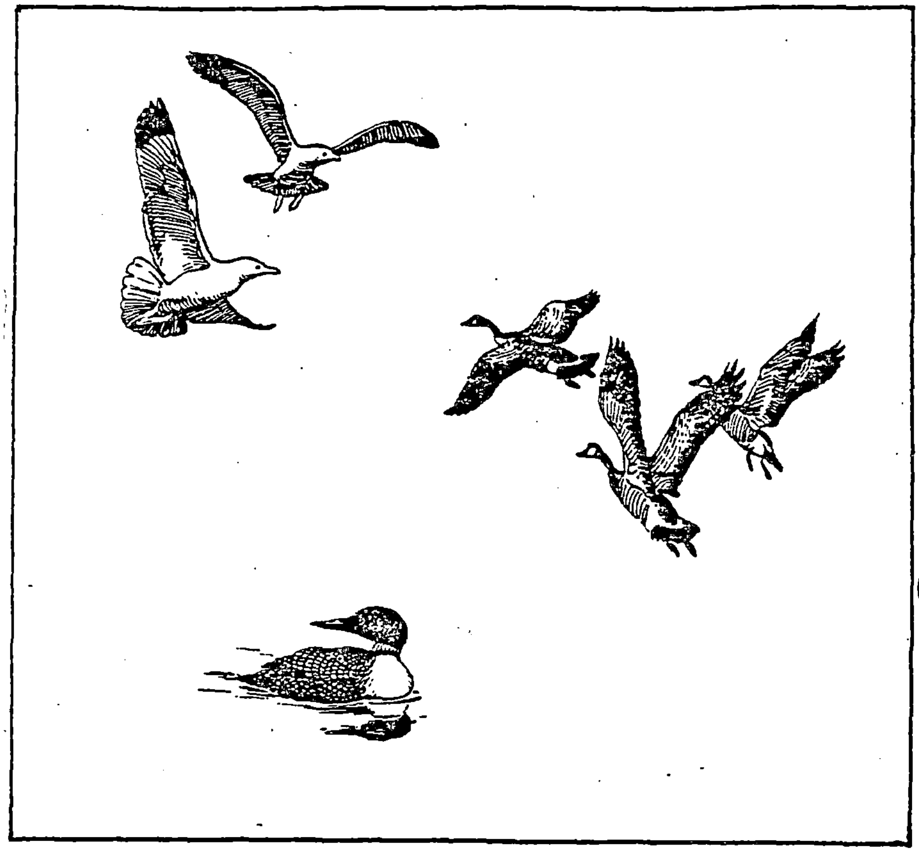
DISTRIBUTION AND ABUNDANCE OF WATERBIRDS IN RELATION TO HABITAT AND SEASON IN PRINCE WILLIAM SOUND, ALASKA, 1983-1984.



Progress Report

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ABSTRACT

The Trans-Alaska Pipeline terminus is located in Prince William Sound (PWS). Consequently, all oil extracted from the North Slope of Alaska (71,000,000 gal/day) is transported over the waters of PWS. Potential impacts from oil development, logging activities, fish hatchery development, and increased recreational use emphasize the need to quantify the wildlife resources in PWS. In reponse to this need the U. S. Fish and Wildlife Service initiated this study to examine waterbird use in PWS. Surveys were conducted to relate waterbird densities to habitat type and season. These consisted of transects that were repeated throughout the year and one-time shoreline surveys of the entire western half of PWS in summer. In addition, black-legged kittiwake (Rissa tridactyla) colonies were censused. Our data indicated that results from multispecies summer surveys can be highly variable, however, gross trends were observed. More birds were along shorelines than in open water throughout PWS in all seasons. There were more birds in summer than winter, but there were more species in winter. We found local differences in shoreline densities and diversity between study areas. There were also differences between transects with high wave exposure and transects that were protected. In summer more birds were in exposed transects than protected transects. In winter the opposite was true. Two factors caused much of the difference in bird densities. The presence of black-legged kittiwakes at colonies caused a tremendous increase in the number of birds near colony sites during summer. In winter, waterfowl use of large grass-covered tidal flats caused an increase in the numbers of birds in those areas.

Concentrations of birds offshore were extremely patchy in time and space. During summer most offshore concentrations were composed of murrelets (Brachyramphus spp.). Feeding flocks of kittiwakes and gulls (Larus spp.) were present in lower numbers. In winter, gulls and murres (Uria aalge) were most common offshore.

Censuses of kittiwake colonies demonstrated that significant changes have occurred in recent years. Between 1972 and 1984, 6 of 26 kittiwake colonies were abandoned and 6 were intiated. The number of nests at island colonies decreased 53% while the number of nests at colonies associated with glaciers decreased only 3%. Preliminary analysis of time-lapse photography demonstrated that a knowledge of attendance patterns of kittiwakes at colonies may be useful in improving census techniques and in helping to intrepret fragmentary data on productivity.

I. INTRODUCTION

Seventy-one million (71,000,000) gallons of oil flow through the Trans-Alaska Pipeline each day. Fifty (50) oil tankers per month are needed to transport North Slope oil through Prince William Sound (PWS) to its destination. Recently, the operators of the Alaska pipeline were accused of dumping toxic wastes into the waters of Port Valdez in PWS. Potential for impacts from oil development, timber harvest, fish hatchery development, and increased recreation has provided stimulus to quantify the wildlife resources in PWS (AEIDC 1977). In addition, the Alaska Department of Natural Resources has proposed to prepare a Prince William Sound Area Plan. Other state agencies and the U. S. Fish and Wildlife Service (USFWS) will cooperate in the preparation of this plan.

Few surveys of waterbirds (i. e., seabirds, waterfowl, and shorebirds) have been conducted in PWS. In 1971 Haddock and others with the USFWS conducted aerial surveys. They were dissatisfied with the results so in 1972 and 1973 they surveyed by boat. Unfortunately, Haddock and his co-workers were killed in a plane crash. As a result the aerial data lay dormant in files until Hogan and Murk (1982) reduced the reams of data to report form, but there were many uncertainties in interpreting the data. Dwyer et al. (1976) compiled the boat survey data; however, the report offers no information as to the specific areas of the transects. Therefore, it is difficult to use this information except in a general manner. Baird (1980) surveyed some parts of PWS in summer in conjunction with a bald eagle nest survey. Hogan (1985) surveyed the Port Valdez area by boat throughout the year, and recorded birds in relation to shoreline type. With the exception of the work by Hogan, these past studies provided only general and patchy information about the distribution and abundance of waterbirds in PWS.

Studying habitat selection of birds (Rice et al. 1983) has provided significant management tools and scientific knowledge. Hogan's work in Port Valdez was an excellent beginning, but much more data is needed for other parts of PWS. By relating bird densities to habitat types, our work will define critical habitats on a species specific basis for each season of the year.

