POPULATION ESTIMATES AND TEMPORAL TRENDS OF PRIBILOF ISLAND SEABIRDS

by

F. Lance Craighead and Jill Oppenheim

Alaska Biological Research
P.O. BOX 81934
Fairbanks, Alaska 99708

Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 628

November 1982

ACKNOWLEDGEMENTS

Dan Roby and Karen Brink, University of Pennsylvania, Philadelphia, were especially helpful to us during our stay on St. George and shared their observations with us. Bob Day, University of Alaska, Fairbanks, also provided comparative data from his findings on St. George in 1981. We would like to thank the Aleut communities of St. George and St. Paul and Roger Gentry and other NMFS biologists on St. George for their hospitality and friendship. Bob Ritchie and Jim Curatolo edited an earlier version of this report. Mary Moran drafted the figures. Nancy Murphy and Patty Dwyer-Smith typed drafts of this report. Amy Reges assisted with final report preparation. Finally, we'd like to thank Dr. J.J. Hickey for initiating seabird surveys on the Pribilof Islands, which were the basis for this study.

This study was funded by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, as part of the Outer Continental Shelf Environmental Assessment Program.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

EXECUTIVE SUMMARY

Replicate counts were made in 1982 of study areas established on St. Paul and St. George islands in 1976. Eleven species of seabirds were represented. Study area populations totaled 16,700 on St. Paul in 1976 and 8,862 in 1982. On St. George the totals were 35,739 in 1976 and 32,394 in 1982. In 1982, thick-billed murre and red-faced cormorant numbers had decreased significantly over 1976 on both islands, common murre, parakeet auklet, and horned puffin numbers had increased significantly on St. George, least auklet numbers had increased significantly on both St. George and St. Paul islands. A significant increase of tufted puffins on St. George should be viewed in light of a small sample size.

Red-legged and black-legged kittiwake numbers had not changed significantly in 1982, but the number of active nests had decreased for both species. No significant change was detected in crested auklet or northern fulmar numbers on either island. Fulmar estimates, however, are probably low, especially on St. George, due to the inaccessibility of their nesting habitat.

Population estimates were made using the 1976 estimates as a baseline and assuming the study population comprises the same proportion of the total population in both years. Estimates for 1976 and 1982 are listed below.

	St. Paul		St. George	
	1976	1982	1976	1982
Thick-billed murres	110,000	54,000	1,400,000	1,100,000
Common murres	39,000	39,000	220,000	280,000
Black-legged kittiwakes	42,000	42,000	94,000	94,000
Red-legged kittiwakes	3,600	3,600	220,000	220,000
Parakeet auklets	34,000	34,000	158,000	290,000
Least auklets	24,000	44,000	220,000	310,000
Crested auklets	6,000	6,000	28,000	28,000
Horned puffins	4,400	4,400	30,000	36,000
Tufted puffins	1,000	1,000	5,200	9,100
Red-faced cormorants	2,500	700	6,300	4,500
Northern fulmars	700	700	79,000	79,000

These estimates are considered accurate to order-of-magnitude with one significant digit. Confidence limits vary with species, but approximate a 95 percent confidence interval of ±36 percent.

Comparisons between years suggest that 1976 was a year of high productivity for the fish-eating seabirds while 1982 was a year of reproductive failure. Burrow and crevice nesters, and/or inshore feeders, in general increased in numbers. These changes in seabird numbers are most likely due to changes in food supply but may be due partly to weather effects, habitat modification, and possibly, on St. Paul, human disturbance.

INTRODUCTION

The Pribilof Islands contain the largest nesting colonies of seabirds along the Alaskan Continental Shelf. Eleven species of seabirds totaling over two million birds breed there[1]. Much of the baseline data on the ecology, population numbers, species composition, distribution, and foraging of seabirds has been acquired through NOAA/OCSEAP supported projects (Hickey 1976, 1977; Hunt 1976, 1977, 1978). Population estimates in 1975 and 1976 were made on the basis of a stratified random sampling technique using photos of birds on the nesting ledges. Reference areas were established on both St. Paul and St. George islands during 1976. Our visit was made to attempt to resurvey these discrete segments of cliff.

Specific objectives of this study were:

1. To re-census representative study areas of seabird nesting habitat, examining as many species as possible;

2. To develop population estimates for nesting seabird species, including in the estimates measures of confidence in the data;

3. To compare seabird populations estimates made during this study with previous investigations on the Pribilof Islands, especially 1976;

4. To test a time and cost-efficient methodology for indexing these seabird populations and their species composition; and

5. To acquire additional baseline data in preparation for proposed oil development activities in the St. George Basin.

---

[1] Scientific names for these species are listed in Appendix 7.

‘STUDY AREA

The study areas are located on St. George and St. Paul islands, in the Pribilof Islands. These study areas are well-defined sections of cliff-nesting habitat that can be approached and censused on foot. Study area locations are detailed in Figures 1 and 2.

FIGURE . ST. PAUL ISLAND STUDY AREAS

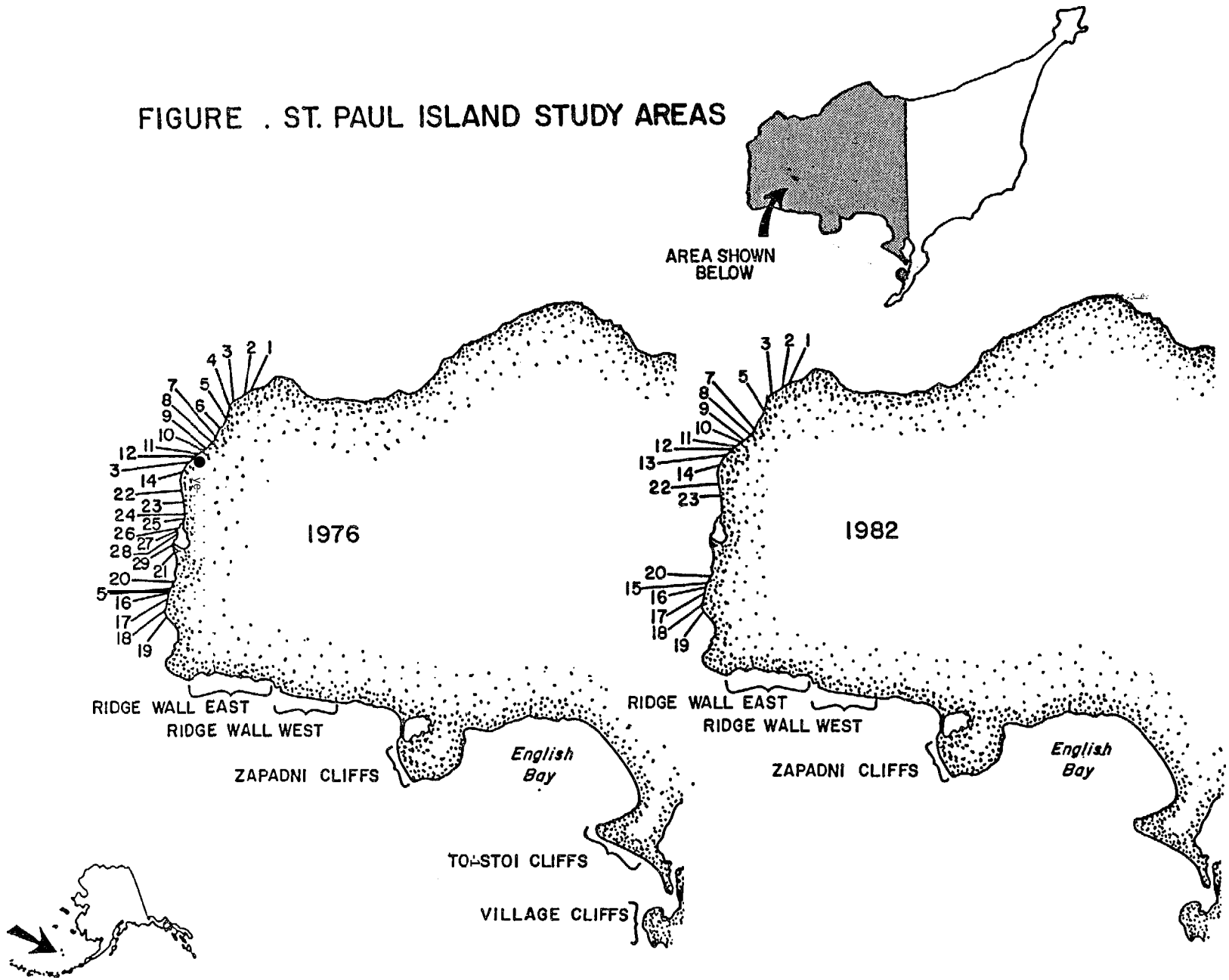
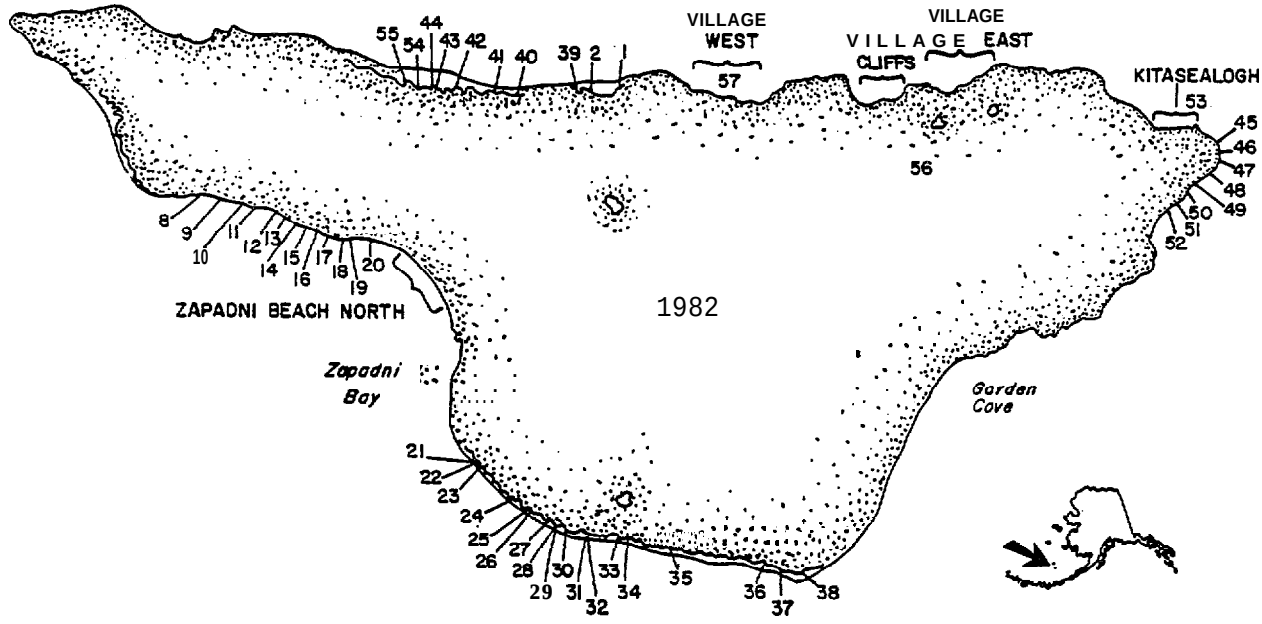
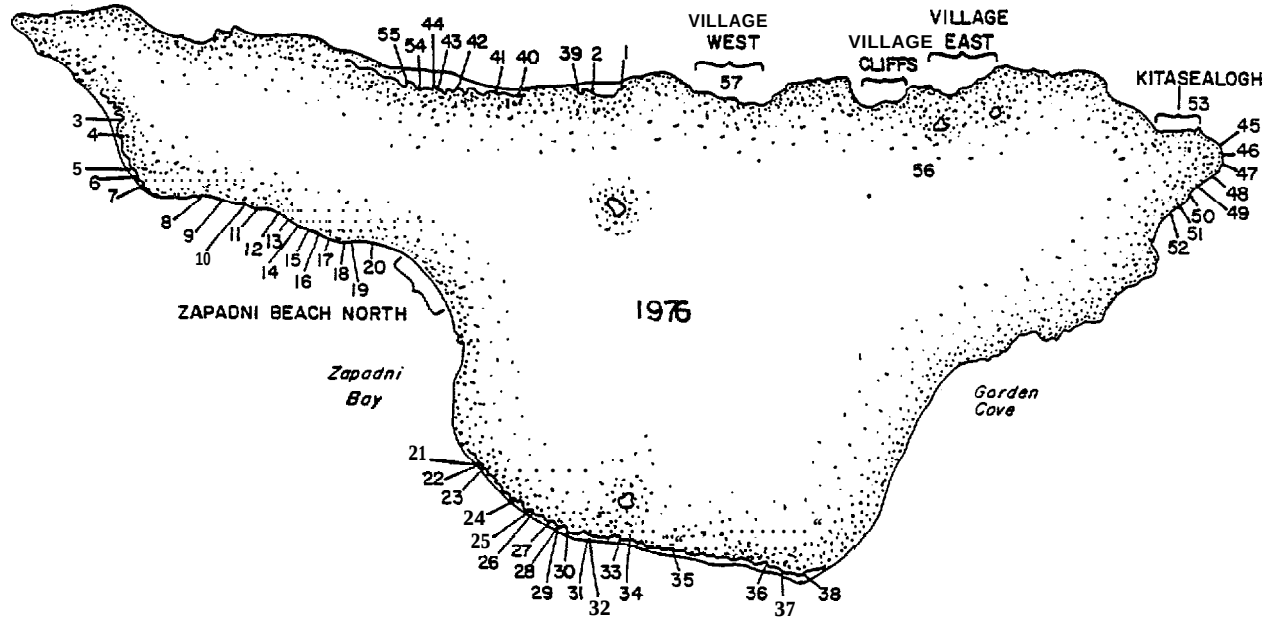


