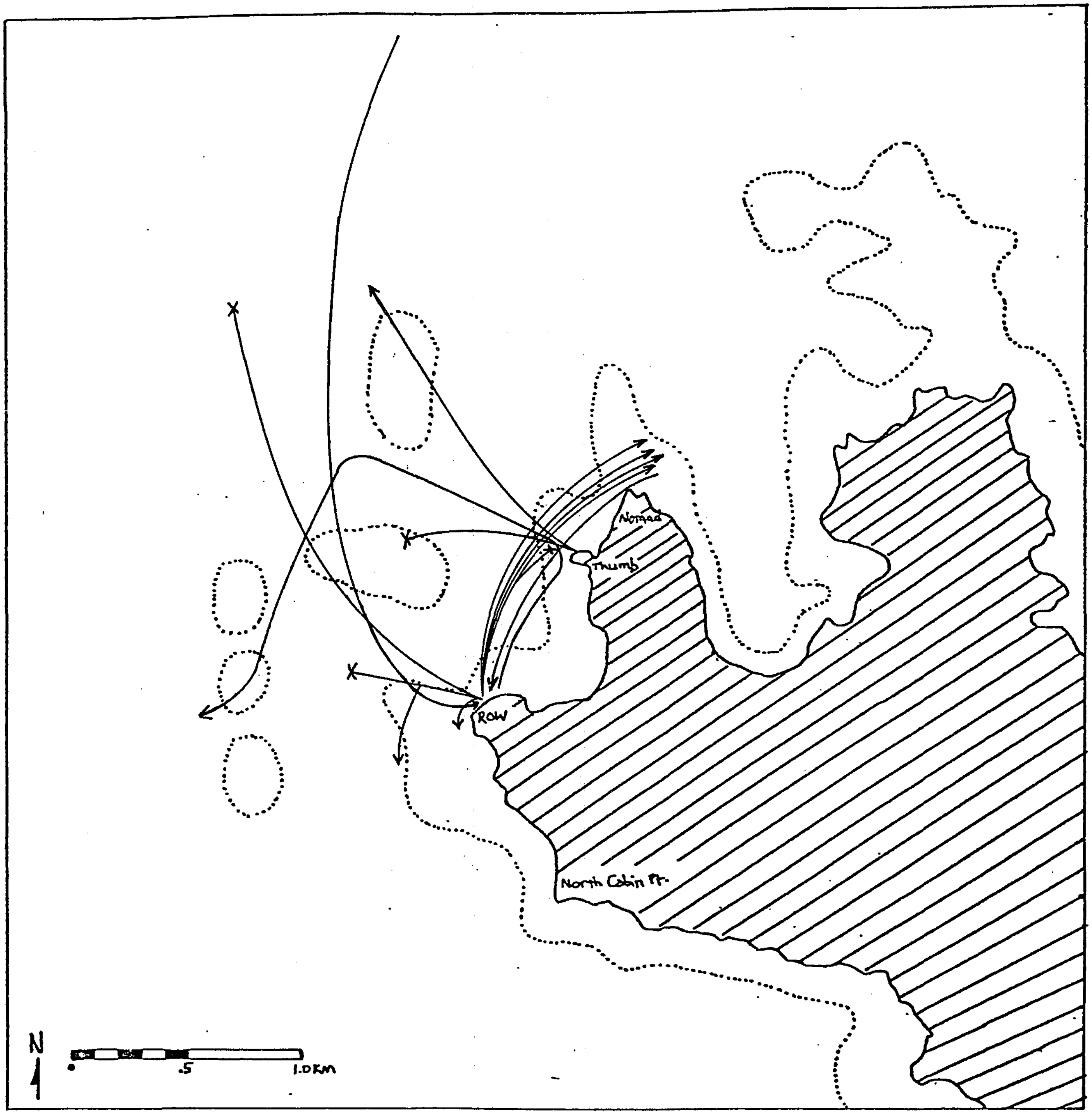

Figure 8. Foraging flight directions of pigeon gullemots from Row colony before the chick feeding period.

