Volume 2. Marine Birds

Principal Investigators' Reports for the Year Ending March 1976

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Environmental Assessment of the Alaskan Continental Shelf

Volume 2. Marine Birds

Fourth quarter and annual reports for the reporting period ending March 1976, from Principal Investigators participating in a multi-year program of environmental assessment related to petroleum development on the Alaskan Continental Shelf. The program is directed by the National Oceanic and Atmospheric Administration under the sponsorship of the Bureau of Land Management.

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ANNUAL REPORT

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Identification, Documentation and Delineation of Coastal Migratory Bird Habitat in Alaska.

Paul D. Arneson

Alaska Department of Fish and Game

April 1, 1976

I. Summary

An aerial survey was conducted along the shoreline and in the estuaries of the north side of the Alaska Peninsula during the fall migration of waterfowl. The avifauna of the estuaries at that time was extremely abundant although the peak of migration was not in progress. The migration for some species had already occurred and others were yet to commence. Concurrent habitat surveys revealed large expanses of feeding and likely nesting habitat above high tide but below storm tide levels that were associated with the estuaries or freshwater streams. Entire world populations of certain species and discrete subpopulations of other species utilize these areas for staging prior to migration. An oil spill during the fall could immediately affect 100,000 seaducks inhabiting those waters. The long-term effects of damage to the ecosystem could produce much more devastating results. Destruction of plant and animal food sources in the estuaries would have great long-lasting impact on several populations. The eelgrass beds of Izembek Lagoon are the most renowned food source for many bird species, perhaps the most critical being black brant. Onshore oil and gas development in or near any of the estuaries could cause equal harm to large numbers of birds.

In Lower Cook Inlet it appeared from aerial surveys that the severity of winter could influence how damaging an oil spill would be. Prior to the survey mild weather predominated and ice had retreated in bays. During the short duration of the survey when cold weather prevailed, ice quickly formed, conceivably forming a barrier to oil on the water. This would save shoreline habitat but perhaps concentrate the seaducks and other marine birds where they would be more susceptible. The coast from Port Chatham to Gore Point remained relatively ice-free and there was perhaps a more diverse composition and greater density of birds there than on the ice bound northern portion of Lower Cook Inlet. On a long-term basis, oil development would not be as harmful to the relatively small numbers of birds wintering on nearshore waters of this region as it would be to the food sources.

Without further data analysis of bird surveys on Kodiak Island, absolute densities are not known. However, large groups of murres, cormorants and seaducks were recorded in count areas. Large flocks of other alcids were seen outside the count areas. These are the species most vulnerable to direct oiling and their wintering populations could be substantially reduced on Kodiak in the event of an oil spill. A milder climate resulting in more ice-free bays cause far greater densities and species diversity of wintering birds on Kodiak than on portions of Lower Cook Inlet. Location of onshore oil and gas facilities would determine the extent of potential damage to bird populations. Protected waters in bays are most ideally suited for development but also the greatest densities of birds were found in these waters.

II. Introduction

There are approximately 54,700 km of tidal coastline in Alaska with an associated 1,425,000 km^2 of outer continental shelf (Sowl and Bartonek 1974). This vast coastline and the associated continental shelf provide abundant habitat to millions of seabirds, waterfowl, passerines and other birds at some stage of their life cycle. Sanger (1972) estimated that 51 million seabirds summer in subarctic Alaskan waters and Nisbet (1975) suggested a magnitude of 100 million birds for all Alaskan waters. Most of these except shearwaters breed on islands or other portions of the coastline. According to Sanger (1972), who conducted pelagic boat surveys, about 8 million seabirds winter in Alaska but this estimate may increase when more information is obtained on wintering populations near shore. Over 13 million waterfowl including 1 million geese, 12 million ducks, 70,000 swans and 150,000 cranes utilize Alaskan waters for breeding, migration staging or wintering (A.D.F.& G. 1975). An undetermined number of passerines, raptors and other birds use the littoral zone during some or all seasons of the year.

Most major waterfowl, shorebird and seabird habitats are known, but in most instances bird use or habitat diversity and size are not well quantified. Many areas of lesser importance have not been identified. Since the State of Alaska's jurisdiction extends out three miles from the coast and since this is the area most crucial to all breeding and many feeding marine birds, it is extremely important to fully assess the avifauna of the littoral zone to determine which areas are more critical than others for proper land-use planning.

In order to evaluate coastal areas to determine which areas are more critical than others, it is necessary to synthesize existing literature and unpublished data on the distribtuion, abundance, behavior and food dependencies of birds associated with littoral and estuarine habitat within the study area. Since many areas have not been surveyed either in a particular season or in a quantitative manner, it is also necessary to conduct surveys to determine the seasonal density distribution, migratory routes, chronology of migrations, breeding locales and critical habitats for all bird species utilizing the littoral zone within the study area.

Many factors threaten Alaska's seabird populations but developments by the petroleum industry including onshore and offshore drilling, pipelines, ship transport and various associated activities pose the greatest potential hazard to birds (King and Lensink 1971). Oil spills in marine waters directly affect many species of pelagic feeding and molting birds including shearwaters, fulmars, kittiwakes, phalaropes, gulls, alcids, cormorants and seaducks (Bartonek et al. 1971). The mechanical effect of oil on bird plumage is well documented (see Vermeer and Vermeer 1974). Less obvious are the long-term effects on the ecosystem. Organisms lower on the food chain than the birds may be affected less dramatically but the long-term impact on the avifauna can be great. This may be especially true when oil is washed by tides or winds onto the productive littoral zone. Food organisms-both plant and animal-may be killed, thereby destroying extensive areas of feeding habitat for many ducks, geese and shorebirds (Vermeer and Vermeer 1975).

It is therefore essential to assess all coastline habitats for species composition and abundance of birds on a seasonal basis in order to determine use of the areas and then set priorities as to their importance to birds. This first assessment will be an extensive reconnaissance of the study area. Specific sites found to be more important than others will be studied intensively to determine why birds are attracted to them. More stringent restrictions on oil development could then be set for those areas determined to be most critical.

III. Current state of knowledge

Much of the literature to date deals with pelagic surveys, colony information, general life history and distribution information on seabirds, and censuses of waterfowl-particularly game ducks and geese. Little quantitative information exists on seasonal use of the littoral zone by marine birds. Listed below are brief accounts of what is know about bird use of the intertidal zone of the eight subunits of the study area. Tables in these accounts represent minimal numbers of ducks and geese because coverage was usually sporadic or opportunistic and observers had varying degrees of experience at estimating numbers of birds from aircraft. These tables are included to show the relative importance of a few areas and the paucity of significant information that is available. As will be reported later, methods used, timing and conditions during surveying can greatly affect the numbers of birds observed.

North-Bristol Bay

Summer: A seabird colony on the cliffs of Cape Newenham is one of the largest in the North Pacific (King and Lensink 1971) and other large rookeries are present in the Walrus Islands. Nesting waterfowl are most abundant in the Kvichak Bay and Nushagak Peninsula areas. Nearshore waters are commonly used by feeding birds and to a lesser extent by molting birds.

Winter: During severe winters heavy icing conditions preclude use of this area by wintering birds. They will, however, utilize open leads in the ice or ice-free areas in mild weather.

Migration: Bays and river mouths receive extensive use by waterfowl and shorebirds during both spring and fall migrations. Spring migrants may be held up there while waiting for thawing further north. During fall many migrants may bypass this area for staging if conditions are right for continuing their flight.

Table 1 lists surveys of game ducks and geese done by ADF&G personnel during several different times of the year. Most noteable is the use of Nanvak Bay during the late summer and fall and Nushagak Flats during spring migration. A portion of the nearshore area of this region was surveyed by King and McKnight (1969) who found an average of 47.8 birds per square mile during October. A pelagic survey in May 1972 (USDI-USFWS 1972) revealed 52.1 birds per square mile but most of these were found in nearshore waters on both the north and south ends of the transects.

Table 1: Ducks and geese found in bays of the north side of Bristol Bay by aerial survey.

Location	Date of Survey 5-4-70	6-30-70	8-24-70	6-7-71	9-8-71
Nanvak Bay	-	-	3467	200	2000
Osviak Bay	-	-	-	24	500
Kanik River	30	-	1804	-	-
Tvativak Bay	43	-	400	-	-
Protection Point	50	705	282	-	-
W. Nushagak Flats	1073	681	236	-	-

North-Alaska Peninsula

Summer: Most of the habitat of the north side of the Alaska Peninsula is not suitable for nesting seabirds. There are, however, rookeries on Amak Island, Unimak Island and Cape Seniavin. An estimated 1120 pelagic and red-faced cormorants plus 15 times as many black-legged kittiwakes were counted at Cape Seniavin on June 8, 1971 (ADF&G 1973). Little is known about the amount of nesting between the stormtide and high tide line by waterfowl, shorebirds and other bird species.

Bristol Bay is used extensively by feeding birds during summer and to some degree by molting waterfowl. Bartonek and Gibson (1972) found 32 species of birds during pelagic boat surveys during July and August 1972 but many of the individuals were on nearshore waters or sighted from land.

Winter: Much of Bristol Bay freezes during cold winters and wintering birds are forced to the southern part of this area. Hundreds of thousands of diving ducks and seabirds use the area as winter habitat (USDI-USFWS 1972). The massive die-off of common murres in April 1970 (Bailey and Davenport 1972) from Unimak Island to Port Heiden due to intense storms revealed that many of the birds were wintering in nearby waters. Total mortality may have been greater than 100,000 murres.

Migration: The most important function of the intertidal zone of the north side of the Alaska Peninsula is as a staging area for migrant birds. The lagoons and estuaries provide excellent habitat for spring migrants waiting for northern areas to thaw. More spectacular are the concentrations of waterfowl using the area in the fall. King and Lensink (1971) stated: "The entire world population of American emperor geese and black brant can be found in this area in October. Most of the cackling Canada geese, large numbers of lesser Canada geese and substantial numbers of snow geese can also be found here in October." Ducks and shorebirds exceed the geese in abundance although the timing of their migration many differ. The most renowned estuary is Izembek Lagoon which contains the largest eelgrass beds in the world. Migrating black brant utilize this plant to acquire sufficient energy stores for their sustained migration across the Gulf of Alaska. Jones (in press) reported that most bird species in the Cold Bay area depend on the eelgrass beds of Izembek Lagoon either directly or indirectly.

Table 2 also points out the importance of estuaries on the Alaska Peninsula to fall migrant waterfowl. Since these counts did not represent total coverage of the areas and other species of birds were not tallied, they do not depict the true value of the estuaries to avian species. Year to year differences likely represent timing of the surveys. They may have just preceded or succeeded a vast waterfowl migration. The survey by King and McKnight (1969), which consisted of transects running from the shoreline out to twelve miles offshore, also demonstrated the importance of this area to migrating birds. Their total population estimate which did not include the estuaries was 385,702 birds. Almost half of this total were scoters.

Table 2. Ducks and geese* found in estuaries of the north side of the Alaska Peninsula and Unimak Island by aerial survey.

Location	Date of Survey 10-23-68	5-13-69	10-6-69	12-15-69	3-3-70	6-29-70	8-25-70	9-24-70	10-8-70	9-14-71	10-4-71
Egegik	170	1397	43,580	-	0	1671	-	-	-	-	4478
Ugashik	2550	1145	70,190	-	1000	1142	2128	7362	75,850	3408	19,300
Cinder River	50,000	5200	115,000	1250	500	869	7271	20,195	25,450	3498	38,313
Port Heiden	41,000	4800	99,350	405	-	2499	5355	118,800	56,190	5762	51,765
Ilnik	38,500	3110	16,500	1156	-	3038	4460	16,965	7400	7906	39,812
Port Moller	3177	3641	-	7025	-	1461	-	35,770	44,962	6630	444,655
Hook Lagoon	-	-	-	-	-	81	1510	4550	-	-	-
Kvichak River	-	-	-	-	-	-	245	-	-	-	-
Urilia Bay	-	-	-	-	-	-	-	-	-	-	17,000
Swanson Lagoon	-	-	-	-	-	-	-	-	-	-	9365

* The total does not represent a complete count of each area and the experience of observers to estimate numbers varied. All counts were from a fixed-wing aircraft.

South-Alaska Peninsula

Summer: The habitats of the south side of the Alaska Peninsula are not conducive to waterfowl and shorebird nesting, but the topography provides ideal nesting cliffs for seabirds. Over 30 recorded major seabird colonies are found on the shores of the mainland and the many islands in this region. Exposure to the open ocean and inclement weather has prevented thorough searching of this area for nesting birds so more colonies are likely to be discovered. The extent of use by other bird species using the littoral zone is generally unknown at present.

Winter: Warm ocean currents keep this area relatively ice-free in winter resulting in substantial use by wintering birds. Table 3 includes a winter survey of the area and most of the species encountered were sea ducks (eiders, scoters and old squaw) and emperor geese. Seabirds were not recorded on these flights but three areas were suggested as deserving consideration as key waterfowl habitat: Kujulik Bay, Morzhovoi Bay and the Sanak Islands. On the latter, Canada geese, swans and mallards were also found wintering. Quantitative information on wintering seabirds is not available but numbers are likely substantial.

Migration: Few estuaries are present on the south side of the Peninsula for use as staging areas for migrating birds. Nevertheless, the many dabblers observed on the October 1972 survey indicate use is made of river mouths and the lagoons that are present in the area. Black brant also use Morzhovoi and Cold Bays on the western end of the Peninsula.

Kodiak-Afognak

Summer: The steep rocky coastline and many small islands of Kodiak-Afognak Islands are quite conducive to seabird nesting. Over 85 colonies have been recorded and many more will likely be reported with further intensive surveys. In July and August 1975 Dick et al. (1975) visited 59 colonies in Chiniak and Marmot Bays and reported the most abundant species to be tufted puffins, black-legged kittiwakes, glaucous-winged gulls and common murres. Nesting habitat for waterfowl and shorebirds is limited but several species do breed on Kodiak and Afognak Islands.

Nearshore waters provide feeding habitat for many breeding and non-breeding birds. Pelagic boat surveys were conducted in summer 1975 in the region (USFWS 1975) with the following results: "Densities of birds were consistently high near the Barren Islands and Afognak Island and along the entire outer coast of Kodiak Island. Densities are probably significantly higher in the inshore waters and the populations represented by a greater number of species but these areas were not surveyed to the same extent as were the offshore waters."

Winter: More winter bird surveys have been conducted for Kodiak than any other portion of the state. Table 4 lists the results of ADF&G surveys for waterfowl and Table 5 lists boat surveys for all species by Kodiak National Wildlife Refuge personnel (USFWS in prep.). Many species use the littoral zone and coastal waters of Kodiak in winter. Most

Table 3. Ducks and geese found in bays of the south side of the Alaska Peninsula by aerial survey.

Location	Date of Survey 3/20-23/70	Date of Survey 10/11-12/72
Puale Bay		685
Portage Bay		184
Wide Bay	462	631
Agripina Bay area	465	200
Chiginagak Bay area	505	352
Yantarni Bay area	625	141
Amber Bay	465	240
Aniakchak Bay	1145	449
Cape Kumlik	198	
Sutwik Island	263	
Kujulik Bay	3915	391
Cape Kumlium	250	
Hood Bay	20	
Chignik Bay	} 430	35
Chignik Lagoon	}	1153
Castle Bay	95	287
Castle Cape to Seal Cape	65	
Kuiukta Bay	5	
Mitrofania Bay & Island	38	
Ivanoff Bay	65	1045
Stepovak Bay	42	862
Grub Gulch Bay	}	241
Clark Bay	}	104
Orzinski Bay	} 124	85
American Bay	}	62
Chichagof Bay	}	76
Dorenoi Bay	295	32
Balboa Bay	510	
Beaver Bay	123	224
Shumagin Islands	4086	
Canoe Bay		1362
Pavlof Bay		715
Pavlof Islands	1118	
Deer Island	345	
Sandman Reefs	412	
Sanak Islands	2762	
Cold Bay	462	3057
Morzhovoi Bay	2925	4439
Otter Cove	434	

Table 4. Ducks and geese found in bays of Kodiak Island by aerial survey.