FIGURE 2. ST. GEORGE ISLAND STUDY AREAS





METHODS

Census Procedures

Four days were spent on St. Paul and two weeks on St. George in late July 1982. Counts of all birds present on study areas and all active kittiwake nests were recorded. Active was defined as containing an incubating adult, an egg, or a chick. All red-faced cormorant nests were also recorded, and all successful nests were noted. Observers used photos taken in 1976, with the study area outlined to locate the identical area, and made counts from the 1976 observation points. The resultant count was then a re-census of the area delineated in 1976 and a replicate count of that area's bird numbers.

In order to make comparisons between years as close as possible, efforts were made to re-census each ledge at the same phase of the breeding cycle and at the same part of the diurnal cycle as in the previous census. Most censuses of study areas in 1976 were timed to coincide with an afternoon peak in ledge attendance of the smaller alcids that occurred between 1200 and 1500 hours, during the late incubation period of thick-billed murres. This peak was established by a series of counts made at 30-minute intervals throughout the day at various ledges.

In 1982, a similar series of counts was made at 30-minute intervals at ledge 29 on St. George to determine the afternoon peak of alcid numbers on the cliffs. Censuses of study areas in 1982 were timed to coincide with this afternoon peak which occurred between 1300 and 1700 hours.

Nine study areas censused in 1976 on St. Paul were not censused in 1982 due to poor weather, time constraints, or gross physical changes in the study area. Similarly, five areas on St. George were not re-censused due to weather and time constraints.

Data Analysis

Counts made in 1982 are replicate counts of the numbers of birds present on clearly defined study areas, previously counted in 1976. The study areas were chosen on a basis of accessibility and location, and vary greatly in area. Therefore, the sampled populations cannot be assumed to be normal and have equal variances. Nonparametric statistics were used to determine levels of confidence; in particular, Wilcoxson's paired-sample test was applied:

$$T' = m(n+1) - T$$

where m = the number of the ranks with the less frequent sign,

n = the number of samples,

T = the sum of the ranks with the less frequent sign

for ranked differences in sample populations between 1976 and 1982 data.

This test was the basis for determining whether or not observed differences in bird populations on study areas were significant between years. Differences were considered significant when $p<0.05$ and highly significant when $p<0.01$.

Secondly, overall estimates of the population of each bird species were derived. This estimate was derived in 1976 using stratified random samples from photos of the entire cliff area of St. George. Parametric statistical methods used with these data gave an accuracy of order-of-magnitude with one significant digit. Confidence limits varied among species estimated, but approximated a 95 percent confidence interval of ±36 percent.

Following the final report of NOAA/OCSEAP in 1976 (Hickey 1977), some further refinements were made in overall species estimates (Craighead, Hickey, and Squibb 1977; Craighead, Hickey, and Cary 1977). These refined 1976 estimates are presented in Tables 1 and 2.

Using this overall population estimate as a basis, we have used the significant changes in 1982 in the sub-population on study areas to extrapolate 1982 overall population estimates for each species on each island (Tables land 2). This overall estimate has the same accuracy as the 1976 estimate: order-of-magnitude with one significant digit. Corrected proportions are presented for various species as follows. On St. Paul, the census of Ridge Wall was taken earlier in the day than the expected afternoon peak in alcid attendance in 1982, and the Zapadni census was taken before the afternoon peak in 1976. Since the correspondence in times for these counts was not close, these data were ignored in the case of parakeet, least, and crested auklets, and horned puffins. This edited data set results in the corrected 1982/1976 proportions for St. Paul (Table 1). The closest correspondence

in time and date of replicate counts on St. George occurred on the lowest and highest cliff strata, although all occurred within the incubation phase of thick-billed murres. Using data from only these strata for parakeet and least auklets and horned and tufted puffins results in the corrected 1982/1976 proportions for St. George (Table 2).

In most cases, the corrected proportion also reflected significant population changes. In these, the more conservative 1982/1976 proportion was used to derive the 1982 estimate, since this figure represented a larger sample size. In only one case, tufted puffins on St. George, was a corrected proportion found to be significant where the overall proportion was not. Since the data for the other auklet species indicate that overall counts are reliable, this edited count (tufted puffins) must be viewed with skepticism, particularly as it is based upon a very small sample size.

RESULTS AND DISCUSSION

Our observations in 1982 suggest a number of changes in seabird numbers in the Pribilof Islands since 1976. Population estimates for each seabird species and differences between 1976 and 1982 are presented for St. Paul (Table 1) and St. George (Table 2) islands. Population changes summarized in these tables can be described in relation to changes in years for each seabird species and comparisons between islands.

The results of counts at individual study areas are presented in Appendices 1 through 5B. Appendix 1 contains daily ledge attendance counts made at 30-minute intervals on ledge 29, St. George, to determine peak attendance times for census purposes. Appendices 2A through 5B present census counts at study ledges.

Species Accounts

Thick-billed murre

Thick-billed murres were censused during both 1976 and 1982 just prior to hatching. The mean hatching date in 1976 was 3 August. There was little change in numbers of murres on ledges between 1300 and 1700 hours when censuses were made. Attendance of ledge 29, St. George Island, 25 July, is summarized in Figure 3.

