# Chapter 8

## SEABIRD COLONIES

by

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## TABLE OF CONTENTS

## SUMMARY

This report describes several facets of a study of seabirds conducted at Egg Island and vicinity in the Unimak Pass area in summer 1987. Studies to develop and test call-count techniques for censusing storm-petrels and other nocturnal, burrow-nesting seabirds were carried out at a seabird colony on Egg Island. A distributional survey of Whiskered Auklets was made on Egg Island and the Baby Islands. Observers also counted Tufted Puffin burrows on study plots on Egg Island and monitored activity and percent occupancy of these burrows. Finally, project personnel identified additional colony locations, important feeding concentrations, and other concentrations of seabirds observed in the vicinity of the islands visited during the summer field studies. The findings are summarized below:

(1) The call-count technique for censusing storm-petrels was found generally inaccurate, time-consuming, and not easily transferable among workers. Sky-counts do offer some potential to monitor population levels of storm-petrels, but even this technique has problems.

(2) Call-counts appear to have promise for estimating numbers of nesting Ancient Murrelets, but the surveys must be well-timed and supported with estimates of the extent to which nesting burrows are used.

(3) Call-count techniques offer good potential for monitoring numbers of Cassin's Auklets, especially when burrow count data are also available.

(4) Whiskered Auklets were present as isolated pairs on vertical cliff faces around the entire perimeter of Egg Island and on two of the Baby Islands surveyed. Observers located 20 calling birds at 17 sites on Egg Island, 44 calling birds at 29 sites on Tangagm Island, and 27 calling birds at 24 sites on Excelsior Island.

(5) From 180,000 to 200,000 Tufted Puffins were estimated to use Egg Island in summer 1987. Puffin burrow density ranged from 0.62 to 0.82 burrows/$m^2$. Although 98.8 percent of all burrows monitored on sample plots were occupied, occupancy by breeding birds was estimated to be about 35 percent.

(6) The species compositions of the colonies observed in 1987 were found to be similar to those observed for the same colonies in 1982.

## LIST OF FIGURES

## LIST OF TABLES

## INTRODUCTION

Within the Unimak Pass study area (Fig. 1) there are over 50 colony sites of seabirds (Sowls et al. 1978, U.S. Fish and Wildlife Service, unpubl. data). Several of these have been estimated to contain over 100,000 breeding birds each. Most of the colonies are present on relatively small (generally less than 200 ha), fox-free islands and are located largely in the Krenitzin group.

These colonies are quite different from seabird colonies farther north in the Bering Sea. The latter colonies contain a large proportion of species that visit the colonies by day and nest in the open on sheer cliffs (e.g., kittiwakes, murres, fulmars, cormorants). In the eastern Aleutians and the Unimak Pass area, the above species are either absent or constitute only a small percentage of total birds in most colonies. Colonies here are dominated by Tufted Puffins (a diurnal, burrow-nesting species) and smaller seabirds that visit their underground nest sites only at night (storm-petrels, murrelets, and some auklets).

The habits of these burrow-nesting species present a unique problem to biologists attempting to estimate colony populations and monitor trends in population levels. The techniques in general use for monitoring diurnal cliff-nesters in most cases cannot be applied directly to burrow-nesting species. Therefore, prior to monitoring seabird colony populations in the Unimak Pass area, techniques for conducting census work must be tested.

To meet these needs, the objectives for this study were to investigate methods for quantifying numbers and monitoring populations of seabirds on islands in the Unimak Pass area, with a lesser effort to document the use of surrounding waters by seabirds for feeding and other activities. Specific study objectives were to:

(1) <u>Develop and test census methods for storm-petrels and other nocturnal species</u>—The major emphasis of this objective was to evaluate the call-count technique as a method for producing estimates that could be used to monitor trends in populations of storm-petrels and other nocturnal, burrow-nesting species at colony sites. This technique was attractive in that it has the potential for standard, repeatable surveys, and should cause much less disturbance to nesting seabirds than does inspection of nest burrows.

(2) <u>Conduct a distributional survey of Whiskered Auklets</u>—The goal was to better document the time of day, and period during the breeding season, when calls by Whiskered Auklets could be used for identifying breeding

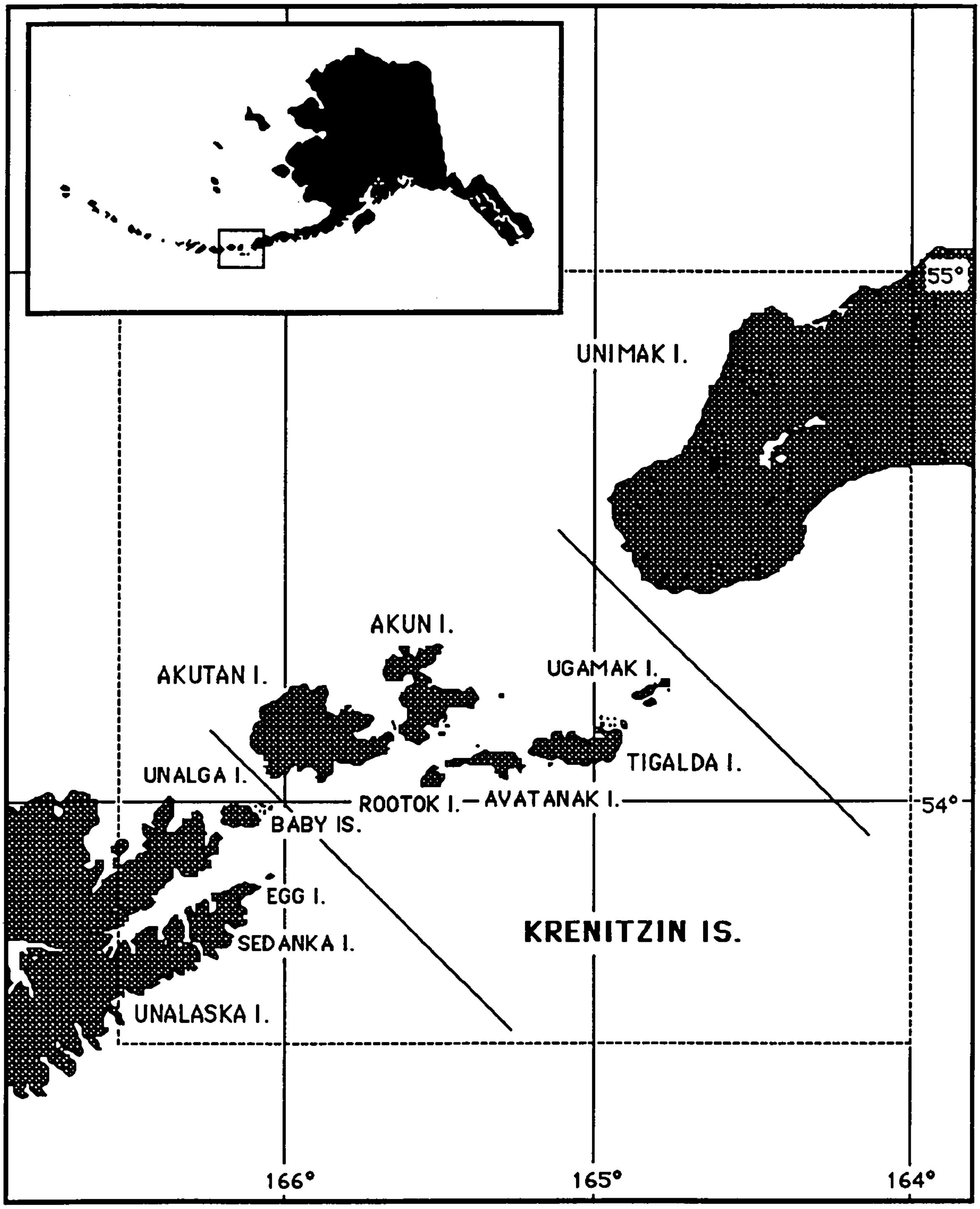


Figure 1. Location of Egg Island and other island groups in the Unimak Pass study area, Alaska.

locations and estimating populations. Several islands in the study area were to be sampled to provide information to compare with previous studies (i.e., Nysewander et al. 1982).

(3) Monitor Tufted Puffins—Specifically, observers were to make counts of burrows on study plots and to monitor activity in and percent occupancy of these burrows. The study plots would be permanently marked, enabling investigators to use the same plots to monitor population trends in future years.

(4) Make general observations of seabird colony sites and other seabird concentrations—This secondary objective was designed to identify additional colony locations, important feeding congregations, and other concentrations of seabirds in the vicinity of islands visited during summer field studies.

## CURRENT STATE OF KNOWLEDGE

### Breeding Biology of Species Studied

Although over 20 species of seabird may breed in the Unimak Pass study area, census activities were focused on six species that were selected based on their numerical abundance in the study area, vulnerability to offshore petroleum development, and/or restricted geographic ranges. These species were Fork-tailed Storm-Petrel, Leach's Storm-Petrel, Ancient Murrelet, Cassin's Auklet, Whiskered Auklet, and Tufted Puffin. The following sketches summarize basic information on the breeding biology of the major species we studied.

#### Fork-Tailed Storm-Petrel

Fork-tailed Storm-Petrels are endemic to the North Pacific Ocean where they breed primarily on small, predator-free islands from northern California and the Kurile Islands north to the Aleutians and islands in the Gulf of Alaska (Harrison 1983). Storm-petrels are not known to nest anywhere in the Bering Sea north of the Aleutians (Sowls et al. 1978). Fork-tailed Storm-Petrels are significantly larger than Leach's Storm-Petrels, nest earlier, and, at least at some colonies, return to nests earlier in the evening. Spring arrival dates at most colonies in Alaska probably occur in April. Birds were present on Buldir Island in the Aleutians by late April (Byrd and Trapp in prep.). Laying begins as early as mid-April in the Gulf of Alaska and becomes progressively later westward through the Aleutians, with initiation as late as early June in the western Aleutians. Fork-tailed Storm-Petrels lay a single whitish egg within a nest burrow (Boersma et al. 1980). Burrows average about 0.35 m in length and may occur as natural crevices in rocks, or as burrows in soil excavated by the adult birds. Hatching dates also vary with location; at Buldir Island, hatching occurs primarily from early July through August (Byrd and Trapp in prep.). Storm-petrels may exhibit intermittent incubation, presumably because the metabolic cost becomes too high after several days, causing the incubating bird to depart before its mate has regained enough lipid reserves to take over incubation duties (Boersma and Wheelwright 1979). Fork-tailed chicks require 50-66 days to fledge from the nest (Quinlan 1979, Simons 1981), therefore adults may continue to visit some colonies until early November. Fork-tailed Storm-Petrels produce a scratchy, usually four-note call on the nesting islands.

**Leach's Storm-Petrel**

This species nests both in the North Atlantic and the North Pacific regions. In the Pacific, it is found breeding on islands from southern Baja California, Mexico, and northern Japan, north to the Aleutians and islands in the Gulf of Alaska. Leach's Storm-Petrels in the north Pacific often nest in mixed colonies with Fork-tails, but tend to nest later in the season. At some colonies, Leach's Storm-Petrels arrive later in the evening than their congeners (Byrd and Trapp in prep., Quinlan 1979). Arrival at Alaskan colonies occurs from mid- to late May, with the onset of laying underway by late May and continuing through July. Laying dates on Buldir Island were recorded as late as 5 August (Byrd and Trapp in prep.). As in Fork-tailed Storm-Petrels, egg neglect is frequent and incubation may take from 41 to 52 days (Byrd and Trapp in prep.). Hatching occurs from early July to early September. Breeding chronology is generally later farther westward in the Aleutian Islands. Chicks require from 63 to 70 days to fledge, therefore activity at some colonies in the Aleutians continues until at least mid-November. Leach's Storm-Petrels give a soft purring call usually in or near the nest burrow, but more commonly produce lengthly cackling calls.

**Ancient Murrelet**

This species nests from the Queen Charlotte Islands, British Columbia, and Korea northward to the Aleutians and islands in the Gulf of Alaska (Harrison 1983). Ancient Murrelets are unusual alcids in that they lay two eggs rather than one, and the chicks are precocial at birth. The chicks are not fed on land, but are led to the water by the adults at night within a few days of hatching (Jones et al. 1987). Growth of the chicks to fledging takes place completely at sea. The chronology of breeding for Ancient Murrelets is poorly known in Alaska. Indications from British Columbia are that they initiate the clutches relatively early, from late April to late May (Sealy 1976). Clutches are probably initiated later in the Aleutians. Nest sites are either burrows dug in the soil by the adults, or natural cavities, sometimes enlarged by the nesting pair. The eggs are easily identified by the spotted pattern, unlike the plain white shell of other burrow nesters. Average length of incubation is approximately 35 days (Sealy 1976). Ancient Murrelet chicks in the Aleutians probably hatch from late June through July. Adults give two types of calls outside the nesting burrows--a short "chirrup" call, and a longer "song", of several recognizable elements (Jones 1985, Gaston et al. 1988, Jones et al. 1989).

### Cassin's Auklet

The most widespread auklet in the Pacific, the Cassin's Auklet nests from Baja California, Mexico, north through the Gulf of Alaska and throughout the Aleutian Islands (Harrison 1983). Few studies of this species have been conducted in the Aleutians, but some information on breeding biology is available from colonies in Southeast Alaska, as well as from British Columbia and California. Cassin's Auklets initiate egg-laying from April through May both in Southeast Alaska and California, and, as is common for almost all auklets, lay a single whitish egg (Thoresen 1964, DeGange et al. 1977). The incubation period averages approximately 38 days (Manuwal 1974, 1979). The small chick is brooded by the adults for a few days, but is then left alone and periodically fed in the burrow for the majority of the remaining nestling period. Fledging occurs after 41 to 50 days (Thoresen 1964). On Forrester Island in Southeast Alaska, chicks fledged from mid-July through August (DeGange et al. 1977). In British Columbia and California, Cassin's Auklets nest in both rock crevices and soil burrows (Manuwal 1974; Vermeer et al. 1979). In the Aleutians, however, most nests are in soil burrows and occur in tight groups among colonies of other species (Nysewander et al. 1982). These researchers, as well as DeGange et al. (1977) and Gaston et al. (1988), found that burrows of Cassin's Auklets could be identified by their typically muddy entrances, characteristic fishy odor, and the frequent presence of feces at the entrance. Cassin's Auklets produce a series of loud, grating calls on the nesting colonies (Manuwal 1974).

### Whiskered Auklet

This species is restricted to, and largely resident throughout the year in, the Aleutian, Commander, and Kurile Islands of the northcentral and northwestern Pacific Ocean (Harrison 1983). It has been found to be decidedly nocturnal in the eastern Aleutians (Nysewander et al. 1982). Contrary to its general behavior in the western Aleutians (Buldir Island), where it visits the nesting colonies mainly during the day (Byrd et al. 1983), in the eastern Aleutians, researchers heard Whiskered Auklet calls throughout the night, though most frequently just after dark or just before dawn. Nest sites on Buldir Island in the western Aleutians were found in crevices of talus slopes and under beach boulders (Knudtson and Byrd 1982). In the eastern Aleutians, the birds appeared to nest in rock crevices on sheer cliffs (Nysewander et al. 1982), and on Buldir, they nested within large colonies of Least and Crested auklets. However, in the eastern Aleutians where these other auklets do not breed, Whiskered Auklets were distributed in a low-density pattern similar to that of Pigeon Guillemots and Horned Puffins. Egg-laying by Whiskered Auklets occurred from 24 May to 5 June in 1976 on Buldir Island, and the eggs hatched from 24 June to 8 July (Knudtson and Byrd 1982). Fledglings were first noted on the sea by late July, but most probably fledged on Buldir during the first 10 days of August. Calls of this species include loud, distinctive, gull-like notes given in a rapid series (Nysewander et al. 1982).

