CHANGES IN COLONY SIZE AND REPRODUCTIVE SUCCESS OF SEABIRDS AT THE SEMIDI ISLANDS, ALASKA, 1976-1991

by

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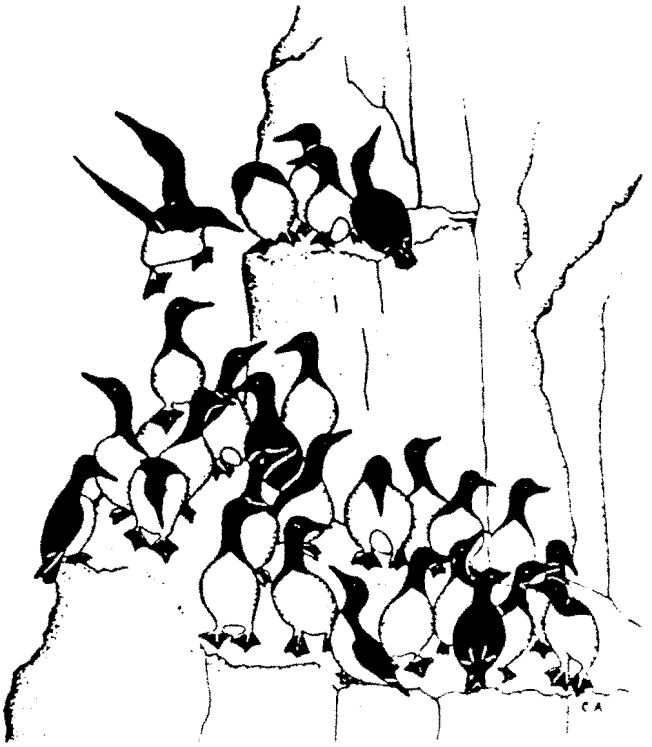

Key words: Gulf of Alaska, Semidi Islands, Chowiet Island, seabirds, northern fulmar, Fulmarus gracialis, black-legged kittiwake, Rissa tridactlya, common murre, Uria aalge, thick-billed murre, U. lomvia, populations, productivity, phenology, monitoring, Exxon Valdez oil spill

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November 1991

ABSTRACT

Field work at Chowiet Island, Semidi Islands, Alaska continued in the summer of 1991 as part of the T/V Exxon Valdez oil spill damage assessment studies. Productivity and population monitoring of northern fulmars, black-legged kittiwakes and common and thick-billed murres was conducted from 21 May to 31 August. Our 1991 estimate of numbers of northern fulmars on population plots was higher than all other estimates except for those from 1981 and 1989. We found significant differences between fulmar counts among years, but no trends. Northern fulmar productivity (0.18 chicks fledged/egg laid) was one of the lowest on record for Chowiet Island fulmars. We found significant differences between fulmar productivity estimates among years, but no trends. The population estimate of black-legged kittiwakes on plots was the lowest on record, as was the number of nests counted on plots. We found a significant difference between kittiwake population estimates among years, but no trends. Black-legged kittiwakes failed to produce any fledged chicks on Chowiet Island plots in 1991 (0 chicks fledged/nest with eggs). They laid eggs in only 10% of the nests they built. Mean clutch size was 1.06 eggs/nest where eggs were laid. We found a significant difference between productivity estimates among years, but no trends. A significant positive correlation exists between the number of kittiwake nests counted on plots and kittiwake productivity. The 1991 population estimate of murres (species combined) was the highest on record. We found a significant difference between murre estimates among years, but no trends. Common murre counts from 1989 were significantly lower than those from 1991. There was no significant difference between the counts of thick-billed murres taken in 1989-1991. Productivity of common murres on our plots (0.52 chicks fledged/breeding site) was the second lowest on record for Chowiet Island. Thick-billed murre productivity (0.47) was similar to other years. The ratio of sites where an egg was laid to mean number of adults on productivity plots was 0.58 for common murres and 0.77 for thick-billed murres.

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INTRODUCTION

When the T/V Exxon Valdez ran aground on 24 March 1989, on Bligh Reef in Alaska's Prince William Sound it released some eleven million gallons of crude oil. This was the largest such spill in American history (Galt et al. 1991). Oil from this spill fouled hundreds of kilometers of the Alaskan coastline and adversely impacted pelagic and nearshore water columns, benthic substrates, and intertidal and supratidal coastal habitats. While most of the oiling occurred in western Prince William Sound, oil also washed ashore in the western Gulf of Alaska, southern Kenai Peninsula, the Barren Islands, lower Cook Inlet, the Kodiak archipelago, Shelikof Strait and the Alaska Peninsula as far west as Mitrofania Bay (B. Sharp, Pers. Comm.). Piatt et al. (1990) estimated that between 100,000 and 300,000 marine birds were killed as a result of the oil spill. Of the 30,000 oiled bird carcasses recovered after the spill, 74% were murres (Piatt et al. 1990).

The U. S. Fish and Wildlife Service initiated a program in 1989 to assess the injury to the highly susceptible marine birds that utilize the coastal areas affected by the oil. As part of this program, monitoring of the productivity and populations of seabirds was initiated or continued at colonies in Prince William Sound, the outside coast of the Kenai Peninsula, the Barren Islands, the Alaska Peninsula and the Semidi Islands. Three hundred twenty of the 386 seabird colonies in this region occur within the area affected by the oil spill (Baggot et al. 1989).

Because many seabirds feed near the top levels of ocean food webs, they are useful as indicators of changing conditions in the marine environment (Harris and Wanless 1990). Since seabirds also tend to be numerous and conspicuous, and nest in concentrated colonies, they are relatively easier to study than other representatives of upper trophic level feeders such as whales, seals, sea lions and fishes (Harris and Wanless 1990). Diving seabirds are known to be especially susceptible to the impacts of oil fouling (King and Sanger 1979, Piatt et al. 1990). While surface feeding seabirds may not themselves be as susceptible to oiling as divers, they are still at risk if the environment they depend on is disrupted.

Hatch (1987a) states that northern fulmars in Alaska breed in four genetically isolated colonies. These colonies are also widely separated from one another. Any Alaskan fulmar colony adversely impacted by an oil spill would likely take many years to recover since there is apparently very little exchange of individuals between fulmar colonies in Alaska (Hatch 1987a) and immigration of new breeders into a

decimated colony would probably be minimal. In light of the above traits, cliff nesting seabirds were chosen as the subject of intense scrutiny at Chowiet Island during the summers of 1989, 1990 and 1991.

This report focuses on work done on Chowiet Island, one of the Semidi Islands, during the 1991 seabird breeding season. Chowiet Island was chosen as a monitoring site because it was near to, but outside of, the area of oiling from the T/V Exxon Valdez spill. Thus, these colonies served as controls to those that were within the oiled area (e.g., Barren Islands, Puale Bay). The results from Chowiet Island can be compared to those from oiled colonies to aid in the assessment of the damage to seabird resources from oil pollution.

The objective of this study was to determine if populations and productivity of northern fulmars (Fulmarus glacialis), black-legged kittiwakes (Rissa tridactyla) and common and thick-billed murres (Uria aalge, U. lomvia) on Chowiet Island plots had changed relative to those reported in previous studies.

STUDY AREA

The Semidi Islands are located in the western Gulf of Alaska and lie about 80 km south of the Alaska Peninsula, the nearest point of the mainland (Fig. 1). This report covers work that was conducted on Chowiet Island (56° 02'N, 156° 42'W, Orth 1971) during the summer of 1991. At 1,300 ha, Chowiet is the largest of the nine major islands in the archipelago (Hatch 1987a). The topography and habitats prevalent in the Semidi Islands have been described in other reports (ie. Leschner and Burrell 1977, Baggot et al. 1989) and articles (ie. Hatch and Hatch 1983).

The Semidi Island group is of major importance to marine birds (Baggot et al. 1989), providing breeding sites for approximately 25 percent of the total number of seabirds in the Gulf of Alaska (Hatch and Hatch 1983). These islands constitute one of only four major breeding areas for northern fulmars in the northeastern Pacific Ocean (Hatch 1987a). Hatch and Hatch (1983) estimated that 90,000 northern fulmars, more than 15,000 black-legged kittiwakes and 220,000 murres (common and thick-billed combined) were present in the late 1970's on Chowiet Island alone. On this island, common murres constitute approximately 90 percent of the combined murre total (Hatch and Hatch 1983).

METHODS

DATA COLLECTION

The four person field crew arrived at Chowiet Island, aboard the M/V Tiglax, on 21 May and departed, again aboard the M/V Tiglax, on 31 August 1991. Supplies and mail were brought out on the M/V Surfbird on 25 July. The M/V Surfbird remained in the area until 1 August.

A series of population and productivity plots was established along 2 km of cliffs, ranging from 50 m to 200 m in height, on the west side of Chowiet Island (Fig. 2) in 1976, 1977, 1986, 1989 and 1990 (Hatch 1978, Baggot et al. 1989, Dragoo et al. 1991). These plots consist of discrete areas on the cliff face which have easily identifiable boundary features. Black and white or color photographic enlargements, with boundaries drawn on them in permanent ink, were used to locate plots. Appendix A lists the numbers of plots of each type for each monitored seabird species. Some plots were devoted to a single species while others contained two or more monitored species.

We collected population data by counting individual adult birds on plots from designated observation points, utilizing spotting scopes, a telescope and/or binoculars. Counts were conducted only on days with good visibility and light to moderate winds. Fog, rain and high winds sometimes impaired our ability to obtain accurate counts.

Every plot was initially counted twice for each species on any given count day. If these two values were within 5 percent of each other a mean of them was taken and used as the count for that plot on that day (replicate). If the first two counts differed by more than 5 percent we continued counting until our counts clustered to within the 5 percent level. A mean was then taken of the counts closest in value and used as the count for that species on that plot and date. A single count of black-legged kittiwake nests (defined as a site to which vegetation was added during the current season) was conducted on 7 July 1991.

The census period differed somewhat with each species or genus (murres). We made our counts during the period in which daily variability in bird attendance on the cliffs was at its lowest (Table 1). We also restricted our counts to between the hours of 0900 and 1800 Alaska Daylight Time, the hours during which within-day variability in cliff attendance of seabirds is least. These time periods were established by Hatch (1987a), and Hatch and Hatch (1988, 1989) based on counts made at many of the same Chowiet Island plots that we used.

