MONITORING POPULATIONS AND PRODUCTIVITY OF SEABIRDS AT COLONIES IN LOWER COOK INLET, ALASKA, 1995

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EXECUTIVE SUMMARY

As part of the Minerals Management Service's program to monitor seabird populations in areas of oil and gas development on the Alaskan continental shelf, breeding seabirds were surveyed at colonies in lower Cook Inlet, Alaska. Research was conducted on all of the common species including cormorants, kittiwakes, gulls, murres, and puffins. The primary study areas were Chisik and Duck islands near Tuxedni Bay, and Gull Island and 60-foot Rock in Kachemak Bay. The objectives of the surveys were to assess population status and reproductive success of key species. In addition, comparisons were made with past data to assess trends. Major findings were:

1. At Chisik Island double-crested and pelagic cormorant, black-legged kittiwake, common murre, horned puffin, and tufted puffin populations have continued to decline. Glaucous-winged gull populations have remained stable. In contrast, black-legged kittiwake and common murre populations at Gull Island have increased. Pelagic cormorant and glaucous-winged gull populations have remained stable. Pelagic cormorant, and black-legged kittiwake populations at 60-foot Rock have fluctuated. Common murre numbers have declined, and glaucous-winged gull numbers have remained stable.

2. During the 1995 breeding season, double-crested cormorants, pelagic cormorants, gulls, and murres produced chicks at both islands. Kittiwakes experienced almost complete reproductive failure at Chisik and Duck Islands but had average reproductive success at Gull Island. Horned puffins had average reproductive success at Duck Island. Gulls and kittiwakes at 60-foot Rock produced chicks.

3. Gull and murre chick growth did not differ significantly between Chisik and Gull Island.

4. Pacific sand lance predominated in puffin, murre, kittiwake, and gull chick diets. Pacific herring was the second most common fish in murre chick meals, and capelin was the second most common fish in kittiwake and gull chick diets.

5. During the past 20 years, it appears that overall conditions for breeding seabirds have worsened at Chisik and Duck islands while they have improved at Gull Island.

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ABSTRACT

In 1995, we monitored the status of seabirds at major breeding colonies in lower Cook Inlet, Alaska, a region in which the U.S. Minerals Management Service (MMS) is considering offering new leases for oil development. The objectives were to collect information on population trends and patterns of reproductive success for assessment of potential impacts of the MMS leasing program. Survey efforts were devoted primarily to cormorants, kittiwakes, murres, gulls, and puffins. Some information was also gathered on guillemots. The primary study sites were Chisik and Duck Islands off Tuxedni Bay, the largest and most diverse seabird colonies in the area, and Gull Island and 60-foot Rock in Kachemak Bay. We did not survey the tufted puffin colony at Flat Islands this year. Our surveys and historical data that we reviewed provided a basis for evaluating changes in populations since the mid-1970s in some cases and since the mid-1980s in most cases. At Chisik and Duck Islands the predominant breeding species of seabirds have either declined or remained stable since the early 1970s. Double-crested cormorant, pelagic cormorant, black-legged kittiwake, common murre, horned puffin, and tufted puffin populations appear to have declined most. In contrast, black-legged kittiwake and common murre populations at Gull Island have increased since the mid-1970s. Pelagic cormorant, red-faced cormorant, and glaucous-winged gull populations appear to have remained unchanged. Patterns of change at 60-foot Rock are less clear. At this small colony, counts of pelagic cormorants have been highly variable since the mid-1970s. Glaucous-winged gull numbers may have remained stable. Black-legged kittiwake numbers have continued to fluctuate. Numbers of common murres have declined since the mid-1970's. The breeding population of murres appears to have disappeared. During the 1995 breeding seasons, most species of seabirds had low rates of productivity at Chisik and Duck Islands. Kittiwakes had a nearly total breeding failure. In contrast, all species on Gull Island appeared to have moderate success. Kittiwakes and gulls at 60-foot Rock also appeared to be productive. At Duck Island, horned puffins chicks were fed primarily sand lance, similar to past records. At Gull Island kittiwakes and gulls fed chicks primarily sand lance, but capelin comprised a moderate proportion of their diet. Murres fed chicks primarily sand lance and, to a lesser extent, herring. Gull and murre chick growth did not differ significantly between Chisik and Gull Island. Conditions for nesting seabirds at Chisik and Duck Islands seem to have worsened over the past 20 years while they have continued to improve at Gull Island. Both remain substantial breeding colonies. In contrast, nesting conditions at 60-foot Rock remain unstable.

INTRODUCTION

Seabird colonies in lower Cook Inlet are composed of predominantly pelagic cormorant (*Phalacrocorax pelagicus*), red-faced cormorant (*P. urile*), double-crested cormorant (*P. auritus*), glaucous-winged gull (*Larus glaucescens*), black-legged kittiwake *(Rissa tridactyla)*, common murre *(Uria aalge)*, pigeon guillemot (*Cepphus columba*), horned puffin (*Fratercula corniculata*) and tufted puffin (*F. cirrhata*) (Sowls et al. 1978). These seabird populations are vulnerable to environmental disturbance and pollution that can result from activities associated with oil and gas exploration and production (Snarski 1974). The greatest damage to seabirds from the Exxon Valdez oil spill occurred in this area (Piatt et al. 1990). In light of planned industrial activity, the Minerals Management Service (MMS) provided funding to collect baseline information on the population size and reproductive performance of the most common species at the largest seabird colonies in lower Cook Inlet. Monitoring studies enable biologists to evaluate the health of seabird populations and provide a basis for assessing the effects of oil spills. The primary objective of this project was to assemble past data and characterize the current status of major seabird colonies in Cook Inlet (Fig. 1).

The largest colonies of nesting black-legged kittiwakes, common murres, and horned puffins in Cook Inlet occur at Chisik and Duck Islands (Jones and Petersen 1979). Population estimates of kittiwakes were made on these islands in the early 1970s (Snarski 1970, 1971 a-c, 1974). Jones and Petersen (1979) investigated the breeding success of black-legged kittiwakes, and reproduction and feeding habits of horned puffins in 1978 and 1979. Biologists of the AMNWR have monitored populations and reproductive success of kittiwakes and murres intermittently throughout

the 1980s and 1990's (Jones et al. 1980, Kafka 1984, Muhlberg 1984, Beringer and Nishimoto 1988, Slater et al. 1995). Smaller colonies of common murres and black-legged kittiwakes have been monitored on Gull Island and 60-foot Rock by private consultants and government biologists periodically since 1976 (Erikson 1976, Nishimoto et al. 1987, Nishimoto and Beringer 1989, 1990). Little information on seabirds is available from Flat Islands (Sowls et al. 1978).

STUDY AREAS

Chisik & Duck Islands

Chisik and Duck Islands are located on the western side of lower Cook Inlet (60° O9'N,152° 34'W, Fig. 1). Both are part of the Alaska Maritime National Wildlife Refuge. Chisik Island is approximately 10.5 by 3.6 km in size, encompasses about 2606 ha, has a peak elevation of 815 m, and is located about 0.8 km from the mainland. Duck Island is 0.4 km east of Chisik, covers about 2.4 ha, and reaches a maximum elevation of 49 m.

The vegetation on both islands is dominated by dense alder (*Alnus crispa*) thickets with an understory containing devil's club (*Oplopanax horridus*), salmonberry (*Rubus spectabilis*), elderberry (*Sambucus racemosa*), nettles (*Urtica Lyallii*), and several representatives of the Umbelliferae.

The islands are composed mainly of sedimentary materials such as sandstone, conglomerate, siltstone, and shale formations; surface layers are compacted fallout from volcanic eruptions of Mounts Redoubt and Iliamna (Mark Clark, Soil Conserv. Serv., pers. comm.). Substrate configuration results in continuous surface erosion and unsafe climbing conditions.

Recent seabird population estimates at Chisik and Duck Islands are as follows:

double-crested cormorant: 150 birds
pelagic cormorant: 10-20 birds
glaucous-winged gulls: 1000-2000 birds
black-legged kittiwakes: 16,000-20,000 birds
common murre: 2000-5000 birds
pigeon guillemot: 13 birds (on Fossil Point near Chisik)
horned puffin: 5000
tufted puffin: 1000

Kittiwakes nest primarily along cliffs located on the southwest side of Chisik Island, extending to the southern tip. Smaller numbers of kittiwakes and the majority of murres have historically nested along the central portion of the eastern coast and all along the cliffs of Duck Island. Double-crested cormorants nest and roost on cliffs along the east and northeast sides of Chisik Island and cliffs on Duck Island. Pelagic cormorants nest along the mid-eastern cliffs of Chisik. Horned puffins nest in crevices found over much of Duck Island. Pigeon guillemots nest off of Fossil Point on the mainland to the west of Chisik Island (Fig. 2).

Gull Island & 60-foot Rock

Gull Island, owned by the Seldovia Native Corporation, is about five km southeast of the tip of the Homer Spit (59° 35'10"N, 151° 19' 45"W). 60-foot Rock, part of the Alaska Maritime National Wildlife Refuge, lies about six km south of the Spit (59° 33'N, 151° 28'W) (Fig. 1). Both islands erupt sharply from the water and are composed of fractured bedrock. Gull Island has three portions which connect at extreme low tides (Fig. 3). Herbaceous vegetation grows on the plateau area of Gull Island; 60-foot Rock is mostly nonvegetated.

Recent seabird population estimates are as follows:

Gull Island

pelagic cormorant: 200 birds
red-faced cormorant: 30 birds
glaucous-winged gull: 700-800 birds
black-legged kittiwake: 7000-8000 birds
common murre: 5000-8000 birds
pigeon guillemot: 12-15 birds
horned puffin: 10
tufted puffin: 500

60-foot Rock

pelagic cormorant: 30-50 birds
glaucous-winged gull: 80-100 birds
black-legged kittiwake: 300-400 birds
common murre: 150-230 birds
pigeon guillemot: 2 birds
tufted puffin: 50 birds

Kittiwakes, murres and cormorants, and to a lesser extent, pigeon guillemots, nest throughout the cliffs along the entire perimeter of the island and outlying rocks. Murres also nest on flat, open surfaces on top of the island. Gulls primarily nest in the vegetation across the top of the island. Tufted puffins burrow above the cliffs along the edge of the island.

Gull Island, and to a lesser extent, 60-foot Rock, are frequently visited by tour and charter boats throughout the breeding season. It is not uncommon for boats to approach within 5 m of nesting birds and periodically cause birds to flush (pers. obs.).

METHODS

Data was collected on a daily basis at Chisik and Duck Islands from 21 June to 20 August by two researchers living on Chisik. Crews of two to four researchers monitored Gull Island regularly from 6 June to 29 August. 60-foot Rock was surveyed three times (14 and 21 June, and 2 August).

Population Counts

Chisik & Duck Islands

Population estimates were by censusing all visible birds on the islands 1-2 times during the breeding season. On Chisik Island, gulls and kittiwakes on adjoining sections of cliff were counted on separate days. The census period extended between 2 July - 22 July. At Duck island, horned and tufted puffins were counted twice (24 July, 7 August). Counts were done at low tide, to allow circumnavigation of the island by foot, and in the evening, when most puffins returned to the colony (Wehle 1976, Amaral 1977). The total count included birds in flight, in offshore rafts within 100-150 m of the island, and roosting on cliffs around the island.

For some species, plots were monitored regularily to provide a population index. Plot boundaries were established prior to this study and delineated on photographs. Kittiwakes, gulls and murres were monitored on eight plots (Nishimoto et al. 1987, Slater et al. 1995).

Counts were typically made by two biologists in a small boat kept within 100 m of the plot. Using binoculars (8x40 or 10x40) and reciprocating counters, observers made repetitive counts until the difference between their totals was ten percent or less. The mean of the two counts was recorded for each plot. Population estimates were made by combining the counts from all plots for the day. A seasonal population estimate was calculated from the mean of the daily plot totals. Counts were made in late-June to early-August when the maximum numbers of breeding birds were present (i.e., between mid-incubation and early hatching stages for each species), and between 1100 and 1800 hrs when within-day variability in nest-site attendance was lowest (Dragoo et al. 1991, Byrd 1989).

To count pigeon guillemots, observers anchored within 100 m of the guillemot colony at Fossil Point on the northwest side of Tuxedni Channel, Chisik Island. Three counts were made during the chick rearing period (3, 19 July, 2 August). To minimize tidal influence, surveys were conducted near high tide (Andres 1993).

Gull Island and 60-foot Rock

Population estimates were made using the two methods described above. At Gull Island, kittiwakes were counted three times (8-9 June, 13 July, 9 August). Pelagic and red-faced cormorants were counted four times (8-9 June, 8, 30-31 July, 21 August). Murres were counted twice (8-9 June, 30-31 July). Tufted puffins were counted twice (8-9 June, 21 August). Gulls were censused once (8-9 June). 60-foot Rock was censused 7 June, before the mid-incubation stage for all species. At Gull Island, weekly counts of all ledge-nesting seabirds were made on permanent plots previously established by AMNWR personnel. Plots at 60-foot Rock were counted twice (14 June, 2 August).

Phenology

Chisik & Duck Islands

Limited cormorant phenology data were collected since nest contents were not visible until chicks were large enough to be seen from the water (pelagic cormorant) or from an observation point on Duck Island (double-crested cormorant). Observations of double-crested cormorants were made on those nests which could be easily identified at consecutive checks. Thirty-one nests at the NE Chisik colony were observed with a 30x scope from Duck Island. Birds and chicks were difficult to distinguish due to the distance to the colony. Four pelagic cormorant nests were checked regularly using binoculars from a distance of 50-100 m offshore in an inflatable boat. Detailed observations were difficult due to variable sea conditions and distance to nests.

Breeding events were monitored on 12 kittiwake plots and 4 murre plots. Plots were visited every 2-3 days to record reproductive status of each nest (i.e. numbers of eggs and chicks) until the birds departed. When common murre nest contents could not be seen, observers relied on behavioral cues to indicate reproductive status (Mendenhall et al. 1991). Birds exhibiting incubating postures during three consecutive visits were considered to have an egg, and birds showing brooding posture were assumed to have a chick (see Byrd 1989 for description of behaviors). We used direct observations of eggs or young for kittiwakes. Phenology of horned puffins was determined by examining occupied crevices to record the presence of eggs or chicks about once per week. In cases where the reproductive status of a site changed between visits, we used the intermediate date between visits to date the event.

Gull Island & 60-foot Rock

Breeding events were followed in 5 kittiwake plots and 2 gull plots. Nest contents in three kittiwake plots and 10 pelagic cormorant nests were monitored opportunistically from the island. Gull plots and 2 kittiwake plots were checked every 2-3 days for nest contents. Twenty pelagic cormorant and 7 red-faced cormorant nests were also

monitored once chicks were large enough to be seen from the water. Murre phenology was inferred from incidental sightings.

Productivity

Chisik & Duck Islands

Procedures for estimating productivity varied among species depending on access to observation points. Cormorant productivity was determined by counting the number of chicks produced per nest on each plot where cormorants bred. Active nests were defined as those having vegetation added during the current breeding season. Crude estimates of gull productivity were determined from the presence of fledged chicks.

Kittiwake productivity was monitored in 12 plots. We defined active kittiwake nests as those containing vegetative material added in the current breeding season. Nest status (i.e. number of eggs and chicks) was recorded every 2-3 days. Nest contents were observed with binoculars and spotting scopes or a 6m pole with a mirror attached at the end. Using plots as sample units, data were used to calculate mean clutch size, hatching success (chicks hatched per egg laid), fledging success (chicks fledged per chick hatched), and productivity (chicks fledged per nest with eggs).

Murre productivity was monitored in 4 plots at Duck Island. Nest status (i.e. presence of eggs or chicks) was recorded every 2-3 days. Data were used to calculate mean hatching success between plots. Fledging success and productivity could not be calculated since observations ended prior to fledging.

Horned puffin productivity was estimated on Duck Island by monitoring nesting crevices. Crevices were checked once per week from late June through mid-August for the presence of eggs, chicks, and adults. Hatching success was derived from the number of eggs hatched to eggs seen. Productivity was extrapolated from the ratio of productivity per pair to hatching success from 1993 (Slater et al. 1995). Fledging success could not be determined since observations ended prior to fledging. Horned puffins do not nest on any of the other islands included in this study.

Gull Island & 60-foot Rock

Procedures for estimating productivity also varied among species depending on access to observation sites. Use of land-based observation points was extremely limited, resulting in incomplete data and some unknown nest fates.