On both St. Paul and St. George and in all vertical strata, numbers of thick-billed murres were significantly ($p<0.05$) lower than in 1976 (Tables 1 and 2). On St. Paul, the greatest decrease, 49 percent of the

1976 total, was recorded. Thick-billed murres constituted 53 percent of the total birds on study areas on St. Paul in 1976 and 49 percent in 1982. A total of 54,000 thick-billed murres was estimated on St. Paul in 1982.

Thick-billed murres declined in numbers to 81 percent of the 1976 total on St. George. Their numbers represented 64 percent of the total birds estimated in 1976 and 57 percent in 1982. A total of 1,100,000 thick-billed murres was estimated on St. George in 1982.

1982 was almost certainly a year of nesting failure for thick-billed murres. A single chick was observed on 25 July. Additionally, very few eggs were observed on St. George study areas as compared to 1976. This failure may have attributed to the decline in numbers of birds observed on the cliffs.

Common murre

On St. Paul in 1982, there was no significant change in numbers over 1976 (Table 1), although there was an apparent decline in numbers. Apparently common murres decreased in some study areas but increased in others, perhaps shifting to new sites. Several of the St. Paul ledges that previously had common murres were covered with debris, while others were bare, but unused. Common murres were estimated at 39,000 on St. Paul in 1982.

Common murres on St. George, however, showed a 27 percent increase in population (Table 2) which was highly significant ($p<0.01$). Overall,

KEY TO ABBREVIATIONS IN TABLES 1 AND 2.

TM Thick-billed murre
CM Common murre
RK Red-1egged kittiwake
PA Parakeet auklet
LA Least auklet
CA Crested auklet
HP Horned puffin
TP Tufted puffin
RC Red-faced cormorant
LF Northern fulmar (light phase)
DF Northern fulmar (dark phase)
BK Black-legged kittiwake

Table 1. Estimated total population of cliff-nesting seabirds, St. Paul Island, 1976 and 1982.

	TM	CM	BK	RK	PA	LA	CA	HP	TP	RC	LF
1976 Total Estimate	110,000	39,000	42,000	3,600	34,000	24,000	6,000	4,400	1,000	2,500	700
1982 Total Estimate[1]	54,000[2]	39,000	42,000	3,600	34,000	44,000[3] (52,000)3	6,000	4,400	1,000	7002	700

'Numbers in parentheses refer to estimates made which ignored counts made when auklets were not at peak attendance.

[2]Represents a highly significant change (p<0.01).

[3]Represents a significant change (p<0.05).

Table 2. Estimated total population of cliff-nesting seabirds, St. George Island, 1976 and 1982.

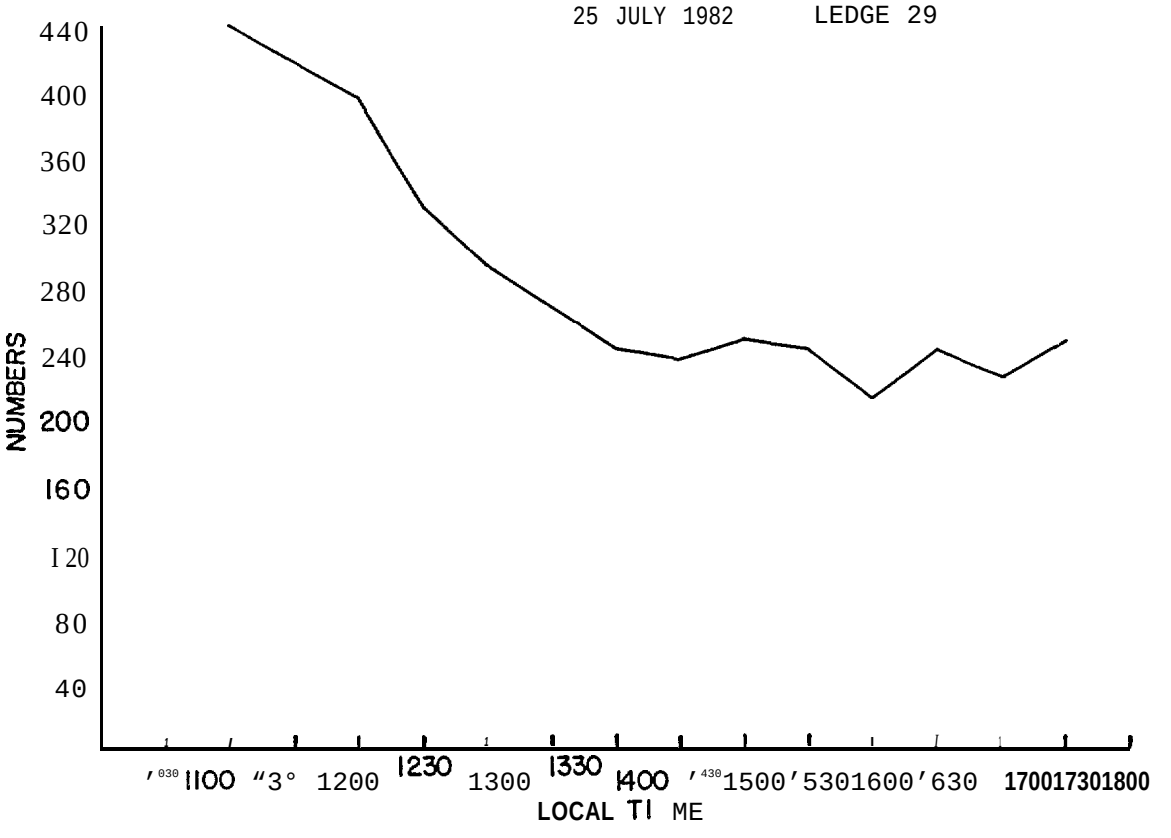
	TM	CM	BK	RK	PA	LA	CA	HP	TP	RC	LF
1976 Total Estimate	**1,400,000**	**220,000**	**94,000**	**220,000**	**158,000**	**220,000**	**28,000**	**30,000**	**5,200**	**6,300**	**79,000**
1982 Total Estimate[1]	1,100,0002	280,000[3]	94,000	220,000	290,000[2] (290,000)[2]	310,0002 (630,000)[2]	28,000	36,0002 (77,000)2	**5,200 (9,100)[3]**	4,5003	79,000

[1]Numbers in parentheses refer to estimates made that ignored counts made when auklets were not at peak attendance.

[2]Represents a highly significant change (P<0.01).

[3]Represents a significant change (P<0.05).

FIGURE 3. LEDGE ATTENDANCE OF THICK-BILLED MURRES, ST. GEORGE ISLAND



there was an increase in the lower cliffs and in the higher cliffs with little change in the cliffs of medium height. Some of the ledges that previously had common murres were empty in 1982. Common murres were estimated at 280,000 on St. George in 1982.

Although few eggs and no chicks were observed in the study areas, common murres may have fared better than thick-billed murres. A common murre ledge at Egg Rock on St. George, for instance, was cleared of eggs for subsistence; a second laying of about 160 eggs (from roughly 200 birds) was then collected on 25 July (D. Roby, pers. comm.).

Common murre phenology and daily ledge attendance is similar to that of thick-billed murres (Hickey 1977). Although common and thick-billed murres eat similar food items, they exhibit differences in relative proportions of various prey species and foraging zones [common murres generally forage closer to shore than thick-billed murres (Hunt 1977)].

Black-legged kittiwake

Although black-legged kittiwake numbers did not change significantly ($p<0.05$) on either island (Tables 1 and 2), they experienced a severe reproductive failure. Only three black-legged kittiwake chicks were observed on St. George: one was almost fully feathered while the other two were small and downy. In 1976 most young were well feathered at this date in late July. These significant declines in success occurred at all elevations and appeared to occur early in the nesting season since few birds completed nests and many birds did not even attempt to build nests. On St. Paul in 1982 there were only 17 percent (highly significant, $p<0.01$) as many active nests as in 1976. Similarly, the number of active nests on St. George in 1982 was only 19 percent (highly significant, $p<0.01$) of the 1976 total. In 1976, however, estimates were derived only from the low and high cliffs. Furthermore, many nests described as active may have been inactive (see Results and Discussion: Census Problems).

Black-legged kittiwake populations were estimated at 42,000 and 94,000 for St. Paul and St. George, respectively. Numbers of both black- and red-legged kittiwakes on cliffs showed little variation throughout the day according to 1976 data. Our 1982 sample size at

ledge 29, St. George was too small to use for a daily ledge attendance curve.

Red-legged kittiwake

Red-legged kittiwakes also experienced a severe breeding failure (only three chicks and one addled egg were noted), although numbers of birds present on cliffs were not significantly ($p<0.05$) reduced on either island (Tables 1 and 2). The difference in number of active nests between 1976 and 1982 was highly significant ($p<0.01$) for both islands, however.