We visited productivity monitoring plots every 3 days, weather permitting. We monitored the plots from observation points located on nearby headlands. On each visit we identified any new nest starts (e.g. eggs laid by fulmars or murres, sites with new vegetation added by kittiwakes) on the plot by assigning each such site a unique number. These numbers were written on the plot photographs in permanent ink. During subsequent visits, the status (e.g. egg(s) or chick(s), or adult present but nest contents unknown) of each numbered nest site was noted. Observations were made using spotting scopes, a telescope and/or binoculars. We monitored all of the kittiwake and murre productivity plots listed in Appendix A, but only four plots (P03N01, P04N01, P09N02/N01 and P12N01) were monitored for fulmar productivity.

DATA ANALYSIS

Populations

Our population estimates were calculated by taking the means of the total numbers of birds counted on all plots on any given count day (replicate). These means represent our estimates of the population levels of birds on our plots, not on the island as a whole. Estimates of this type can be used to identify trends in the numbers of birds present on monitored plots (Byrd 1989). By assuming that events on our plots reflect those that occur island-wide, we can then infer that any trends we identify on plots represent changes in the island bird populations.

We performed all of the statistics using SYSTAT (Wilkinson 1988). The totals for each replicate count from every year (1976-1981, 1989, 1990 & 1991 for fulmars; 1977-1981, 1989, 1990 & 1991 for kittiwakes and murres) were entered into SYSTAT data files. Kolmogorov-Smirnov goodness of fit tests for the normal distribution showed that our population data are not normally distributed (all p's < 0.001). Therefore, a Kruskal-Wallis one-way analysis of variance (ANOVA) was conducted for each species. If a significant difference ($p < 0.10$) was found when all years were included, we proceeded to test for differences between each given pair of years. We followed the procedure outlined by Zar (1984:200-201) to accomplish this.

Murres counted on population plots were not differentiated by species during the early years of counts (1977-1981). Because of this, the numbers of the two murre species were combined for the purposes of testing for differences among all years. In 1989, 1990 and 1991, however, counts of common and thick-billed murres were documented separately. This made it possible for us to test for differences in the

counts of these individual species among these three years. A Kruskal-Wallis one-way ANOVA was calculated for each species. We calculated multiple comparison statistics as described above.

We used a Spearman rank correlation coefficient (r_s) to evaluate the relationship between mean population counts and productivity of northern fulmars. We tested for significant correlation ($p < 0.10$) between mean population counts, as well as total nest counts, and productivity of black-legged kittiwakes. This was not done for murres because, until 1989, population estimates did not differentiate between the two species, whereas productivity estimates did.

Productivity

We used different techniques to calculate productivity estimates for each of the four monitored species. The productivity estimate used for northern fulmars was the number of chicks that survived to fledging per egg laid (chicks fledged/egg laid) at the sites we monitored this year. Fulmar chicks that were still alive on the last check prior to our departure were assumed to have fledged.

The number of chicks living long enough to fledge for every monitored black-legged kittiwake nest on our plots where at least one egg was laid (chicks fledged/nest with eggs) was used to estimate the annual productivity of this species. Murre productivity was characterized as the number of fledged chicks for every site at which an egg was laid (chicks fledged/breeding site). In all cases, the ultimate fate of every monitored nest site present on our productivity plots was recorded.

The number of chicks fledged per breeding attempt, as defined above, was entered into a ratio estimator spreadsheet that was developed on Lotus 123 by B. Ackerman and E. O. Garton (Dept. Fish and Wildlife Resources, Univ. of Idaho, Moscow, ID). This spreadsheet calculated the productivity estimate for each species of seabird studied (Appendix B). Estimates of productivity were made by using the plots as sample units and letting the average productivity for a plot be the sample observation. This was done because of questions about whether nests that occur in clusters (e.g. plots) are independent samples for the purpose of estimating parameters (Byrd 1989).

Byrd (1989) also suggested that each plot contain at least 25 nesting pairs. In some cases, it was necessary for us to combine nests from more than one plot to achieve this. This was only done if the plots were reasonably similar with regards to elevation, aspect and geographic location. Nests

from some plots could not be combined with those from others due to a lack of similarity with any other nearby plot. We let these few plots stand as they were. See Appendix B for the exact groupings of plots used in productivity calculations.

Productivity estimates for every year for which there are data (1976-1981, 1983, 1985, 1986, 1989, 1990 & 1991 for fulmars; 1977-1981, 1989, 1990 & 1991 for kittiwakes; 1979-1981, 1989, 1990 & 1991 for murres) were entered into SYSTAT data files. We tested for differences among years between the proportions of chicks that fledged. This was done by testing for significant heterogeneity ($p < 0.10$) among years using a contingency table and calculating the log-likelihood ratio (G).

We calculated a ratio of the number of active murre (both species) breeding sites (site where an egg was laid) on all monitored productivity plots to the mean number of birds that occurred on the plots. This was done to facilitate an estimate of the breeding potential lost at other colonies due to the effects of the T/V Exxon Valdez oil spill.

RESULTS AND DISCUSSION

NORTHERN FULMAR

Populations

A total of 7 replicate counts was made of this species on plots between 27 June and 13 July in 1991 (Table C1). Our 1991 estimate of the numbers of northern fulmars on population plots (481) was higher than all other estimates except for those from 1981 and 1989 (Table 2, Fig. 3). The differences between counts among all years were highly significant (Kruskal Wallis = 61, $p < 0.001$).

Northern fulmar counts from 1976 were significantly lower than those from 1980, 1981, 1989 and 1991 ($p < 0.001$ for all except 1991, $p < 0.10$). The two years with the highest counts (1981 and 1989) were each significantly higher than 1977 ($p < 0.002$ and $p < 0.10$ respectively) and 1979 ($p < 0.001$ and $p < 0.02$ respectively). Fulmar counts on plots in 1981 were also significantly higher than those from 1978 ($p < 0.05$). There was no significant correlation ($p > 0.10$) between fulmar population indices and productivity. There was no pattern to the differences in the annual population estimates of northern fulmars at Chowiet Island.

Productivity

Northern fulmars began laying later in 1991 than in any year except 1989 (Table 3). The mean laying date for fulmars in 1991 was the same as that for 1989. The mean laying dates from 1989 and 1991 were later than those for any other year. Our 1991 mean hatching date was the latest on record. The same is true for our projected fledging date for the chicks that were still alive when we last checked.

The 1991 estimate of northern fulmar productivity (0.18 chicks fledged/egg laid, n = 91) is one of the lowest recorded for this species on Chowiet Island (Table 2). Thirty percent of the eggs laid at monitored sites hatched. Fifty-nine percent of the chicks that hatched were still alive when we left, and were assumed to have fledged. Typically, eggs or chicks that were lost merely disappeared between our visits to the plots. Hatch (1987a) suggested that most fulmar egg losses could be attributed to glaucous-winged gulls (Larus glaucescens) or to common ravens (Corvus corax). This was consistent with our observations in 1991. Observers frequently saw ravens or gulls flying near the colony with what appeared to be fulmar eggs in their beaks.

Our productivity estimate must be considered maximal because we did not stay long enough to see any actual fledging of chicks. Some chick mortality may have occurred after our departure. There were highly significant differences in the productivity of fulmars among years tested ($G = 753$, $p < 0.001$). Hatch (1987a) reported that annual fulmar productivity is highly variable at colonies in both the Atlantic and Pacific. There was no pattern to these annual differences in productivity at Chowiet Island.

BLACK-LEGGED KITTIWAKE

Populations

A total of 10 replicate counts was made of population levels of black-legged kittiwakes on plots between 22 June and 18 July in 1991 (Table C2). A nest count was conducted on 7 July. The estimate of black-legged kittiwakes on plots for 1991 (268) is the lowest on record (Table 4, Fig. 4). The 1991 nest count for this species was also the lowest on record (Table 4, Fig. 5) There was a highly significant difference between the estimated population levels on plots among all years (Kruskal-Wallis = 128, $p < 0.001$).

The population estimate for kittiwakes on plots in 1977 was significantly higher than those in 1978 ($p < 0.001$), 1979 ($p < 0.001$), 1980 ($p < 0.001$), 1981 ($p < 0.02$) and 1991 ($p < 0.001$). Populations on plots in 1981 were significantly

higher than those in 1979, 1980 and 1991 ($p < 0.001$ for all). The 1991 population estimate was also significantly lower than those from 1978 ($p < 0.02$) and 1990 ($p < 0.01$). There was, however, no pattern or trend among all years to these population differences.

Hatch and Hatch (1988) found that their counts (1977-1981) of black-legged kittiwakes on plots did not change appreciably from first egg laying through the end of hatching within any one season. This was not the case in 1989 or 1990, when numbers of adults attending the cliffs declined significantly after failing to breed (Dragoo et al. 1991). This decline in attendance was especially pronounced in 1989, when the lowest replicate count (considering all 13 counts) was only 15 percent as large as the highest count (as opposed to 45 percent in 1990, considering all 12 counts). The lowest count of kittiwakes in 1991 was about 39% as large as the highest count. However, there was no definite pattern of lower counts later in the breeding season in 1991 as there was in 1989 and 1990. This year the highest counts occurred early in the season and, again, later in the summer. The lowest counts were taken in the middle of the season (Table C2).

We found no significant correlation between kittiwake population levels and productivity (Table 4). However, a significant positive correlation ($r_s = 0.87$, $p < 0.05$) does exist between the number of kittiwake nests counted on plots (Fig. 5) and the productivity of this species in any given year (Table 4), suggesting that nest counts are more indicative of breeding effort within a given year than any actual change in the populations of breeders.

Nysewander and Dippel (1990, 1991) reported pre- and post-oil spill population data for black-legged kittiwakes from several Gulf of Alaska colonies. Kittiwake populations did not appear to have been adversely affected by the oil spill, especially when compared to the magnitude of change found in murres.

Productivity

Black-legged kittiwakes initiated egg laying later in 1991 than in any other year on record, except 1989 (Table 5). The 1991 mean laying date was also later than those in other years except 1989, when mean laying was later still (Baggot et al. 1989). The last new kittiwake egg was laid later in 1991 than in most other years, except 1979, 1981 and 1989. The mean date of hatching was the latest on record.