Pelagic cormorant productivity was monitored in 2 plots. Cormorant productivity was also estimated for the entire island by using the 2-visit method described by Byrd (1989). All active nests were counted 8 July and all visible chicks were counted 21 August. Productivity was also determined by counting chicks produced in nests constructed within the index plots. Kittiwake productivity was monitored on 5 plots. Nest contents in 2 plots were checked regularly using a mirror pole while 3 land-based plots were checked opportunistically. Kittiwake productivity was also estimated for the entire island by counting all active nests 13 July and nests with chicks 9 August. Limited murre productivity data were collected in 5 plots visited 1-3 times during the late chick-rearing stage.

Chick Growth & Diet

Weight was chosen as primary measure of growth. Where possible, growth rates were compared between islands using t-tests.

Chisik & Duck Islands

Glaucous-winged gulls
Eight gull chicks of unknown age were weighed and measured 1-9 times, with 3 chicks measured ≥ 8 times. Weight (g), right wing chord (mm), and culmen (mm) were recorded each time. For each chick, weights were plotted against calendar day. Individual growth rates were calculated by least squares regressions within the period of linear weight increase. Growth rates were averaged for the island.

Common murres
Thirty-one unmarked murre chicks of unknown ages were weighed and measured once between 18 and 20 August. Weight (g), right wing chord (mm), and culmen (mm) were recorded for each chick. Since wing chord is an accepted measure of age in murres (Uttley et al. 1994), all mass values were plotted against wing chord. For measurements within the period of linear weight increase, mass was divided by wing chord to yield an index of body condition. These values were compared to the mean Gull Island value by t-tests.

Several attempts to collect chick meals were made by using velcro bands to prevent chicks from swallowing. Bands were removed from chicks 2-4 hours later. No meals were recovered.

Horned puffins
Eighteen horned puffin chicks from marked nests were weighed and measured 1 - 6 times, with 12 measured ≥ 3 times from mid-July to late-August. Weight (g), right wing chord (mm), and culmen (mm) were recorded. For each chick, weights were plotted against calendar day. Individual growth rates were calculated by least squares regressions within the period of linear weight increase. Growth rates were averaged for the island.

Chick diet samples were collected by blocking the crevice entrances with squares of wire mesh (about 25 cm x 1 cm mesh) after adults had departed and were rechecked after 1-3 hours. Adults ideally drop their prey at the crevice entrance when access to their chick is blocked (Piatt, pers. obs.). The majority of samples were collected opportunistically, as found at unblocked crevices. Samples were identified, measured, weighed, and preserved in a 10% formalin solution for 24 hours, and subsequently stored in ethyl alcohol. Percent diet composition was calculated.

Gull Island

Glaucous-winged gulls
On Gull Island 42 known age chicks were weighed and measured 1 -7 times between hatching and fledging, with 25 measured ≥ 3 times. Fifteen chicks were banded with uniquely numbered AVISE metal bands to facilitate identification. Weight (g), right wing chord (mm), and culmen (mm) were recorded for each chick. For each chick, weight was plotted against age. Individual growth rates were calculated by least squares regressions within the period of linear weight increase. Growth rates were averaged for the island. 10 chick regurgitations were collected while handling chicks.

Black-legged kittiwakes
Thirty-one kittiwake chicks were weighed and measured 1 - 7 times between hatching and fledging, with 24 chicks measured ≥ 3 times. Fifteen chicks were banded with uniquely numbered AVISE metal bands to facilitate identification. Weight (g), right wing chord (mm), and culmen (mm) were recorded for each chick. Since hatch dates were not known, ages were estimated by comparing morphometric measurements with those of known age kittiwake chicks in Shoup Bay, Alaska. For each chick, weight was plotted against age. Individual growth rates were calculated by least squares regressions within the period of linear weight increase. Alpha chicks (hatched first), beta chicks (hatched second), and singleton chicks (either from a one egg clutch or a chick that was alone in the nest for ≥50% of the days that we measured growth) were treated separately. Growth rates were averaged for the island.

Forty chick regurgitations were collected primarily from chicks outside of our plots. A few samples were collected from measured chicks.

Common murres

Ten to twenty unmarked murre chicks of unknown ages were weighed and measured during two visits to a small colony. Weight (g), right wing chord (mm), and culmen (mm) were recorded for each chick. Since wing chord is an accepted measure of age in murres (Uttley et al. 1994), all mass values were plotted against wing chord. For measurements within the period of linear weight increase, mass was divided by wing chord to yield an index of body condition. These values were averaged and compared to the mean Gull Island value by t-tests.

Thirty-five murre chick diet samples were collected in three visits to a small colony. Attempts were made to collect chick meals using plastic cable ties to prevent chicks from swallowing. Cable ties were removed after 2-3 hours. One fish was recovered with this process. The majority of fish collected were picked up opportunistically from the colony substrate.

RESULTS & DISCUSSION

Chisik and Duck Islands

Double-crested Cormorant

Populations.--Double-crested cormorants were observed periodically on the cliffs of both islands. None were seen on the established plots (Table 1). 80-100 were counted in the colony on the northeast cliffs of the island (Table 2). A group of birds occupied a colony 300 m north of the Snug Harbor cannery in May, but abandoned before researchers arrived in mid-June (Kissler pers. obs.). This same colony was present throughout the breeding season in 1993 and at the beginning of the season in 1994 (Slater et al. 1995).

Double-crested cormorants roosted occasionally on and near murre productivity plots Q and R on Duck Island. 42 birds were observed on 14 August. One nest was built within the north Glaucous-winged gull plot, just west of the murre plots. In addition, 15-20 double-crested cormorants commonly roosted on shore just north of the observation point for murre productivity plots M and P.

Productivity.--Productivity was inferred from regular nest attendance by adults throughout the season. Eighteen fully-feathered chicks were seen on the last check at the northeast plot on 10 August.

Pelagic Cormorant

Populations.--Pelagic cormorants did not nest within any plots this year (Table 1). A small nesting colony composed of 12 adults and 7 nests was found on the east side of Chisik during the island census in early July. Overall, the pelagic cormorant population has decreased since the 1970's (Table 2).

Breeding Phenology.--We obtained little information on breeding phenology due to poor observation conditions. Nests were active by early July and contained chicks on the last check on 20 August.

Productivity.--Productivity in 4 monitored nests was 1.0 chick per nest. This may be the first year in which pelagic cormorants have been productive. Pelagic cormorants have not successfully produced young in any previous years of study (Nishimoto et al. 1987, Beringer & Nishimoto 1988, Slater et al. 1995).

Glaucous-winged Gull

Populations.--The mean number of gulls (13) on population plots has increased in the past 2 years, but remains lower than means from the mid-80's (Table 3).

The gull population at Duck Island was estimated at 159 birds. However, accurate counts were impeded by dense vegetation. In 1978, the nesting distribution of glaucous-winged gulls included the coasts of the southern two-thirds of Chisik Island and all of Duck Island (see Jones et al. 1980). We observed birds in these areas, but were unable to accurately count birds nesting high on cliffs or under dense vegetation.

The gull population at Chisik Island was estimated to be 1800 birds (Table 4). This population has increased in the past two years and is similar to 1978 when numbers were estimated at 1500-2000 (Jones et al. 1980, Muhlberg 1984).

Breeding Phenology.--The first chicks were observed on productivity plots on 22 June. Hatching appeared complete by 31 July. The first fledged gull chick was observed on 28 July on Chisik Island.

Productivity.--Minimal information was collected on productivity due to the small sample of nests in the plots and difficulty in seeing the nest contents. The population plot count on 4 July did not occur until after the early hatch period and likely missed earlier nesting attempts in these areas. Production was inferred by the presence of 16 fledged chicks.

Chick Growth.--Chicks grew at an average rate of 33.43 ± 3.10 grams per day (n = 3) (Table 5). A t-test detected no significant difference between values for each island (df = 14, p = 0.074).

Black-legged Kittiwake

Populations.--Counts of kittiwakes on index plots this year (691) have continued to decline from 1986 (Table 6, Figure 4).The island population was estimated at 16,504 birds (Table 7). This count is similar to counts from the last two years, but continues the general population decline begun in the 70's (Figure 5).

We also noted a small colony (≤100 birds) behind our campsite northwest of Snug Harbor. Birds have been reported here in the past (Snarski 1970). This colony abandoned within a week after our arrival to the island in late June.

Breeding Phenology.--Egg-laying was nearly complete when observers arrived on 21 June. Egg-laying and hatching dates were similar to those obtained in the past (Table 8). All eggs hatched between 6-26 July. Chicks appeared to have fledged by 20 August. Most adult kittiwakes had left the colony by 5 August.

Productivity.--286 nests were monitored in 1995 (Table 9). Eggs were laid in 50% of the nests and the average clutch size was 1.08 ± 0.12 (n=12 plots). Hatching success was 0.22 (n=2 plots). Productivity was 0.02 (n=12 plots). Fledging success was 0.06 ± 0.04 (n=2). Twenty three fledglings were sighted on the entire island on 20 August.

Nest loss was largely due to adult desertion. Some egg loss was attributable to ravens, gulls, and bald eagles. Kittiwake productivity has been extremely low in all years of detailed study. Data since the seventies shows nearly total breeding failure for at least 7 years and productivity (fledged chicks per nest) of 0.25 or more in 3 years.

Common Murre

Populations.--The mean number of murres counted on index plots in 1995 was 199 birds (Table 10). This continues a general decline since 1986 (Figure 6). The island population was estimated at 2246 individuals (Table 11).

There was a substantial reduction in the island population of murres at Chisik between 1970 and 1978, and another decline between 1978 and 1983 (Fig. 7).

Breeding Phenology.--Common murres had not begun to attend cliffs consistently when observers arrived in late June. Depredated eggs were first observed on 23 June, but egg-laying did not take place on study plots until early to mid-July when murres began to attend colonies regularly. Common murre chicks began to hatch within study plots on 9 August. On the last visit to the plots on 20 August, 72% of the eggs laid had hatched. Observations ended before hatching was complete and before fledging began on study plots. Assuming murres fledge after 23 days (Hatch & Hatch 1990), fledging probably occurred in early to mid-September.

Productivity.--Productivity could not be accurately determined because researchers left the island before hatching was complete and before chicks had fledged. Minimum hatching success was 0.67 ± 0.11 chicks per pair (n=4 plots) (Table 12). Assuming that all chicks fledged, maximum productivity could have been as high as 0.65 ± 0.11 chicks per pair.

Chick Growth.--Chick weights increased linearly between wing lengths of 21 - 50 mm. Within this range, murre chick body condition at Chisik was 3.71 ± 0.15 grams per mm wing length (n = 36) (Table 5). A t-test indicated no significant difference between values at Gull and Chisik Islands (df = 50, p = 0.071).

Pigeon Guillemot

Populations.--The only site believed to be used for breeding by pigeon guillemots is at Fossil Point, on the west side of northern Tuxedni Channel. We obtained a median of 13 adults (range 11-14) from two counts conducted in early July (Table 13).

Historical information on pigeon guillemots indicates birds have nested on Chisik Island in the past (Slater et al. 1995). We rarely saw birds near Chisik and found no signs of birds nesting there, although the talus slopes may provide good nesting habitat.

Horned Puffin

Populations.--An average of 1782 horned puffins on Duck Island were counted on 24 July and 7 August. This is a decrease from estimates of 5000-6000 birds counted in 1978, 1979 and 1983 (Jones et al. 1980, Muhlberg 1984).

Breeding Phenology.--69% of active crevices (either containing eggs, adults, or both) surveyed on 22 and 23 June had eggs (n=29 crevices). The mean hatch occurred on 25 July, and assuming birds fledge at 37-46 days (Hatch & Hatch 1990), fledging probably began by 23 August. Final chick measurements on 20 August indicated several chicks were close to fledging. Horned puffin phenology dates are similar to those of the past (Table 14).

Productivity.--An estimate of hatching success was 0.66 (n=29 nests). Exact productivity was not determined, but was estimated at 0.46 chicks per pair (Table 15).

Chick Growth.--During the period of linear weight increase, horned puffin chicks grew 12.29 ± 0.72 grams per day (n = 12) (Table 5). This is higher than the rate in 1993 when chicks grew 9.4 grams per day (n=16) (Slater et al. 1995).

Chick Diets.--Sand lance comprised 98% of fish collected from chick diets (n=93 fish) (Table 16). The remaining samples were salmonids. The sand lance averaged 93.1 ± 2.60 mm long and weighed 2.9 ± 0.28 grams.

In 1993 sand lance comprised 90% of total chick diets (n=68 fish) and had an average total length of 82.5 ± 3.24 mm (Slater et al. 1995). The remaining prey were unknown fish. Historical data show that sand lance comprised the majority

of chick diets at Chisik Island (Jones et al. 1980, Slater et al. 1995). Jones et al. (1980) observed only two instances in which identified fish were not sand lance (those samples were comprised of three capelin (*Mallotus villosus*) and two pink salmon (*Onchorhynchus gorbuscha*).

Tufted Puffin

Population.--An average of 40 tufted puffins were counted at Duck Island on 24 July and 7 August. We observed a few tufted puffins nesting at Duck Island but did not conduct any detailed research on this species. Historical counts estimate the population at 750-1000 birds in 1971 (Snarski 1971c).

Gull Island

Pelagic Cormorant

Populations.--The mean number of adult pelagic cormorants observed on index plots this year was 42 birds (Table 1, Fig. 8). This number has remained stable since 1986, except for the unusually low count in 1992. The mean number of nests has increased slightly, with the greatest number (28) observed this year. The island population was estimated to be 246 individuals (Table 2). In contrast, the total colony population appears to have decreased from a relatively stable level between 1976 and 1990 (Fig. 9). However, strong conclusions regarding the breeding population are hard to make because cormorants show variable site fidelity (Slater et al. 1995)

Breeding Phenology.--Ten pelagic cormorant nests with observable contents were monitored throughout the season. Seventy five percent of nests checked on 11-16 June contained eggs (n=8 nests). Egg-laying appeared to be complete by 9 July. Chicks were first seen on 17 July, and all appeared to have hatched by 28 August. The first fledgling was seen at the island 23 August, but most nests still had chicks on our last visit on 28 August.

Productivity.-- Productivity was assessed for the entire island as well as for plots within the island. Overall productivity was 1.15 chicks per nest, based on a count of all visible chicks on 21 August (late chick-rearing stage) and all nest structures on 8 July (mid-incubation). Assuming chicks seen between mid-brood and early fledging stage fledged, mean productivity was 1.22 ± 0.11 chicks per nest (n=2 plots).Productivity was 0.64 chicks per nest in productivity plots. This continues the decrease from peaks seen in 1992 and 1993 (Table 17).

Red-faced Cormorant

Populations.--The mean number of red-faced cormorants on the island this year was 27 birds (Table 2). This number is similar to those counted in 1990. However, the infrequent population counts show no obvious trend since 1976. Nest numbers appear to have remained stable (8-17) in the past ten years (Fig. 10).

Breeding Phenology.--Little data was collected on phenology. We began monitoring 6 active nests 26 June and added one late nest initiated 3 July. When last checked 28 August 4 nests contained one or more visible chicks.

Productivity.--Assuming chicks seen 28 August fledged, minimum productivity in 7 monitored nests was 0.71 chicks per nest. Based on island-wide counts of chicks and active nests (including the monitored nests) overall productivity was 0.67 chicks per nest.

Glaucous-winged Gull

Populations.--The mean number of gulls in the index plots was 21 birds (Table 3). This number has remained stable in the past seven years, except for the unusually low count in 1994. However, relatively few of the breeding gulls on Gull Island nest on the cliff plots thus counts are not representative of colony size. Most gulls occupied sites in the

vegetation on top of the island and therefore are difficult to count accurately. We estimated the gull population at 500 individuals (Table 4, Fig. 11).

Breeding Phenology.--Over half of the gull nests in two plots monitored consistently contained eggs when first checked 11 June. Egg-laying appeared complete by 25 June. The first gull chicks were seen 28 June, and all chicks in the plots appeared to have hatched by 18 July. We did not observe exact fledging dates; however, assuming chicks fledge at 40-45 days, fledging was expected to begin 7 August. (Hatch and Hatch 1990).

Productivity.--We monitored nests through egg-laying and hatching stages. Mean clutch size in four plots was 2.1 ± 0.08 eggs per pair. Mean hatching success in two plots in which egg fate was known was 0.8 ± 0.07 chicks hatched per egg. Due to the difficulty in determining exact fledging dates, we did not estimate overall productivity. However, the presence of fledged gull chicks throughout the island suggest that production was substantial.

Chick Growth.--Chick weights increased linearly between the ages of 8 - 24 days. Within this period, chicks grew an average of 44.73 ± 2.67 grams per day (n=13 chicks) (Table 5).

