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RESULTS OF MONITORING STUDIES FOR PUFFINS IN THREE LOCATIONS IN
THE ALEUTIAN ISLANDS IN SUMMER 1989

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Key Words: tufted puffin, horned puffin, Aleutian Is., Agattu I., Buldir Is., Aiktak Is., populations, reproductive success food habits

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ABSTRACT

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Following the death of thousands of tufted and horned puffins in drift gill nets near the western Aleutian Islands, we began an incidental study of puffins at Buldir and Agattu islands where crews were involved in other surveys in 1988 and 1989. Buldir and Agattu breeding populations were closest to the drift net fishing, therefore impacts were probably most severe at these breeding sites.

Plots designed to detect changes in density were established at Buldir and Agattu and at control sites in the central and eastern Aleutians. Furthermore, delineation of nesting locations at all study sites was begun.

To understand the influence of environmental factors on changes in populations, we also gathered data on nesting phenology, reproductive success, chick growth, and food habits.

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INTRODUCTION

During the early and mid-1980's thousands of puffins died annually in Japanese high-sea salmon drift gill nets near the western Aleutian Islands. The magnitude of the mortality was put into perspective by DeGange et al. (1985) who estimated that roughly 14% and 29% of the horned and tufted puffins respectively were killed in the vicinity of the fishery annually 1981-1984. Breeding colonies at Agattu and Buldir islands were probably most severely affected. A restraining order on this fishery was issued in 1988 due to the illegal take of marine mammals, and the Supreme Court declined to review lower court rulings prohibiting the Japanese fleet from fishing within 200 miles of Alaska. It is unknown whether this fishery will resume in the near future.

If this commercial fishery has been limiting breeding populations of puffins in the western Aleutian Islands, that fact needs to be documented to demonstrate the potential impacts of future fisheries. Furthermore, if future considerations are given to allowing this fishery to again become active, knowledge about its impact on marine resources would be useful.

Prior to 1988, data on puffins in the Aleutian Islands were limited primarily to descriptions of distribution and crude estimates of breeding populations. Incidental to other studies, the U.S. Fish and Wildlife Service began in 1988 and continued in 1989 implementation of a monitoring system whereby moderate changes in populations may be detected with specified confidence. Furthermore, several relatively sensitive indicators of annual success (e.g., productivity, chick growth) were measured, and

prey items fed to puffin chicks were recorded.

Specific objectives of this monitoring program include documenting trends in populations and productivity of tufted and horned puffins at Buldir and Agattu islands, the sites which may have been most severely affected by the gill net fishery. Rates of productivity will suggest the role of recruitment in population change, and fluctuations in chick growth and the prey base will help to explain processes influencing the ecosystem.

STUDY AREA

Agattu and Buldir islands, are the primary study sites in the western Aleutians. In 1988 and 1989 plots were established at Adak and Aiktak, respectively, for control sites (Fig. 1). All sites had accessible populations of tufted puffins, but only Buldir has relatively accessible horned puffins.

Prior breeding population estimates of unspecified accuracy are: 20,000 tufted and 20,000 horned puffins at Buldir (Byrd and Day 1986), 16,000 tufted and less than 2,000 horned puffins for Agattu (Trapp 1975), and 100,000 tufted puffins at Aiktak (Nysewander et al. 1982). Tufted puffins nest primarily in earthen burrows while horned puffins usually occupy rock crevices.

No obvious habitat changes have occurred at Buldir recently that might account for changes in populations of puffins irrespective of release from gillnet mortality. In contrast, introduced arctic foxes were removed from Agattu in 1978 so a large amount of potential nesting habitat has become available

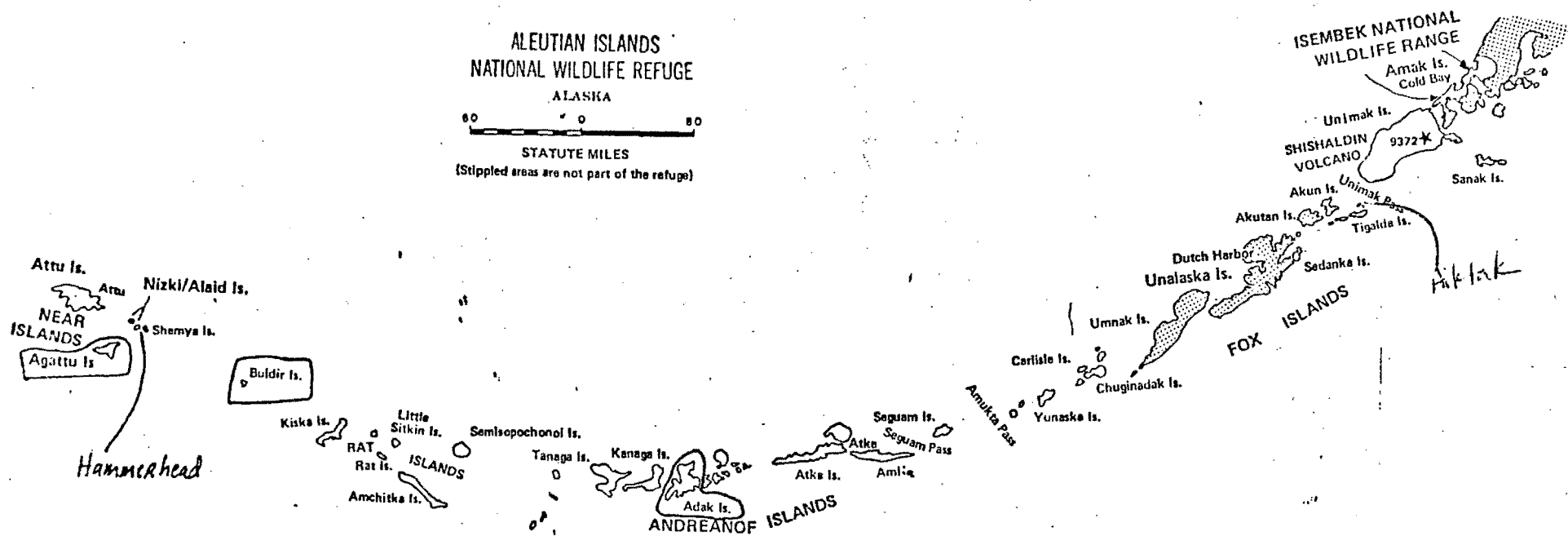


Figure 1. Map of the Aleutian Islands; puffin study areas are circled.

since then.

METHODS

Delineation of Colonies

A relatively crude form of monitoring population change is to detect expansion or contraction of nesting areas. In 1989 we continued to delineate nesting areas at Agattu and Buldir by walking stretches of coastline and recording locations of all colonies. Unfortunately it was not possible for us to document the exact edges of colonies at Agattu or Buldir. At the former location, birds nesting on the main island were restricted to slopes too steep for us to safely climb, and at Buldir the densities of inland colonies were so low that edges of clusters were not distinct. Nevertheless, an effort was made to map at least the general locations of nesting birds in portions of the islands so that large changes may be detected.

Estimates of Density

As indicated in our previous report (Byrd et al. 1989), there is currently no known method of monitoring densities of crevice-nesting horned puffins. In order to develop an acceptable monitoring method it is necessary to understand colony attendance patterns. In 1989 we continued to gather information on attendance patterns using time lapse cameras at Buldir. Furthermore, we set up several plots on the surface of the Main Talus at Buldir and made periodic counts throughout activity peaks.