Location	1-19-66	2-11-66	3-14-66	11-11-66	3-12-69	1-21-71	2-18-72
	Date of Survey						
Sharatin Bay			30		2	175	
Kizhuyak Bay			149		4	79	
Settler Cove					8		
Spruce Bay					75		
Viekoda Bay			2		30	85	
Terror Bay	270	385	616	288	102	155	
Uganik Island			231		23		
N.E. Arm Uganik			205				
E. Arm Uganik	573	392	489	229	125	576	
S. Arm Uganik			15				
Spiridon Bay			101		6	138	
Zachar Bay	111	668	470	612	235		
Larsen Bay	197		6	184		1058	
Uyak Bay	991	1237	1378	1325	490		
Karluk Lagoon			90				
Sturgeon Lagoon					235		
Halibut Bay					75		
Sukoi Lagoon					300		
Alitak Lagoon					150		85
Tugidak Island					600		390
Sitkanak Lagoon					50		
Deadman Bay							125
Olga Bay							170
Portage Bay					75		145
Kaiugnak Bay					175		175
Three Saints Bay							310
Barling Bay					100		50
Midway Bay					30		120
Amee Bay					15		
Port Holbron					8		
McDonald Lagoon					45		
Hidden Basin					123		
Kiliuda Bay					410		528
Shearwater Bay					130		
Gull Cape							75
Eagle Harbor					50		
Ugak Bay						469	
Saltery Cove					60		
Pasagshak Bay						125	
Narrow Cape						258	
Chiniak Cape						257	
Kalsin Bay				35		360	
Middle Bay			261	175		181	
Women's Bay			30			375	
Monashka Bay					160		

Table 5. Marine bird survey via M/V Aleutian Tern by Kodiak National Wildlife Refuge personnel, Jan. 25-Feb. 8, 1973 and Feb. 5-22, 1975.

	1973	1975
Loon sp.	424	83
Grebe sp.	7	72
Red-necked	1	
Cormorant sp.	1982	1728
Emperor Geese	621	52
Mallard	700	2556
Pintail	200	4
Gadwall	30	75
Dabbler sp.	-	50
Scaup (Greater)	80	15
Goldeneye sp.	1142	1205
Common	146	
Barrows	24	30
Bufflehead	36	27
Harlequin	691	675
Eider sp.	67	1745
Common	4512	58
King		4654
Steller's	340	1176
Old squaw	7863	9410
Scoter sp.	[illegible]	[illegible]
Black	2154	1402
White-winged	3059	2073
Surf	1194	327
Merganser sp.	39	27
Common	21	21
Red-breasted	13	34
Hawk sp.		3
Marsh		1
Bald Eagle age?	4	8
Adult	183	179
Immature	37	50
Golden Eagle		1
Sandpiper sp.		50
Gull sp.	124	1589
Glaucous-winged	32	923
Mew	356	731
Murre sp.	8420	14,994
Common		179
Thick-billed	66	
Pigeon guillemot	46	106
Horned Puffin		1
Tufted Puffin		1
Crested Auklet	15,083	7011
Murrelet sp.	63	280
Ancient	3	
Magpie	28	84
Raven	8	3
Crow	524	879

emperor geese are found on the lowland areas at the south end of the island, mallards and other dabblers inhabit the deltas of fresh water streams and lagoons, and auklets prefer tidal upwelling areas of Whale Passage and Alitak and Uyak Bays. Seaducks and other alcids are well dispersed in bays throughout the island.

Migration: No extensive staging areas are found on Kodiak but many migrants stop over either in the spring or fall. Detailed records of the chronology of migration have been kept for the past three years by Richard A. MacIntosh, National Marine Fisheries Service biologist. Some species that frequent the island in the spring such as black brant bypass the island in their southern fall migration.

Lower Cook Inlet

Summer: Fourteen colonies of nesting seabirds were listed by ADF&G (1973) within the boundaries of Lower Cook Inlet (as delineated by this report) but many more subcolonies have been discovered the past two summers by the USFWS in the Barren Islands (Bailey 1975a). Bailey's summer estimate of birds on the Barren Islands includes 205,000 tufted puffins, 91,000 common murres, 33,800 black-legged kittiwakes and 15,700 horned puffins. In another study of the colonies on Tuxedni National Wildlife Refuge, Snarski (1971) estimated 45,000 black-legged kittiwakes, 20-25,000 common murres and 4-5000 horned puffins. It is unknown how far these birds travel from their nests to feed but it may be as far as 12 miles or more. In a report by Bailey (1975b) of six air transects flown 12 miles out from the Barren Islands, affinity for shore was less evident than in other areas because shearwaters predominated in the transects. In their combined surveys greatest densities were within three miles of shore. The seabird density for July in this area was an astounding 1,238 birds per square mile.

Winter: Too few winter bird surveys have been done to adequately assess the importance of Lower Cook Inlet to wintering populations. Transects flown by ADF&G at the mouth of Kachemak Bay in December 1968 revealed 9,966 ducks (including dabblers, divers and sea ducks). Another 10,000 scoters were seen near Dangerous Cape of which only 1500 were in the transect. Nearshore waters appear to have large numbers of sea ducks and larids and some wintering shorebirds but few alcids.

Migration: Massive concentrations of waterfowl and shorebirds use river deltas for feeding prior to migration in both spring and fall. Table 6 lists a few superficial surveys done primarly during migration periods. The most important of these areas are the Kenai RiverFlats, Fox River Flats, Bachatna Flats and Drift River Flats. Several others are important in Upper Cook Inlet.

South-Kenai Peninsula

Summer: Little is recorded for summer bird populations in this region except for 13 known major seabird colonies. Likely many more colonies are present along this rocky coastline and a more intensive search for them is planned. Little habitat is available for dabblers and shorebirds

Table 6. Ducks and geese found in bays in Lower Cook Inlet by aerial survey.

Location	Date of Survey										
	8-25-69	9-9-69	10-2-69	4-16-70	6-1-70	8-12-70	9-28-70	2-9-71	5-12-71	10-5-71	11-3-72
Redoubt Bay	1626	2632	2630	1170		1917	2587			3531	
Kalgin Island				50	39	71					
Fox River Flats								915	1650		1950
Aurora Lagoon								50	0		334
Halibut Cove								185	250		408
China Poot Bay								110	0		682
Neptune Bay											18
Sadie Cove								56	5		
Tutka Bay								165			
Kasitsna Bay											390
Jackolof Bay								160			
Seldovia								195	128		
Port Graham								208	1025		

except at the heads of some bays. Breeders from nearby colonies and some non-breeders from other parts of Alaska feed in nearshore waters. These would generally consist of alcids, larids, cormorants and some seaducks.

Winter: Little is known of wintering bird populations in this region. Since it is warmed by ocean currents, the bays are relatively ice-free and many seaducks, alcids, larids, cormorants and loons likely inhabit nearshore areas while dabbler and diving ducks occupy heads of bays and lagoons. Unknown numbers of shorebirds, particularly rock sandpipers and black oystercatchers, would also be present.

Migration: Although no extensive areas for staging are present, many migrating birds pass over or by this region. In fall some waterfowl cross the Kenai Mountains over Upper Russian Lake on the Kenai Peninsula and follow the Resurrection drainage down to Seward and out to the ocean. The reverse may be true in spring and other birds may also use this corridor. Other birds follow the outer coastline to Lower Cook Inlet but it is likely few stop to feed in this area.

Prince William Sound

Summer: Isleib and Kessel (1973) published a comprehensive account of bird species found within this area during all seasons. Their annotated list of birds contains all species found and an estimate of the birds' abundance in factors of 10 for all seasons. Isleib (1971) stated that of the 208 species known to occur in the area, 100 are present in summer. Seventy species utilize inshore areas for feeding. Eight major colonies are listed for the area (ADF&G 1973) but many more are likely present. The most abundant species found on these rocky rookeries are alcids, larids and cormorants. The 250,000 marbled murrelets found on a USFWS survey in 1972 constituted the largest avian biomass in Prince William Sound (Isleib and Kessel 1973). Large concentrations of non-breeders, particularly scoters, also use the area in summer.

Winter: With protected, ice-free bays, inlets and fiords Prince William Sound offers excellent winter habitat for many species of waterbirds. According to Isleib (1971) 71 species overwinter in the vicinity. Most summering species remain and are joined by loons, grebes and shorebirds. Many dabblers winter along stream mouths along with Canada geese and many shorebirds.

Migration: Most migrants in both summer and fall are only transients through this area, preferring extensive staging habitats in adjacent regions. Many species travel up and over the mountains to the north and west of Prince William Sound using corridors such as Portage Pass. Other groups of birds follow the outer islands over to the Kenai Peninsula or bypass the area by flying over the Gulf of Alaska.

Northeast Gulf of Alaska

Summer: The Copper River Delta is by far the best habitat in this region for breeding and staging birds, although the 1964 earthquake raised the land 6–8 feet and caused slight changes in species composition of nesting birds. Most of the world's population of dusky Canada geese now numbering 17,000-26,000 (breeding population), nests on the Delta. Their numbers have not changed significantly since the earthquake and the same is true for trumpeter swans (Mickleson in prep.) An aerial survey of swans in 1974 revealed 282 birds with 52 active nests (Mickleson in prep.). About 5,000 pairs of ducks are summer residents of the Delta (Michelson 1975) and their numbers were reduced significantly by the earthquake. At least seven species of shorebirds breed on the Delta but their numbers have not been estimated.

In other parts of NEGOA breeding and summering birds occur in protected waters of river deltas and bays but their numbers have not been estimated. On a flight over Russell Fiord 4300 molting scoters were observed by ADF&G biologists in July 1975. As many as 10,000 breeding pairs of glaucous-winged gulls occur in NEGOA with most of these on the islands near Copper River Delta (Samuel M. Patten, Jr. pers. comm.).

Winter: Because of exposure to the open ocean, few birds winter in this region. Little is recorded for wintering populations in southern portions of NEGOA.

Migration: The primary use of this region is for staging both in spring and fall. Tremendous concentrations of waterfowl and shorebirds utilize the tidal and marsh areas of this region. Densities of 250,000 shorebirds per square mile were recorded in May 1964 (Isleib and Kessel 1973). Fall migration is not as intense and concentrated with the chronology differing greatly between species. The Copper River Delta and Orca Inlet are the most prominent of the staging areas and host as many as 20 million birds (Isleib and Kessel 1973). Other deltas and bays are utilized farther down the coast but little is known of the magnitude of their use. For example, a concentration of 10,000 arctic terns remained several days near Ocean Cape on the east side of Yakutat Bay in July 1968 (Islieb and Kessel 1973). During some fall migrations, birds overfly the area entirely, attemping instead to get farther south while suitable weather conditions prevail.

IV. Study Area

The portion of Alaskan coastline under direction of the Anchorage ADF&G office for this study is bounded on the north by Cape Newenham and on the south by Cape Fairweather and includes Kodiak-Afognak Islands (Fig. 1). ADF&G's responsibility in the arctic, directed by the Fairbanks' office, is reported by George Divoky. Studies of the Alaskan coast from Cape Newenham to Cape Prince of Wales are under the direction of the USFWS.

A further breakdown of the Gulf of Alaska and Bristol Bay into eight subunits is shown in Fig. 2: Area 1, Northeast Gulf of Alaska,

Figure 1. Study area for OCSEAP coastal marine bird project, Alaska Department of Fish and Game, Anchorage Office, Cape Newenham to Cape Fairweather.

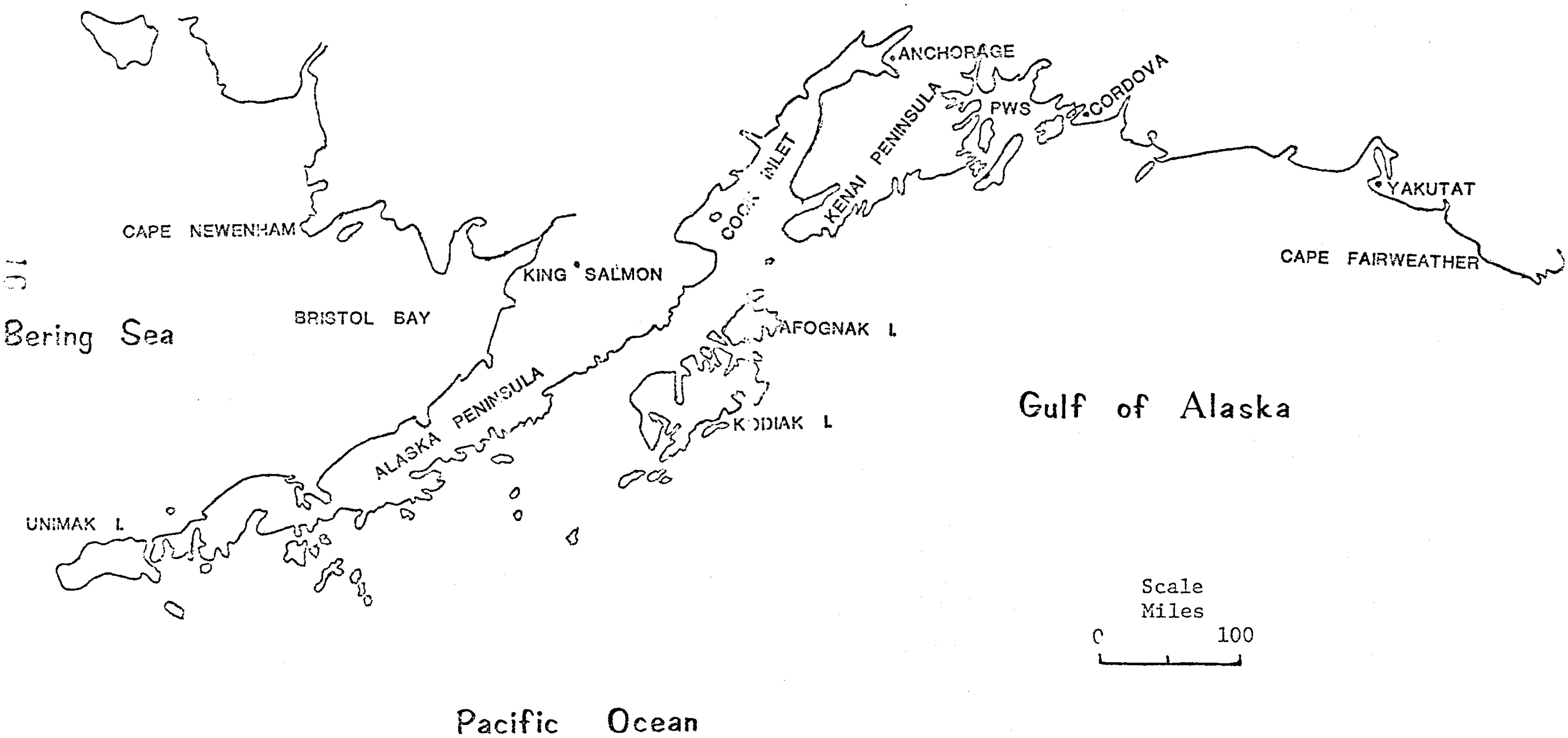
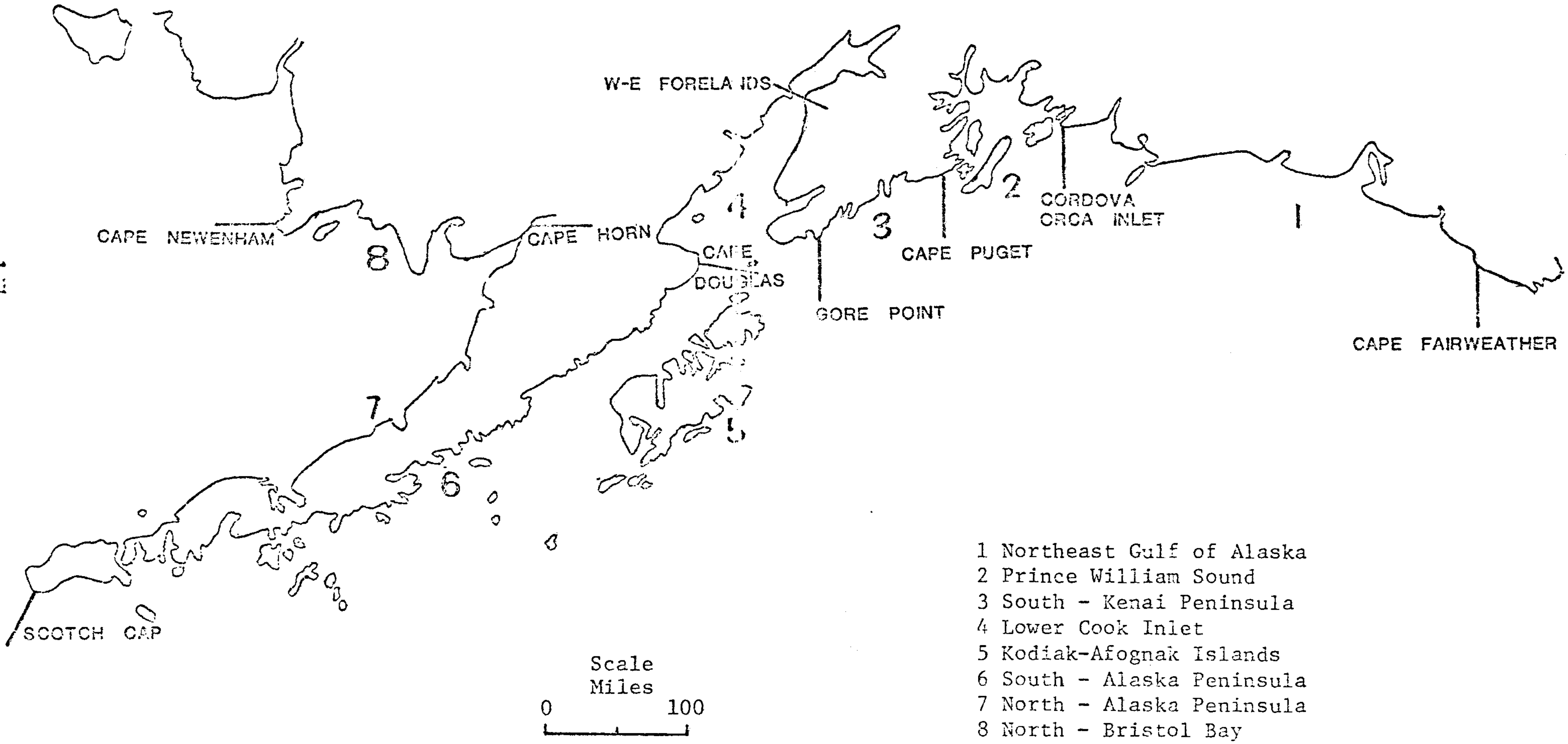