Black-legged kittiwakes (<u>Rissa Tridactyla</u>) are the most abundant nesting seabird in PWS with the probable exception of murrelets (<u>Brachyramphus</u> spp.). Twenty-six kittiwake colonies were identified by Sowls et al. (1978). The large number of colonies in PWS offers a unique oppurtunity to study several important questions implicit to monitoring seabird populations. There are potentially three different food chains affecting productivity of kittiwakes in the Gulf of Alaska: the open ocean (i. e., Milddleton Island and Kodiak Island), the enclosed estuarine system of PWS, and the small but potentially highly productive tidewater glacier ecosystems. Since there are several colonies in each of these systems it provides an excellent opportunity to compare productivity and population trends of kittiwakes, as well as a chance to understand the effects of limited nesting areas and/or limited food resources on kittiwake populations.

The International Council for Bird Preservation held its eighteenth world conference in London in 1982. The Alcid Working Group of the Seabird Workshop identified four alcid species in the world as experiencing or likely to experience serious population problems, the marbled murrelet (B. marmoratus) being one of these four. Numerous sources (Islieb and Kessel 1972; Dwyer et al. 1976; Nysewander and Knudston 1977; Sangster et al. 1978; Oakley and Kuletz 1979; and Eldridge and Kuletz 1981) have reported some of the highest recorded densities in this species' range. Other studies have been intiated in the southern portion of the murrelets' range. Sealy and Carter (1982) set up a monitoring program along the coast of Vancouver Island in Canada. The Non-game section of the Alaska Fish and Game Department has attempted radio telemetry of murrelets in southeast Alaska. Our present study has noted high variability in activity patterns of murrelets which stresses the need to design meaningful monitoring techniques in PWS.

The objectives of this study are threefold. First, to provide more precise estimates of numerical abundance of waterbirds in PWS that would enable us to predict the magnitude and diversity of waterbirds using major shoreline and offshore habitats in each season of the year in PWS. Second, to set up a long term monitoring program to compare colony status and reproductive success of black-legged kittiwake colonies within PWS. Third, to develop techniques to monitor murrelet populations.

II. STUDY AREA

PWS lies 100 km southeast of Anchorage and is an unusual estuarine system due to the deep inland waters and shallow sill at the entrance. PWS is a relatively protected body of water composed of a myriad of habitat types resulting from a mixture of deep narrow fiords, shallow protected bays, and exposed shorelines adjacent to shallow and deep water, all with variable salinity. Thousands of marine mammals and 100,000's of marine birds inhabit the waters of PWS (Islieb and Kessel 1973), yet there is relatively little shallow water area to accommodate bottom feeding animals such as diving waterbirds and sea otters (Enhydra lutris).

III. METHODS

Periodic shoreline surveys were conducted throughout the year along Passage Canal, Naked Island, and sections of Port Wells and Perry Island (Fig. 1). Open water surveys were done in Passage Canal, Port Wells, Wells Passage, and between Perry Island and Naked Island.

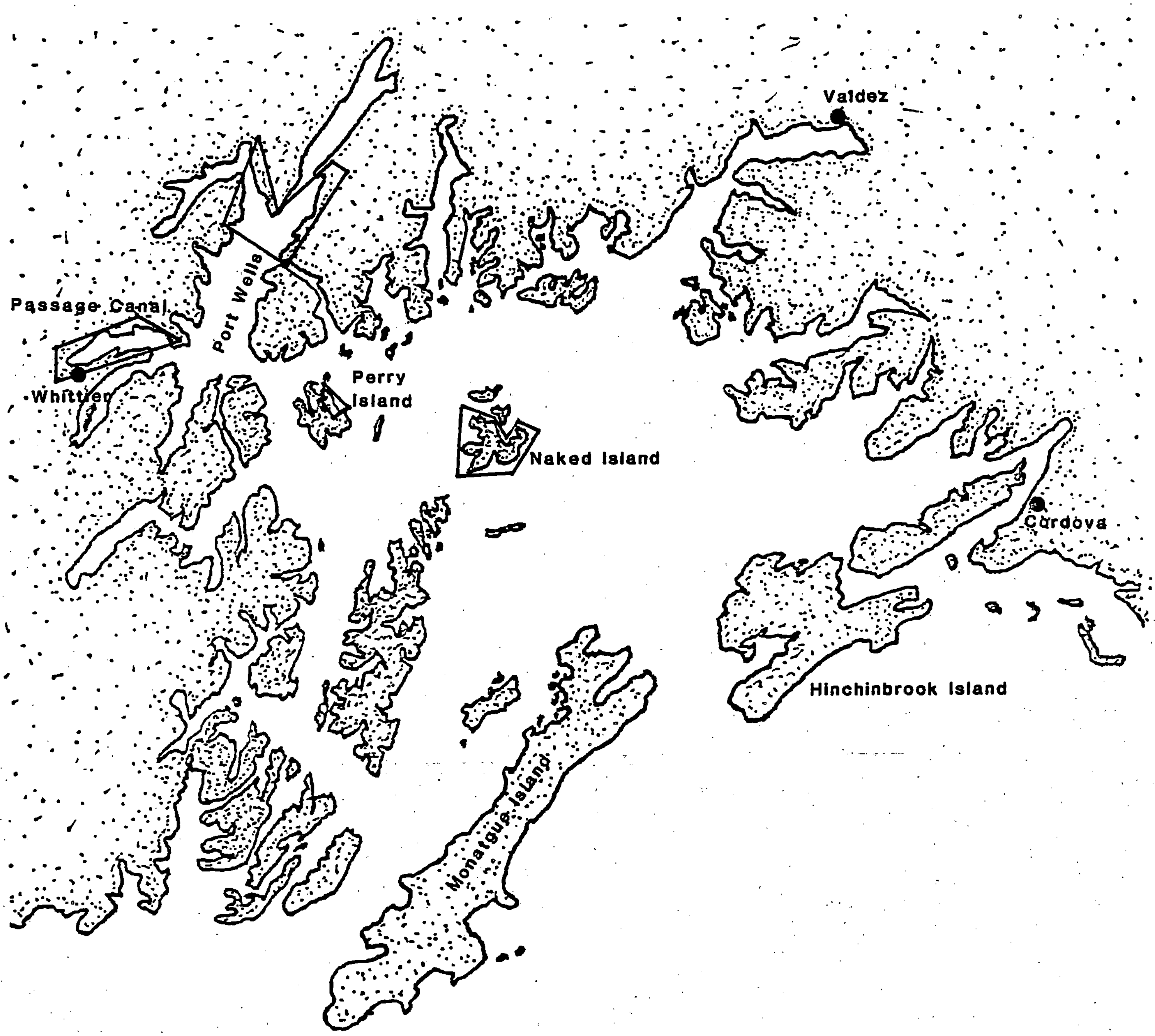

Figure 1. Map of Prince William Sound showing four study areas (Port Wells, Passage Canal, Naked Island, and Perry Island) where shorelines were surveyed periodically throughout the year.