For tufted puffins we counted burrow entrances in several plots established earlier (Byrd et al. 1989), and we set up additional plots at Buldir and Aiktak. Occupancy rates were estimated by checking a sample of burrows late in the nesting season for characteristic signs of activity (e.g., egg shell fragments, feathers, or droppings).

Reproductive Success

We used a flashlight to look into rock crevices at Main Talus, Buldir for horned puffin eggs, and in this manner we found eggs at different stages of incubation. Locations were marked with a spot of paint and numbered with felt markers. Sites were checked about every 4-5 days through late August. Eggs of tufted puffins were located by shining lights into burrows. Only a small proportion of burrow tunnels were straight enough for nest chambers to be visible from the entrance. Sites where contents could be seen were marked with flagging for relocation, and as with horned puffins, observations were made at 4-5 day intervals.

Chick Growth Rates

Tufted puffin chicks were weighed periodically (i.e., every 3-10 days) at both Agattu and Buldir during the linear phase of their growth. A small sample of horned puffin chicks was also weighed at Buldir. Since we did not know exact ages of chicks, the standard method of using the slope of a regression of age and mass to estimate average growth could not be used. Instead we estimated change in mass per day as follows: 1. Weights were

plotted over dates for each chick so that the linear part of its growth could be identified; 2. Differences between each pair of consecutive weights were divided by the number of days between weighings for all chicks (i.e., the sample unit was a single estimate of growth rate--any interval for any chick); 3. All samples were averaged to obtain an overall estimate for each island and species.

Food Habits

As in 1988, we placed screens at entrances to nest sites to collect food brought to chicks (Sanger and Hatch 1987). Samples of prey we did not recognize were collected for later identification. All prey items were weighed and lengths were measured in the field. Specimens we could identify and those for which vouchers had previously been collected were tossed into burrow chambers for chicks to consume.

RESULTS AND DISCUSSION

Distribution of Nesting Puffins

Agattu. -- In 1988 and 1989 selected stretches of coastline were surveyed to delineate nesting puffins (Fig. 2). Due to the difficulty in accurate mapping concentration areas, narrative descriptions were recorded for 13 locations (Figs. 3-5, Appendix A).

The only substantial nesting colonies of tufted puffins noted on the mainland coast were near Gillon Pt., (Area B, Fig.

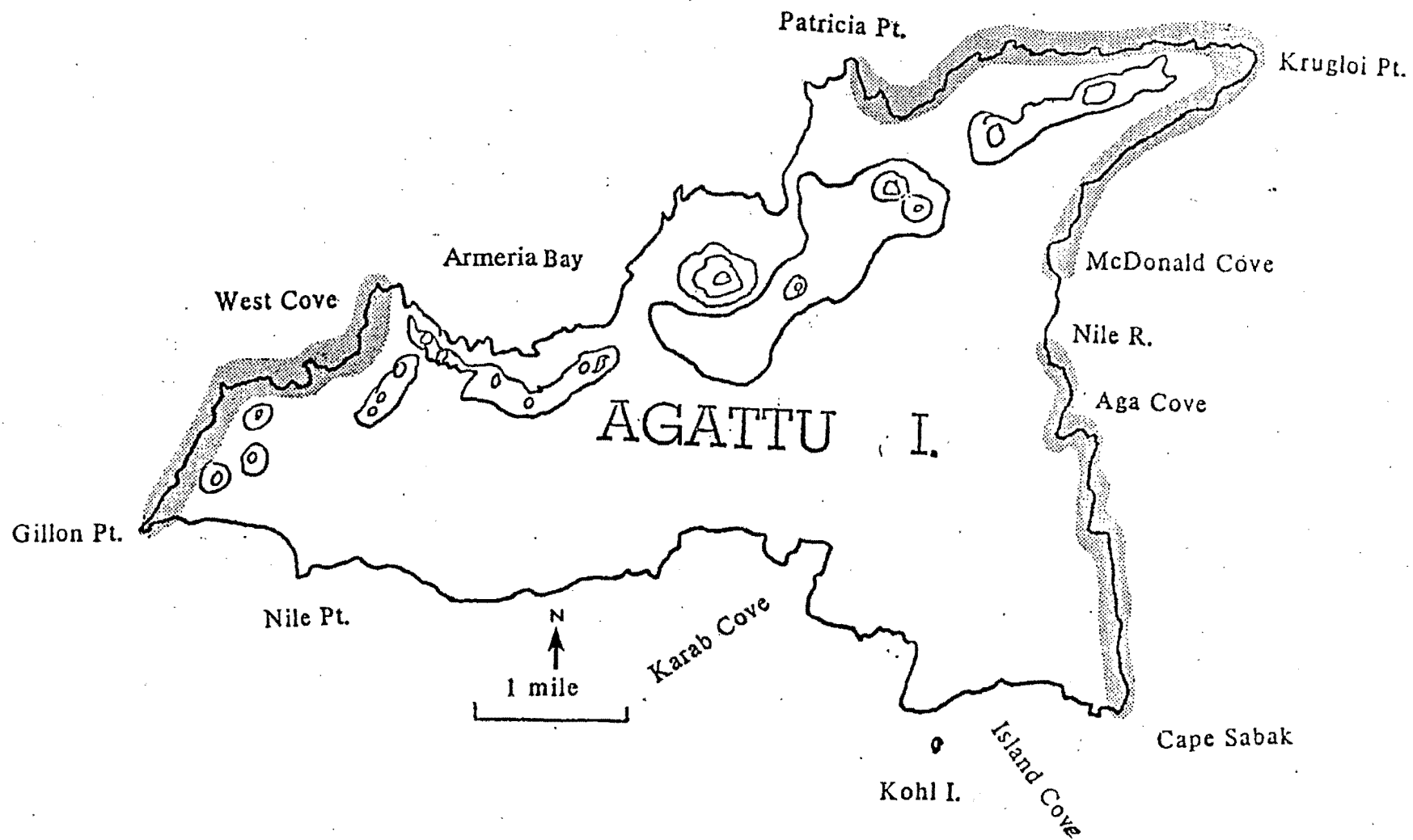


Figure 2. Areas at Agattu Island, Alaska surveyed for puffins in 1988 and 1989.