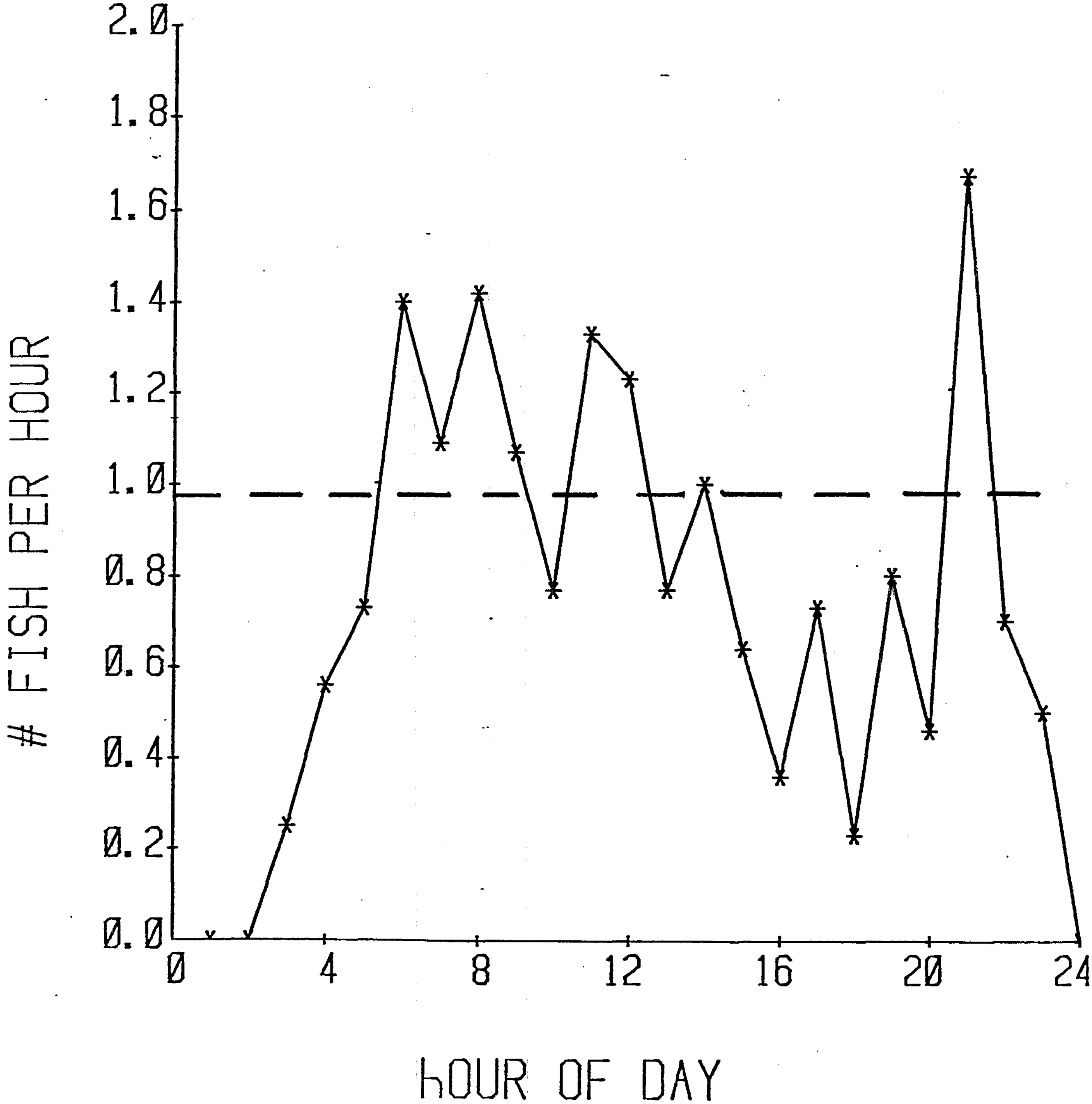

Figure 9. Number of fish delivered to nest 47 at Nomad colony by hour of the day by both adults.

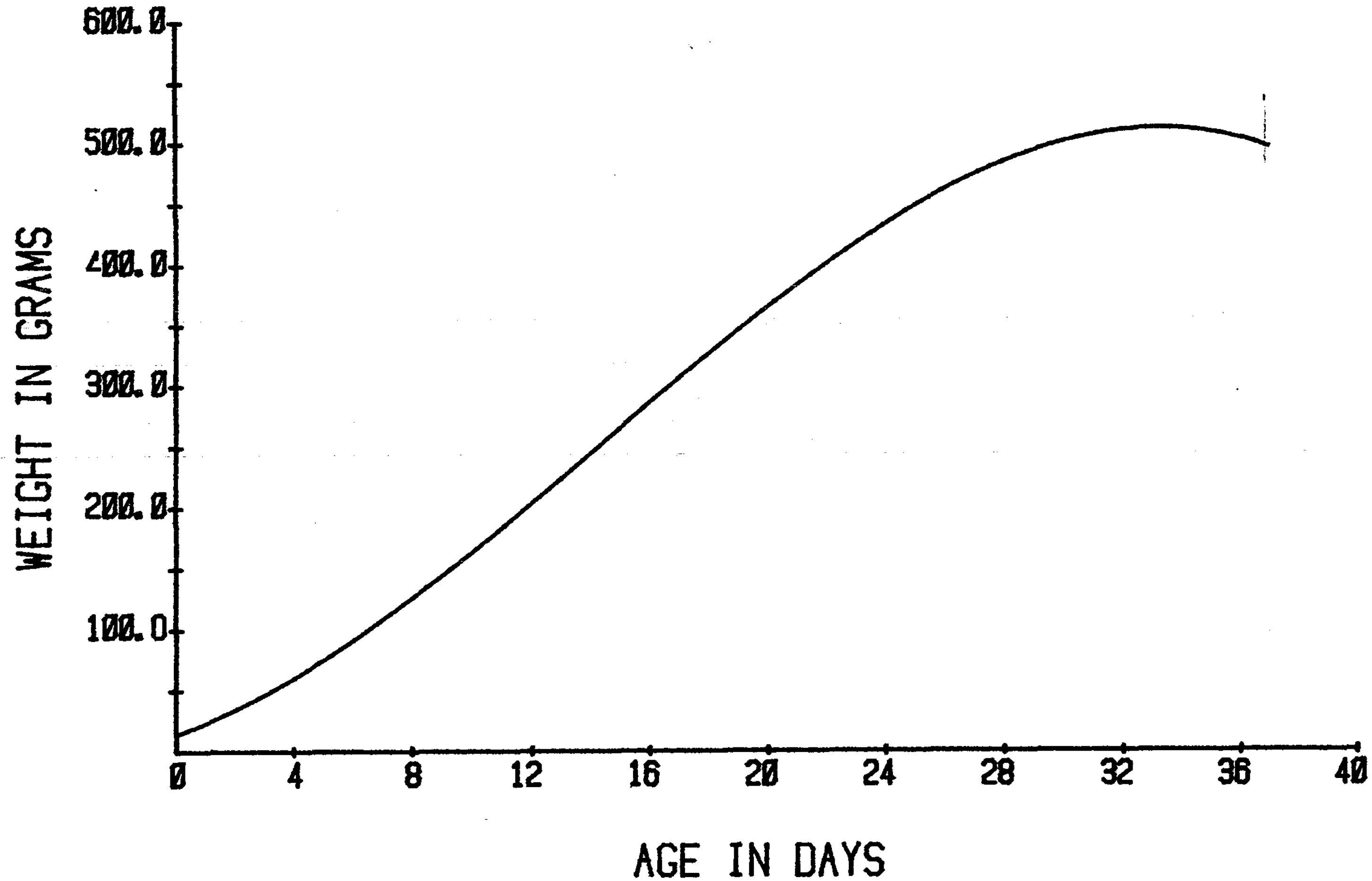

Figure 10. Weight of pigeon guillemot chicks determined at 4-day intervals after hatching.