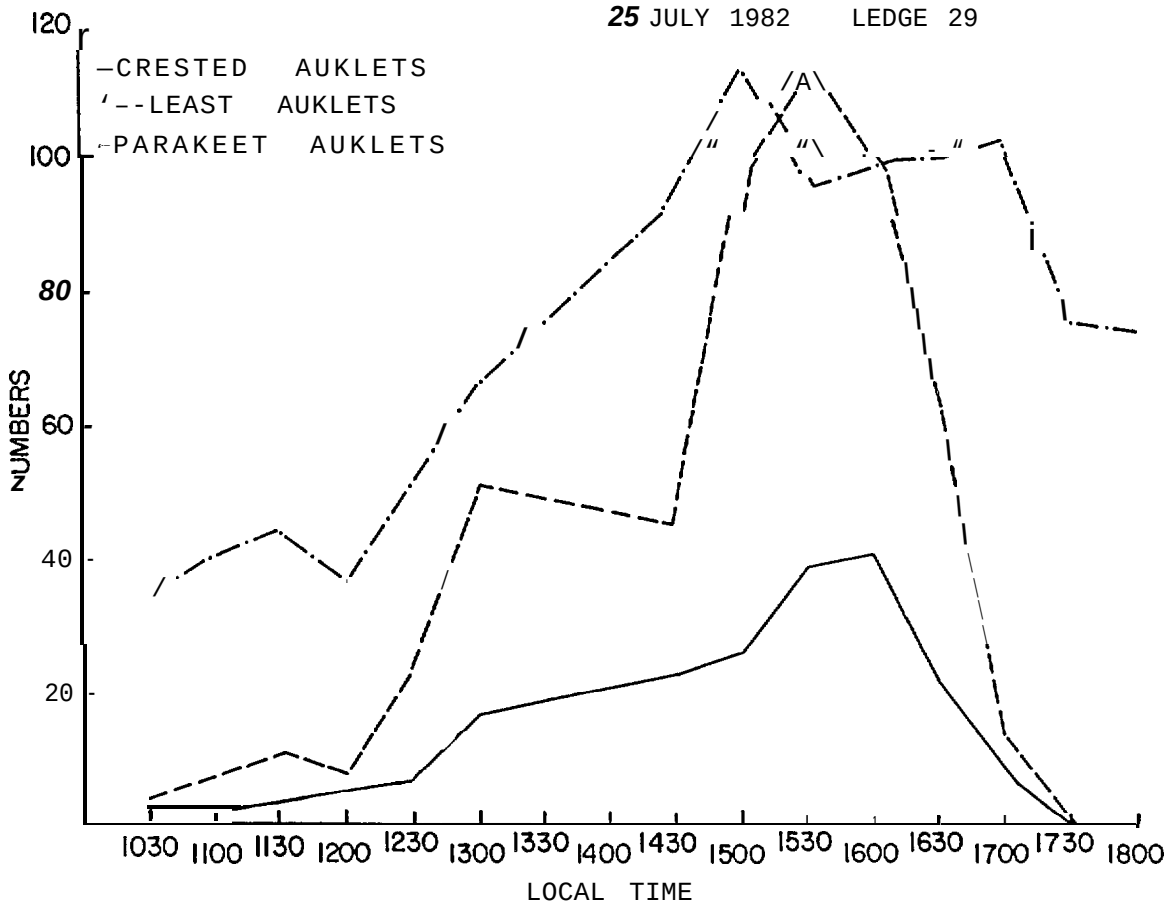
No active red-legged kittiwake nests were seen on St. Paul's lower cliffs. The higher (400 ft) cliffs could not be surveyed because of fog. Three thousand six hundred red-legged kittiwakes were estimated on the cliffs of St. Paul in 1982.

On St. George the number of active nests on high and low cliffs in 1982 was only eight percent (highly significant, $p<0.01$) of the 1976 total. There is a marked zonation in kittiwake habitat with elevation on St. George: as elevation increases there is a relative increase of red-legged kittiwake nests and a decrease in black-legged kittiwakes. In 1982 there appeared to be a slight increase in nesting of red-legged kittiwakes with elevation: on the low cliffs, active nests were -five percent of the 1976 total, while on the high cliffs active nests were nine percent of the 1976 total. An estimate of 220,000 red-legged kittiwakes, the majority of the world population, was made for St. George.

Parakeet auklet

Parakeet auklet numbers were unchanged on St. Paul (Table 1), but increased on St. George (Table 2). As mentioned before, auklet numbers fluctuate greatly during the day (Figure 4). Some counts were made at times when low numbers would be expected, and some were made at a different point in the diurnal cycle than the previous count in 1976. Accordingly, these counts were left out of the analysis for corrected proportions.

FIGURE 4. LEDGE ATTENDANCE OFAUKLETS, ST. GEORGE ISLAND



On St. Paul there was no significant difference between the 1976 and the 1982 counts. Thirty-four thousand birds were estimated.

The closest correspondence in timing of replicate counts on St. George occurred on the lowest and highest cliff strata. Using data from only these strata shows a highly significant ($p<0.01$) increase of 82 percent between study years. A similar estimate wes derived from counts at all study areas (Table 3). The result, which is probably conservative, is an estimate of 290,000 parakeet auklets on St. George in 1982.

Parakeet auklets also nest on several large talus piles at the bases of cliffs. We were unable to census these in 1982, and they represent a small fraction of the total population.

Least auklet

There are three types of nesting habitat for least auklets on the Pribilof Islands: beach boulder piles and talus, crevices on cliffs, and an inland colony in a boulder slope of Ulukaia Hill on St. George. No attempt was made to census the beach boulder and talus habitat in 1976 or 1982. The number of least auklets censused on cliffs increased significantly ($p<0.05$) in 1982 on both islands (highly significant on St. George, $p<0.01$) (Tables 1 and 2). Daily ledge attendance on cliffs is summarized in Figure 4.

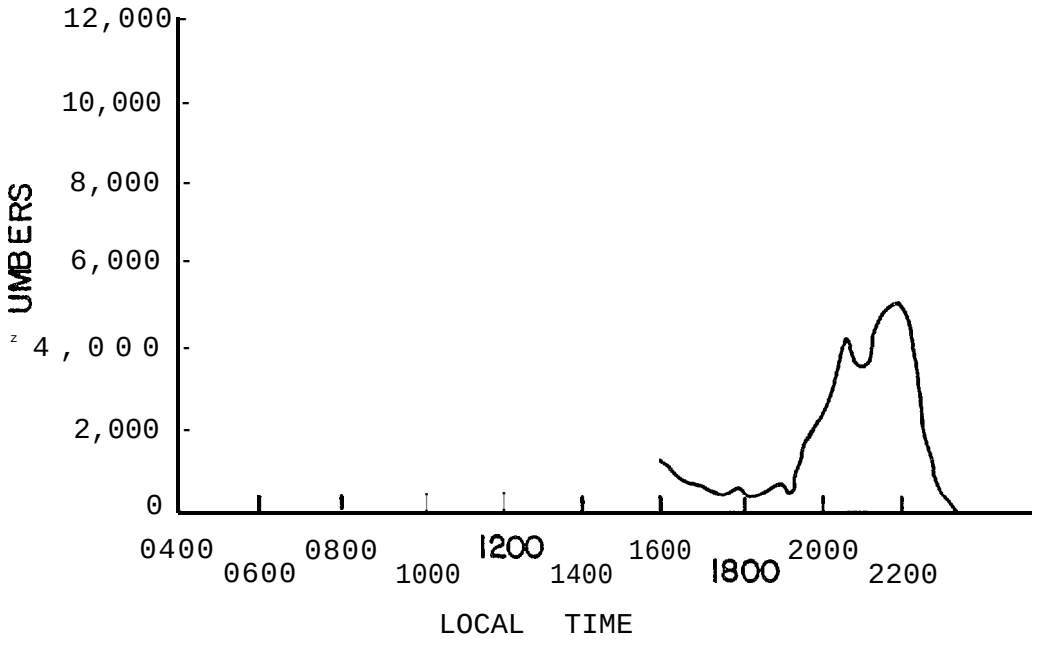
On St. Paul, the study population was at least 82 percent greater than that recorded in 1976, if all study areas are included in the estimate. This is a conservative estimate.

On St. George the 1982 estimate is at least 43 percent greater than the 1976 estimate if all cliff counts are included in the estimate.

Although the numbers of cliff-nesting least auklets has increased greatly, there has been a decrease in the number of birds nesting in the Ulukaia Hill colony. Flight counts of least auklets flying into the Ulukaia Hill colony on 31 July 1982 from the afternoon low, until darkness prevented counting, revealed a total of 72,760 parakeet auklets (Appendix 6 and Figure 5). This flight count can be compared to two similar counts made in 1976: 26 July and 10 August (Figure 6). Our closest actual count was 26 July 1976, which totaled 96,700. Phenologically, the count made in 1982 should be similar to counts made in 1976 (mean date of hatching was 13 July in 1982 [Dan Roby, pers. comm.] and 17 July in 1976). Counts in both years were made before fledging at a time when adults were making repeated trips to the colony to feed young.

It appears that the colony size in 1982 has been reduced to roughly 75 percent of its size in 1976. This decrease may be due to loss of habitat. In 1976 it was estimated that the colony covered an area of 126,500 square meters mapped on 17 June. The east end of the colony, which was used intensely for nesting in 1976 was heavily overgrown with moss and rye grass, Elymus spp., in 1982. Soil and debris has apparently filled in the boulder interstices where auklets nest. No least auklets were found to nest in this area in 1982 (Dan Roby, pers. comm.). This area appears to be slightly less than 25 percent of the former colony area. The 1976 estimate of population size for this colony was 106,700 breeding birds.

