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APPENDIX V

THE BREEDING BIOLOGY OF MARINE BIRDS ASSOCIATED WITH CHINIAK BAY, KODIAK ISLAND, 1977

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ABSTRACT

Ten island breeding colonies of seabirds were censused and studied in varying degrees in the inner portions of Chiniak Bay while two tern colonies were monitored on mainland Kodiak.

The number of cliff nesting birds overall for the bay was similar to that found in 1975 by Dick, but individual colonies had changed in their composition and numbers.

Breeding phenology was determined for the eight major species of the study while incidental notes were gathered on seven other study species. Productivities were gathered only on the eight major study species: Black-legged Kittiwake, Tufted Puffin, Pelagic and Red-faced Cormorants, Mew and Glaucous-winged Gulls, and Arctic and Aleutian Terns.

Black-legged Kittiwakes overall raised 0.78 chicks per nest attempt. Tufted Puffins had a maximum possible productivity of 0.67 chicks per nest attempt. Pelagic Cormorants fledged 1.35 young per nest attempt while Red-faced Cormorants had a productivity of 1.91 young per nest attempt. A minimum figure of productivity for Glaucous-winged Gulls at one high density plot was 1.15 young per nest attempt. Storms and predators greatly lessened the success of the Mew Gull and the two tern species, but estimates of surviving chicks are attempted.

One hundred and twelve birds were collected for food and parasite analysis. A roughsort indicates that Sandlance (Ammodytes hexapterus), Capelin (Mallotus villosus), euphausids (Thysanoessa raschii), and unidentified Gadidae are the major food items found in the three major species collected: Black-legged Kittiwake, Tufted Puffin, and Common Murre.

Four sea mammals and seven birds were found in the 25.6 kilometers of beach walked the summer of 1977.

Banding of young birds with U.S. Fish and Wildlife leg bands was done on Puffin, Zaimka, and Mary Island between 4 and 8 August. This involved a total of 349 birds of three species: 267 Glaucous-winged Gulls, 75 Mew Gulls, and 7 Arctic Terns.

I. INTRODUCTION

Lease sales are imminent for many portions of the continental shelf areas surrounding Kodiak Island. The town of Kodiak and parts of Chiniak Bay are slated to be staging and resupply areas. Two Kodiak oil spills in January and March 1970 have already indicated what adverse impacts offshore shipping can have: at least 10,000 birds died with the possibility of 100,000 birds having been killed (Bureau of Land Management, 1976). If marine birds are valid indication of the health of the food chain and there is increasing evidence to support this concept, then it is essential to continue expanding baseline data and monitoring studies of the marine birds in the region.

The authors arrived in Kodiak on 8 June 1977. The field work began in earnest on 13 June and continued until the end of August. Ten island breeding colonies involving thirteen species of marine birds were found within a radius of 5-7 kilometers of the Kodiak small boat harbor and three mainland colonies of terns were available from the island road system. Four of these island colonies and two of those on the mainland were used for intensive study sites (a visit every 3-5 days) while the remaining were visited only 2-4 times during the entire summer.

There were five specific objectives for the 1977 summer field work:

1. To set up sample plots on breeding colonies as a monitoring system.

2. To describe the local phenology of the reproductive biology of certain species such as the Black-legged Kittiwake, the Tufted Puffin, and others determined in the field.

3. To provide estimates of productivity of species mentioned in objective 2.

4. To determine major food items of the breeding species mentioned in objective 2.

5. To expand both the beached bird surveys and the bird-banding program.

II. CURRENT STATE OF KNOWLEDGE

The coastal waters of Kodiak Island provide excellent habitat for large numbers of both breeding and wintering seabirds and waterfowl. Some general and historical species' accounts like "The birds of Kodiak Island, Alaska" by Herbert Friedmann (1935) are available, but until recently this important resource was largely ignored by wildlife biologists.

In 1975 the U. S. Fish and Wildlife Service (Office of Biological Services - Coastal Ecosystems, Anchorage) initiated three primary types of studies in Chiniak and southern Marmot Bays: 1) beached bird surveys (Dick, 1976); 2) small boat censuses of inshore waters (Dick, et. al., 1976a); and 3) census and cataloguing of seabird breeding colonies (Dick, et. al., 1976b, 1976c). In 1976 some sample plots on breeding colonies were established in Chiniak Bay, but the primary emphasis was colony census work centering around Afognak Island. Much of the remaining Kodiak Island shoreline was censused for breeding colonies and this data will be published in a catalogue of Alaskan seabird colonies (U. S. Fish and Wildlife Service, in preparation).

In the winter of 1976-77 Matt Dick began more intensive collections of seabirds for purposes of analyzing some of the trophic relationships of the marine birds wintering in the Chiniak Bay region. John Trapp (1977) conducted aerial surveys March 9-14, 1977 which covered more than 90% of the Kodiak Island coastline. The staff of the Kodiak National Wildlife Refuge had previously conducted ship-board surveys along much of the coastline in February of 1973 and 1975 (U.S. Fish and Wildlife Service, 1973 and 1975) while the Alaska Department of Fish and Game conducted aerial transects of Kodiak and Afognak Islands' coastal waters in February and March of 1976 using a stratified-random design (Arneson, 1977).

III. STUDY AREAS

Ten of the seabird colonies utilized in this study were found in the inner portions of Chiniak Bay: Women's Bay, St. Paul Harbor, Woody Island Channel, and Middle Bay (Figure 1). Six of the ten colonies were located on islands smaller than 0.5 kilometer in length while only one colony (excepting those of terns) was found on the mainland (Kodiak Island proper).

The small offshore islands utilized most by seabirds are almost all similar in structure. Most range between 15 and 30 meters in height and are ringed by sloping to vertical, bare or partly vegetated, broken or sheer sea cliffs or by steep vegetated sea slopes. The island periphery vegetation is a beach rye (Elymus arenarius) - umbelliferous herb association with bluejoint (Calamagrostis canadensis) grass replacing the beach rye on the top and interior of the islands. Shrubs and trees were sparse or absent.

Puffin, Zaimka, and Mary Islands had high levels of human activity and intermittent low levels of egging while the remaining islands all (except Viesoki which had no human disturbance) had low levels of human activity associated with them and essentially little or no egging activity. Mary Island also had intermittent naturally occurring mammalian predators.

The three tern colonies studied on mainland Kodiak were located at the heads of Kalsin and Middle Bay. The colony at Middle Bay was located in coastal lowland between the American River and the outer active beach drift line. One tern colony at Kalsin Bay was located in coastal lowland on the shore of the Olds River while the second colony was on a low deltaic island at the mouth of the Olds River. Restrictive factors at Middle Bay were grazing by cattle (nests were stepped on), low levels of human activity, intermittent natural mammalian predators, and domestic predators like dogs. The Kalsin Bay colonies had less human disturbance, but the other limiting factors were similar.

The climate of Chiniak Bay is influenced by the marine environment characterized by moderately heavy precipitation, cool temperatures, high cloud and fog frequency with little or no freezing weather. The summer months usually have the least rainfall, but 1977 was an exception. The first part of the summer was normal or drier than normal, but a series of storm systems moved into the Kodiak area from the middle of July to the middle of August bringing rain at the average rate of 1.27 inches per day. The past overall mean precipitation for the month of August (1949-74) was 4.65 inches. The highest previous mean for August was 9.30 inches in 1964. In just the first thirteen days of August 1977, 15.2 inches had been recorded at Kodiak. Storms can occur in August, but those this summer appeared to be more severe than normal.

IV. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Censuses and Densities

All cliff-nesting seabirds were censused on the ten islands or colony sites in the study area. Density of nest sites of gulls, terns, and puffins were determined by line transects or quadrat sampling (Nettleship, 1976) with care to include data from the periphery of colonies or low density sites. Burrow occupancy and/or attendance by nocturnal species were estimated by placing toothpicks upright in burrow entrances. This data is compared with eggs found in the same burrows.

Breeding Phenology and Productivity

The major effort was devoted to the eight species of colonial seabirds breeding at accessible sites in Chiniak Bay. Incidental notes were also gathered on the scattered nests of species like Horned Puffin, Pigeon Guillemot, Black Oystercatcher, and Common Eider.

Black-legged Kittiwake (Rissa tridactyla)

The colony on Kulichkof Island was visited every 4 to 5 days during hatching and most of the chick stage. Nests were not individually marked. The colony was subdivided into six sub-areas for nest-checking purposes, but data were combined since total nest numbers were consistently similar and sub-area data varied from visit to visit. This variation was due to the difficulty of censusing the denser parts of the colony. All censusing was done from clifftop vantage points.

The colony at Gibson Cove was used for just productivity studies. Two visits on 16 and 20 June ascertained nesting attempts while two visits on 11 and 20 August recorded the number of chicks. All censusing was done from a dory immediately offshore from the colony.

Tufted Puffin (Lunda cirrhata)

All of the productivity work on this species in Chiniak Bay was done on Cliff Island because it had shallower soil as well as both peripheral and slope burrows. A line transect (15 meters) and a quadrat (10 x 10 meters) were laid out on 26 June and checked for activity by toothpicking the burrow entrances. To reduce soil erosion and nest desertion by adults, the two sample plots were checked only three times: 1) late in incubation; 2) during hatching; and 3) just before fledgling (only on quadrat). The quadrat lay in entirety on the cliff slope while the line transect also samples some of the island top. The line transect included all burrows that lay within one meter of either side of the transect.

A few burrows on Puffin Island were frequently checked to discover the beginning of hatching, but this was not done on Cliff Island because of the tendency for adults to abandon at this stage in their breeding phenology.

Pelagic and Red-faced Cormorants (Phalacrocorax pelagicus and P. Urile.)

Intensive phenology work was done only on Kulichkof Island where Pelagic Cormorant nests were mixed in with the kittiwake colony. The cormorant nests in the kittiwake colony were censused every 4-5 days during hatching and most of the chick stage.

The remaining cormorant nests on Kulichkof plus portions of colonies on Bird, Puffin, Cliff, and Zaimka Islands as well as Gibson Cove were checked for productivity by two or three visits: 1) once or twice during the middle of incubation (14-21 June); and 2) once about 1-2 weeks before fledgling (4-12 August). All of the islands mentioned above except Kulichkof had both species nesting.

Glaucous-winged Gull (Larus glaucescens)

The same quadrats were checked in 1977 that Matt Dick set up in 1976; 1) 3 10 x 10 meter quadrats of low density nesting habitat on Cliff Island; 2) 6 10 x 10 meter quadrats of low-density on Zaimka Island; and 3) 1 irregular larger sample plot (766 sq. meters) of high-density nesting habitat on Zaimka. Nests were marked and all plots were visited every 4-6 days during hatching.