Figure 2. Subunits of study area for OCSEAP coastal marine bird project, Alaska Department of Fish and Game, Anchorage Office.



includes the coastline from Cape Fairweather to Cordova including Orca Inlet; Area 2, Prince William Sound, includes the coastline and islands from Cordova to Cape Puget; Area 3, South-Kenai Peninsula, includes the coastline from Cape Puget to Gore Point; Area 4, Lower Cook Inlet, includes the coastline from Gore Point to East Forelands, across to West Forelands, thence down to Cape Douglas, back to Gore Point to include the Barren Islands; Area 5, Kodiak-Afognak Islands, includes the coastline of the entire Kodiak Archipelago; Area 6, South-Alaska Peninsula, includes the coastline from Cape Douglas to Scotch Cap; Area 7, North-Alaska Peninsula, includes the coastline from Scotch Cap to Cape Horn; Area 8; North-Bristol Bay, includes coastline from Kvichak River opposite Cape Horn to Cape Newenham.

V. Methods

All known sources of information on birds in the eight subunits have been or will be searched as intensively as possible. These includes many unpublished records that are filed with various government agencies. Field notes of many ornithologists or other persons whose avocation is ornithologically-related provide valuable information. Published journal articles and reports are also being collected and synthesized.

Aerial surveys are being used in determining seasonal densities, migratory routes, breeding locales and critical habitats. Amphibious aircraft are used in rocky coastal areas and single-engine aircraft on wheels along sandy coastline. Aircraft speed may vary from 80 to 120 knots but an altitude of 100 ft. (30m) is maintained as much as is practicable. Observers are used on both sides of the aircraft.

Techniques vary with the type of habitat being surveyed. While surveying long, straight beaches the aircraft flies slightly seaward of the waterline and the shoreside observer enumerates all birds visible to the beach ridge. The oceanside observer records all birds within 1/8 mile (200m) of the aircraft and notes concentrations outside of this zone. This distance may have to be shortened to 100 meters on faster flying aircraft. In extensive estuaries where total counts would not be possible, transects are flown at equidistant intervals and birds and recorded by both observers within 1/8 mile of the aircraft. Upland vegetation inundated by storm tides is also surveyed. A new technique is being tried on Kodiak as explained in Part X of this report.

All observations are recorded on cassette-type tape recorders. Information recorded is: bird identification to lowest taxa possible (order, family, genus, species); bird numbers, habitat type in which the bird is found. Other information including activities, sex, color phase, etc., as outlined in the data processing format. Weather observations are recorded at the start of each flight and a coded survey conditions number is noted as often as conditions change. Time is recorded each time a new station is started and ended.

Because of the speed at which observations must be made from aircraft, only a limited number of environmental parameters can be recorded. Choppy water and diving birds can make species identification and number estimation difficult. Photographs are taken where it is practical-largely for enumeration of large flocks.

A second survey is conducted at higher altitudes (300-400 ft) to map habitat types and to denote the storm tide line wherever possible. Mapping is done on USGS 1:63,360 maps on areas where this scale map was available. This process need be only conducted once per area but cannot be done in the winter.

The method used by Arbib (1972) to practice estimating numbers by throwing beans or other small objects in order to establish a picture in one's mind of a given number of objects has been and continues to be practiced in order to become as proficient at enumerating bird numbers as possible.

The order in which areas for surveying were selected was based largely on the presumed importance of the area to bird populations, the vulnerability of the area to oil development and the proposed schedule of oil lease sales. The amount of existing knowledge about certain areas also played a role as did the extent of current research being conducted by other organizations or individuals. Bird populations in Prince William Sound, for example, have been studied for the past several years by U.S.F.W.S. personnel because of the termination of the Alaska pipeline in Valdez. M.E. (Pete) Isleib continually monitors bird populations in Prince William Sound and the Northeast Gulf of Alaska so more is known of birds in these areas.

VI. Results

Due to the delay in receiving final data processing formats, most of the recorded information collected so far has not been transcribed from the tapes to avoid duplication of effort. Brief summaries of total birds seen during the first survey in October 1975 on the north side of the Alaska Peninsula are listed in Tables 7 and 8. And a track of this survey, in which over 40 species were observed, is shown in Appendix Figure A-9.

Habitat was delineated for most of the trackline including the coast from the Naknek River to Cape Horn. In areas where only 1:250,000 scale maps were available, mapping of the storm tide line and sedge meadow areas became impossible. Summations of the habitat types found on the shoreline and in the estuaries are shown in Tables 9 and 10, respectively.

In cooperation with the Habitat Section, an ADF&G a survey was done of wintering populations in Lower Cook Inlet on February 9, 10 and 18, 1976. A trackline of this survey is shown in Appendix Figure A-4. Data for this survey have not been transcribed as yet.

A third survey was started during the last week of February but bad weather delayed flights and the urgency of writing this report precluded completion of the survey. The number of sample units that were completed are shown in Appendix Figure A-6 and in Part X, this report. It is hoped the survey can be completed before spring migrants move into the area.

Table 7. Total number of birds observed during aerial surveys along beach of the north side of the Alaska Peninsula, October 1975.

Section of Beach	Sandy Beach	Open Water	Mouth of Stream
Naknek River to Smoky Point	2,238	2,836	735
South Spit to South End of Cinder River	439	5,604	
South End Cinder River to Ilnik*	1,442	413	40
Ilnik to Cape Leontovich	1,192	19,975	368
Cape Leontovich to Cape Krenitzin	2,076	2,858	93
Chunak Point to Otter Point	549	187	44
Total	7,936	31,873	1,280

*Right side of aircraft only because of recorder malfunction.

Table 8. Total number of birds observed in estuaries during aerial surveys of the north side of the Alaska Peninsula, October 1975.

Estuary	Sedge Meadow	Mudflat	Beach	Open Water	Total
Egegik (transects*)	460	2,836	2,195	188	5,679
Ugashik (transects*)	12,609	4,567	2,124	1,145	20,445
Cinder River (transects**)	1,576	9,824	61	15,680	27,141
Port Heiden (transects*)	2,713	3,989	233	4,535	11,470
Seal Islands (total count)	3,134	2,968	6,989	12,993	26,084
Port Moller (total count)	0	116	3,915	9,117	13,148
Herendeen Bay (total count)	0	25	1,158	8,513	9,696
Mud Bay - Deer Island (total count)	0	4,827	857	11,678	17,362
Nelson Lagoon (total count)	2,535	13,126	3,122	45,213	63,996
Izembek Lagoon (total count)	---	---	---	---	342,507

* Not complete coverage: 200 meters on either side of aircraft along transects.

** One side of aircraft only due to recorder malfunction.

Table 9. Quantity of various habitat types for the outside beach of the north side of the Alaska Peninsula.

Section of Beach	Habitat Types: Distance in Kilometers — Sandy Beach	Rocky Beach	Gravel Beach	Area in Hectares — Sedge Meadow	Beach Rye	Mud Flats
Cape Horn to Naknek River	16.45	0	0	2874.9	0	0
Naknek River to Bishop (at Egegik Bay)	67.1	0	0	1509.9	0	0
Goose Point (at Egegik Bay) to Smoky Point (at Ugashik Bay)	67.1	0	0	3703.7	854.7	543.9
South Spit (at Ugashik Bay) to Meshik (at Port Heiden)	97.7	0	0	699.3	2393.2	0
Strogonof Point (at Port Heiden) to Entrance Point (at Port Moller)	134.6	0	9.0	1090.4	1963.2	0
Lagoon Point (at Nelson Lagoon) to Moffet Point (at Izembek Lagoon)	109.0	0	0	2356.9	543.9	233.1
Cape Galzenap (at Izembek Lagoon) to Cape Krenitzin (at Bechevin Bay)	36.7	0	0	0	0	0
Chunak (at Bechevin Bay) to Otter Point (at Unimak Island)	25.2	0	0	0	0	0

Table 10. Quantity of various habitat types for the major estuaries of the north side of the Alaska Peninsula.

	Habitat Types												
	Distance in Kilometers						Area in Hectares						
Estuary	Sandy Beach	Gravel Bench	Rocky Beach	Mud/Sedge Meadow Ecotone	Mud/ Beach Rye Ecotone	Total	Sedge Meadow	Sand	Beach Rye	Mud Flat	Total	Estuary Area*	Possible Estuary Influence
Egegik	13.4	0	0	11.8	0	25.2	3833.3	0	51.8	4327.9	8213.0	9764 4	0
Ugashik Bay	50.9	0	0	118.5	4.5	173.9	8282.9	2416.5	4009.3	3056.2	17764.9	19281.1	5128.2
Cinder River	16.2	0	0	71.1	12.5	99.8	4662.0	385.9	2305.1	5027.2	12380.2	10800.4	0
Port Heiden	30.0	0	0	61.6	14.3	105.9	7964.3	598.3	1087.8	11106.1	20756.5	27255.0	0
Seal Islands	31.1	0	0	58.7	33.8	123.6	3952.4	1383.0	823.6	1551.4	7710.4	9521.0	0
Port Moller Total Estuary	216.7	65.7	10.9	40.3	0	333.6	3095.0	2463.0	543.9	37135.9	40621.1	75370.1	11940.1
Port Moller (East)	55.8	49.3	7.1	2.9	0	115.1	261.6	157.9	0	13014.9	13424.4	31883.4	0
Herendeen/ Mud Bays Deer Is.	73.8	16.4	3.8	0	0	94.0	1201.7	0	0	8218.2	9419.9	27330.8	0
Nelson Lagoon	87.1	0	0	37.4	0	124.5	1631.7	2305.1	543.9	13286.9	17767.6	16135.9	0

*Includes open water portion

VII. Discussion

The outer coastline habitat is relatively homogeneous the entire length of the north side of the Alaska Peninsula. Some bird species were fairly evenly distributed throughout the area but fewer birds were found on the uppermost third of the Peninsula. Larids in particular were evenly dispersed overall except they tended to congregate on roosting sites at mouths of streams all along the Peninsula. On the outer coasts seaducks (primarily scoters) congregated more in areas where the shoreline was steepest as at Capes Greig and Seniavin. Emperor geese and shorebirds were generally only found on the exposed beaches in association with estuaries. Many birds such as alcids, procellarids and seaducks were likely missed that were beyond visibility from the aircraft flying along the beach. Snow buntings were the only common passerine seen and were fairly abundant along beach ridges in the beach rye.

Bird densities within estuaries were much greater than those of the beach survey. Seaducks seemingly congregated on the leeward side of barrier islands and spits near the mouth of the estuary. This may have been related to the height of tide or activity at the time of survey, however. Flocks of several thousand eiders and scoters were observed at the ends of several sand spits.

Steller's eiders were by far the most abundant eider seen. Common eiders were much less abundant and only a few king eiders were seen.

Canada geese inhabited the mudflat--sedge meadow ecotone or sedge meadows innundated by tidal waters. Emperor geese roosted on outer sandy beaches or on mudflats but also joined Canadas in sedge meadows or fed on tundra berries. Few alcids and procellarids were observed in estuaries except at the large estuarine complex at Port Moller. Shorebirds dispersed over mudflats when the tide was out but congregated in tight flocks to roost on the sandy beaches at high tide.

Delineation of the storm tide line was easy where debris had collected over the years. In other areas the mark was difficult to discern and was estimated by looking at vegetation coloration. It may have been grossly misjudged in these areas which normally were the sedge-meadow habitat type of estuaries.

Results of the two winter bird surveys wait further data analysis. In Lower Cook Inlet most bays on the eastern side were choked with ice but old squaws did venture into broken and slush ice. Volcanic ash fallout from Mt. Augustine delayed surveys in Kamishak Bay and it was not determined what effect the ash had on seabirds. An amazingly large group of shorebirds roosted on the ice of Tuxedni Channel near a small, open lead. The entire vicinity was frozen except for the mudflats of Squarehead Cove. Kachemak Bay continually froze during the surveys but old squaws were found in the broken ice. Substantial numbers of mallards were observed on the flats of China Poot Bay and vicinity and also at heads of bays around to Port Dick. The usual diving and seaducks were found along the entire ice-free coast. Little ice was found beyond Port Chatham except in shallow lagoons with a fresh water source. Few alcids were located except in Sadie Cove and mew gulls were fairly common at stream mouths and at Homer Spit along with glaucous-winged gulls. No notable observations can be made about the Kodiak survey until transcription of the data, but large numbers of alcids (common murres mostly) and seaducks were found around the entire island. Large numbers of dabbling ducks also utilized the sedge-meadow habitat. Small numbers of emperor geese were observed at several locations on the island.

Because of adverse weather, aerial bird surveys in Alaska must often be conducted under less than ideal conditions. One must fly in unfavorable weather and at times of the day or stages of the tide when bird distributions make surveying difficult or inaccurate. The diurnal distribution varies with species and untimely surveys may result in missing a large segment of a population which has recently moved out to sea or up on the tundra to feed or roost. Some species are best surveyed during high tide while others are more easily surveyed at low tide. A slight chop on the water during the survey may make small dark alcids or other species nearly impossible to see. It is for these reasons that in order to derive meaningful data, surveys must be conducted as often as time and money will allow under varying conditions.

Bcause of abnormal weather conditions, migration timing may change slightly from one year to the next or normal staging areas may not be visited. This past year (1975) for example snow geese did not follow their "usual" pattern and most bypassed the Egegik, Ugashik and Cinder River areas. Only a few hundred were observed on the survey in October. This fall's counts were too late in the season to record terns or many shorebirds and too early for king eiders. Surveys at the wrong time would grossly underestimate the importance of that area to migrating birds.