FIGURE 5. 1982 LEAST AUKLET FLIGHT COUNTS FROM SEA TO COLONY



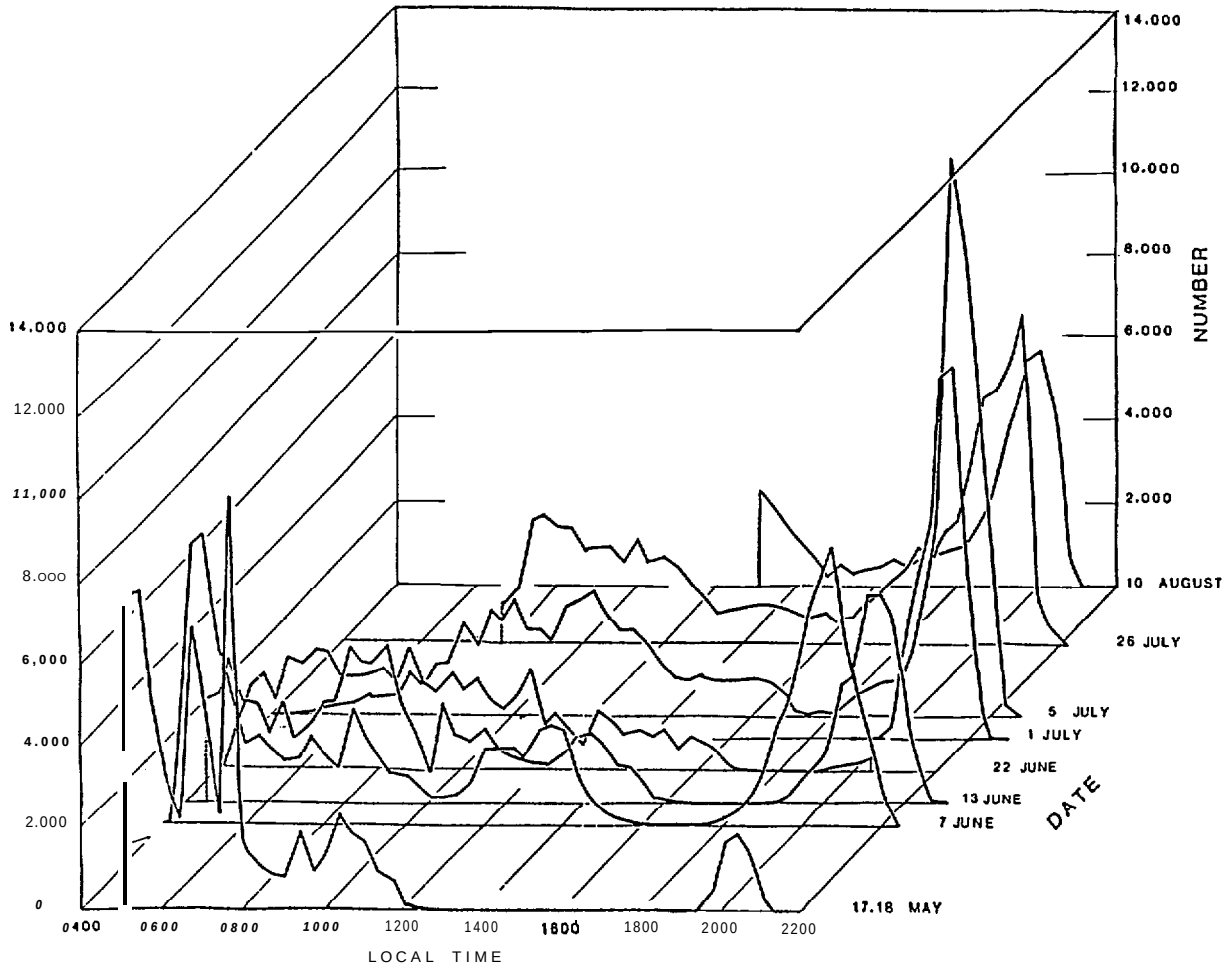
A 25 percent reduction in 1982 would result in approximately 80,000 birds remaining. This figure closely resembles our 1982 estimate.

The number of least auklets breeding on St. George in 1982, exclusive of beach nesters but including Ulukaia colony, was approximately 390,000. It is likely that beach-nesting birds may number on the order of 100,000 more. The numbers of birds on both islands, therefore, increased greatly over the 1976 population, perhaps even doubling in size.

Crested auklet

Crested auklet numbers did not change significantly on the cliffs of either island (Tables 1 and 2). Small sample sizes and the secretive habits of this species preclude a lengthy discussion. Crested auklets nest in crevices on cliffs and in three or more large boulder slopes

FIGURE 6. 1976 LEAST AUKLET FLIGHT COUNTS FROM SEA TO COLONY

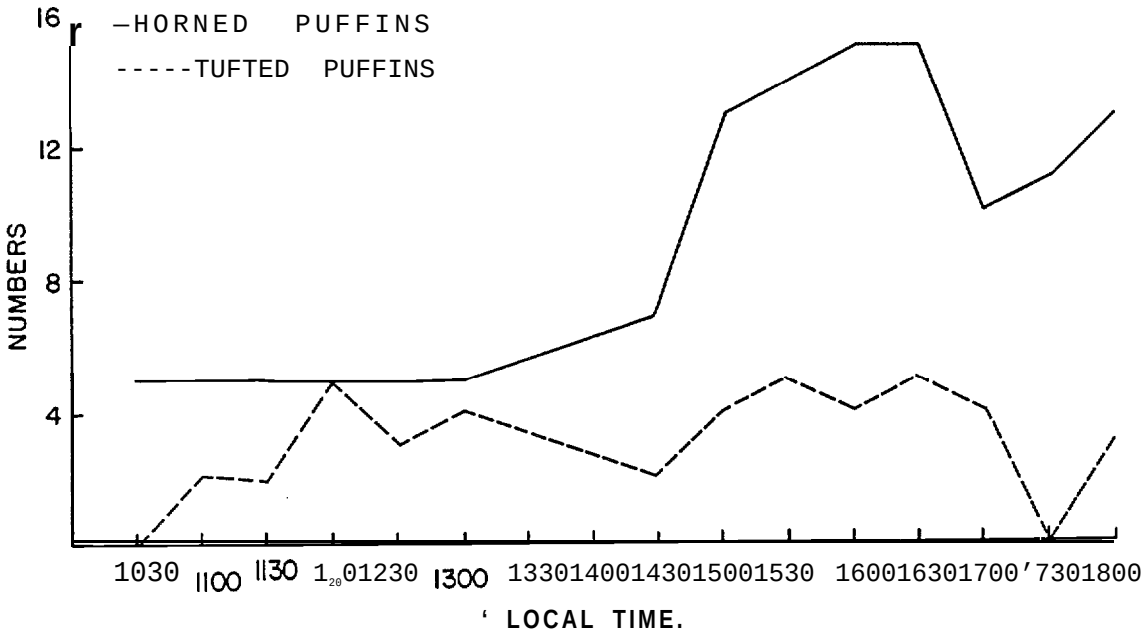


below the cliffs of St. George. Their daily ledge attendance patterns are summarized in Figure 4.

Horned puffin

Both horned and tufted puffins are found in relatively smal 1 numbers on both islands. Consequently, sample sizes for daily ledge attendance figures are small. The data for 1982 indicate that there was a slight afternoon peak in ledge attendance for horned puffins (Figure 7).

FIGURE 7. LEDGE ATTENDANCE OF HORNED AND TUFTED PUFFINS, ST. GEORGE ISLAND
25 JULY 1982 LEDGE 29



The St. Paul data for horned puffins include counts at Ridge Wall and Zapadni that probably missed an afternoon peak (Table l). Neither these sets of data, nor a corrected form ignoring these counts reveal any significant change in population, however.

On St. George the data show a highly significant increase ($p<0.01$) in numbers when all study ledges are considered, and also when a corrected estimate is made using only data from the high and the low cliffs (Table 2). Selecting the larger sample size, we estimated 36,000 horned puffins on St. George.

Tufted puffin

The daily ledge attendance counts do not show an afternoon peak for tufted puffins, but the sample size is very small (Figure 7).

There is no indication that the tufted puffin population has changed significantly on St. Paul (Table 1). Approximately 1,000 tufted puffins occupy St. Paul. On St. George, though, if only the high and the low cliffs are used to obtain a corrected estimate, a significant increase ($p<0.05$) can be described (Table 2). If an increase of 75 percent over the 1976 population is accepted, 9,100 tufted puffins were estimated for St. George in 1982.

Red-faced cormorant

On St. Paul there was a highly significant decrease ($p<0.01$) in numbers of red-faced cormorants. There was no significant difference in numbers of completed nests, but only one nest was successful. Three nests contained dead, downy chicks.

On St. George there was a significant decrease ($p<0.05$) in adults present, but no decrease in number of completed nests compared with 1976. Eleven of 38 nests were successful. No dead chicks were observed on St. George.

Although there was no decrease in nesting attempts, there was probably a decrease in successful nests on both islands in 1982. It appears that this was a year of reproductive failure for cormorants and it is likely that nest failure was the reason that fewer adults were found on study cliffs during surveys.

Northern Fulmar

Nesting, light-phase fulmars predominate on the Pribilofs. Ship-board transects of foraging fulmars reveal that birds at sea near the Pribilofs are primarily dark-phase fulmars presumed to be nesting in the Aleutians (Hunt 1978). No change in the ratio of light-phase to dark-phase fulmars was noted in 1982 and there was no significant change in numbers present on cliffs.

St. Paul has a relatively small population of fulmars, with only 700 estimated for both 1976 and 1982.

St. George had an estimated population of 79,000 fulmars in 1976 and 1982. There are large areas of cliffs that appear to be prime fulmar habitat. Because these ledges are inaccessible, population estimates are probably low for both islands.

Fulmars are the one species breeding on the Pribilofs that would be expected to be the least susceptible to the vagaries of environmental change: they nest early, selecting the most sheltered nesting cavities; they can select from a wide variety of prey items; and they can forage far afield when necessary without reducing the amount of food used for feeding chicks.