The high-density plot was also checked for chick productivity on 6 August since geographical and water conditions restrained most if not all chicks from wandering far from nest sites.

Mew Gull (Larus canus)

Essentially the same quadrats were run on Mary Island as those set up in 1976 by Matt Dick. The south colony had 11 quadrats (10 x 10 m) arranged linearly so as to cross from periphery to periphery of the colony. The northeast colony had 5 quadrats (10 x 10 m) lined up mostly in the middle of the colony.

Nests were marked in those plots and the plots were monitored every 4-5 days during hatching for phenology purposes. Estimates of productivity were made by comparing ratios of banded chicks near fledging/ total number of chicks clustered nearshore to banded/non-banded dead chicks found on beaches two weeks later.

Arctic and Aleutian Terns (Sterna paradisaea, and S. aleutica)

Three colonies were monitored for phenology during incubation and hatching: 1) a mixed species colony on Mary Island; 2) a small Aleutain Tern colony along the Olds River at the head of Kalsin Bay.

Individual nests were marked and much time was devoted to finding every nest in a sub-colony. Densities were obtained from nearest neighbor measurements and habitat quadrats (usually 10x 10 m) that were taken from the four habitats the large colony on Mary Island occupied.

Trophic Ecology

Collection of seabirds were made periodically to determine diet and parasites. The two primary study species, Tufted Puffin and Black-legged Kittiwake, were collected by the systematic serial method recommended by Sanger (pers. comm.). This necessitated the collection of three individuals of each species every five days, if possible. Birds actively feeding away from colony sites were collected and these birds were evaluated in terms of reproductive condition, feeding habits, plumage, and general morphological data. Stomach contents of collected birds as well as food samples brought to chicks were preserved for identification and quantification at a later date.

Mortality

Beached bird surveys were run monthly or bimonthly on the four strips established in 1975 by Matt Dick. Four addtional beaches were surveyed in 1977.

Banding young with U.S. Fish and Wildlife leg bands was emphasized during the first week of August for two species: Mew and Glaucous-winged Gulls. These species were selected because of the high probability of recoveries.

IV. RESULTS AND DISCUSSION

Censuses and Densities

Variations were noticed in numbers of active nests of three cliff-nesting species of seabirds between 1975 and 1977 (Table 1). The nesting population of kittiwakes remained relatively constant with increases at Gibson Cove and Kulichkof Island countering the decreases at Viesoki Island. Red-faced Cormorants increased nest numbers in 1977 at essentially every island except Viesoki which decreased so greatly from 1975 that the 1977 overall total was lower than 1975. Pelagic Cormorant nests increased almost twofold in 1977 compared to 1975 nesting.

Burrow or ground nesting colonial seabirds are hard to totally census and hence mean nesting densities of sample plots were used for monitoring purposes of the five species studied in Chiniak Bay (Table 2). The distance to nearest nest of the same species was used in evaluating and monitoring nest densities.

Two sample plots of Tufted Puffins on Cliff Island were used to extrapolate an estimate of the breeding pairs on the island. One quadrat (100m2) had 74 burrows and 61 appeared active. Of the 61, nest chambers or burrow ends could be reached in 30 and only 25 had eggs. The line transect (30 m2) had 30 burrows and 26 appeared active. Of the 26 nest chambers or burrow ends were reached in 12 and in these, only 10 had eggs. Since 35 of 42 reached to the end were active in 130 m2, then a similar proportion of all active burrows (found by toothpick method) would be 73 or 80 active burrows out of the total 97 burrows that appeared active. The variation depends on whether each plot is extrapolated separately or together. Using the lower figure, 73 active burrows in 130 m2, gives an estimate of the breeding population as 1094 pairs for Cliff Island since there were 1949 m2 of habitat being used for burrows. This estmate may be high as there may have been different burrow densities in the total habitat used than those recorded in the sample plots. Matt Dick estimated 400 breeding pairs in 1975 on Cliff Island.

The nesting densities of Mew and Glaucous-winged Gulls are similar as are the mean distances of nearest neighbor nests ($t = 0.17$, d.f. = 103, $P > .95$), but they utilize two different habitats. The Glaucous-winged Gull used the Elymus, Calamagrostis, or umbel plant associations for nesting with highest densities found toward the island perimeter. The Mew Gull had its highest nesting densities in more interior portions of islands where Calamagrostis was dominant. Even though there were low and high density nesting plots for each species, the differences in mean distance of nearest nest are not significant for either species ($t=1.56$, d.f.=59, $P > .10$; $t=1.37$, d.f.= 62. $P > .10$). Behavioral needs apparently require a certain amount of clumping even in less desirable habitat.

Arctic Tern nesting density varied from 7 to 13 nests per square dekameter with a mean of 10.6 nests. The mean distance of the nearest neighbor nest was 2.13 ± 0.08 m. Aleutian Terns had two nesting strategies in 1977. On Mary Island where they nested with the Arctic Tern colony, they were clumped in several points along the perimeters of the Arctic Tern colony. The Aleutian Tern nests subsequently had a higher density (13 nests per square dekameter) and a significantly smaller distance between neighboring nests of 1.38 ± 0.10 m ($t=4.52$, d.f.=105, $P < .01$). When the Aleutian Terns nested by themselves at the heads of bays, the mean distance of nearest neighbor nests expanded significantly to 30.99 ± 4.34 m ($t=9.81$, d.f.=31, $P < .01$).

Breeding Phenology and Productivity

Black legged Kittiwake

The sample plot on Kulichkof Island included almost all of the nesting kittiwakes found there (210 of 218 nests). The colony utilized approximately 630m2 of cliff face with most of the nests found between 5 and 12 meters above sea level on the cliff faces. This gave a nesting density of 33 nests per square dekameter.

Field work began just after egg laying had begun. Intensive observation from then on indicated that all egg loss occurred during the first two weeks of July (78% between 9 and 15 July). Hence an extrapolation of laying dates from hatching dates would be fairly accurate since avian predation was limited in time and amount. An incubation time of 28 days (Swartz, 1966) was used for this extrapolation. Hatching began on 2 July and peaked on 10 July with the mode (middle two thirds) occurring between 7 and 20 July (Figure 2). This would mean that egg laying started about 4 June peaking on 12 June. The last known hatching date was 26 July making egg laying end during the last week of June. Generally speaking, the 1977 Chiniak Bay breeding phenology is 1-2 weeks behind that of Hinchinbrook Island 1976-77 (Nysewander and Knudtson, 1977; Sangster, pers. comm.) and a few days earlier than that at Sitkalidak Island in 1977 (P. Baird and A. Moe, pers. comm.)

The mean number of eggs per completed clutch for the Kulichkof Island colony was 1.91. Hatching success of known eggs (n=338) was 84.9% and fledging success of known chicks (n=287) was 90.2% This gave a productivity of 1.23 chicks fledged per nest attempt or 1.46 chicks fledged per nest with eggs. Table 3 compares this reproductive success with that at Gibson Cove where only 0.30 chicks fledged per nest attempt.

Predation appeared to be the mortality factor that caused the difference found in kittiwake reproductive success between Gibson Cove and Kulichkof Island. Although the Gibson Cove colony was studied only periodically, Bald Eagles were observed twice carrying off kittiwake chicks while crows and magpies were quite abundant and nesting nearby. The only avian predators noticed at Kulichkof Island were the low number of Glaucous-winged Gulls nesting on the island. As mentioned, essentially no noticeable kittiwake egg loss occurred at Kulichkof Island until the first two weeks of July. This egg loss occurred just as most of the kittiwake hatching began and just after the hatching peak of the Glaucous-winged Gulls.

The only mortality caused by human disturbance occurred on 18 July when 5 chicks fell from nests into the water while we were checking nests. This type of chick loss (17.8% of total chick mortality) did not occur either before or after this time during our visits.

Table 4 lists the egg, chick, and fledging distributions found during different reproductive stages on the Kulichkof Island colony.

The egg and clutch data were taken on 30 June while brood data were collected on 18 July. Fledging data were gathered 4 August. The number of three egg clutches and one nest that managed to fledge three chicks indicate the high reproductive success noted on Kulichkof Island this year.

Tufted Puffin

One quadrat (100m2) had a slope density of 1.04 active burrows per square meter. The island top measured by the line transect (20m2) had a density of 0.08 active burrows per square meter. The overall mean of 0.56 burrows per square meter was very similar to that found in the Barren Islands (0.54) by Amaral in 1976.

Hatching began on 10 July and peaked on 19 July with a mode occurring between 14 and 25 July (Figure 3). The last known hatching was 8 August. Using a 45 day incubation period (Sealy, 1973), this would mean that egg laying began 26 May peaking on 4 June and that fledging probably peaked somewhere during the first week of September. This phenology for Chiniak Bay was essentially the same as that found in the Barren Islands and Prince William Sound in 1976 (Amaral, 1977 , Nysewander and Knudtson, 1977).

Hatching success of known eggs (n=35) was 88.6% while fledging success of known chicks (n=22) was 90.2% (Table 5). This gave a productivity of 0.67 chicks fledged per nest attempt or 0.80 young fledged per nests with eggs. This is essentially the same as that found at Hinchinbrook Island in 1976 (Nysewander and Knudtson, 1977), but much higher than that found at the Barren Islands (0.28) by Amaral (1977). Nettleship (1972), however, found a success rate for Common Puffin similar to that found for Tufted Puffins in Chiniak Bay. My experience with intensive or daily studies of both Tufted Puffins and Rhinoceros Auklets on Destruction Island leads me to believe that these daily studies greatly lower the reproductive success of puffins. Visiting this species a minimum of three visits at certain less critical times at Prince William Sound and Chiniak Bay appear to support this hypothesis. The three periods of time primarily used this year in Chiniak Bay for checking puffin burrows were as follows: 1) 26-28 June, late incubation; 2) 14-19 July, hatching; and 3) 23 August, fledging.

Table 6 lists the egg, chick, and fledging distributions found during different reproductive stages at the Cliff Island plots.

Pelagic and Red faced Cormorants

The intensive phenology and productivity plot for cliff nesting species on Kulichkof Island included only 26 of the 71 Pelagic Cormorant nests found on the island. The density of the phenology plot was 4.1 nests per square dekameter of utilized habitat while the density of the remaining 45 nests was 11.5 nests per square dekameter of suitable habitat used. Nesting densties of cormorants

(2 species mixed) on seven other islands varied from 2.7 - 9.3 nests per square dekameter. The overall colony mean for Chiniak Bay (2 species combined) was 6.2 nests per square dekameter.