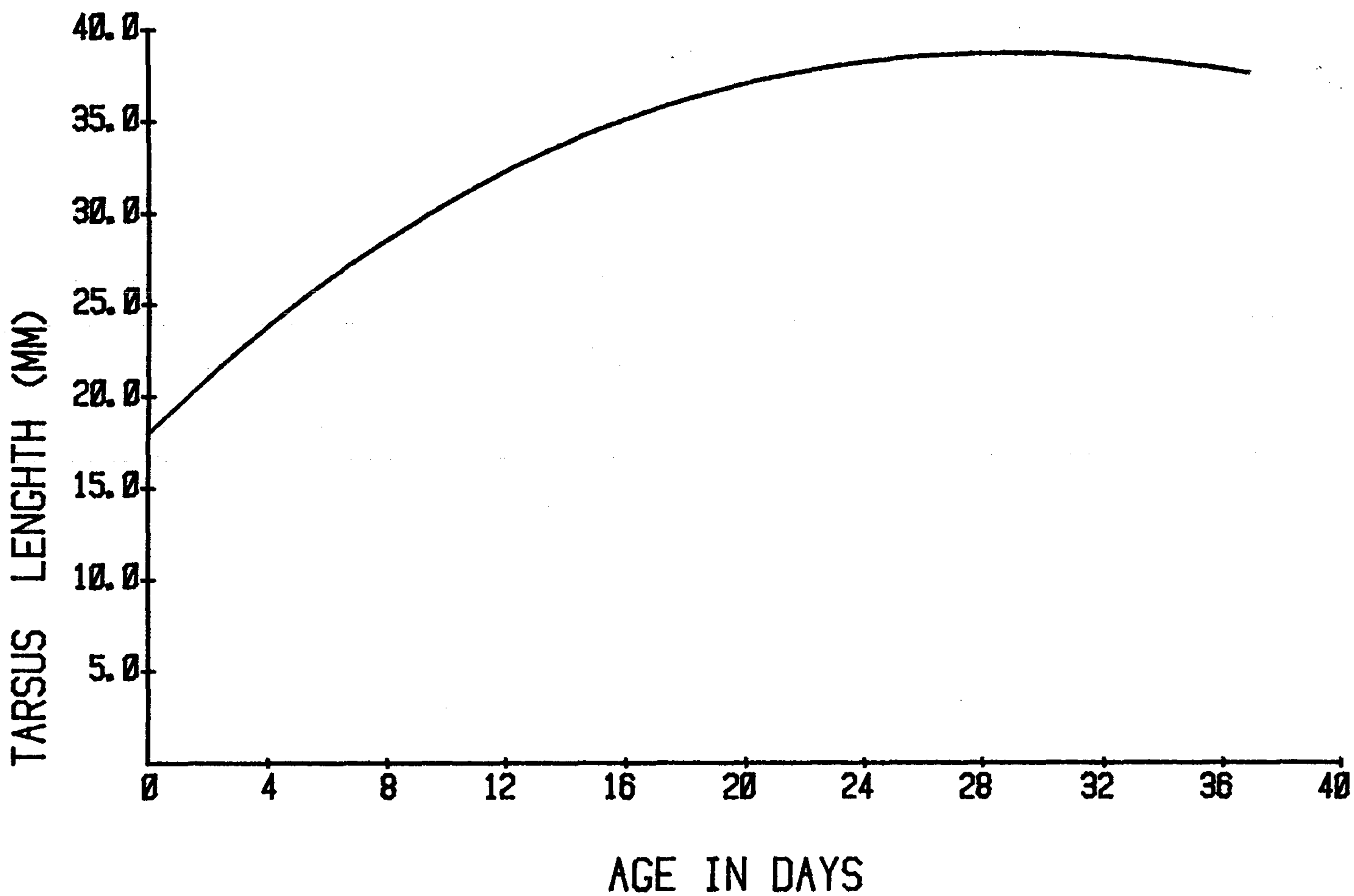

Figure 11. Tarsus length of pigeon guillemot chicks determined at 4-day intervals after hatching.