Aerial surveys may not record some bird species that could easily be affected by oil development. Some of the species not generally assumed to be associated with the littoral zone or marine habitats are belted kingfishers, several species of swallows, winter wren, American robin, varied thrush, and several species of fringillids. These species are often seen feeding along coastlines and still others may nest in the upland between high tide and storm tide lines. Site-specific, ground studies may be necessary to determine the degree of use by these species.

The distribution of birds within bays or estuaries may also be a function of how susceptible they would be to oil development. Birds feeding on sessile mussels or other food organisms in nearshore waters may be more drastically affected than those feeding in the middles of bays on planktonic organisms. Again, site-specific projects would be needed to determine how potential oil impacts would be affected by spatial distribution of birds.

VIII. Conclusions

From the aerial bird surveys conducted since the start of this project on September 5, 1975 and without the results of complete data analysis, the following conclusions are implied:

1. The estuaries of the north side of the Alaska Peninsula are extremely important to fall migrant waterfowl and shorebirds.

2. Port Moller-Herendeen Bay-Mud Bay-Nelson Lagoon complex appeared to have the greatest species diversity but Izembek Lagoon had the greatest bird density.

3. Certain portions of the outer beaches and mouths of streams are heavily utilized by other species of birds (e.g. gulls, cormorants, scoters and eiders) in fall.

4. A better method of determining the storm tide line is needed where debris is not present.

5. Winter severity can greatly affect the extent of use of Lower Cook Inlet by wintering birds.

6. The nearshore waters of Lower Cook Inlet appeared to be a more important wintering area for waterfowl and gulls than for alcids.

7. Large numbers of alcids, larids, cormorants and waterfowl and lesser numbers of geese and shorebirds winter on Kodiak Island.

8. Bird distribution within a given bay or estuary should be determined more accurately to ascertain more precisely their susceptability to oil development.

IX. Needs For Further Study

Since aerial surveys began, several areas needing further study have been disclosed. As mentioned in previous sections, flights cannot always be timed to coincide with the proper activity patterns of all birds of the littoral zones. Population estimates may therefore be low. To help solve this problem more site-specific studies should be carried out to learn more about diurnal movements of birds with regard to tide levels, time of day differences and how far the different species are flying to feed. What the birds are feeding on and where within the bay or estuary they spend most of their time feeding and roosting could also be determined at that time. Equipped with better knowledge of these parameters and by recording tide level and time of each survey, perhaps an estimate or correction factor can be applied to more accurately express utilization of an area by birds.

The speed at which many aerial observations must be made often makes species identification and enumeration difficult. Concurrent ground and boat surveys could check the accuracy of the aerial surveys. If the counting error is relatively constant a correction factor could be developed to correct likely underestimations.

With the development of onshore support facilities in the petroleum industry, increased air traffic in the vicinity of these facilities is likely. Studies to determine what effects aircraft have on birds-particularly breeding birds-would be very beneficial. Corridors may have to be established during nesting season if low flying aircraft are determined to be severely detrimental to birds.

Little is mentioned in OCSEAP work statements about studies to determine effects of oil on vegetation, particularly that from high tide to the storm tide line. With the ecosystem principal and trophic levels firmly in every PI's mind, more should be found out on what oil does to growth and reproduction in plants that may be food or cover for birds and other animals. Concomitant studies of bird use in this vegetative region should also be accomplished.

If oil spills in the northern part of the Gulf eventually end up on Kodiak Island as suggested, the Chiniak-Marmot-Tonki-Perenosa Bay region may end up as the "trap." Baseline beached bird (and other debris components) surveys should be extended to include the most vulnerable areas. Kamishak Bay in Lower Cook Inlet is another likely "trap" and areas where weather-killed birds have washed up on shore e.g. Montague Island (January 1970, Kenneth Mitchell, U. S. Forest Service in Isleib and Kessel 1973) or Harbor Point (April 1970 in Bailey and Davenport 1972) may also be collecting points for flotsam.

Sex and age differences in migration patterns of birds are well known. From winter surveys conducted so far it appeasd there may be a preponderance of females and immature males of king and common eiders in certain locations. If the females of a certain species were congregating in a relatively small area, an oil spill could conceivably impair the breeding potential of the population by killing off a large portion of females. Perhaps sex ratios of wintering birds should be looked at more closely for any potential problem areas.

Many bird species assemble in tight masses and flush or dive wildly at the approach of a censusing aircraft. Black brant in Izembek Lagoon are an example of this. Possibly inexpensive photo techniques similar to those being tried in Minnesota to census waterfowl (Meyer in press.) could be used to more accurately determine the number of individuals present. Transects lines could be established that could monitor populations before and after oil development. Behavior of the birds in relation to tides would have to be considered. Certain other species may lend themselves well to censusing by this technique.

Invertebrate work statements were not detailed anough to find out what OCSEAP projects involve the study of larval and adult insects in the intertidal and supratidal zone. Some species of insects may be a mainstay in the diet of certain birds using the upland below the stormtide line. It is a portion of the food chain that may warrant further study.

X. Summary of 4th Quarter Operations.

1. On February 9, 10, and 18, 1976 a DeHavilland Beaver was chartered from Kachemak Air Service in Homer to fly surveys in Lower Cook Inlet. February 22 - March 6 was spent in Kodiak attempting to do surveys with an Alaska Department of Public Safety Grumman Goose.

2. On the Lower Cook Inlet surveys, David Erikson and Warren Ballard, both ADF&G biologists, were used as observers. On the Kodiak survey, Vernon Berns, U.S. Fish and Wildlife Service, Kodiak National Wildlife Refuge, was the second observer.

3. A wheeled plane was used for the Lower Cook Inlet survey and therefore the technique of flying near the shoreline was used as described for the beach survey on the Alaska Peninsula. The seaside observer enumerated birds within 200 meters of the aircraft and the shoreside observer counted all those to the high tide line.

   On Kodiak a new technique was attempted. The entire Archipelago was stratified into eight habitat types and count units within each type were marked off using identifiable geographic features to mark the starting and ending points of each unit. These count units were then numbered and totaled. The habitat types and total numbers of units were:

Strata Code	Stratum	Number of Sample Units
A	Outside Waters - Forested	20
B	Inside Waters - Forested	44
C	Heads of Bays - Forested	4
D	Outside Waters - Rock/tundra/alder	46
E	Inside Waters - Tundra/alder	86
F	Mudflats Heads Bays - Tundra/alder	20
G	Estuaries/lagoons	30
H	Low Tundra/mud-sand Beach	17

With the help of Dr. Samuel J. Harbo, Jr., Univ. of Alaska biometrician, relative bird densities for each strata were decided upon and the minimum number of units to be sampled was finalized:

Stratum	Density Rating	Strata	Number Sampled
A	1	A	4
D	1	B	12
H	2	C	4 (all units)
B	8	D	6
E	8	E	24
F	8	F	6
G	8	G	8
All "C" units to be censused.		Total	68

It was felt that weather, time and money would not allow a complete census of the islands so a stratified-random sampling design was used.

Units to be sampled were selected using a table of random numbers. Open water portions needed to be surveyed so an amphibious aircraft was used and an attempt was made to count all birds within the count unit. Because the necessity of writing this report precluded the completion of the survey (at least temporarily), it is unknown whether this technique is a useful one for that type of coastline.

Office-type duties during this quarter included literature search and review, establishment of a systematic reprint file, and gathering as much unpublished material as possible, particularly in Kodiak. Problems with data processing formats also took up much time.

4. Tracklines for the Lower Cook Inlet survey are shown in Appendix Figure A-4. The sample units surveyed so far in Kodiak are marked on Appendix Figure A-6.

5. Approximately 112 stations or count areas in Lower Cook Inlet were censused covering about 625 miles of shoreline. An estimated 25 species were identified in primarily four habitat types.

   On Kodiak, 40 of the ramdomly selected plus five other sample units have been censused to date. About 30 species were observed in five habitat types. In this survey a definite trackline is not involved.

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______________________________. 1975. Oil threat to birds on the Canadian West Coast. Canadian Field-Natur. 89:278-298.

APPENDIX

Maps of subunits within study area with trackline and sampled units of completed surveys and most place names used in the text of the report.

Figure A-1. Subunit 1 - Northeast Gulf of Alaska, Cape Fairweather to Cordova with associated geography.

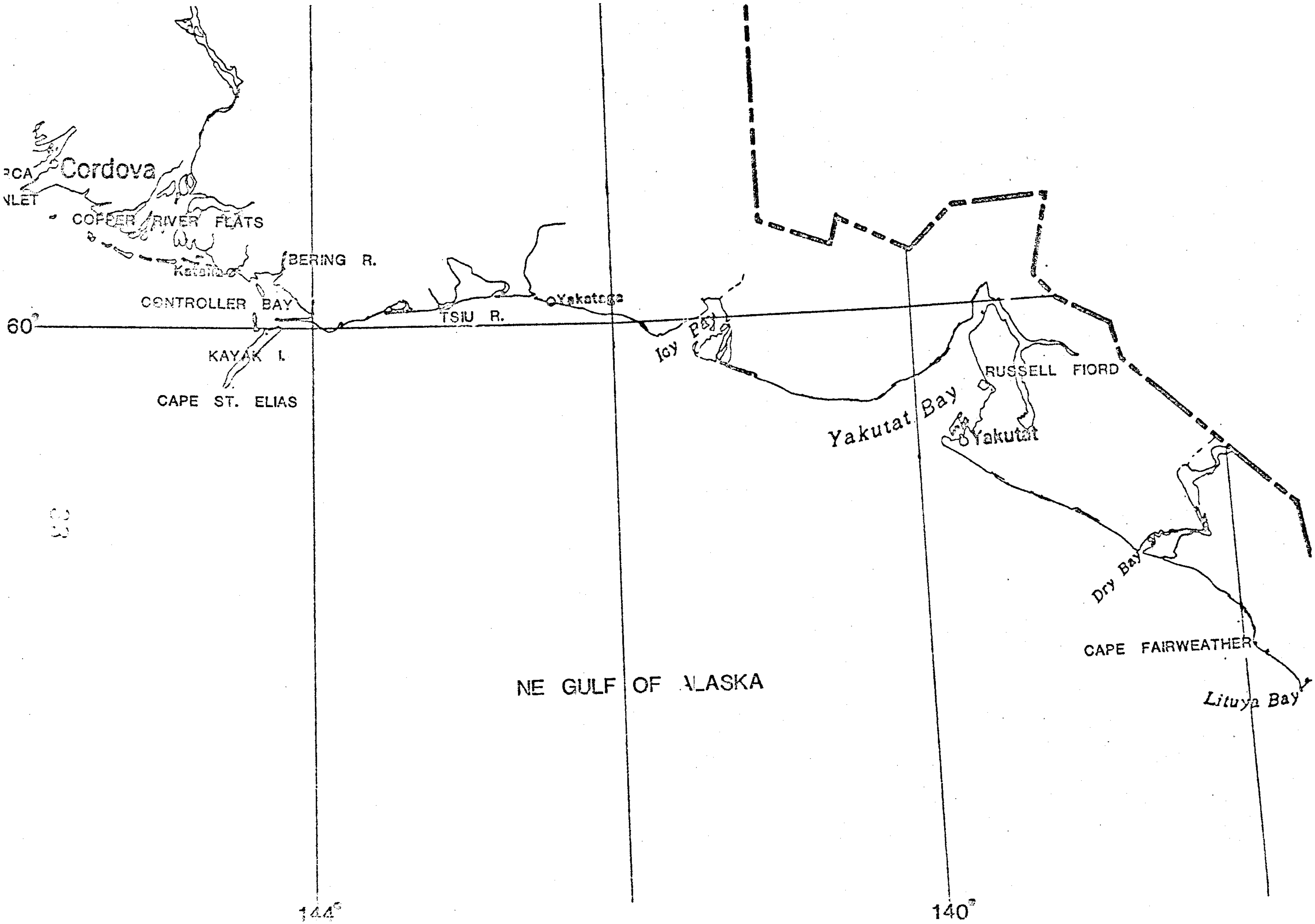


Figure A-2. Subunit 2 - Prince William Sound and associated geography.

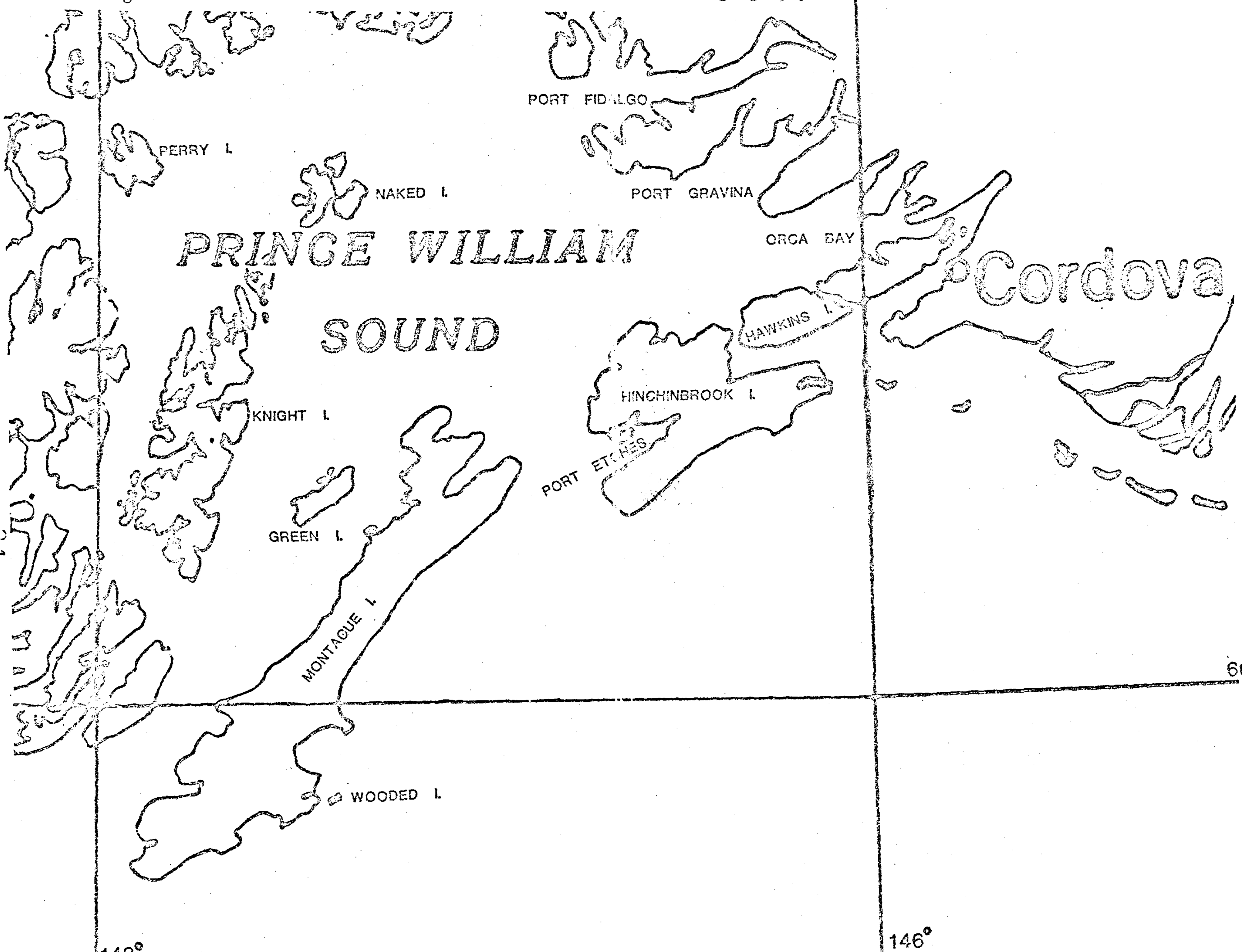


Figure A-3. Subunit 4 - Lower Cook Inlet with portion of subunit 3, South Kenai Peninsula with associated geography.