Hatching for Pelagic Cormorants began on 4 July peaking on 11 July with the mode extending from 9 to 14 July (Figure 4). The last hatching was noted on 18 July. Using a 31 day incubation period (Van Tets, 1959), this would make egg laying begin on 3 June peaking on 10 June. This makes the Pelagic Cormorant phenology in Chiniak Bay about a week ahead of that of Black-legged Kittiwake which are nest-site competitors (Dick, 1975). No phenology was gathered on Red-faced Cormorants in 1977 at Chiniak Bay due to the late start of field work.

The mean number of eggs per completed clutch for Pelagic Cormorants was 3.48 on Kulichkof Island. Hatching success of known eggs (n=87) was 69.0% and fledging success of known chicks (n=60) was 61.7%. This gave a productivity of 1.42 young fledged per nest attempted or 1.48 young fledged per nest with eggs (Table 7). Productivity by nest attempt of Pelagic Cormorants varied on five other islands from 0.13 - 1.94 young fledged with the six island mean being 1.35 young fledged. Red-faced Cormorants had a five island mean productivity of 1.91 chicks fledged per nest attempt. Both of these averages were lowered by the essentially total breeding failure of either species on Zaimka Island. This is attributable to the colony of crows breeding on Zaimka as well as the human disturbance that is common on that island. The crows were observed several times taking eggs when people scared the cormorants off their nests.

Both species did well on the remaining islands and Red-faced Cormorants were more successful than Pelagic Cormorants in almost every case where they nested together ($X2 = 10.4$, $P = .01$).. The inclusion of highly successful single species (Pelagic Cormorant) colonies like Kulichkof Island still shows Red-faced Cormorants to have been more successful in producing fledglings ($X2 = 4.44$, $P > .05$)

Table 8 compares reproductive success, phenology, and breeding parameters of Pelagic Cormorants nesting in Chiniak Bay with those of Mandarte Island (Drent, et. al. 1964) and Cape Peirce (Dick, 1975). It appears that Chiniak Bay birds are intermediate in all categories Although the southern site has higher overall success and clutch size, there is an inverse relationship between hatchings and fledging success in northern versus southern colonies. Northern colonies appear to have greater hatching success and lower fledging success than southern colonies. Possibly, this indicates that gulls and crows are important mortality causes in the south while predation by eagles, food, or weather may be more important limiting factors in the north. Chiniak Bay was interesting in this respect in that crows certainly elminiated breeding on Zaimka Island, but most of the cormorant colonies were not bothered by avian predators even when humanly disturbed. This lack of predation contrasts greatly

with this author's experience with cormorant colonies in Washington.

The two study plots on Kulichkof Island point up how either human disturbance, association with kittiwake nests, and/or cormorant nest density does affect the reproductive success of Pelagic Cormorants. The cormorants associated with the kittiwakes in our intensive study area produced 1.48 young per nest attempt while the more dense, less disturbed and single species colony of cormorants on the rest of the island produced 2.14 young per nest attempt which was significantly different ($X2 = 4.05$, $P > .05$). Since nesting gull populations are low (see discussion under Glaucous-winged Gull section) and crows are clumped in their distribution at this time, weather and possibly food appeared to be more important. The unusually heavy rainfall and storm from mid-July to August caused some noticeable losses. Only two chicks fell from their nests due to human disturbance.

Table 9 lists the egg, chick, and fledgling distributions found during different reproductive stages on the Kulichkof Island intensive study plot. The egg and clutch data were taken on 26 June while brood data were collected on 14 July. Fledging data were gathered 4 August. This was 1-2 weeks before fledging, but the young would leave the nest too easily during that last week.

Glaucous-winged Gull

The low density sample plots on Cliff Island (300 m2) included 10 nests of the total estimated 20-25 nests found on the island. The low density plots on Zaimka Island (600 m2) included 13 nests while the high density plots (766 m2) contained 40 nests. Dick (1976 b) estimated 400 breeding pairs on Zaimka island in 1975, but the 1977 breeding population seemed smaller (250-300 pairs). The mean density for the low density plots was 2.6 nests per square dekameter while the high density plot had 5.2 nests per square dekameter. As mentioned earlier, the mean distance to nearest nest of the same species was not significantly different between low and high density plots. The general impression of Chiniak Bay is that there is plenty of gull nesting habitat not being used compared to that seen by this author in Puget Sound and Washington State. This lower level of gull population may be due to several of the following mortality factors: 1) This species is the main one egged by local residents; 2) At least 15 of the smaller boats in the Kodiak Tanner Crab fleet use gulls for hanging bait taking between 11,000 and 15,000 birds annualy (up to 80 per day per boat: Dick, 1977); 3) Large gulls are usually winter food limited and thus winter conditions may be more severe in Kodiak than in Washington with fewer garbage dumps to carry them over. At any rate, the lower number of large gulls certainly reduces egg predation pressure on the other seabirds nesting in the bay.

Hatching began for this species on 25 June peaking on 2 July with the mode extending from 28 June to 4 July. The last hatching of initial clutches was on 11 July, but as seen in Figure 5 a second peak of hatching occurred because of re-nesting attempts caused by native egging. Egging by natives usually occurred early in June, but some was observed on Puffin Island on 22 June. The hatching of re-nest attempts extended from 15 to 25 July. Using a 28 day incubation time (Vermeer, 1963), this would indicate that egg laying began 28-29 May with the peak around 4-5 June.

The mean number of eggs per completed clutch for the Zaimka-Cliff Islands' plots was 2.64. Hatching success of known eggs (n= 87, 51) was 86.2-92.2%, while the minimum fledging success of known chicks (n=75) was 61.3% (Table 10). This gave a productivity of 1.15 chicks fledged per nest attempt or 1.39 chicks fledged per nest with eggs.

Since most of the egging occurred before field work began this season, the hatching success figures do not measure this mortality. Vermeer (1963) found in Glaucous-winged Gulls in British Columbia that were not subject to egging a hatching success of 71-83%, a fledging success of 65-75%, a mean clutch size of 2.82, and mean productivities that ranged from 1 to 1.7 fledgling per nest attempt. It would appear that Chiniak Bay gulls have better hatching success, but that productivities are no better than those found in the southern more dense colonies. However, additional years of data are needed because reproductive success is quite variable in seabirds from year to year.

Table 11 lists the egg and chick distributions found in Chiniak Bay in 1977.

Mew Gull

Bianki (1967) found that Larus canus in the Soviet Union had a strong nesting preference for maritime meadows with soil base while much lesser densities of nesting sometimes occurred in crowberry habitat. Densities ranged from 0.03 to 0.06 nests per square dekameter. In contrast, the Mew Gulls in Chiniak Bay nested solely on maritime meadows completely avoiding the beach rye water periphery vegetation but the mean nesting densities ranged from 1 to 5.5 nests per square dekameter (Table 2). Dick et. al. (1976b) estimated 60 breeding pairs in 1975 on Mary Island. In 1977 the south colony covered approximately 3640 m2 while the northeast colony covered 4100 m2. Visually, we estimated 200 breeding pair while extrapolation from densities found in sample plots gave an estimate of 340 breeding pair. I feel the latter estimate is high because the total colony probably included more low density nesting area than that covered by the sample plots.

Hatching began in Chiniak Bay on 15 June peaking on 24 June with the mode extending from 19 to 29 June (Figure 6). The last

hatching was noted on 14 July. It is felt that nests hatching 10-14 July were re-nests after egging since these nests were all associated with Glaucous-winged Gull nests that had been egged. Using 26 days as the incubation length(Barth, 1955; Bianki,1967), egg laying in Chiniak Bay apparently began around 19-20 May peaking near the end of May. This makes the species one of the earliest to lay eggs in Chiniak Bay. Figure 7 illustrates how the Mew Gull phenology is definitely ahead of the Glaucous-winged Gull. Mew Gulls are similar to terns in having the peak of hatching occur before the Glaucous-winged Gull peak of hatching.

The mean number of eggs per completed clutch for the Mary Island Mew Gull plots was 2.63. This is quite similar to that found by Bianki (1967): 2.6 with range of 2.3-2.8. Hatching success of known eggs (n=158) in Chiniak Bay was 83.5% ranging from 77.8 to 86.5% (Table 12) while Bianki (1967) had hatching successes of 76.9% (range 66-81.9%).

Fledging success is quite difficult to estimate since chicks disperse so widely and there are few physical features to contain them. On Mary Island the chicks migrated towards water's edge in 1977 as they neared the time of fledging. On 5 August (somewhat late due to intense storms during the previous 3 weeks) we banded 75 chicks found in the beach vegetation. There were 335 other chicks who escaped to or were already in the water even though most all were flightless. The heavy storm activity continued for another week. On 11 August I found 1 banded chick out of 12 dead chicks on beaches at the head of Women's Bay. Some chicks were even observed far from water wandering through the Bell Flats housing area at the head of Women's Bay, pushed there no doubt by the prevailing easterly storm winds. On 20 August we revisited Mary Island and found 128 dead Mew Gull chicks of which 12 were banded. Comparisons of these ratios would suggest that a maximum of 199 chicks had survived and possibly less. This would give a productivity of 0.6-1.0 chicks per nest attempt depending upon the colony estimates (200-340 breeding pairs). Bianki (1967) notes that Larus canus chicks have a relatively high fledging mortality at times, but that as a rule this species averages about 1.5 fledglings per pair.

In the egg stage the two most common mortality factors were human egging activity and egg damage or disappearance (unknown bird predator). Mortality in the chick stage in 1977 was primarily that of starvation and exposure during the last two weeks prior to fledging. Some chicks were killed and/or harassed by Glaucous-winged Gulls picking at the chicks' heads. About the same time, a River Otter arrived on Mary Island and proceeded to devastate the tern colonies and essentially eliminate much if not all of this productivity in 1977. Some Mew Gulls were taken by a mammalian predator and possibly the appearance of the Otter may have driven the Mew Gull chicks prematurely to the water's edge. However, many chicks died on the beaches untouched by bird or mammal.

Thus it appears that the unusual storm activity and/or food shortages were the most important factors that changed a very good hatching success into a fledging failure. Mew Gulls are not observed in seabird feeding flocks. Perhaps the storm drove forage fish out of the nearshore waters where Mew Gulls feed. At any rate, no other seabird species breeding in Chiniak Bay was affected by the storms to the degree that Mew Gulls were.

Table 13 lists the egg and chick distribution found on Mary Island in 1977.