Black-legged Kittiwake

Populations.--The mean number of kittiwakes in the index plots this year was 1361 birds (Table 6). This is the second highest value recorded since monitoring was initiated in 1984 (Fig. 12). Numbers have increased or remained stable in plots 1-10 with the exception of the higher mean counts of 1454 birds in 1988.

We counted 8166 kittiwakes on the island on 12 July (early hatching stage). This is an increase from the last colony estimate (6986 birds) in 1990 (Table 7). The 1995 colony estimate is similar to that in 1985 (8202) and higher than in 1976 (3194). This suggests that the population expansion seen 10-20 years ago has leveled off in recent years (Fig. 13).

Breeding Phenology.--Eighty-five percent of kittiwake nests contained eggs when first checked 13 June (n=37 nests). Egg-laying appeared complete by 22 June with the exception of one probable re-lay 27 June (Table 8). Most chicks hatched between 3-11 July; hatching was complete by 26 July. The first fledgling was seen at the island 8 August. Most chicks in the plots were expected to fledge by 16 August, based on a 36 day fledge estimate (Hatch and Hatch 1990). Exact fledge dates were difficult to determine as young kittiwakes will return to nest sites after fledging (pers. obs.).

Productivity.--Forty percent of nests counted during mid incubation (13 July) contained chicks when surveyed again at the end of the late chick rearing period (9 August). This number reflects a minimum productivity as numerous nests had two chicks. However, mean productivity in five monitored plots with known nest contents was 0.39 ± 0.13 chicks per nest, including one plot of 35 nests which all failed (Table 9). Two plots, including the failed plot, were checked with a mirror pole, which may have artificially lowered productivity due to disturbance. Productivity in one additional plot, which was subject to disturbance by observers climbing past every 1-3 days, was 0.10 chicks per nest.

Although assessed in different plots this year, kittiwake productivity appears to have increased from the low estimates in 1992-1993 and returned to the relatively stable levels of previous years, with the exception of the extremely poor productivity in 1987. Mean nest numbers in the plots have increased since 1992 and are approaching the peak numbers counted in 1988-1990.

Chick Growth.--Chick weights increased linearly between the ages of 6 - 22 days. In this period, average chick growth for all chicks was 14.51 ± 2.16 grams per day (n = 16). For alpha chicks, the average rate was 15.85 ± 5.91 grams per day (n = 2), while the average rate for beta chicks was 16.89 ± 1.74 grams per day (n = 2). The average rate for singleton chicks was 14.64 ± 2.69 (n = 12) (Table 5).

Common Murre

Populations.--The mean number of murres in index plots 1-3 was 212 birds (Table 10, Fig. 14). This number has continued to increase steadily from the earliest counts in 1985, with the exception of the decrease in plots 1-3 in 1993. Furthermore, whole-island counts increased from approximately 2000 - 3000 birds in the mid-1970s and mid-1980s to over 5000 birds in 1988-1990 (Table 11). The island population was estimated to be 8553 individuals. This was the highest recorded since 1976, and a substantial increase from the exceptionally low count (1732 individuals) in 1991. Island counts taken from the water may be inaccurate given most murres are on the top of the island. However, the increase in the more easily viewed index plots suggests the colony is expanding.

Breeding Phenology.--Limited data were collected on phenology due to the lack of appropriate vantage points from which to observe contents of murre sites. The first murre eggs were seen on 25 June; however, early nests appeared to be heavily impacted by predators (bald eagles, crows, glaucous-winged gulls) (pers. obi.). Most birds did not appear to be incubating until early July. The first chick was seen on 3 August. In one plot, approximately 64% of eggs had hatched by 18 August (n=39 eggs). Six possibly inviable eggs remained unhatched on 28 August. We observed four murre chicks fledging 28 August. Some fledging appeared to have occurred on earlier nights, but the majority of chicks had not yet fledged.

Productivity.--Due to the limited observation points, we were not able to accurately assess murre productivity. Nevertheless, observations of chicks and fledglings indicate that production was high. The mean number of chicks per adult in five plots checked 28 August (early fledging stage) was 0.44 ± 0.06 chick per adult (total adults = 337, total chicks = 134).

Chick Growth.--Chick weights increased linearly between wing lengths of 26 - 50 mm. Within this range, murre chick body condition was 4.17 ± 0.16 grams per mm wing length (n = 16 chicks). A t-test indicated no significant difference between values at Gull and Chisik Islands (df = 50, p = 0.071).

Chick Diet.--Sand lance comprised 59% of murre chick meal samples. Pacific herring (20%), Pacific cod (6%), surf smelt (6%), salmonids (3%), and others (6%) comprised the rest of the samples.

Pigeon Guillemot

Populations.--We did not attempt to census the pigeon guillemot population this year. The highest incidental count was 15 birds. Past counts of pigeon guillemots at Gull Island ranged from 24 to 42 birds in the late 1980's (Table 13). Few guillemots were seen in the index plots, although three crevices within the plots appeared to be occupied for some of the season.

60-foot Rock

Double-crested Cormorant

Populations.--Double-crested cormorants were not observed on the index plots in 1995 (Table 1). Double-crested cormorants usually do not nest on 60-foot Rock. However, three roosting adults were seen on the eastern wash rocks on 7 June. One cormorant nested on the island in 1993.

Pelagic Cormorant

Populations.--No pelagic cormorants were observed on index plots this year (Table 1). Few have been observed in the plots in past years, although cormorants commonly roost and sporadically nest elsewhere on the island (Table 2). We counted 35 individuals on the entire rock on 7 June. Cormorants shift nesting locations periodically, so the change

among years may represent a shift to another nesting location (Slater et al 1995). Counts at 60-foot Rock since 1976 have been highly variable.

Glaucous-winged Gull

Populations.--We counted 21 gulls on the plots during the mid-incubation stage (Table 3). This was the highest count recorded since 1987. The island population was estimated to be 79 (Table 4). The island population appears to have increased between 1976 and 1986, then remained relatively stable.

Productivity.-Production was inferred by the presence of 10 chicks approximately one week before fledging was expected based on gull phenology at Gull Island.

Black-legged Kittiwake

Populations.--We counted 119 kittiwakes on the plots this year near the time of mid-incubation (Table 6). Numbers have fluctuated between 100 - 300 in the past 10 years. We counted 439 kittiwakes on the entire island on 7 June (Table 7). This is a substantial increase from previous years, however the timing of this year's count (at approximately nest-initiation stage) may have biased the population estimate. Whole-island counts since 1976 suggest there was a substantial increase between 1976 and 1984. It appears the population at 60-foot Rock peaked during the period 1988-1990, then peaked again this year.

Productivity.--Of 89 kittiwake nests counted in the plots on 21 June, 19 contained chicks on 2 August. Nesting success in plots was 0.21 chicks per nest, based on counts of nests with chicks on 2 August and nest structures seen on 21 June (n=89 nests) (Table 9).

Common Murre

Populations.--Only one murre was seen on the index plots this year (Table 10). This represents a continued population decline from numbers seen between 1985 and 1993. Whole-island counts suggest there were more murres at this small colony in 1976 than in recent years (Table 11). It is unclear whether there was ever a stable breeding population here. The breeding population appears to have disappeared.

Pigeon Guillemot

Populations.--Pigeon guillemots have not been intensively monitored at 60-foot Rock, and historical counts have been low (Table 13). We did not see any on our visits to the island this year. In 1986 two adults and one active crevice were noted (Nishimoto et al. 1987).

CONCLUSIONS

The primary objective of the study was to evaluate population and productivity trends in seabird populations at Lower Cook Inlet breeding colonies (i.e., Chisik and Duck Islands, Gull Island, and 60-foot Rock). The following conclusions were reached:

1. Double-crested cormorants appear to have declined since the early 1970s at Chisik Island, but they are still producing chicks. Chisik Island is the only colony where this species regularly nests.

2. Pelagic cormorants declined at Chisik, but produced chicks this year for the first time. The largest pelagic cormorant population in lower Cook Inlet is at Gull Island, where numbers are stable and reproductive success is high. Populations are fluctuating at 60-foot Rock.

3. Gull Island is the only colony where red-faced cormorants nest (with the exception of one nest at 60-foot Rock). The populations is stable.

4. Glaucous-winged gulls populations and productivity have remained at the same level at all colonies.

5. Black-legged kittiwake population trends varied between the colonies. Populations have declined and birds have consistently failed to produce chicks at Chisik Island and 60-foot Rock. At Gull Island the population increased and had high reproductive success.

7. Common murres declined at Chisik Island and increased at Gull Island. The nesting population has disappeared at 60-foot rock.

8. At Chisik Island, the single substantial colony of Horned Puffins appears to be declining. Productivity is stable.

LITERATURE CITED

Andres, B.A. 1993. Potential impacts of oiled mussel beds on higher organisms: black oystercatchers. Unpayable. rep., U.S. Fish and Wildl. Serv. Anchorage, AK.

Beringer, B. and M. Nishimoto. 1988. The status of breeding seabirds at Chisik and Duck Islands during the summer of 1987. Unpayable. rep., U.S. Fish and Wildl. Serv., Alaska Maritime Natl. Wildl. Refuge, Homer, AK. 12 pp. + appendix.

Byrd, G.V. 1989. Seabirds in the Pribilof Islands, Alaska: trends and monitoring methods. M. S. Thesis, Univ. of Idaho. 96 pp.

Byrd, G.V., E.C. Murphy, G.W. Kaiser, A.Y. Kondratyev, and Y.V. Shibaev. 1993. Status and ecology of offshore fish-feeding alcids (murres and puffins) in the North Pacific. In The status, ecology, and conservation of marine birds of the North Pacific. Vermeer, K., K.T. Briggs, K.H. Morgan, and D. Siegel-Causey (eds.). Can. Wildl. Serv. Spec. Publ., Ottawa.

Dragoo, D.E., B.K. Bain, M.J. Melendez, and C.M. Minch. 1991. Changes in colony size and reproductive success of seabirds at the Semidi Islands, Alaska, 1976-1991. Unpayable. rep., U.S. Fish and Wildl. Serv., Alaska Maritime Natl. Wildl. Refuge, Homer, AK. 43 pp.

Dragoo, B.K. and K. Sundseth. 1993. The status of northern fulmars, kittiwakes, and murres at St. George Island, Alaska, in 1992. Unpayable. rep., U.S. Fish and Wildl. Serv., Homer, AK. 19 pp. + figures, tables, and appendices.

Erikson, D. 1976. Distribution, abundance, migration and breeding locations of marine birds in Lower Cook Inlet, Alaska. Vol. 8. In Trasky, L.L., L.B. Flagg and D.C. Burbank, eds. Environmental studies of Kachemak Bay and Lower Cook Inlet. Unpayable. admin. rep., AK. Dep. Fish and Game, Marine/Coastal Habitat Manage. Anchorage.

Erikson, D. 1993. Surveys of murre colony attendance in the norther Gulf of Alaska following the Exxon Valdez oil spill. Presentation at the Third ASTM symposium on Environment, Toxicology, and Risk Assessment; Aquatic, Plant, and Terrestrial, April 25-28, 1993, Atlanta, GA.

Gabrielson, I. and F. Lincoln. 1959. The Birds of Alaska. The Wildlife Management Institute. Stackpole Press.

Jones, R.D. and M.R. Petersen. 1979. The pelagic birds of Tuxedni Wilderness, Alaska. Unpayable. rep., U.S. Fish and Wildl. Serv., Biological Serv. Prog., Anchorage, AK. 41 pp.

Jones, R.D., M.R. Petersen, C. Slater and J. Burke-Ogan. 1980. The pelagic birds of Chisik and Duck Islands. Final report. U.S. Fish and Wildl. Serv., Biological Serv. Prog., Anchorage, AK. 33 pp.

Kafka, D.M. 1984. Kittiwake productivity on Chisik and Duck Islands, Cook Inlet, Alaska. Unpayable. rep., Univ. of AK., Fairbanks. 14 pp.

Krohn, W.B. 1966. A brief survey of the Tuxedni National Wildlife Refuge. Unpayable. rep., U.S. Bur. Sport Fisheries. Kenai, AK. 12 pp.

Mendenhall, V.M., D.E. Dragoo, L. Haggblom and E.C. Murphy. 1991. Chapter II. Monitoring of populations and productivity of seabirds at St. George Island, Cape Peirce, and Bluff, Alaska, 1989. Rep. by U.S. Fish and Wildl. Serv., Anchorage, AK., to Minerals Manage. Serv. No. 90-0049, Anchorage, AK.

Muhlberg, G. 1984. Chisik and Duck Islands report (draft). Unpayable. rep., U.S. Fish and Wildl. Serv., Anchorage, AK.

Murie, O.J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. North Am. Fauna, Number 61, Dep. of the Interior. Washington, D.C. 406 pp.

Nishimoto, M. and B. Beringer. 1989. Breeding seabirds at Gull Island and Sixty-foot Rock during 1987-88. Unpayable. admin. rep., U.S. Fish and Wildl. Serv., Homer, AK. 24 pp. + appendices.

Nishimoto, M. and B. Beringer. 1990. Breeding seabirds at Gull Island and Sixty-foot Rock during 1989. Unpayable. admin. rep., U.S. Fish and Wildl. Serv., Homer, AK.

Nishimoto, M., D. Debinski, K. Rose and K. Thounhurst. 1987. Breeding seabirds at Gull Island and Sixty-foot Rock during 1984-86. Unpayable. admin. rep., U.S. Fish and Wildl. Serv., Homer, AK. 19 pp. + appendices.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorck, and D. Nysewander. 1990. Immediate impact of the Exxon Valdez oil spill on marine birds. Auk 107: 387-397.

Nishimoto, M. and K. O'Reilly. 1989. Status of the fork-tailed storm-petrel at East Amatuli Island during the summer of 1988. Unpayable. rep., U.S. Fish and Wildl. Serv., Homer, AK. 26 pp. + appendices.

Nishimoto, M. and C. Thomas. 1991. Breeding seabirds at Gull Island and Sixty-foot Rock during 1990. Unpayable. rep., U.S. Fish and Wildl. Serv., Homer, AK. 24 pp. + appendices.

Sanger, G. and M. Cody. 1994. Surveys of pigeon guillemot colonies in Prince William Sound, Alaska. Exxon Valdez Final Restoration Rep. 93-034.

Snarski, D.A. 1970. Kittiwake ecology, Tuxedni National Wildlife Refuge. Alaska Coop. Wildl. Res. Unit. Quarterly Rep. July-September 22: 10-13.

Snarski, D.A. 1971a. Kittiwake ecology, Tuxedni National Wildlife Refuge. Alaska Coop. Wildl. Res. Unit. Quarterly Rep. July-September 21: 6-8.

Snarski, D.A. 1971b. Kittiwake ecology, Tuxedni National Wildlife Refuge. Alaska Coop. Wildl. Res. Unit. Quarterly Prog. Rep. Jan-March 22: 15-23.

Snarski, D.A. 1971c. Seabird colony data sheet for Tuxedni National Wildlife Refuge. Unpublished.

Snarski, D.A. 1974. Some aspects of the ecology of the black-legged kittiwake during two years of nesting failure. Univ. Alaska., Coop. Wildl. Research Unit, Fairbanks. Thesis manuscript. 38 pp.

Sowls, A.L., S.A. Hatch, and C.J. Lensink. 1978. Catalog of Alaskan seabird colonies U.S. Fish and Wildlife Service FWS/OBI - 78/78. Washington, D.C.

Sowls, A.L. 1985. Seabird colony catalog update. Unpayable. computer printouts, U.S. Fish and Wildl. Serv., Anchorage, AK.

Uttley et al. 1994. The effects of food abundance on breeding performance and adult time budgets of guillemots Uria aalge. Ibis 136. 205-213.

Table 1. Summary of double-crested (DCCO), pelagic (PECO), and red-faced cormorant (RFCO) population estimates on plots in lower Cook Inlet colonies.