### Tufted Puffin

This species is more widespread in the North Pacific than are the nocturnal alcids, breeding from islands off the central California coast and the southern Kurile Islands northward to the Chukchi Sea coast at Cape Lisburne and northeastern Siberia (Harrison 1983). The center of breeding abundance is thought to be in the eastern Aleutian Islands, where Nysewander et al. (1982) estimated that over 1 million breed. Although occasionally nesting at low densities in rock crevices, Tufted Puffins are more typically found nesting in large, dense colonies in soil burrows of their own making. In the Gulf of Alaska, Tufted Puffins lay their single whitish eggs from late May through late June. Hatching occurs from late June through mid-August, and fledglings appear on the water any time from mid-August to the end of September (DeGange and Sanger 1986). Tufted Puffins are mostly silent at the nesting colonies, but occasionally give a low growling call not audible at any great distance.

## Census Techniques Used By Others

Seabird colonies in the eastern Aleutian Islands were identified and surveyed by Nysewander et al. (1982) during the summers of 1980 and 1981. These broad-based studies documented colony sites and species distribution throughout our study area. The investigators made population estimates for each colony, but they did not evaluate for accuracy those estimates for species in which adults or nests could not be directly counted.

Nysewander et al. (1982) estimated numbers of Tufted Puffins by two techniques: 1) counting burrows on a 10-m-wide census strip extending from the highest puffin burrows down to the lowest, striving for at least 10 strips per colony, and 2) for some smaller islands, counting numbers of burrows directly. Storm-petrel numbers also were estimated by two techniques: 1) counting of burrows on study plots, and 2) call-counts conducted at night. The colony population estimates for storm-petrels obtained by Nysewander et al. (1982) were based primarily on call-counts for most colonies, because the observers found it impossible to count the often low densities of burrows in the wide variety of habitats used for nesting (talus, rock crevices, root systems of heavy grass cover, puffin burrows, and other burrows). They found that the ability to record calls of storm-petrels and other nocturnal seabirds was affected by several variables, and cautioned that "...the estimates of storm-petrels are one of the least precise obtained this field season". They also stated: "The resulting subjective estimates (of storm-petrel numbers) are valuable until better techniques are found. With further research, call counts may be reproducible when carefully correlated with these variables."

## STUDY AREA

Summer field activities were based at Egg Island (53°52'N 166°03'W) off the northeast tip of Sedanka Island, and approximately 20 air miles (32 km) from Dutch Harbor (see Fig. 1). Egg Island, located in the western portion of the Unimak Pass area, hosts the largest single seabird colony in the eastern Aleutians. From the main camp on this island short visits were made to nearby islands via inflatable boats, but most of the studies were conducted at the Egg Island colony. The field party of four arrived at Egg Island via amphibious aircraft (Grumman "Goose") on 21 June and remained in the study area continuously until 10 August. Camp locations on Egg Island and the Baby Islands followed those of Nysewander et al. (1982). In addition, camp was moved to the head of Sisek Cove, Sedanka Island, several days prior to departure from the study area, again via amphibious aircraft.

## METHODS

Methods tested for monitoring populations of nocturnal seabirds are described in detail in this section. Brief descriptions of how we surveyed for Whiskered Auklets, monitored Tufted Puffin burrow use, and conducted general observations are also included.

### Population Monitoring of Nocturnal Seabirds

#### Field Methods

Plot Setup. To assess potentially useful techniques for monitoring populations of seabirds that visit nesting colonies only at night, we established 20 study plots on Egg Island. On these plots we conducted call-counts and searched for nesting burrows of the four nocturnal species not solely restricted to cliff habitats (i.e., Fork-tailed and Leach's Storm-Petrels, Ancient Murrelet, and Cassin's Auklet) and counted calls of one additional species (Whiskered Auklet). These plots were designed to provide a quantitative evaluation of nesting densities of the first four species in the immediate vicinity of stations at which call-counts were conducted.

We subjectively chose paired plot locations in areas representing high, medium, and low calling frequencies of the storm-petrels (the most common and widespread nocturnal seabirds on the island), and in areas where the two small alcid species (Cassin's and Whiskered Auklets) were present. Because of concerns that calling frequencies and nesting densities varied among the habitats, physiographic features present on the island were also taken into account in locating plots (e.g., coastal cliffs, coastal slopes, interior hills, upland tundra, dense grass habitat, and Tufted Puffin colonies). Locations of study plots are presented in Figure 2. Criteria used in choosing the location of each pair of plots are provided in Table 1.

Study plots were 25 X 25 m square, and were marked on all four corners by flagging tape. We conducted call-counts from a listening post located roughly in the center of the plot and marked with a stake (Fig. 3). Observers moved to and from the listening post via only one trail so as to minimize disturbance to nesting birds. Plots were located in pairs but pair members were separated by over 100 meters. This was done to increase sampling frequency in each habitat, and to provide (at least partially) non-overlapping counts in the same general area. At the end of the study period we removed the listening post markers and permanently marked all plots at the lower left corner with locally-available materials. Bearings for the baselines from this stake, from which the plots could be reproduced, are provided in Table 2.

**Call-Counts.** We conducted call-counts exclusively on the 20 study plots on Egg Island. During count evenings, one person (the "recorder") conducted call-counts for the entire period of darkness (between 0100 and 0530 hrs Alaska Daylight Time in late June to between 0030 and 0600 hrs ADT by early August). At each plot sampled, 10 counts of 15-30 sec duration each, were conducted every half-hour for each species present. Calls of only one species were recorded during each 15-30 second count. After conducting 10 counts per species on a plot, the recorder moved to the adjacent plot of the pair but did not commence counting until the next half-hour mark was again reached. Moving back and forth between plot pairs every half-hour enabled each recorder to sample two plots per habitat type each night, and the occasional movement helped to reduce counting fatigue. During counts, recorders remained as quiet as possible and in a sitting position facing downhill. On some plots, count posts were located on small mounds or hummocks to elevate the counter above the level of the grass. Counts were taken only during nights when sound interference from background sources (wind and surf) was low enough to hear most calls. Counts were taken on 14 days from 25 June through 3 August 1987. The schedule of counts for each pair of plots is given in Table 3.

We used 15-second to 30-second call-count periods because initial tests indicated that concentration levels of recorders tended to decrease and counters frequently lost track if they listened for longer periods. Recorders used digital stop-watches to record elapsed time, but estimated the 15-30 second intervals to avoid the distraction of using lights for "watching the clock". Thus the recorder used a headlamp for keeping track of 30-min periods and recording data in notebooks, but not for timing the count intervals.

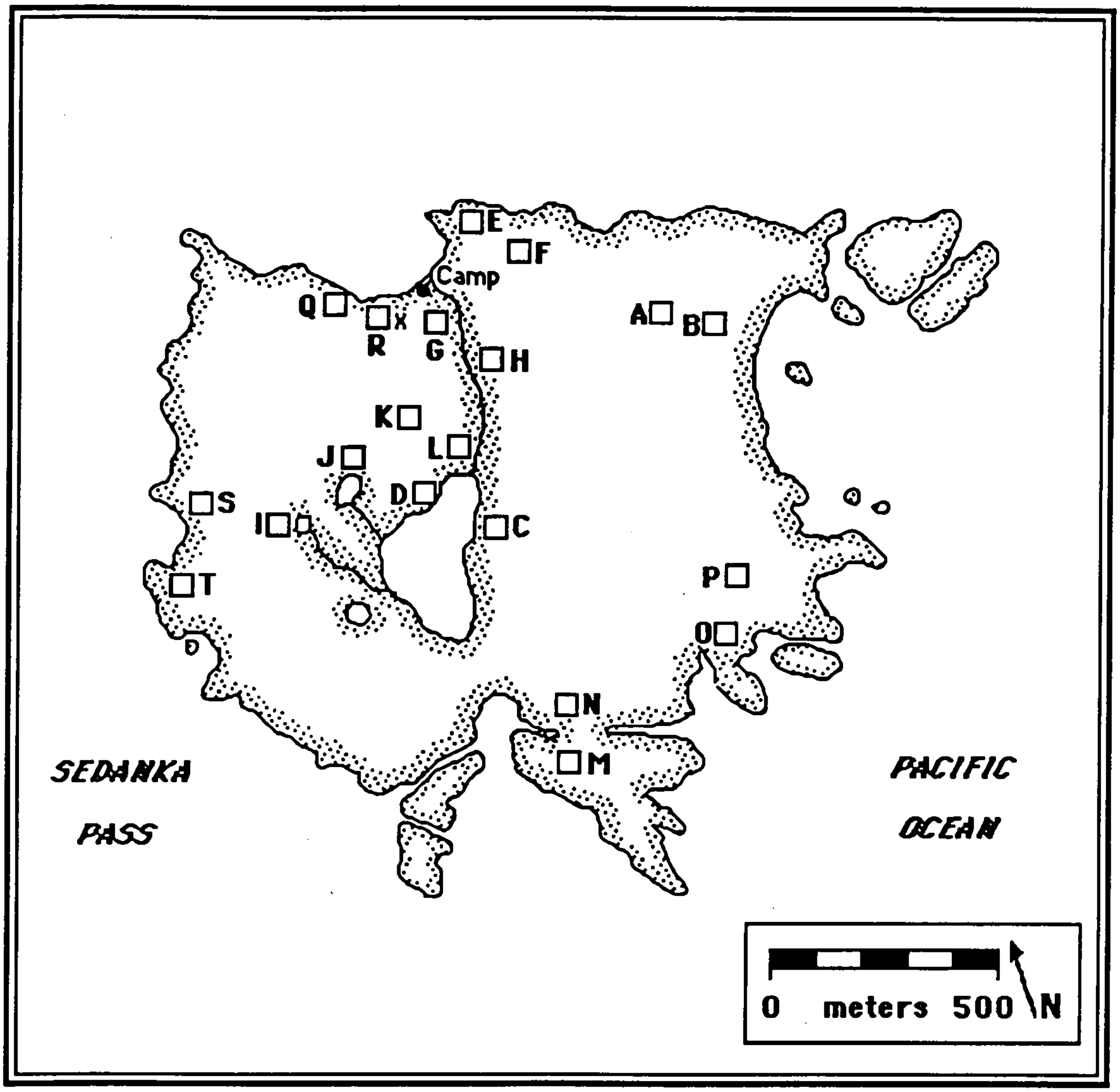


Figure 2. Locations of the 20 study plots established for estimating nest densities and conducting call-counts, Egg Island, Alaska.

Table 1. Characteristics used in selecting study plot locations at Egg Island, Alaska.

| Plot | Characteristics |
|---|---|
| A,B | LOW density storm-petrel calling locations, upland tundra habitat. |
| C,D | HIGH density storm-petrel calling locations, inland hills habitat. |
| E,F | MODERATE density storm-petrel calling locations, presence of Ancient Murrelets, Tufted Puffin nesting habitat. |
| G,H | MODERATE density storm-petrel calling locations, presence of Ancient Murrelets, dense grass habitat. |
| I,J | MODERATE density storm-petrel calling locations, inland hills habitat. |
| K,L | MODERATE density storm-petrel calling locations, upland tundra habitat |
| M,N | HIGH density storm-petrel calling locations, presence of Cassin's Auklets, coastal sea slope habitat. |
| O,P | MODERATE density storm-petrel calling locations, presence of Cassin's Auklets, coastal sea slope habitat. |
| Q,R | LOW density storm-petrel calling locations, presence of Ancient Murrelets, cliff habitat. |
| S,T | MODERATE density storm-petrel calling locations, presence of Cassin's Auklets, Tufted Puffin nesting habitat. |

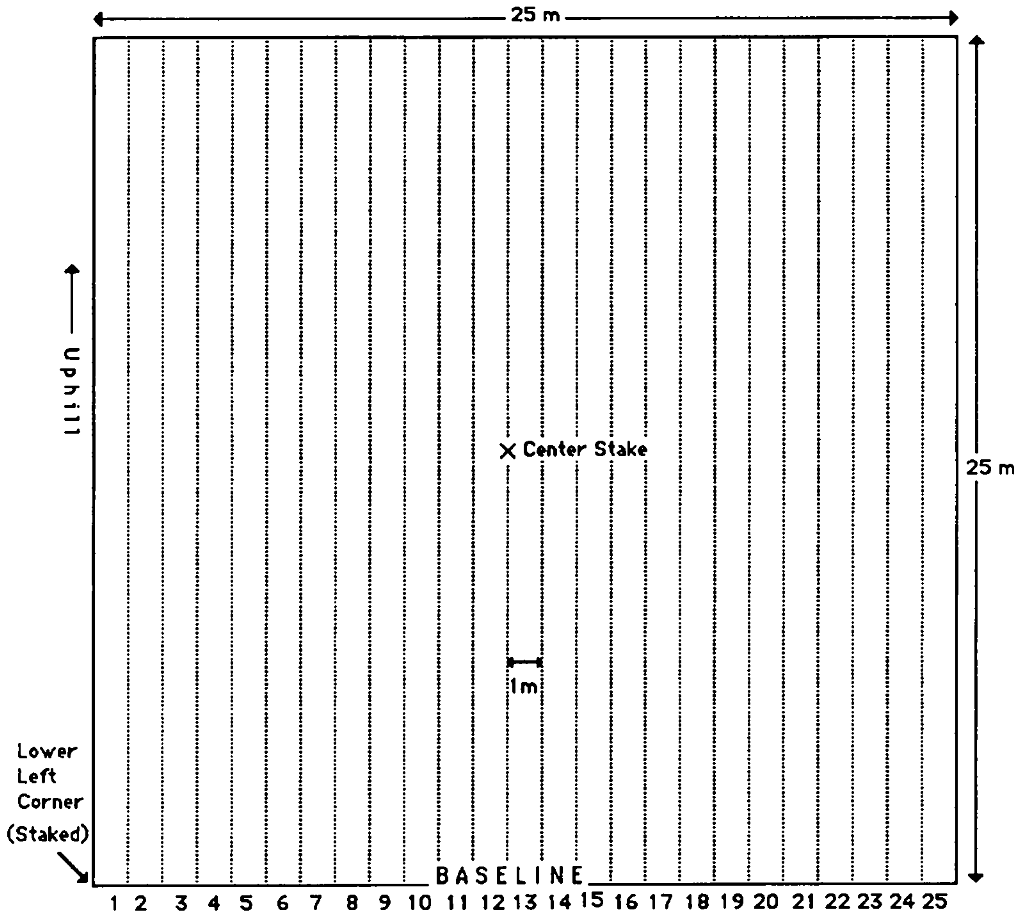


Figure 3. Layout of study plots at Egg Island, Alaska. (All features are imaginary except for the center stake and the flagging at all four corners.)

Table 2. Descriptive information for the 20 study plots at Egg Island, Alaska. Compass bearings for the baselines are based on true north and describe the direction of the baseline from the permanent marker (at lower left corner).

| Plot | Baseline bearing | Plot | Baseline bearing |
|---|---|---|---|
| A | 52° | K | 324° |
| B | 19° | L | 276° |
| C | 163° | M | 82° |
| D | 352° | N | 51° |
| E | 236° | O | 47° |
| F | 233° | P | 50° |
| G | 238° | Q | 250° |
| H | 200° | R | 220° |
| I | 352° | S | 125° |
| J | 248° | T | 125° |

Table 3. Schedule of plot coverage for call-counts at Egg Island, Alaska.

| Plot Pairs | Dates Censused |
|---|---|
| A, B | 25 June, 5 July*, 16 July, 27 July |
| C, D | 25 June, 3 July, 16 July*, 1 August |
| E, F | 26 June, 30 June, 23 July*, 1 August |
| G, H | 26 June*, 30 June, 16 July, 27 July |
| I, J | 26 June, 3 July, 16 July, 27 July* |
| K, L** | 26 June, 3 July, 17 July*, 27 July |
| M**, N | 27 June, 5 July, 17 July, 1 August* |
| O, P | 27 June*, 5 July, 17 July, 23 July |
| Q, R | 28 June, 3 July*, 22 July, 1 August |
| S, T | 5 July, 17 July, 23 July, 3 August |

* Counts which were later deleted from analyses because of significant differences in one person's counts.

**Additional counts were taken on these plots to assess the variation in calling frequencies of Fork-tailed and Leach's Storm-Petrels (Plot L) and Cassin's and Whiskered Auklets and Ancient Murrelets (Plot M) throughout the night and over the breeding season. We conducted these counts on Plot L on 28 June, 6 July, 23 July, and 3 August. We conducted additional counts on Plot M on 6 July and 22 July.