Arctic and Aleutian Terns

The mean number of nests per square dekameter for Arctic Terns on Mary Island was 10.6 with a range between 8 and 13 nests. The highest densities were found in the maritime meadows with the lowest found on hillsides. Intermediate densities occurred near the water's edge. On Mary Island the Aleutian Terns nested only on the maritime meadows just adjacent to the Arctic Tern Colony. Their nesting density was 13 nests per square dekameter. Apparently the Aleutian Tern nests were more dense in this situation as the nearest nest of the same species was a mean distance of 1.38 meters while Arctic Terns had a mean distance of 2.13 meters. Aleutian Terns nesting by themselves at the heads of bays had a nearest neighbor mean distance of 30.99 meters, thereby utilizing a very different nesting strategy. Bianki (1967) found lower densities in the Soviet Union where 75% of all tern nests were found within 3 and 20 meters of each other. On Mary Island in Chiniak Bay, the Arctic Tern nests covered roughly 1166m2 while Aleutian Tern nests covered 206m2. This would give colony estimates of 130-140 breeding pairs for Arctic Terns and 27 pairs for Aleutian Terns on Mary Island. Specifically, we marked and monitored 96 Arctic and 23 Aleutian Tern nests on Mary Island with an additional 22 Aleutian Tern nests checked at Kalsin and Middle Bay.

Hatching of Arctic Terns began on 18 June peaking on 26 June with the mode occurring between 23 June and 5 July (Figure 8). Aleutian Terns began hatching on 22 June peaking on 1 July with a mode running from 27 June to 10 July (Figure 9). The last hatching of either species was around 15 July. This would mean that egg laying begins during the last part of May and the first week of June with the Aleutian Tern essentially 4 days behind the Arctic Tern in phenology.

The mean number of eggs per completed clutch was 2.21 for Arctic and 1.84 for Aleutian Terns. Hatching success of known eggs was 85.4% (n=212) for Artic Terns on Mary Island while Aleutain Terns were 95.2% (n=42) successful on Mary Island and 79.4% (n=39) successful on Mainland Kodiak (Table 14). All of these compare favorably with those averages found by Bianki (1967) in the Soviet Union (62.7-82.0%) and Hawksley (1957) in Canada (64%). However, most all tern studies report that fledging mortality varies more from year to year than does hatching mortality or success.

Lemmetyinen (1973) reported that most of this mortality occurs in the first two weeks after fledging. Most researchers mention the lethal influences of inclement weather and high winds on tern chicks due to starvation. In certain cases mammals prey heavily on fledlings. In 1977 at Chiniak Bay both of these mortality factors occurred. A River Ottor showed up for a week on Mary Island and apparently killed many tern chicks. On 5 August we found 34 predated chick carcasses at or near sites. The intense storm activity during this period also took its share of mortality. The exact extent and proportion of mortality is hard to ascertain since tern chicks do not usually congregate near the water's edge in the visible way that Mew Gulls did. Bianki (1967) had productivities ranging between 1 and 1.19 chicks per breeding pair while Hawksley (1957) had 0.5 fledging per pair. It would seem that the Mary Island Colony had no better and possibly worse success.

Tables 15 and 16 list the egg and chick distributions found in Chiniak Bay in 1977.

Incidental Notes on Additional Breeding Species

Horned Puffins (Fratercula corniculata) were common in Chiniak Bay, but their nesting is distributed much like the Pigeon Giullemot — low density scattered over shorelines of numerous islands. One nest was monitored on Zaimka Island and hatching occurred on 21 July.

One nest of Pigeon Guillemot (Cepphus columba) was monitored on Zaimka Island and hatching occurred on 12 July. On 14 April Matt Dick censused 202 Pigeon Guillemots along 14 kilometers of shoreline in the Near Island group (includes Popof, Kulichkof, and Bird Island). It is unlikely that these all nest in that area, but this census does give some idea of densities (14.4 birds/km) found in the Chiniak Bay region.

Black Oystercatchers (Haematopus bachmani) were found nesting on Zaimka Island (3 pairs), Cliff Island (1 pair), Blodgett Island (1 pair), and Mary Island (1+ pairs). Nesting was probable on Puffin, Kulichkof, and Bird Islands, but the breeding attempts may have failed as no nests were found near hatching on these islands this year. Hatching in 5 nests extended from 15 June to 14 July with the majority occurring during the third week of June. Hatching success of known eggs (n=13) was 84.6% but past studies (Nysewander, 1977) have shown that nesting attempts were probably missed.

The Common Eider (Somateria mollissima) was a common but low density breeding species in Chiniak Bay in 1977. Most islands had 2 or 3 nests with Mary Island having 11 nests. Hatching ranged from 22 June to 14 July. Hatching success of known eggs (n=84) was 59.5%. The female and brood leave the nest and island soon after hatching and are rarely, if ever, seen after that.

Nests of Red-breasted Merganser (Mergus serrator) were found on Mary and Puffin Islands. One nest hatched between 6-8 July and the other hatched sometime after 9 July.

A few nests of Semipalmated Plover (Charadrius semipalmatus) and Least Sandpiper (Calidris minutilla) were monitored at the heads of Kalsin and Middle Bays. The one plover nest hatched on 28 June while the two sandpiper nests hatched on 26 and 29 June.

Trophic Ecology

One hundred and twelve birds were collected for food and parasite analysis. A roughsort has been completed and Table 17 lists the species or items found in each of the nine bird species collected. Attempts were made to collect three species in feeding flocks away from colony sites: Common Murre, Tufted Puffin, and Black-legged Kittiwake. The other species or samples were incidentally collected mostly for parasite analysis or were regurgitations at colony sites. The percentage of prey by frequency or volume is not available now, but will be included in the expanded feeding program planned next year at this site.

Mortality

Eight beached bird surveys covering 14.9 kilometers were conducted along the road system that extends from Kodiak to Narrow Cape. These surveys were run every two weeks during the summer. Four sea mammals and seven birds were found in the 25.6 kilometers of beach walked the summer of 1977. For further detail, refer to the beached bird survey reports consolidated overall for the Gulf of Alaska by Kent Wohl, (U.S. Fish and Wildlife Service, OBS-CE).

Banding of young with U.S. Fish and Wildlife leg bands was done on Puffin, Zaimka, and Mary Island between 4 and 8 August. This involved a total of 349 birds of 3 species: 267 Glaucous - winged Gulls, 75 Mew Gulls, and 7 Arctic Terns.

VI. NEEDS FOR FURTHER STUDY

The research in 1977 at this study area gives a single estimate of productivities. Without two or more years of research at any one spot, it becomes impossible to separate normal population fluctuations from those caused by oil pollution or development.

Now that some baseline data of productivity is available, it is possible to disturb some colonies so as to answer some feeding or trophic questions: 1) the food brought to young measured by regurgitations; 2) why immature murres feed in Chiniak Bay; and 3) how this all compares with resources available (which the Kodiak integrated OCS study may supply).

Chiniak Bay offers some unique opportunities to develop some baseline data on breeding biologies of marine birds that have no published data on them. The lack of predators makes feasible the study of both the Pelagic and Red-faced Cormorants. We intend to expand our work on the latter species since nothing is known about it and it is a common Alaskan species. The presence of Aleutian Tern colonies and an unusual Mew Gull colony afford similar opportunities.

One of the critical times for marine birds in Chiniak Bay is the winter when numerous waterfowl and alcids frequent the bay. These types of birds have long been recognized as those most vulnerable to oil pollution. Yet the winter populations and trophic relationships have had the least research and effort devoted to them. The OCSEAP program in Kodiak should not end without some additional effort to fill in this data gap.

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Table 1. Variations in Cliff-Nesting Seabirds on Breeding Colonies, Inner Chiniak Bay, 1975 and 1977

Species	Island	Number of Nests 1975	1977
Black-legged Kittiwakes	Zaimka	20	0
	Gibson Cove	114	199
	Kulichkof	104*	218
	Holiday	5	5
	Viesoki	1306	1096
	Total	1549	1518
Pelagic Cormorant	Bird	56	100
	Kulichkof	25	71
	Gibson Cove	0	50
	Puffin	39	31
	Cliff	0	5
	Zaimka	17	25
	Holiday	43	58
	Blodgett	0	47
	Viesoki	22	4
	Total	202	391
Red-faced Cormorant	Bird	3	31
	Gibson Cove	0	10
	Puffin	17	33
	Cliff	2	2
	Zaimka	22	21
	Holiday	0	23
	Blodgett	0	5
	Kulichkof	5	0
	Viesoki	103	14
	Total	152	139

* Data missing in 1975, and 1976 data substituted (Dick, pers. comm.).

Table 2. Nesting Densities of Certain Colonial Burrow or Ground Nesting Seabirds in Chiniak Bay.

Species (n=nests) (m^2=area)	Mean Number of Nests Per Square Dekameter	Mean Distance ± S.E. of Nearest Neighbor Nest (in meters)
Tufted Puffin	56.2	--
n=42		
m^2=130		
Glaucous-winged Gull		
Low Density	2.6	3.77 ± 0.23
n=21		
m^2=900		
High Density	5.2	3.07 ± 0.29
n=40		
m^2=766		
Mew Gull		
Low Density	1.0	4.33 ± 0.59
n=4		
m^2=400		
High Density	5.5	3.31 ± 0.22
n=60		
m^2=1100		
Arctic Tern		
n=87	10.6	2.13 ± 0.08
m^2=820		
Aleutian Tern		
Colonial Mixed Species Island Site	13.0	1.38 ± 0.10
n=22		
m^2=170		
Semi-Colonial Single Species Mainland Site	---	30.99 ± 4.34
n=11		
m^2=?		

Table 3. Reproductive Success of Black-legged Kittiwake in Chiniak Bay 1977.

Reproductive Success	Sample Plots: Gibson Cove	Kulichkof Island	Combined
Sample Size (nest attempts)	199	210	409
Hatching of Known Eggs	-	287/338 = 84.0%	-
Fledging of Known Chicks	-	259/287 = 90.2%	-
Mean Number of Young Fledged/ Nest Attempt	0.30	1.23	0.78
Mean Number of Young Fledged/ Nest with Eggs	-	1.46	-

Table 4. Egg, Chick, and Fledging Distribution of Black-legged Kittiwake in 1977 at Kulichkof Island, Chiniak Bay.

	Reproductive Stages		
Number of Nests Containing:	Eggs Laid	Chicks Hatched	Fledglings
0	33	39	54
1	24	57	64
2	145	112	96
3	8	2	1

Table 5. Reproductive Success of Tufted Puffin in Chiniak Bay 1977.