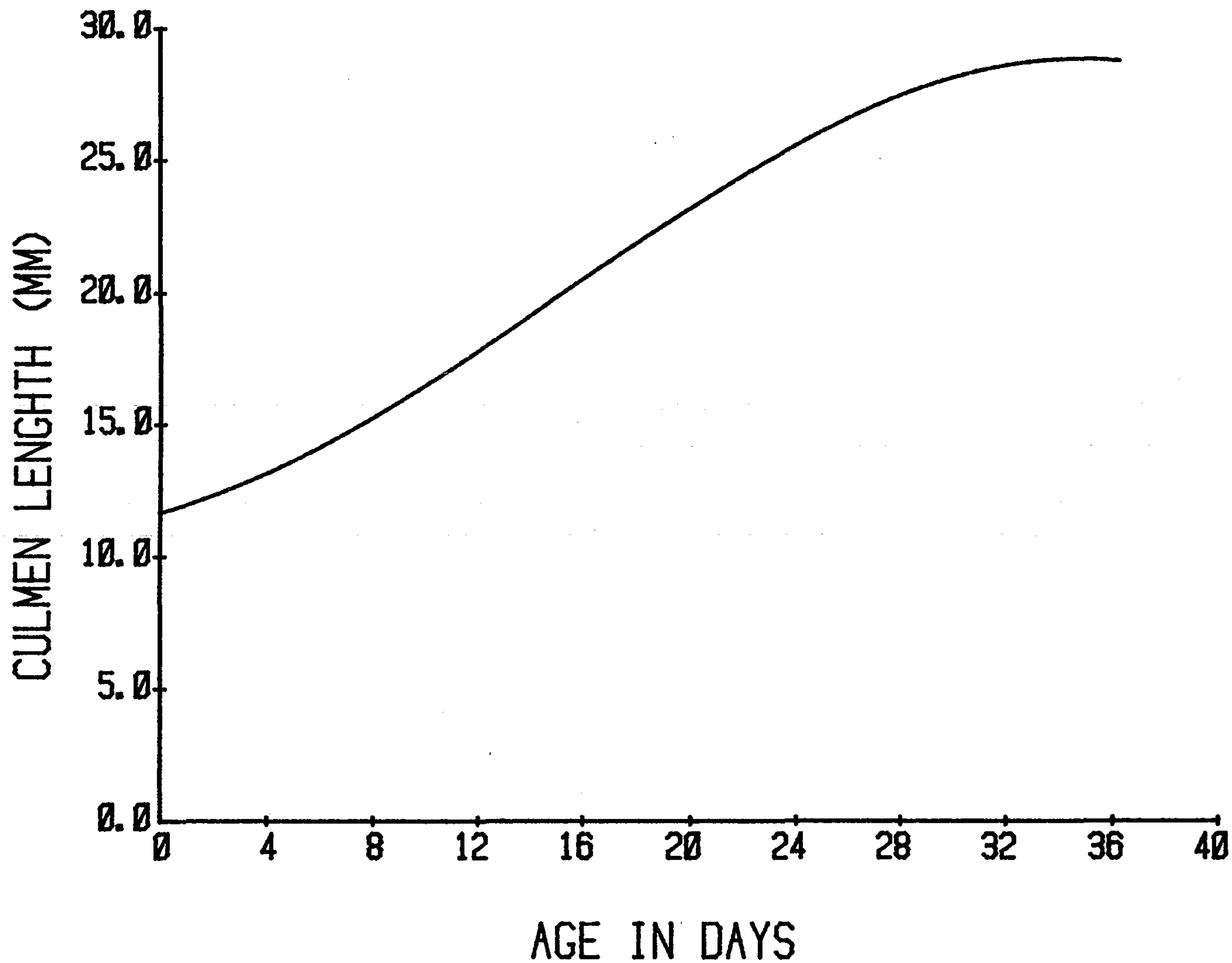

Figure 12. Culmen length of pigeon guillemots determined at 4-day intervals after hatching.

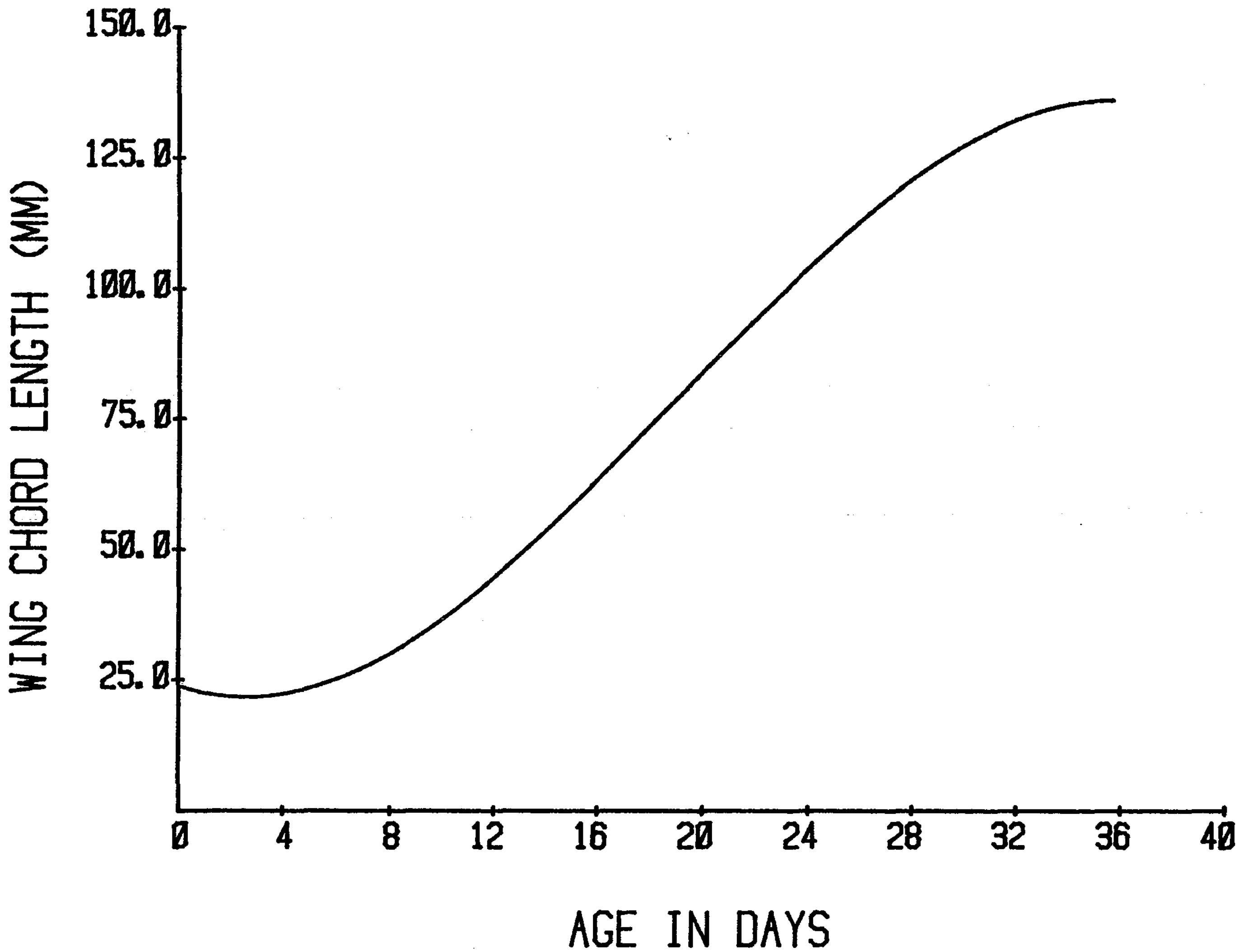

Figure 13. Wing chord growth curve determined at 3-day intervals after hatching.