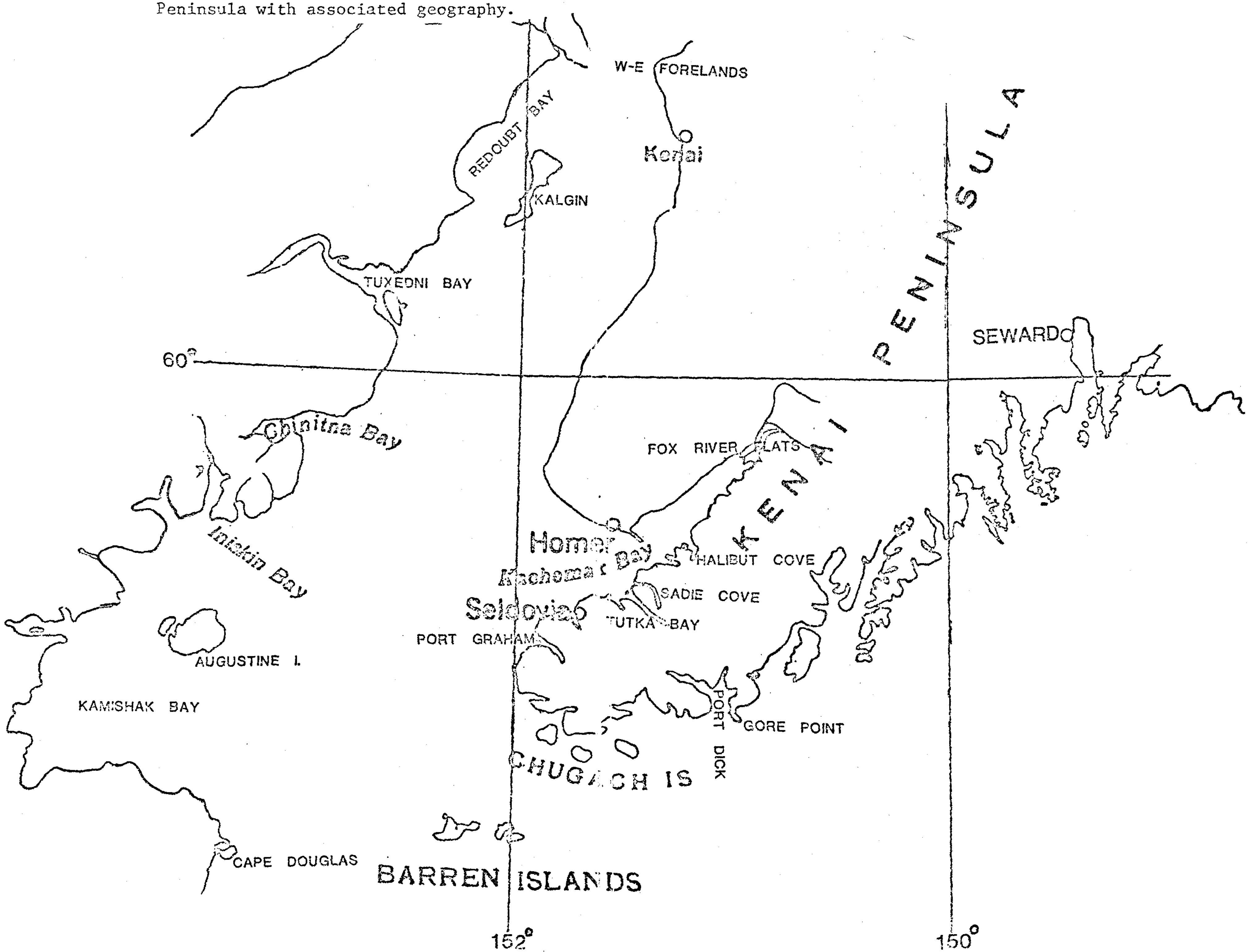


Figure A-4. Trackline of aerial marine bird survey on shoreline of Lower Cook Inlet, February 1976.

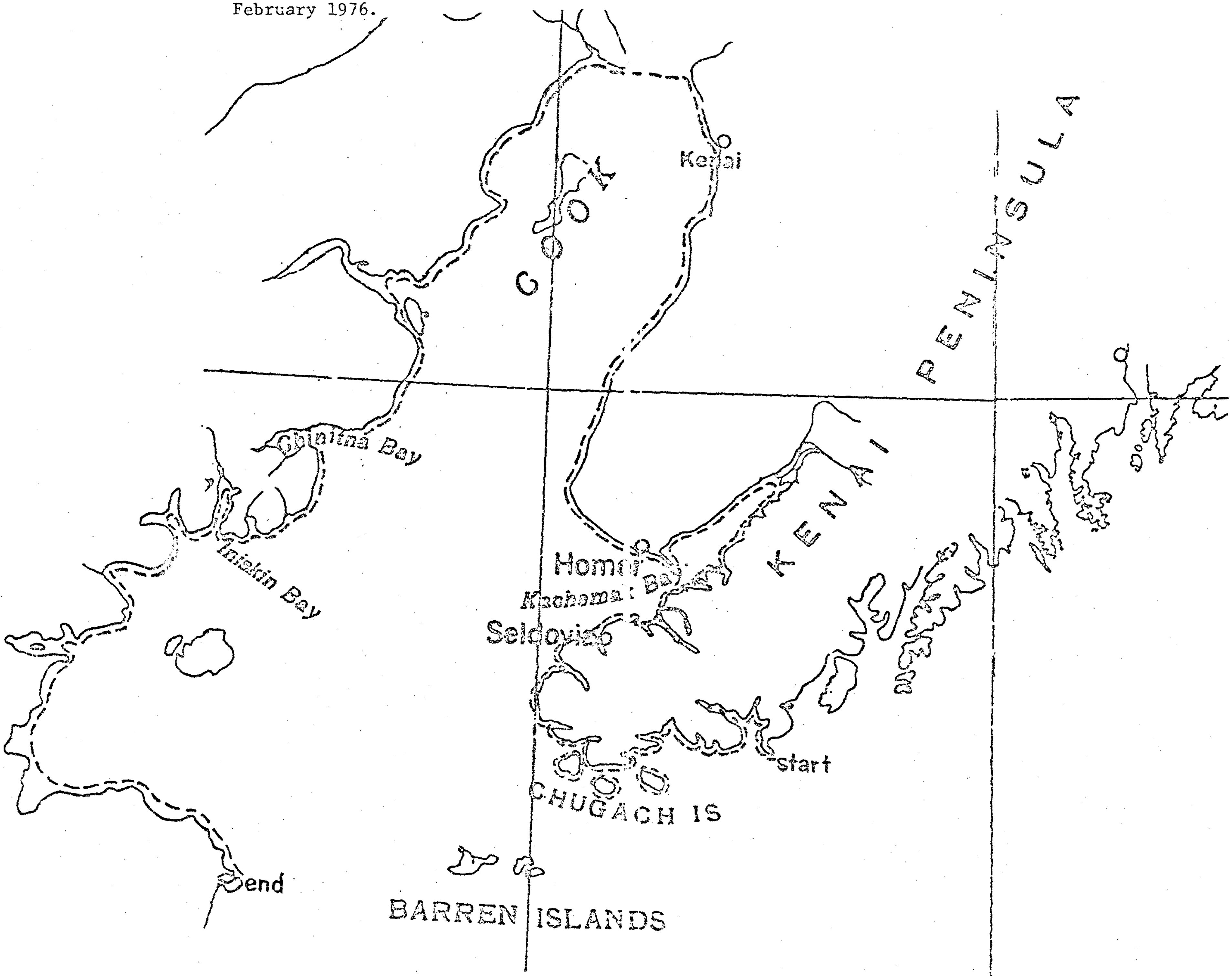


Figure A-5. Subunit 5 - Kodiak-Afognak Islands and associated geography.

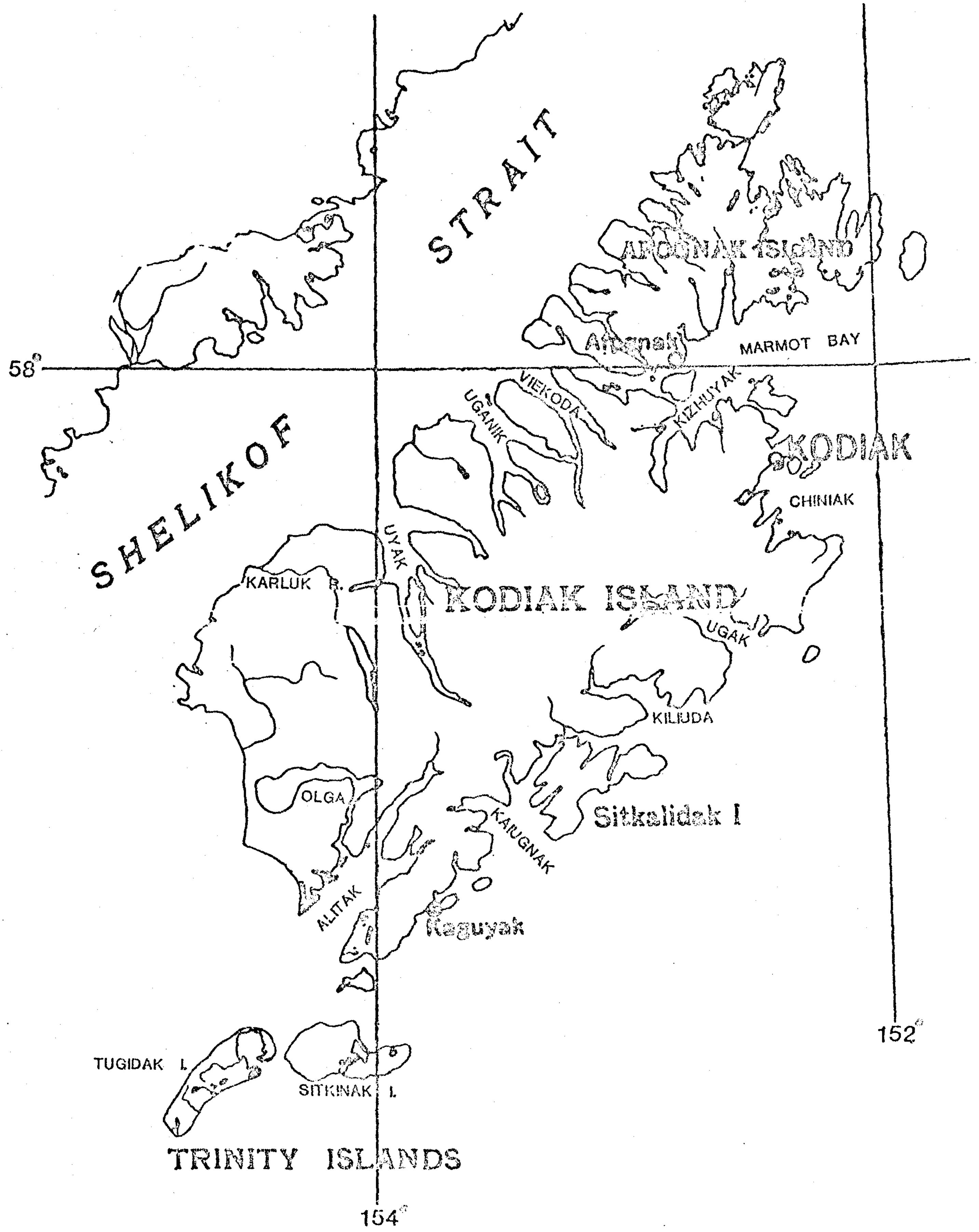


Figure A-6. Count units sampled on marine bird survey, Kodiak Island, February 23-March 6, 1976.

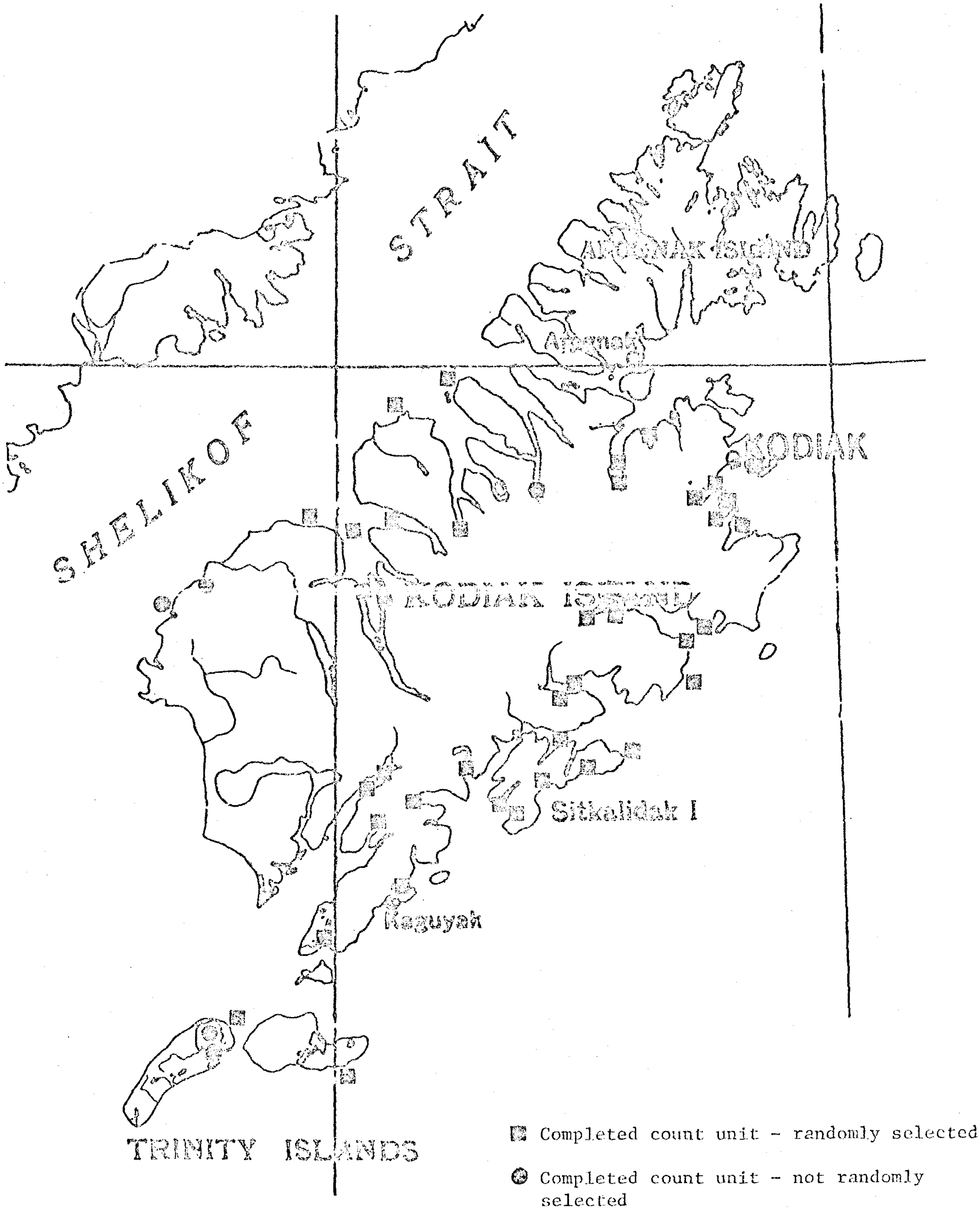


Figure A-7. Subunit 6 - South Alaska Peninsula, Cape Douglas to Scotch Cap with associated geography.