Location	Year	Estimate [a]				Source	Comments
		DCCO[b]	PECO[c]	RFCO[d]	Unknown species		
Chisik Island	1986	1 (1)	0	0	4 (2)	Nishimoto et al. 1987	
(plots 1-7)	1987	1 (1)	0	-		Beringer and Nishimoto 1988	
	1993	0	0	0	0	Slater et al. 1995	
	1994	0	0	0	0	Slater et al. 1995	
	1995	0	0	0		this study	
Gull Island	1986	0	55(20)	0		Nishimoto and Thomas 1991	plots 1-8
	1987	0	44(15)	0		Nishimoto and Thomas 1991	plots 1-8
	1988	0	43(21)	0		Nishimoto and Thomas 1991	plots 1-8
			49(22)				plots 1-10
	1989	0	30(16)	0		Nishimoto and Thomas 1991	plots 1-8
			33(16)				plots 1-10
	1990	0	38(21)	0		Nishimoto and Thomas 1991	plots 1-8
			39(21)	1(1)			plots 1-10
	1992	0	6(5)	0		Erikson, unpub. data	plots 1-8
			6(5)	1(1)			plots 1-10
	1993	0	39(25)	0			plots 1-8
			41(26)	0		Slater et al. 1995	plots 1-10
	1994	0	43(26)	0			plots 1-8
			44(27)	0		Slater et al. 1995	plots 1-10
	1995	0	41(27)	0		this study	plots 1-8
			42(28)	0			plots 1-10
60-Foot Rock	1985	0	0	0		Nishimoto et al. 1987	
	1986	0	0	0		Nishimoto et al. 1987	
	1987	0	0	0		Nishimoto and Beringer 1989	
	1988	0	0	0		Nishimoto and Beringer 1989	
	1989	0	(2)	0		Nishimoto and Thomas 1991	
	1990	0	0	0		Nishimoto and Thomas 1991	
	1993	0	3(0)	0		Slater et al. 1995	
	1994	0	0	0		Slater et al. 1995	
	1995	0	0	0		this study	plots 1-2

[a] estimate is the mean of counts pooled for plots, nests in parentheses
[b] double-crested cormorant
[c] pelagic cormorant
[d] red-faced cormorant

Table 2. Summary of double-crested (DCCO), pelagic (PECO), and red-faced cormorant (RFCO) population estimates in selected lower Cook Inlet colonies.

Location	Year	Estimate [a]			Source	Comments
		DCCO	PECO	RFCO		
Chisik Island [b]	1970	500	20-30	---	Snarski 1971c	
	1971	500	20-30(1)	---	Snarski 1971c	
	1973	---	(2)	---	Snarski 1974	
	1978	common	7(0)	---	Jones and Peterson 1979	
	1983	150(17)	---	---	Muhlberg 1984	+150 roosting on Duck Island
	1986	(16)	(2)	---	Nishimoto et al. 1987	+150 unid. cormorants roosting on SE
	1987	50+(1)	0	---	Beringer & Nishimoto	derived from partial 1988 island count
	1993	160	30(12)	---	Slater et al. 1995	entire island
	1994	81	2	0	Slater et al. 1995	NE bluffs not in count
	1995	113(45)	12(7)	0	this study	min. pop size
Gull Island	1976	0	222	62	Erikson 1976	entire island
	1984	0	(54)	(4)	Nishimoto et al. 1987	entire island
	1985	0	105	14	Nishimoto et al. 1987	entire island
	1986	0	272(111)	45(14)	Nishimoto et al. 1987	entire island
	1987	0	296(103)	56(17)	Beringer & Nishimoto 1988	entire island
	1988	0	(130)	(8)	Nishimoto & Beringer 1989	entire island
	1989	0	(129)	(15)	Nishimoto & Thomas 1991	entire island
	1990	0	246(111)	29(15)	Nishimoto & Thomas 1991	entire island
	1995	0	194(92)	27(12)	this study	entire island
60-Foot Rock	1976	0	0	0	Erikson 1976	
	1984	0	30	---	Nishimoto et al. 1987	
	1985	0	28	0	Nishimoto et al. 1987	
	1986	1	13	0	Nishimoto et al. 1987	
	1987	0	9	0	Nishimoto & Beringer 1989	
	1988	0	2	0	Nishimoto & Beringer 1989	
	1989	0	29(3)	0	Nishimoto & Thomas 1991	
	1990	0	62(6)	1(1)	Nishimoto & Thomas 1991	
	1993	1(1)	45(39)	0	Slater et al. 1995	
	1994	0	29(0)	0	Slater et al. 1995	
	1995	0	35	0	this study	single count 6/8

[a] number of nests are in parentheses

[b] includes Duck Island;

Table 3. Summary of glaucous-winged gull population estimates on plots in lower Cook Inlet colonies.

Location	Year	Estimate [a]	Source	Comments
Chisik	1986	18	Nishimoto et al. 1987	
Island [b]	1987	33	Beringer & Nishimoto 1988	
(plots 1-7)	1993	9	Slater et al. 1995	
	1994	10	Slater et al. 1995	
	1995	13(4)	this study	
Gull Island	1988	30	Nishimoto & Beringer 1989	
(plots 1-10)	1990	24	Nishimoto & Thomas 1991	
	1992	22	Erikson, unpublished data	single count on 8/15
	1993	20(1)	Slater et al. 1995	
	1994	2	Slater et al. 1995	
	1995	21(2)	this study	
60-Foot Rock	1987	10	Nishimoto & Beringer 1989	
(plots 1-2)	1988	15	Nishimoto & Beringer 1989	
	1989	18	Nishimoto & Beringer 1990	
	1990	16(2)	Nishimoto & Thomas 1991	
	1993	20(12)	Slater et al. 1995	
	1994	17(4)	Slater et al. 1995	
	1995	21(15)	this study	

[a] estimate is the mean of total plot counts, number of nests are in parentheses
[b] includes Duck Island

Table 4. Summary of glaucous-winged gull population estimates in selected lower Cook Inlet colonies.

Location	Year	Estimate [a]	Source	Comments
Chisik Island [b]	1978	1500-2000	Jones et al. 1980	
	1983	1500-2000	Muhlberg 1984	Tuxedni Bay area
	1993	1000	Slater et al. 1995	
	1995	1955(229)	this study	single count 7-22 Jul
Gull Island	1976	216	Erikson 1976	
	1984	200	Nishimoto et al. 1987	
	1985	442	Nishimoto et al. 1987	
	1987	592	Nishimoto & Beringer 1989	
	1988	1054	Nishimoto & Beringer 1989	
	1989	762	Nishimoto & Thomas 1991	
	1990	713	Nishimoto & Thomas 1991	
	1995	500	this study	estimate, 8 June
60-Foot Rock	1976	64	Erikson 1976	
	1984	21	Nishimoto et al. 1987	
	1986	113	Nishimoto et al. 1987	max count, 31 July
	1987	86	Nishimoto & Beringer 1989	
	1988	96	Nishimoto & Beringer 1989	
	1989	95	Nishimoto & Thomas 1991	
	1990	80	Nishimoto & Thomas 1991	
	1993	98	Slater et al. 1995	
	1994	60	Slater et al. 1995	
	1995	79	this study	single count 8 June

[a] numbers of nests are in parentheses
[b] includes Duck Island

Table 5. Summary and comparisons of murre (COMU), gull (GWGU), puffin (HOPU), and kittiwake (BLKI) chick growth rates at Lower Cook Inlet colonies in 1995.

	Chisik	Gull	p[a]
COMU	3.71± 0.15 grams / mm wing length, n=36	4.17 ± 0.16 grams / mm wing length, n=16	p = 0.071 (n.s.)
GWGU	33.43 ± 3.10 grams / day, n=3	44.73 ± 2.67 grams / day n=13	p = 0.074 (n.s.)
HOPU	12.29 ± 0.72 grams / day, n=12		
BLKI		*all chicks*: 14.51 ± 2.16 grams / day, n=16 *alpha chicks*: 15.85 ± 5.91 grams / day, n=2 *beta chicks*: 16.89 ± 1.74 grams / day, n=2 *singleton chicks*: 14.64 ± 2.69 grams / day, n=16	

[a] Significance indicated when $p < 0.05$.

Table 6. Summary of black-legged kittiwake population plot counts at lower Cook Inlet colonies.

Location	Year	Estimate[a]	Source	Comments
Chisik[b]	1986	1498 (1201)	Nishimoto et al. 1987	completed in July
(plots 1-7)	1987	(626)	Beringer & Nishimoto 1988	completed in July
	1993	919(569)	Slater et al. 1995	completed in July
	1994	1045(996)	Slater et al. 1995	completed in July
	1995	691(583)	this study	
Gull Island	1984	145 (80)	Nishimoto et al. 1987	plots 1-3
	1985	149 (56)	Nishimoto et al. 1987	plots 1-3
	1986	224(158)	Nishimoto et al. 1987	plots 1-3
		993(769)		plots 1-8
	1987	213(101)	Beringer & Nishimoto	plots 1-3
		725(300)	1988	plots 1-8
	1988	240(189)	Nishimoto & Beringer	plots 1-3
		1289 (949)	1989	plots 1-8
		1454 (1071)		plots 1-10
	1989	234(164)	Nishimoto & Thomas	plots 1-3
		1082(875)	1991	plots 1-8
		1219		plots 1-10
	1990	218(164)	Nishimoto & Thomas	plots 1-3
		1156(817)	1991	plots 1-8
		1301(929)		plots 1-10
	1992	191(135)	Erikson, unpub. data	plots 1-3
		1027(600)		plots 1-8
		1165(685)		plots 1-10
	1993	222(94)	Slater et al. 1995	plots 1-3
		909(515)		plots 1-8
		1025(571)		plots 1-10
	1994	204(138)	Slater et al. 1995	plots 1-3
		926(751)		plots 1-8
		1067(847)		plots 1-10
	1995	272(164)	this study	plots 1-3
		1200(774)		plots 1-8
		1361(879)		plots 1-10
60-Foot Rock	1985	(35)	Nishimoto & Beringer 1989	
	1986	96(75)	Nishimoto & Beringer 1989	
	1987	71(31)	Nishimoto & Beringer 1989	
	1988	112(82)	Nishimoto & Beringer 1989	
	1989	98(90)	Nishimoto & Thomas 1991	
	1990	101(88)	Nishimoto & Thomas 1991	
	1993	65(47)	Slater et al. 1995	
	1994	103(89)	Slater et al. 1995	
	1995	119(89)	this study	

[a] estimate is the mean of total plot counts, nests in parentheses

[b] includes Duck Island

Table 7. Summary of black-legged kittiwake population estimates in selected lower Cook Inlet colonies.

Location	Year	Estimate [a]	Source	Comments
Chisik Island [b]	1936	25,000	Murie 1959	may include only the SW colony
	1970	20,000	Snarski 1971a	
	1971	47,690	Snarski 1974	counted in early August
	1978	28,000	Jones and Peterson 1979	
	1979	28,000	Jones et al. 1980	
	1983	20,000	Kafka 1984	estimate of "Tuxedni Bay area"
	1985	18,170	Nishimoto, unpublished data	counted prior to nest building
	1986	27,228	Nishimoto 1987	
	1993	14,191	Slater et al. 1995	
	1994	17,804	Slater et al. 1995	
	1995	16504(13303)	this study	single count 2-19 July
Gull Island	1976	3194	Erikson 1976	
	1984	(4204)	Nishimoto et al. 1987	
	1985	8202	Nishimoto et al. 1987	
	1990	6986(5684)	Nishimoto & Thomas 1991	
	1995	8166(5719)	this study	
60-Foot Rock	1976	68	Erikson 1976	
	1984	(199)	Nishimoto et al. 1987	
	1985	(177)	Nishimoto et al. 1987	
	1986	289	Nishimoto et al. 1987	
	1987	250	Nishimoto & Beringer 1989	
	1988	414	Nishimoto & Beringer 1989	
	1989	351	Nishimoto & Thomas 1991	
	1990	391	Nishimoto & Thomas 1991	
	1993	186	Slater et al. 1995	
	1994	294	Slater et al. 1995	
	1995	439	this study	single count 8 June

[a] estimate is the mean of total plot counts; number of nests in parentheses
[b] includes Duck Island

Table 8. Summary of nesting phenology of black-legged kittiwakes at lower Cook Inlet colonies.

Location	Year	Egg-laying	Hatching	Fledging	References
Chisik Island	1966	early-mid June [a]	---	unquantified, but presumably "good"	Krohn 1966
	1970	19 Jun -5 July	18 July - ?	none	Snarski 1971b
	1971	27 June -10 July [b]	26-29 July		Snarski 1974
	1973	late May-early June	<27 June>	< August>	Snarski 1974
	1978	10-30 June	6-25 July	23 August	Jones and Peterson 1979
	1979	14 June-6 July	10 July-4 Aug	19 Aug-8 Sept 1980	Jones et al
	1983	18-22 June	---	none on plots; 11 juveniles seen in water 8/27	Muhlberg 1984
	1993	≤ 17-26 June	9-15 July	none	Slater et al. 1995
	1994	---	---	chicks last seen in nests on 18 Aug.	Slater et al. 1995
	1995	≤ 21 June - 3 July	6-26 July	16 Aug-20 Aug	this study
Gull Island	1971	early-mid June	---	no data; "good nesting success" on 9/2	Snarski 1974
	1984	early June	---	---	Nishimoto et al. 1987
	1985	early June	---	---	Nishimoto et al. 1987
	1986	early June	---	---	Nishimoto et al. 1987
	1987	18 June - ?	---	<10 August>	Beringer & Nishimoto 1988
	1988	---	---	<26 July>	Nishimoto & Beringer 1989
	1990	---	early-mid July	---	Nishimoto & Beringer 1989
	1993		began~23 July	most fledged by 31 Aug	Slater et al. 1995
	1994		mid-July	all fledged by 23 Aug	Slater et al. 1995
	1995	≤ 13-27 June	4-26 July	8 Aug - ?	this study

[a] Chick age estimated from photographs by Krohn (1966) (Snarski ca 1974)
[b] Chick age estimated by Snarski during brief visit to colony (Snarski ca 1974)

Table 9. Summary of black-legged kittiwake productivity on plots at lower Cook Inlet colonies.

Location	Year	# Nests[a]	Productivity[b]	Comments	References
Chisik	1970	---[d]	0.0		Snarski 1970
Island[c]	1971	74	0.0		Snarski 1971b
(plots 1-7)	1973	---	"very good"	~1.5 young/nest	Snarski 1974
	1978	115	0.02	in sample area	Jones & Peterson 1979
	1979	60	0.36		Jones et al. 1980
	1983	90	0.0	no chicks seen on cliffs, but 11 fledglings seen later with adults	Muhlberg 1984
	1986	1201	0.25		Nishimoto
	1987	626	0.0		Nishimoto
	1993	341	0.0		Slater et al. 1995
	1994	---	---	fledging mostly complete before 2nd visit; 31 fledglings:1,624 adults seen near the SW cliffs	Slater et al. 1995
	1995	286	0.03		this study
Gull	1985	428	0.33		Nishimoto et al. 1987
Island	1986	769	0.69		Nishimoto et al. 1987
(plots 1-10)	1987	300	0.03		Nishimoto et al. 1987
	1988	1071	0.63		Nishimoto & Beringer 1989
	1989	985	0.53		Nishimoto & Thomas 1991
	1990	929	0.47		"
	1992[e]	685	0.36		Erikson, unpublished data
	1993	608	0.10		Slater et al. 1995
	1994	847	0.21		Slater et al. 1995
	1995	149	0.39	plots A,B,C,E,F	this study
60-Foot	1985	177	0.10		Nishimoto et al. 1987
Rock	1986	230	0.40		Nishimoto et al. 1987
	1987	106	0.00		Nishimoto et al. 1987
	1988	280	0.58		Nishimoto & Beringer 1989
	1989	281	0.16		Nishimoto & Thomas 1991
	1990	301	0.04		"
	1993	156	0.06		Slater et al. 1995
	1994	230	0.01		Slater et al. 1995
	1995	89	0.21[f]		

[a] determined from the mean of total plot counts
[b] calculated from the mean number of chicks/nest (using the max number of chicks during replicate counts) unless otherwise noted
[c] includes Duck Island
[d] exact sample size unknown
[e] single count of nests on 15 August
[f] nesting success (ratio of nests with chicks to total nests)

Table 10. Summary of common murre population plot counts for lower Cook Inlet colonies.

Location	Year	Estimate [a]	Source	Comments
Chisik Island [b]	1986	337	Nishimoto et al. 1987	
(plots 1-7)	1987	392	Beringer & Nishimoto 1988	
	1993	173	Slater et al. 1995	
	1994	342	Slater et al. 1995	
	1995	199	this study	
Gull Island	1985	49	Nishimoto & Thomas 1991	plots 1-3
	1986	67		plots 1-3
		107	Nishimoto & Thomas 1991	plots 1-8
	1987	103		plots 1-3
		158	Nishimoto & Thomas 1991	plots 1-8
	1988	84		plots 1-3
		227	Nishimoto & Thomas 1991	plots 1-8
		228		plots 1-10
	1989	112		plots 1-3
		184	Nishimoto & Thomas 1991	plots 1-8
		202		plots 1-10
	1990	136		plots 1-3
		236	Nishimoto & Thomas 1991	plots 1-8
		250		plots 1-10
	1992	196		plots 1-3
		327	Erikson, unpublished data	plots 1-8
		334		plots 1-10
	1993	60		plots 1-3
		315	Slater et al. 1995	plots 1-8
		328		plots 1-10
	1994	201		plots 1-3
		324	Slater et al. 1995	plots 1-8
		333		plots 1-10
	1995	212		plots 1-3
		355	this study	plots1-8
		364		plots 1-10
60-Foot Rock	1985	23	Nishimoto & Beringer 1989	
	1986	33	Nishimoto & Beringer 1989	
	1987	34	Nishimoto & Beringer 1989	
	1988	20	Nishimoto & Beringer 1989	
	1989	25	Nishimoto & Thomas 1991	
	1990	18	Nishimoto & Thomas 1991	counts done 6/19-7/ 7
	1993	23	Slater et al. 1995	non-breeders
	1994	11	Slater et al. 1995	non-breeders
	1995	1	this study	

[a] estimate is the mean of total plot counts
[b] includes Duck Island

Table 11. Summary of common murre population estimates for lower Cook Inlet colonies.