During summer months extensive surveys covering the entire coastline of western PWS (about 3,000 km) and about 3,000 km of open water were done. All surveys were conducted from small to mid-sized boats (i.e. 17'-32'). The primary vessel was a 25-foot Boston Whaler.

We surveyed the shoreline by paralleling the coast 100 m offshore. One observer counted birds between the shore and the boat and a second observer counted birds from the boat out to 100 m on the seaward side. Using this method we surveyed a strip 200 m wide. Birds beyond the transect area were enumerated separately.

Transect length of shoreline surveys was determined by habitat type (i.e., each transect contains only one major habitat type). Habitat types were based on several parameters: shoreline substrate type, exposure (to waves), and water depth, temperature, and salinity. Transects were divided into protected (less than 2 km to the opposing shore) and exposed (greater than 2 km to the opposing shore) categories for analyses.

Open water transects were conducted similarly, but transect length was standardized and was determined using velocity of the vessel and period of transect. Several instantaneous counts, as described in Forsell and Gould (1981), were made. Because of shorter viewing distances and faster speeds, counts were made more often than done by Forsell and Gould (1981).

Colony sizes and reproductive rates were determined for black-legged kittiwake colonies within PWS. We attempted to count colonies once during early June and once during early August, but logistical problems prevented us from reaching all colonies. Counts were made from boats by two or three observers. In the early censuses all nests and birds were counted. Only chicks were counted in the late censuses.

We initiated a study of attendance patterns and mortality rates of black-legged kittiwakes at colonies. Data was collected at the colony east of Elenor Island through the use of a time-lapse camera. One picture was taken at five minute intervals from dawn to dusk. The camera was set up from July 20 to August 12 which was during the incubation-nestling period.

The colony was divided into four categories: sites with chicks, sites with incubating birds, sites in which the nest failed, and sites that had no nest but were used for roosting by one or two birds.

Attendance was analyzed by recording a 0, 1, or 2, corresponding to the number of adult birds at each site, for each photograph. The data was expressed as the percent of time 0, 1, or 2 birds were present at sites. Data was analyzed to depict daily and seasonal activity patterns. Mortality of eggs or chicks was recorded as it occurred.

IV. RESULTS

A. Repetitive Shoreline Surveys

Seasonal differences in waterbird use were demonstrated by repetitive shoreline surveys. Waterbird densities were higher in summer, but more species were present in winter. During summer there was an average of 51 birds/km of shoreline compared to 33 birds/km in winter. The average number of species per transect during the June and July surveys was 5.0; during the November and February surveys the number of species increased to an average of 8.6 per transect. These figures indicate that in summer there were relatively high numbers of a few species and in winter there were relatively few numbers of several species. Three species (marbled murrelet, black-legged kittiwake, and pigeon guillemot (*Cepphus columbia*)) compromised most of the birds in summer transects. In winter several species (mallard (*Anas platyrhynchos*), Canada goose (*Branta canadensis*), Barrow's goldeneye (*Bucephala islandica*), bufflehead (*Bucephala albeola*), harlequin duck (*Histrionicus histrionicus*), marbled murrelet, horned grebe (*Podiceps auritus*), red-necked grebe (*Podiceps grisegena*), and pelagic cormorant (*Phalacrocorax pelagicus*)) occurred in moderate numbers.

We found differences in bird densities between areas in both summer and winter. We compared three areas (Port Wells, Passage Canal, and Naked Island) (Fig. 1). In summer, Passage Canal had 115 birds/km of shoreline while Port Wells and Naked Island had 23 and 22 birds/km, respectively. In winter, Port Wells had 63 birds/km, while Passage Canal and Naked Island had only 17 and 16 birds/km, respectively.

The number of species of waterbirds also exhibited spatial and temporal variation. Transects in Port Wells averaged 6.7 species in summer while Passage Canal and Naked Island averaged 4.3 and 4.1 species per transect, respectively. During winter, the number of species in Port Wells increased to 10.3 per transect or 54%, and Passage Canal and Naked Island increased to 7.0 (63%) and 8.4 (105%) species per transect, respectively. These data indicate that there were species that were common in Port Wells in summer and winter that were infrequent in Passage Canal and Naked Island.

To explore the possible effects of wave exposure on bird diversity the transects in the three study areas were separated into protected and exposed categories (see Methods for definitions). During summer the protected transects averaged 16 birds/km and the exposed transects averaged 86 birds/km. In winter the protected areas had a mean of 45 birds/km as compared to 22 birds/km along exposed coasts. Colonies of nesting seabirds along exposed coasts were responsible for high densities in summer and concentrations of dabbling ducks and Canada geese caused an increase numbers of birds along protected coasts in winter. Is there a causal relationship between the amount of exposure and colony sites and/or concentrations of ducks and geese? We hope to answer this question, through further analysis and data collection.

B. Repetitive Offshore Surveys

Little analysis has been done on the offshore survey data, but gross observations can be summarized qualitatively. During all seasons of the year, and in all areas of PWS that were surveyed, there were fewer birds offshore than nearshore. Concentrations of birds offshore were extremely patchy in space and time. During summer, most offshore concentrations were composed of murrelets with fewer concentrations of feeding kittiwakes and gulls. In winter, gulls and murres were most common with fewer oldsquaw, cormorants, murrelets, and scoters. Winter densities were lower than summer densities. Because of the large variation caused by low densities and patchiness of offshore birds it is difficult to quantify their numbers meaningfully without a very large sample size.

C. Additional Summer Shoreline Surveys

The large amount of data gathered during the summer surveys dictates a computer analysis, which has not yet been completed. However, we can make qualitative statements about the gross distribution and abundance of waterbirds in western PWS. Near shore, marbled murrelets and black-legged kittiwakes were the most abundant species followed by pigeon guillemots. Marbled murrelets were the most ubiquitous, kittiwake's were concentrated near colonies and along routes to apparent feeding areas, and pigeon guillemots were distributed widely along rocky shores. Kittlitz's murrelets (B. brevirostris) were found in a few fiords and in bays on Knight Island. Their numbers were lower than marbled murrelets and they were more patchy in distribution. Harlequin ducks, mergansers (Mergus spp.) and goldeneyes nested along streams in PWS; therefore, shoreline surveys for these species were ineffective until they brought their broods to open water in July and August. As a result, early summer surveys underestimated the abundance of these species. Horned and tufted puffins and parakeet auklets nested on only a few islands in PWS. Their shoreline distribution was patchy and concentrated around the colonies. Glaucous-winged gulls and mew gulls (Larus canus) were found in PWS in low numbers most of the summer with concentrations near colonies. Large numbers were concentrated around salmon streams during late July and August when spawned-out salmon provided an abundant food source. Gulls apparently came from outside PWS to feed on dead salmon.