Reproductive Success	Cliff Island		
	Quadrat ($100M^2$)	Line Transect ($30M^2$)	Combined
Sample Size (nest attempts)	30	12	42
Hatching of Known Eggs	22/25 = 88.0%	9/10 = 90.0%	31/35 = 88.6%
Fledging of Known Chicks	20/22 = 90.9%	-	-
Mean Number of Young Fledged/ Nest Attempt	0.67	-	-
Mean Number of Young Fledged/ Nest with Eggs	0.80	-	-

Table 6. Egg, Chick, and Fledgling Distribution of Tufted Puffin in 1977 at Cliff Island, Chiniak Bay.

Reprod. Stages	Number of Nests Containing 0 eggs or chicks	1 egg or chick
Eggs Laid	25 (18/7)	35 (25/10)
Chicks Hatched	29 (21/8)	31 (22/9)
Fledglings	($\overline{23}$/–)	($\overline{20}$/–)

Only the quadrat was checked for fledgling. The differences in earlier stages between quadrat and line transect noted respectively in the parentheses.

Table 7. Reproductive Success of Pelagic and Red-faced Cormorant in Chiniak Bay 1977.

	Sample Plots		
	Pel. Cormorant Phenology (1 Island)	Pel. Corm. Productivity (6 Islands)	R. F. Corm. Productivity (5 Islands)
Sample Size (nest attempts)	26	127	57
Hatching of Known Eggs	60/87 = 69.0%	-	-
Fledging of Known Chicks	37/60 = 61.7%	-	-
Mean Number of Young Fledged/Nest Attempt	1.42	1.35	1.91
Mean Number of Young Fledged/Nest with Eggs	1.48	-	-

Table 8. Comparison of Reproductive Success and Data on Pelagic Cormorants at Three Sites in the Northeastern Pacific Ocean.

Study Sites	Cape Peirce 1970 [1]	Chiniak Bay 1977	Mandarte Island 1957-59[1]
Egg-laying	15-24 June	3 June-17 June	26 May-4 Aug
Clutch Size Range	1-5	1-6	1-6
Mean Clutch Size	3.1-3.2	3.5	3.8
Hatching Success	78%	69%	50%
Fledging Success	56%	62%	76%
Productivity	1.33	1.42-1.48[2]	1.97

[1]Data sources are Dick (1975) and Drent et al (1964).

[2]It is unclear whether productivites of Cape Peirce and Mandarte Island are chicks fledged per nest attempt or nests with eggs, but both respective figures at Chiniak Bay fall in between the two other sites.

Table 9. Egg, Chick, and Fledgling Distribution of Pelagic Cormorants on Kulichkof Island, Chiniak Bay 1977.

	Reproductive Stages		
Number of Nests Containing:	Eggs Laid	Chicks Hatched	Fledgling
0	1	6	8
1	0	1	2
2	3	4	11
3	7	9	3
4	15	6	1

Table 10. Reproductive Success of Glaucous-Winged Gull in Chiniak Bay 1977.

Reproductive Success	SAMPLE PLOTS: High Density Zaimka Is. ($766M^2$)	Low Density Cliff & Zaimka ($800M^2$)	Combined
Nest Attempts (nests with eggs)	40 (33)	23 (19)	63 (52)
Hatching of Known Eggs	75/87 = 86.2%	47/51 = 92.2%	122/138 = 88.4%
Fledging of Known Chicks	46/75 = 61.3%*	-	-
Mean Number of Young Fledged/ Nest Attempt	1.15*	-	-
Mean Number of Young Fledged/ Nest with Eggs	1.39*	-	-

*This is a minimum figure since some chicks may have moved away from nesting area.

Table 11. Egg, Chick, and Fledgling Distribution of Glaucous-winged Gull in Chiniak Bay 1977

Number of Nests Containing:	Reproductive Stages		
	Eggs Laid	Chicks Hatched	Fledgling
0	11	15	-
1	4	3	-
2	11	16	-
3	36	29	-
4	1	0	-

Table 12. Reproductive Success of Mew Gull in Chiniak Bay 1977.

Reproductive Success	SAMPLE PLOTS - Mary Is. South Colony (1000 M^2)	N.E. Colony (500 M^2)	Combined
Nest Attempts (nests with eggs)	43 (38)	23 (21)	66 (60)
Hatching of Known Eggs	90/104 = 86.5%	42/54 = 77.8%	132/158 = 83.5%
Fledging of Known Chicks	-	-	-
Mean Number of Young Fledged/ Nest Attempt	-	-	199/340 = 0.59*
Mean Number of Young Fledged/ Minimum Number of Nests	-	-	199/200 = 1.0*

*Estimate based on extrapolation from nest density, total colony areas, chick counts and banding near fledging, and percentages of banded chicks in beached bird counts.

Table 13. Egg and Chick Distribution of Mew Gulls in Chiniak Bay 1977

Number of Nests Containing:	Reproductive Stages	
	Eggs Laid	Chicks Hatching
0	6	8
1	5	8
2	13	27
3	41	22
4	1	1

Table 14. Reproductive Success of Arctic and Aleutian Tern in Chiniak Bay 1977.

Reproductive Success	Study Sites		
	Arctic Tern	Aleutian Tern	
	Mary Is.	Mary Is.	Mainland
Sample Size	97	23	22
Hatching of Known Eggs	181/212 = 85.4%	40/42 = 95.2%	31/39 = 79.4%
Fledging of Known Chicks	-	-	-
Mean Number of Young Fledged/ Nest Attempt	-	-	-
Mean Number of Young Fledged/ Nest with Eggs	less than* 1.53	-	-

*This estimate of the maximum possible productivity comes from subtracting number of chick carcasses found (River Otter predation) from total chicks hatched.

Table 15 Egg and Chick Distributions of Arctic Terns in Chiniak Bay 1977

Number of Nests Containing:	Reproductive Stages: Egg Laying	Reproductive Stages: Chick Hatching
0	1	7
1	8	17
2	60	55
3	28	18

Table 16 Egg and Chick Distributions of Aleutian Terns in Chiniak Bay 1977

Number of Nests Containing:	Reproductive Stages	
	Egg Stages	Chick Hatching
0	0	3
1	8	12
2	35	28
3	1	1

Table 17. Prey Items Taken by Nine Seabird Species in Chiniak Bay, June - August 1977.

Rissa tridactyla (n=15)

Sandlance (*Ammodytes hexapterus*)
Capelin (*Mallotus villosus*)
Unidentified fish
Plant material
Spruce needles

Lunda cirrhata (n=33)

Sandlance
Capelin
Unidentified fish
Plant material

Uria aalge (n=11)

Capelin
Unidentified Gadidae
Unidentified fish
Euphausids (*Thysanoessa raschii*)
Plant material

Larus glaucescens (n=32)

Capelin
Unidentified fish
Fish eggs
Mussels (*Mytilus edulis*)
Unidentified Pelecypoda
Chiton
Insects (Diptera)
Plant material

Puffinus tenuirostris (n=3)

Euphausids (*Thysanoessa* spp.)
Capelin
Unidentified fish
Squid beaks (Cephalopoda)

Fratercula corniculata (n=13)

Unidentified fish

Sterna paradisaea (n=3)

Surf Smelt (*Hypomesus pretiosus*)
Rock Greenling (*Hexagrammos lagacephalus*)
Decapod

Xema sabini (n=1)

Unidentified fish

Phalacrocorax pelagicus (n=1)

Sea Urchin (Echinoidea)

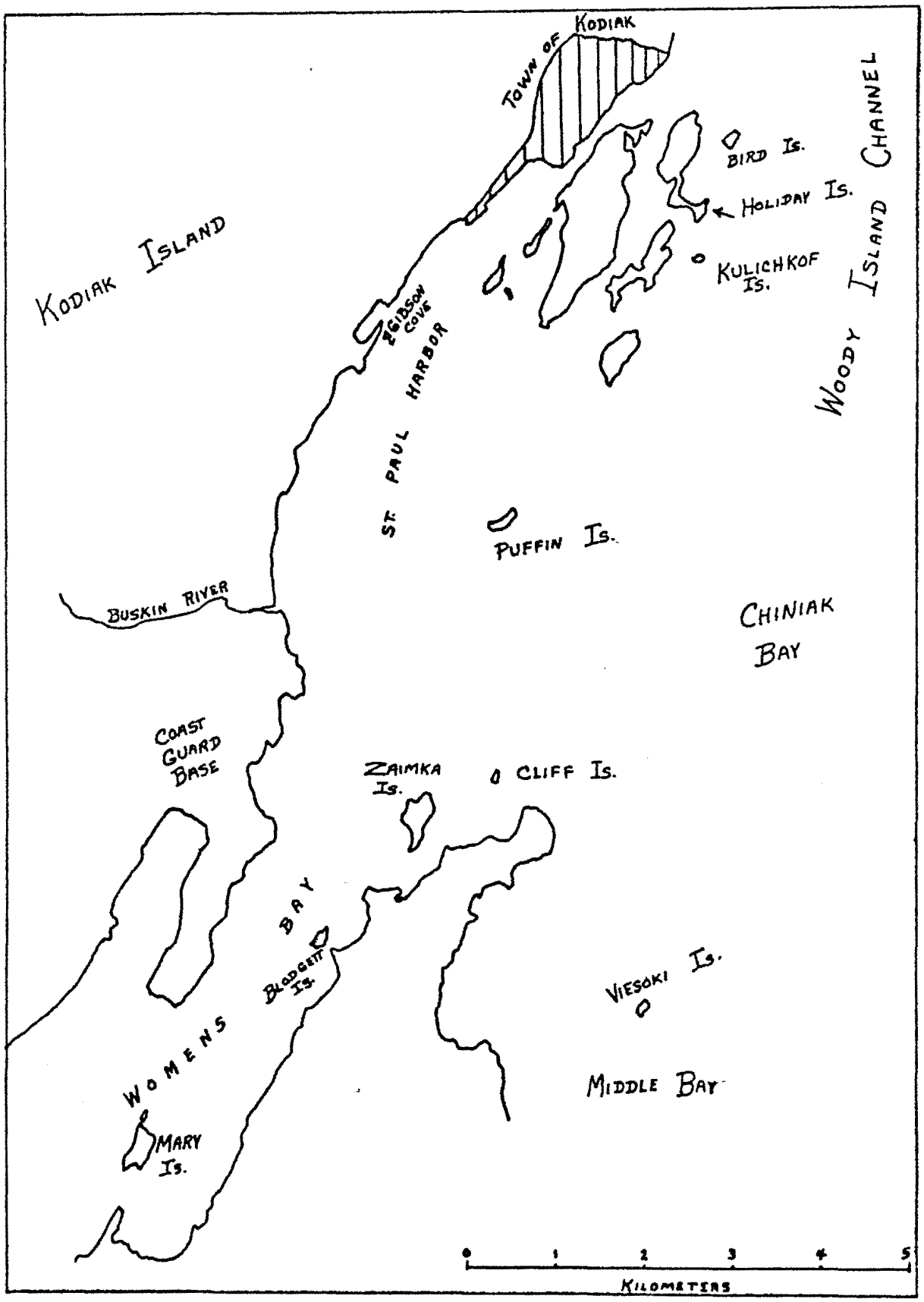

Figure 1. Study Sites in Inner Chiniak Bay.