Location	Year	Estimate [a]	Source	Comments
Chisik Island [b]	1970	20,000-25,000	Snarski 1971b	
	1970	22,500	Sowls 1985	
	1971	20,000-25,000	Snarski 1971b	
	1978	10,000	Jones & Peterson 1979	gross estimate; no plot counts estab.
	1983	5000	Muhlberg 1984	
	1986	4101	Nishimoto et al. 1987	
	1991	7536	Erikson 1993	
	1993	2558	Slater et al. 1995	4 replicate counts made
	1994	3057	Slater et al. 1995	single count made (12 July)
	1995	2246	this study	single count, 3-19 July
Gull Island	1976	3200	Erikson 1976	
	1984	2652		referenced in Nishimoto & Beringer 1989
	1985	1994		referenced in Nishimoto & Beringer 1989
	1988	5500	Nishimoto & Beringer 1989	birds flushed to complete count
	1989	5176	Nishimoto & Thomas 1991	
	1990	5075	Nishimoto & Thomas 1991	
	1991	1732	Erikson 1993	
	1995	8553	this study	single count, 30-31 July
60-Foot Rock	1976	350	Erikson 1976	
	1984	234	Nishimoto et al. 1987	
	1985	91	Nishimoto et al. 1987	
	1986	99	Nishimoto et al. 1987	
	1987	221	Nishimoto & Beringer 1989	
	1988	155	Nishimoto & Beringer 1989	
	1989	232	Nishimoto & Thomas 1991	
	1990	190	Nishimoto & Thomas 1991	
	1993	150	Slater et al. 1995	
	1994	140	Slater et al. 1995	

[a] estimate is the mean of the total plot counts
[b] includes Duck Island

Table 12. Common murre productivity at Duck Island, Alaska, in 1993 and 1995.

Plot	Sites with Eggs		Chicks Hatched		Hatching Success	
	1993	1995	1993	1995	1993	1995[c]
1	15	12	13	9	0.87	0.75
2	3	---[b]	3	---	1.00	---
3	2	---	1	---	0.50	---
4	9	15	7	5	0.78	0.33
5	7	59	5	46	0.71	0.78
6	5	20	4	16	0.80	0.80
Overall ratio [a]					0.77 ± 0.07	0.67 ± 0.11

[a] Based on all nest sites in 6 plots

[b] Nest contents not visible

[c] Number represents minimum hatching success because observations ended before all egg fates were known

Table 13. Pigeon guillemot counts in Lower Cook Inlet.

Location	Year	Total [a]	References
Gull Island	1976	12	Nishimoto & Thomas 1991
	1984	5	Nishimoto & Thomas 1991
	1985	13	Nishimoto & Thomas 1991
	1986	---	Nishimoto & Thomas 1991
	1987	42	Nishimoto & Thomas 1991
	1988	27	Nishimoto & Thomas 1991
	1989	24	Nishimoto & Thomas 1991
	1990	22	Nishimoto & Thomas 1991
	1994	13	Slater et al. 1995
	1995	15[b]	this study
60-Foot Rock	1976	0	Nishimoto & Thomas 1991
	1984	---	Nishimoto & Thomas 1991
	1985	---	Nishimoto & Thomas 1991
	1986	2(1)	Nishimoto & Thomas 1991
	1987	3	Nishimoto & Thomas 1991
	1988	no count	Nishimoto & Thomas 1991
	1989	0	Nishimoto & Thomas 1991
	1990	3	Nishimoto & Thomas 1991
	1994	2	Slater et al. 1995
	1995	0	this study

[a] maximum count in the particular year, number of nests in parentheses
[b] single count 8 June

Table 14. Breeding phenology of horned puffins at Duck Island, 1978-1993.

Year	Egg-laying	Hatching	Fledging	Source
1978	5-29 June	18-27 July	28 Aug-19 Sept	Jones et al. 1980
1979	15 June-4 July	25 July-4 August	30 Aug-11 Sept	Jones et al. 1980
1983	<10 June-?	16 July-11 August	---	Muhlberg1984
1993	≤ 23 June-?	15 July-7 August	3-≥ 13 Sept	Slater et al. 1995
1995	7 June-11 July[a]	17 July-20 August	≤ 23 Aug - ?[b]	this study

[a] estimate for egg-laying based on 38-43 day incubation (Hatch and Hatch 1990)
[b] estimate for hatching based on 37-46 brooding period (Hatch and Hatch 1990)

Table 15. Summary of horned puffin productivity at Duck Island, 1978-1995.

Year	Hatching Success	Broods with Fledged young	Mean # of young Raised/pair	Source
1978	0.73	0.92	0.60	Jones et al. 1980
1979	0.44	0.71	0.24	Jones et al. 1980
1993	0.53	0.69	0.37	Slater et al.1995
1995	0.66	---	0.46 [a]	this study

[a] An extrapolation based on the ratio of mean number of young raised per pair to hatching success

Table 16. Numbers (and percent composition) of fish in puffin (HOPU) chick diets at Chisik Island, and murre (COMU), kittiwake (BLKI), and gull (GWGU) chick diets at Gull Island in 1995.

	HOPU	COMU	BLKI	GWGU
n	93	35	94	19
Sand lance	91 (98.0)	21 (60.0)	75 (80.0)	14 (74.0)
Capelin	0	0	13 (14.0)	3 (16.0)
Pollock	0	0	1 (1.0)	1 (5.0)
Surf smelt	0	2 (5.7)	0	0
Salmonid	2 (2.0)	1 (2.9)	0	0
Herring	0	7 (20.0)	0	0
Pacific cod	0	2 (5.7)	0	0
Other	0	2 (5.7)	5 (5.0)	1 (5.0)

Table 17. Summary of pelagic cormorant productivity on Gull Island plots, 1988-1995.

Year	No. of chicks/nests	Source
1988	0.33	Nishimoto et al. 1987
1989	0.56	Beringer & Nishimoto 1988
1990	1.24	Beringer & Nishimoto 1988
1992	2.80	Beringer & Nishimoto 1988
1993	0.77	Slater et al. 1995
1994	0.81	Slater et al. 1995
1995	0.64	this study

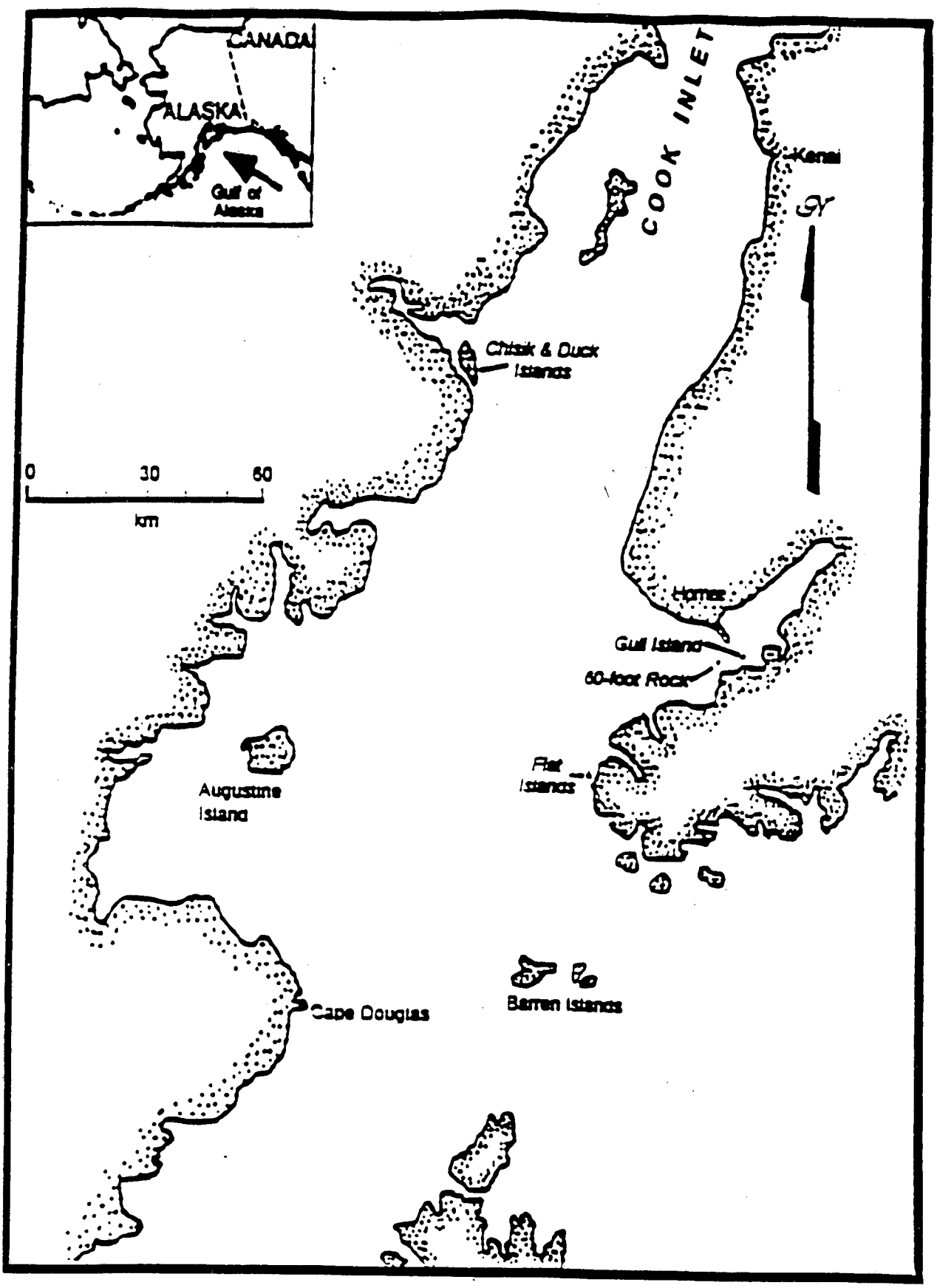

Figure 1. Study locations in lower Cook Inlet, Alaska.

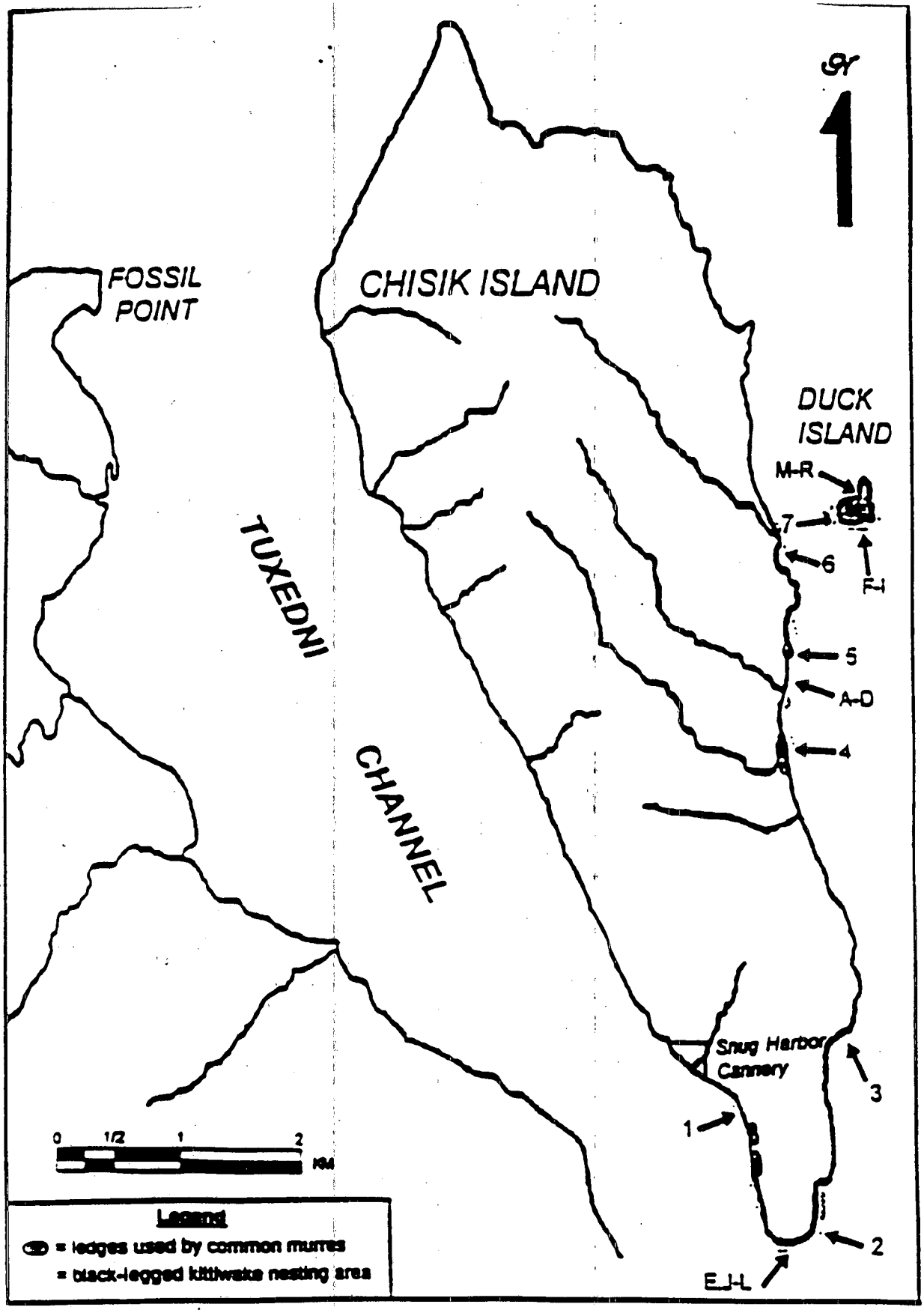

Figure 2. Nesting distributions of black-legged kittiwakes and common murres, and plot locations on Chisik and Duck Islands, lower Cook Inlet, Alaska.