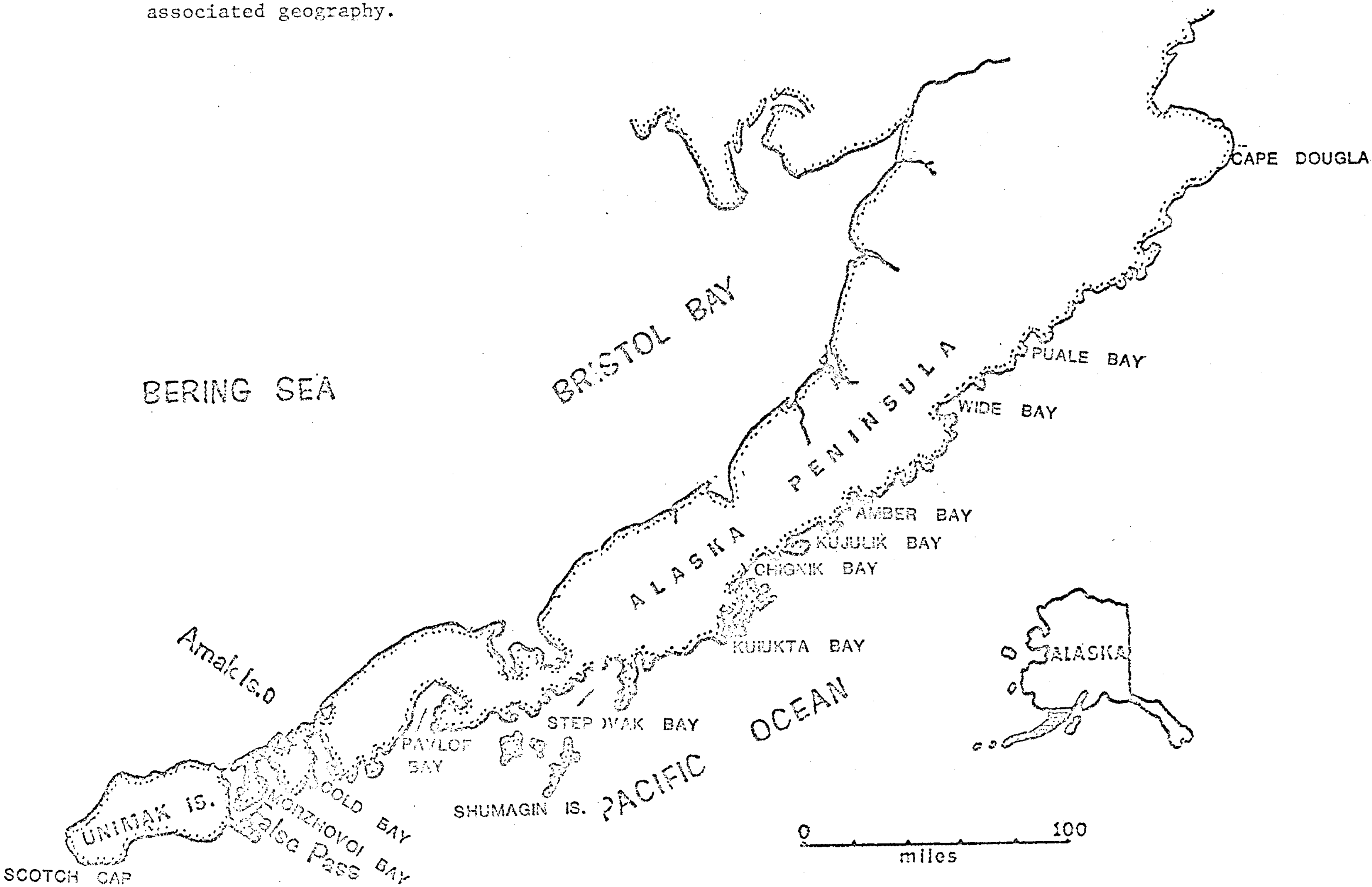


Figure A-8. Subunit 7 - North Alaska Peninsula, Scotch Cap to Cape Horn with associated geography.

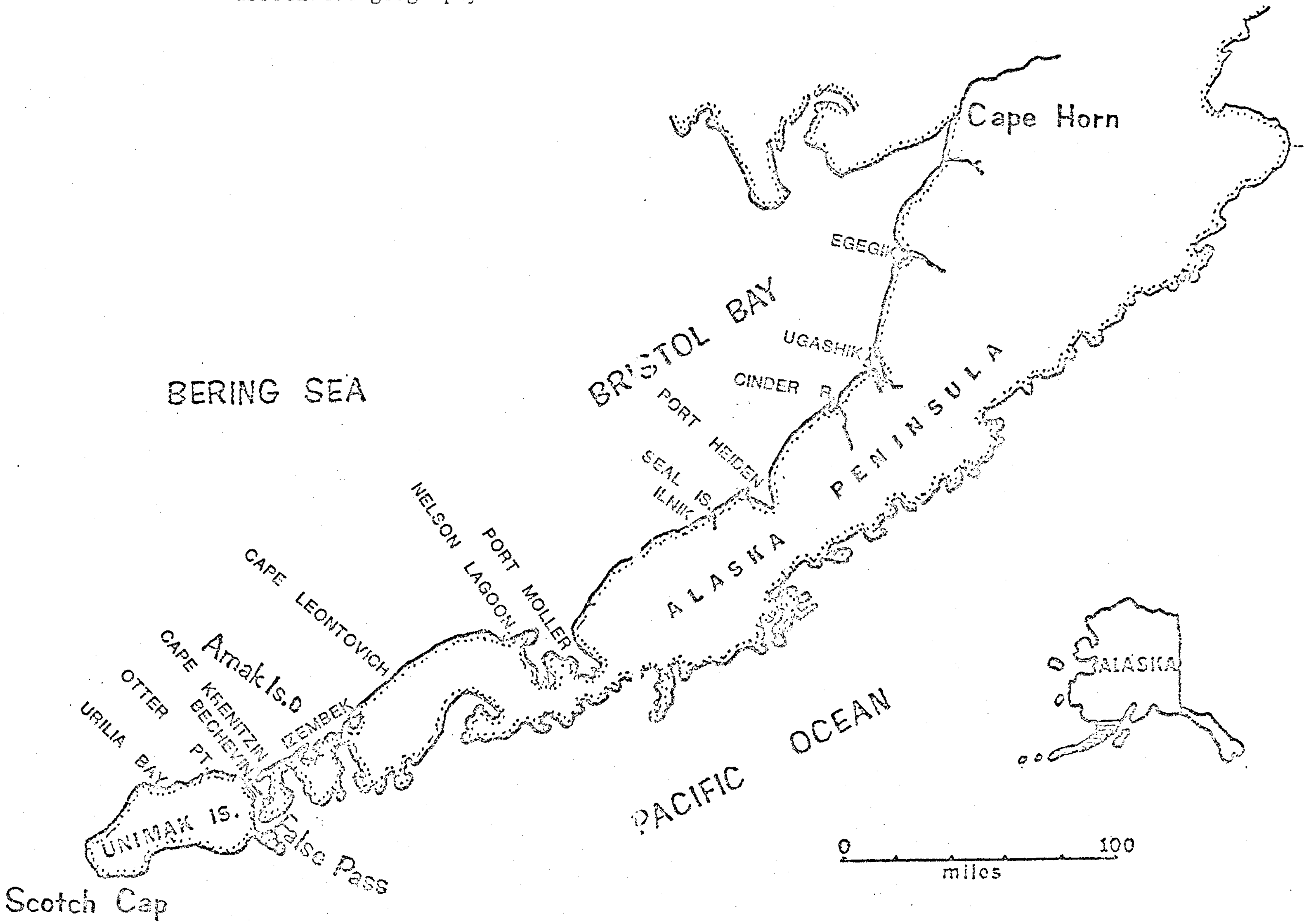
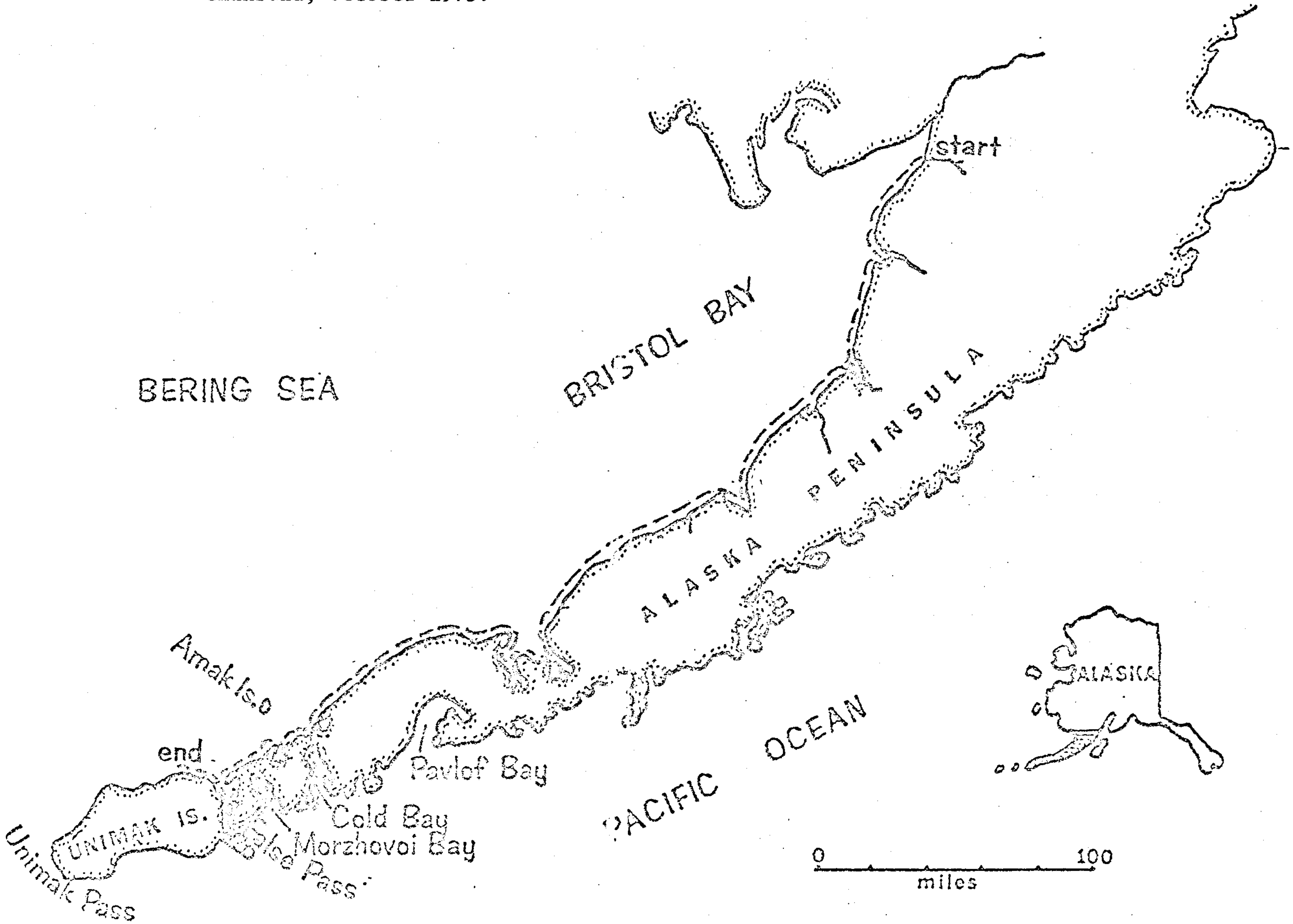
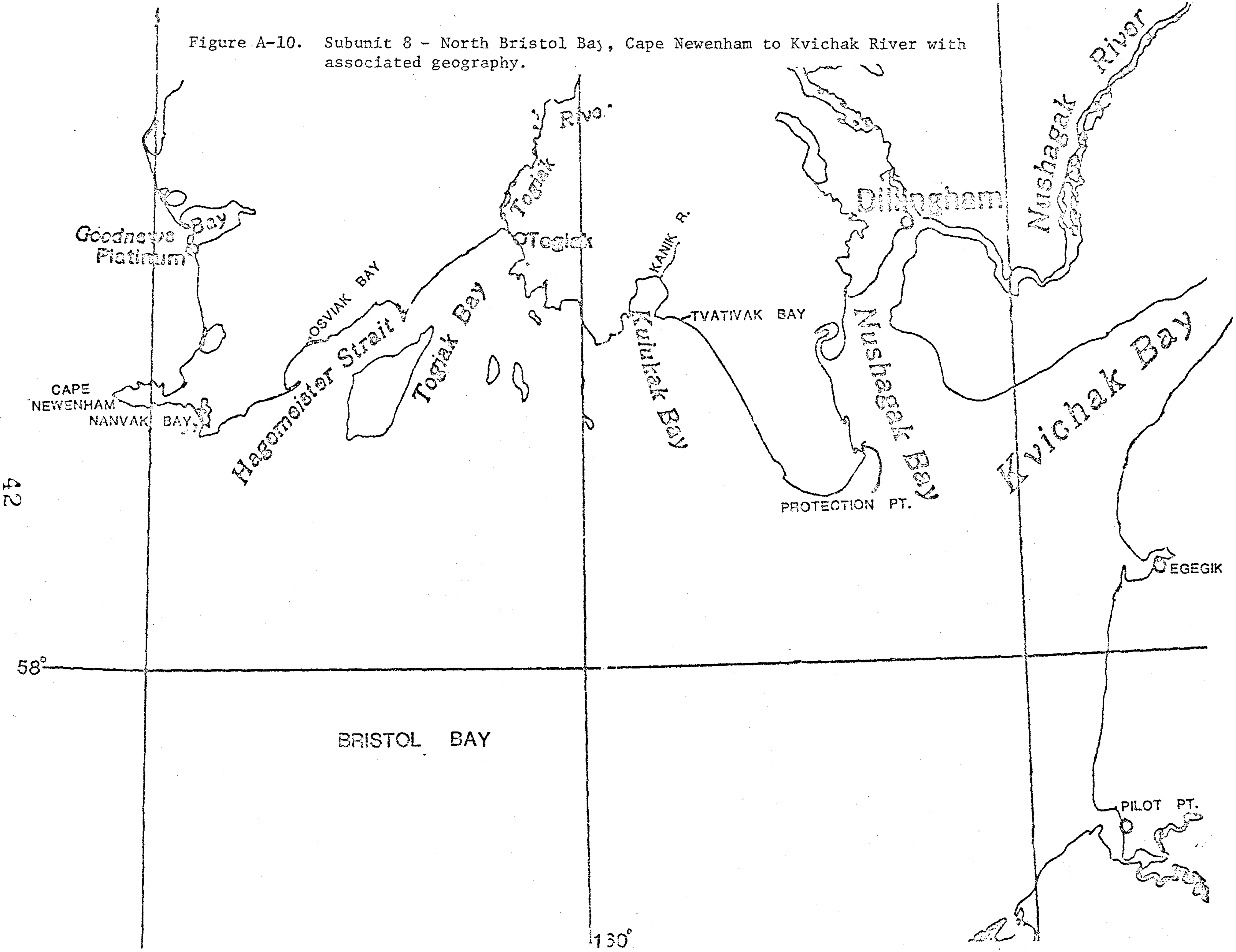


Figure A-9. Trackline of aerial marine bird survey on north shoreline of Alaska Peninsula, October 1975.



41

Figure A-10. Subunit 8 - North Bristol Bay, Cape Newenham to Kvichak River with associated geography.



RU# 3/4
APPENDIX

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

JAY S. HAMMOND, GOVERNOR

333 RASPBERRY ROAD
ANCHORAGE 99502

April 12, 1976

RECEIVED
APR 14 1976
NEGOA

Dr. Herb Bruce, Project Manager
National Oceanic and Atmospheric Administration
OCS Environmental Assessment Program
Juneau Project Office
P. O. Box 1808
Juneau, Alaska 99802

Dear Dr. Bruce:

Since the completion of my annual report (RU 3/4), I received the most recent update of Lensink's and Bartonek's seabird colony report. In many cases this greatly increases the number of colonies as I had listed in the annual report so I thought perhaps an amendment to my report would be in order.

Enclosed is a copy of an appendix that could be attached to the end of the annual report bringing it up to date for the eight subunits of the study area if you thought it was necessary to do so. I was not sure how far along the review of annual reports prior to printing are but thought possibly this appendix could still be added without too much difficulty or confusion.

Thanks for your help in this matter.

Sincerely,

Paul Arneson

Paul D. Arneson
Game Biologist

Enclosures

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3.	South-Kenai Peninsula	11
4.	Lower Cook Inlet	18
5.	Kodiak-Afognak	57
6.	South-Alaska Peninsula	161
7.	North-Alaska Peninsula	4
8.	North-Bristol Bay	15
	Total	354

* All colonies from Cape Fairweather to Unimak Island are found in Lensink, C. J. and Bartonek, J. C. 1976. Preliminary catalog of seabird colonies and photographic mapping of seabird colonies. Annual Report. Outer Continental Shelf Environmental Assessment Program. Research Units: 338/343. U. S. Department of Commerce, NOAA. 138 pp.