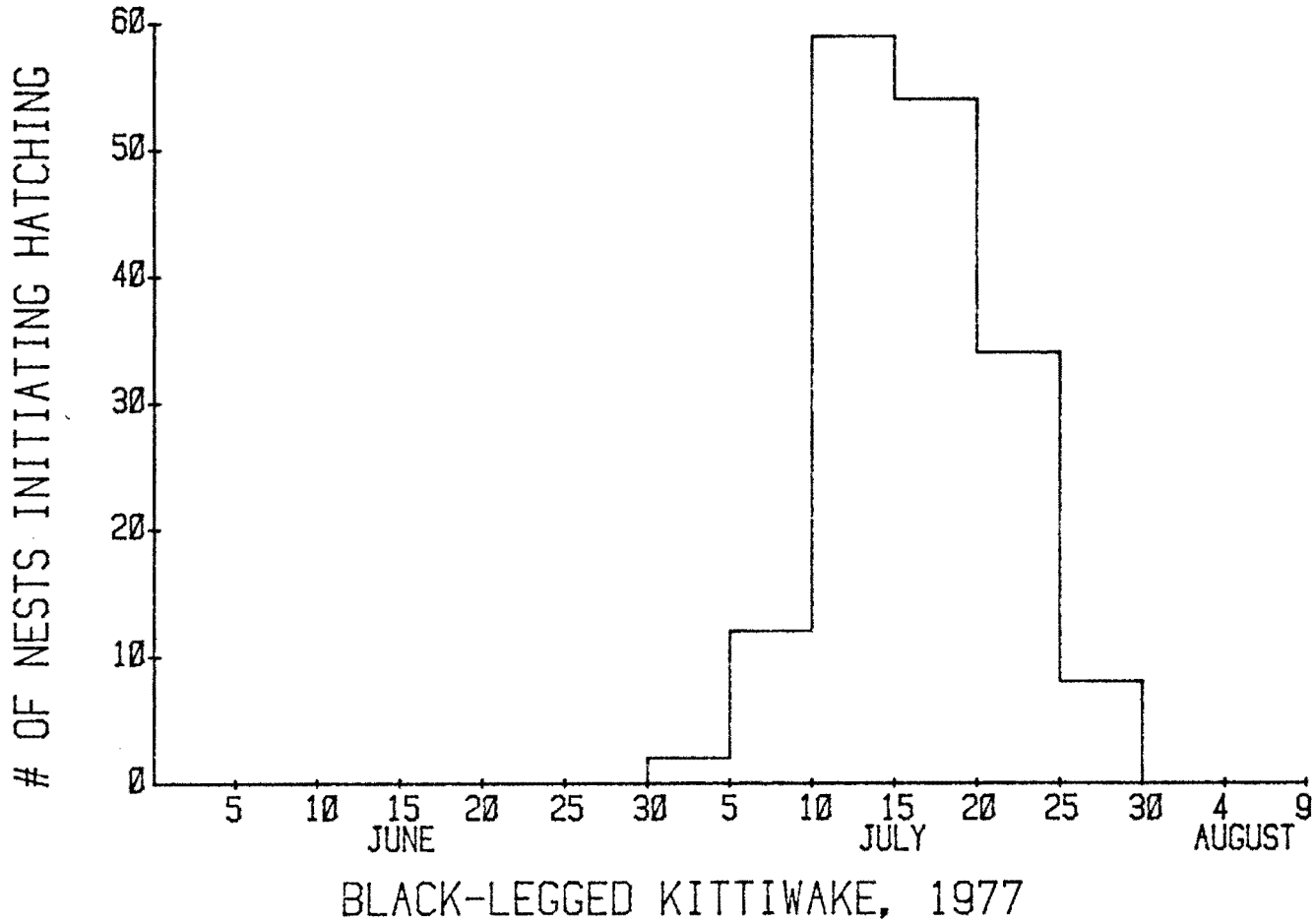

Figure 2. Hatching Phenology of Black-legged Kittiwake in Chiniak Bay 1977.

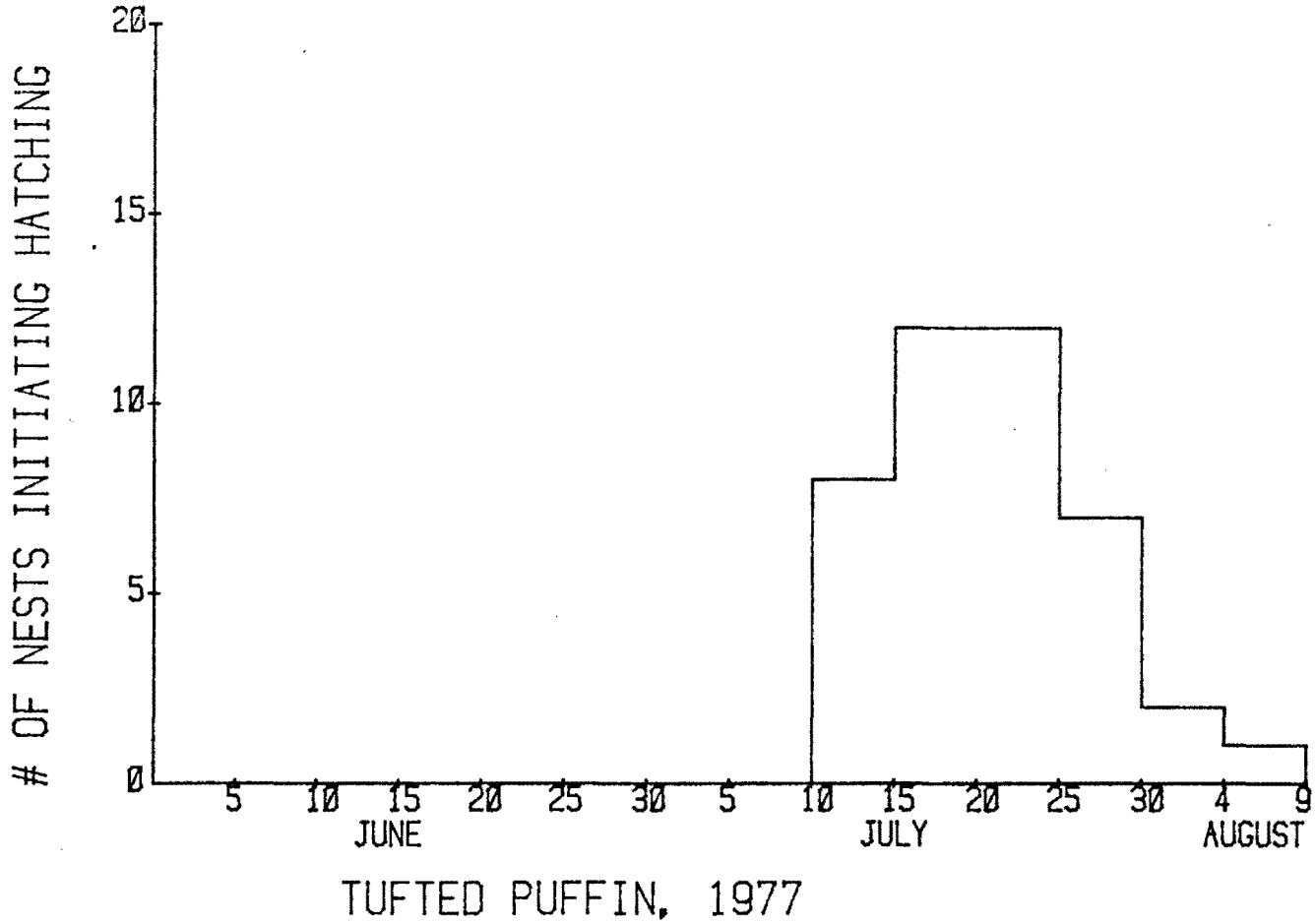

Figure 3. Hatching Phenology of Tufted Puffin in Chiniak Bay 1977.