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Table 1. Pigeon guillemot chick plumage categories.

Category	Description	Approximate ages (days)
I	All black downy.	1-14
II	Black downy. Some white corners.	15-20
II+	Black downy, with contours on belly,	21-33
III	Head feathered, belly mostly feathered with a streak of down in the middle, down on collar, back and rump.	24-26
III+	Head and belly feathered. Down on collar, back, and rump.	24-26
IV	Head, belly, and back feathered. Down on collar and rump.	27-29
IV+	Fully feathered with traces of down on collar and/or rump.	30-32
V	Fully feathered.	33-fledging

Table 2. Median date and range of the hatching, laying and fledging periods of Pigeon Guillemots at Naked Island in 1978* and 1979.

Period	Median	Range	Range in Days
Laying			
1978	7 June	25 May - 26 June	33
1979	2 June	25 May - 26 June	33
Hatching			
1978	4 July	26 June - 26 July	31
1979	5 July	27 June - 26 July	30
Fledging			
1978	11 August	31 July - 31 August	30
1979	1 August	1 August - 23 August	28+

* Oakley and Kuletz 1979

Table 3. Condition of Pigeon Guillemots collected for food habits analysis, Naked Island, summer 1979.

Collection Number	Date	Sex	Body Weight (g)	Plumage	Molt	Gonad Size (mm)	Brood Patch size of 1 lobe (mm)
1	5-22	Male	515	Br	No wing molt	21.0 x 11.5	None
2	5-22	Female	510	Br	-	1.3	None
3	5-22	Female	455	Br	-	1.9	None
4	5-22	Male	520	Br	None	19.8 x 5.6	None
5	5-22	Female	512	Br	None	5.1	None
10	5-24	Female	470	Br	-	2.8	None
11	5-24	Male	467	Br	None	20.2 x 9.7	Beginning - not distinct
12	5-24	Male	495	Br	None	28.0 x 10.4	None
13	5-24	Female	510	Br	None	11.7	Beginning - not distinct
14	5-24	Female	520	Br	None	15.4	44 x 19
15	6-29	Female	530	Br	-	39.0	34 x 32.5
16	6-29	Female	530	Br	-	30.0	32 x 20
17	6-29	Male	540	Br	-	13.0 x 5.7	43 x 33
18	6-29	Male	590	Br	-	17.5 x 6.2	41 x 29
19	6-29	Male	510	Br	-	13.0 x 5.0	45 x 28
20	6-29	Male	545	Br	-	20.0 x 5	None
21	6-29	Male	520	Br	-	16.0 x 8.0	40 x 21
22	6-29	Female	540	Br	-	4.0	None
23	6-29	Male	497	Br	-	17.5 x 5	41 x 17
24	6-29	Female	480	Br	-	3.5	None

Table 4. 1978* and 1979 mean clutch size, hatching and fledging percentages.

Year	Clutch Size	Percent Hatched	Percent Fledged	Number of Nests
1979	1.81	70.0	64.0	28
1978	1.74	83.3	75.9	31
1979**	1.81	65.8	73.7	23**
1978**	1.71	83.3	23.3	23**

* Oakley and Kuletz 1979

** Only 1978 nests that were re-used in 1979

Table 5. Percent frequency of food items found in 20 adult pigeon guillemot stomachs.

Item	% Frequency
Protozoa	
Foraminifera sp.	5
Nematoda	65
Mollusca	
Bivalvia	5
Mysella sp.	5
Gastropoda	
Alvania sp.	10
Arthropoda	
Crustacea	
Ostracada	50
Copepoda	
Calanoida	5
Cyclopoida	15
Harpacticoida	55
Cirripedia	
Barnacle nauplius	5
Malacostraca	
Amphipoda	
Melita sp.	5
Decapoda	95
Natantia	85
Pandalidae	70
Pandulus sp.	60
Pandulus mentasui	10
Hippolytidae	20
Lebbeus groenlandicus	5
Spirontocaris lilieborgii	10
Evalus fabricii	5
Crangonidae	20
Reptantia	40
Inachidae	
Pugettia sp.	5
Cancridae	5
Cancer oregonensis	15
Xanthidae	5
Lophopanopeus sp.	10
Paguridae	
Pagurus sp.	5

Table 5. Percent frequency of food items found in 20 adult pigeon guillemot stomachs.

Item			% Frequency
Chordata			
Osteichthyes			95
	Cottidae		
		Myoxocephalus polyacanthocephalus	5
	Liparidae		
		Liparis sp.	20
	Bathymasteridae		
		Bathymaster signatus	5
	Stichaeidae		
		Lumpenus sp.	15
	Pholidae		
		Pholis sp.	5
	Ammodytidae		
		Ammodytes hexopterus	30
Unknown fish			90

Table 6. Feeding intensity of Pigeon Guillemots by distance from shore and flock size.

Distance to shore (m)	Dives/minute/bird One bird	Two birds	>Two birds
0 - 100	.256	.135	.003
101 - 500	.282	.063	.002
501 - 1000	.131	.317	.300
>1000	.294	.166	.022
Mean	.241	.170	.082

Table 7. Percent composition of food items brought to nests by adult Pigeon Guillemots and Black Guillemots.