Comparisons Between Islands

St. Paul and St. George are about 100 km apart. For all practical purposes they share the same weather. Foraging areas for the larger, offshore feeding seabirds are essentially the same. Any significant relative changes in seabird numbers between islands should therefore reflect differences in nesting habitat or differences in disturbance.

Exceptions to this generalization might be the plankton-feeding alcids and perhaps the common murres, which appear to forage inshore.

There are differences in nesting habitat, due to the differing geologic histories of the two islands: St. George is older and is composed of high basaltic cliffs reaching 305 m (1,000 ft) in elevation, while St. Paul is largely composed of cinder cones and scoria with small cliffs along the southwestern end of the island. Consequently, there are differences in the numbers and proportions of seabirds nesting on each island.

The St. George cliffs are relatively undisturbed. Subsistence activity (egg collecting and shooting of adults) occurs, but is probably negligible considering the size of the colony. St. Paul, on the other hand, has a much smaller seabird population and a greater degree of disturbance. During the breeding season, tourists visit the cliffs near Southwest Point several times per week. It is possible that the greater magnitude of the decrease of thick-billed murres is due in part to this disturbance. The feature of disturbance may explain why there was no change in numbers of common murres on St. Paul while they increased on St. George.

Census Problems

Using established study areas located throughout the cliff-nesting habitat for replicate counts of nesting seabirds appears to be a feasible method for assessing population trends on the Pribilof Islands. There are, however, some difficulties with this method.

First, gross physical changes of cliffs reduce opportunities to standardize counts. The basaltic rock composing nesting ledges is subject to collapse, accumulation of debris, and a resultant growth of vegetation. These types of changes were noticeable, particularly on St. Paul. Four study areas on St. Paul had some accumulation of debris and one contained a small area of recent rock fall (occurring since the previous census in 1976). Similarly, even though no study areas were noticeably altered, a quick survey around the island of St. George by boat in 1982 revealed three large rockfalls and 20 small ones since 1976.

Second, nesting success for many species is difficult to determine and there is little information available to correlate adult numbers on cliffs with breeding pairs and reproductive performance. At this stage of the reproductive cycle one might assume that increased numbers on cliffs represent an increase of breeding pairs. Numbers of murres, however, increase in the late breeding season as non-breeding birds "prospect" for nest sites (Tuck 1969). Similar behavior may apply to other species as well. Similarly, failed pairs of some species may spend more time loitering on the cliffs rather than foraging and returning with food.

Kittiwakes also exemplify problems with determining breeding success from these censuses. One problem encountered is determining whether a nest is 'active' or 'inactive', due to the fact that some adults that appear to be incubating are actually sitting on empty nests. It is likely that in a bad year, such as 1982, a greater number of nests would be identified as active due to this behavior.

SUMMARY AND CONCLUSIONS

Several species of seabirds nesting on study areas on St. George and St. Paul islands experienced significant population changes between 1976 and 1982. Although 1976 was a year in which the onset of breeding began relatively late, due in part to delayed snow melt, it was a good year, reproductively, for kittiwakes, murres, and cormorants. In contrast, 1982 was a poor reproductive year for these species.

Thick-billed murres present on study areas decreased significantly. Common murres increased on St. George. Although no quantitative measure of reproductive success was obtained for either species of murre, it appeared to be much lower than in 1976.

There was no significant change in kittiwake numbers on either island, but both red-legged and black-legged kittiwakes experienced a significant breeding failure. Red-faced cormorants decreased in numbers on both islands.

Although there was no significant decrease in nesting attempts by red-faced cormorants in 1982, it appeared that most nests were unsuccessful.

In general, the plankton-feeding alcids appeared to have increased in numbers. Parakeet auklet numbers increased on St. George. Least auklet numbers increased on both islands although the least auklet colony on Ulukaia Hill, St. George, decreased in numbers. No significant change in crested auklet numbers could be detected on either island.

Horned puffin numbers increased on St. George, and tufted puffin numbers probably increased, although our sample size was small. Puffin numbers on St. Paul did not change significantly. Increases in numbers present on cliffs represent either an actual increase in breeding birds or an apparent increase due to the behavior of unsuccessful nesters. We are assuming an actual increase.

No change in numbers of northern fulmars could be detected. It appears that estimates of the fulmar populations on both islands may be low.

Several avenues of speculation are possible to explain these changes. A decrease in fish food items could explain the reproductive failure of murres, kittiwakes, and cormorants; the plankton feeding alcids may have been relatively successful. If this were the case, the puffins may have suffered a reproductive failure also, since they feed on many of the same prey items (Hunt 1977).

Severe weather effects could also have inhibited the reproduction of the cliff-nesting murres, kittiwakes, and cormorants. Presumably, the burrow- and crevice-nesters with their more sheltered nesting habitats would be less adversely affected. In this case, the puffins and auklets would have probably been reproductively successful in 1982. Weather effects, however, seem unlikely because of the nature of the kittiwake failure. If nests had been destroyed by weather, *many* birds would have still been building nests at the time of the census.

Finally, especially on St. Paul, human disturbances may have influenced seabird attendance and reproductive success.

Some problems are involved with using established ledges to monitor population trends. Physical changes in the cliffs can be accommodated by careful observation and appear to be less critical to survey procedures on St. George with its much larger area of cliffs than on St. Paul.

A conceptual model of ecosystem stability for the Southeast Bering Sea has been proposed (McRoy and Walsh 1980) which predicts that successful reproduction in species nesting on the Pribilof Islands is coupled to primary production with less influence by the variegation of seasonal events (i.e., storm frequency) than coastal populations. Coastal populations are expected to have frequent reproductive failures, while the more stable Pribilof populations should not. In light of the breeding failures on the Pribilofs in 1981 (Robert Day, pers. comm.) and in 1982, some modifications of this model may be necessary.

APPENDICES

KEY TO ABBREVIATIONS

TM	Thick-billed murre
CM	Common murre
RK	Red-legged kittiwake
PA	Parakeet auklet
LA	Least auklet
CA	Crested auklet
HP	Horned puffin
TP	Tufted puffin
RC	Red-faced cormorant
LF	Northern fulmar (light phase)
DF	Northern fulmar (dark phase)
BK	Black-legged kittiwake

APPENDIX 1. Ledge attendance of nesting seabirds of St. George Island, 25 July 1982 [Ledge 29].

Time	TM	CM	BK	RK	PA	LA	CA	HP	TP	LF
1030	--	--	--	--	35	4	2	5	0	--
1100	443	2	12	8	41	7	1	5	2	14
1130	420	1	12	5	44	11	3	5	2	16
1200	399	0	13	7	37	7	5	5	5	14
1230	330	2	12	4	51	24	6	5	3	15
1 300*	294	0	12	5	66	51	16	5	4	16
1 330*	221	--	--	--	43	28	5	--	5	3
1400*	244	0	13	5	72	42	10	7	2	16
1430	238	0	10	4	93	44	22	7	2	17
1500	249	0	10	9	114	99	26	13	4	20
1530	241	0	14	8	95	115	39	14	5	20
1600	214	0	7	7	99	101	41	15	4	24
1630	243	1	9	7	100	63	22	15	5	25
1700	226	1	8	6	103	13	8	10	4	25
1730	249	1	9	6	75	0	0	11	0	23
1800	234	0	12	5	74	0	2	22	13	3

* fog at time of count.

APPENDIX 2A. Reference ledge counts, St. Paul Island, 17-21 July 1976.

Location	Time	TM	CM	BK	BK Active Nests	RK	RK Active Nests	PA	LA	CA	HP	TP	RC	RC Nests	LF
1	1225	72	15	X	28	9	5	1	0	0	0	0	14	12	0
2SW	1255	26	2		10	0	0	16	11	0	1	0	4	0	0
3	1310	79	3	47	24	2	0	14	19	0	2	0	10	7	0
5SW	1430	266	0	93	51	0	0	28	10	0	2	0	15	5	0
5NE	1405	120	1	14	8	0	0	5	1	0	0	0	3	2	0
7	1515	142	256	47	30	0	0	7	0	0	0	0	2	1	0
8	1525	253	20	20	9	0	0	20	3	0	0	0	4	3	0
9	1545	133	104	94	50	5	2	16	0	0	5	1	1	1	2
10	1600	284	648	44	24	0	0	8	0	0	0	0	4	2	3
11	1625		0	21	13	0	0	5	0	0	1	0	0	0	0
12	1345	1;:	0	78	37	0	0	3	0	0	1	0	23	10	0
13	1355	110	0	40	23	1	0	13	0	0	0	0	2	2	0
14	1415	369	184	20	8	6	2	15	0	0	3	1	3	1	2
15	1200	206	11	50	31	2	0	2	0	0	5	0	7	2	4
16	1145	187	106	60	28	1	1	17	7	0	4	0	0	0	1
17	1130	88		24	14	1	0	5	0	0	5	0	1	0	0
18	1115	254	1:;	40	17	3	1	3	0	0	0	0	8	5	0
19	1100	179	133	43	27	0	0	8	7	0	2	0	1	0	2
20	1220	37	0	15	13	0	0	0	0	0	1	0	0	0	1
22	1430	563	6	66	47	2	0	44	3	0	8	0	1	1	3
23	1510	1,073	25	80	56	11	5	42	0	0	11	0	2	2	17
Ridge Wall	1000-1700	2,179	752	914	492	61	26	696	246	14	113	13	64	43	3
Zapadni	1030-1230	1,952	558	720	462	15	8	322	135	12	29	5	48	19	2
TOTAL		8,805	3,037	2,591	1,502	119	50	1,290	442	26	193	20	217	118	40

APPENDIX 2B. Reference ledge counts, St. Paul Island, 18-20 July 1982.