Consensus was required to determine which calls to count. Ideally, one would count only those birds actually using the study plot being censused. This was impossible, however, because the exact edge of each plot and its relationship to the locations of calling birds could not be estimated by the recorder. In addition, the large number of birds (particularly storm-petrels) using Egg Island precluded counting every call heard, because calls tended to blend into a background cacophony of sounds on some parts of the island. To avoid some of these problems and to standardize the sampling methods, we established the following criteria for counting calls:

(1) Only those calls for which the beginning and end of the entire call could be discerned were counted.

(2) Each call was counted, even if several calls were given by a known bird in rapid succession.

(3) All calls that could be heard by the recorder were counted, regardless of how far away the birds may have been.

During each call-count, we recorded location, species, time, level and type of environmental noise, weather, and observer variables (Table 4). The number of species heard varied from two to five species per plot (Figure 4).

Calls of all species were very distinctive, but were variable in duration and intensity of sound. Only one general call type was recorded per species, except for Leach's Storm-Petrel. For this species we noted that two very different call types were regularly produced. The first was a cackle-like call (call type 1), also called the flight call (*sensu* Harris 1974, Hall-Craggs and Sellar 1976, Ainley 1980, Randall and Randall 1986) or the chatter call (*sensu* Grubb 1973, Cramp and Simmons 1977) which was given frequently in flight or on or in the ground. The second was a lower-pitched trill or frog-like call (call type 2), also called the purr call (*sensu* Wilbur 1969, Grubb 1973, Harris 1974, Cramp and Simmons 1977, Randall and Randall 1986) or the chatter call (*sensu* Ainley 1980) which was given less often than type 1 calls and usually by birds on or in the ground. We recorded both types of Leach's Storm-Petrel calls separately on the study plots.

Near the end of the field study period (on 3 and 6 August), we compared the abilities of the four recorders to detect calls. Pairs of recorders seated close together on the same plot coordinated count durations but did not communicate the number of birds counted until all trials (10 repetitions of 15-30 sec. counts) were completed. Each pair of recorders (total of six pairs) counted on each of two plots and for each of three call types (Fork-tailed Storm-Petrel calls and both types of Leach's Storm-Petrel calls). The two plots were selected to assess recorders' abilities to count calls in areas of relatively

Table 4. Data recorded during each nocturnal call-count conducted at Egg Island, Alaska.

| Variable | Description |
|---|---|
| Location | Plot identifier (A to T) |
| Call Type | Type of call recorded. All call types were species -specific except for Leach's Storm-Petrel, for which two call types were recorded (see text) |
| Call | Number of calls counted per count period |
| Count Period | Number of seconds |
| Cloud Cover | Estimated in tenths |
| Disturbance (environmental noise) | Estimated on a scale of 0 - 3 |
| | 0 = no disturbance<br>1 = slight wind and/or surf noise audible, but not affecting recorder's ability to detect calls<br>2 = some loss of detectability due to wind and/or surf noise<br>3 = strong disturbance from wind and/or surf noise affecting recorder's ability to detect calls |
| Time counts recorded | Start hour and start minute for each series of 10 |
| Date | Julian date recorded |
| Recorder | Unique code number assigned to each recorder |

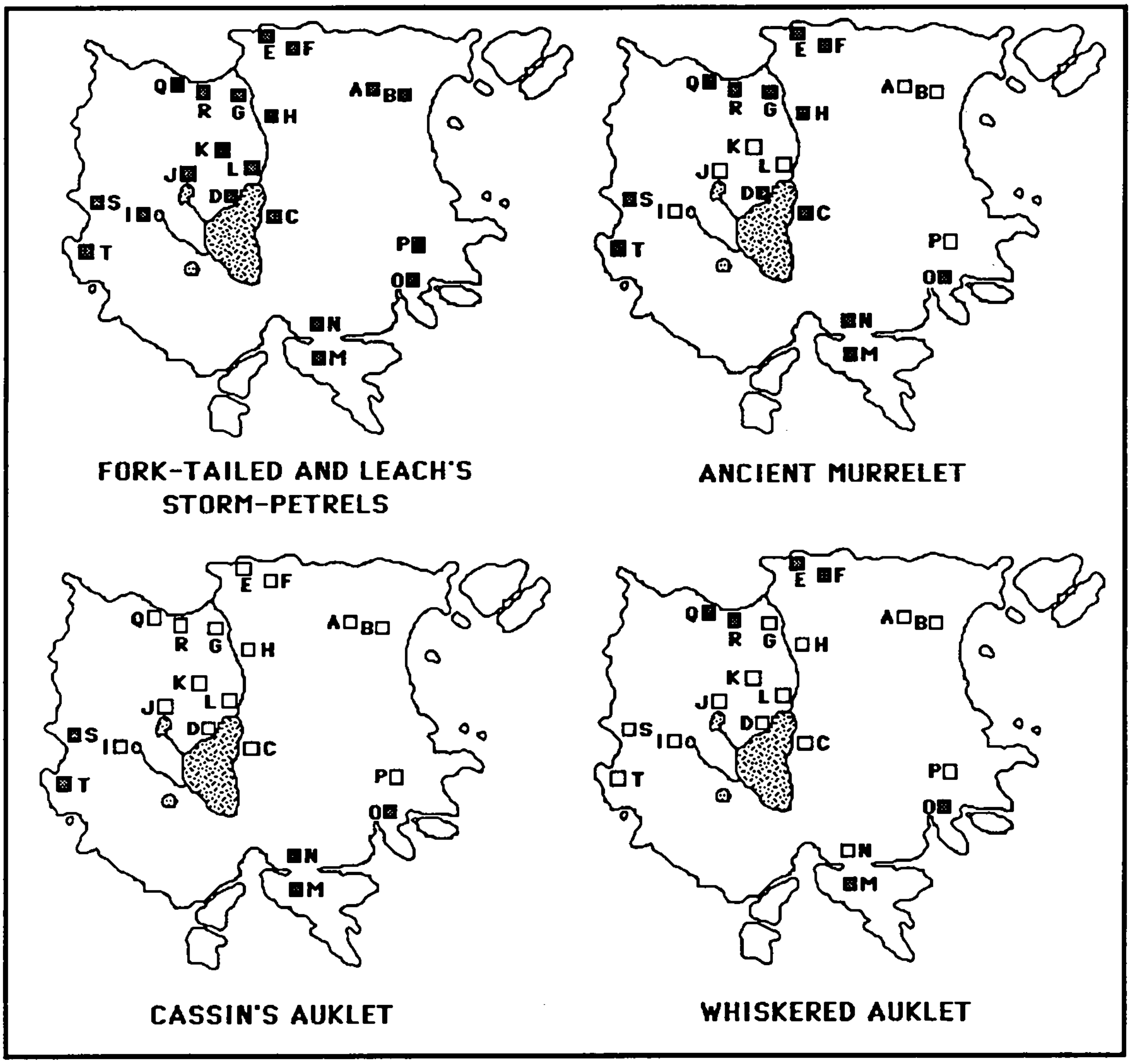


Figure 4. Locations of study plots at Egg Island, Unimak Pass, Alaska, on which the calls of the five nocturnal seabirds were recorded. (see Fig. 1 for location of Egg Island.)

high densities of storm-petrels and in areas with relatively low densities. An additional trial was conducted where Leach's Storm-Petrels were giving type 2 calls on plot L. We could not assess recorders' relative abilities to count either Cassin's or Whiskered Auklets because these species had virtually stopped visiting the island by the dates we conducted the trials. All test counts were completed during the peak (evening) calling period at that time of year (0100 to 0430 hrs).

**Burrow Searches.** To provide an absolute measure of nesting density of nocturnal, burrow-nesting seabirds on the study plots for eventual correlation with call-counts, we searched each plot for nest burrows during daylight hours. Initial burrow searches were conducted in late June and July; however, the birds in burrows were not disturbed until after call-counts were completed on that plot, generally during late July or August. At this later time, we inspected burrows to obtain species identifications and to note contents.

We initially subsampled all 20 plots to determine densities of burrows and to monitor burrow use. Subsampling involved searching three strip transects 1 x 25 m across each plot. To do this we stretched three 25-m ropes across the plot (along randomly chosen strips from 1-25, see Fig. 3) from the downhill side of the plot (baseline) to the uphill side. Searchers proceeded uphill, inspecting the ground beneath the grass canopy thoroughly for burrows. We marked burrows with small plastic flags placed outside and above the entrance, and inserted 1-2 toothpicks upright and just inside the entrance to determine later whether the burrow was being used by seabirds. (There were no small mammals, reptiles, or amphibians on Egg Island, therefore disturbance of toothpicks would have been caused only by birds.) We rechecked these burrows three times during the field period at approximately 10-day intervals and recorded positions of the toothpicks.

We later searched all plots in their entirety to obtain a measure of nesting density of seabirds for use in correlations with call-counts. To do this we searched consecutive 1-m-wide strips, starting at one side and proceeding across the slope (see Fig. 3). Three persons searched each of three adjacent strips, working uphill. One person carried a meter stick for measurements. Burrow location, depth, contents, and other descriptive information were recorded. After all three strips had been searched, the ropes were moved to the next section of the plot, and the procedures were repeated until the plot was completed.

After call-counts were completed, each burrow was inspected for contents. We attempted to obtain species identifications and breeding status by sight (with use of a flashlight). This method was successful for almost all Ancient Murrelet burrows, but for most storm-petrel and Cassin's Auklet burrows, we were forced to extricate the adult and then feel for the presence of eggs or chicks. If necessary, we enlarged the entrance hole to allow us to reach the nest chamber. However, this was rarely required for storm-petrels, and was usually fruitless for Cassin's Auklets. Burrows of the latter species were frequently over 1 m deep. We could not determine the contents of some burrows that were deep or in rocky habitats.

The methods used to determine nest status differed among species because of interspecific variation in nesting chronology (Fig. 5). Most birds still occupied their burrows during inspection but at some Ancient Murrelet nests, particularly those not found until late July or August, eggs had already hatched and the adults and chicks had departed prior to the first inspection. None of the seabirds seemed to remove hatched eggshells from the nest, and we were therefore able to determine this year's use and hatching success for all species even if adults or chicks were not present.

We could not determine species identifications of storm-petrels solely by inspecting their temporarily abandoned eggs. Egg measurements overlap for these species (Byrd and Trapp in prep.), and egg coloration was not always a distinguishing characteristic. Similarly to the findings of Quinlan (1979), we noted that many eggs of Fork-tailed Storm-Petrels had a ring of faint red speckling around the large end. This trait could not be used for positive identification, however, because a few Leach's Storm-Petrel eggs also showed this attribute, and some eggs of both species were essentially pure white. Chicks of the two storm-petrels could be distinguished; Fork-tailed chicks possessed a coat of much lighter gray down than did Leach's chicks.

Most Cassin's Auklet burrows were highly distinctive later in the breeding season due to their relatively large, muddy entrances, fishy odor, and generally greater depth and tunnel width when compared with burrows of Ancient Murrelets and storm-petrels. Auklet burrows also occurred in relatively dense and isolated colonies; this contributed additional evidence for the identification of individual burrows.

**Sky-Counts.** An alternative method of counting storm-petrels--the sky-count--was tested briefly. Overflights of storm-petrels were counted on several plots on two nights in each of July and August (Table 5). Recorders themselves faced skyward near the center of each study plot and counted all petrels that flew through their field of vision. (Recorders had little difficulty detecting birds silhouetted overhead in the night sky, even in cloudy weather, but the two species of storm-petrels could not be separated in these observations.) No counts were made during periods of heavy precipitation. On each plot, petrels were counted during 20-31 periods that ranged in length from 27-62 seconds. All counts were conducted between 0200 and 0301 hours.

### Analysis Methods

Multiple regression techniques were used to investigate relationships between calling frequency and sky-count data and nesting density. Our overall

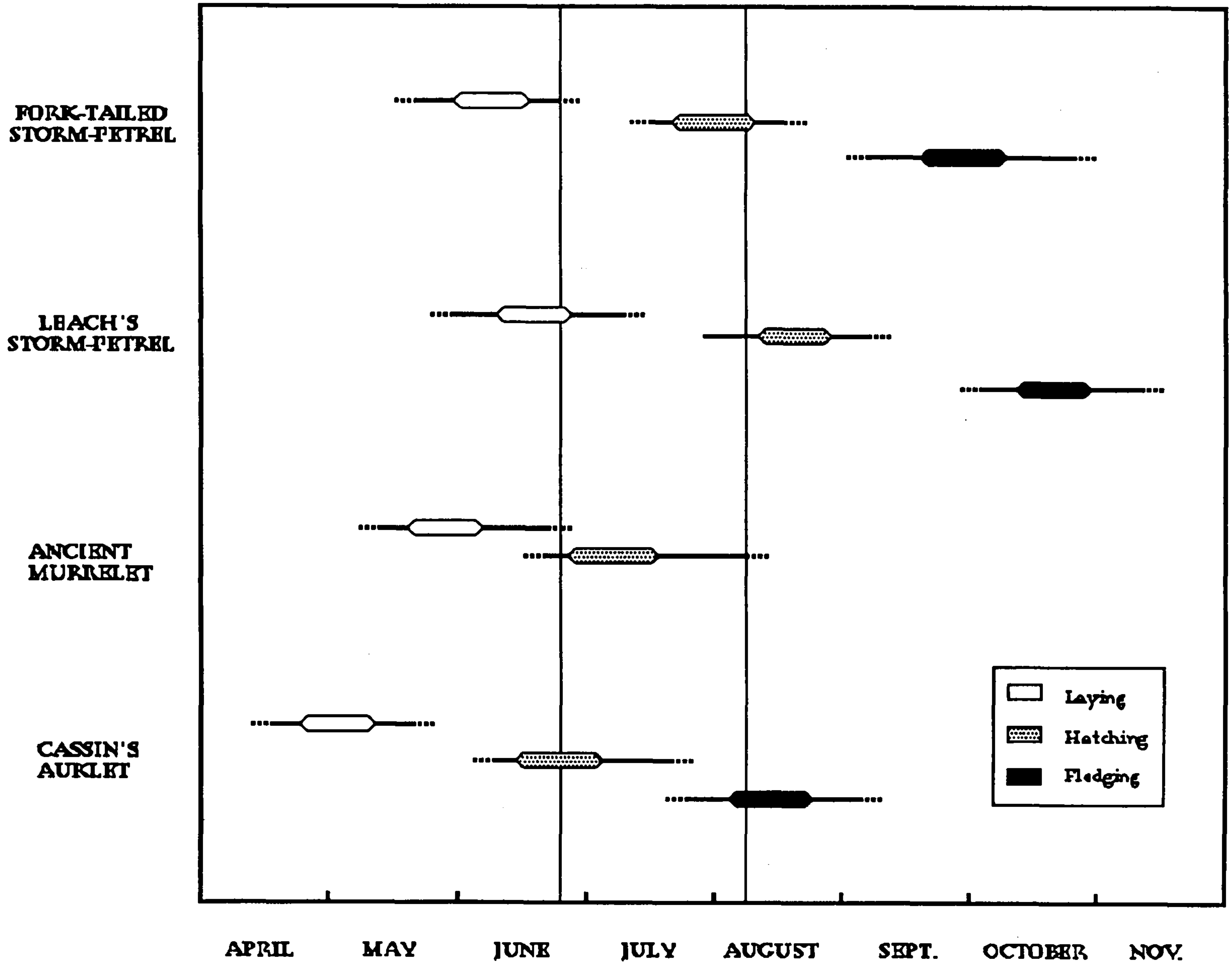


Figure 5. Approximate breeding chronology of the four nocturnal seabirds nesting on the 20 study plots, Egg Island, Alaska.