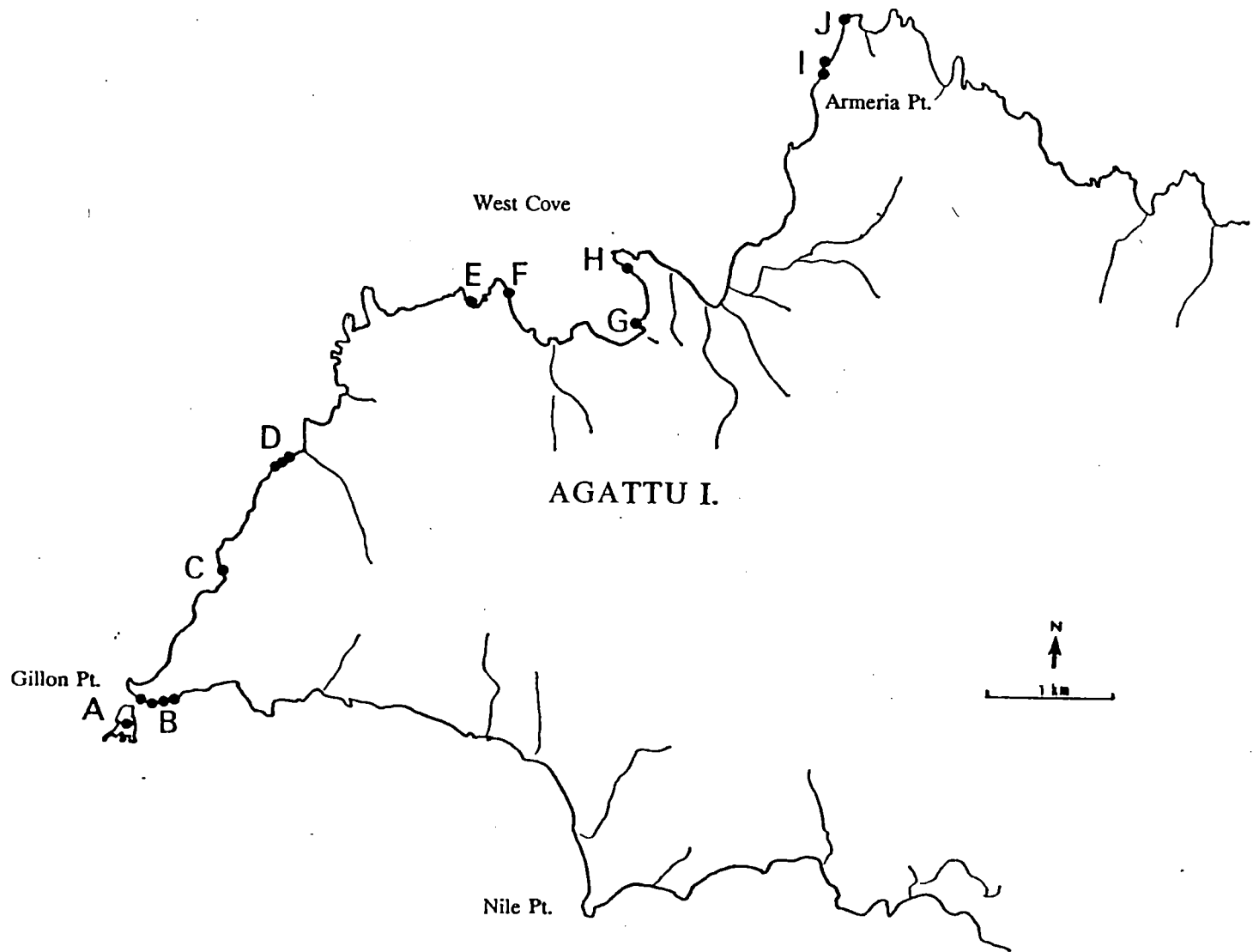


Figure 3. Map of the west end of Agattu Island showing the locations (dots) of puffin nesting areas.

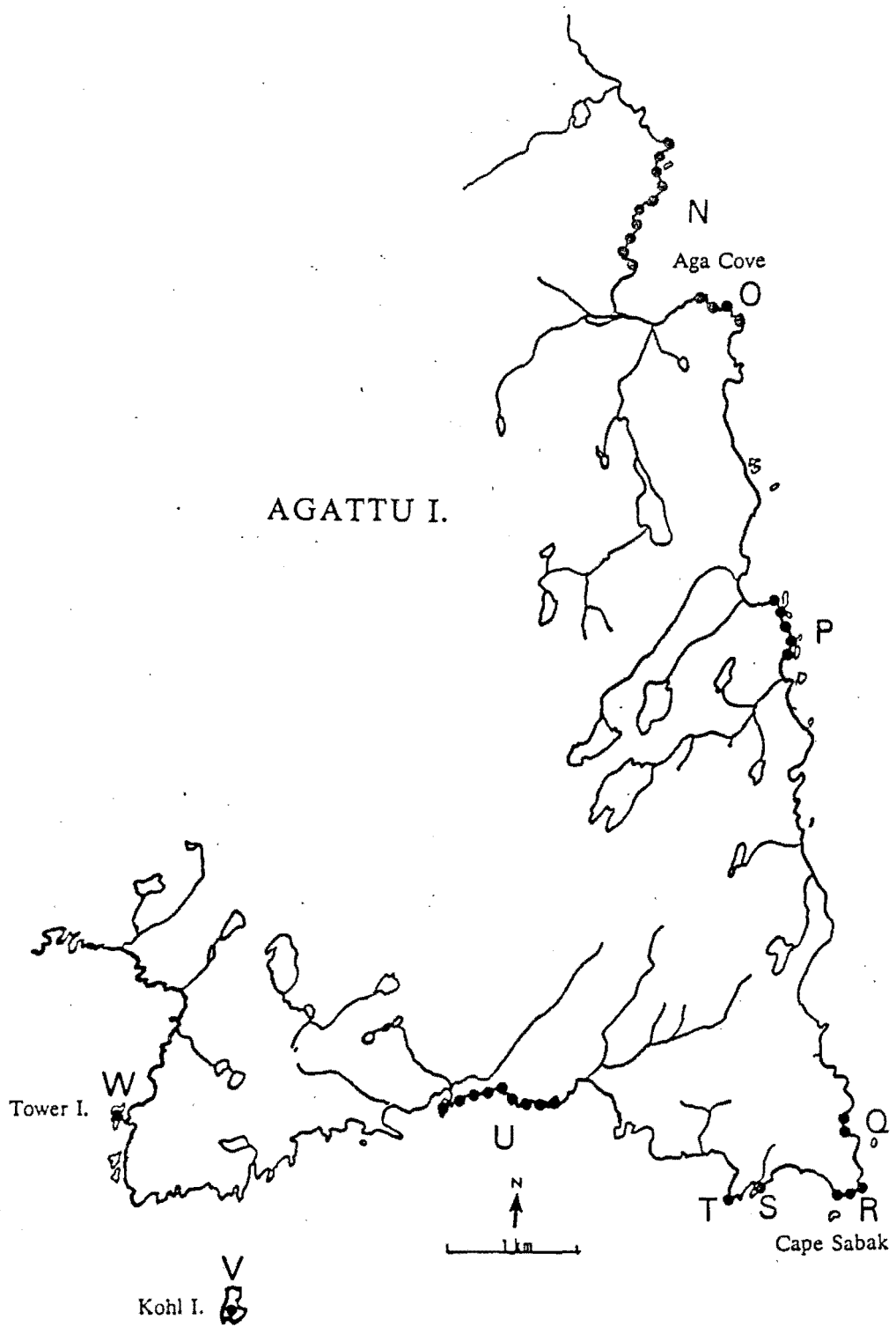


Figure 4. Map of the southeastern portion of Agattu Island showing locations (dots) of puffin nesting areas.