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Annual Report

Contract # 03-5-022-76
Research Unit # 38
Reporting Period May 13, 1975 to
March 31, 1976

A Census of Seabirds on the Pribilof Islands

Joseph J. Hickey, P.I.
Department of Wildlife Ecology
Russell Laboratories
University of Wisconsin
Madison, Wis. 53706

April 1, 1976

I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The main purpose of this study is to determine the actual size of seabird populations nesting on the Pribilof Islands.

St. George, the most important of these islands for birds, has about 48.1 km of cliffs all of which are used for nesting by 11 species. Seabird numbers on this island were considerably down in 1975 from the "millions" reported there in the past. The main least auklet colony held over 200,000 birds, the main murre cliffs, appeared to hold over 400,000, and 10.6 km of the lower cliffs had about 40,000 breeding pairs of 11 species.

St. George now represents the principal nesting ground of the red-legged kittiwake in North America, much smaller numbers being found on nearby St. Paul Island. (Unknown numbers have been reported on the Komandorskie Islands.)

The principal threats to seabird populations on St. George posed by petroleum exploration will be (a) disturbance of the ledge-nesting species by people or aircraft if the island is used as a local or regional base of operations and (b) potential spillage at or near the birds' main feeding area (56°37'30"N, 169°11'W) a shallow area (about 2-5 fathoms) 13.7 km to the northeast.

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II. INTRODUCTION

A. General Nature and Scope of Study

No systematic census or population estimate of the seabirds of the Pribilofs has ever been attempted, although for almost a century ornithologists have reported their numbers as in the "millions." The project proposed here is to provide enumerational data on what supposedly is the largest aggregate of colonial birds anywhere in North America, as a baseline on which to estimate any subsequent effects and environmental impact of petroleum exploration and development on the birdlife of this part of the Bering Sea.

The information required to meet this objective will consist of (a) actual counts of cliff-nesting species in the main colonies on St. George and St. Paul islands and (b) estimates (with confidence limits) of the numbers of puffins and auklets that nest in burrows on St. George and St. Paul.

The population estimates of the burrowing species should be available by 30 September 1976, although the confidence limits on these cannot be predicted at this time. The enumeration of ledge-nesting species will depend on (a) our success in getting photos of the cliffs during the birds' nesting season and (b) the time required to analyze these photographs after they are developed. With presently available techniques, it will take some months to analyze these pictures. The project is actively exploring a new method to expedite this analysis.

B. Specific Objectives

The primary task of this study is to define a major biological population which is subject to potential impact by petroleum exploration and development in the Bering Sea. The particular objectives of the project are twofold:

(a) to obtain precise estimates, for as many species as is practical within the time framework of this study, of the breeding seabirds on the Pribilof Islands, and

(b) to explore the possibilities of obtaining refined estimates of those additional nesting populations that do not readily lend themselves to conventional census techniques.

C. Relevance to problems of petroleum development

Seabirds, because of their large numbers and high visibility, are valuable indicators of the health of a marine ecosystem. Because of their importance in the ecosystem, and their high vulnerability to oil, their numbers are a natural index to the effect of oil on the biology of the area. Birds will be among the first species to be affected by oil pollution, and the techniques to monitor their numbers are now being developed. A repeatable census technique or techniques for colony seabirds is essential to understanding the effects of oil and gas development on the outer continental shelf.

III. CURRENT STATE OF KNOWLEDGE

Ornithological investigations of the Pribilofs began in 1872 when Henry Elliot (1881) described "the vast numbers of water-fowl," their disappearance in winter, and the considerable taking of eggs by the Aleut people. As evidence of the latter, six men on 5 July 1872 at Walrus Island loaded a 4-ton-capacity boat "down to the water's edge"with murre eggs collected in less than three working hours. Elliott regarded least auklets as present by the "millions," but he also encountered thick-billed murres in "immense multitudes," the males circling St. George as "a dark girdle of birds more than a quarter of a mile broad and thirty miles long." Gabrielson reported that in his opinion "St. George Island, considered as a whole, contains the greatest aggregation of breeding birds" he has ever seen and that "the least auklets are the most numerous in the swarming millions of birds" (Gabrielson and Lincoln, 1959; 506).

IV. STUDY AREA

The study area comprises the islands of St. George, St. Paul, Otter, and Walrus. Colonies are found on all cliff areas around the islands, among talus slopes at the bases of cliffs, and among beach boulders. In the past, murres nested on the flat plateau on Walrus Id. In 1975, we concentrated our field work on the main avian concentrations, which are on St. George. Here about 48 km of cliffs offer immense opportunities for seabird nesting (Table 1). The major shallow area in the nearby sea has a depth of about 2-5 fathoms (3.7-9.2 m) extending over about 1 km by 0.5 km.

The weather on the Pribilofs during the breeding season is primarily fog and wind with almost constant rain early in the season.

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

The seabirds nesting on the Pribilofs consist of six species that nest on cliff ledges

- Thick-billed murre, *Uria lomvia*
- Common murre, *U. aalge*
- Black-legged kittiwake, *Rissa tridactyla*
- Red-legged kittiwake, *R. brevirostris*
- Fulmar, *Fulmarus glacialis*
- Red-faced cormorant, *Phalacrocorax urile*

and five species that nest underground

- Parakeet auklet, *Cyclorrhynchus psittacula*
- Crested auklet, *Aethia cristatella*
- Least auklet, *A. pusilla*
- Horned puffin, *Fratercula corniculata*
- Tufted puffin, *Lunda cirrhata*

Table 1. Types of Cliffs on St. George Is.

Stratum		Cliff No.	Name of cliff	Exposure	Height (m)	Length (km)	
A	(40-100 ft)	[12.2-30.5 m]					
		1.	Village W	N	12.2	3.5	
		2.	Village E	N	12.2	1.5	
		3.	Zapadni Beach N	SW	12.2-24.4	0.55	
		4.	Tolstoi W (East Cliffs)	E	12.2-24.4	1.0	
		5.	Zapadni Bay So.	W	24.4	1.6	
		6.	Zapadni Bay to Maynard Pt.	SW	24.4	2.4	
			Total length				10.6
B	(100-200 ft)	[30.5-61 m]					
		7.	Maynard Pt. - Zap. Bay	SW	48.8	3.5	
		8.	Rush Pt.	SW	36.6	0.5	
		9.	N. Tolstoi to Pinacle Pt.	N	24.4-61	0.468	
		10.	Sealion Pt. (S. Tolstoi - Garden Cove)	SE	30.5-61	3.0	
			Total length				7.468
C	(200-300 ft)	[61-91.4 m]					
		11.	Pinnacle Pt. to 3 Boulders Pt.	NE	61	0.460	
		12.	Tolstoi Pt. (3 Boulders-So. Tolstoi)	E	61	1.8	
		13.	Red Bluffs — Zapadni Bay	SW	61-91.4	3.2	
			Total length				5.5
D	(300-400 ft)	[91.4-122 m]					
		14.	Garden Cove SW (Black Cliffs)	SE	61-122	2.5	
		15.	Cascade Pt. NE	SE	91.4	3.6	
		16.	Umanangula Bluffs	S	91.4	2.9	
		17.	Dalnoi Pt.--Samlalogh Ridge	N	97.5-140.2	5.3	
			Total length				14.3
E	(400-600 ft)	[122-182.9 m]					
		18.	Fox Castle W to Dalnoi	W	140.2-182.9	1.7	
		19.	Rush Pt. to Fox Castle	SW	182.9	2.0	
		20.	First Bluff	N	146.3	1.7	
			Total length				5.4
F	(600-1000 ft)	[182.9-308.5 m]					
		21.	High Bluffs	N	122-308.5	4.8	
			Total length				4.8
	Total length km						48.1

Ledge-nesting species.--The conventional method of counting cliff-nesting birds on island situations has been to photograph the birds from aircraft (Nettleship 1975). There has been some conjecture as to how to interpret these data, since under various conditions a pair may be represented by more than two birds. In censusing murres, the Canadian Wildlife Service tries to photograph murres before the nonbreeders arrive (late-June or early July in eastern Canada) and at the same date and hour each year (Nettleship, pers. comm.). In this approach, the Canadians assume each bird equals one pair. The bias in this assumption may be cancelled out in year-to-year comparisons, but the potential bias remains real in single-year data.

To understand this potential bias and to be able to correct for it, we explored ledge attendance by counting birds on a given series of ledges on different days and at different times of the day.

Photographs of the cliffs on St. George were carried out for us by the U. S. Fish and Wildlife Service in 1975, and 306 aerial photos were turned over to us by Dr. James C. Bartonek in December.

Burrow-nesting species.--The sampling scheme for censusing occupied burrows has been worked out by Bédard (1969) whose technique was to lay out quadrats 14.2 by 14.2 m, the observer stationing himself 40 or more meters away between 5 and 8 A.M. during the few days preceding laying (and coinciding with minimum daily attendance of immature birds in the colony and maximum activity of breeding birds on the surface of the slope). This involves making tallies every 30 minutes during the 3-hr. period on three successive days. This procedure further involves (1) ignoring the highest count in each series in order to correct for abnormal values resulting from disturbance and (2) averaging the 2nd-, 3rd-, and 4th-highest census figures for each quadrat.

Reference areas.--In order to provide future indices of population change on these islands, we selected

(1) small but well-described sections of the cliffs that could be recensused in the future; and
(2) observation points where major flights could be counted.

The location of 15 reference cliffs is shown in Figures 1-2, and their coordinates are given in Table 2.

Observation points are located in the same figures and their coordinates set forth in Table 3.

General.--The scientific party for this study consisted of the following from the University of Wisconsin: Joseph J. Hickey (Professor of Wildlife Ecology), F. Lance Craighead (research assistant), and Ronald C. Squibb (undergraduate field assistant). The party arrived on St. Paul on 14 June, was held up by fog, and reached St. George on 21 June. Hickey left on 14 July, Craighead on 8 August, and Squibb on 13 August.

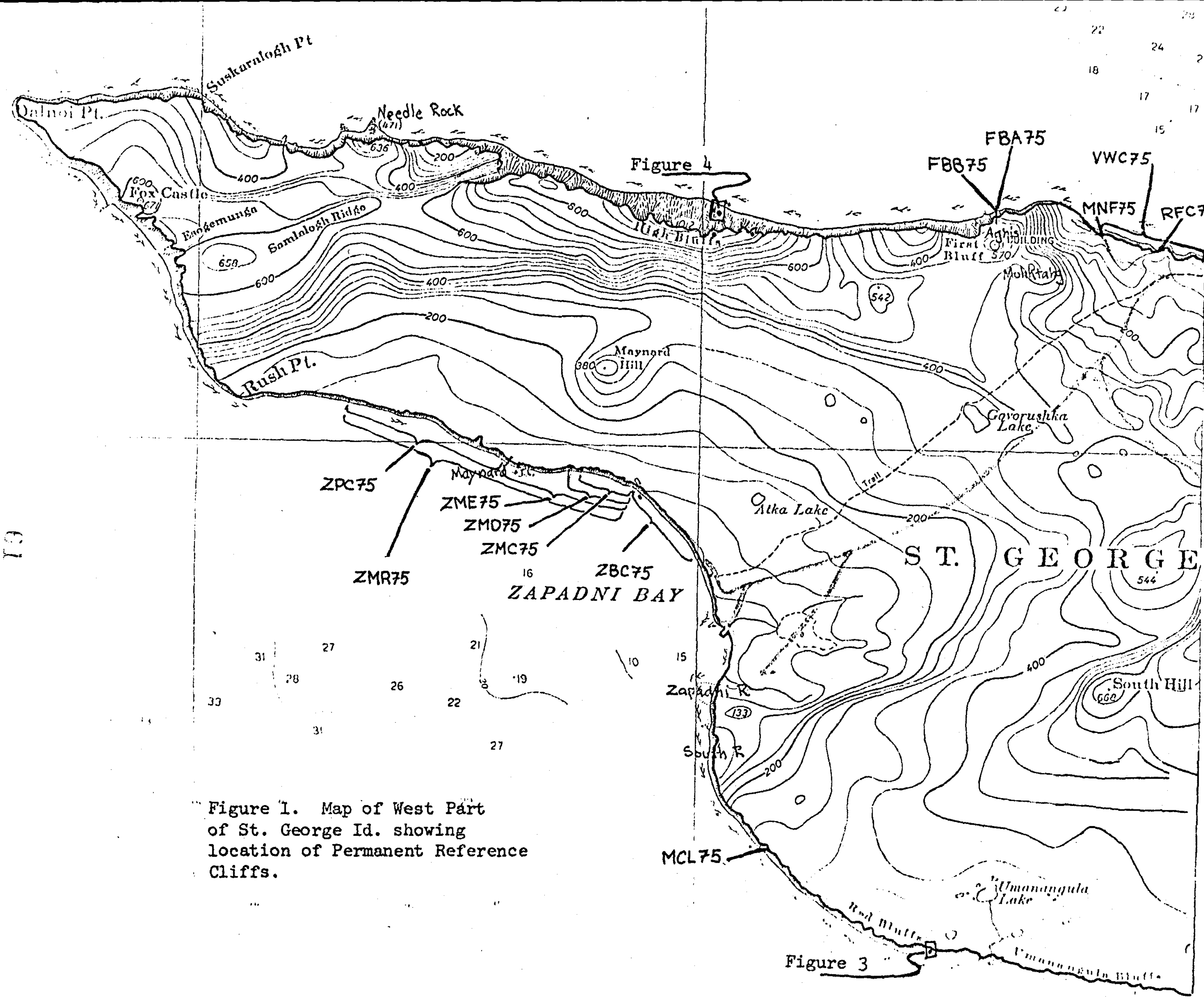

Figure 1. Map of West Part of St. George Id. showing location of Permanent Reference Cliffs.

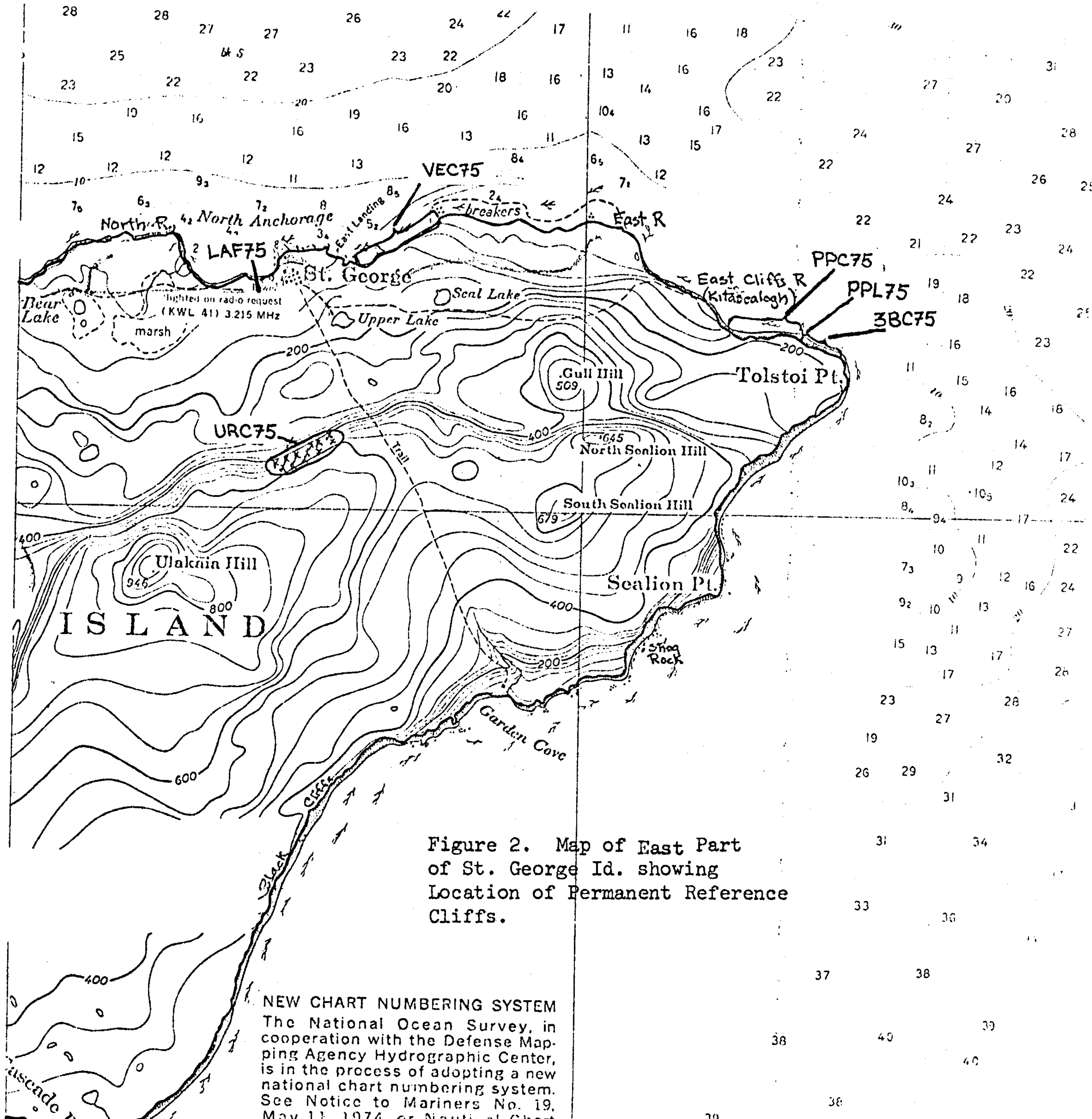

Figure 2. Map of East Part of St. George Id. showing Location of Permanent Reference Cliffs.