Table 5. Schedule of sky-counts of storm-petrels at Egg Island, Alaska.

| Plot | Date | Sky Counts | | |
|---|---|---|---|---|
| | | Number | Total Sec. | Mean Duration(sec) |
| **July Counts** | | | | |
| A | July 10 | 30 | 1867 | 62 |
| B | July 11 | 30 | 1362 | 45 |
| C | July 11 | 30 | 1090 | 36 |
| D | July 11 | 31 | 1118 | 36 |
| G | July 10 | 30 | 1028 | 34 |
| I | July 11 | 30 | 1327 | 44 |
| K | July 11 | 30 | 1191 | 40 |
| L | July 10 | 30 | 1159 | 39 |
| **August Counts** | | | | |
| A | Aug. 6 | 30 | 1112 | 37 |
| B | Aug. 6 | 30 | 1116 | 37 |
| C | Aug. 3 | 30 | 1060 | 35 |
| D | Aug. 3 | 30 | 813 | 27 |
| G | Aug. 6 | 30 | 1058 | 35 |
| I | Aug. 3 | 20 | 856 | 43 |
| K | Aug. 3 | 30 | 983 | 33 |
| L | Aug. 6 | 30 | 1084 | 36 |

goal was to test models that predicted nest density on the basis of calling frequency or sky-counts.

**Call-Count Data**. Calling frequency for some seabirds varied with such factors as time of day (e.g. Fork-tailed Storm-Petrel, Fig. 6), date, cloud cover, level of background noise, and recorder differences. We used stepwise multiple regression analysis (SMRA) to test for variability attributable to these factors. SMRA equations were used to create predicted calling rates using the case-wise values for each variable. The difference between the predicted rate and the recorded rate was a measure of the residual variance in calling rate. These residual values were then averaged for each plot to provide a measure of the amount of calling that was not explained by the predictor variables. Mean residuals were regressed against the number of nests on each plot to determine whether calling frequency could be used as a predictor of nesting abundance. Separate models were developed for each species and call type.

Data were reduced and transformed as necessary to meet the assumptions of the SMRA procedure and to facilitate analysis. Multiple regression rather than analysis of variance (ANOVA) techniques were used for two reasons: 1) unequal sample sizes and missing cells create problems for several ANOVA procedures, and 2) multiple regression techniques use all data, including continuously distributed data, and are sensitive to order information contained in the data. In these cases, multiple regression techniques are more powerful than are ANOVA techniques.

As described earlier, recorders determined the number of calls detected in 10 multi-second sampling periods at each plot. To determine the mean number of calls per minute, we divided the total number of calls detected during the 10 sampling periods by the total number of seconds and then multiplied by 60. 'Mean calls per minute' was considered as the dependent variable in the multiple regression procedures.

Multiple regression procedures assume that plots of residuals between each independent variable and each dependent variable are normally distributed (i.e. the dependent and predictor variables are linearly related). Time (start hour) and date (Julian day) variables were transformed (through the addition of hour-squared and Julian-day-squared terms) to improve the normality of the residuals.

**Burrow Data.** During the complete burrow searches of the plots, information required to determine the breeding status or even the species of bird using a burrow was occasionally unobtainable. Situations in which we lacked sufficient information for a given burrow included the following:

1. The burrow appeared to be active (i.e., toothpicks were repeatedly knocked down, fresh dirt was at the entrance, etc.)

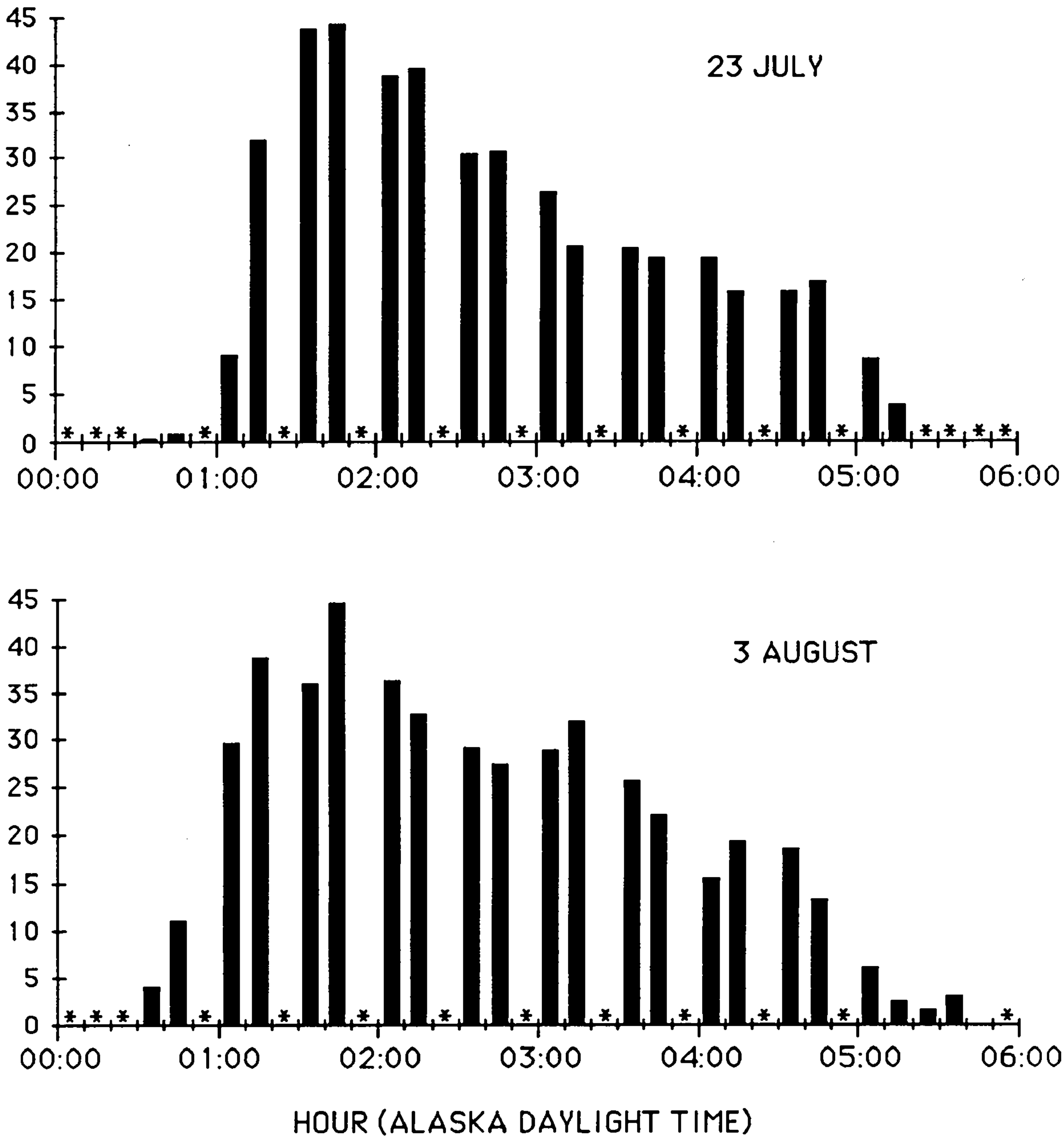


Figure 6. Nocturnal calling rates of Fork-tailed Storm-Petrels at Plot L on two nights. All counts were made by the same recorder. Asterisks (*) indicate ten-minute periods for which no counts were taken.

but no adult was present in the burrow at the time of our visit(s) and no egg was laid.

2. A storm-petrel egg was present (unidentifiable to species) but the adult was absent during visits to the burrow.

3. The burrow was too deep for us to reach the nest chamber and in substrate too rocky to be excavated.

We included in our analysis active burrows in which breeding was not attempted. Old burrows that did not appear to have been used during 1987 were not included as nests. Burrows that were counted as nest sites included any small (usually less than 10 cm in diameter) tunnel at least 10 cm in depth, that contained evidence of recent excavation by birds or other signs of recent use (feathers, fresh droppings).

We assigned burrows to a species whether or not we could identify its occupants. Of the 422 small seabird nest sites located on the 20 study plots, 102 were identifiable only as belonging to some species of storm-petrel, and three could be identified only as a small seabird burrow. We assigned unknown storm-petrel burrows to a species based on proportions of known burrows of the two species on each plot. Resulting numbers were rounded to the nearest whole nest and added to the totals of each species by plot. We assigned three burrows that appeared active but could not be identified to any taxon to the most abundant species of small seabird present in the plot in which they occurred. Final estimates of the number of nest sites used for call-count comparisons are provided in Table 6.

Sky-Count Data. Data were standardized to the number of overflights per minute for each plot on which counts were made. These counts were then regressed against the total numbers of petrel nests (Fork-tailed and Leach's combined) present on the plots (Table 6). Regression analyses were run separately for data collected in July and August.

### Whiskered Auklet Studies

We recorded all Whiskered Auklet calls heard on or near study plots. Data recording procedures and definitions of calls counted were identical to the methods described in the previous section on call-count techniques.

We conducted additional nighttime surveys to better quantify the Whiskered Auklet population using Egg Island and the Baby Islands (Tangagm and Excelsior islands). This species appeared to call only from sites on sheer cliff faces, which precluded nest inspection. We conducted censuses by traversing the circumference of the islands along the cliff tops at night, stopping frequently to listen for calls. We surveyed Egg Island on 27 and 29 June, Tangagm Island on 12 July, and Excelsior Island on 13 July. We counted

Table 6. Numbers of active nest burrows estimated for the 20 study plots at Egg Island, Alaska. Actual counts of Tufted Puffin burrows are included, however this species is not included in analysis of call-count data.

| Plot | Fork-tailed Storm-Petrel | Leach's Storm-Petrel | Ancient Murrelet | Cassin's Auklet | Tufted Puffin |
|---|---|---|---|---|---|
| A | 0 | 0 | 0 | 0 | 0 |
| B | 0 | 1 | 0 | 0 | 0 |
| C | 43 | 23 | 0 | 0 | 0 |
| D | 34 | 10 | 2 | 0 | 0 |
| E | 14 | 19 | 14 | 0 | 481 |
| F | 0 | 5 | 1 | 0 | 285 |
| G | 14 | 1 | 18 | 0 | 0 |
| H | 1 | 1 | 0 | 0 | 0 |
| I | 0 | 0 | 0 | 0 | 0 |
| J | 9 | 0 | 0 | 0 | 0 |
| K | 11 | 8 | 0 | 0 | 0 |
| L | 0 | 9 | 0 | 0 | 0 |
| M | 10 | 15 | 1 | 41 | 0 |
| N | 0 | 10 | 0 | 0 | 6 |
| O | 5 | 16 | 0 | 0 | 0 |
| P | 6 | 0 | 0 | 0 | 0 |
| Q | 4 | 0 | 3 | 0 | 0 |
| R | 4 | 0 | 3 | 0 | 3 |
| S | 1 | 10 | 0 | 1 | 317 |
| T | 6 | 23 | 0 | 20 | 257 |
| Total | 162 | 151 | 42 | 62 | 1349 |

Whiskered Auklets on Egg Island between 0100 and 0500 hours, and surveyed on the Baby Islands between 0415 and 0545 hours.

### Tufted Puffin Studies

We counted nesting burrows of Tufted Puffins and monitored their use on Egg Island on four study plots located within accessible portions of steep slopes. We recorded and monitored all burrows of Tufted Puffins that were found on the initial three survey strips per plot (described below). All burrows on these strips received toothpicks, and we rechecked their status at approximately 10-day intervals. During the complete burrow censuses on the plots, accomplished later in the field season, we recorded all Tufted Puffin burrows on all plots, counting only those that appeared to have been used during the current nesting season. On the study plots used for counting nocturnal seabird calls, we did not extricate adults, eggs, or young or excavate any puffin burrows.

Because many Tufted Puffin nest burrows on Egg Island were greater than 1 m in depth we only rarely observed nest contents of this species on the study plots. We determined the proportion of active-appearing burrows occupied by breeding birds by excavating the entrances of a sample of burrows outside of the study plots. On 6 August, two persons determined the contents of all active-appearing Tufted Puffin burrows on a sample plot 3 x 25 m in size located near the base camp (see Fig. 2). We excavated burrow entrances up to a point at which the contents could be seen with the aid of a flashlight. We did not remove nesting adults, eggs, or young, and we reconstructed burrow entrances to the extent possible following viewing of the contents.

### General Observations

We periodically took counts and made estimates of seabird numbers for some species that were highly visible during daylight hours and/or that were relatively uncommon. These counts were made from shore or from inflatable boats and were made with the aid of 8-10X binoculars. Numbers of birds were either counted directly (for flocks of fewer than 100 birds) or estimated by 10's, 100's, or 1000's (for larger groups). We made counts and estimates opportunistically throughout the summer field period. We also made notes on large aggregations of seabirds on waters near the islands we visited.

## RESULTS

### Population Monitoring of Nocturnal Seabirds

Comparisons of observers' hearing abilities led to our discounting one observer's data. There were 11 significant differences ($P \leq 0.05$) in hearing abilities among the four field personnel counting calls on the study plots

(Table 7). Of the 11 significant differences, all but one involved recorder 2 counting fewer calls than the other member of the pair. Adjustments to this person's counts to make them comparable with data from the other three recorders were not warranted because linear regressions of counts between recorder 2 and other recorders showed little correlation ($r^2 < 0.25$). Counts taken by recorder 2 for all species were not considered in further analyses of call-count data.

Cloud cover, disturbance, time, date, and observer factors explained significant amounts of the variation that occurred in the mean calling rates of all four nocturnal-calling species (Table 8). Case-wise values for the predictor variables were then used to calculate the predicted mean calling rate. The residual variation that remained for each call-count session was then calculated as follows:

Residual variance = predicted mean call rate - actual mean call rate

Residual variances were averaged for all count sessions on each plot (Table 9). The mean residual variance was a measue of the amount of calling that was not explained by cloud cover, disturbance, time, date and observer factors. It was reasonable to expect that this quantity would be correlated with the numbers of birds nesting on the individual study plots.

Despite expectations, regression equations showed that there was no correlation ($P > 0.1$) between mean residual variances in calling rate (Table 9) and the numbers of nests of either storm-petrel species occurring on the 20 plots (Table 10). But regressions using Ancient Murrelet and Cassin's Auklet did show significant correlations between nest numbers and residual variance ($P < 0.02$; Table 10), although sample sizes were smaller (14 and 5 plots, respectively). Residual variation explained 40% and 97% of the variance in nest densities of Ancient Murrelets and Cassin's Auklets (Fig. 7), respectively.

Both storm-petrel species nested within Tufted Puffin burrows, so that on Plots E, F, S, and T (plots with puffins) we almost certainly missed some storm-petrel nests during the burrow searches, because we did not wish to destroy active Tufted Puffin burrows in our search for storm-petrel nests. But when we removed data from puffin plots and re-ran the simple regression analysis for each of the three storm-petrel call types, no improvement in the statistical significance of the re-calculated correlation coefficient was found (Table 11).

A similar approach was undertaken in removing plots representing areas with particularly low or high calling densities of petrels, alone or in combination. Again, however, there was no improvement in the statistical significance of the re-calculated correlation coefficients (Table 11).

Table 7. Results of Wilcoxon Ranked Pairs tests on trials involving pairs of field recorders. Recorders are numbered 1-4 and trials were based on 10 repetitions of approximately 15-sec. counts (except for trials of recorder pair 1:2 on Plot J which were based on approximately 30 sec. counts). The critical region of T is represented by: $-1.6449 \le a_{0.05} \le 1.6449$. Significant differences are highlighted in boldface type.

| | Value of Wilcoxon T | | |
|---|---|---|---|
| | | Leach's Storm-Petrel | |
| Recorder Pairs | Fork-tailed Storm-Petrel | Call Type 1 | Call Type 2 |
| Plot D | | | |
| 1:2 | **2.82** | **2.34** | 0.00* |
| 1:3 | -0.35 | **1.67** | 1.00* |
| 1:4 | -0.42 | -1.29 | -0.74 |
| 2:3 | **-2.21** | -0.54 | -0.58* |
| 2:4 | **-2.14** | -0.01 | 1.00* |
| 3:4 | -1.02 | 1.00 | 0.00* |
| Plot J | | | |
| 1:2 | **2.82** | **2.50** | **2.57** |
| 1:3 | -0.36 | 0.74 | 1.51* |
| 1:4 | 1.62 | -0.36 | -1.00* |
| 2:3 | **-2.86** | -1.12 | 0.38 |
| 2:4 | **-2.82** | **-2.11** | 1.00* |
| 3:4 | 1.15 | 1.18 | 0.00* |
| Plot L | | | |
| 3:4 | no count | no count | 1.42* |

* Trials in which ≥ 50% of counts lacked calls.