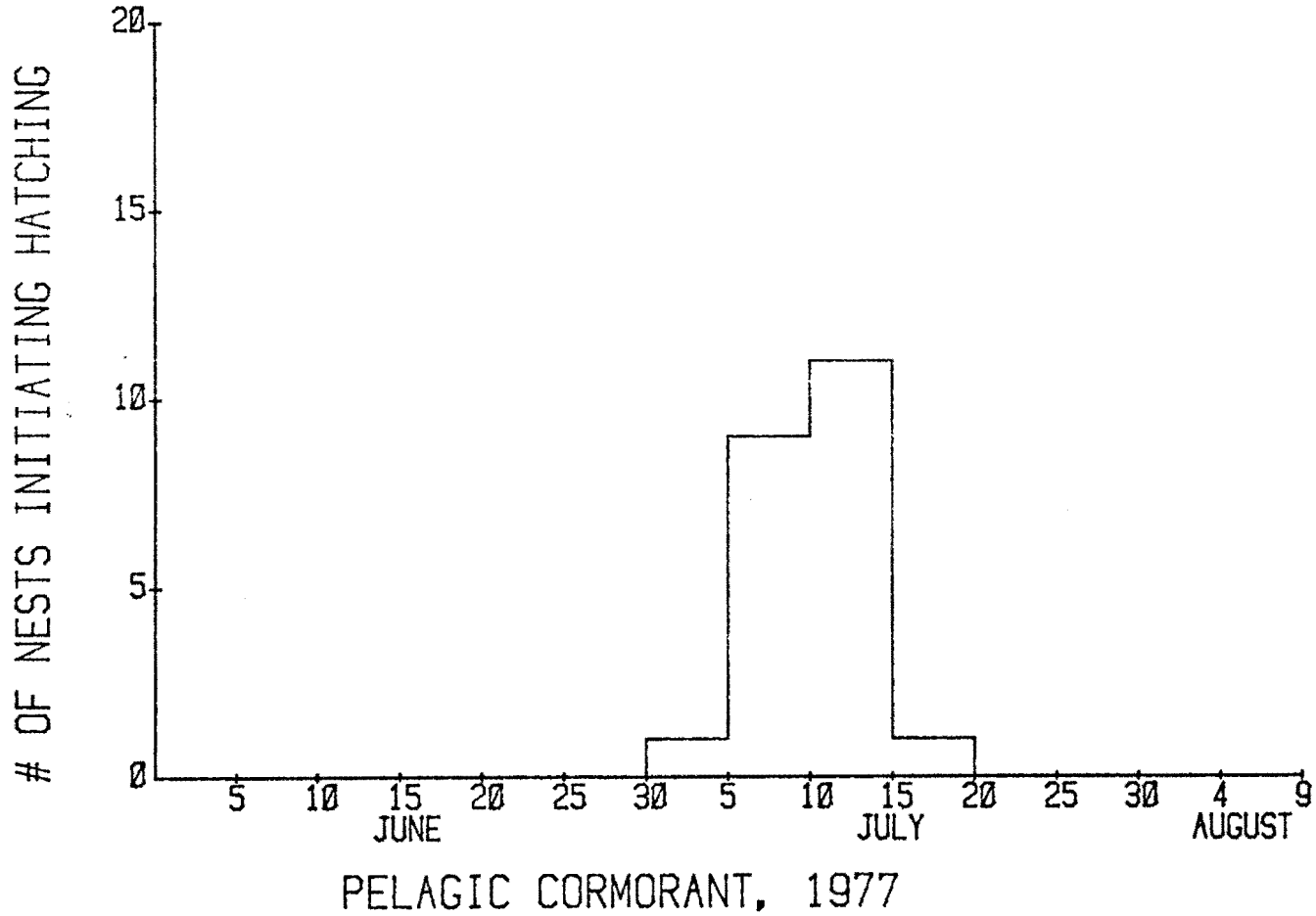

Figure 4. Hatching Phenology of Pelagic Cormorant in Chiniak Bay 1977.

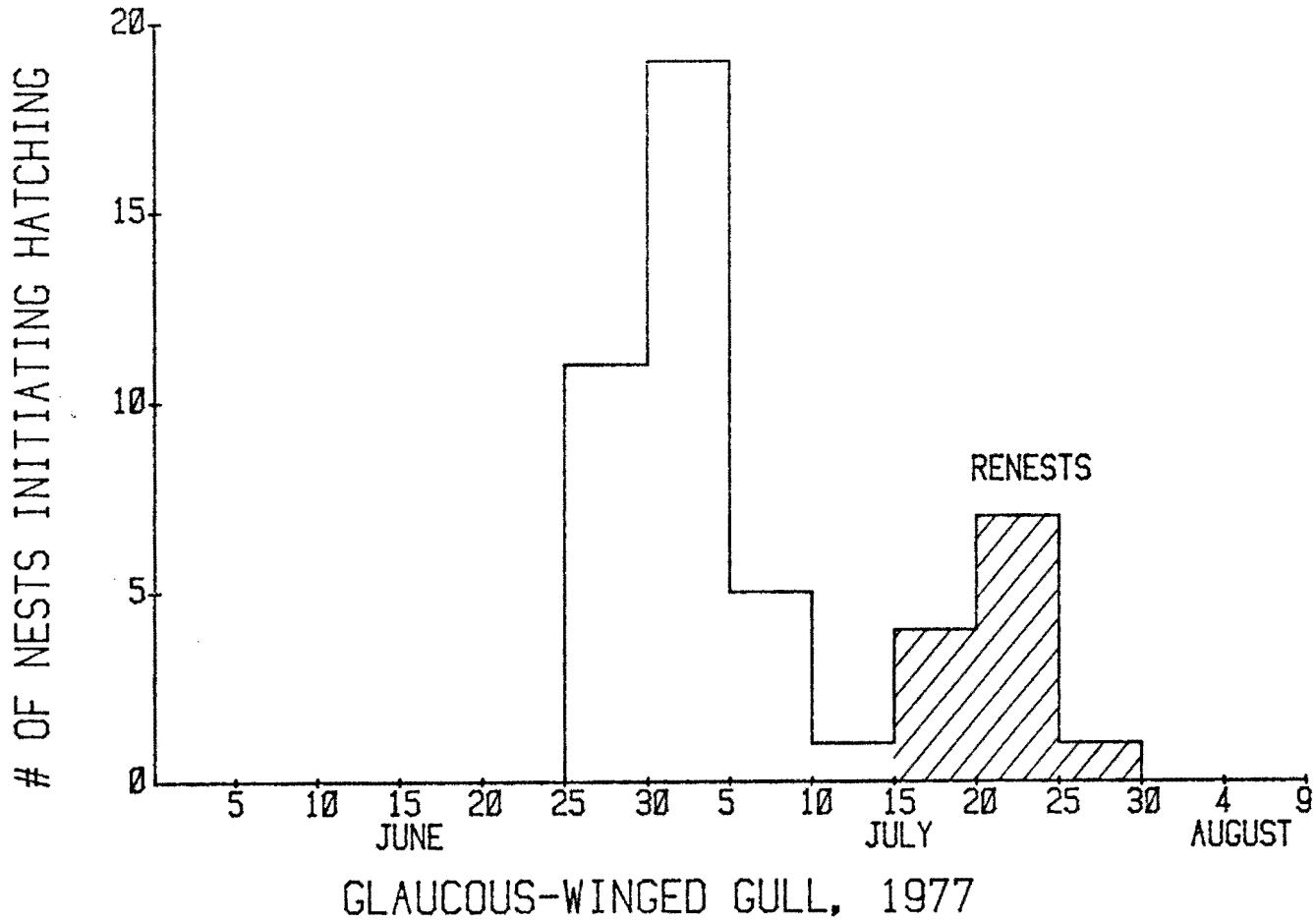

Figure 5. Hatching Phenology of Glaucous-winged Gull in Chiniak Bay 1977.

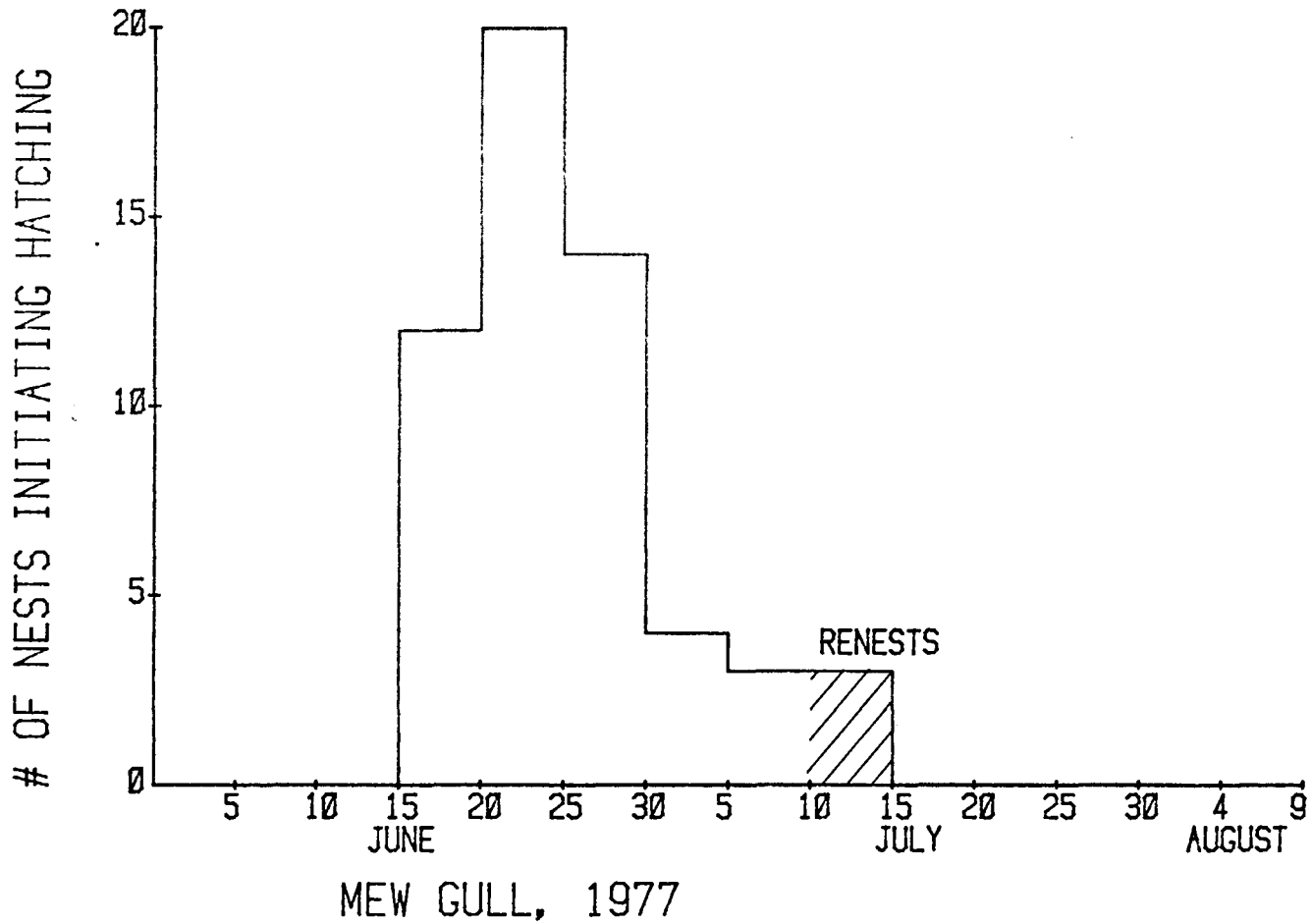

Figure 6. Hatching Phenology of Mew Gull in Chiniak Bay 1977.