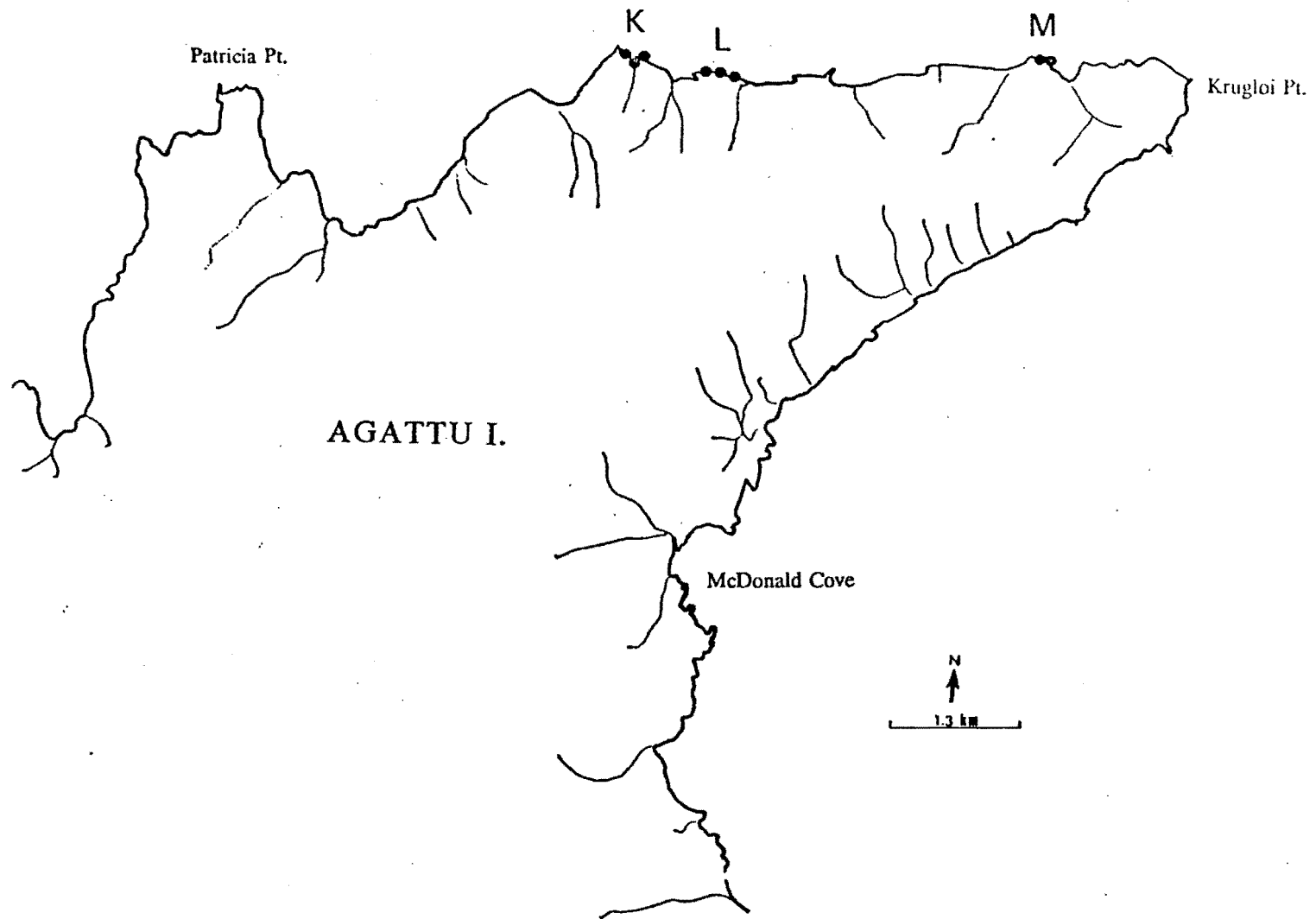


Figure 5. Map of the northeastern portion of Agattu Island showing locations (dots) of puffin nesting areas.

3) and near Camp Cove (Area P, Fig. 4). The largest concentrations were on offshore islets, particularly Kohl and Tower islands (Areas V and W, Fig. 4). Few horned puffins have been located at Agattu.

Buldir. -- In 1988 and 1989, 17 puffin nesting areas were delineated at Buldir (Fig. 6, Appendix B), although much of the eastern and southern portions of the island have not yet been surveyed. Tufted puffins were found in relatively large numbers, but at low densities at Northwest Point and Duff's Slope (Areas A and E, Fig. 6, respectively). One of the densest nesting concentrations was near Peregrine Pt. (Area Q). The largest concentrations of horned puffins were at Main Talus (Area F) and above Peregrine Pt. (Area O).

Aiktak. -- Tufted puffins occupied most of the periphery of Aiktak in 1980 (Nysewander et al. 1982) and during our surveys in 1989. Densities were particularly high along the south shore of the island where population index plots were located (Fig. 7).

Population Indices - Tufted Puffin

Agattu. -- Counts of tufted puffin burrows in study areas at Kohl Island, Agattu in 1988 and 1989 were similar, but the average for these two years was only 77% of the total present in 1982 (Table 1). Burrow occupancy rate in one study plot at Kohl Island was 80% in 1989, up from 60%-63% in 1988.

Buldir. -- Baseline data were obtained for at least one year in 17 plots at Buldir (Table 2). Fewer burrows were counted in 1989 than in 1988 on index plots surveyed both years at Buldir.

BULDIR ISLAND, ALASKA

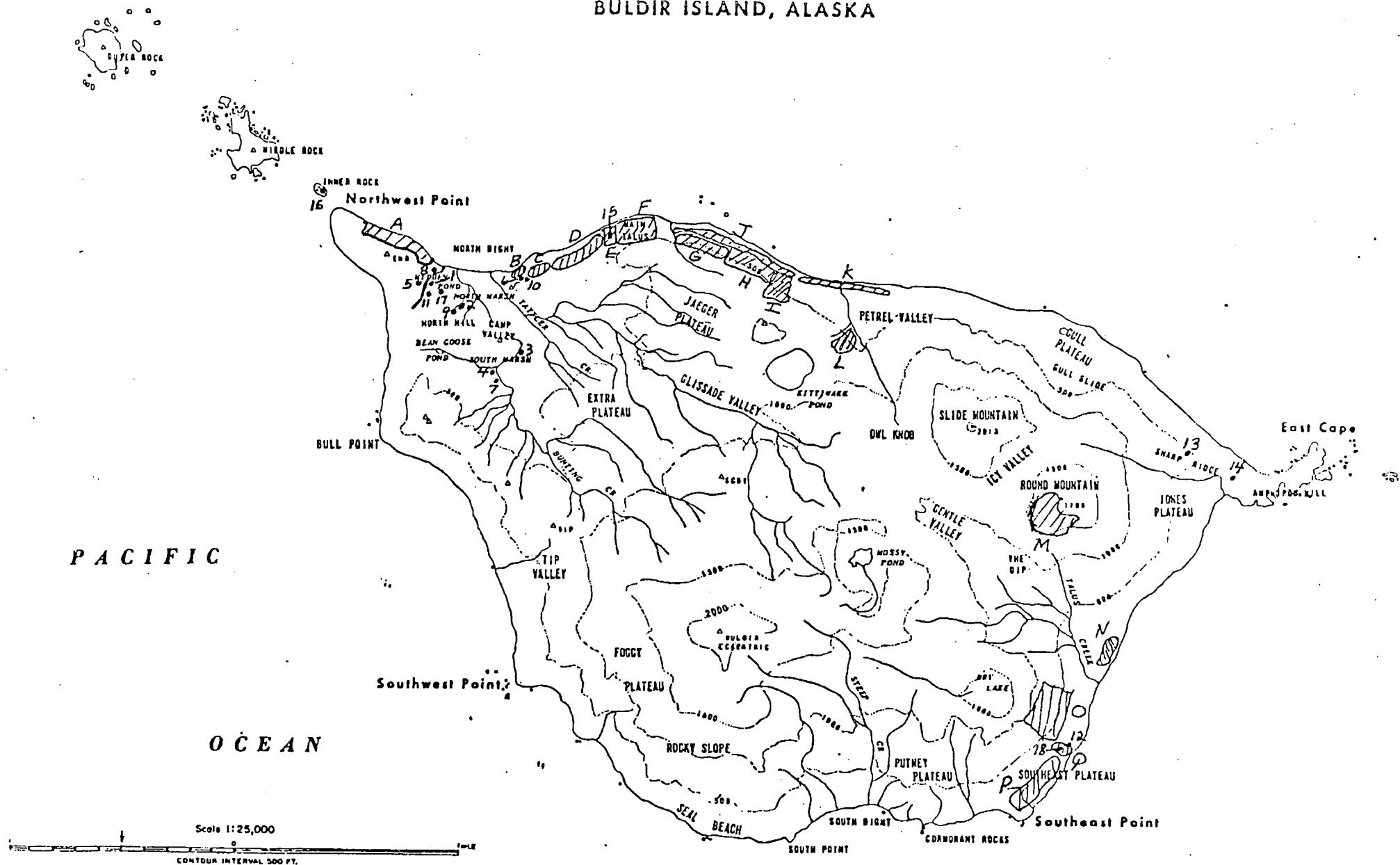


Figure 6. Map of Buldir I., AK showing the location of puffin study areas (cross-hatched areas are sites where the density of nesting burrows was estimated with survey sampling or subjective techniques, numbered dots are locations of quadrates within which all burrows were censured).