Location	Time	TM	CM	BK	BK Active Nests	RK	RK Active Nests	PA	LA	CA	HP	TP	RC	RC Nests	LF
1	1237	9	0	30	4	3	0	0	0	0	0	0	3	3	0
2SW	1247	26	0	24	3	0	0	0	0	0	0	0	17	0	0
3	1259	57	15	46	5	3	0	3	0	0	0	0	1	0	0
5SW	1400	179	81	79	15	1	0	10	18	0	3	0	13	1	0
5NE	1408	27	0	18	4	0	0	5	1	0	0	0	0	0	0
7	1426	117	2	20	3	0	0	0	0	0	0	0	4	2	0
8	1434	122	109	4	0	1	0	0	0	0	0	0	0	0	0
9	1455	191	75	56	6	2	0	6	5	0	6	0	1	1	2
10	1520	157	0	60	6	0	0	6	7	0	1	0	1	0	3
11	1511	38	0	10	2	0	0	6	5	0	0	0	0	0	0
12	1538	49	0	68	8	10	0	3	0			0	8	3*	0
13	1550	186	11	34	6	13	0	0	14	5	0	0	0	0	0
14	1611	244	6	23	4	2	0	19	0	0	0	0	0	0	6
15	1605	107	113	62	7	0	0	2	28	0	10	0	0	0	4
16	1550	26	0	24	2	0	0	23	17	0	2	0	0	0	1
17	1545	59	0	4	1	0	0	3	0	0	9	0	0	0	1
18	1535	72	0	23	6	4	0	20	14	0	3	1	0	0	0
19	1524	48	118	26	10	0	0	4	11	0	4	0	0	0	1
20	1620	82	0	11	0	0	0	9	0	0	2	0	0	0	0
22	1621	308	11	81	16	9	0	27	9	0	11	0	6	4	26
23	1640	259	0	56	6	7	0	38	11	0	5	4	0	0	20
Ridge Wall	1130-1330	1,383	417	390	86	35	0	71	255	11	5 71	2	7	0	7
Zapadn	1445-1622	598	407	207	63	0	0	188	418	122	10	7	0	0	1
TOTAL		4,344	1,365	1,35	263	90	0	757	804	133	142	38	61	14	72

APPENDIX 3A. Reference ledge counts (low cliffs), St. George Island, 24-29 July, 2-3 August 1976.

Location	Time	TM	CM	BK	BK Active Nests	RK	RK Active Nests	PA	LA	CA	HP	TP	RC	RC Nests	LF	DF
Zapadni Beach	1230-1300	675	23	46	13	45	5	115	8	0	15	2	18	0	4	0
Village W	1230-1415	986	141	368	144	210	55	197	205	14	1	0	21	8	42	0
Village E	1500-1630	1,836	254	172	95	55	20	183	44	49	6	3	15	2	66	2
8	1525	307	2	6	2	0	0	60	23	1	9	0	2	0	22	0
9	1445	295	0	38	23	7	2	23	2	0	3	0	1	0	24	0
10	1420	348	15	2	1	7	3	22	9	0	4	0	0	0	36	0
11	1400	115	52	8	6	0	0	1	1	0	1	0	0	0	0	0
12	1345	180	22	4	0	1	0	11	0	0	0	0	0	0	5	0
13	1330	105	0	0	0	0	0	9	5	0	0	0	0	0	15	0
14	1250	177	28	34	14	17	4	15	13	2	3	0	0	0	12	0
15	1210	193	0	6	4	0	0	14	10	0	2	0	0	0	27	0
16	1150	169	0	5	3	0	0	7	12	0	2	0	0	0	0	0
17	1130	148	6	8	3	0	0	12	13	0	2	0	0	0	11	0
18	1105	70	0	0	0	0	0	6	8	0	3	0	1	0	2	0
19	1050	91	16	26	22	0	0	6	0	0	0	0	2	0	10	0
20	1035	58	0	0	0	0	0	4	1	0	0	0	0	0	0	0
45	1110	202	8	5	4	1	1	18	1	0	8	0	2	3	16	1
46	1140	184	0	31	19	7	1	11	0	0	0	0	3	3	0	0
47	1215	156	3	20	7	1	0	14	3	0	2	0	0	0	28	0
48	1255	237	2	17	8	6	1	11	2	0	0	0	13	0	10	0
49	1345		0	21	5	59	26	0	0	0	0	0	0	0	0	0
50	1400	1;;	3	5	4	4	3	4	0	0	0	0	0	0	0	0
51	1510	96	0	50	16	18	5	19	0	4	4	2	0	0	10	0
52	1540		0	1 03	52	15	5	0	0	0	0	0	4	5	4	0
53	1030	1%	3	49	25	94	44	2	0	0	0	0	9	7	0	0
38 lower	1925	181	0	1	0	1	0	0	0	0	2	0	0	0	1	0
26	1200	155	574	3	0	1	0	4	7	0	2	0	12	0	2	0
Village	1630-1730	730	41	358	165	293	41	103	3	0	23	4	10	3	0	0
TOTAL		8,084	1,193	1,386	635	842	216	871	370	70	92	11	113	31	347	3

APPENDIX 3B. Reference ledge counts (low cliffs), St. George Island, 23-28 July, 1-3 August 1982.

Location	Time	TM	CM	BK	BK Active Nests	RK	RK Active Nests	PA	LA	CA	HP	TP	RC	RC Nests	LF	DF
Zapadni Beach	1145-1235	563	50	36	4	23	0	71	102	0	19	2	5	0	2	0
Village W	1300-1530	805	164	321	36	220	1	329	308	9	36	3	34	16	48	0
Village E	1425-1625	1,124	455	195	21	97	3	401	290	65	26	5	8	2	51	1
8	1715	258	7	5	0	2	0	65	47	1	15	0	0	0	30	0
9	1645	273	8	24	1	7	0	51	20	0	10	0	0	0	21	1
10	1616	354	21	2	0	9	0	56	40	5	6	0	0	0	34	0
11	1600	109	59	1	0	0	0	8	0	0	1	0	0	0	0	0
12	1540	198	29	5	0	0	0	26	23	0	4	0	0	0	11	0
13	1525	96	0	1	0	0	0	11	0	4	3	0	0	0	7	0
14	1505	82	0	5	0	0	0	28	16	2	4	4	0	0	8	0
15	1438	160	0	9	2	5	0	34	39	0	3	2	8	1	16	0
16	1430	161	12	4	2	1	0	20	33	0	3	0	2	0	0	0
17	1415	120	10	5	2	1	0	28	50	0	4	1	3	0	8	0
18	1350	90	4	6	0	1	0	41	25	0	10	0	0	0	2	0
19	1333	94	2	15	3	0	0	15	7	0	8	0	0	0	6	0
20	1325	33	0	1	0	0	0	5	4	0	0	0	0	0	0	0
45	1715	61	0	12	2	2	0	39	0	0	22	0	0	0	3	0
46	1348	196	61	44	2	1	0	13	0	0	1	0	0	0	2	0
47	1407	161	2	16	3	48	1	32	26	0	14	0	0	0	20	0
48	1455	141	0	13	3	4	0	24	5	0	18	3	1	0	4	0
49	1630	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	1515	50	2	5	0	9	0	3	0	0	0	0	0	0	0	0
51	1530	65	0	45	2	14	0	22	10	5	5	2	0	0	4	0
52	1550	34	0	82	16	14	0	0	0	0	2	0	2	1	4	0
53*	1216, 1750	92	0	37	3	59	0	4	3	0	0	0	3	0	1	0
38 lower	1840	610	13	0	0	1	0	22	0	0	4	0	0	0	8	0
26	1610	67	822	0	0	0	0	3	0	0	0	0	1	0	0	0
Village	1520-1650	494	44	414	26	199	5	249	9	5	27	6	18	5	0	0
TOTAL		6,523	1,765	1,304	128	719	10	1,597	1,057	96	245	28	85	25	306	0

*Average

APPENDIX 4A. Reference ledge counts (medium cliffs), St. George Island, 9-13 July 1976.

Location	Time	TM	CM	BK	BK Active Nests[1]	RK	RK Active Nests[1]	PA	LA	CA	HP	TP	RC	RC Nests	LF	DF
21	1400	104	0	0	0	6	3	0	0	0	0	0	0	0	0	0
22	1400	174	0	0	0	6	3	1	0	0	0	0	0	0	0	0
23	1400	268	0	1	0	14	4	3	0	0	0	0	0	0	126	0
24 middle	1625	779		0	0	0	0	11	0	0	3	0	0	0	5	0
24 upper	1617	825	1;:	9	--	16	--	12	1	2	4	0	0	0	59	0
25	1215	857	83	25	(19)	3	0	60	122	16	9	1	0	0	51	0
27	1225	979	10	41	(24)	60	(31)	26	57	0	6	7	7	5	99	0
28	1300	704	93	21	(19)	50	(31)	77	126	12	11	2	0	0	85	2
29	1320	592		12	(9)	18	(9)	61	76	26	14	3	0	0	40	0
30	1345	640	13;	20	(14)	16	(11)	56	57	38	19	4	0	0	45	0
31	1514	210	38	0	0	0	0	11	2	15	6	3	0	0	3	0
32	1520	371	55	3	(3)	0	0	16	0	24	2	1	0	0	44	0
33	1600	1,202	2	18	(13)	475	(285)	16	0	0	2	0	0	0	4 7	0
34	1730	116	0	1	0	46	(27)		8	0 0	4	0	0	0	0	0
35	1730	682	0	27	(21)	3	(2)		3	0 1	9	9	2	0	108	0
36	1820	760		14	(10)	8	(5)	0	o	0	26	1	2	2	72	0
37	1900	669	1;	22	(17)	42	(18)	1	0	0	2	0	0	0	1 7	0
38 upper	1925	459	0	5	(4)	67	(53)	1	0	0	6	0	1	0	15	0
39	1350	530	89	57	20	67	23	43	0	0	54	2	0	0	80	0
TOTAL		10,921	722	276	(173)	897	(505)	406	441		134	177	33	12	7 896	2

[1]Numbers in parentheses include nests of undetermined status.