Location	Number of items	Sandlance	Blenny	Sculpin	Cod	Flatfish	Other Fish	Invertebrate	Unidentified
Naked Island, Prince William Sound, Alaska, 1979	1,229	53.1	19.2	14.2	2	1.6	-	0.4	9.5
Mandarte Island, British Columbia Drent - 1965	662	4.7	37.2	19.5	-	9.8	5.6	0.9	22.3
Mandarte Island, British Columbia Koelink - 1972	1,841	5.5	63.7	14.9	-	2.6	2.7	0.7	10.0
Fair Isle, Shetland Slater & Slater 1972 (Black Guillemots)	544	17.4	46.9	8.1	18.4	7.0	-	-	2.2

Table 8. Mean lengths of forage species from estimates of multiples of bill lengths.

Species	Length (mm)
Sandlance	101
Blennies	107
Sculpin	72
Flatfish	70
Cod	76
Invertebrates	63

Table 9. Mean weight and length of potential forage species collected with minnow traps.

Location	Trap hours	Species	No.	g wt	mm length
Cabin Bay	502	Tidepod sculpin (Oligocottus maculosus)	9	5.97	87.8
		Crescent Gunnel (Pholis laeta)	34	5.81	134.4
		Snake prickelback (Lumpenus sagitta)	29	19.8	216.2
		Y-prickelback (Allolumpenus hypochromus)	1	9.0	127.0
		Pacific Tomcod (Microgadus proximus)	1	2.0	70.0
		Hermit Crab	5	1.0	-
		Shrimp (Crangon alaskensis)			
		(Evalus slickleyi)	31	1.53	23-44
Hook Cove	166.5	Northern Ronquil (Ronquilus jordani)	1	7.6	110
		Searcher (Bathymaster signatus)	1	43.5	171
		Shrimp (Pandalus hypsinotus)			
		(Pandalus hypsinotus	100	2.52	19-48
		(Pandalus danae)			

Table 12. Standardized residuals by fish species group at Nomad colony.

Nest Number	Sandlance	Blenny	Sculpin	Other	Unidentified
28	2.17*	0.25	-1.56	-1.38	-1.92
39	1.91	-1.79	-0.35	-1.56	0.23
N1	-5.12**	3.06**	4.13**	0.55	0.65
47	3.13**	-0.64	-1.61	-1.58	-2.31*
N2	-1.44	0.24	0.02	4.42**	-0.32
Unknown	-0.98	-1.59	-1.17	0.06	5.18**

* - Significant at .05 level, z = 1.96

** - Significant at .01 level, z = 2.576

Table 10. Standardized residuals by fish species group at Hook colony.

Nest Number	Sandlance	Blenny	Sculpin	Other	Unidentified
14	1.60	-1.53	-0.74	0.18	0.01
45	2.51*	-1.29	-2.12*	0.32	-0.25
46	2.29*	-1.89	-0.36	-1.08	-0.25
34	1.98*	-1.58	-1.12	-0.71	0.60
H1	1.22	-1.85	-0.58	-1.38	-0.04
H2	-2.81**	2.64**	1.02	-0.59	0.71
H3	-2.98**	2.63**	1.27	1.64	-1.28
H4	-2.00*	2.30*	-0.37	-0.80	1.59
H7	-0.59	-0.23	-0.31	2.16*	0.19
H8	-0.59	-0.56	2.92**	-0.84	-0.91

* - Significant at .05 level, z = 1.96

** - Significant at .01 level, z = 2.576

Table 10. Standardized residuals by fish species group at Hook colony.

Nest Number	Sandlance	Blenny	Sculpin	Other	Unidentified
14	1.60	-1.53	-0.74	0.18	0.01
45	2.51*	-1.29	-2.12*	0.32	-0.25
46	2.29*	-1.89	-0.36	-1.08	-0.25
34	1.98*	-1.58	-1.12	-0.71	0.60
H1	1.22	-1.85	-0.58	-1.38	-0.04
H2	-2.81**	2.64**	1.02	-0.59	0.71
H3	-2.98**	2.63**	1.27	1.64	-1.28
H4	-2.00*	2.30*	-0.37	-0.80	1.59
H7	-0.59	-0.23	-0.31	2.16*	0.19
H8	-0.59	-0.56	2.92**	-0.84	-0.91

* - Significant at .05 level, z = 1.96

** - Significant at .01 level, z = 2.576

Table 11. Standardized residuals by fish species group at Row colony.

Nest Number	Sandlance	Blenny	Sculpin	Other	Unidentified
25	-0.00	-1.39	-1.53	-0.99	4.02**
32	0.74	-0.10	0.03	-1.11	-0.99
49	-1.27	-0.13	-1.35	-0.65	4.94**
R1	-0.85	1.91	0.38	1.38	-1.66
R2	0.34	1.74	-0.33	0.85	-1.98*
R3	1.66	-2.41*	0.14	-1.19	-0.23
R4	2.21*	-1.96*	-1.12	-0.83	-0.85
R5	-2.86**	-2.41*	6.24**	5.86**	-0.72
R6	0.10	2.17*	-1.77	-1.08	-0.37
R7	-0.09	2.80**	-2.18*	-1.05	-0.27

* - Significant at .05 level, z = 1.96

** - Significant at .01 level, z = 2.576

Table 11. Standardized residuals by fish species group at Row colony.

Nest Number	Sandlance	Blenny	Sculpin	Other	Unidentified
25	-0.00	-1.39	-1.53	-0.99	4.02**
32	0.74	-0.10	0.03	-1.11	-0.99
49	-1.27	-0.13	-1.35	-0.65	4.94**
R1	-0.85	1.91	0.38	1.38	-1.66
R2	0.34	1.74	-0.33	0.85	-1.98*
R3	1.66	-2.41*	0.14	-1.19	-0.23
R4	2.21*	-1.96*	-1.12	-0.83	-0.85
R5	-2.86**	-2.41*	6.24**	5.86**	-0.72
R6	0.10	2.17*	-1.77	-1.08	-0.37
R7	-0.09	2.80**	-2.18*	-1.05	-0.27

* - Significant at .05 level, z = 1.96

** - Significant at .01 level, z = 2.576

Table 13. Standardized residuals by fish species group.