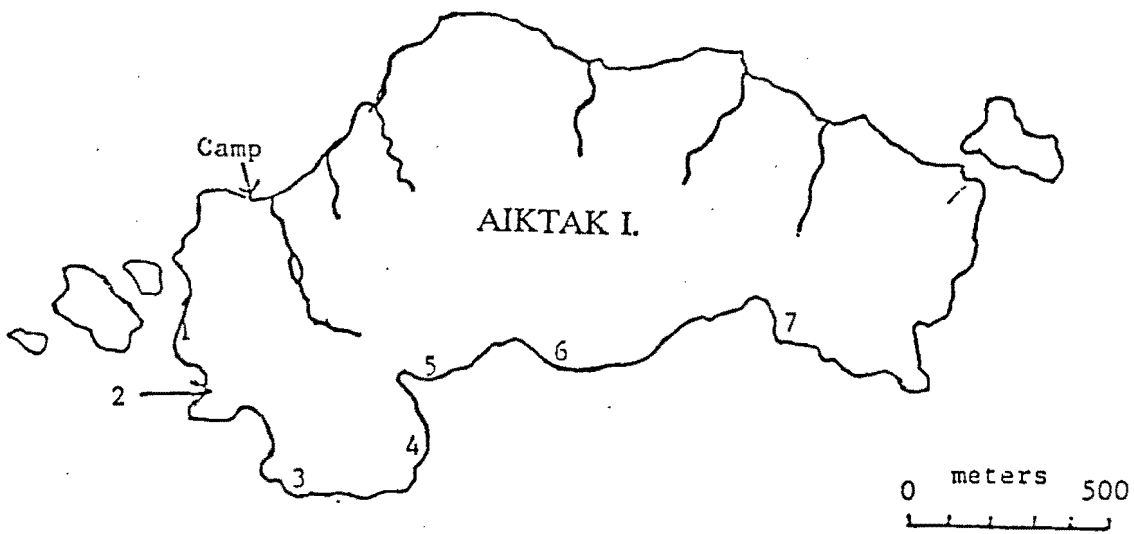


Figure 7. Map of Aiktak Island showing the location of population index plots for tufted puffins.

Table 1. Counts of tufted puffin burrows at Kohl Island, Agattu.

Area	^a 1982	^b 1988	^c 1989
North side	1452	1073	1143
South side	2077	1616	1593
Total	3529	2689	2736

a

from Forsell and Ambroz (1983)

b

from Byrd et al. 1989

c

only "occupied" burrows were counted in 1989 instead of "total" burrows, thus estimates of total burrows are based on the estimated occupancy rate from a study plot (80%)

Table 2. Results of tufted puffin burrow counts on index plots at Buldir I., in 1988 and 1989.

Plot	Total Burrow Entrances	
	1988	1989
1	1	0
2	1	1
3	9	0
4	0	0
5	14	5
6	-	10
7	-	0
8	-	0
9	13	6
10	-	0
11	-	7
12	13	6
13	99	-
14	0	-
15	263 ^b	221
16	89	74
18 ^c	-	38
Total ^d	403	313

a
no count

b
only a 40m x 60m section was comparable between years, thus the difference for the 1988 count from that presented earlier (Byrd et al. 1989)

c
the number 17 was not used for a burrow-nester plot

d
totals for plots where counts were available in both years

Part of the difference might have been that some burrows were missed in 1989, particularly in Area 15 where vegetation at the time of the counts was much lusher in 1989 than 1988.

Aiktak. -- Seven index plots were set up at Aiktak in 1989. These plots contained from 59 to 214 puffin burrows each, and occupancy varied from 61% to 83% (Table 3).

Population Indices - Horned Puffins

Analysis of time-lapse film for 1989 reinforced the results of similar work in 1988 (Byrd et al. 1989) that during the incubation stage of the reproductive cycle, attendance at the nesting colony reaches a daily peak in the evening (Fig. 8). Nevertheless, there was considerable day-to-day variation in the peak number of birds present (Fig. 9). This is reflected by the broad confidence bounds for abundance indices on six monitoring plots recorded for future comparisons (Table 4).

Nesting Phenology

Tufted Puffin.--At Buldir 19 of 20 (95%) tufted puffin eggs hatched between July 12-27 in 1989. At Agattu, 9 of 10 (90%) eggs hatched during about the same period, July 13-29. These breeding schedules are similar to those recorded in 1988 (Byrd et al. 1989).

Horned Puffin.--At Buldir 14 of 17 (82%) horned puffin eggs hatched between July 19-August 5, slightly later than the timing of tufted puffins in 1989, but similar to horned puffins at Buldir in 1988.

Table 3. Counts of puffin burrows in plots at Aiktak I., in July 1989.

	1	2	3	Plot 4	5	6	7
Puffin Burrows ^a	105	160	150	214	93	59	132
Proportion Occupied ^b	(0.61)	(0.83)	(0.76)	(0.76)	(0.74)	(0.73)	(0.73)
Medium Burrows ^c	0	17	91	60	4	9	14
Total	105	177	241	274	97	68	146

^a
 \geq 15cm in diameter

^b
 considered occupied if burrow entrances had guano, feathers, or egg shells present