Table 8. Multiple regression models relating mean call rate and several predictor variables.

**Fork-tailed Storm-Petrel**

Mean calls per minute = -53.63 -4.81(HRSTR2) +25.43(HRSTR) +0.28(JULDAY) - 4.27(REC4) - 4.12(DIST3)

Adjusted $r^2 = .4666$ $F = 69.57$ $P<0.001$

**Leach's Storm-Petrel (Call type 1)**

Mean calls per minute = -36.77 -3.81(DIST2) +11.85(HRSTR) -1.80(HRSTR2) + 0.00075(JULDAY2) +3.42(REC4) +5.48(DIST0) +0.66(CLOUD) - 2.88(REC3).

Adjusted $r^2 = .5567$ $F = 62.85$ $P<0.001$

**Leach's Storm-Petrel (Call type 2)**

Mean calls per minute = -1.84 +2.50(REC4) +1.48(HRSTR) +3.17(DIST0) - 0.19(HRSTR2) +1.66(DIST1).

Adjusted $r^2 = .2492$ $F = 26.82$ $P<0.001$

**Ancient Murrelet**

Mean calls per minute = 23.48 -0.11(JULDAY) +1.15(REC3) -1.26(DIST0).

Adjusted $r^2 = .1341$ $F = 14.11$ $P<0.001$

**Cassin's Auklet**

Mean calls per minute = 14.31 -0.00043(JULDAY2) +4.14(HRSTR) -0.68(HRSTR2) +1.49(DIST1).

Adjusted $r^2 = .3480$ $F = 17.81$ $P<0.001$

Predictor Variables Used In SMRA Equations

| | |
|---|---|
| CLOUD | Cloud cover in tenths |
| DIST0 | No disturbance present? 0 = no, 1 = yes |
| DIST1 | Slight disturbance present? 0 = no, 1 = yes |
| DIST2 | Some disturbance present? 0 = no, 1 = yes |
| DIST3 | Strong disturbance present? 0 = no, 1 = yes |
| HRSTR | Hour that counts in sequence started (0 = midnight) |
| HRSTR2 | Start hour squared |
| JULDAY | Julian date on which counts made (23 June = 174) |
| JULDAY2 | Julian date squared |
| REC1 | Recorder 1 counting? 0 = no, 1 = yes |
| REC3 | Recorder 3 counting? 0 = no, 1 = yes |
| REC4 | Recorder 4 counting? 0 = no, 1 = yes |

Table 9. Mean residual variance in call-counts of four nocturnal seabirds nesting at Egg Island, Alaska.

| Plot | Mean Residual Variance* | | | | |
|---|---|---|---|---|---|
| | FTSP | LCSP (type 1) | LCSP (type 2) | ANMU | CAAU |
| A | -0.63 | 1.06 | -2.46 | — | — |
| B | -3.57 | -1.26 | -0.76 | — | — |
| C | 3.73 | -3.36 | 0.24 | -1.91 | — |
| D | 5.75 | -0.93 | -1.36 | -1.41 | — |
| E | -5.60 | 0.59 | -1.11 | 4.40 | — |
| F | -5.08 | -0.11 | -1.42 | 0.12 | — |
| G | -6.59 | 0.89 | -0.07 | 1.22 | — |
| H | -4.71 | 2.92 | 0.16 | -1.31 | — |
| I | -3.96 | -0.80 | 0.06 | — | — |
| J | -3.39 | 1.55 | 1.93 | — | — |
| K | 0.43 | 3.32 | -0.53 | — | — |
| L | 0.89 | 2.64 | 0.77 | -0.05 | — |
| M | -12.69 | -4.22 | -1.41 | -0.92 | 0.94 |
| N | 10.32 | -2.72 | -2.34 | -2.28 | -1.30 |
| O | 0.47 | 1.48 | 1.12 | -1.08 | -1.74 |
| P | 1.93 | 1.23 | 2.14 | — | — |
| Q | 8.10 | -5.71 | -0.77 | 1.96 | — |
| R | -3.71 | -8.46 | -0.90 | 2.48 | — |
| S | 3.62 | -1.18 | 0.56 | -3.37 | -0.99 |
| T | -1.19 | 0.36 | 0.71 | 0.74 | 0.47 |

* FTSP = Fork-tailed Storm-Petrel, LCSP = Leach's Storm-Petrel, ANMU = Ancient Murrelet, and CAAU = Cassin's Auklet.

Table 10. Regressions between numbers of nests on study plots and mean residual variances in calling rates.

| | | | |
|---|---|---|---|
| **Fork-tailed Storm-Petrel** | | | |
| Number of nests = | (0.33 * Mean Residual Variance) + 8.36 | | |
| | $r = 0.15$ | d.f. = 18 | $P > 0.1$ |
| **Leach's Storm-Petrel (Call type 1)** | | | |
| Number of nests = | -(0.007 * Mean Residual Variance) + 7.55 | | |
| | $r < 0.01$ | d.f. = 18 | $P > 0.1$ |
| **Leach's Storm-Petrel (Call type 2)** | | | |
| Number of nests = | (0.07 * Mean Residual Variance) + 7.57 | | |
| | $r = 0.01$ | d.f. = 18 | $P > 0.1$ |
| **Ancient Murrelet** | | | |
| Number of nests = | (1.70 * Mean Residual Variance) + 3.17 | | |
| | $r = 0.63$ | d.f. = 12 | $P < 0.02$ |
| **Cassin's Auklet** | | | |
| Number of nests = | (14.63 * Mean Residual Variance) + 20.07 | | |
| | $r = 0.94$ | d.f. = 5 | $P < 0.02$ |

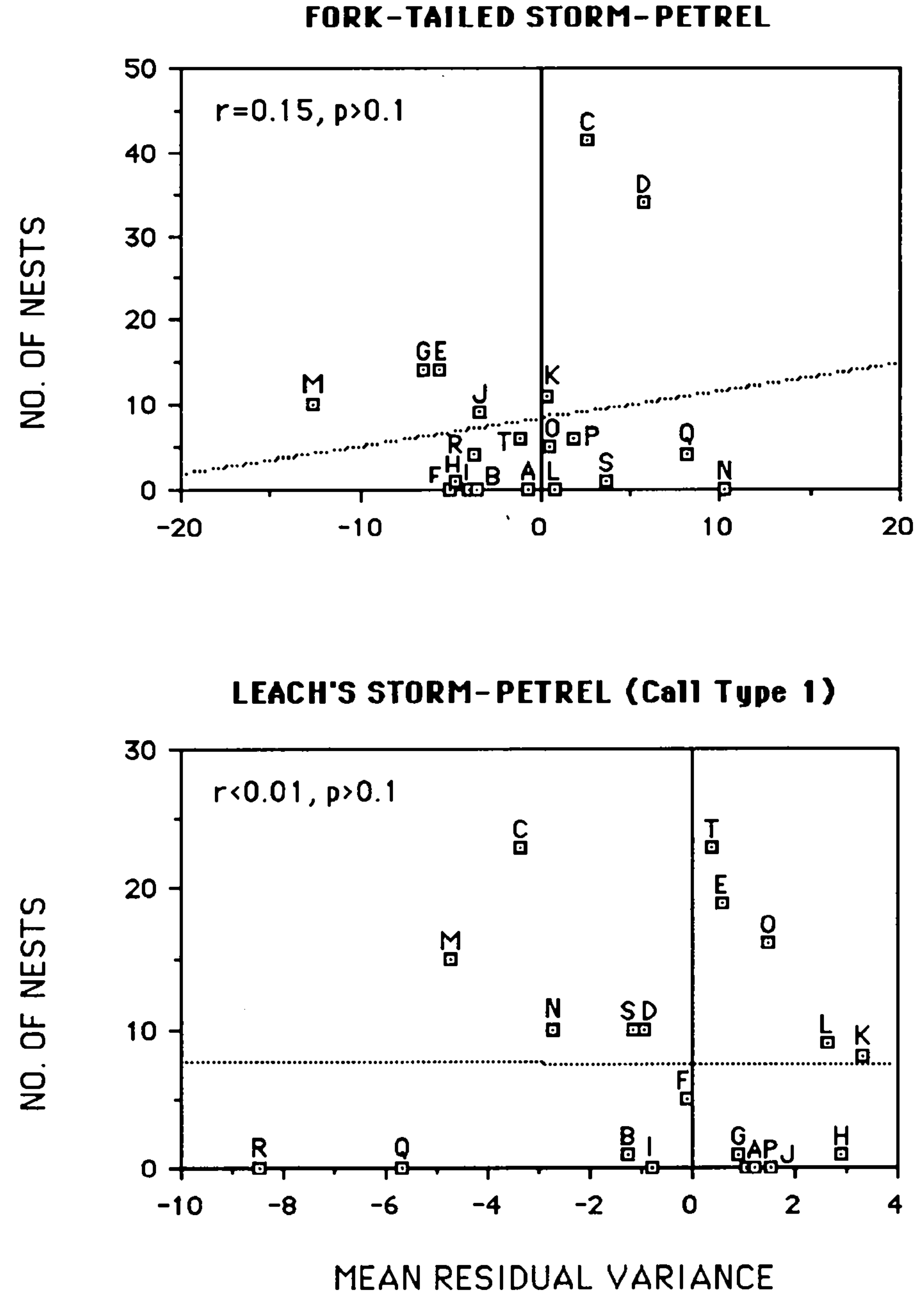


Figure 7. Relationships between the number of nests and mean residual variance in calling rates for three nocturnal seabird species nesting at Egg Island, Alaska. Actual values are plotted. Simple regression lines are also shown.

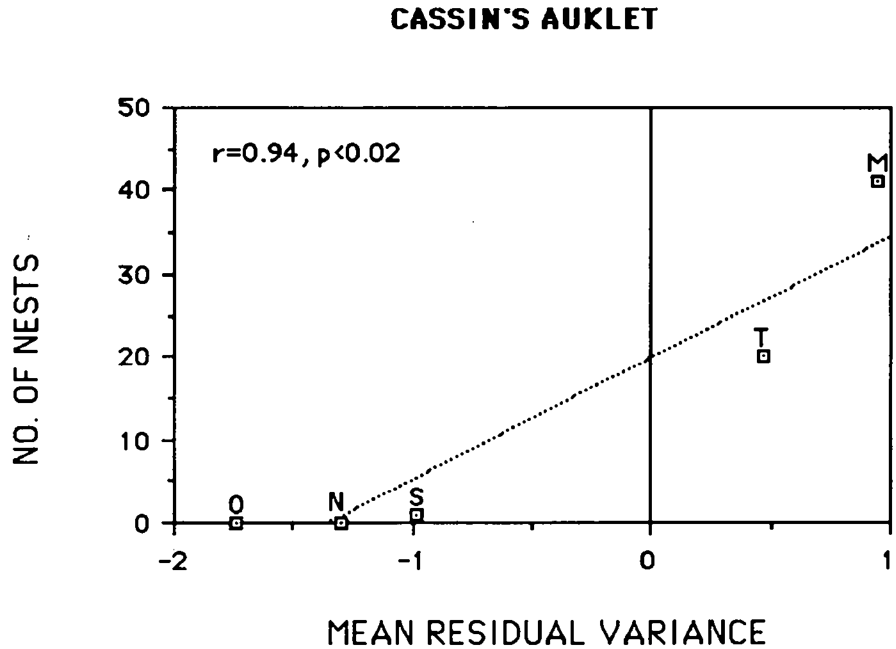


Figure 7 (cont.).

Table 11. Correlation matrix for regressions of number of nests vs. mean residual variances for Leach's and Fork-tailed Storm-Petrels on various sets of sample plots.

| | Fork-tailed Storm-Petrel | | Leach's Storm-Petrel | | | |
|---|---|---|---|---|---|---|
| | | | call type 1 | | call type 2 | |
| Treatment | r | P | r | P | r | P |
| **All Plots** | **0.15** | **>0.1** | **<0.01** | **>0.1** | **0.01** | **>0.1** |
| Remove Puffin Plots (E,F,S,T) | 0.19 | >0.1 | 0.09 | >0.1 | 0.06 | >0.1 |
| Remove High Density Calling Plots (C,D,M,N) | 0.22 | >0.1 | 0.26 | >0.1 | 0.12 | >0.1 |
| Remove Low Density Calling Plots (A,B,Q,R) | 0.19 | >0.1 | 0.40 | >0.1 | 0.22 | >0.1 |
| Remove High and Low Density Calling Plots | 0.32 | >0.1 | 0.11 | >0.1 | 0.19 | >0.1 |
| Remove Puffin and High Density Calling Plots | 0.12 | >0.1 | 0.39 | >0.1 | 0.24 | >0.1 |

There seemed to be no relationship between the calling rates of storm-petrels, as measured in this study, and the numbers of storm-petrel nests occurring on the sample plots. A relationship may have existed between the calling rate of Ancient Murrelets and Cassin's Auklets and their nest densities.

Overflights of storm-petrels were significantly correlated with the numbers of Fork-tailed and Leach's storm-petrel nests on the eight sky-count study plots during July and August (Fig. 8). This indicated that sky-counts of petrels at marked localities in a colony might serve as a monitoring technique. A disadvantage of this approach was that the two species could not be readily distinguished. This disadvantage might be overcome if call-counts conducted simultaneously with sky-counts could provide a reliable indicator of proportions of each species. However, on plots where sky-counts were conducted, we found no correlation between nest ratios and call ratios of Fork-tailed and Leach's storm-petrels during July (Table 12), suggesting that such an approach may not work.

**Whiskered Auklet Studies**

Whiskered Auklets were present as isolated (presumably nesting) pairs occupying sites on vertical cliff faces around the entire perimeter of Egg Island and on both of the Baby Islands visited. We heard calls of Whiskered Auklets on only six of the 20 study plots (Fig. 4), all of which were immediately adjacent to coastal cliffs.

The calling pattern of this species was markedly different from that of the other four nocturnal seabirds. Calling by Whiskered Auklets was most pronounced during the early evening hours of darkness, and again just before daylight (Fig. 9), though some calls were heard throughout the night. Activity of the birds on land was usually restricted to those light levels at which it was very difficult for field personnel to obtain identifiable views of the birds against the cliffs without the aid of portable lights. Although a period of calling often occurred just after nightfall, calling was highly variable at this time (Fig. 10) and frequently absent altogether. A greater rate of calling was noted from 0500-0600 hours than at any other period of the night.

We undertook a census of two of the Baby Islands that were previously investigated by Nysewander et al. (1982), and counted Whiskered Auklets during the peak calling period. A total of 44 calling birds (at 29 sites) on Tangagm Island, and 27 calling birds (at 24 sites) on Excelsior Island were found (Fig. 11).