D. Additional Summer Offshore Surveys

The general impressions stated in the "Periodic Offshore Survey" section hold true for this section. The distribution of concentrations of marbled murrelets appeared to be extremely patchy in time and space. At this time we can offer no hypothesis as to what controls their distribution other than location of prey.

E. Additional Winter Shoreline Surveys

Little has been done on expanded surveys in winter. One week was spent in February surveying new areas. They were somewhat similar to the areas that were surveyed repeatedly, but the data have not yet been carefully analyzed.

F. Additional Winter Offshore Surveys

We found generally low numbers of birds as has been discussed previously. However, birds were more concentrated in areas where there was a steep gradient from shallow water to deep water, similar to that observed along the outer continental shelf break.

G. Black-legged Kittiwake Colony Censuses

Twenty-four of the 26 kittiwake colonies within PWS were censused during the summer of 1984. The number of nests per colony ranged from 4 to 2,075 with a mean of 525. The mean number of nestlings per nest ranged from 0 to 0.79 and averaged 0.23 for the 14 colonies counted (Table 1).

We compared colonies presently or recently located near glaciers with those located on islands away from glaciers (Table 2). The average size of glacial colonies (956 nests) was larger than island colonies (267 nests). Overall productivity was similar between the two groups (glacier colonies - 0.28 and island colonies - 0.24).

H. Attendance Patterns of Black-legged Kittiwakes at Colonies

Significant differences in attendance patterns were found between successful nesters, failed nesters, and roosting birds during the incubation-nestling period (Table 3). Sites with incubating birds and sites with chicks were never abandoned during daylight hours. One bird was present 98% and 97% of the time at incubating sites and sites with chicks, respectively. Two birds were present the remaining 2% and 3% of the daylight hours at sites with incubating birds and chicks (Table 3).

Table 1. Comparisons of numbers of black-legged kittiwake nests in PWS in 1972 and 1984 and number of young per nest in 1984.

Colony name	# of nests in 1972	# of nests in 1984	% change in # of nests from 1972 to 1984	# of young per nest in 1984	Date/Time nests were counted in 1984
			Glacial colonies		
Harriman Fiord	54	0	-100	-	5/2 1100
Passage Canal	2780	2075	-25	.79	6/11 1427
Blackstone Glacier	990	994	+1	.21	7/1 1730
North Icy Bay	550	197	-64	-	7/19 1130
Chenega Glacier	370	743	+101	-	7/8 1800
Icy Bay	2350	1803	-23	-	7/10 1000
Tiger Glacier	280	228	-19	-	7/10 1200
Shoup Glacier	190	1480	+679	.15	6/28 1341
Surprise Glacier	514	0	-100	-	5/2 1100
Yale Glacier	814	424	-48	.00	6/30 1759
Coxe Glacier	0	660	-	.25	6/12 0858
			Island Colonies		
South Eaglek Bay	33	78	+136	.22	6/28 1814
Clove Triangle	277	210	-24	.43	6/8 1228
Seal Island	0	16	-	.50	8/8 1024
Bay of Isles	173	59	-66	.00	6/8 1400
Middle Green Island	183	55	-70	.00	6/8 1607
South Green Island	20+	0	-100	-	8/8 1540
North Green Island	205	0	-100	-	8/8 1355
The Needle	380	326	-14	.32	6/9 1053
Procession Rocks	0	15	-	-	6/9 1526
Naked Islands	0	4	-	-	7/8 1620
North Eaglet Island	0	58	-	.40	6/28 1830
Gravina Rocks	67	48	-28	-	6/28 1050
Canoe Passage	47	0	-100	-	6/28 1000
Pinnacle Rocks	700	88	-87	-	6/27 1402
Boswell Rocks	4936	1754	-75	.03	6/27 1000
Hook Point	53	?*	-	-	- -
Porpoise Rocks	975	1259	+29	.26	6/22 1700
Seal Rocks	275	25	-91	-	6/23 1203
North Twin Bay	25	0	-100	-	6/29 1423
Point Elrington	0	8	-	-	6/9 1454
Wooded Island	780	?*	-	-	- -

*Hook Point and Wooded Island were not counted in 1984

Table 2. Comparisons of parameters of black-legged kittiwake colonies at glacial colonies and island colonies.

Parameters	Glacial Colonies	Island Colonies	All Colonies
Number of nests in 1984			
n*	9	15	24
Total	8,604	4,003	12,607
$\overline{x}$	956.0	266.9	525.3
Number of young in 1984			
n*	5	9	14
$\overline{x}$	0.28	0.24	0.26
Change in number of nests from 1972-1984			
n*	12	19	31
# of nests	-288	-4293	4581
% of nests	-3.2%	-53.0%	27.0%

* number of colonies

Table 3. Percent of time that 0, 1, and 2 birds were at roosts, failed nests, nests with incubating birds, and nests with chicks. Data are from 1507 observations over 9 days.

# BIRDS PRESENT	ROOSTS (n=2)	FAILED (n=6)	INCUBATING (n=8)	CHICKS (n=8)
0	10.8	6.0	0	0
1	57.2	80.2	97.8	96.6
2	31.9	13.8	2.2	3.4
# BIRDS / 100 sites	121.0	107.8	103.4	102.2

Failed sites and roost sites were more variable with one bird present 80% and 57% of the time, two birds present 14% and 32% of the time and zero birds present 6% and 11% of the time, respectively (Table 3).

Attendance patterns were broken down by time of day to examine diurnal patterns. Sites with incubating birds and chicks were consistent. Roost sites and failed sites demonstrated the most variability in the afternoon (Figures 2-4). Long-term activity patterns were looked at by comparing days. Again, sites with chicks and incubating birds showed little variation. Failed sites and roosting were somewhat variable the first four days, then became more stable (Figures 5-7).

We observed one case of mortality. At 1 p.m. on July 23 a bird stopped incubating and left a single egg unattended. Upon returning it incubated for a few hours but not again. Two points can be made about the activity patterns of this pair. First, the activity pattern showed a definite change when incubation stopped. Second, although the bird(s) quit incubating they maintained a high rate of attendance (Fig. 8).

V. DISCUSSION

A. Shoreline Surveys

The literature is somewhat confusing in respect to the numbers of some waterbird species in PWS. The two species that are thought to be the most abundant nesters are good examples. Islieb and Kessel (1973) cited a U.S. Fish and Wildlife Service survey that estimated 250,000 marbled murrelets in PWS in the summer 1972. Dwyer et al. (1976) estimated 103,783 $\pm$ 11,535 marbled murrelets from summer surveys in 1972 and 1973. Dwyer et al. (1976) also estimated 140,854 $\pm$ 35,339 black-legged kittiwakes in the same period. However, (Sowls et al. 1978) lists only 36,000 black-legged kittiwakes nesting in PWS in 1972. Assuming that there were 36,000 nesting kittiwakes it seems unlikely that the total PWS population was 140,000 birds. Although the data are highly variable, they suggest that there are a few to several times as many marbled murrelets as kittiwakes.