^c
 9-14cm in diameter

HORNED PUFFIN ACTIVITY PERIODS

Buldir Island, Alaska 1989

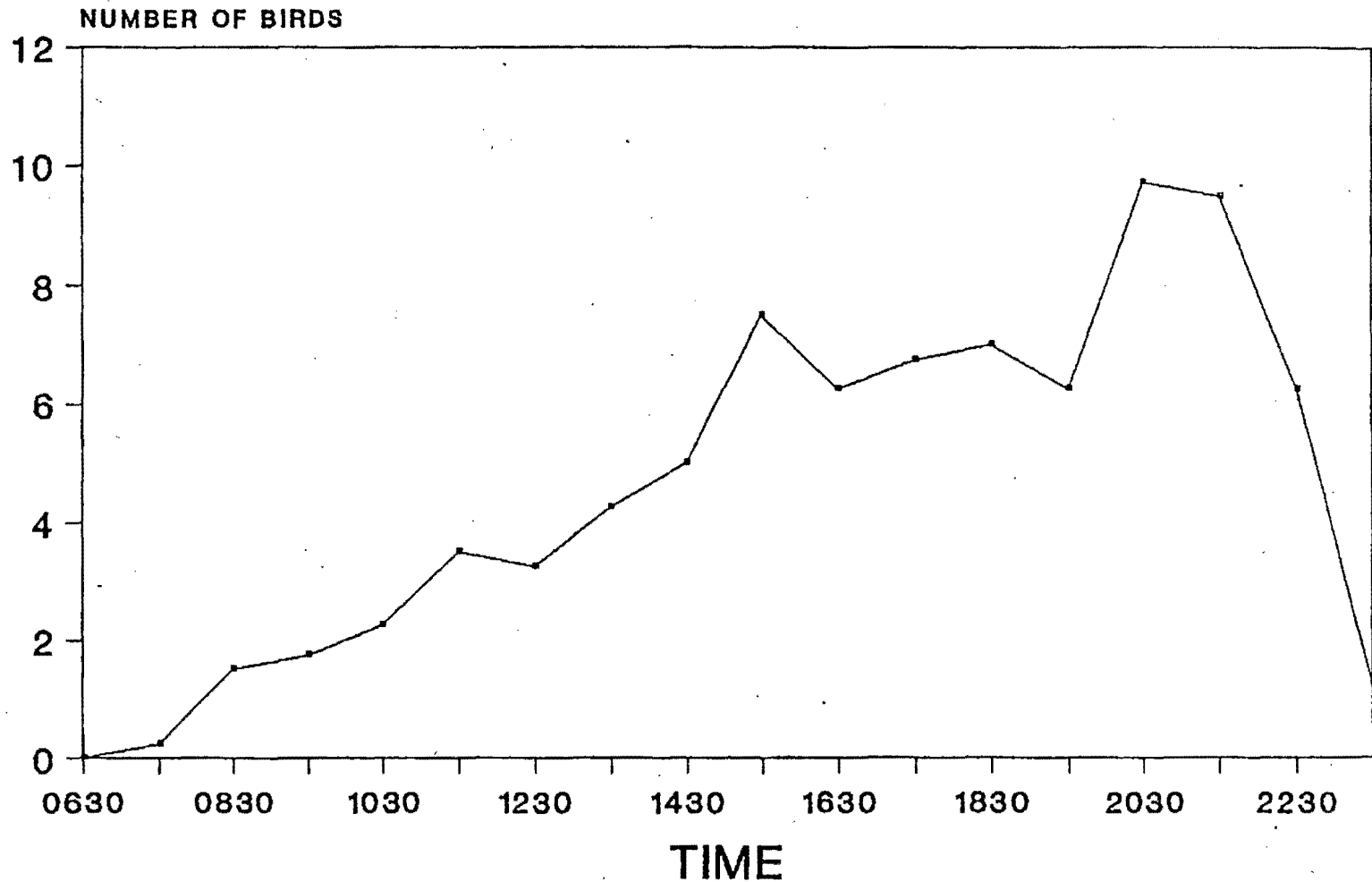


Figure 8. Mean number of horned puffins present at various times of the day during the incubation phase of the reproductive cycle at Buldir Island in 1989.

Horned Puffin Daily Activity

Buldir Island, Alaska 1989

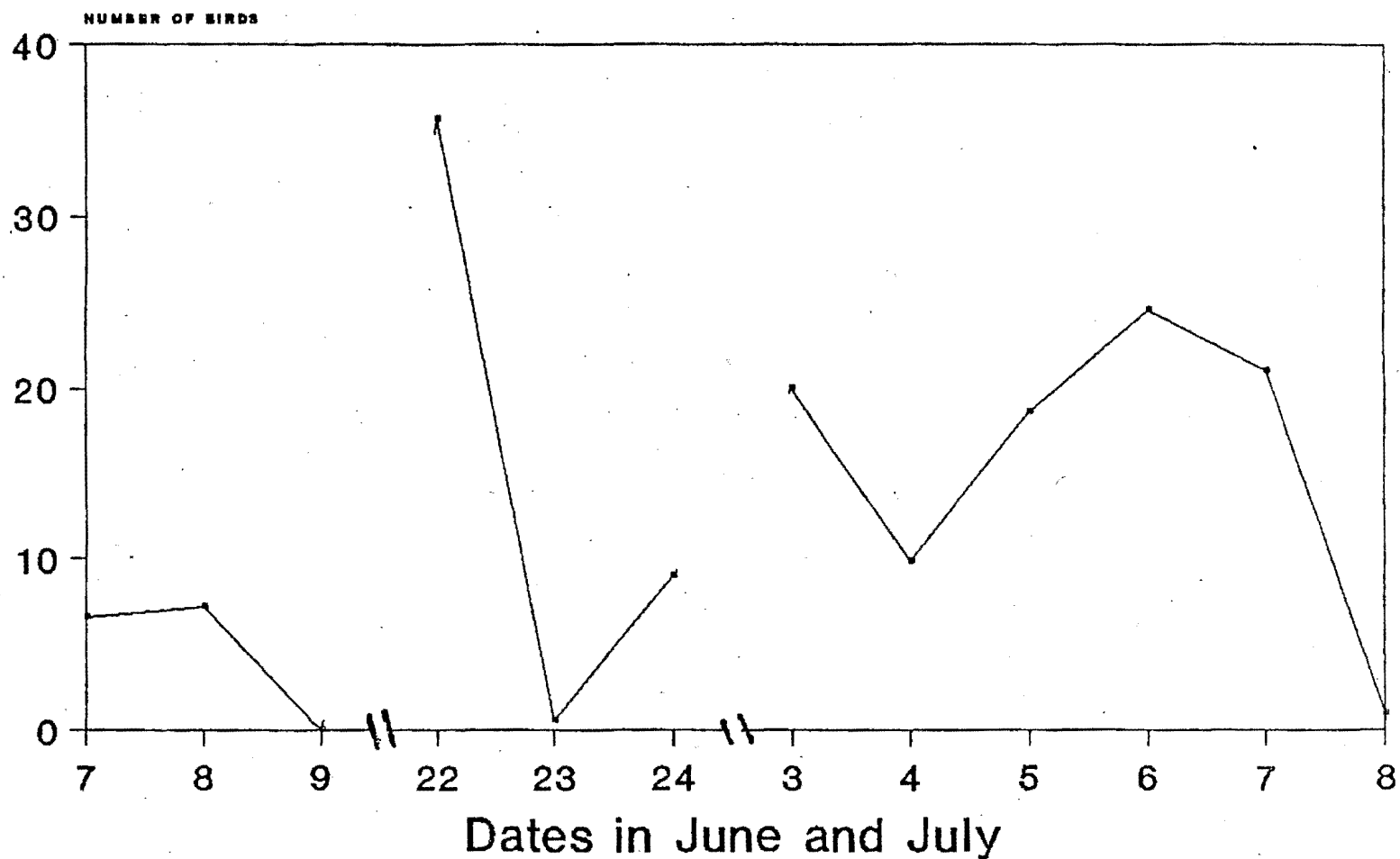


Figure 9. Abundance indices for horned puffins on a time-lapse camera plot at Buldir Island, Alaska in 1989. (abundance index = mean of highest 5 counts during the period 1915-2315).

Table 4. Abundance indices for horned puffins on monitoring plots at the Main Talus, Buldir I., Alaska in 1989.

Plot	Dates					Statistics ^a	
	06/24	06/25	06/27	06/29	07/06	Mean	90%B
1	0 ^b	0.4	0.2	6.2	6.8	2.7	3.3
2	1.4	0.6	4.0	5.8	6.2	3.6	3.5
3	0.2	0.6	0	0.8	0.4	0.4	0.3
4	0.2	4.2	1.0	10.8	6.4	4.5	4.1
5	8.4	11.6	0.6	35.8	24.6	16.2	13.3
6	6.2	7.2	0	10.6	9.8	6.8	4.0
Total	16.4	24.6	5.8	70.0	54.2	34.2	25.7

^a

90%B=90% Confidence Bound

^b

abundance index=Mean of highest 5 counts during evening surveys (usually at least 15 counts were made-every 15 min between 1915h-2315h)

Productivity

Approximately 75%-85% of horned and tufted puffin eggs hatched at Buldir and Agattu in 1988 and 1989 (Table 5). Although estimated success was slightly lower for tufted puffins than horned puffins at Buldir, differences were not significant ($p > 0.1$).