Colony	Sandlance	Sculpin	Blenny	Cod	Flatfish	Unidentified
Row	0.31	1.44	-0.34	-1.45	0.06	-0.39
Hook	-1.73	-4.19	1.72	3.84**	3.80**	1.35
Nomad	-1.60	4.10**	-1.62	1.34	-2.06*	0.47
West Point	3.65**	-3.93**	0.15	-2.61**	-1.45	-1.31
Parakeet	1.31	-0.20	1.38	-2.90**	0.94	-0.86

* - Significant at .05 level, z = 1.96

** - Significant at .01 level, z - 2.576

Table 14. Mean weight and sizes of Pigeon Guillemot adults and fledglings at Naked Island, Alaska.

Location and Reference	Age	Weight (g)			Tarsus (mm)			Culmen (mm)			Wing Chord (mm)		
		x̄	n	s	x̄	n	s	x̄	n	s	x̄	n	s
Naked Island, Alaska 1978*	Adult	517.5	20	47.8	36.6	19	2.7	33.0	19	2.4	173.9	16	5.8
	Juvenile	476.5	24	34.6	37.4	24	1.5	28.2	24	1.2	135.6	24	5.9
Naked Island, Alaska 1979	Adult	504.1	42	24.6	37.1	23	1.7	33.1	23	1.0	177.5	23	3.3
	Juvenile**	506.3	18	37.8	38.8	18	1.7	31.0	18	1.2	136.6	17	3.3
	Juvenile***	503.1	8	43.1	38.2	8	0.8	27.7	8	1.2	137.5	7	2.6
Naked Island, Alaska 1979	Adult:male	519.9	10	17.2	37.8	10	0.9	33.4	10	1.1	178.0	10	4.0
	Adult:female	505.7	10	22.4	37.3	10	1.6	33.0	10	0.8	177.0	10	3.0

* Oakley and Kuletz 1978

** Within 1-4 days of fledging

*** Within 24 hours of fledging

Table 15. June 5-6, 1979 survey results of Naked Island complex.

Species	Naked Island	Smith Island	Little Smith Island	Storey Island	Peak Island	Total
Loon sp.	3			1		4
Cormorant sp.	65					65
Great Blue Heron	1			1		2
Harlequin Duck	18			15		33
Merganser sp.	22			5		27
White-winged Scoter	1					1
Bald Eagle	13	3		7		23
Black Oystercatcher	2			3		5
Glaucous-winged Gull	231			2	24	257
Mew Gull	7					7
Black-legged Kittiwake	87			28	23	138
Arctic Tern	33	1	34	42	45	155
Pigeon Guillemot	1227	301	58	506	150	2242
Marbled Murrelet	197	4		41	44	286
Parakeet Auklet	78	293	156	35	5	567
Horned Puffin	20	13	10		10	53
Tufted Puffin	113	248	45	206	35	647
Common Raven	1	1				2
Northwestern Crow	2	3				5

Table 16. Colony census counts for three species of alcids over five years. Blank spaces indicate areas not surveyed that year.

Colony	Parakeet Auklet					Horned Puffin					Tufted Puffin				
	1972	1976	1977	1978	1979	1972	1976	1977	1978	1979	1972	1976	1977	1978	1979
Storey Island	14	–	18	76	35	14	–	27	35	0	120	–	68	201	206
Peak Island	–	–	–	–	5	–	–	–	20	10	–	–	–	23	35
East Point, Naked Island	14	–	0	56	248	10	–	16	13	37	90	–	20	56	113
Bass Harbor Island	0	–	40	72	37	0	–	0	0	3	1000	–	105	205	292
Little Smith Island	–	186	113	44	156	80	35	25	20	10	500	83	52	59	45
Smith Island	–	214	237	70	293	120	37	32	25	13	1100	277	87	173	248

Table 16. Colony census counts for three species of alcids over five years. Blank spa

Colony	Parakeet Auklet					Horned		
	1972	1976	1977	1978	1979	1972	1976	19
Storey Island	14	–	18	76	35	14	–	
Peak Island	–	–	–	–	5	–	–	
East Point, Naked Island	14	–	0	56	248	10	–	
Bass Harbor Island	0	–	40	72	37	0	–	
Little Smith Island	–	186	113	44	156	80	35	
Smith Island	–	214	237	70	293	120	37	

Table 17. Summary of bird observations on two inshore transects and one offshore transect at Naked Island, 1978 and 1979.

	Inshore T1 1978	Inshore T1 1979	Inshore T2 1978	Inshore T2 1979	Offshore Transect B 1979
Number of times transect was run	20	20	22	14	10
Species					
Loon sp.					
Average density*	0	0.7	0	1.0	0.6
% frequency of occurrence	0	15.0	0	28.6	10.0
% of all birds recorded	0	0.3	0	0.3	1.5
Pelagic Cormorant					
Average density*	0.2	0.2	0.4	0.6	0
% frequency of occurrence	5.0	10.0	13.6	21.4	0
% of all birds recorded	0.1	0.01	0.1	0.2	0
Harlequin Duck					
Average density*	0	0.6	0	2.1	
% frequency of occurrence	0	10.0	0	28.6	
% of all birds recorded	0	0.3	0	0.6	
White-winged scoter					
Average density*	7.6	1.5	1.8	0	3.4
% frequency of occurrence	50.0	15.0	18.2	0	10.0
% of all birds recorded	5.3	0.7	0.6	0	9.0
Merganser sp.					
Average density*	0	0.6	0	0.8	
% frequency of occurrence	0	15.0	0	14.3	
% of all birds recorded	0	0.3	0	0.2	
Mew Gull					
Average density*	0.5	0.2	2.2	0.2	0
% frequency of occurrence	15.0	5.0	13.6	7.1	0
% of all birds recorded	0.4	0.01	0.8	0.1	0

Table 17(con't.) Summary of bird observations on two inshore transects and one offshore transect at Naked Island, 1978 and 1979.