In addition to intraspecies discrepancies, the ratios of marbled murrelets to kittiwakes derived from total estimates for PWS do not agree with observed densities from several surveys (Table 4). Only surveys in Port Wells and Naked Island revealed more murrelets than kittiwakes.

These discrepancies probably result from inadequate sampling designs. Some of the problems may be: (1) sample sizes too small, (2) differential observability between species or time, (3) differential activity patterns between species or time, or (4) double counts of flying birds.

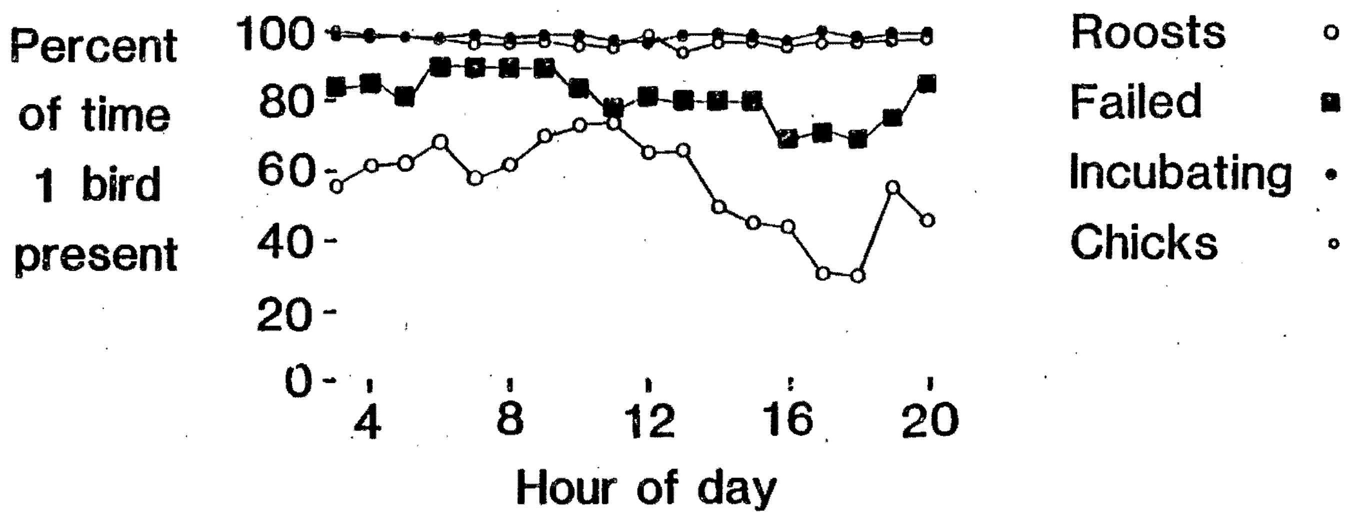

Figure 2. Percent of time 1 bird is present at roost sites, failed nests, nests with incubating birds, and nests with chicks for each hour of the day.

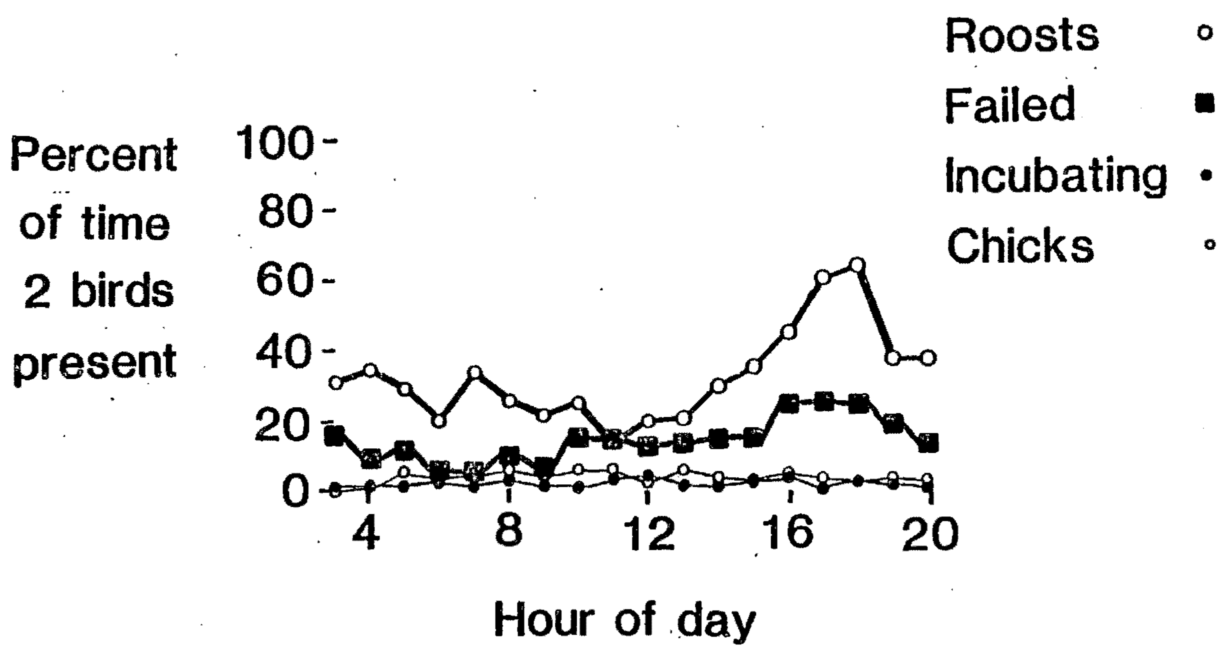

Figure 3. Percent of time 2 birds are present at roost sites, failed nests, nests with incubating birds, and nests with chicks for each hour of the day.