Kittiwakes failed to produce fledged young on Chowiet Island plots in 1991 (Table 4). They laid eggs in only 17 (10%) of

the 163 nests that they built. The mean clutch size was 1.06 eggs per nest where eggs were laid. This is lower than the mean clutch size for either 1989 (1.24, Baggot et al. 1989) or 1990 (1.47, Dragoo et al. 1991). Of the nests that contained an egg(s) only 3 (18%) hatched a chick(s), one of these had two chicks. Black-legged kittiwake eggs hatched on only two of the ten plots we monitored. No kittiwake chicks fledged on any plot we monitored in 1991 (0 chicks fledged/nest with eggs, n = 17). We saw only one flying young-of-the-year kittiwake near our plots this year. Based on this and other observations, we feel that our productivity estimate for kittiwakes on our plots is indicative of that for this species on the island as a whole.

There was a highly significant difference between productivity levels among years tested ($G = 564$, $p < 0.001$). Typically, eggs or chicks that were lost simply disappeared between our visits to the plots, frequently after the adult had ceased to incubate or brood. Observers occasionally saw ravens or gulls carrying what appeared to be kittiwake eggs. Black-legged kittiwake reproductive output on our plots varied from year to year in such a way that no pattern was evident.

In 1989, kittiwakes at the Semidi Islands failed to hatch any chicks (Baggot et al. 1989). All of the mortality in that year occurred during the egg incubation stage. Most of the mortality in 1990 and 1991 occurred during that stage as well, although some loss occurred during the chick stage. We frequently observed eggs or young chicks that had been left unattended by the parent birds. In some cases, nests were unattended for the whole duration of our visit to a plot or area (1 or more hours).

Black-legged kittiwake productivity varies considerably between years and colonies in Alaska (e.g., Hatch 1987b, Byrd 1989, Dragoo et al. 1990), and years of zero productivity occasionally occur. These years of poor reproductive success seem not to be related to any discernable environmental variable but may be caused by food shortages during either the pre-laying or chick rearing periods (Hatch 1987b, Harris and Wanless 1990).

Nysewander and Dippel (1991) have reported that there were no discernable differences in the reproductive output of black-legged kittiwakes at oiled versus unoiled colonies. The tendency of kittiwakes to exhibit highly variable annual production makes it difficult to assess the likelihood of potential adverse affects to their breeding success from such environmental perturbations as oil spills.

COMMON AND THICK-BILLED MURRES

Populations

A total of 10 replicate counts was made of murres on plots at Chowiet Island between 28 June and 21 July in 1991 (Table C3). The population estimate of murres on plots for 1991 (3117) was the highest on record (Table 6, Fig. 6). We found a highly significant difference between murre population levels on plots among years (Kruskal-Wallis = 111, $p < 0.001$). Murre populations on plots in 1979 and 1980 were each significantly lower than the counts obtained in 1977, 1981, 1989, 1990 and 1991 ($p < 0.001$ for all). However, there was no pattern or trend among years to these population differences.

When the counts of the two murre species were considered separately for the last three years, we found that there was a significant difference among years for common murres (Kruskal Wallis = 9.8, $p = 0.008$) but not for thick-billed murres. Common murre counts in 1989 were significantly lower than those from 1991 ($p < 0.01$). There was no significant difference between the counts of common murres for any other pair of years.

Nysewander and Dippel (1990, 1991) reported pre- and post-oil spill population data for murres. Generally, colonies that were in the path of the oil spill have shown significant declines in murre numbers since the spill (Nysewander and Dippel 1991). The murre populations at the Chiswell Islands since the oil spill have not differed significantly from counts made prior to the spill. Murre numbers did increase slightly in 1991 when compared to 1990 (Nysewander and Dippel 1991). Nysewander and Dippel (1990) found that murre populations in the Barren Islands had declined significantly since the oil spill. The 1991 counts of murres at the Barren Islands were similar to those from 1989 and 1990 (Nysewander and Dippel 1991). Post-oil declines in murre numbers were also significant at Puale Bay. Murre numbers were apparently down at Kodiak Island area colonies as well (Nysewander and Dippel 1990). The small murre colonies at Ugaiushak Island near the Alaska Peninsula have also apparently declined (Nysewander and Dippel 1991). Murre numbers at Middleton Island, an unoiled (control) site have not changed significantly since the oil spill (Nysewander and Dippel 1991).

Productivity

The date of first egg laying for common murres in 1991 was later than for any other year except 1989 (Table 7). The same can be said for the mean laying date. The mean

hatching date for common murres in 1991 was the same as that for 1989 and 1990. Mean hatching was later in these three years than for any previous year. The mean date of fledging for common murres in 1991 was the latest on record. Thick-billed murre phenology was similar this year to that exhibited in other years (Table 8), with the exception that the 1991 mean fledging date was the latest on record.

Productivity of common murres that bred on our plots in 1991 (0.52 chicks fledged/breeding site, n = 208) was the second lowest ever recorded for this species on Chowiet Island (Table 6). This year was, however still a reasonably successful reproductive season for this species. Sixty-one percent of the eggs laid by common murres hatched. Most mortality occurred during incubation. Gulls and ravens were occasionally seen carrying murre eggs in their beaks. We observed a raven taking a common murre egg from a ledge. Of those chicks that hatched, 86 percent fledged. The mean age at fledging was 24 days in 1991, as opposed to 23 days in 1990. There was no significant heterogeneity in productivity estimates among years for which we have data ($p > 0.10$). The ratio of sites where an egg was laid to the mean number of adult common murres on productivity plots in 1991 was 0.58. This was slightly lower than that for 1990 (0.61).

Our 1991 productivity estimate for thick-billed murres breeding on plots on Chowiet Island (0.47 chicks fledged/breeding site, n = 133, Table 6) was similar to all other years except 1981, when success was significantly higher ($g = 13$, $p = 0.025$). Sixty-three percent of the eggs laid by thick-billed murres in 1991 hatched, and 75 percent of the chicks that hatched this year fledged. Both of these values are slightly higher this year than in 1990. The mean age at fledging in 1991 was 24 days, as opposed to 22 days in 1990. As was the case with common murres, most mortality of thick-billed murre young occurred during the egg stage. The ratio of sites where an egg was laid to the mean number of adult thick-billed murres on productivity plots was 0.77, the same as for 1990. There were no patterns to the differences in productivity estimates for either species of murre.

Nysewander and Dippel (1990, 1991) reported productivity estimates for murres at various colonies within the area contaminated by the oil spill. In general, murres at oiled colonies exhibited late and asynchronous breeding chronology, and low productivity (Nysewander and Dippel 1991). Murres at some colonies, however (e.g. Chiswell Islands), apparently began to breed at more normal times in 1991. Nysewander and Dippel (1991) concluded that few, if any, murre chicks fledged from the Barren Island colonies,

but more eggs and chicks were observed there in 1991 than in any other post-spill year. Very few murre chicks fledged at the Puale Bay colonies in 1990 (Nysewander and Dippel 1990). In 1991, common murres produced an estimated 0.38 chicks per site there. The productivity estimate for Puale Bay thick-billed murres was 0.48 chicks per site (Nysewander and Dippel 1991). This was in spite of a late start by both murre species. Murres at Ugaiushak Island have apparently produced few fledged chicks since the oil spill (Nysewander and Dippel 1991).

ACKNOWLEDGEMENTS

We would like to thank the following people for their assistance, advice and support. Dave Nysewander and Cris Dippel were instrumental in getting this project off the ground. Both provided valuable assistance and expertise during the planning and implementation of this project. Dave and Cris, along with their crew, paid us a visit in mid-season aboard the MV Surfbird. Our thanks to the captain and crew of the MV Surfbird. We appreciated the mail, as well as the fresh food and faces they delivered. The Migratory Bird Section provided the majority of our field gear. The crew of the MV Tiglax were especially accommodating and helpful. Their good cheer and smiling faces were always welcome, as was their help in getting our camp set up in the spring and dismantled in the fall. As always, our project was possible only because of the assistance and support of the rest of the staff of the Alaska Maritime NWR in Homer, especially Trina Fellows and Carol Hagglund. It was always a pleasure to talk to them, and other members of the staff, during our nightly radio check.

LITERATURE CITED

Baggot, C. M., B. K. Bain, and D. R. Nysewander. 1989. Changes in colony size, and reproductive success of seabirds at the Semidi Islands, Alaska, 1977-1989. U. S. Fish & Wildlife Ser., Homer, AK. Unpubl. Admin. Rep.

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

Coulson, J. C., and E. White. 1958. Observations on the breeding of the kittiwake. Bird Study 5:74-83.

Dragoo, D. E., S. D. Schulmeister, and B. K. Bain. 1990. The status of kittiwakes and murres at St. George Island, Alaska in 1989. U. S. Fish & Wildlife Ser., Homer, AK. Unpubl. Admin. Rep.

Dragoo, D. E., B. K. Bain, and A. Perillo. 1991. Changes in colony size and reproductive success of seabirds at the Semidi Islands, Alaska, 1977-1990. U. S. Fish & Wildlife Ser., Homer, AK. Unpubl. Admin. Rep.

Galt, J. A., W. J. Lehr, and D. L. Payton. 1991. Fate and transport of the Exxon Valdez oil spill. Environ. Sci. Technol. 25(2):202-209.

Gaston, A. J., and D. N. Nettleship. 1981. The thick-billed murres of Prince Leopold Island. Canadian Wildl. Ser. Monograph Series No. 6, Ottowa, Canada.

Harris, M. P., and T. R. Birkhead. 1985. Breeding ecology of the Atlantic Alcidae. Pp. 155-204 in The Atlantic Alcidae. Edited by D. N. Nettleship and T. R. Birkhead. Academic Press, London.

Harris, M. P., and S. Wanless. 1990. Breeding success of British kittiwakes Rissa tridactyla in 1986-88: Evidence for changing conditions in the northern North Sea. J. Appl. Ecol. 27:172-187.

Hatch, S. A. 1978. Breeding and population ecology of fulmars at Semidi Islands, Alaska, with observations on the reproduction of sympatric seabird species. U. S. Fish & Wildlife Ser., Anchorage, AK. Unpubl. Admin. Rep.

Hatch, S. A. 1987a. Adult survival and productivity of northern fulmars in Alaska. Condor 89:685-696.

Hatch, S. A. 1987b. Did the 1982-1983 El Nino-southern oscillation affect seabirds in Alaska? Wilson Bull. 99:468-474.

Hatch, S. A., and M. A. Hatch. 1979. Studies of the breeding and population ecology of seabirds at Semidi Islands, Alaska. U. S. Fish & Wildlife Ser., Anchorage, AK. Unpubl. Rep.

Hatch, S. A., and M. A. Hatch. 1983. Populations and habitat use of marine birds in the Semidi Islands, Alaska. Murrelet 64:39-46.