Fledging success is difficult to measure for puffins because as chicks get older their mobility increases and it becomes harder to spot them in burrows or nest crevices. This increases uncertainty about whether chicks remain alive. Nevertheless, it was obvious that chick mortality for tufted puffins was higher at Buldir in 1988 than in 1989 (Table 5).

Chick Growth

Both horned and tufted puffins grew slightly, but not significantly ($p > 0.1$), slower in 1989 than in 1988 at Buldir. Annual estimates of growth rates for the two species ranged from 8.0-9.5 g/day (Table 6).

Tufted puffin chicks gained on average 16.3 g /day at Agattu in 1989, similar ($p > 0.1$) to the 1988 estimate of 13.5 g/day. In both years, growth rates at Agattu were higher ($p < 0.1$) than at Buldir (Table 6).

Food Habits

In 1989, we collected 6 food loads containing 30 fish for horned puffins at Buldir (Table 7). Sand lance (Ammodytes

Table 5. Reproductive performance of puffins at Buldir and Agattu Is., Alaska in 1988 and 1989.

Parameter	Buldir				Agattu	
	Tufted		Horned		Tufted	
	1988	1989	1988	1989	1988	1989
Total Eggs ^a	27	45	42	69	-	17
Hatching Success ^b	0.78	0.73	0.86	0.84		0.82
Fledging Success ^d	0.36	0.81	0.63	^c -		0.86
Reproductive Success	0.25	0.59	0.46	-	^e -	0.71

a

proportion of known-fate eggs that hatched

b

proportion of known-fate chicks that were still alive when we departed in late-August (most were within 7-14 days of fledging)

c

we could not check sites frequently enough late in the season to estimate success, nevertheless at least 5 chicks died of 58 known to have hatched.

d

proportion of known-fate eggs that produced chicks

e

sample in 1988 too small to estimate success

Table 6. Average growth rates of puffin chicks at Buldir and Agattu Is., Alaska in 1988 and 1989.

Statistic	Tufted Puffin				Horned Puffin	
	Buldir		Agattu		Buldir	
	1988	1989	1988	1989	1988	1989
Mean ^a	9.5	8.0	13.5	16.3	9.4	8.2
s ^b	5.5	5.9	5.9	6.4	5.6	4.8
90% C.B. ^c	2.0	1.0	1.4	3.6	1.7	1.5
No. chicks ^d	7	14	20	7	6	14
No. weights ^e	23	37	48	20	11	27

a mean change in weight/day during the linear phase of chick growth

b standard deviation

c 90% Confidence Bound

d number of chicks in the sample

e sample size=number of weight changes measured for all chicks combined (i.e. sample unit=one interval between weighings)

Table 7. Prey items delivered to puffin chicks at Buldir and Agattu Is., Alaska in 1988 and 1989.

Prey	Horned Puffin		Tufted Puffin			
	Buldir		Buldir		Agattu	
	1988	1989	1988	1989	1988	1989
Sand Lance	a					
No. Loads	29(0.64)	6(0.67)	30(0.48)	12(0.50)	9(1.00)	9(0.78)
No. Fish	292(0.88)	30(0.67)	261(0.79)	68(0.43)	10(1.00)	26(0.87)
Squid						
No. Loads	6(0.13)	4(0.44)	16(0.26)	12(0.50)		
No. Fish	11(0.03)	5(0.11)	29(0.09)	38(0.24)		
Greenling						
No. Loads	4(0.08)	3(0.33)	5(0.08)	12(0.50)		
No. Fish	5(0.02)	4(0.09)	11(0.03)	20(0.13)		
Pollock						
No. Loads	1(0.02)	2(0.22)	4(0.07)	3(0.13)		
No. Fish	11(0.03)	4(0.09)	11(0.03)	11(0.03)		
Pacific Cod						
No. Loads						2(0.12)
No. Fish						4(0.13)
Other						
No. Loads	5(0.11)	1(0.11)	7(0.11)	1(0.04)		
No. Fish	13(0.04)	2(0.04)	18(0.06)	1(0.01)		

a
percent of totals in parentheses

b
includes Pleurogrammus monopterygius, Stenobranchius leucopsarus, Agonidae Family, and Ptilichys goadei

hexapterus) was the most frequently recorded prey item occurring in two-thirds of the samples and comprising two-thirds of the fish brought to chicks (Table 7). Squid, greenling (Hexagrammos lagocephalus), and walleye pollock (Theragra calcogramma) were also taken by horned puffins. The species composition and relative abundance of prey was similar in 1988 and 1989 (Table 7).

In both 1988 and 1989 most sand lance in our samples were from 5-8 cm long (Table 8). Most of the squid, and greenling ranged from 5-11 cm, and pollock were less than 8 cm long.

Prey diversity for tufted puffins was higher at Buldir than at Agattu in both 1988 and 1989 (Table 7). Tufted puffins took primarily sand lance at Agattu. This prey was also the most important item brought to chicks at Buldir, but squid, greenling and pollock were also used frequently there (Table 7).

Although the same prey items were relatively important at the respective sites in 1988 and 1989, there was a difference in the size of sand lance taken at Agattu between years. In 1988, 70% of the fish found at nesting burrows were over 11 cm long. In contrast, only 4% exceeded 11 cm in 1989 (Table 8).

Another interyear difference was the increase of squid, greenling, and pollock in the samples for both species of puffins at Buldir in 1989 (Table 7). Sand lance comprised a smaller percentage of the total prey items in 1989 although the species occurred in about the same proportion of food loads in both years (Table 7).

Table 6. Length frequencies of major food carried to puffin chicks at Buldir and Agattu islands, Alaska in 1988 and 1989.

Species Range (cm)	Buldir				Agattu	
	Horned Puffin		Tufted Puffin		Tufted Puffin	
	1988	1989	1988	1989	1988	1989
Sand Lance n=	214 ^a	31	165	74	10	26
2-5	0.01 ^b	0	0.02	0.16	0	0.04
5.1-8	0.97	0.97	0.98	0.82	0.20	0.62
8.1-11	0	0	0	0.01	0.10	0.31
11.1-14	0	0	0	0	0.10	0
14.1-17	0.01	0	0	0	0.40	0.04
17.1-20	<0.01	0	0	0	0.10	0
>20	<0.01	0.03	0	0	0.10	0
Squid n=	24	4	15	33		
2-5	0.13	0	0.13	0.18		
5.1-8	0.42	0.25	0.27	0.36		
8.1-11	0.33	0.75	0.27	0.27		
11.1-14	0.08	0	0.27	0.15		
14.1-17	0.04	0	0.07	0.03		
17.1-20	0	0	0	0		
>20	0	0	0	0		
Greenling n=	5	4	11	32		
2-5	0	0	0.64	0.47		
5.1-8	0	0.25	0.19	0.09		
8.1-11	1.00	0.75	0.19	0.34		
11.1-14	0	0	0	0.09		
14.1-17	0	0	0	0		
17.1-20	0	0	0	0		
>20	0	0	0	0		
Pollock n=	6	5	10	9		
2-5	0.50	0	0.30	0		
5.1-8	0.50	1.00	0.70	1.00		
8.1-11	0	0	0	0		
11.1-14	0	0	0	0		

a
number of prey

b
proportion of total

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Appendix A. Descriptions of areas where puffins have been recently seen on Agattu I., Alaska (see Fig. 3, 4 and 5 for locations of Areas A-M).