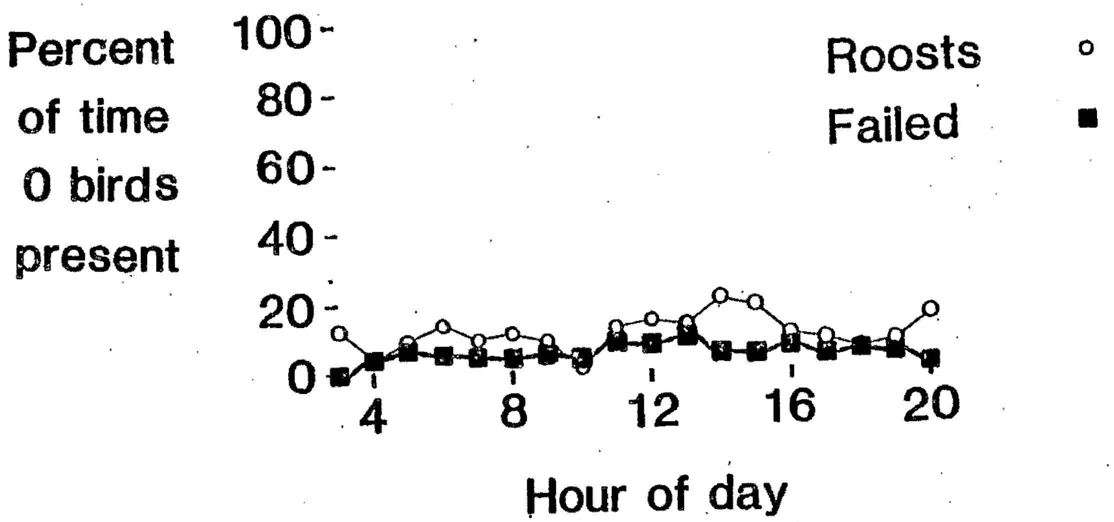

Figure 4. Percent of time 0 birds are present at roost sites, failed nests, nests with incubating birds, and nests with chicks for each hour of the day.

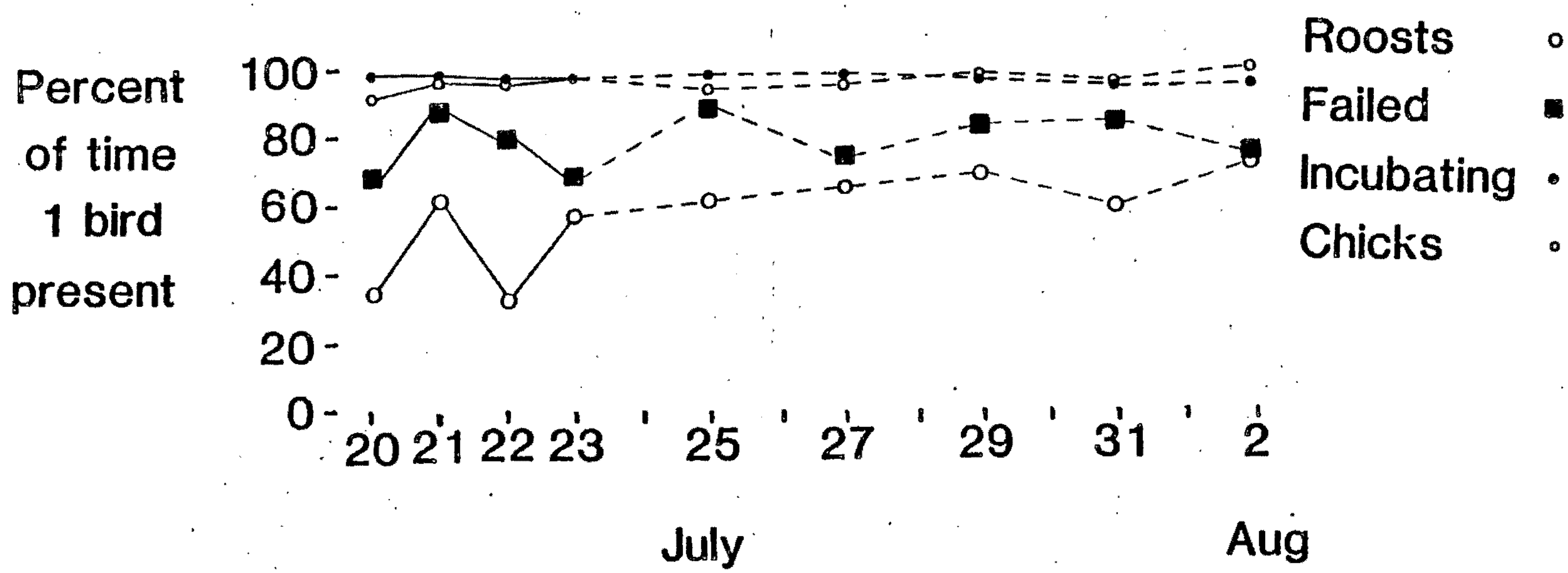

Figure 5. Percent of time 1 bird is present at roost sites, failed nests, nests with incubating birds, and nests with chicks during 9 days of observations.

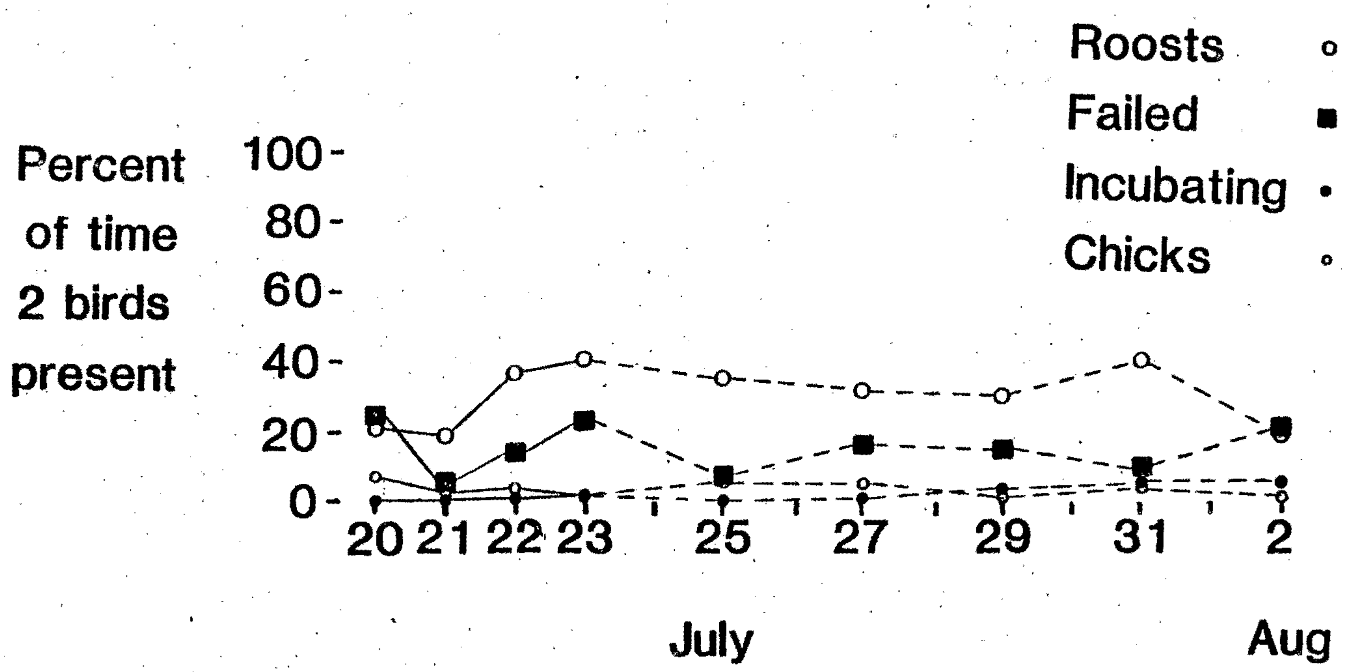

Figure 6. Percent of time 2 birds are present at roost sites, failed nests, nests with incubating birds, and nests with chicks during 9 days of observations.