Hatch, S. A., and M. A. Hatch. 1988. Colony attendance and population monitoring of black-legged kittiwakes on the Semidi Islands, Alaska. Condor 90:613-620.

Hatch, S. A., and M. A. Hatch. 1989. Attendance patterns of murres at breeding sites: implications for monitoring.

J. Wildl. Manage. 53:483-493.

Hatch, S. A., and M. A. Hatch. 1990. Breeding seasons of oceanic birds in a subarctic colony. Can. J. Zool. 68(8):1664-1679.

King, J. G., and G. A. Sanger. 1979. Oil vulnerability index for marine oriented birds. Pp. 227-239 in J. C. Bartonek and D. N. Nettleship, Eds. Conservation of marine birds of northern North America. U. S. Fish and Wildl. Ser., Washington, D.C. 319pp.

Leschner, L. L., and G. Burrell. 1977. Populations and ecology of marine birds on the Semidi Islands. Pp. 13-109 In Environmental Assessment of the Alaskan Continental Shelf Vol. 4 (1977). NOAA, Boulder, CO.

Nysewander, D., and C. Dippel. 1990. Population surveys of seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, Barren Islands, and other nearby colonies, with emphasis on changes of numbers and reproduction of murres. Bird Study No.3. U. S. Fish and Wildl. Ser. Homer, AK.

Nysewander, D., and C. Dippel. 1991. Population surveys of seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, Barren Islands, and other nearby colonies, with emphasis on changes of numbers and reproduction of murres. Bird Study No.3. U. S. Fish and Wildl. Ser. Homer, AK.

Orth, D. J. 1971. Dictionary of Alaska place names. U. S. Geological Survey Professional Paper 567. GPO, Wash., D. C. 1084 pp.

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

Swartz, L. G. 1966. Sea-cliff birds. Pp. 611-678 in Environment of the Cape Thompson Region, Alaska. Edited by N. J. Wilimovsky and J. N. Wolfe. U. S. Atomic Energy Comm., Oak Ridge, TN.

Wilkinson, L. 1988. SYSTAT: The system for statistics. SYSTAT, Inc., Evanston, IL.

Zar, J. H. 1984. Biostatistical analysis, 2nd Edition. Prentice-Hall, Inc., Englewood Cliffs, NJ. 718 pp.

Table 1. Population census period for fulmars, kittiwakes, and murres on the Semidi Islands, Alaska as established by Hatch (1987a) and Hatch and Hatch (1988, 1989).

Species	Census Period
Northern Fulmar	30 days extending from 11 days after first egg to 40 days after first egg
Black-legged Kittiwake	50 days extending from first egg-laying through final hatching (plus one count of nests on or about 4 July)
Murres	43 days extending from 20 June to 1 August[a]

[a]Murres have a fixed census period because egg-laying has remained relatively constant from year to year.

Table 2. Comparison of northern fulmar census parameters in 12 years with different levels of breeding success on the Semidi Islands, Alaska[a].

	Year											
Parameter	1976	1977	1978	1979	1980	1981	1983	1985	1986	1989	1990	1991
Productivity[b]	0.15	0.51	0.46	0.60	0.66	0.72	0.37	0.07	0.19	0.47	0.26	0.18
Mean population counts	354	424	439	414	464	507	--	--	--	549	447	481

[a]Data from Hatch and Hatch (1987a), Baggot et al. (1989), Dragoo et al. (1991), and this study.
[b]Chicks fledged/egg laid.

Table 3. Phenology of northern fulmars on the Semidi Islands, Alaska in different years[a].

	Year								
	1976	1977	1978	1979	1980	1981	1989[b]	1990	1991
Laying									
First laying date	5/29	6/02	5/26	6/02	5/27	5/31	6/06	5/31	6/05
Mean date	6/06	6/11	6/07	6/11	6/08	6/10	6/15	6/06	6/15
Sample size	208	386	397	400	389	395	31	68	91
Hatching[c]									
Mean date	*7/24	*7/29	*7/25	*7/29	*7/26	*7/28	7/30	7/24	8/01
Sample size	--	--	--	--	--	--	26	29	25
Fledging[d]									
Mean date	9/15	9/20	9/16	9/20	9/17	9/19	9/21	9/15	9/23
Sample size	--	--	--	--	--	--	--	16	16

[a]Data from Hatch and Hatch (1990), Baggot et al. (1989), Dragoo et al. (1991), and this study.

[b]We were unable to determine the phenology for the majority of the eggs that were laid and the chicks that were hatched due to the difficulty in monitoring northern fulmars. The given dates and figures for the laying and hatching phenology represent, respectively, only 17% and 23% of the total sample size - the given sample size being only a fraction of the total sample size.

[c]*Asterisks denote data that were extrapolated from the laying dates using the mean incubation period for northern fulmars.

[d]Extrapolated from the hatching dates using the mean time of chick departure for northern fulmars (53 days). Chick departure data from Hatch and Hatch (1979) and Mougin (1967; cited in Hatch 1987a).

Table 4. Comparison of black-legged kittiwake census parameters in 8 years with different levels of breeding success on the Semidi Islands, Alaska[a].

	Year							
Parameter	1977	1978	1979	1980	1981	1989	1990	1991
Productivity (chicks fledged/nest w/eggs)	0.70	0	0.51	0.34	1.15	0	0.01	0
Total nests[b]	--	256	305	381	411	219	279	102
Mean of population counts during census period[c]	485	406	383	377	438	436	456	268

[a]Data from Hatch and Hatch (1988), Baggot et al. (1989), Dragoo et al. (1991), and this study.
[b]Total nests include all structures to which vegetation was added in the current year. Dates of nest counts are as follows: 3 July 1977, 27 June 1978, 8 July 1979, 3 July 1980, 4 July 1981, 5 July 1989, 2 July 1990, and 7 July 1991.
[c]Includes only the first 3 replicate counts during the census period for 1989 and only the first 4 replicate counts during the census period for 1990.

Table 5. Phenology of black-legged Kittiwakes on the Semidi Islands, Alaska in different years[a].

	Year								
	1976	1977	1978	1979	1980	1981	1989	1990	1991
Laying[b]									
First laying date	6/10	6/09	6/05	6/17	6/05	6/05	6/27	6/04	6/23
Mean date	6/20	6/19	6/15	6/24	6/14	6/14	7/01	6/17	6/28
Last laying date	6/30	6/30	6/27	7/09	7/03	7/05	7/07	6/29	7/05
Sample size	41	54	46	99	129	126	32	98	17
Hatching[c]									
Mean date	*7/16	*7/15	*7/11	*7/20	*7/10	*7/10	--	7/13	7/26
Sample size	--	--	--	--	--	--	--	15	3
Fledging[d]									
Mean date	*8/27	*8/26	*8/22	*8/31	*8/21	*8/21	--	8/15	--
Sample size	--	--	--	--	--	--	--	1	0

[a]Data from Hatch and Hatch (1990), Baggot et al. (1989), Dragoo et al. (1991) and this study.
[b]Data of the first egg laid in multiple-egg clutches. Data do not include relaid eggs.
[c]*Asterisks denote data that were extrapolated from the laying dates using the mean incubation period for black-legged kittiwakes.
[d]*Asterisks denote data that were extrapolated from the hatching dates using the mean time of chick departure for black-legged kittiwakes (42 days). Chick departure from Swartz (1966) and Coulson and White (1958).

Table 6. Comparison of COMU and TBMU census parameters in 8 years with different levels of breeding success on the Semidi Islands, Alaska[a].

	Year							
Parameter	1977	1978	1979	1980	1981	1989	1990	1991
Productivity of COMU (chicks fledged/breeding site[b])	--	--	0.48	0.64	0.59	0.58	0.54	0.52
Productivity of TBMU (chicks fledged/breeding site)	--	--	0.48	0.46	0.63	0.43	0.42	0.47
Mean of COMU population counts during census period	--	--	--	--	--	2705	2835	2976
Mean of TBMU population counts during census period	--	--	--	--	--	118	145	141
Mean of COMU+TBMU population counts during census period	2816	2635	2308	2451	2856	2823	2980	3117

[a]Data from Hatch and Hatch (1990), Baggot et al. (1989), Dragoo et al. (1991), and this study. COMU = common murre TBMU = thick-billed murre
[b]Breeding site = a site where an egg was laid.

Table 7. Phenology of common murres on the Semidi Islands, Alaska in different years[a].

	Year					
	1979	1980	1981	1989	1990	1991
Laying[b]						
First laying date	6/07	6/07	6/05	6/15	6/06	6/10
Mean date	6/18	6/16	6/16	6/25	6/21	6/24
Sample size	69	83	83	144	214	205
Hatching[c]						
Mean date	*7/20	*7/18	*7/18	7/25	7/25	7/25
Sample size	--	--	--	113	145	121
Fledging[d]						
Mean date	*8/12	*8/10	*8/10	8/14	8/14	8/18
Sample size	--	--	--	65	97	106

[a]Data from Hatch and Hatch (1990), Baggot et al. (1989), Dragoo et al. (1991), and this study.
[b]Data do not include relaid eggs.
[c]*Asterisks denote data that were extrapolated from the laying dates using the mean incubation period for common murres.
[d]*Asterisks denote data that were extrapolated from the hatching dates using the mean time of chick departure for common murres (23 days). Chick departure data from Hatch and Hatch (1990) and Harris and Birkhead (1985).

Table 8. Phenology of thick-billed murres on the Semidi Islands, Alaska in different years[a].

	Year						
	1978	1979	1980	1981	1989	1990	1991
Laying[b]							
First laying date	6/09	6/07	6/07	6/05	6/09	6/09	6/10
Mean date	6/17	6/17	6/17	6/15	6/23	6/19	6/19
Sample size	43	107	105	108	95	121	132
Hatching[c]							
Mean date	*7/19	*7/19	*7/19	*7/17	7/23	7/21	7/23
Sample size	--	--	--	--	85	73	84
Fledging[d]							
Mean date	*8/11	*8/11	*8/11	*8/09	8/12	8/12	8/15
Sample size	--	--	--	--	47	46	60

[a]Data from Hatch and Hatch (1990), Baggot et al. (1989), Dragoo et al. (1991), and this study.
[b]Data do not include relaid eggs.
[c]*Asterisks denote data that were extrapolated from the laying dates using the mean incubation period for thick-billed murres.
[d]*Asterisks denote data that were extrapolated from the hatching dates using the mean time of chick departure for thick-billed murres (23 days). Chick departure data from Hatch and Hatch (1990) and Gaston and Nettleship (1981).