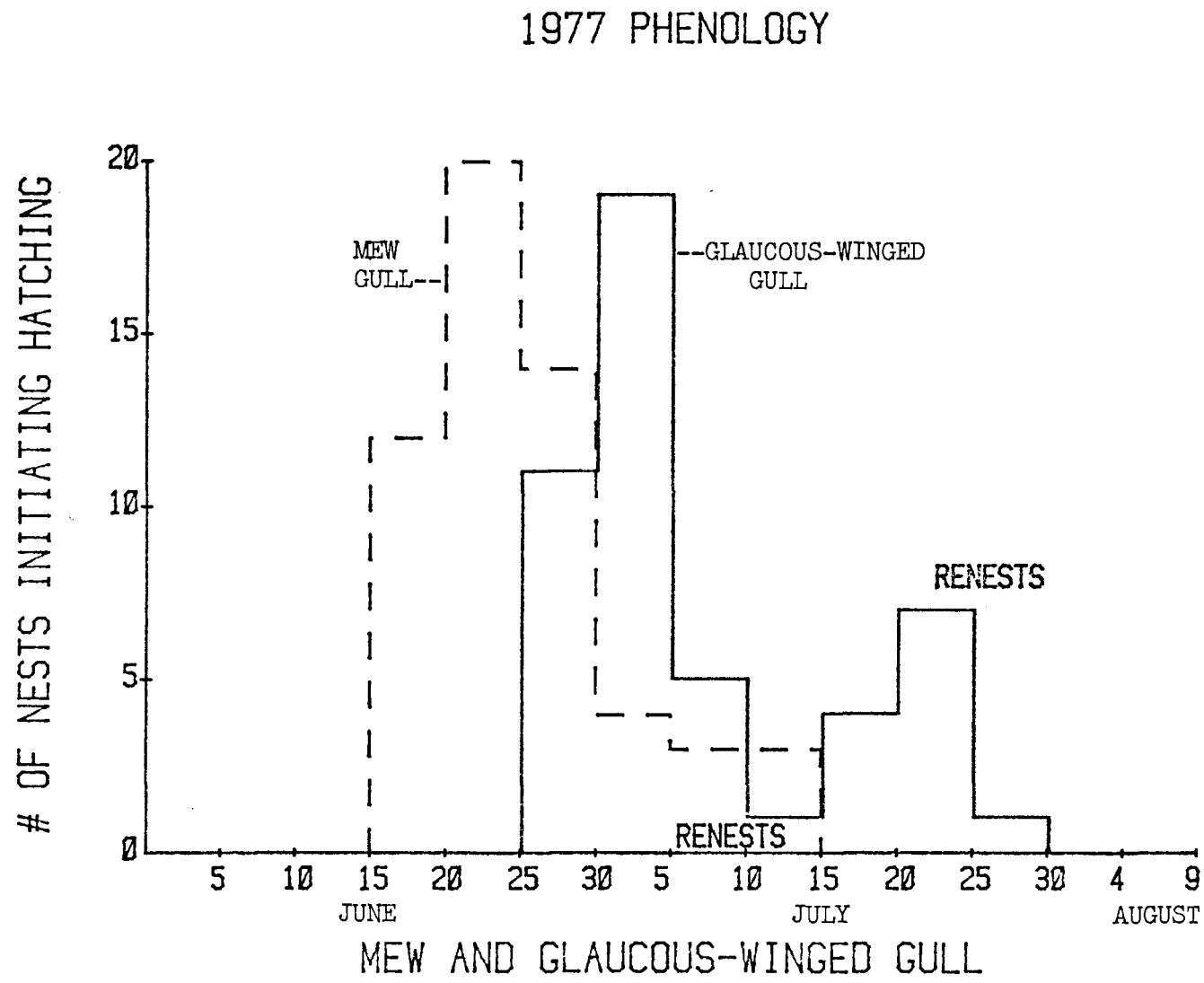

Figure 7. Comparison of Hatching Phenology of Mew and Glaucous-winged Gull in Chiniak Bay 1977.

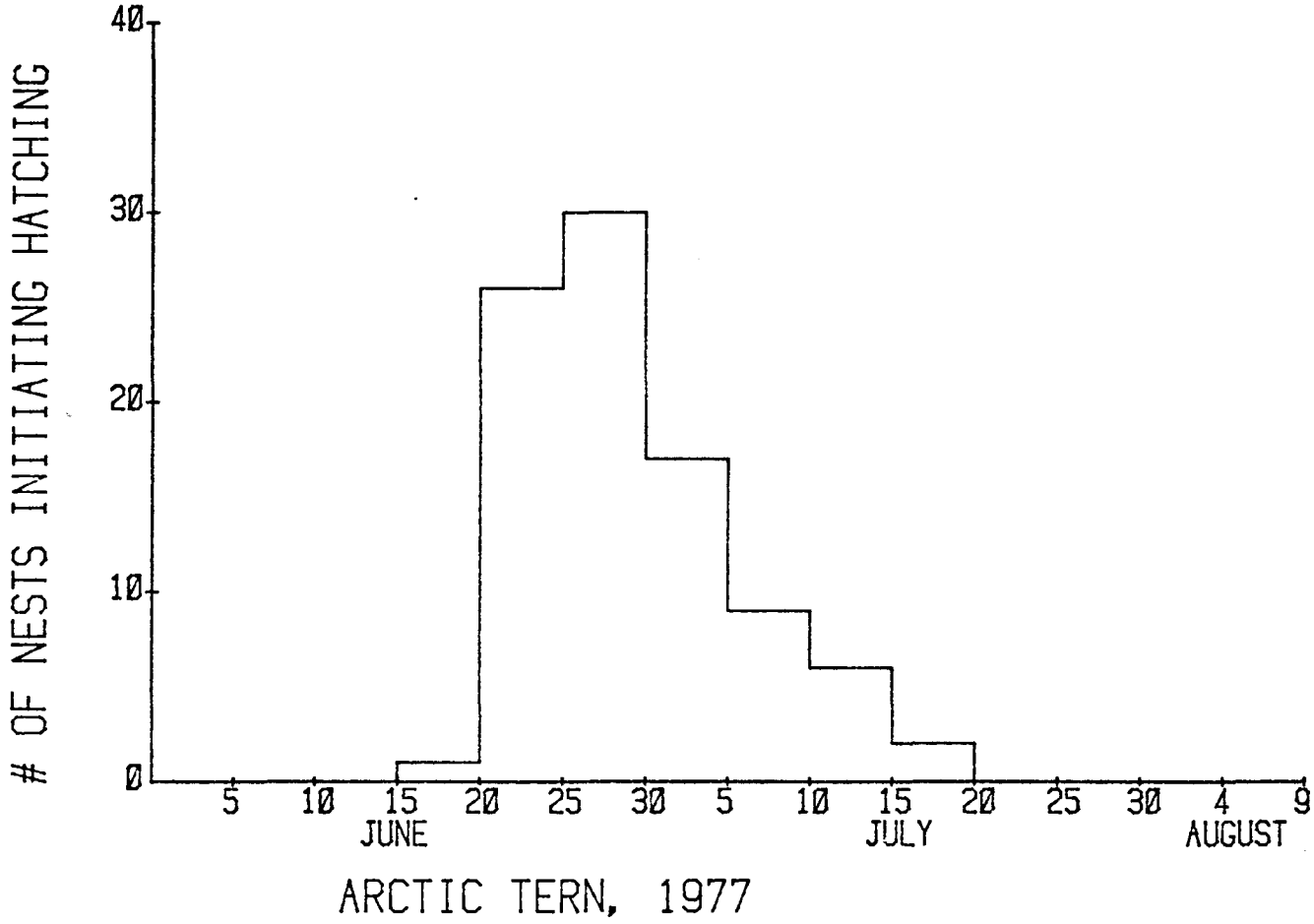

Figure 8. Hatching Phenology of Arctic Tern in Chiniak Bay 1977.

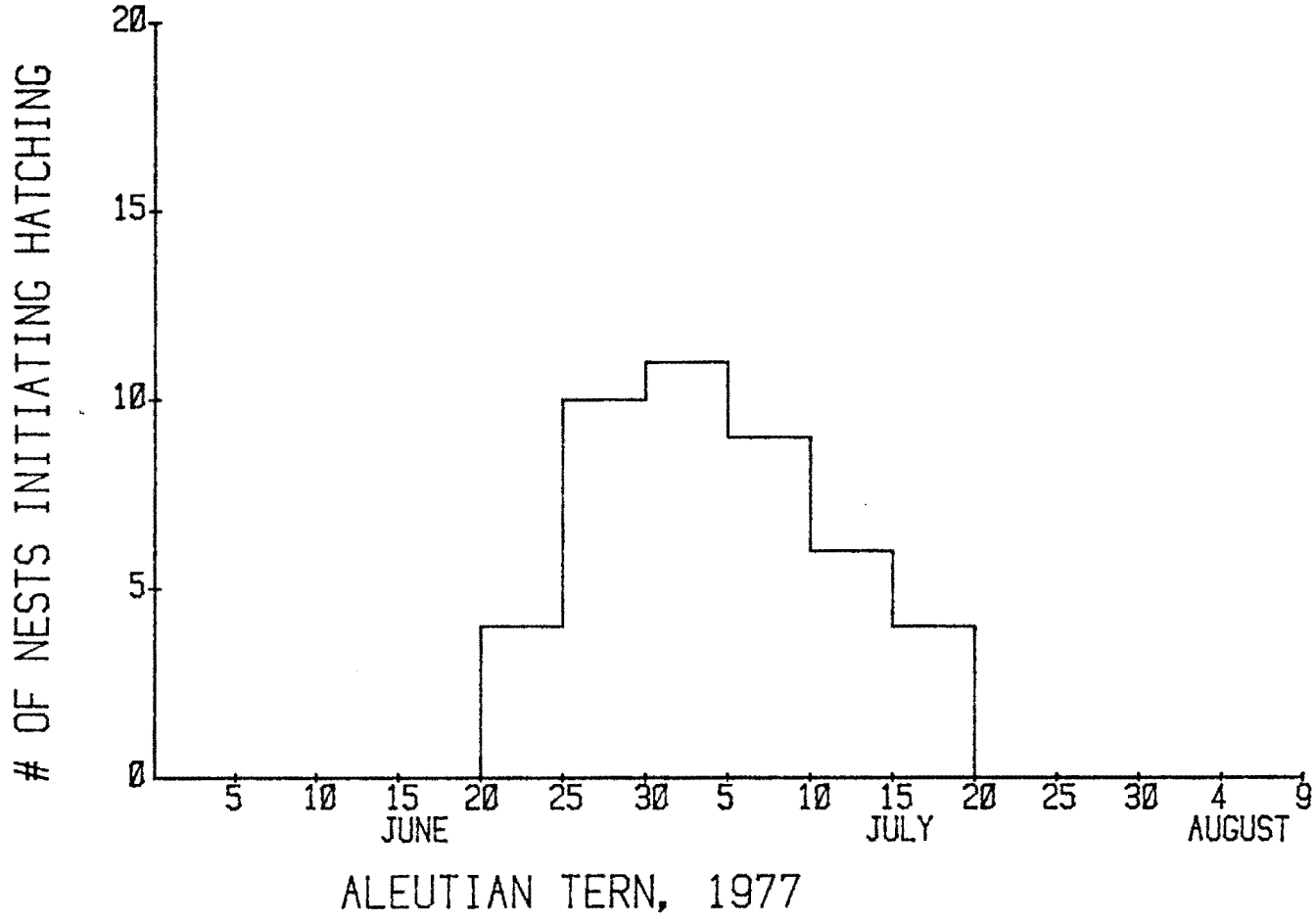

Figure 9. Hatching Phenology of Aleutian Tern in Chiniak Bay 1977.