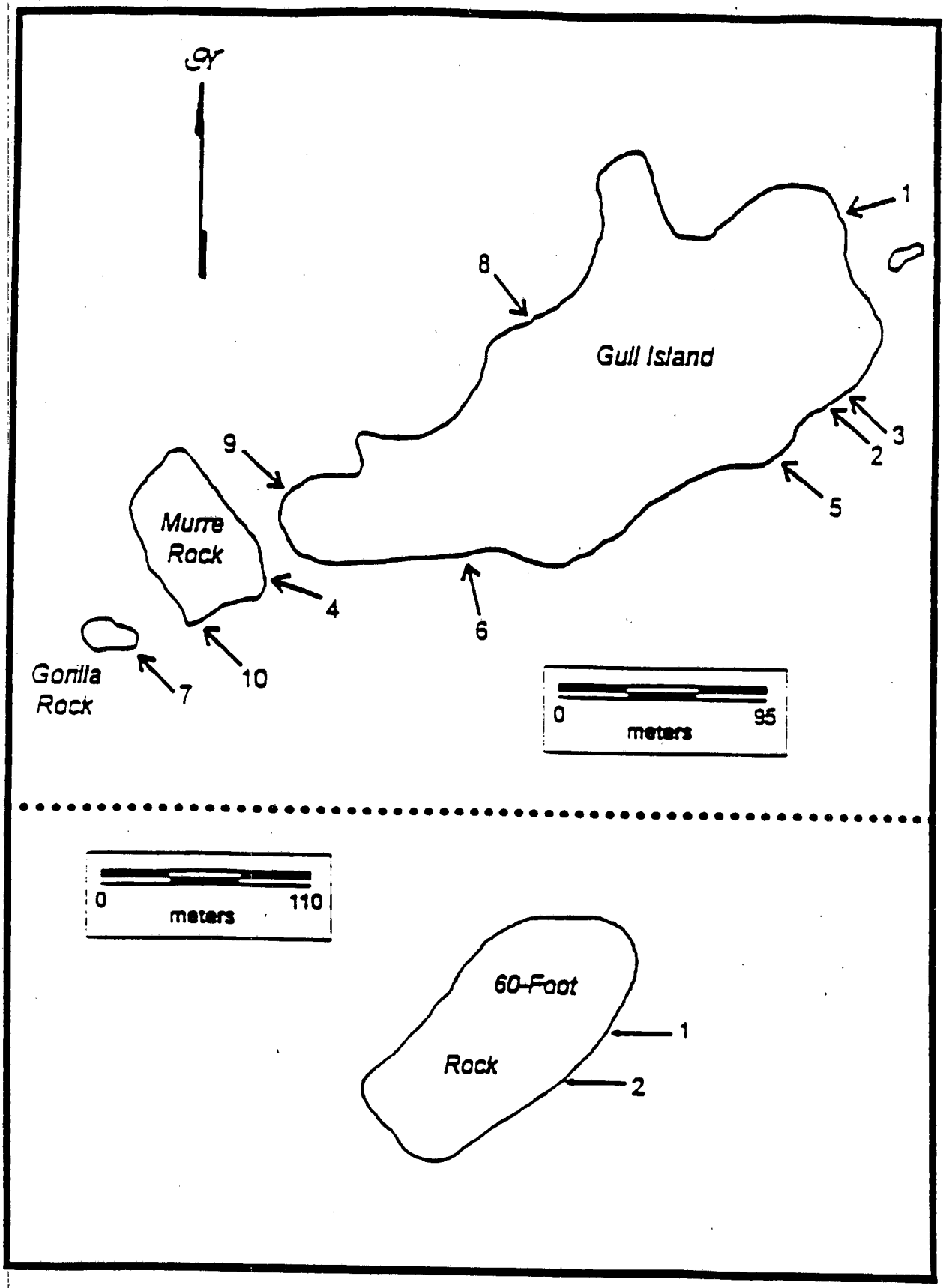

Figure 3. Seabird monitoring plot locations on Gull Island and 60-foot Rock, Kachemak Bay, Alaska.

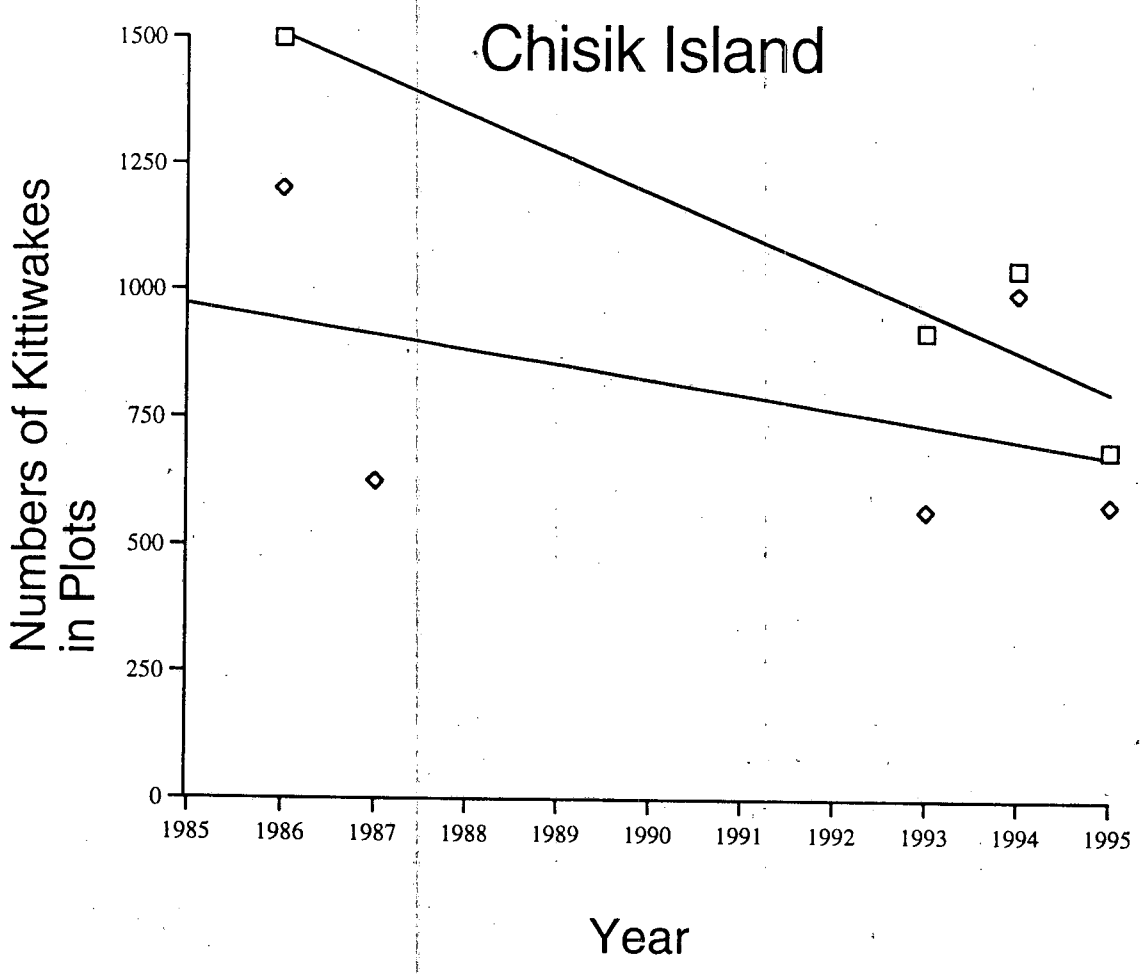

Figure 4. Numbers of black-legged kittiwakes (□; r = -0.94) and nests (◇; r = -0.43) on plots 1 - 7 at Chisik Island, 1986 - 1995.

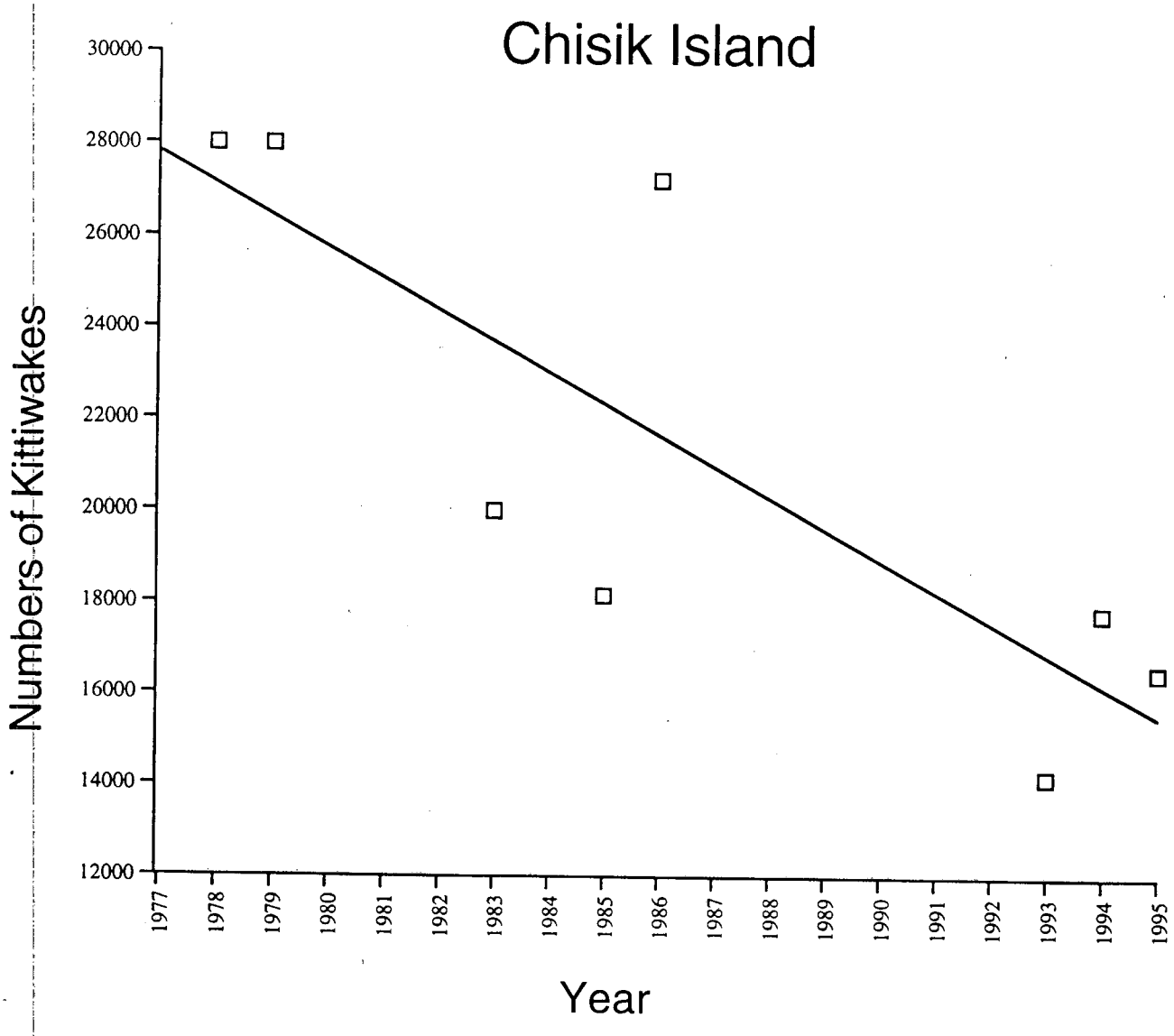

Figure 5. Numbers of black-legged kittiwakes at Chisik Island, 1978 - 1995 (r = -0.81).

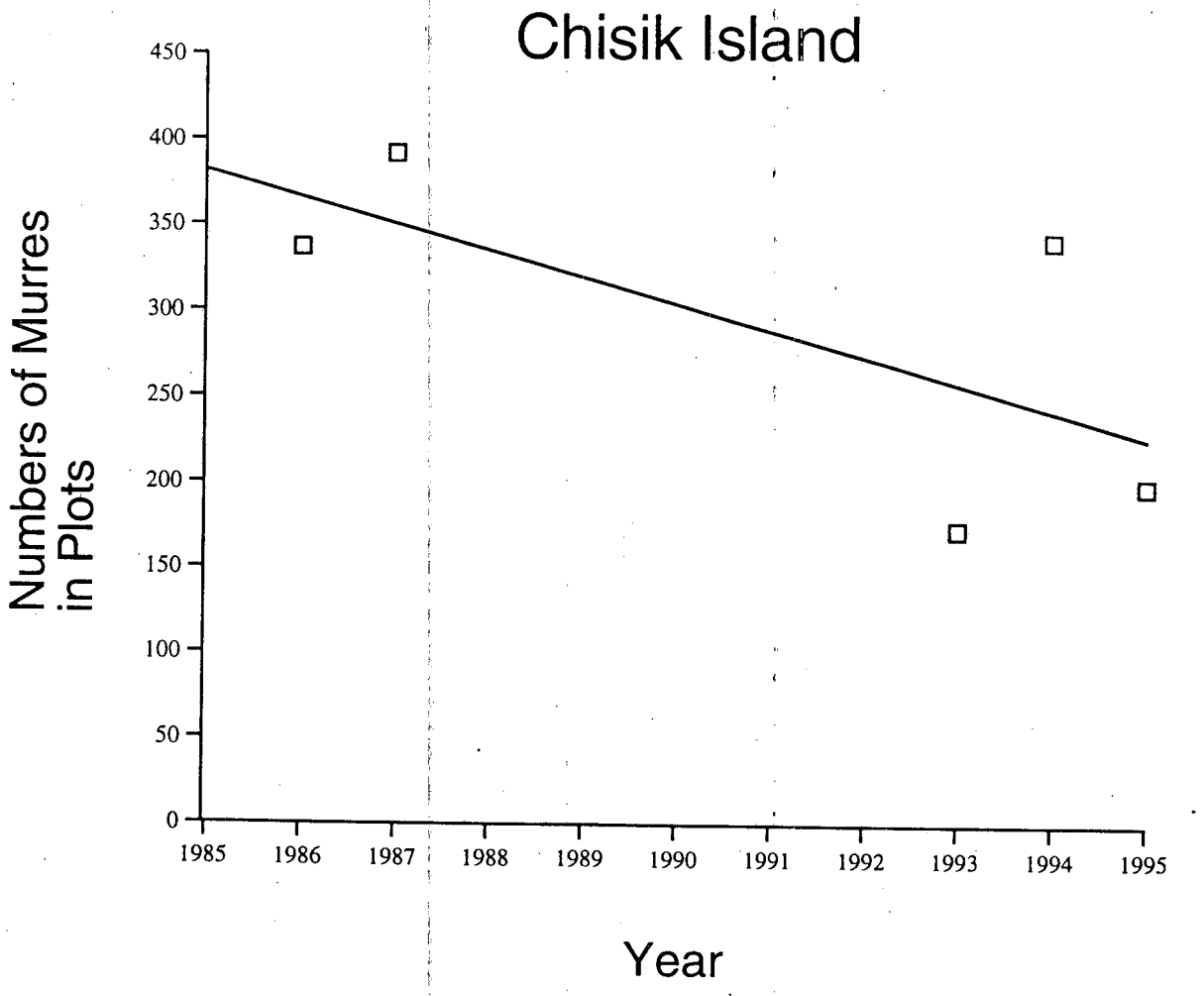

Figure 6. Numbers of common murres in plots 1 - 7 at Chisik Island, 1986 - 1995 (r = -0.67).

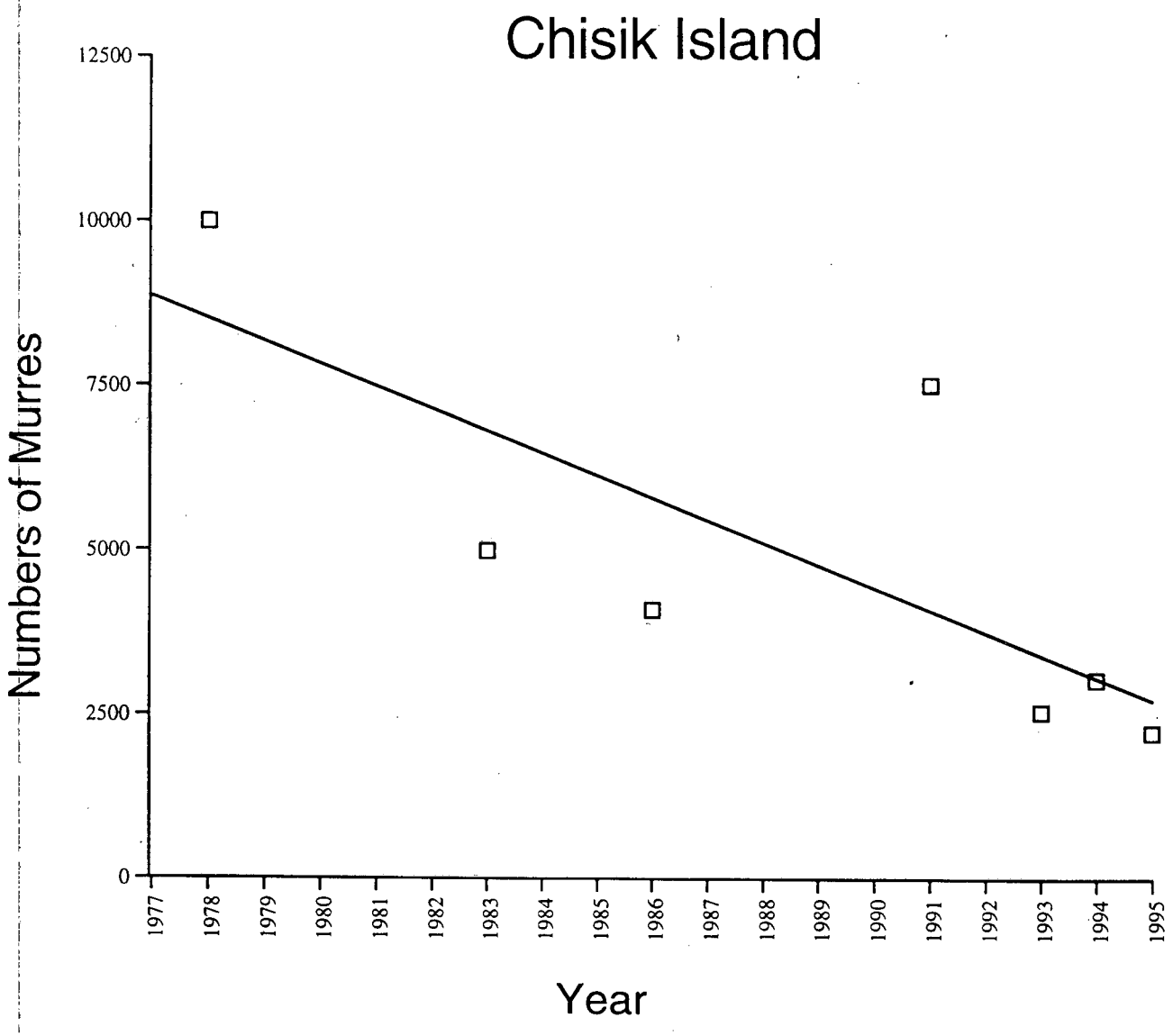

Figure 7. Numbers of common murres at Chisik Island, 1978 - 1995 (r = -0.76).