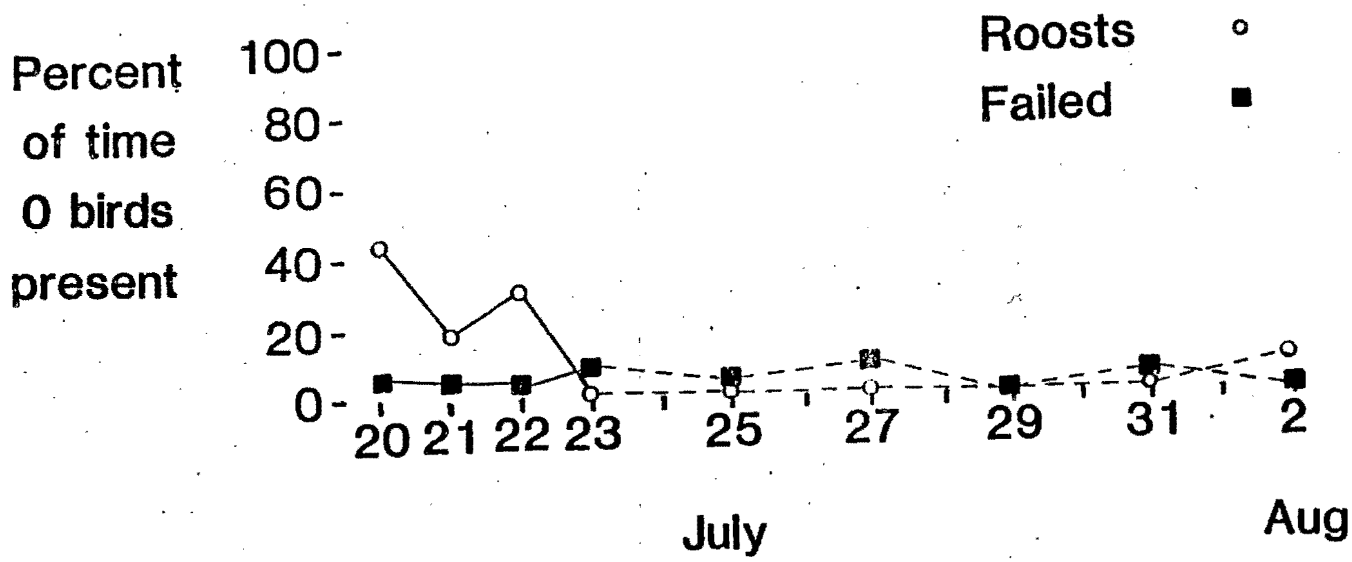

Figure 7. Percent of time 0 birds are present at roost sites, failed nests, nests with incubating birds, and nests with chicks during 9 days of observations.

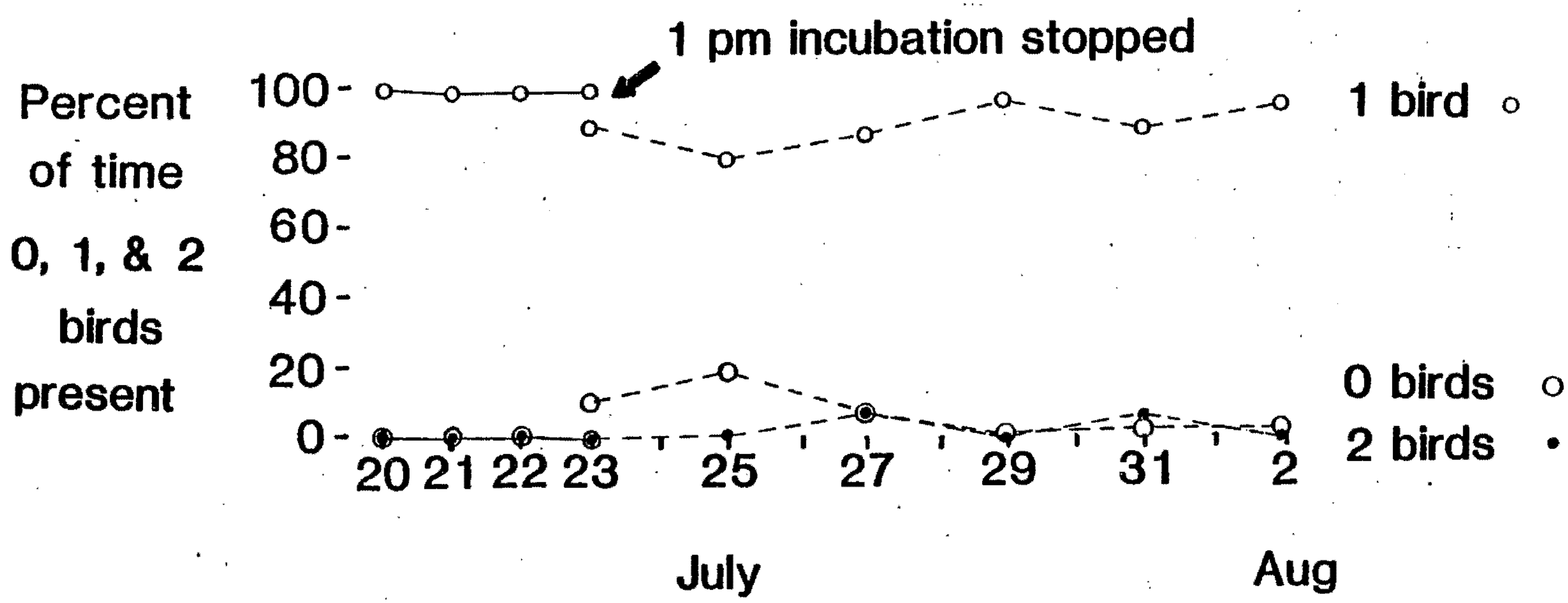

Figure 8. Percent of time 0, 1, and 2 birds were present at a nest in which the birds stopped incubating.

Table 4. Variation in observed shoreline densities of marbled murrelets and black-legged kittiwakes in summer.