Our censuses of Whiskered Auklets on Egg Island were conducted throughout the night and revealed 20 calling birds (at 17 sites; Fig. 12). This is

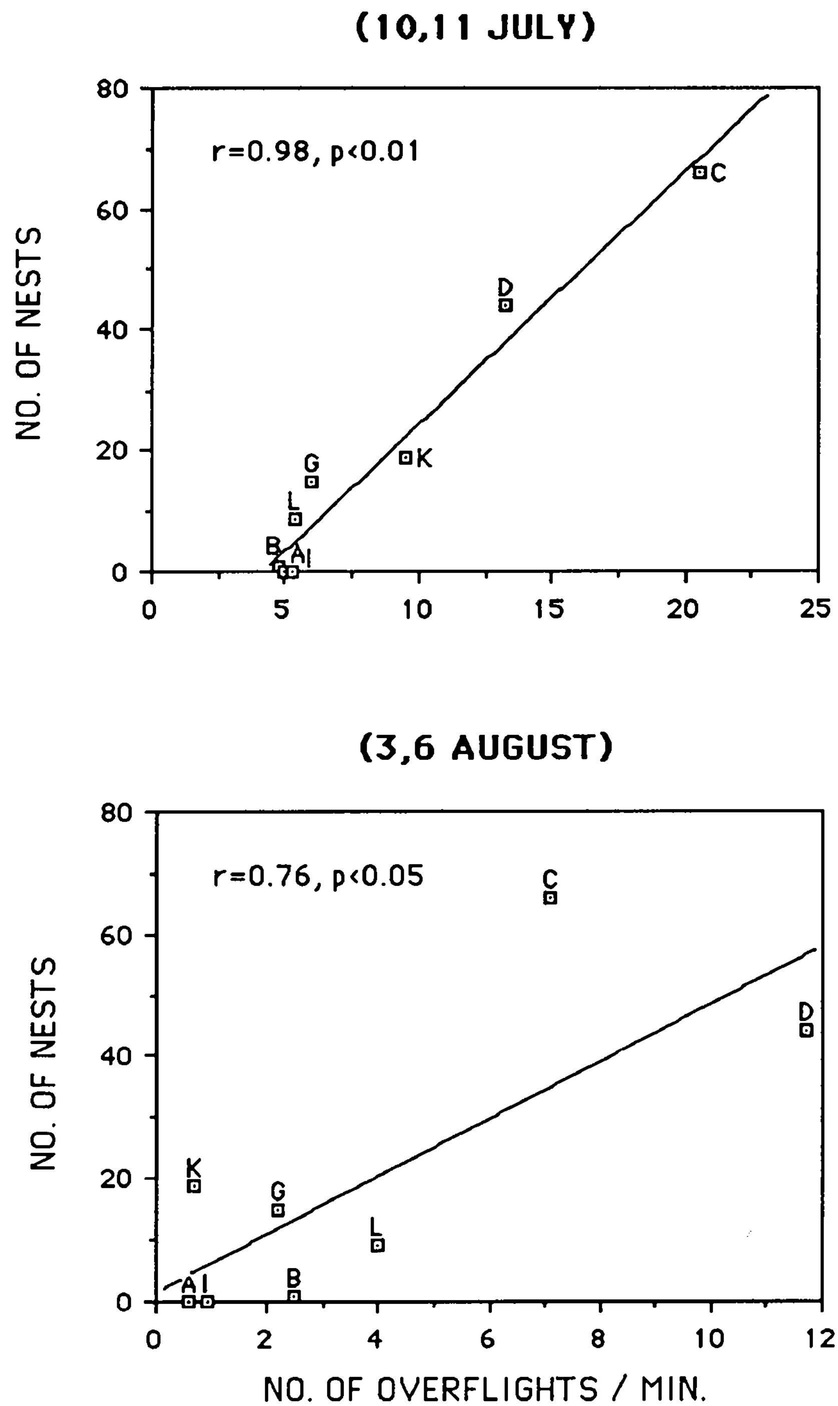


Figure 8. Relationships between the number of nests and the number of overflights of storm-petrels (both Fork-tailed and Leach's) on sampled plots at Egg Island, Alaska. Simple regression lines are shown.

Table 12. Correlations between nest ratios[1] and call ratios[2] for Leach's (LCSP) and Fork-tailed Storm-Petrels (FTSP) on plots[3] where sky-counts were conducted.

| | | Call Ratios from 02:00-03:00 hours | | | |
|---|---|---|---|---|---|
| | Nest Ratios | FTSP/LCSP | r | FTSP/LCSP | r |
| Plot | FTSP/LCSP | (type 1) | (P) | (type 2) | (P) |
| **Actual calls per minute** | | | | | |
| B | 0.00 | 3.02 | | 5.27 | |
| C | 1.87 | 4.92 | | 19.68 | |
| D | 3.40 | 2.75 | 0.47 | 31.13 | 0.39 |
| G | 14.00 | 1.88 | (>0.1) | 1.82 | (>0.1) |
| K | 1.38 | 2.15 | | 25.04 | |
| L | 0.00 | 3.07 | | 166.63 | |
| **Predicted calls per minute** | | | | | |
| B | 0.00 | 2.59 | | 16.06 | |
| C | 1.87 | 2.18 | | 8.64 | |
| D | 3.40 | 2.18 | 0.61 | 8.64 | 0.43 |
| G | 14.00 | 1.88 | (>0.1) | 9.90 | (>0.1) |
| K | 1.38 | 3.64 | | 76.71 | |
| L | 0.00 | 3.69 | | 77.76 | |
| **Residual calls per minute** | | | | | |
| B | 0.00 | 2.25 | | -13.89 | |
| C | 1.87 | -0.81 | | -3.19 | |
| D | 3.40 | 0.23 | 0.32 | 0.29 | 0.47 |
| G | 14.00 | 1.88 | (>0.1) | -0.77 | (>0.1) |
| K | 1.38 | 0.19 | | 1.39 | |
| L | 0.00 | 0.91 | | -11.11 | |

[1] Plots A and I were not considered. No nests of either species were found and the resulting nest ratio (0:0) is undefined.

[2] Nest data from Table 6.

[3] Call-count data were obtained on the following nights: plots B and G, 16 July; all other plots, 3 July.

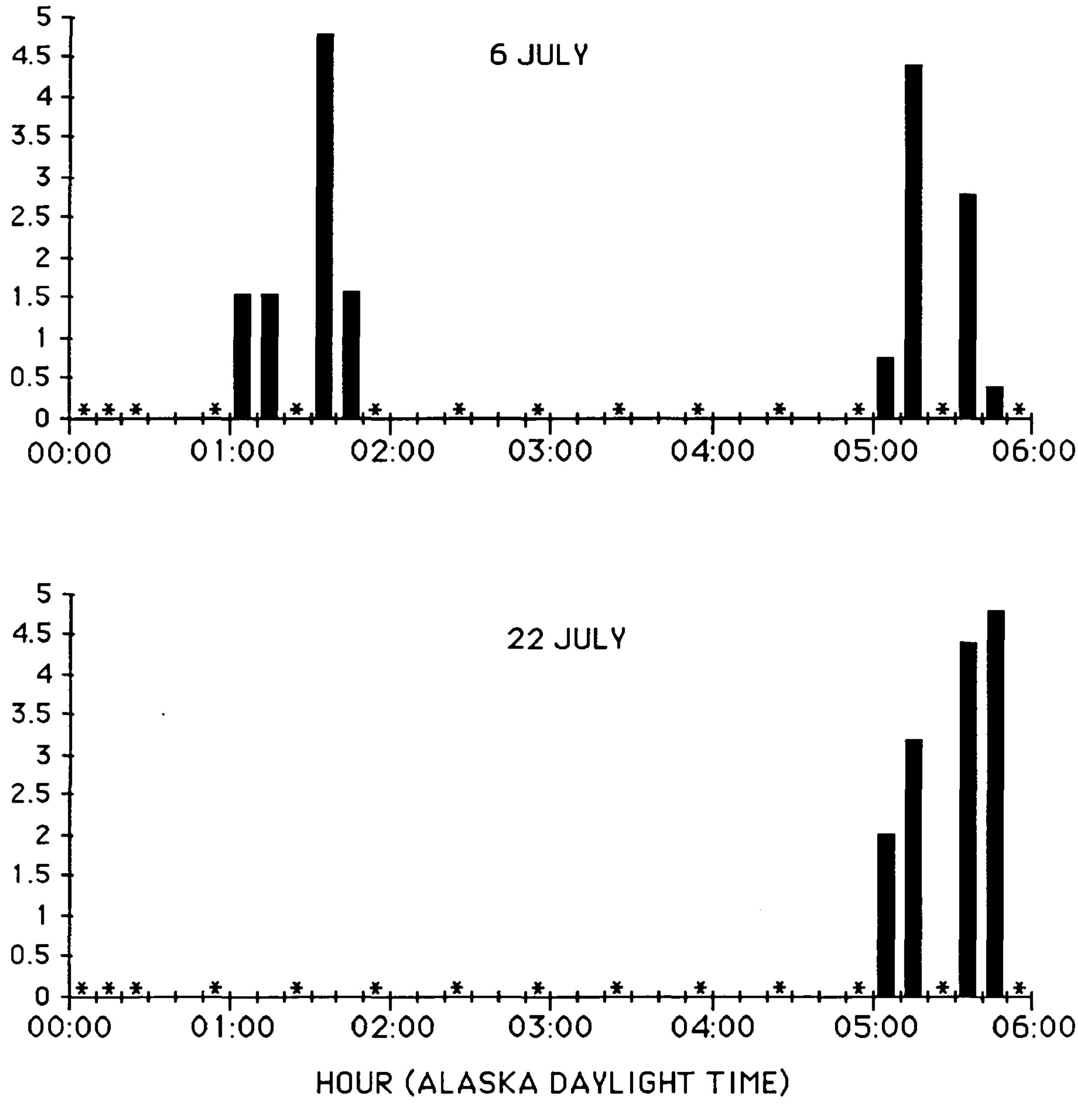


Figure 9. Nocturnal calling rate of Whiskered Auklets at Plot M, Egg Island, Alaska, on two nights. Both counts were made by the same recorder. Asterisks (*) indicate ten-minute periods for which no counts were taken.

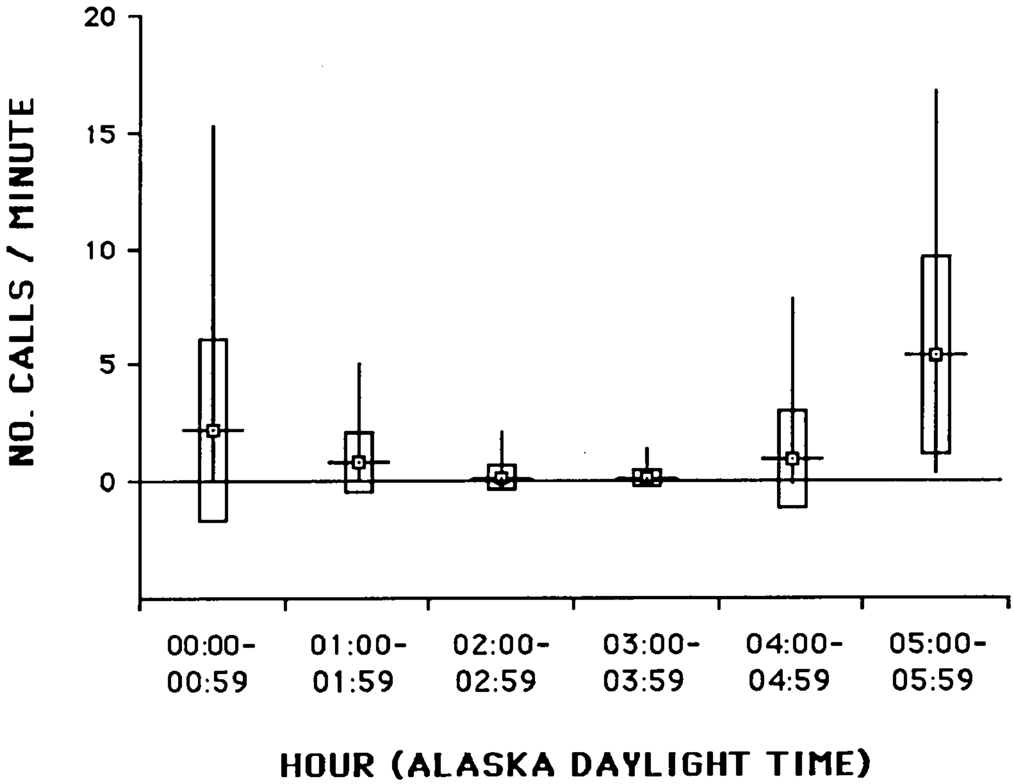


Figure 10. Nocturnal calling rate of Whiskered Auklets on six study plots at Egg Island, Alaska. Data were recorded from 26 June through 1 August 1989. Center point = mean, vertical bar = range, and box = standard deviation.

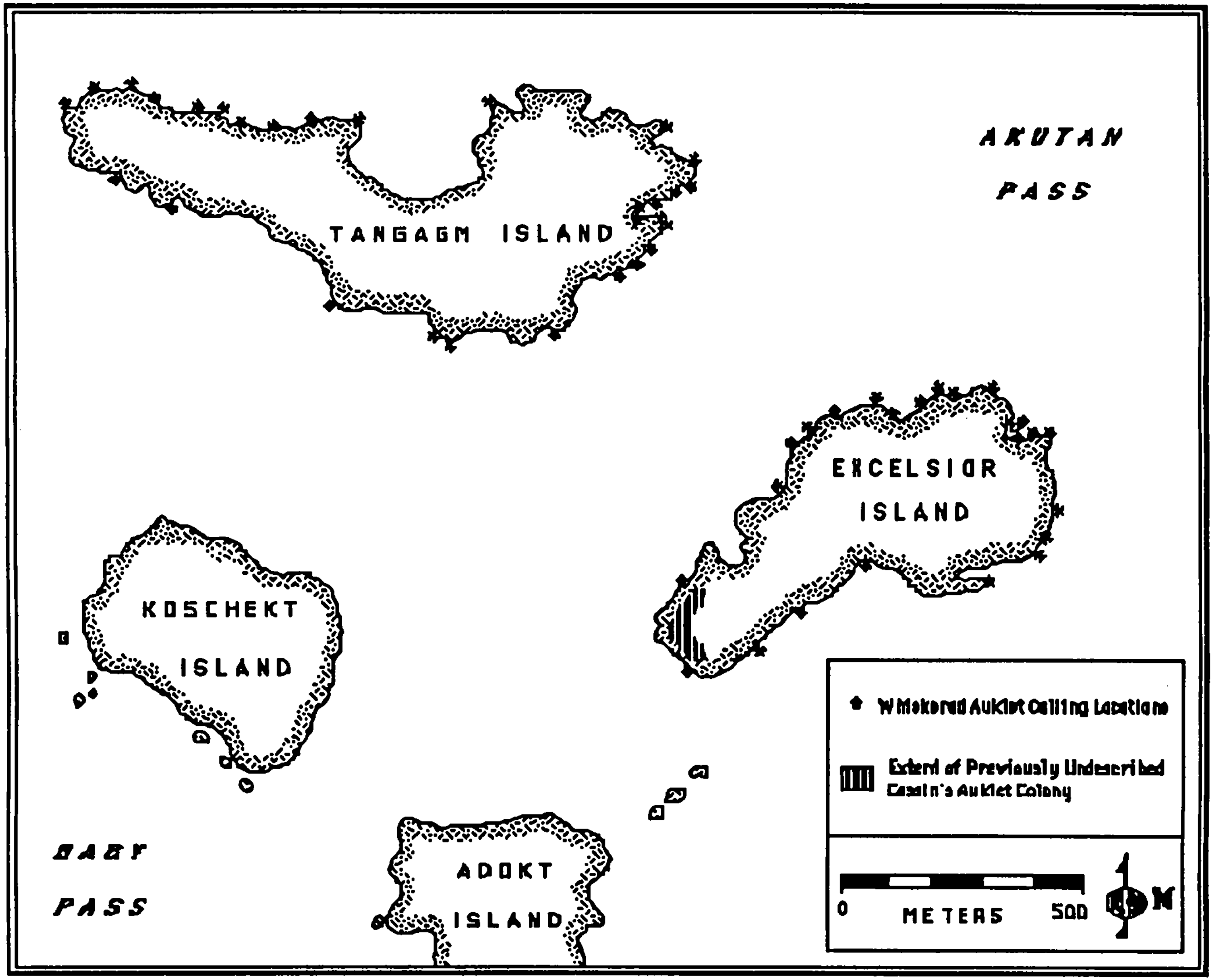


Figure 11. Locations of calling sites of Whiskered Auklets on Tangagm and Excelsior islands and in the Baby Islands, Unimak Pass, Alaska. A previously unreported Cassin's Auklet colony is also shown. (see Fig. 1 for location of Baby Islands.)