APPENDIX 4B. Reference ledge counts (medium cliffs), St. George Island, 29 July-1 August 1982.

Location	Time	TM	CM	BK	BK Active Nests	RK	RK Active Nests	PA	LA	CA	HP	TP	RC	RC Nests	LF	DF
21	1300	49	0	2	0	8	0	0	0	0	0	0	0	0	0	0
22	1300	51	0	0	0	3	0	0	1	0	0	0	0	0	0	0
23	1315	200	0	1	0	14	0	14	10	0	3	0	0	0	79	0
24 middle	1430	476	12	0	0	0	0	44	11	0	2	0	0	0 1	7	0
24 upper	1400	486	80	29	2	5	0	75	35	16	6	2	0	0	23	0
25	1600	335	92	15	0	1	0	83	8	20	4	2	0	0		0
27	1640	1,227	11	33	3	97	4	55	2	0	10	1	0	0	1;;	0
28	1717	561	90	29	1	58	0	109	1	20	4	0	0	0	57	0
29	1740	338	4	10	2	5	0	119	1	6	4	0	0	0	13	0
30	1315	480	67	6	0	6	0	72	6	1	5	4	0	0	27	0
31	1350	138	40	1	0	1	0	6	1	2	0	0	0	0	1	0
32	1415	299	100	10	0	20	0	13	2	10	2	0	0	0	24	0
33	1510	1,745	36	19	1	433	14	19	0	0	5	0	0	0	29	0
34	1545	98	0	0	0	0	0	9	1	0	2	0	0	0	0	0
35	1630	420	13	16	2	14	0	25	2	2	3	5	0	0	75	0
36	1730	262	18	3	0	3	0	17	0	0	4	0	4	1	27	0
37	1755	680	55	20	0	54	1	39	0	2	3	0	0	0	17	0
38 upper	1840	182	0	4	0	18	0	15	0	0	3	0	0	0	10	0
39	1220	547	100	51	2	45	0	70	21	3	18	0	0	0	71	0
TOTAL		8,574	718	249	13	785	19	784	102	82	78	14	4	1	605	0

APPENDIX 5A. Reference ledge counts (high cliffs), St. George Island, 29 July-5 August 1976.

Location	Time	TM	CM	BK	BK Active Nests[1]	RK	RK Active Nests[1]	PA	LA	CA	HP	TP	RC	RC Nests	LF	DF
1	1300	116		1	0	46	(27)	8	0	0	4	0	0	0	0	0
2	1445	466	10:	3	o	22	12	6	0	0	2	0	0	0	4	0
40	1645	113	0	17	9	169	7	7	0	0	0	0	0	0	0	0
41	1830	1,760	362	38	27	334	170	0	0	0	0	0	0	0	0	0
42	1450	185	1	4	0	362	141	0	0	0	0	0	0	0	0	0
43	1435	196	0	21	14	580	260	3	0	0	0	0	0	0	0	0
44	1950	473	0	12	6	521	277	0	0	0	0	0	0	0	1	0
54	1600	222	0	0	0	299		3	0	0	0	0	0	0	0	0
55	1650	425	181	19	12	326	1%	4	0	0	0	5	0	0	2	6 0
TOTAL		3,956	644	115	68	2,659	1,197	24	0	0	6	5	0	0	31	0
GRAND TOTAL (all cliffs)		22,961	2,559	1,777	(876)	4,398	1,918	1,301	811	204	275	49	125	38	1,274	5

[1] Numbers in parentheses include nests of undetermined status.

APPENDIX 5B. Reference ledge counts (high cliffs), St. George Island, 30 July-2 August 1982.

Location	Time	TM	CM	BK	BK Active Nests	RK	RK Active Nests	PA	LA	CA	HP	TP	RC	RC Nests	LF	DF
1	1130	298	0	14	0	77	1	1	1	0	4	0	0	0	2	0
2	1205	33	15	0	0	16	0	0	0	0	0	0	0	0	8	0
40	1310	75	0	9	0	153	1	0	0	0	0	0	0	0	0	0
41	1835	1,715	496	40	6	410	15	3	0	0	0	0	0	0	1	0
42	1430	178	7	3	0	255	6	0	0	0	0	0	0	0	0	0
43	1500	156	0	3	0	491	25	9	0	0	0	0	0	0	0	0
44	1545	311	0	5	2	462	38	3	0	0	0	0	0	0	0	0
54	1630	261	0	0	0	277	18	6	0	0	0	0	0	0	0	0
55	1700	381	238	10	0	220	3	13	0	0	2	0	0	0	12	0
TOTAL		3,408	756	84	8	2,361	107	35	1	0	6	0	0	0	23	0
GRAND TOTAL (all cliffs)		18,505	3,239	1,637	149	3,865	136	2,416	1,160	178	329	42	89	26	934	2

APPENDIX 6. Least auklet flight count from sea to Ulukaia Hill colony, St. George, 30-31 July 1982.

Time	Least Auklets	Time	Least Auklets
1550	1,470	1930	1,460
1600	1,400	1940	1,640
1610	1,290	1950	2,220
1620	890	2000	2,040
1630	630	2010	2,610
1640	900	2020	3,800
1650	690	2030	4,860
1700	650	2040	4,260
1710	630	2050	3,290
1720	620	2100	2,970
1730	380	2110	4,480
1740	490	2120	3,440[2]
1750	620	2130	5,040
1800	400	2140	5,500
1810	450	2150	4,360
1820	330[1]	2200	5,100
1830	540	2210	5,510
1840	550	2220	2,310
1850	460	2230	2,300
1900	730	2240	1,150
1910	730	2250	540
1920	870	2300	0

TOTAL OF EVENING PEAK 72,760

[1]Evening low.

[2]Average of 2 counts.

Appendix 7. Scientific names of seabird species discussed in this report[1].

Species		Abbreviation
Northern fulmar (light phase}	*Fulmarus glacialis*	LF
Northern fulmar (dark phase)	*Fulmarus glacialis*	DF
Red-faced cormorant	*Phalacrocorax urile*	RC
Black-legged kittiwake	*Rissa tridactyla*	BK
Red-legged kittiwake	*Rissa brevirostris*	RK
Common murre	**Uris** *aalge*	CM
Thick-billed murre	*Uria lomvia*	TM
Parakeet auklet	*Cyclorrhynchus psittacula*	PA
Least auklet	*Aethia pusilla*	LA
Crested auklet	*Aethia cristatella*	CA
Tufted puffin	*Fratercula cirrhata*	TP
Horned puffin	*Fratercula corniculata*	HP

[1]Phylogenetic sequence, scientific nomenclature, and English names of species all follow the American Ornithologists' Union (34th Supplement to the AOU Check-List of North American Birds [Auk 99(3) :1 CC-16CC, 1982]).

REFERENCES CITED

Craighead, F. Lance, J. J. Hickey, and J. R. Cary. 1977. Methods for censusing talus-nestingleast auklets (*Aethia pusilla*). Unpub. M.S. Thesis, University of Wisconsin, Madison. 38 pp.

Craighead, F. Lance, J. J. Hickey, and R. C. Squibb. 1977. Some problems in censusing alcids and other cliff-nesting seabirds. Unpub. M.S. Thesis, University of Wisconsin, Madison. 80 pp.

Hickey, Joseph J., and F. L. Craighead. 1976. A census of seabirds on the Pribilof Islands. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Rept. of Principal Investigators. Vol. 2, March 1976. NOAA/OCSEAP.

Hickey, Joseph J., and F. L. Craighead. 1977. A census of seabirds on the Pribilof Islands. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Rept. of Principal Investigators. Vol. 2, March 1977. NOAA/OCSEAP.

Hunt, George L., Jr. 1976. Reproductive ecology, foods, and foraging areas of seabirds nesting on the Pribilof Islands. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Rept. of Principal Investigators. Vol. 2, March 1976. NOAA/OCSEAP.

Hunt, George L., Jr. 1977. Reproductive ecology, foods, and foraging areas of seabirds nesting on the Pribilof Islands. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Rept. of Pr ncipal Investigators. Vol. 2, March 1977. NOAA/OCSEAP.

Hunt, George L., Jr. 1978. Reproductive ecology, foods, and foraging areas of seabirds nesting on the Pribilof Islands. In: Environmenta Assessment of the Alaskan Continental Shelf. Annual Rept. of Pr ncipal Investigators. Vol. 2, March 1978. NOAA/OCSEAP.

McRoy, C. P., and J. J. Walsh. 1980. Ecosystem analysis and synthesis in the southeast Bering Sea. In: J. J. Goering 1980. Processes and Resources of the Bering Sea Shelf. PROBES Progress Rept, Vol. 1, pp. 399-406.

Tuck, L. 1969. The murres. Canadian Wildlife Service, Monograph Series, No. 1. 260 p.