	Inshore T1 1978	Inshore T1 1979	Inshore T2 1978	Inshore T2 1979	Offshore Transect B 1979
Glaucous-winged Gull					
Average density*	3.6	4.9	11.1	21.4	1.8
% frequency of occurrence	60.0	45.0	50.0	71.4	50.0
% of all birds recorded	2.5	2.3	3.8	6.3	4.8
Black-legged Kittiwake					
Average density*	39.1	43.6	58.1	65.8	2.2
% frequency of occurrence	95.0	85.0	100.0	100.0	50.0
% of all birds recorded	27.2	20.3	19.7	19.3	5.8
Arctic Tern					
Average density*	1.1	4.6	6.9	4.4	1.4
% frequency of occurrence	20.0	20.0	54.5	57.1	30.0
% of all birds recorded	0.7	2.2	2.3	1.3	3.7
Common Murre					
Average density*	3.2	0.1	1.0	0	1.2
% frequency of occurrence	40.0	5.0	9.1	0	30.0
% of all birds recorded	2.3	0.01	0.3	0	3.2
Pigeon Guillemot					
Average density*	33.9	59.3	73.0	98.6	9.8
% frequency of occurrence	100.0	100.0	100.0	100.0	90.0
% of all birds recorded	23.6	28.1	24.8	28.9	26.0
Marbled Murrelet					
Average density*	50.9	94.7	139.2	145.9	12.9
% frequency of occurrence	95.0	100.0	100.0	100.0	100.0
% of all birds recorded	35.4	44.8	47.2	42.8	34.2

Table 17 (con't.) Summary of bird observations on two inshore transects and one offshore transect at Naked Island, 1978 and 1979.

	Inshore				Offshore
	T1		T2		Transect B
	1978	1979	1978	1979	1979
Horned Puffin					
Average density*	1.7	0.2	0.2	0	1.4
% frequency of occurrence	25.0	5.0	4.5	0	20.0
% of all birds recorded	1.2	0.01	0.1	0	3.7
Tufted Puffin					
Average density*	0.8	0	0.2	0	1.2
% frequency of occurrence	20.0	0	9.1	0	40.0
% of all birds recorded	0.6	0	0.1	0	3.2
Parakeet Auklet					
Average density*		0		0	0.6
% frequency of occurrence		0		0	10.0
% of all birds recorded		0		0	1.5

* Birds/km^2

Table 18. Summary of marine mammal sightings on inshore and offshore transects.

	T1 1978	T1 1979	T2 1978	T2 1979	Offshore Transect A 1978	Offshore Transect B 1979
Number of surveys	20	20	22	14	4	10
<u>Species</u>						
Sea Otter						
Average density*	1.2	4.2	1.8	6.6	0.7	1.1
% frequency of occurrence	35.0	65.0	31.8	71.4	25.0	20.0
% of all marine mammals recorded	29.0	50.0	6.3	11.0	27.4	28.2
Harbor Seal						
Average density*	1.9	3.4	26.2	51.3	0.2	
% frequency of occurrence	20.0	55.0	59.1	92.9	25.0	
% of all marine mammals recorded	50.0	40.5	90.6	85.8	9.5	
Killer Whale						
Average density*	0	0	0	21.6	0.4	
% frequency of occurrence	0	0	0	7.1	25.0	
% of all marine mammals recorded	0	0	0	2.5	17.9	
Harbor and Dall Porpoise						
Average density*	0.6	0.4	0	0	1.1	1.7
% frequency of occurrence	10.0	5.0	0	0	50.0	50.0
% of all marine mammals recorded	15.7	4.8	0	0	45.3	43.6
Minke Whale						
Average density*	0.2	0.1	0.9	0	0	1.1
% frequency of occurrence	10.0	5.0	22.7	0	0	10.0
% of all marine mammals recorded	5.3	1.2	3.0	0	0	28.2
Humpback Whale						
Average density*	0	0	0	0.4		
% frequency of occurrence	0	0	0	7.1		
% of all marine mammals recorded	0	0	0	0.7		
River Otter						
Average density*	0	0.3	0	0		
% frequency of occurrence	0	10.0	0	0		
% of all marine mammals recorded	0	3.6	0	0		

* Number/km^2

	May 1978	May 1979	June 1978	June 1979	July 1978	July 1979	August 1978	August 1979	TOTAL 1978	TOTAL 1979
Weather (% of days)										
Clear	21	26	27	33	25	28	50	40	32	32
Overcast	26	35	30	16	34	14	7	20	24	23
Rain	53	39	43	40	41	55	43	40	44	45
Wind Speed (% of days)										
Less than 5 knots	68	52	87	37	79	66	55	36	73	48
More than 5 knots	32	48	13	53	21	32	45	64	27	52
Wind Direction (% of days)										
SE	59	78	62	48	81	66	58	60	65	56
SW	18	17	38	30	4	31	23	20	21	25
NW	23	5	0	12	15	9	19	4	14	11
Variable		-		10		-		16	-	8
Rain (cm)	14.7	27.8	21.2	5.2	29.5	9.70	10.8	11.35	76.2	54.0
Temperature (C°)										
Average daily maximum	7.3	14.0	8.9	16.7	15.2	17.6	20.3	16.04	-	-
Average daily minimum	2.2	3.16	4.1	5.8	9.7	10.1	11.0	9.8	-	-