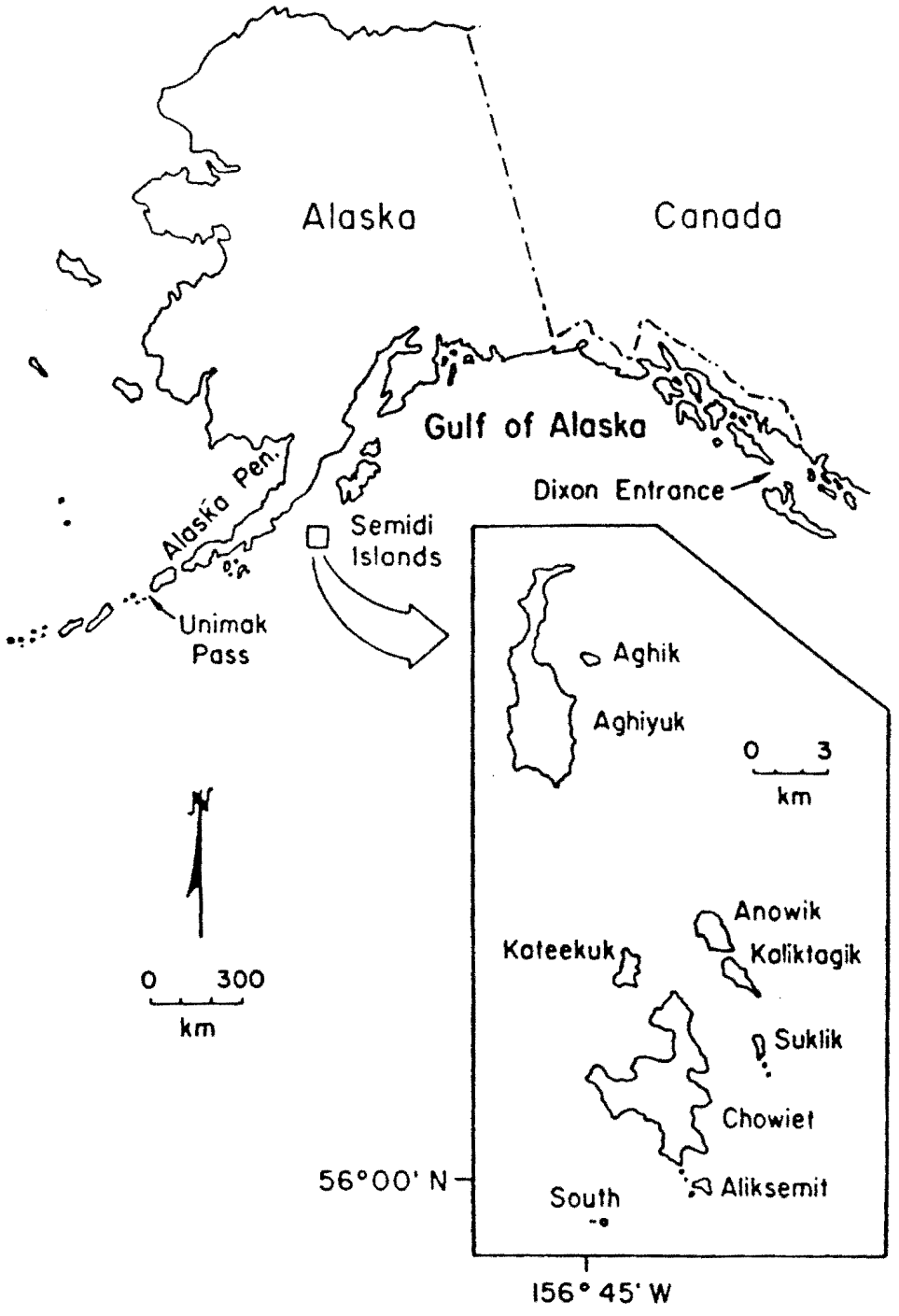

Figure 1: Location of the Semidi Islands in the western Gulf of Alaska.

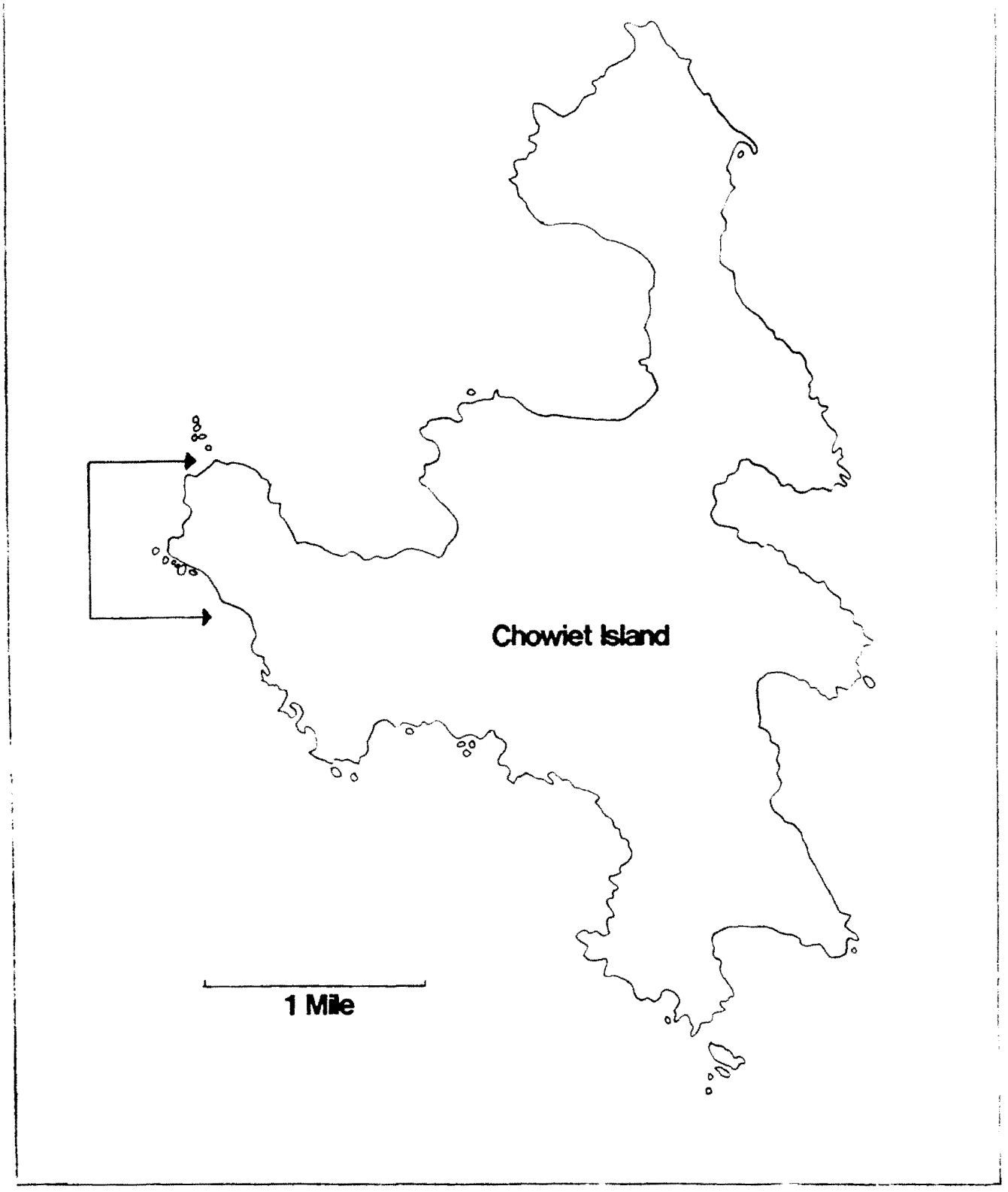

Figure 2. Seabird study plots at Chowiet Island, Alaska.

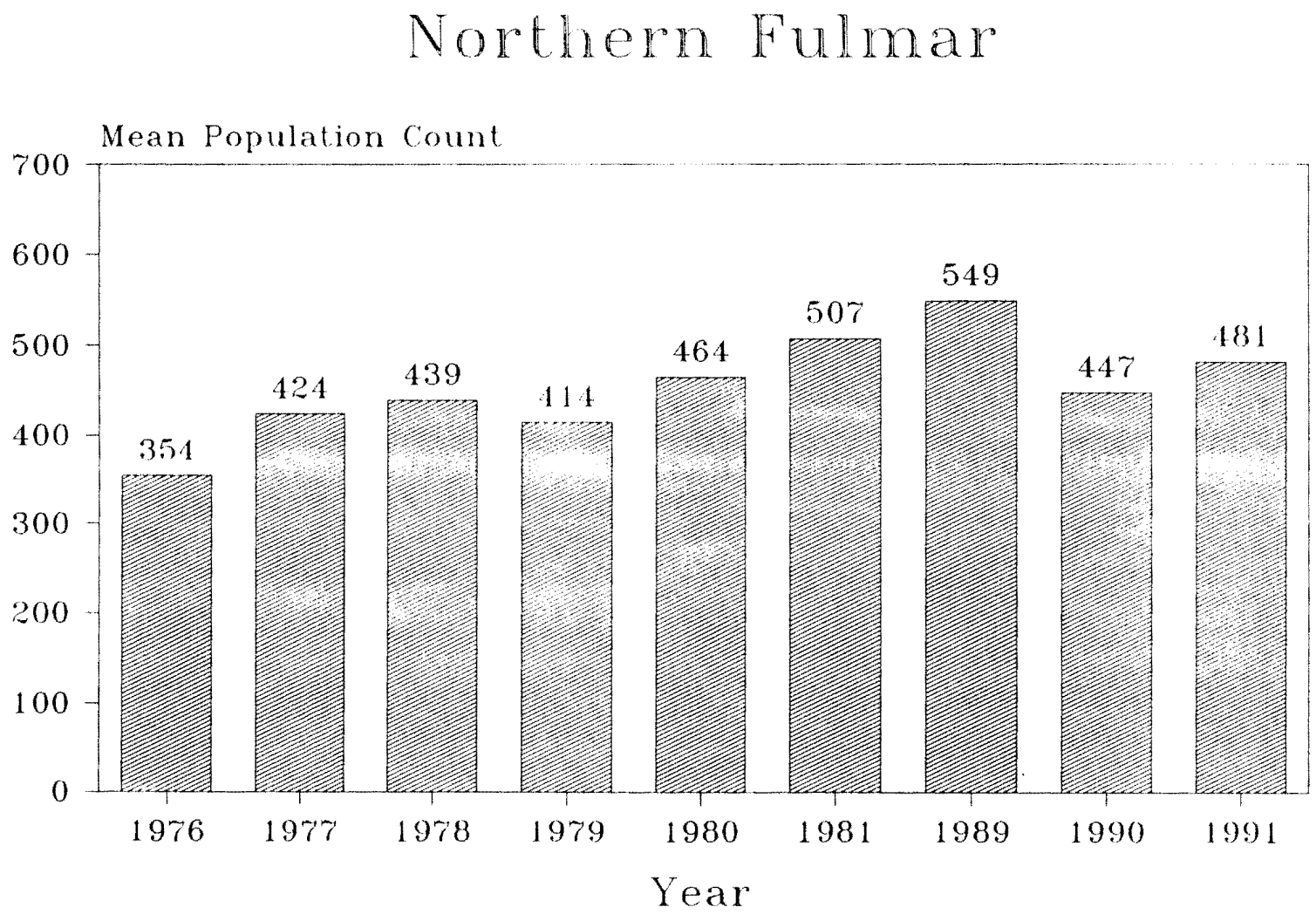

Figure 3. Northern fulmar mean population counts on plots during census period at the Semidi Islands, Alaska.