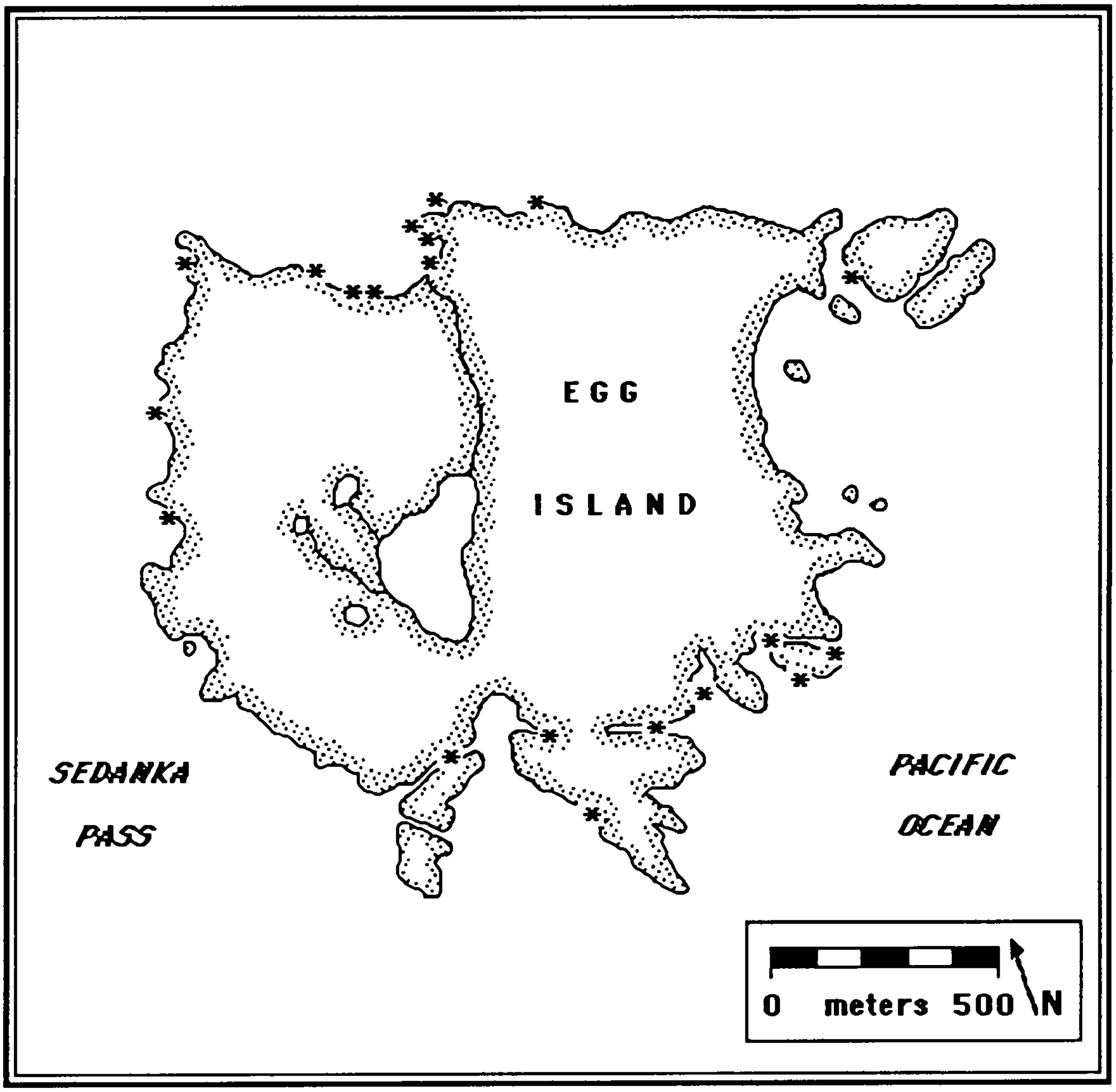


Figure 12. Locations of calling Whiskered Auklets at Egg Island, Alaska on 27 and 29 June 1987. (see Fig. 1 for location of Egg Island.)

probably a low estimate, however, because these counts took place throughout the night and we were unable to repeat the census exclusively during the pre-dawn period.

### Tufted Puffin Studies

Shore-based observations of Tufted Puffins on the waters surrounding Egg Island on 7 July yielded an estimate of from 180,000 to 200,000 birds present. The counts were made during the laying/early incubation phase of the nesting cycle, and there were relatively few birds standing at the entrances to burrows on the island at the time. Birds from nearby colonies (e.g., the Baby Islands), however, may have also been present in this large aggregation of puffins. Nysewander et al. (1982) estimated that 163,316 breeding Tufted Puffins used Egg Island.

Puffin burrows varied in number among the four study plots that overlapped puffin colonies (see Table 6). But burrow densities were remarkably similar within colony boundaries, especially if terrain slope was similar. On plots E and F, puffin habitat occurred on very steep slopes and occupied approximately 597 and 346 $m^2$ of these plots, respectively, yielding densities of 0.81 and 0.82 burrows/$m^2$. In the more gentle terrain found at plots S and T, puffin nesting burrows occupied approximately 513 and 381 $m^2$ of the plots, respectively, and yielded densities of 0.62 and 0.67 burrows/$m^2$. On the 75 $m^2$ plot near the base camp where we excavated puffin burrow entrances, the 52 burrows found yielded a density of 0.69 burrows/$m^2$.

All burrows excavated had well-defined nest chambers at the distal end. Mean burrow depth was 1.16 (±0.53) m and ranged from 0.2 to 3.0 m. Of the 52 active-appearing nest burrows found on the survey strip, 17 contained an egg and one contained a small chick (both usually contained an attending adult as well), yielding a breeding occupancy of 34.6 percent. An additional 13 burrows contained nest chambers lined with grass but no egg or chick.

Of 167 burrows monitored on the regular plots, all but two burrows were used at some time by seabirds (probably puffins). Toothpicks at burrow entrances were regularly knocked over or more frequently missing when observers rechecked the burrows. On this basis, we calculated an occupancy of 98.8 percent for all burrows monitored on the four plots. This does not mean that the burrows were occupied by breeders because, as noted above, a much lower percent of the the 52 sample burrows excavated contained adults with eggs or chicks.

### General Observations

Approximate distribution of nesting seabirds on Egg Island in 1987 is presented in Figure 13. Our estimates of seabird numbers in comparison with

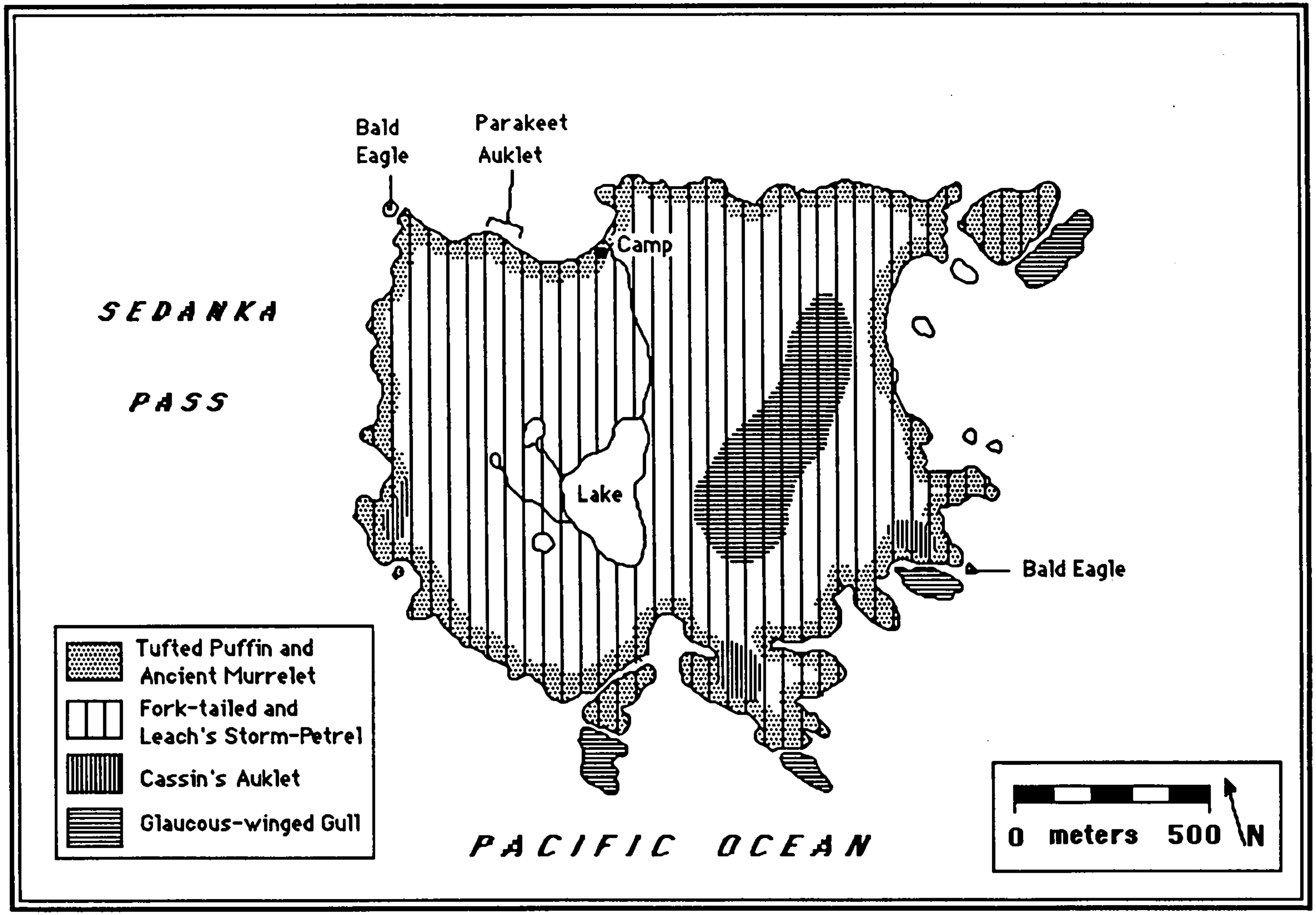


Figure 13. Approximate distribution of nesting seabirds at Egg Island, Alaska.

estimates made by Nysewander et al. (1982) based on 1980-81 studies appear in Table 13. How our estimates relate to breeding populations for most species is unknown. For example, we observed Horned Puffins daily on the waters near the island but never recorded them on the cliffs in potential nesting habitat. Similarly, we observed Pigeon Guillemots swimming near the island daily, but we also saw them flying into nest sites carrying fish to calling young so we are confident that they nested on the island.

Major differences in seabird numbers we observed in 1987 compared with those reported by Nysewander et al. (1982) include:

(1) We found no cormorants in 1987; Nysewander reported several hundred in 1980-81.

(2) Glaucous-winged Gulls apparently failed to produce any young in 1987. Similar numbers of adults were present as in 1980-81, but very few eggs were found, and we never observed a chick during our stay, although nest sites were occupied by pairs. We also noted use of small islets around Egg Island for additional limited nesting by this species.

(3) Based on counts of birds on the water, we found similar or higher numbers of Tufted Puffins than did Nysewander based on burrow counts.

(4) We found a small colony of approximately 30 Parakeet Auklets among beach boulders on the northwest corner of Egg Island. Adults were observed landing on beach boulders and disappearing into crevices.

(5) We found no definite Horned Puffin nest sites on Egg Island; Nysewander reported them "present". We observed them resting on the water daily within 100 m of the island, and during a circumnavigation of Egg Island by boat on 9 July, we observed approximately 150 of them resting on the water within 100 m of the island. Crevice nest sites could have occurred on some inaccessible cliffs.

In addition to the seabirds seen on Egg Island, we observed two other Tufted Puffin colonies on nearby islets along the coastline of Sedanka Island (Fig. 14). We travelled along the north shore of Sedanka Island, and in the area of Old Man Rocks, but noted no puffin concentrations nor other potential seabird colony sites (except for small numbers of Pigeon Guillemots) in these areas. During Whiskered Auklet censuses on the Baby Islands, we also noted the presence of a previously unreported colony of Cassin's Auklets on the west end of Excelsior Island (see Fig. 11).

Table 13. Estimated numbers of seabirds seen on or near Egg Island, Alaska in 1980-81 (Nysewander et al. 1982) and in 1987.

| Species | 1980-81 | Method | 1987 | Method |
|---|---|---|---|---|
| Fork-tailed Storm-Petrel | 200,000 | Extrapolation from burrow counts | | No estimate made |
| Leach's Storm-Petrel | 70,000 | Extrapolation from burrow counts | | No estimate made |
| Double-crested Cormorant | 82 | Actual count of birds or nests | 0 | Count by boat along shoreline |
| Pelagic Cormorant | 20 | Estimate probably within 25% | 0 | Count by boat along shoreline |
| Red-Faced Cormorant | 598 | Actual count of birds or nests | 0 | Count by boat along shoreline |
| Glaucous-winged Gull | 1508 | Adjusted from counts of adults and/or nests | ~2000 | Estimates of adults at nesting colonies |
| Pigeon Guillemot | 350 | Adjusted from counts of adults on the water | ~200 | Estimates of adults on the water* |
| Ancient Murrelet | 5000 | Estimate probably within 50% | | No estimate made |
| Cassin's Auklet | 2000 | Estimate probably within 50% | | No estimate made |
| Whiskered Auklet | 10+ | Present in this plus unknown number more | 20+ | Counts of calling adults on cliffs |
| Horned Puffin | + | Present in unknown numbers | ~150 | Estimates of adults on the water* |
| Tufted Puffin | 163,316 | Extrapolated from counts of burrows | 180,000 to 200,000 | Estimates of adults on the water* |
| **TOTAL** | **442,906** | | | |

* Includes birds seen resting on the water within 200 m of the island.

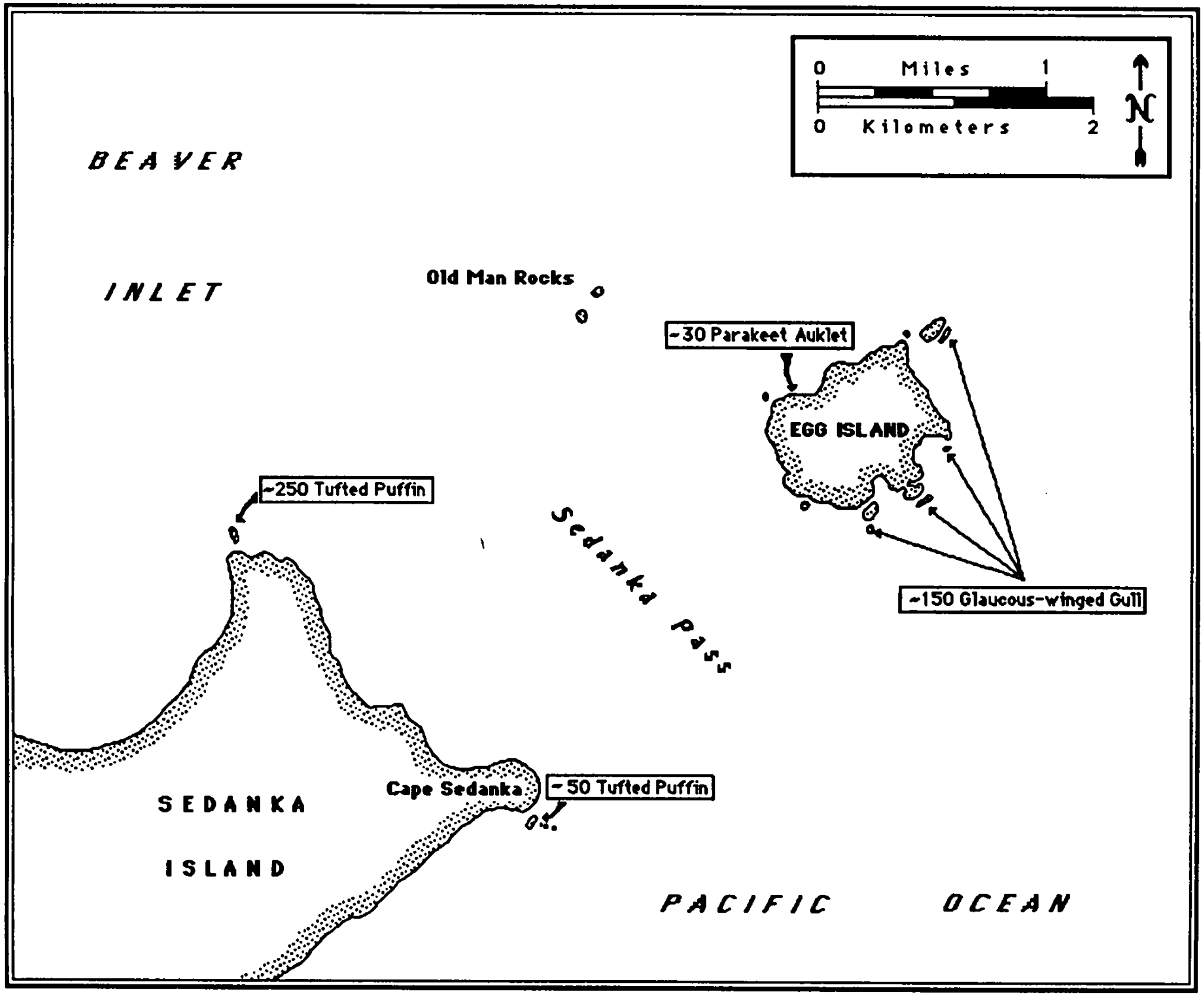


Figure 14. Locations of seabird colonies found in summer 1987 but not previously reported by Nysewander et al. (1982).