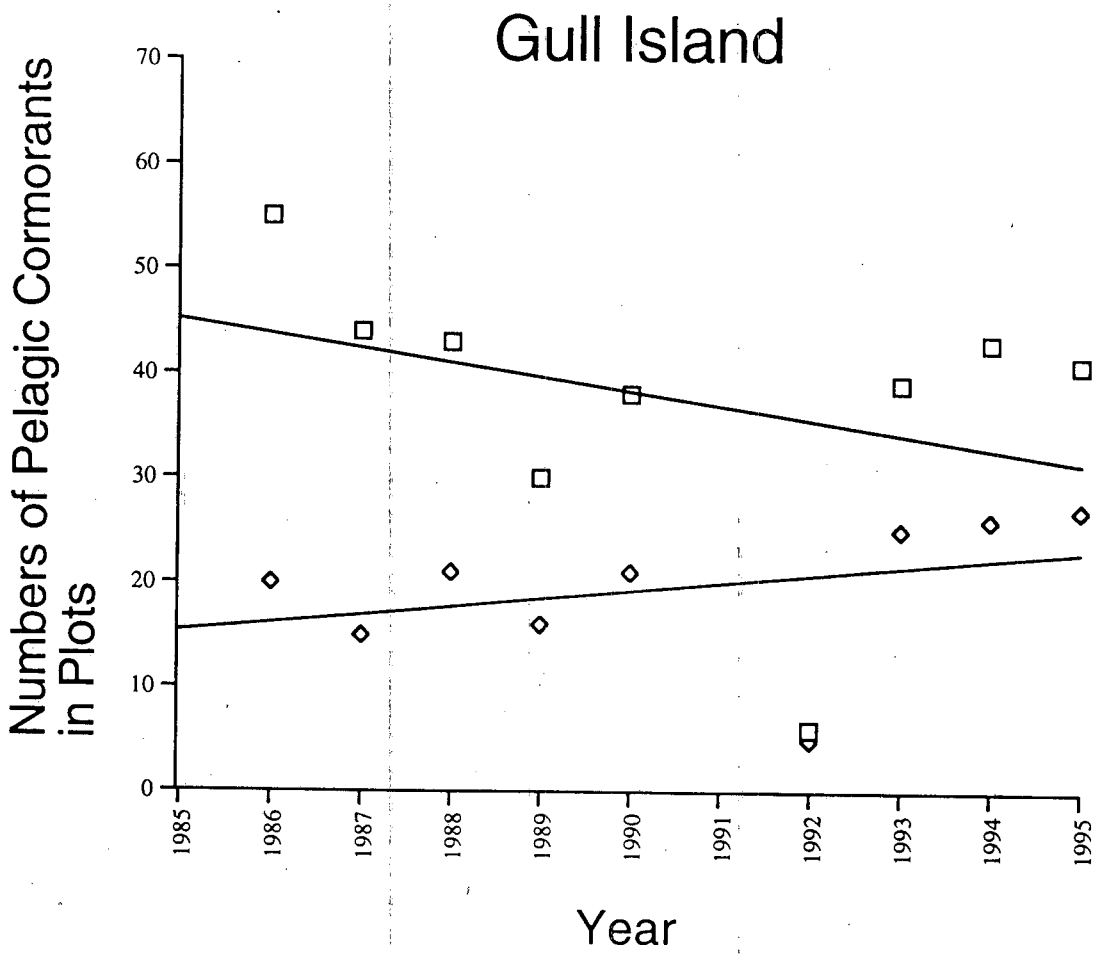

Figure 8. Numbers of pelagic cormorants (□; r = -0.32) and nests (◇; r = 0.36) in plots 1 - 8 at Gull Island, 1986 - 1995.

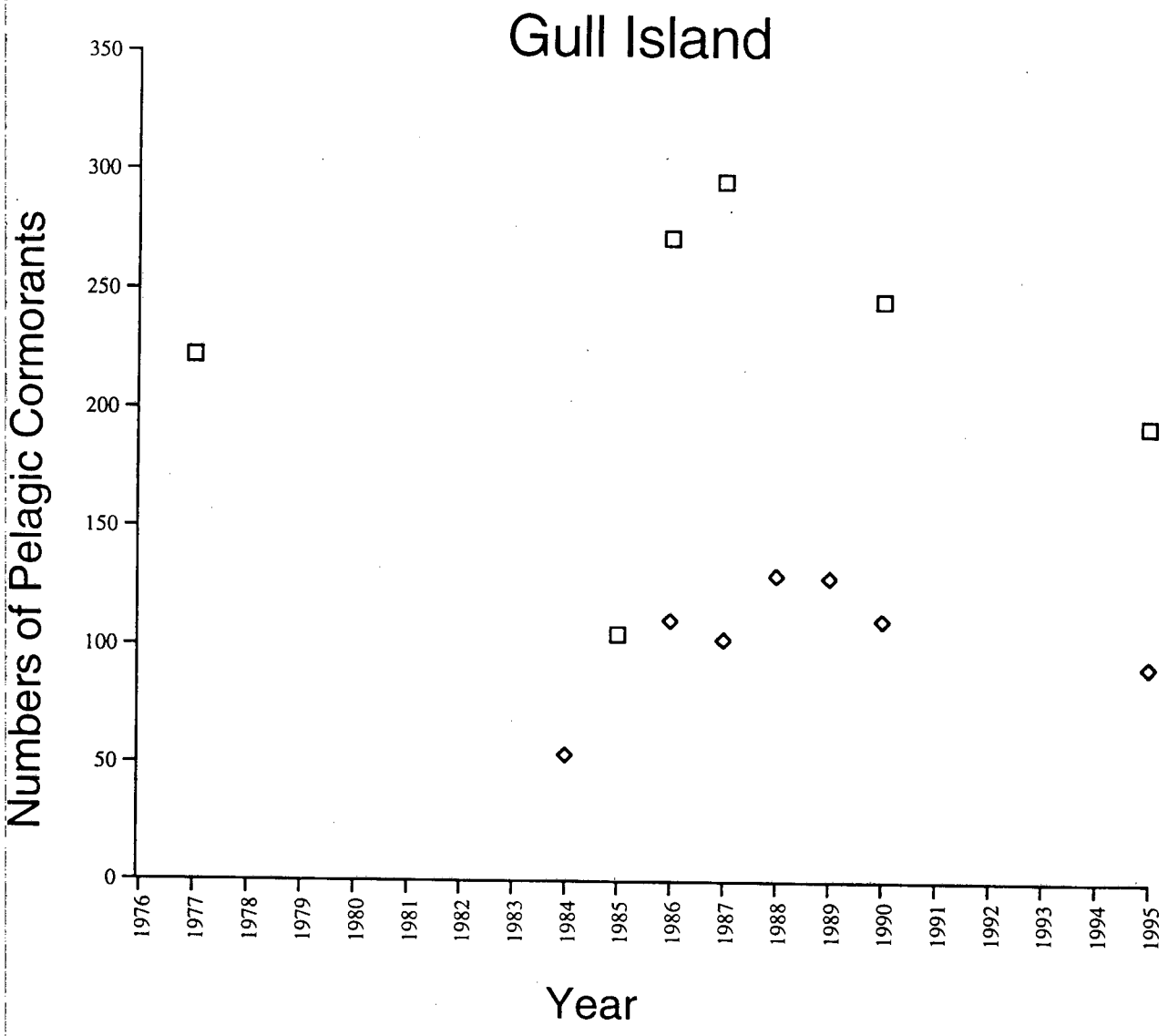

Figure 9. Numbers of pelagic cormorants (□) and nests (◇) at Gull Island, 1977 - 1995.

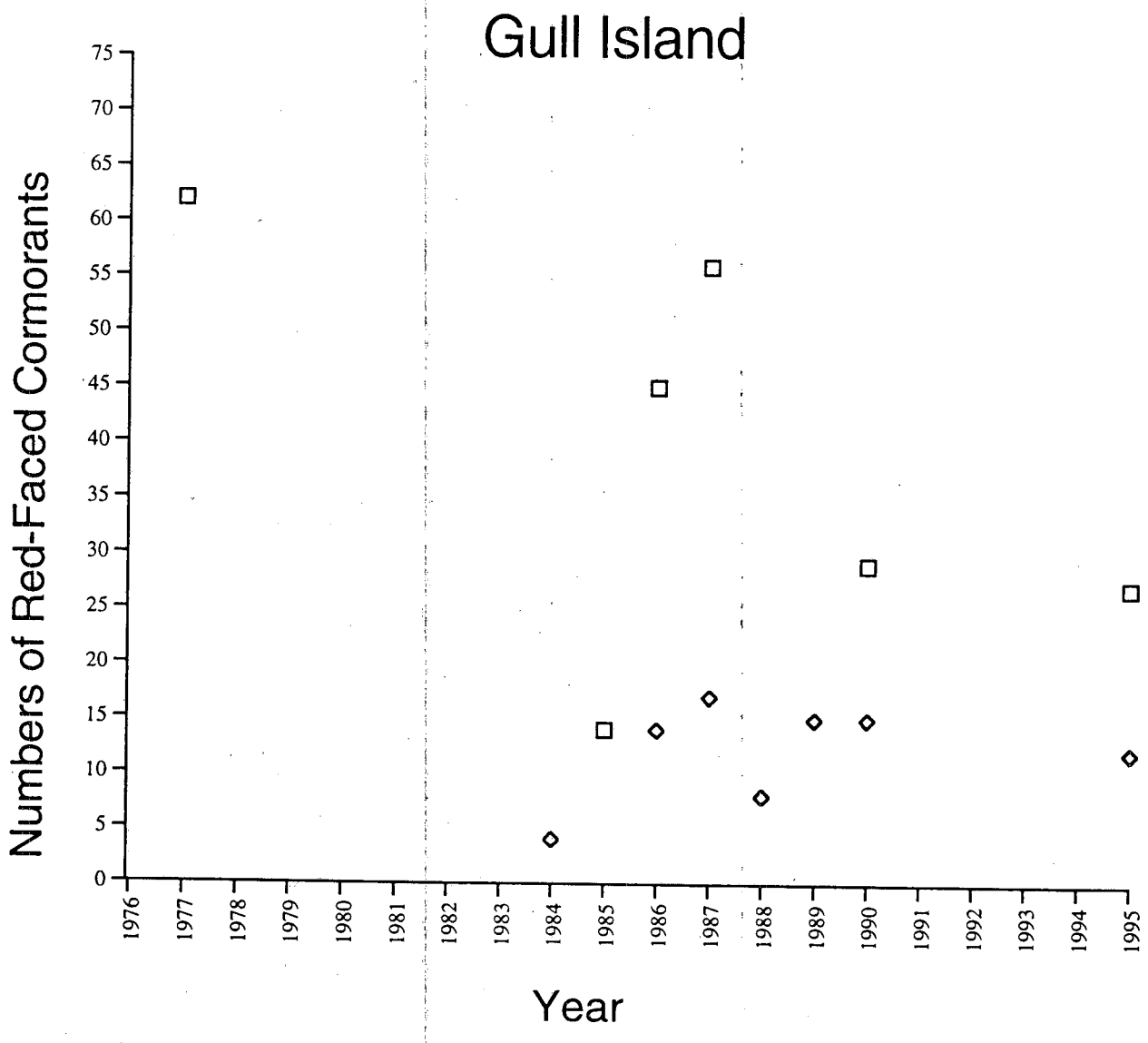

Figure 10. Numbers of red-faced cormorants (□) and nests (◇) at Gull Island, 1977 - 1995.

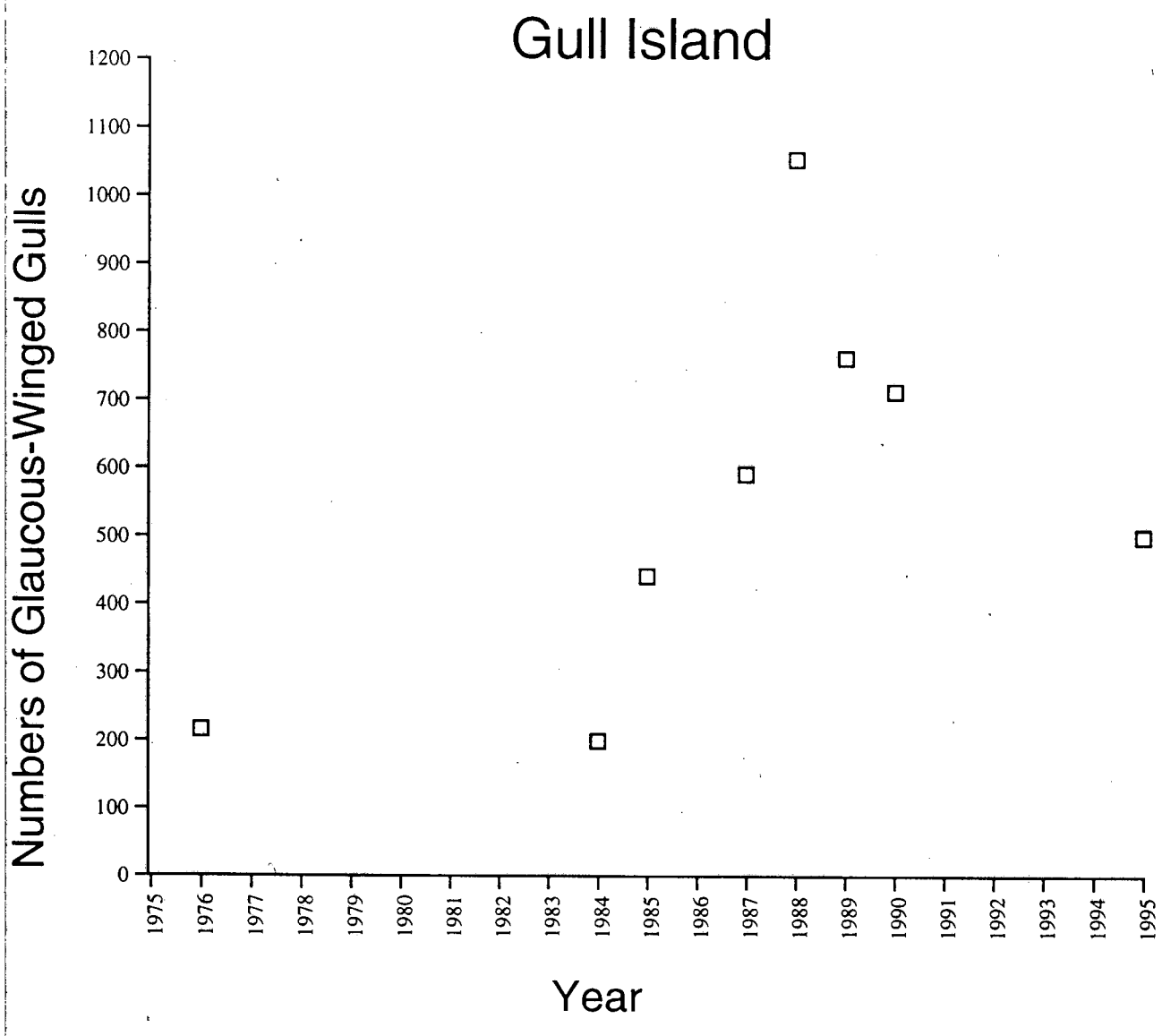

Figure 11. Numbers of glaucous-winged gulls at Gull Island, 1976 - 1995.