Source	Location	Kilometers of shoreline surveyed	Date	Number of murrelets per km of shoreline	Number of kittiwakes per km of shoreline	Ratio of murrelets to kittiwakes
Dwyer et al. (1976)	Prince William Sound*	?	late July to mid Aug 1972	7.0	9.0	0.77
			late July to mid-Aug 1973	4.5	31.7	0.14
Baird (1980)	Central & Eastern PWS*	646	7/28/80 to 8/10/80	1.8	7.5	0.24
Hogan (1985)	Port Valdez*	73	6/28/79	2.0	22.6	0.09
			7/10/79	1.8	21.2	0.08
			8/44/79	0.1	8.7	0.01
present study	Passage Canal*	66	6/11/84	0.9	c. 85.0	0.01
			7/9/84	3.9	c. 85.0	0.05
	Port Wells	64	6/12/84	1.4	0.4	3.50
			7/9/84	14.9	5.2	2.90
	Naked Island	71	6/7/84 (PM)	0.3	0.5	0.60
			6/8/84 (AM)	2.1	1.2	1.75
			7/7/84	2.2	0.9	2.44

*Black-legged kittiwake colonies present

Previous studies have not considered daily or seasonal changes in activity patterns as a variable affecting numbers of birds observed in surveys. This is an obvious void in survey techniques, and may explain some of the variation in the results. In the summer of 1985 we will conduct repetitive surveys in a large area to examine the effects of daily and perhaps seasonal variation. In the following paragraphs we discuss other factors that may affect distribution of waterbirds.

In summer, there were more birds in Passage Canal than at Naked Island or Port Wells. In winter, Port Wells had a higher density than Passage Canal and Naked Island. These gross differences in bird use can be explained by two factors. In summer, Passage Canal had a black-legged kittiwake colony that raised the density in one transect to 2,232 birds/km. Other transects in Passage Canal averaged 26 birds/km. The average summer density for all transects in the three study areas (excluding the one with the kittiwake colony) was 23 birds/km. Therefore, over one-half of the birds counted in 199 km of shoreline during summer were associated with one colony. In winter, dabbling ducks and Canada geese concentrated in two areas of tidal grass flats in Port Wells. In these two transects, the bird density was 135 birds/km compared to an average of 38 birds/km in other Port Wells' transects and 22 birds/km in all other transects. About one-third of all winter birds were waterfowl that concentrated in two of the 50 transects. By analyzing the data in this manner, it becomes obvious that the birds in PWS are not evenly dispersed in summer or winter. Further analysis may manifest other important factors affecting the distribution of waterbirds in PWS.

It should be noted that waterbird densities in transects without seabird colonies or concentrations of ducks and geese, were similar in summer and winter. Our present data indicate that few areas have high concentrations, therefore, much of the coastline in PWS has similar densities of waterbirds in summer and winter.

We attempted to survey as much of the shoreline of PWS as possible during one summer. Our primary objective was to do a complete shoreline sea otter survey of PWS (Irons et al. 1984) in conjunction with our waterbird survey. Our results indicated that a one-time multispecies waterbird survey in summer is of limited value. There are several problems with doing blanket surveys involving many species. Most of these problems arise from different daily and seasonal activity patterns among species. These problems were well demonstrated by surveying transects on Naked Island one evening in June, then resurveying the same six transects the next morning. The evening count revealed 162 birds, while we counted 1149 birds in the morning. Colonies of auklets and puffins exaggerated these differences, but the same phenomenon occurs throughout PWS.

B. Black-legged Kittiwake Colony Censuses

Several changes have occurred in the kittiwake colonies of PWS between 1972 and 1984. Six colonies were abandoned and six colonies were initiated. In western Harriman Fiord (in the northwestern portion of PWS) two colonies that totaled 568 nests in 1972 were abandoned, but a new colony with 660 nests was found about 15 km away at the east end. This evidence suggested that these kittiwakes have moved their colonies. To our knowledge, the movement of colonies this large over such a distance has not previously been recorded. The total number of nest attempts in PWS decreased 27% (with no new data on two colonies). However, the change in number of nests from 1972 to 1984 decreased only 3% at glacial colonies, and decreased 53% at island colonies (Table 2). Two of 10 glacier colonies were abandoned and one was intiated compared to island colonies in which four of 15 were abandoned and five were intiated (Table 1). Based on this information, it appears that glacier colonies are more stable than island colonies. More information will be collected and hypotheses for these population trends will be discussed in the final report.

In the 14 colonies that were checked, productivity was highly variable with three colonies producing no young. A food shortage is often thought to be the primary cause for poor reproductive success in seabirds. Therefore, it is intriguing that highly developed flyers such as kittiwakes may be affected by food shortages on such a local scale. Future work may provide more information toward resolving this enigma.

C. Attendance Patterns of Black-legged Kittiwakes at Colonies

Our results indicated attendance patterns of kittiwakes were more consistent than others have reported (Biderman and Drury 1978, Hatch 1978). We also found that most of the daily and seasonal variation during the incubation-nestling period came from failed nesters and roosting birds. Therefore, we suggest that much of the variation recorded by others came from failed breeders, nonbreeders, and/or mates of successful breeders. Galbraith (1983) found that only one parent of successful breeders stayed around the colony during the nestling period so it is likely that the variation during the nestling period reported by others was due to failed breeders and nonbreeders. If more studies prove that this pattern is consistent, then high variation would indicate "poor" years and low variation would indicate "good" years. Our results also pointed out that there may be differences between successful breeders and failed breeders in the percent of time that two birds are present at the nest site. If this proves to be true, then one may be able to determine the percent of successful and failed breeders simply by counting a colony once and recording the number of birds per nest.

RECOMMENDATIONS

These are the recommendations of the authors and do not necessarily represent policies of the U. S. Fish and Wildlife Service.

1. Document the influences of daily and seasonal activity patterns of birds on survey results for the major species in PWS, especially during summer. Past surveys have demonstrated that activity patterns of some species can cause tremendous variation in the number of birds observed.

2. Conduct surveys that account for variation caused by activity patterns of different species.

3. Map entire PWS area by habitat type.

4. Develop a model to predict general importance of each habitat type to each species during winter and summer, thereby identifying critical areas for waterbirds in PWS in summer and winter.

5. Compare diets of kittiwakes at glacial colonies and island colonies. The hypothesis is that kittiwakes at glacial colonies eat mostly invertebrates (i. e., lower on the food chain) and kittiwakes at island colonies eat mostly fish (i. e., higher on the food chain).

6. Monitor black-legged kittiwake population trends and reproduction at glacial colonies and island colonies over a 10 year period. The hypothesis is that island colonies will do better than glacial colonies in "good" years and the reverse will occur in "poor" years. The reason for this may be that kittiwakes at glacial colonies have a more constant but lower quality food source (i. e., invertebrates) while island colonies have a higher quality prey (i. e., fish) but it is more variable between years.

7. Determine consistency of black-legged kittiwake activity patterns for successful breeders, failed breeders, and nonbreeders. This may allow us to learn more about reproductive success of kittiwake colonies by one visit.

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