Feeding flocks of Whiskered Auklets were observed near Egg Island, the Baby Islands, and surrounding straits and passes in summer. Smaller flocks of up to 200 birds each were commonly seen in Sedanka Pass, Unalga Pass, at the mouth of Beaver Inlet, and in the straits between Egg Island and Unalga Island throughout the summer field period. During trips to the Baby Islands, we noted several flocks of over 1000 Whiskered Auklets approximately 1 km south of these islands and off Unalga Island in mid-July. Groups of auklets were most often associated with tide rips and other areas of strong currents, as previously noted by Byrd and Gibson (1980). On 14 July we counted approximately 11,400 Whiskered Auklets as they passed from west to east, flying from feeding sites in Unalga Pass eastward along the south side of Unalga Island. These flocks streamed past the island continually for almost an hour in late afternoon.

Other aggregations of seabirds in the area were usually associated with colony sites. As mentioned previously, concentrations of close to 200,000 Tufted Puffins were seen daily around Egg Island. We observed smaller groups on the waters at nearby small colonies around Sedanka Island. Flocks of Tufted Puffins numbering in the low 10,000's were also present on waters around the Baby Islands, where they nested on every island in the group. Other species of seabirds were present in small flocks or as isolated pairs and individuals throughout the inter-island area, but no notable concentrations were seen. Flocks of dark shearwaters (Short-tailed or Sooty) were frequently seen flying between islands toward either the Bering Sea or Pacific Ocean, but these birds rarely rested on waters near the islands.

## DISCUSSION AND RECOMMENDATIONS

### Population Monitoring of Nocturnal Seabirds

A prime objective of this study was to evaluate the call-count technique as a method for monitoring population trends of nocturnal seabirds. Ideally, any monitoring technique should; a) provide an accurate index of population trends, b) be easy to carry out, c) be readily transferable among different workers, and d) cause negligible disturbance to breeding birds (Gaston et al. 1988). Call-counts are an attractive technique because they offer the potential for standard, repeatable surveys that would cause considerably less disturbance to nesting birds than more traditional burrow-inspection techniques. Below, we discuss the usefulness of various techniques in monitoring the population levels of Fork-tailed and Leach's Storm-Petrels, Ancient Murrelets, and Cassin's Auklets.

### Fork-tailed and Leach's Storm-Petrels

The call-count technique, as employed in this study, was found to be an inappropriate method for estimating the population levels of nesting storm-petrels. Our poor success in correlating call frequency and nest density probably resulted from several basic problems. Often a single problem would be exacerbated when present in combination with other problems.

(1) Scale of Measurement—Call-counts were conducted from near the centers of 25 X 25 m sample plots. It was usually impossible to accurately determine whether a given call occurred on or above a sample plot, near it, or farther away. The ability to hear calls and to estimate their distance varied with the observer, weather conditions, volume of calls, and distance from the observer of each call. The overwhelming cacophony of calls at several plot locations meant that it was impractical to accurately estimate the distance at which a bird was calling without losing track of a number of other calls. As a result, we recorded all calls for which we could determine a distinct beginning and end. Therefore, the call-count plots were of an undefined and probably temporally-varying size, whereas the plots from which we determined nesting density were of fixed size. Call-count plots probably were not representative of nesting densities that we found nearby in other plots.

(2) Recorder Abilities—Prior to undertaking formal call-counts, recorders listened to calls as a group, compared their approaches in accepting vs. rejecting questionable storm-petrel calls and their methods of recording data, and agreed upon a set of standard procedures. Near the end of the study period, we conducted paired comparisons of recorder abilities. We found that one recorder consistently counted fewer calls than other recorders. In spite of our efforts to standardize measurement techniques, plus a season's experience at counting calls, the significant differences found in recorder abilities suggest that the call-count techniques we employed are not generally transferable among workers. Furthermore, the recorder was also a significant predictor in estimating mean calling rates for storm-petrels. This indicates that variable recorder capabilities existed among all recorders throughout the study period.

(3) Operational Considerations—The call-counts made during this study were usually conducted during calm weather periods with little or no precipitation. It was clearly evident that high winds, pounding surf, or driving rain severely compromised a recorder's ability to hear storm-petrel calls. On some nights, counting had to be discontinued due to deteriorating weather conditions, and on many more nights, sampling was not even attempted. Multivariate analyses showed that weather disturbance affected the rate of calling in both storm-petrel species--calling rates were high with little weather disturbance and generally decreased with increasing disturbance. The windy and rainy summer weather typical of the Aleutians suggests that call-count techniques cannot necessarily be undertaken easily on a given study site.

(4) Biological Considerations—Several biological considerations affect the usefulness of call-count techniques for monitoring population levels of storm-petrels. First, the numbers, activities, and extent of vocalization of non-breeding storm-petrels visiting nesting islands are largely unknown. British Storm-Petrels (*Hydrobates pelagicus*) first return to colonies at two or three years of age, flying over the colonies at night but not occupying burrows. They take ownership of a burrow a year or two later, and first breed when four or five years old. Failed breeders apparently behave like nonbreeders. Furness and Baillie (1981) noted considerable variation in the relative numbers of breeders vs. non-breeders on St. Kilda Island. Harris (1974) also noted that suspected non-breeding Leach's Storm-Petrels visited colonies in California, and the same is presumably true of Fork-tailed Storm-Petrels. If non-breeders call at sampling sites, considerable bias is thus introduced to the use of call-counts as a measure of breeding populations. Second, breeding storm-petrels do not necessarily visit their nesting islands every night (Boersma and Wheelwright 1979; Quinlan 1979), and breeding activities can extend over several months (e.g. Byrd and Trapp, in prep.). Third, we noted that there appeared to be general approaches to interior portions of the island that were used by large numbers of calling birds; such areas (e.g. plots A and B) had virtually no nesting birds. Finally, storm-petrel behavior is affected by ambient light conditions (Quinlan 1979, Watanuki 1986), with fewer birds visiting nesting

islands on moonlit nights. It would have been difficult to control our sampling procedures for any of the biological considerations except ambient light conditions.

Given all of these problems, it is perhaps not too surprising that call-counts of the two storm-petrel species were not correlated with nest density on the 25 X 25 m sample plots. Call-counts were not useful measures of the abundance of either Fork-tailed or Leach's Storm-Petrels nesting on Egg Island.

In contrast, sky-counts correlated well with the numbers of nesting storm-petrels on eight plots sampled in July and August. This technique is reasonably quick, and causes very little disturbance to nesting birds. The technique is somewhat constrained by driving rain, but it could probably be successfully implemented in stronger winds than could call-counts. The strong correlation between counts of birds in overflights and nest densities suggests that the presence of non-breeders may not invalidate this technique.

The main problem with sky-counts is our present inability to distinguish between the two species of storm-petrel while looking upward at the night sky. Until this problem can be solved, species-specific information from sky-counts will not be obtainable in multi-species colonies of storm-petrels. Future workers should also investigate possible inter-observer variation in the ability to observe night-flying birds.

**Ancient Murrelets**

The results of this study suggest that call-counts may offer potential for monitoring Ancient Murrelet populations. Gaston et al. (1988), however, found the frequency of vocalizations of Ancient Murrelets to vary enormously on plots established at Reef Island in the Queen Charlotte Islands, British Columbia. On some nights, no calls were heard, while on others, more than 200 were recorded in the first 100 min. These authors concluded that vocalization rates were not very useful in monitoring the numbers of birds using a single plot.

It is possible that many of the calls recorded by us were given by prospecting non-breeders, since many of our call-count surveys were conducted after unknown numbers of adult Ancient Murrelets and their chicks had left Egg Island. However, unlike storm-petrels, Ancient Murrelets seem to have more direct flight routes from the sea to their nesting areas, so we were probably less influenced by calls emanating from birds not associated with the sampled study plot.

The use of knock-down tags, placed at the burrow entrances and checked daily, provided less variable estimates of the numbers of Ancient Murrelets using a study area on the Queen Charlotte Islands than did call-counts, but caused more disturbance to birds (Gaston et al. 1988). Further, use of the tag technique requires a large level of effort to detect even a 20% difference in the proportion of burrows occupied. Thus it is probably worthwhile to further investigate the use of call-counts as a potential technique for estimating numbers of nesting Ancient Murrelets.

In future work, call-counts should begin earlier in the season than was possible in this study, knock-down tags should be monitored on all sample plots, and burrow examination should be conducted as late in the study period as is practical. It would also be valuable to measure more environmental and habitat variables as potential reasons for call-count variance.

**Cassin's Auklets**

It appears that call-count techniques offer good potential for monitoring numbers of Cassin's Auklets. Similar to Ancient Murrelets, their behavior of flying directly to and from nesting areas and the sea, and their tendency to call mostly from the top of or below ground surface probably reduces the variation in calling rates introduced by individuals not associated with the site under investigation.

Because Cassin's Auklet burrows are easily distinguishable (e.g., DeGange et al. 1977, Nysewander et al. 1982, Gaston et al. 1988), call-counts combined with burrow-counts should enable future workers to establish relationships between these variables for other colonies. Further information on nesting success at Egg Island would be difficult to obtain easily, due to the extreme lengths of the majority of Cassin's Auklet burrows. Relatively new developments in fiber-optic equipment may be useful for inspecting burrows.

## Whiskered Auklet Studies

Monitoring breeding populations of Whiskered Auklets by any technique is difficult. Characteristics of the breeding biology which complicate population monitoring include:

(1) Nest site selection is variable across the nesting range; sites include rock crevices in cliffs in the eastern Aleutians (Nysewander et al. 1982) and talus slopes and beneath beach boulders at Buldir Island (Knudtson and Byrd 1982). Nest sites are invariably difficult to access by human researchers.

(2) Nesting densities are low, with pairs probably scattered along all suitable nesting cliffs in the eastern Aleutians, including many larger islands (e.g., Tigalda and Akun--Nysewander et al. 1982).

(3) Activity patterns at colonies are also variable. In the western Aleutians, birds on Buldir Island visited land during the day (although near dusk and dawn) (Byrd et al. 1983), but in the eastern Aleutians they visited land at night (Nysewander et al. 1982, this study).

(4) Activity on land at night is bimodal. Instead of calling at the colonies throughout the night as do many other nocturnal seabirds, Whiskered Auklets call for approximately an hour immediately after dark, call sporadically at night, and are most active for approximately an hour just prior to daylight.

It would be possible, but difficult, to monitor the Whiskered Auklet population in the eastern Aleutians by call-counts. Because of the inaccessibility of nests on Egg Island, we could not compare call-counts with breeding effort. But the loudness of the calls of this species made it relatively easy to pinpoint presumed nest locations on maps, and the restricted nesting habitat (crevices in coastal cliffs) helped to narrow the area to be censused. If all or at least a large and consistent majority of nesting pairs call from the nest site just prior to sunrise, counts at this time in appropriate habitat could be useful in monitoring populations. The restricted period of calling, however, will limit the amount of habitat that can be censused by an individual or team of workers. During counts on Tangagm and Excelsior islands, four team members were able to census each island thoroughly from 0415 to 0545. Islands larger than these would be difficult to census during the peak calling period using the same number of persons.

## Tufted Puffin Studies

Tufted Puffins present several problems to researchers attempting to monitor population levels. This species is known to be particularly sensitive to disturbance at the nest site, frequently abandoning breeding efforts after even a single visitation by field researchers (Pierce and Simons 1986, Baird and Jones 1986). Destruction of burrows by persons walking though colonies is also a potential hazard. In addition, preferred nesting habitat at most colonies is on very steep slopes, and is frequently inaccessible without appropriate climbing equipment. Tufted Puffins also vocalize only infrequently at the colonies, and the low-pitched quality of the call does not carry far. Further, the tendency for adults to appear at the entrance of burrows also seems to be highly variable between colony sites. At some locations, adults may stand near burrow entrances for considerable portions of the day (pers. obs.; D.G. Roseneau, pers. comm.), but on Egg Island puffins seldom stood near burrows, usually entering and exiting as rapidly as possible. The abundance of Bald Eagles (*Haliaeetus leucocephalus*), a known predator, may have contributed to this behavior.

Techniques for population monitoring of Tufted Puffins may be most practical through use of burrow-inspection techniques. Monitoring by burrow-counts should not require use of the same sample area from year to year if the sampling is carried out appropriately. This would allow use of plot or transect techniques even if disturbance is a problem. However, at least on Egg Island, burrows are very deep and in some years appear to contain far fewer breeding birds than the inter-colony average. Obtaining information on breeding occupancy would require sacrificing the breeding effort of most of the birds sampled, because of the extent of excavation required to obtain these data. Repeated monitoring in this fashion could lead to major alteration of nesting habitat. Puffins on Egg Island also appear to at least periodically inspect almost every available burrow, and monitoring of activity at burrows would not in itself be highly useful. Clearly a technique that involves remote observations of samples of burrows, or methods of inspecting burrows that require minimal disturbance to the birds, would be most useful for monitoring puffins. Use of flexible glass fiber-optical equipment for inspecting nest burrows may prove valuable for monitoring purposes, although this technique has not proven very useful for Ancient Murrelets, another burrow-nesting species (Gaston et al. 1988).

Monitoring of breeding Tufted Puffins would best occur during the early chick-rearing period. At this time, puffins are less prone to desert nests, no new nests would likely be initiated afterward, and chicks would not yet have fledged. Timing of monitoring activities would require careful planning, because breeding chronology differs among colonies and can be quite prolonged within a colony. Our studies indicated the breeding chronology of Tufted Puffins on Egg Island was later than at colonies in the western Gulf of Alaska. Most puffins were on eggs and only one newly-hatched chick was found on 6 August, about the time most hatching is completed at colonies farther east (Baird and Jones 1986).

## General Observations

We found the species compositions of the colonies we visited to be generally similar to those reported by Nysewander et al. (1982). The absence of nesting cormorants on Egg Island in 1987 was not considered alarming because cormorants are known to use different nest sites from year to year, abandoning entire colonies in the process (Palmer 1962, Sowls et al. 1978).

The nesting failure of Glaucous-winged Gulls on Egg Island could have been caused by poor body condition of breeding adults, poor weather, predation, or other factors, but may also have been human-related. Local natives used the gull colony on nearby Koschekt Island (Baby Islands) for subsistence egging in June 1980 (Nysewander et al. 1982), and they may have used Egg Island in 1987 for this purpose before our arrival. We found no evidence of recent human presence on Egg Island; however, if egging similarly took place in early June, grass growth would have likely covered human sign by the time of our arrival in late June. The fact that this, and many other islands throughout Alaska, are called "Egg Island" often reflects the use of these islands by natives to gather eggs. Colonies of large gulls are frequently used as egg sources because of the relatively easy access to nests (which are often on level terrain) and the large size of the eggs.

Similar to the findings of Byrd and Gibson (1980), Whiskered Auklets congregated in flocks within tide rips and other areas of strong current convergence during the summer as well as at other seasons. Summer concentrations of this species at times were large; we found over 1000 birds per flock in several flocks south of Unalga Island and the Baby Islands in mid-July. Nysewander et al. (1982) also reported large flocks of this species, primarily in Avatanak Strait, but they also found smaller numbers near the Baby Islands. Flocks of auklets during the breeding period, however, would disperse in the evening, with at least breeding adults moving to nest sites scattered throughout the nearby islands.

Tufted Puffins were also concentrated in large, dense flocks during the breeding period, primarily in areas immediately adjacent to the nesting islands. These flocks dispersed and reformed throughout the day during the breeding season.

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