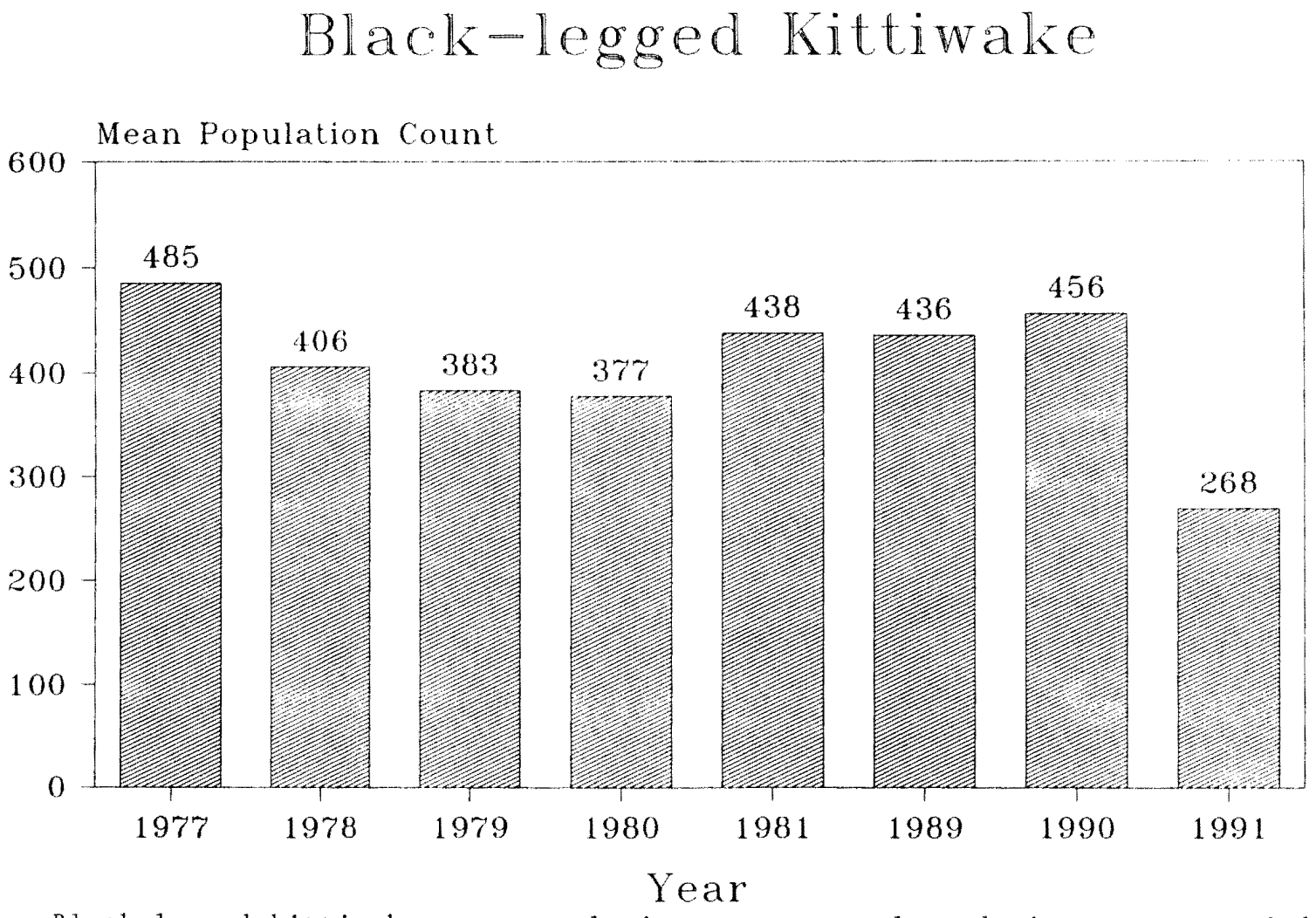

Figure 4. Black-legged kittiwake mean population counts on plots during census period at the Semidi Islands, Alaska.

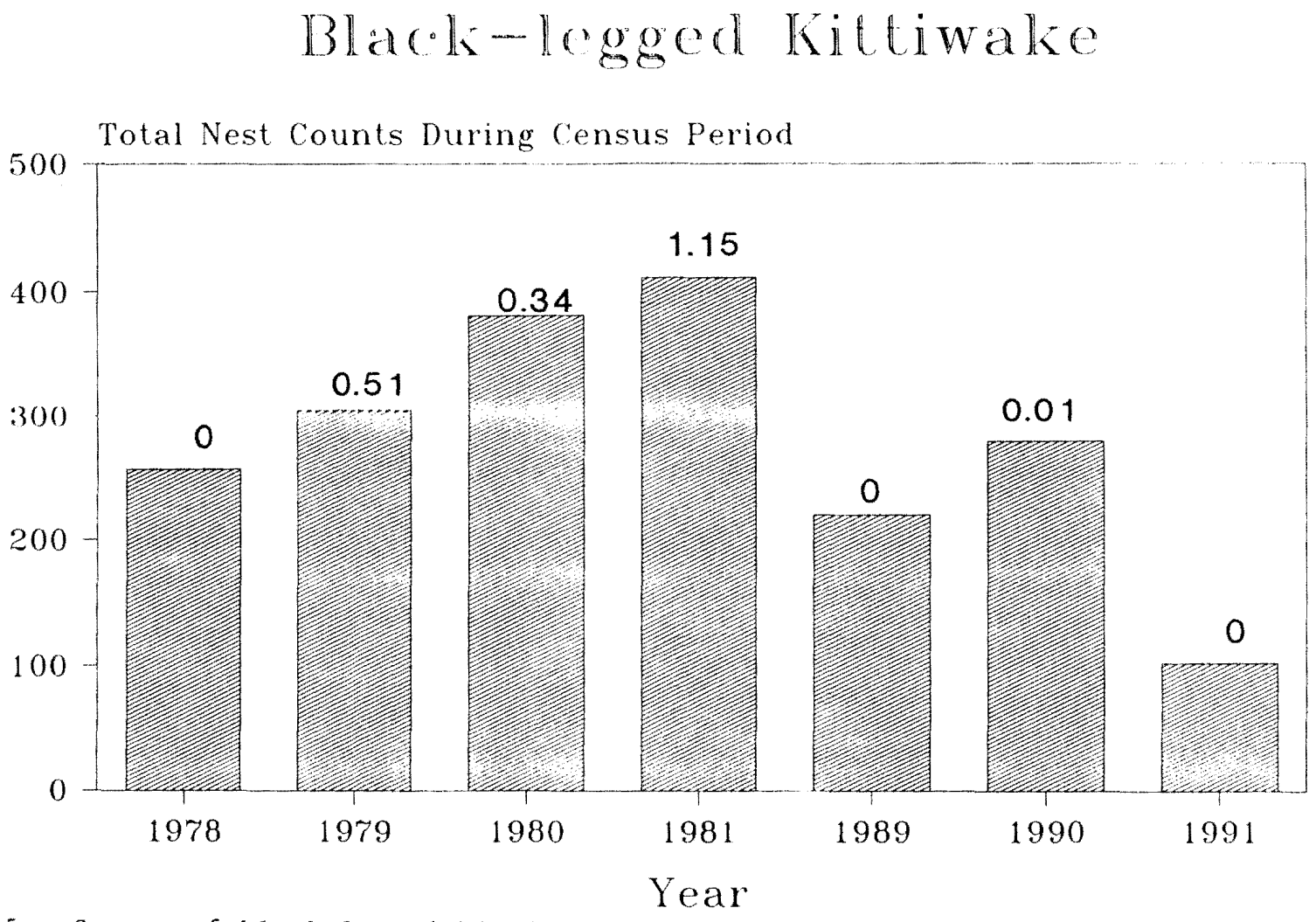

Figure 5. Counts of black-legged kittiwake nests on plots during census period at the Semidi Islands, Alaska. Numbers above bars are annual productivity.