Area	Habitat Type	Species Present	Est. Length of Coastline Occupied	Burrows Confirmed	Approximate Number Present
A	Small island	TUPU		Y	Areas A-D 5-6 July 1979 - 435 TUPU counted by boat census
B	Mainland Cliffs	TUPU	225m	Y	Area A: June 1989 - Thousands of TUPU
C	Cliff face	TUPU HOPU	90m	Y	Area B: June 1989 - One to Two thousand TUPU
D	Mainland Cliffs & offshore rocks	TUPU HOPU	120m	Cliffs-Y Rocks-M	Areas C & D: 9 June 1989 - 196 TUPU and 38 HOPU. TUPU were divided about equally between areas; majority of HOPU in area D.
E	Cliff face	TUPU	60m	Y	Areas E, F, G: 4 June 1989 - 196 TUPU
F	Cliff face	TUPU HOPU	60-90m	Y	Areas F & G: 1 June 1989 - 73 TUPU in both areas; 10 HOPU on offshore rocks in area G.
G	Cliff face & offshore rocks	TUPU HOPU	60m	Y	
H	Cliff face	TUPU	30m or less	Y	
I	Offshore rocks	TUPU HOPU	60-90m	N	Areas I & J 2 June 1989 - 6 HOPU in area I; 52 TUPU divided between I & J
J	Edge of point on mainland	TUPU	60-90m	Y	5 June 1989 - 63 HOPU and 51 TUPU in areas I & J; most HOPU in I.
K	Coastline	TUPU		N	1989 - Fewer than 100
L	Coastline	TUPU		N	5 & 6 July 1979 - 100 TUPU 1989 - Fewer than 100
M	Coastline	TUPU		N	1989 - Fewer than 100
N	Coastline	TUPU		Y	June 1982 - 48 burrows on plots (200 m apart) from 190 m to 2400 m north of Aga Cove. 1988 - Burrows confirmed southern 1/3 of area N.
O Aga Cove	Cliff faces	TUPU HOPU		Y (several)	20-26 May 1982 - Up to 20 HOPU June 1982 - 93 TUPU burrows on plots (200 m apart) from 0-2870 m south of Aga Cove. 25 & 26 May 1983- HOPU fairly common; TUPU nesting around Aga Cove. 23 June 1985- 197 puffin sp.

P	Mainland cliff faces & offshore rocks	TUPU HOPU	Y (numerous)	Approx. 100 HOPU on cliff faces during summer 1985; did not see any in 1988. 23 June 1985 - 502 Puffin sp.
Q		TUPU	Y (few scattered)	
R	Mainland Slope	TUPU	Y	
Cape Sabak				
S	Top of mainland peninsula	TUPU	Y	23 June 1985 - 114 Puffin sp.
T	Top of cliffs on mainland	TUPU	Y	1988 - present
U	Offshore island & mainland coastline	TUPU	island-Y (200+) mainland -Y (at least 100)	23 June 1985 - 163 Puffin sp. 1989 - Est. 500 TUPU on island, 200 on mainland.
V	Offshore island	TUPU	Y	23 June 1985 - 178 Puffin sp.
Kohl I.			(1982-3529+) (1988-2689) (1989-2736)	
W	Offshore island	TUPU	Y	
Tower I.			(2333)	

a

Early et al. (1980) Boat census

b

Forsell and Ambrose (1983) (the + next to burrow number (area V) indicates an estimate of 300 more burrows in inaccessible areas)

c

Zeillemaker (1982)

d

Dragoo and Deines (1983)

e

Kord and Deines (1985) Boat census

f

Klett, E.V. pers. comm.

Appendix B. Annotated List of Areas Checked for Puffins at Buldir I., Alaska in 1988 and 1989 (see Fig. 6 for locations of areas).

Area A. -- This is a steep slope on the northeast side of the Northwest Point peninsula where we estimated there were about 3,500 burrows in 1988 (Byrd et al. 1989).

Area B. -- Beginning just west of Crested Pt. and extending east to the gully at the west end of North Bight Beach, this stretch contains several dozen burrows in lush umbel vegetation along the top of the cliff.

Area C. -- This area begins just east of the jutting rocky bluff above Crested Pt. Pockets of medium density (i.e., 10-30 burrows/100 m) occur in lush vegetation near the rock face (includes plot #6). The remainder of the slope to the east had very few burrows.

Area D. -- This Elymus-umbel habitat had less than 10 burrows/m . It is bounded on both the east and west sides by obvious drainages. The areas containing burrows are primarily confined to a narrow swath of umbel vegetation behind the cliff face along the east (Duff's Slope) and west rims of the drainage.

Area E (Duff's Slope). -- Most of the area is covered by plot #15. There were at least 350 tufted puffin burrows and probably at least 100 horned puffin crevices here in 1988 (Byrd et al. 1988). The area is also occupied by Cassin's Auklets, Ancient Murrelets, Parakeet Auklets, and storm-petrels making it difficult to accurately count "puffin" burrows.

Area F (Main Talus). -- This is one of the main nesting areas for horned puffins on Buldir. Tufted puffins also occur at medium to low densities in vegetated areas, particularly at the periphery of the talus slope.

Area G. -- This area is east of the U.S.G.S. marker "Bluf" and it extends to as far east as North Rock. Puffins nest in low densities between slides from the top of the slope down to about 250 ft in elevation.

Area H. -- From North Rock to the east, low densities of puffins occur in a band near the top of the slope between slides.

Area I. -- A continuous band of habitat extends from a large slide below the U.S.G.S. marker "Pon" to about 50 m west from the top of the slope down to about 250 feet in elevation. Puffin burrows were present in low to medium densities being relatively more common on the east-facing slopes than on the west-facing slopes.

Area J. -- Moderate numbers of horned puffins nested in crevices in cliff faces and among talus boulders throughout this area from the Main Talus to the northwest edge of Petrel Valley. The band of habitat extends from the beach to 250 feet elevation.

Area K. -- Low (<10 burrows/100 m) to medium (10-30 burrows/100 m) densities were found in elymus-umbel habitat in a narrow swath at the eastern edge of Petrel Valley. Talus and fine materials sliding off slopes of Pon and down over rocky cliff faces accumulated at the top of the bench in small fan-shaped talus piles. Pockets of umbels occur in these areas. The habitat broadens progressively to the east across Petrel Valley.

Area L. -- The west flank of Petrel Valley contained very low densities of burrows (<5 burrows/100 m).

Area M. -- This area of talus contained horned puffins, but no density estimates were made.

Area N. -- This is the area below the Dip where transects were used to estimate about 400 burrows were present in 1988 (Dip "A" and "B", Byrd et al. 1988).

Area O. -- Extending from nearly the top of the ridge to Peregrine Pt. this talus slope is occupied primarily by horned puffins. The talus slide is relatively old because it is becoming covered by vegetation. No density estimates were made, but certainly several thousands of horned puffins used this area.

Area P. -- A narrow bench extending from the southern edge of the Peregrine Pt. area to Southeast Point contained a low density of tufted puffin burrows.

Area Q (Peregrine Pt.). -- The butress called Peregrine Pt. is surrounded by relatively deep soil which is occupied by tufted puffins in densities up to about 40 burrows/100m (Plot 18 is in the highest density portion).