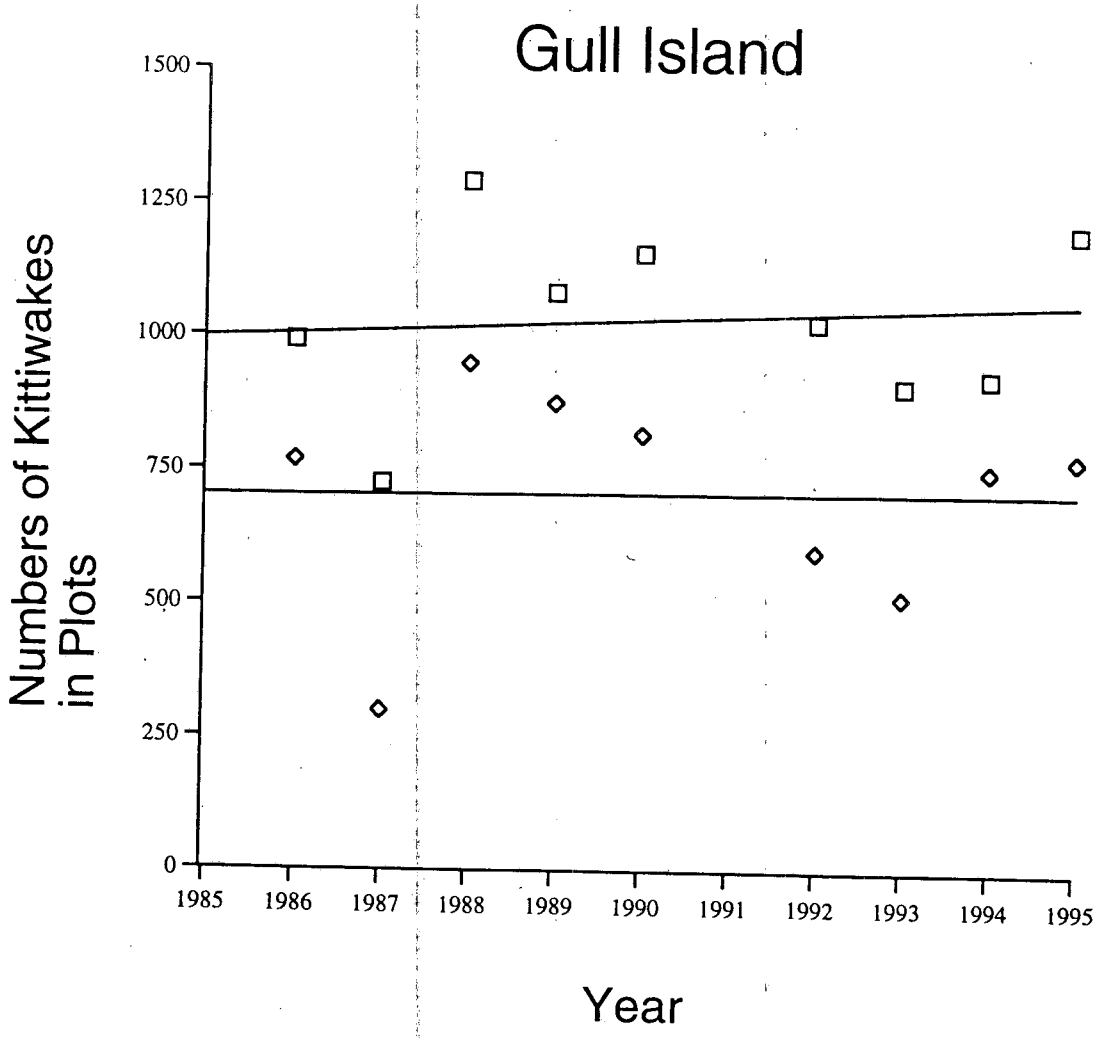

Figure 12. Numbers of black-legged kittwakes (□; r = 0.12) and nests (◇; r = 0.01) in plots 1 - 8 at Gull Island, 1986 - 1995.

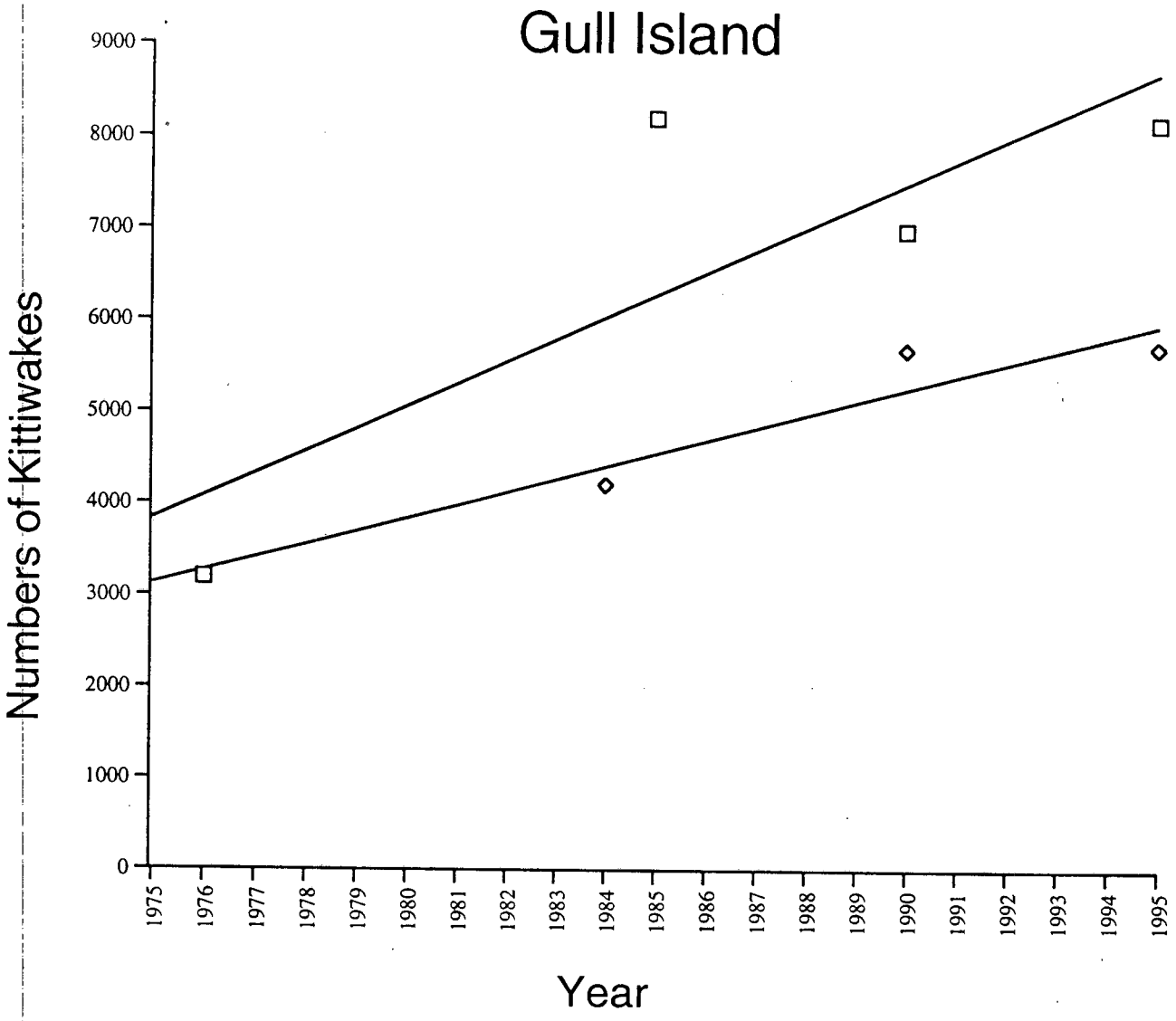

Figure 13. Numbers of kittiwakes (□: r = 0.84) and nests (◇; r = 0.90) at Gull Island, 1976 - 1995.

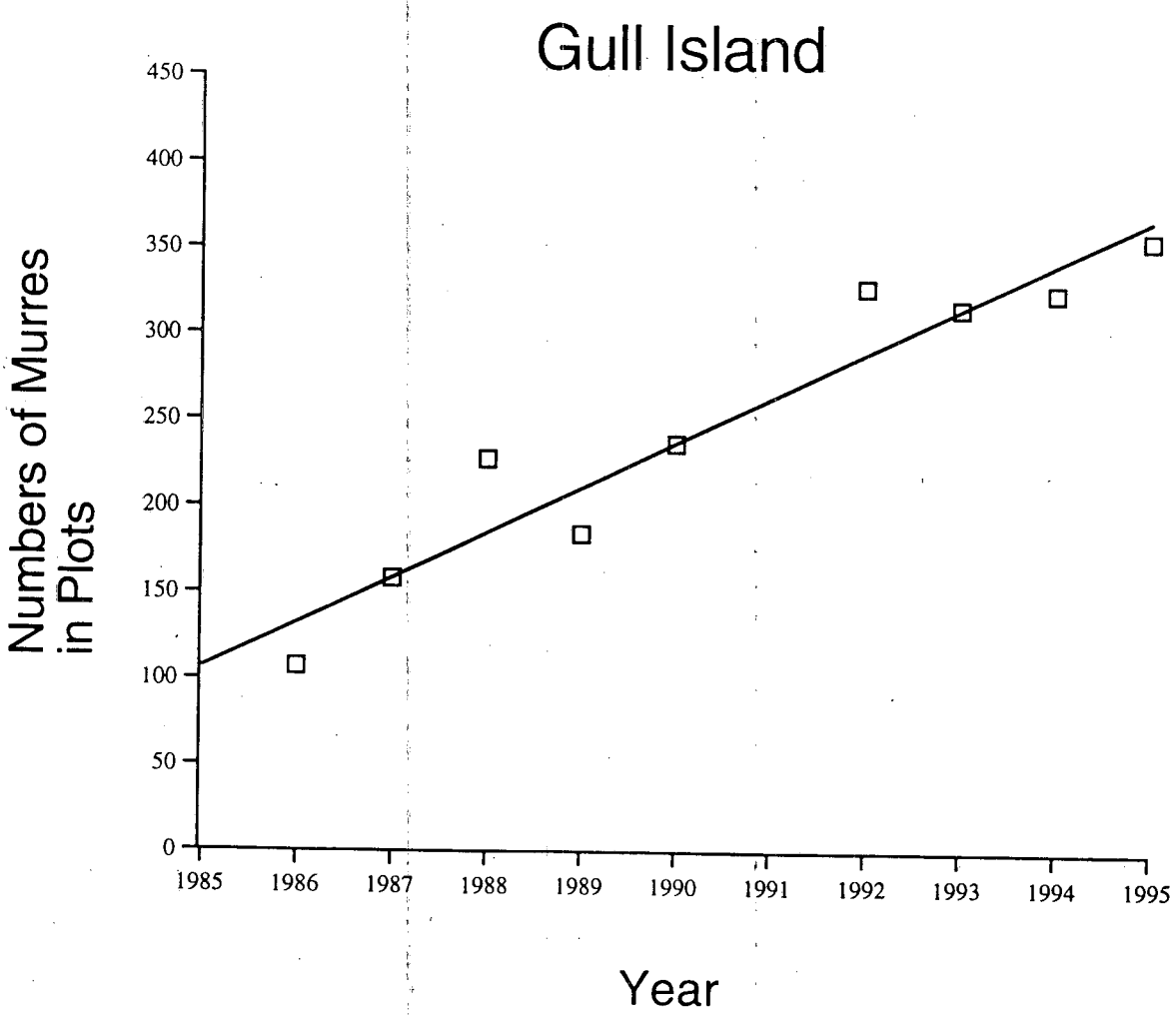

Figure 14. Numbers of common murres in plots 1 - 8 at Gull Island, 1986 - 1995 (r = 0.96).

Appendix 1. Common murre chick diet samples collected from Gull Island, 1995.

Date	Sample	Prey Type	Prey Length (mm)	Prey Weight (g)
08/18/95	1	Sandlance	118	7.41
08/18/95	2	Sandlance	115	2.89
08/18/95	3	Surf Smelt	123	9.26
08/18/95	4	Pacific Herring	98	5.03
08/18/95	5	Pacific Cod	88	5.20
08/18/95	6	Sandlance	108	4.77
08/18/95	7	Sandlance	112	2.60
08/18/95	8	Sandlance	114	4.29
08/18/95	9	Sandlance	110	2.98
08/18/95	10	Pacific Herring	129	13.86
08/18/95	11	Sandlance	124	4.71
08/18/95	12	Sandlance	122	4.11
08/18/95	13	Sandlance	108	3.78
08/18/95	14	Sandlance	129	7.76
08/18/95	15	Sandlance (part)	34	1.29
08/18/95	16	Sandlance	124	3.22
08/18/95	17	Sandlance	122	7.03
08/18/95	18	Sandlance(part)	99	5.14
08/18/95	19	Sandlance	119	4.72
08/21/95	20	Sandlance	120	4.20
08/21/95	21	Herring (dried)	114	6.18
08/21/95	22	Herring (part)	(92)	(5.82)
08/21/95	23	UNK (part)	(55)	(3.68)
08/21/95	24	UNK (part)	(64)	(2.21)
08/21/95	25	Herring (part)	(94)	(8.69)
08/21/95	26	Sandlance	84	1.64
08/21/95	27	Sandlance (dried)	126	3.27
08/21/95	28	Sandlance	117	2.12
08/21/95	29	Sandlance (dried)	135	3.43
08/21/95	30	Herring	107	8.78
08/21/95	31	Surf Smelt	124	12.37
08/21/95	32	Salmonid (Pink?)	105	10.18
08/21/95	33	Sandlance	116	5.96
08/21/95	34	Herring	110	11.94
08/21/95	35	Pacific Cod	84	3.19

Appendix 2. Numbers (and percent composition) of fish in adult seabird stomach samples from lower Cook Inlet colonies.

	Barrens				Chisik				Gull	
	GWGU	TUPU	BLKI	COMU	GWGU	HOPU	BLKI	COMU	BLKI	COMU
n	5	10	10	10	3	9	11	13	10	11
Sand lance	0	0	1.0 (4.0)	0	3.0 (10.0)	127.0 (95.0)	37.0 (80.0)	45.0 (52.0)	2.0 (4.0)	366.0 (92.0)
Capelin	2.0 (10.0)	1.0 (3.0)	14.0 (64.0)	5.0 (8.0)	0	0	0	1.0 (1.0)	51.0 (96.0)	0
Pollock	0	22.0 (76.0)	3.0 (14.0)	60.0 (91.0)	0	0	3.0 (7.0)	19.0 (22.0)	0	23.0 (6.0)
Pacific cod	0	0	0	0	0	1.0 (1.0)	0	0	0	4.0 (1.0)
Saffron cod	0	0	0	0	4.0 (14.0)	0	1.0 (2.0)	15.0 (17.0)	0	0
unid. Cod	0	0	3.0 (14.0)	0	0	2.0 (1.0)	0	2.0 (2.0)	0	0
Other	19.0 (90.0)	6.0 (21.0)	1.0 (4.0)	1.0 (2.0)	22.0 (76.0)	4.0 (3.0)	5.0 (11.0)	5.0 (6.0)	0	5.0 (1.0)
number / sample	4.2	2.9	2.2	6.6	9.7	14.9	4.2	6.7	5.3	36.2

Appendix 3. Biomass (and percent composition) of fish in adult seabird stomach samples from lower Cook Inlet colonies.

	Barrens				Chisik				Gull	
	GWGU	TUPU	BLKI	COMU	GWGU	HOPU	BLKI	COMU	BLKI	COMU
n	5	10	10	10	3	9	11	13	10	11
Sand lance	0	0	10.0 (6.0)	0	10.0 (14.0)	174.2 (95.0)	32.5 (76.0)	61.5 (32.0)	133.5 (92.0)	924.0 (95.0)
Capelin	4.7 (53.0)	4.7 (15.0)	116.0 (74.0)	17.9 (34.0)	0	1.0 (1.0)	0	0.5 (1.0)	0	0
Pollock	0	11.4 (36.0)	11.4 (7.0)	33.9 (64.0)	0	0	4.4 (10.0)	40.8 (21.0)	11.0 (8.0)	19.0 (2.0)
Pacific cod	0	0	17.9 (11.0)	0	0	4.9 (3.0)	0	0	0	21.7 (2.0)
Saffron cod	0	0	0	0	39.0 (55.0)	0	2.1 (5.0)	31.5 (17.0)	0	0
unid. Cod	0	0	0	0	0	1.6 (1.0)	0	6.1 (3.0)	0	0
Other	4.2 (47.0)	15.5 (49.0)	1.0 (1.0)	1.0 (2.0)	22.0 (31.0)	1.5 (1.0)	4.0 (9.0)	50.5 (26.0)	0	5.0 (1.
biomass / sample	1.8	3.2	15.6	5.3	23.7	20.4	3.9	14.7	14.5	88.2