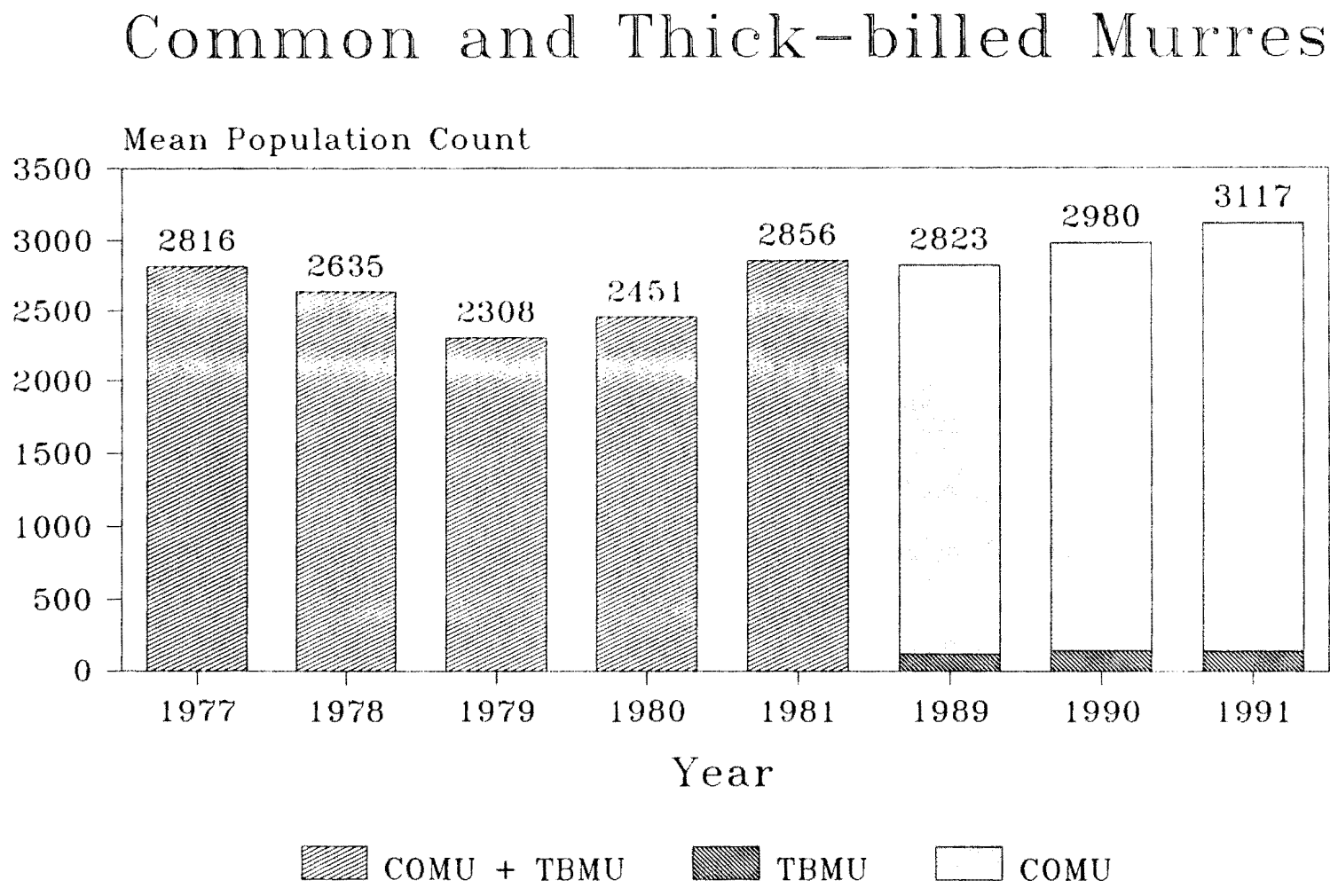

Figure 6. Common and thick-billed murre mean population counts on plots during census period at the Semidi Islands, Alaska.

Appendix A. Population (attendance) and productivity plot codes used at Chowiet Island in 1991 with reference to prior plot codes used by Hatch.

1989 Plot Code	Plot Codes used by Hatch	Comments
Northern Fulmar Population Plots		
A03N01	F1	
A04N01	F2	
A07N01	F5	
A10N01	F6A	
A10N02	F6B	
A12N01	F7	
A12N02	F8	
Black-legged Kittiwake Population Plots		
A02B01	1	
A02B02	2	
A03B01	3	
A03B02	3A	
A03B03	3	Separate section of plot 3 located on different cliff face
A06B01	4	
A06B02	5	
A09B01	6	
A09B02	7	
Murre Population Plots		
A03M01	1	
A03M02	2	
A03M03	3	
A03M04	4	
A03M05	5	
A06M01	6	
A09M01	7	
A09M02	8	
A10M01	9	
A10M02	10	

Appendix A. Population (attendance) and productivity plot codes used at Chowiet Island in 1991 with reference to prior plot codes used by Hatch (continued).

1989 Plot Code[a]	Plot Codes used by Hatch	Comments
Northern Fulmar Productivity Plots		
P03N01	Q	
P04N01	P	
P07N01	M1	
P07N02	M2	
P07N03	M3	
P09N01	L1	
P09N02	L2	
P12N01	B	
Black-legged Kittiwake Productivity Plots		
P03B01	A	
P03B02	B	
P03B03	C	
P03B04	D	
P03B05	E	
P03B06	F	
P09B01	C-1	
P10B01		Established in 1989
P10B02		Established in 1990
P11B01	E	
Murre Productivity Plots		
P03M01	A-1	
P03M02	A-2	
P03M03	A-3	
P03M04	A-4	
P03M05	A-5	
P03M06	A-6	
P03M07	A-7-1	
P03M08	A-7-2	
P03M09	A-8	
P03M10		Established in 1989
P03M11	B-1	
P03M12	B-2	
P03M13	B-3	
P03M14		Established in 1989
P03M15		Established in 1989
P09M01	D-2	
P09M02	D-3	
P09M03	D-4	
P09M04	D-5	

Appendix A. Population (attendance) and productivity plot codes used at Chowiet Island in 1991 with reference to prior plot codes used by Hatch (continued).

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[a]1989 plot codes (Baggot et al. 1989) were established in the following manner:

Plot code A03N01
Key 122344

Key explanation:

1 = A for Population (Attendance) Plot
1 = P for Productivity Plot
2 = Stake location from which plot is viewed (01-12)
3 = N for Northern Fulmar
3 = B for Black-legged Kittiwake
3 = M for murre (both Common and Thick-billed Murres)
4 = Plot number for the given species (01-15), additional plots could be added at the same location by increasing the plot number suffix

APPENDIX B

Ratio Estimation Spreadsheets - Lotus 1-2-3
Semidi Islands, Alaska 1991

RATIO ESTIMATION LOTUS SPREADSHEET
Developed by Bruce Ackerman and Oz Garton, November 1987
Dept. Fish and Wildlife Resources
University of Idaho
Moscow ID 83843

Seabird Productivity - 1991
Semidi Islands - Northern Fulmar
NUMBER OF OBSERVATIONS (PLOTS) n = 4

UNIVARIATE STATISTICS

	Nest Started X	Fledged Y
TOTAL	91	16
MEAN	22.750	4.000
STAND DEV	5.188	3.559
STAND ERR	2.594	1.780
CV (%)	22.805	88.976
95% BOUND	5.188	3.559
90% BOUND	4.151	2.847

LINEAR REGRESSION COEFFICIENTS

START HERE Regression Output:
Constant (INTERCEPT) ERR
Std Err of Y Est ERR
R Squared ERR
No. of Observations ERR
Degrees of Freedom ERR

X Coefficient(s) ERR (SLOPE)
Std Err of Coef. ERR

RATIO ESTIMATION PROCEDURE

		Fledglings/ Nest Start
SUM(DEVIATION SQUARED)	Sum((Y-rX)^2) =	29.947
OVERALL RATIO	R = Sum(Y)/Sum(X) =	0.18
VARIANCE OF RATIO	Var(R) =	0.00482

			Limits Low	High
95% BOUND ON RATIO	= 3.182*Sqrt(Var(r))=	0.2210	-0.0451	0.3968
90% BOUND ON RATIO	= 2.353*Sqrt(Var(r))=	0.1634	0.0124	0.3392

Column 1	2	3	4	5	6	7
Obs. i	Nest Started X	Fledged Y	Fledglings/ Nest Start r = Y/X	Deviation From Exp. Y-rX	Deviation Squared (Y-rX)^2	Predict Y from X Y'=RX
P03N01	25	9	0.36	4.6044	21.2005	4.3956
P04N01	15	1	0.07	-1.6374	2.6810	2.6374
P09N02/N01	25	2	0.08	-2.3956	5.7389	4.3956
P12N01	26	4	0.15	-0.5714	0.3265	4.5714

RATIO ESTIMATION LOTUS SPREADSHEET
Developed by Bruce Ackerman and Oz Garton, November 1987
Dept. Fish and Wildlife Resources
University of Idaho
Moscow ID 83843

Seabird Productivity - 1991
Semidi Islands - Black-legged Kittiwake
NUMBER OF OBSERVATIONS (PLOTS) n = 4

UNIVARIATE STATISTICS

	Nest w/Eggs X	Fledged Y
TOTAL	17	0
MEAN	3.400	0.000
STAND DEV	3.548	0.000
STAND ERR	1.774	0.000
CV (%)	104.346	ERR
95% BOUND	3.548	0.000
90% BOUND	2.838	0.000

LINEAR REGRESSION COEFFICIENTS

START HERE Regression Output:

Constant (INTERCEPT)	ERR
Std Err of Y Est	ERR
R Squared	ERR
No. of Observations	ERR
Degrees of Freedom	ERR
X Coefficient(s)	ERR (SLOPE)
Std Err of Coef.	ERR

RATIO ESTIMATION PROCEDURE

		Fledglings/ Nest w/Eggs
SUM(DEVIATION SQUARED)	Sum((Y-rX)^2) =	0.000
OVERALL RATIO	R = Sum(Y)/Sum(X) =	0.000
VARIANCE OF RATIO	Var(R) =	0.00000

		Limits Low	High
95% BOUND ON RATIO	= 3.182*Sqrt(Var(r))= 0.0000	0.0000	0.0000
90% BOUND ON RATIO	= 2.353*Sqrt(Var(r))= 0.0000	0.0000	0.0000

Column 1	2	3	4	5	6	7
Obs. i	Nest w/Eggs X	Fledged Y	Fledglings/ Nest w/Eggs r = Y/X	Deviation From Exp. Y-rX	Deviation Squared (Y-rX)^2	Predict Y from X Y'=RX
P03B01-B06	9	0	0.00	0.0000	0.0000	0.0000
P09B01	2	0	0.00	0.0000	0.0000	0.0000
P10B01/B02	2	0	0.00	0.0000	0.0000	0.0000
P11B01	4	0	0.00	0.0000	0.0000	0.0000

RATIO ESTIMATION LOTUS SPREADSHEET
Developed by Bruce Ackerman and Oz Garton, November 1987
Dept. Fish and Wildlife Resources
University of Idaho
Moscow ID 83843

Seabird Productivity - 1991
Semidi Islands - Common Murre
NUMBER OF OBSERVATIONS (PLOTS) n = 7

UNIVARIATE STATISTICS

	Nest Started X	Fledged Y
TOTAL	208	108
MEAN	29.714	15.429
STAND DEV	9.464	8.867
STAND ERR	3.577	3.351
CV (%)	31.851	57.470
95% BOUND	7.154	6.703
90% BOUND	5.723	5.362

LINEAR REGRESSION COEFFICIENTS

START HERE Regression Output:

Constant (INTERCEPT)	ERR
Std Err of Y Est	ERR
R Squared	ERR
No. of Observations	ERR
Degrees of Freedom	ERR
X Coefficient(s)	ERR (SLOPE)
Std Err of Coef.	ERR

RATIO ESTIMATION PROCEDURE

		Fledglings/ Nest Start
SUM(DEVIATION SQUARED)	Sum((Y-rX)^2) =	162.946
OVERALL RATIO	R = Sum(Y)/Sum(X) =	0.52
VARIANCE OF RATIO	Var(R) =	0.00439

			Limits Low	High
95% BOUND ON RATIO	= 2.447*Sqrt(Var(r))=	0.1622	0.3570	0.6814
90% BOUND ON RATIO	= 1.943*Sqrt(Var(r))=	0.1288	0.3904	0.6480

Column 1	2	3	4	5	6	7
Obs. i	Nest Started X	Fledged Y	Fledglings/ Nest Start r = Y/X	Deviation From Exp. Y-rX	Deviation Squared (Y-rX)^2	Predict Y from X Y'=RX
P03MO1	24	12	0.50	-0.4615	0.2130	12.4615
P03M03/M04	29	18	0.62	2.9423	8.6572	15.0577
P03M5/7/10	22	10	0.45	-1.4231	2.0251	11.4231
P03M6/8/9	29	18	0.62	2.9423	8.6572	15.0577
P03M11-M15	50	33	0.66	7.0385	49.5399	25.9615
P09M01/M04	30	6	0.20	-9.5769	91.7175	15.5769
P09M02/M03	24	11	0.46	-1.4615	2.1361	12.4615

RATIO ESTIMATION LOTUS SPREADSHEET
Developed by Bruce Ackerman and Oz Garton, November 1987
Dept. Fish and Wildlife Resources
University of Idaho
Moscow ID 83843

Seabird Productivity - 1991
Semidi Islands - Thick-billed Murre
NUMBER OF OBSERVATIONS (PLOTS) n = 4

UNIVARIATE STATISTICS

	Nest Started X	Fledged Y
TOTAL	133	63
MEAN	33.250	15.750
STAND DEV	6.850	6.397
STAND ERR	3.425	3.198
CV (%)	20.600	40.613
95% BOUND	6.850	6.397
90% BOUND	5.480	5.117

LINEAR REGRESSION COEFFICIENTS

START HERE Regression Output:

Constant (INTERCEPT)	ERR
Std Err of Y Est	ERR
R Squared	ERR
No. of Observations	ERR
Degrees of Freedom	ERR
X Coefficient(s)	ERR (SLOPE)
Std Err of Coef.	ERR

RATIO ESTIMATION PROCEDURE

		Fledglings/ Nest Start
SUM(DEVIATION SQUARED)	Sum((Y-rX)^2) =	42.305
OVERALL RATIO	R = Sum(Y)/Sum(X) =	0.47
VARIANCE OF RATIO	Var(R) =	0.00319

		Limits Low	High
95% BOUND ON RATIO	= 3.182*Sqrt(Var(r))= 0.1797	0.2940	0.6534
90% BOUND ON RATIO	= 2.353*Sqrt(Var(r))= 0.1329	0.3408	0.6066

Column 1	2	3	4	5	6	7
Obs. i	Nest Started X	Fledged Y	Fledglings/ Nest Start r = Y/X	Deviation From Exp. Y-rX	Deviation Squared (Y-rX)^2	Predict Y from X Y'=RX
P03M01-M10	43	23	0.53	2.6316	6.9252	20.3684
P03M11	28	12	0.43	-1.2632	1.5956	13.2632
P03M12-M15	33	19	0.58	3.3684	11.3463	15.6316
P09M01-M04	29	9	0.31	-4.7368	22.4377	13.7368

APPENDIX C

Summary of seabird population counts at plots in 1991 at Chowiet Island, Alaska

Table C1. Summary of northern fulmar population counts at plots in 1991 at Chowiet Island, Alaska.

Plot #	Replicate Counts						
	1	2	3	4	5	6	7
A03N01	142	77	78	107	83	42	71
A04N01	31	32	39	26	31	31	28
A07N01	199	164	217	224	131	156	172
A10N01	58	47	64	29	32	22	27
A10N02	47	37	27	40	43	20	33
A12N01	75	67	90	69	71	52	63
A12N02	37	42	39	55	34	34	33
Total	589	466	554	550	425	357	427

Table C2. Summary of black-legged kittiwake population counts at plots in 1991 at Chowiet Island, Alaska.

Plot #	Replicate Counts									
	1	2	3	4	5	6[a]	7	8	9	10
A02B01	34	30	20	16	22	19(12)	24	19	37	30
A02B02	83	82	60	34	57	55(26)	61	82	100	92
A03B01	36	30	14	20	19	21(14)	17	33	40	40
A03B02	30	27	21	9	19	31(9)	25	27	43	41
A03B03	14	10	3	3	3	3(4)	4	8	9	14
A06B01	24	29	23	19	15	17(12)	23	29	29	34
A06B02	16	16	11	6	9	19(4)	14	18	26	24
A09B01	25	16	17	7	12	22(7)	23	24	32	32
A09B02	59	45	51	39	28	45(14)	40	53	72	68
Total	321	285	220	153	184	232(102)	231	293	388	375

[a]The numbers within the parentheses indicate nest counts that were taken during the sixth replicate count on 7 July 1991.

Table C3. Summary of common and thick-billed murre population counts at plots in 1991 at Chowiet Island, Alaska.

Plot #	Replicate Count 1	2	3	4	5	6	7	8	9	10
A03M01										
COMU	205	168	210	204	203	171	223	205	203	204
A03M02										
COMU	103	88	99	108	107	95	115	119	121	102
A03M03										
COMU	95	85	101	91	103	97	120	93	95	92
A03M04										
COMU	191	203	204	252	211	227	244	230	221	230
TBMU	28	21	30	27	29	25	40	26	29	22
A03M05										
COMU	44	43	45	39	38	42	49	38	41	41
TBMU	9	14	9	19	11	12	13	12	11	13
A06M01										
COMU	279	249	281	279	278	261	300	303	300	274
TBMU	2	4	2	4	2	3	6	2	2	3
A09M01										
COMU	73	69	77	71	68	71	73	74	68	69
A09M02										
COMU	601	540	622	563	572	623	577	589	547	645
TBMU	117	98	120	96	98	91	102	92	92	75
A10M01										
COMU	865	801	882	836	795	948	903	866	877	853
A10M02										
COMU	450	468	502	550	475	496	489	614	540	491
Total	3062	2851	3184	3139	2990	3164	3254	3263	3147	3114

Appendix D. Birds sighted in the Semidi Islands, Alaska.

Species	Year			
	1976	1977	1990	1991
Yellow-billed Loon*				
Pacific Loon	X			
Red-necked Grebe*				
Northern Fulmar	X	X	X	X
Leach's Storm Petrel	X	X	X	
Fork-tailed Storm Petrel	X	X		
Double-crested Cormorant	X			
Pelagic Cormorant	X	X	X	X
Red-faced Cormorant	X	X	X	
Canada Goose		X	X	X
Brant	X	X	X	
Mallard	X	X		
Green-winged Teal	X		X	
American Widgeon	X		X	
Northern Pintail	X	X		
Northern Shoveler		X		
Greater Scaup	X		X	
Common Eider	X	X	X	X
King Eider	X			
Black Scoter	X			
White-winged Scoter	X	X	X	
Surf Scoter*				
Harlequin Duck	X	X	X	X
Red-breasted Merganser	X		X	X
Black Oystercatcher	X	X	X	X
Semipalmated Plover	X	X		X
Bristle-thighed Curlew		X		
Whimbrel		X		
Yellowlegs (unid)	X			
Spotted Sandpiper				X
Wandering Tattler	X	X	X	X
Red-necked Phalarope***			X	
Red Phalarope		X		
Dowitcher (unid.)	X			
Common Snipe	X			X
Ruddy Turnstone	X	X		
Black Turnstone	X	X		X
Surfbird**	X			
Rock Sandpiper	X	X		X
Dunlin	X			
Semipalmated Sandpiper	X	X		X
Western Sandpiper**	X		X	
Least Sandpiper	X	X	X	X
Pectoral Sandpiper**	X			

Appendix D. Birds sighted in the Semidi Islands (continued).

Species	Year			
	1976	1977	1990	1991
Parasitic Jaeger	X	X	X	X
Mew Gull**	X			
Glaucous-winged Gull	X	X	X	X
Black-legged Kittiwake	X	X	X	X
Aleutian Tern				X
Common Murre	X	X	X	X
Thick-billed Murre	X	X	X	X
Pigeon Guillemot	X	X	X	X
Ancient Murrelet	X	X	X	
Cassin's Auklet	X	X		
Parakeet Auklet	X	X	X	X
Crested Auklet	X		X	
Least Auklet	X	X	X	X
Rhinoceros Auklet	X	X	X	
Horned Puffin	X	X	X	X
Tufted Puffin	X	X	X	X
Bald Eagle	X	X	X	X
Peregrine Falcon	X	X	X	X
Short-eared Owl	X			
Hummingbird (unid.)****				X
Tree Swallow	X	X	X	
Violet-green Swallow		X		
Bank Swallow	X	X	X	X
Barn Swallow	X			
Common Raven	X	X	X	X
Winter Wren	X	X	X	X
Hermit Thrush	X	X	X	X
Varied Thrush	X	X	X	
American Robin			X	
Water Pipit	X	X	X	
Yellow Warbler	X	X	X	X
Wilson's Warbler	X	X		
Savanna Sparrow	X	X	X	X
Song Sparrow	X	X	X	X
White-crowned Sparrow				X
Golden-crowned Sparrow	X	X	X	X
Fox Sparrow	X	X	X	X
Lapland Longspur	X	X	X	X
Snow Bunting	X	X	X	
Rusty Blackbird				X
Pine Siskin**	X			
White-winged Crossbill			X	

Appendix D. Birds sighted in the Semidi Islands (continued).

Species	Year			
	1976	1977	1990	1991
Common Redpoll		X		
Rosy Finch	X	X	X	X

* Reported by W. Troyer, May, 1971.

** Reported by L. Leschner and G. Burrell, 1976.

*** Reported by I. N. Gabrielson, 1940 or 1945.

**** A hummingbird was sighted a few days later and identified as a Rufous Hummingbird by J. Hague and A. Manville.