Table 2. Coordinates of Fifteen Reference Cliffs

Station No.	Island Stratum	Project No. Local Name	Coordinates
Entire Cliffs			
VWC75	A	No. 1 Village West	563612N to 563606N 1693601W 1693500W
VEC75	A	No. 2 Village East	563625N to 563610N 1693115W 1693155W
ZBC75	A	No. 3 Zapadni Beach N.	563420N to 563448N 1693958W 1694042W
	A	No. 6 Zapadni towards Rush Pt.	
ZMC75		(First 524 meters)	563448N to 563452N 1694042W 1694112W
ZMD75		(First 545 meters)	563448N to 563452N 1694042W 1694118W
ZME75		(First 1,346 meters)	563448N to 563454N 1694042W 1694200W
ZPC75		(Next 1,573 meters)	563454N to 563514N 1694200W 1694332W
ZMR75		(Total 2,919 meters)	563448N to 563514N 1694042W 1694332W
PPC75	B and C	No. 9 Kitasealogh to Pinnacle Point	563554N to 563552N 1692842W 1692802W
3BC75	C	No. 11 Pinnacle Point to 3 Boulders Point	563552N to 563548N 1692802W 1692742W
Partial Cliffs	-		
MCL75	A	No. 13 Murie Cove Ledges	563250N 1693913W
PPL75	C	No. 9 Pinnacle Point Ledges	563552N 1692802W
	E	No. 20 First Bluff Ledges	
FBA75		(area A)	563614N 1693710W
FBB75		(area B)	563614N 1693711W
RFC75	A	No. 1 Rosy Finch Cove Ledges	563609N 1693524W

C3

Table 3. Coordinates of Least Auklet colony and Flight-count observation points.

Station no.	local name	coordinates
Least Auklet Colony		
URC75	Ulakaia Ridge	563518N 1693230W
Flight Observations		
LAF75	Airstrip, Least Auklet Flights to Colony	563606N 1693300W
MNF75	Staraya Artel Observation Point, Murre Flights, East to West	563612N 1693554W

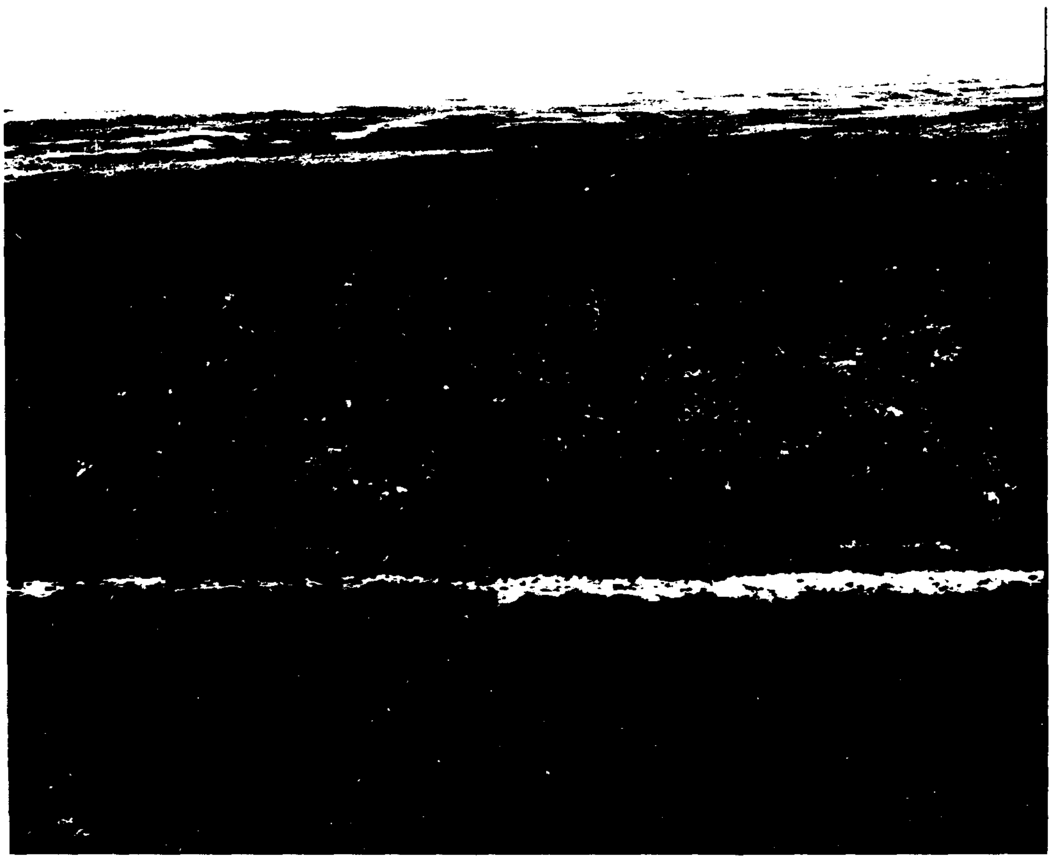

Figure 3. Cliff Section of Red Bluffs, SE coast of St. George Is. (shown also on figure 1) height 300 ft. (91.4 m).

This coastline is used by nesting:

- thick-billed murre
- common murre
- red legged kittiwake
- black legged kittiwake
- red faced cormorant
- fulmar
- tufted puffin
- horned puffin
- parakeet auklet
- least auklet
- crested auklet

Figure 4. Cliff Section of High Bluffs, N. coast of St. George Island (shown also on Figure 1, height 900 ft. (274.3 m) upper 300 ft. obscured by fog.

Seen from land, this coastline is used by nesting:

- thick-billed murre
- red legged kittiwake
- black legged kittiwake
- red faced cormorant
- fulmar
- tufted puffin
- horned puffin
- parakeet auklet

VI. RESULTS

Aerial Photographs.--A photographic survey of the cliff-nesting birds on St. George was run by the U. S. Fish and Wildlife Service on 1 August 1975, a relatively clear day on the island. The resulting 306 positive prints were turned over to us in December by Dr. James G. Bartonek of USFWS. Two examples of these prints are illustrated in Figures 3 and 4.

Quadrat Counts.--No progress was made in laying these out. A number of the talus slopes, including part of the great Ulakaia Ridge (famed for its nesting colony of least auklets) were covered with snow throughout June and July. Field work on St. George did not begin until 22 June when nonbreeding birds appeared to be everywhere present on least auklet nesting sites.

Reference Cliffs and Reference Ledges.--Fifteen cliff study areas were laid out (Table 2) and subjected to repeated censuses. In reporting on these reference cliffs, we have used a series of symbols (Table 4) in order to tighten up the tables of data that follow. The actual observations on entire cliff sections are set forth in Tables 5-9; those on partial cliffs are given in Tables 10-13.

Flight Observations.--A virtually complete count of the flight of least auklets from the sea in to the famed colony on Ulakaia Ridge was obtained on 1 July (Table 14), and additional data on evening flights were secured on 22 June and 17 July (Table 15). For roughly comparable evening periods, the successive totals were

22 June	38,357
1 July	50,940
17 July	33,130

Counts of the murre flights along the north shore of St. George were carried out for brief periods on 25 June, 30 June, and 1 July (Table 16) by two men and then by a single observer on 3-6 July (Table 17).

Table 4. Symbols Used in This Report

BK	Black-legged kittiwake	PA	Parakeet auklet
CA	Crested auklet	pr N	Pair observed on nest
CM	Common murre	RC	Red-faced cormorant
F	Fulmar	RK	Red-legged kittiwake
H	Height of cliff (in m)	s N	Single bird on nest
hole	crevice- or hole-nesting bird observed in front of crevice or hole	sec	Section measured
HP	Horned puffin	sit	Sitting bird
K	Kittiwake (species not distinguished)	std	Standing
L	Length of section (m)	TM	Thick-billed murre
LA	Least auklet	tot	Total
M	Murre (species not distinguished)	TP	Tufted puffin
N	Nest	W	Width of beach

Throughout the tables, a dash indicates that no counts were attempted. Numerical observations are handled as follows:

479	no. of birds observed
(53)	no. of nests observed
[47]	no. of birds presumed brooding or incubating

When three such numbers are used, as for kittiwakes, the first number is always the total and includes the other two.

Station VWC75

Table 5. Census Data--Stratum A
Cliff No. 1
Village West--Cumulative Data
From Staraya Artil Pond to North Rookery
Length--1.2 km, by tape

Date	Time	TM	CM	RK	BK	F	HP	TP	PA	CA	LA	RC
27 July	0930-1000	300	4	55 (16) [14]	15 (9) [6]	0	2	0	34	0	35	(7)
	-1030	415	36	96 (54) [39]	24 (10) [4]	0	0	0	12	0	10	(14)
	-1100	176	0	40 (7) [4]	69 (42) [26]	(11)	1	0	16	0	24	0
	-1130	196	65	32 (13) [4]	63 (30) [27]	(33)	3	0	19	1	21	0
	-1200	136	4	67 (9) [9]	187 (112) [78]	(42)	3	0	22	1	59	(1)
Total[a]	0930-1200	1223	109	290 (99)[b] [70]	358 (203) [141]	(86)	9	0	103	2	149	(22)
8 August	1300-1330	308	19	191 (13) [13]	44 (7) [6]	0	7	1	80	1	9	(7)
	-1400	450	19	68 (40) [36]	34 (21) [8]	0	7	0	73	0	2	(14)
	-1430	140	0	86 (4) [4]	81 (42) [32]	(22)	1	0	8	0	3	0
	-1500	272	209	113 (13) [5]	138 (76) [52]	(41)	2	0	70	1	0	0
	-1530	177	7	208 (5) [5]	172 (80) [45]	(42)	7	4	34	0	1	(1)
Total[a]	1300-1530	1347	254	666 (75) [63]	469 (226) [143]	(105)	24	5	265	2	15	(22)

a/ Total birds of all species: 27 July--2,351; 8 August--3,174. When only nests are counted for kittiwakes, the totals are 2,005 and 2,340 respectively.

b/ This included the start of nests; on 8 August such started nests were not counted.

Station VEC75

Table 6. Census Data--Stratum A

Cliff No. 2

Village East Cliffs--Cumulative Data

Length--1,073 km, by tape

Date	Time	L	H	W	TM	CM	BK	RK	F	RC	PA	CA	LA	TP	HP
5 July	Sec. A. (W. end to "Pahoehoe Pt") - counted from cliff top														
	1410-50	-	-	-	500	64	22(1)	22(4)	(4)	-	-	-	-	-	-
11 July a/	Sec. B. ("Pahoehoe Pt" to E. end) - counted from beach														
	1723-1824	-	-	-	1,559	96	164(110)	65(32)	(59)	13(3)	-	-	-	7	23
20 July	entire cliff counted from beach with exception of E. extreme														
sea 0-1;	1400-30	273 m	-	-	454	23	110(53)[38]	34(6)[5]	(13)	6(3)	96	11	63	8	13
light fog;	-1500	180 m	-	-	686	14	87(46)[31]	35(14)[12]	(49)	1	72	4	19	5	7
counted from	-1530	190 m	23 m	17 m	57	0	3(1)[1]	2 0		2	15	2	1	0	2
W. end to	-1600	290 m	10 m	22 m	294	25	22(11)[8]	33(12)[7]	(12)	0	0	0	0	0	0
E. end.	-1630	140 m	-	-	47	0	22(2)[2]	81 (8) [4]	(8)	0	0	0	0	0	0
Total a/	1400-1630	1,073 m			1,538	62	244(113)[80]	185(40)[28]	(82)	9(3)	183	17	83	13	22

a/ Total birds of all species were 2,156 on 11 July and 2,438 on 20 July. When only nests are used for kittiwakes and cormorants, these totals become 1,889 and 2,156 respectively.

Station No. ZBC75 Table 7. Census Data--Stratum A

Cliff No. 3

Zapadni Beach North--Cumulative Data a/

includes cliffs above beach from beginning of cliffs north to headland where beach ends and boulders begin. Length--0.55 km, by tape.

Date	Time	TM	CM	BK	RK	F	HP	TP	PA	CA	LA	RC	
25 June	958-1045	M:	931	K:	83	11	22	4	—	—	—	—	1,051
27 June	1110-1130	M:	263	K:	62	7	12	2	110	4	540	1	1,021
	1135-1155	M:	224	K:	68	6	10	1	115	0	370	0	794
8 July	1235-1355	569	13	43(37)	35(14)	5(5)	0	0	115	14	855	3	1,652
16 July	1535-1620	760	13	77(35) [18]	139(19) [16]	17(9)	0	2	23	0	23	5	1,036
6 August	1030-1105	542 [9]	17	73(24) [13]	96(16) [16]	15(10)	14	5	25	1	12	6	806
10 August	0930-1007	836 [58]	7	—	—	8(6)	21	4	112	0	6	17	1,124
	1014-34	—	—	48(24) [15]	65(3) [1]	—	—	—	—	—	—	—	
Mean of 2nd-, 3rd-, and 4th- highest counts of birds		624	11	55	65	9	16	3	112	2	311	5	1,613
Same for nests				28	11	7							46

a/ This cliff had extensive snow drifts covering many of its talus slopes right into August. The auklets were quite often seen on these snow banks, and most of them undoubtedly were nonbreeding birds.

Station ZMR75

Table 8. Census Data--Stratum A

Cliff No. 6

Zapadni Bay to Maynard Point and beyond

Total distance 2.919 km, by tape

Date	Time	L	H	W	TM	CM	BK	BK-N	RK	RKN	F(N)	RC	PA	CA	LA	TP	HP
Partial Count (524 m)			Station No. ZMC75														
July	0940-1005	55	30 m		43	0	27	(17)	5	(2)	(1)	0	8	0	110	0	5
	-1030	45	29		68	0	16	(7)	0	0	0	1	6	0	40	0	3
	-1047	40	25		29	0	15	(11)	0	0	0	0	15	0	45	0	
	-1130	110	20		144	0	22	(15)	11	(4)	(1)	1	13	0	75	1	7
	-1150	48	23		89	0	22	(16)	2	(2)	(5)	0	7	0	10	0	1
	-1200	60	19		142	2	4	(2)	2	(0)	(2)	0	15	0	70	0	3
	-1300	127	23		262	8	33	(22)	2	(1)	(5)	0	28	0	280	0	6
	-1327	39	19		126	17	7	(2)	0	0	0	0	12	0	60	0	4
otal	0940-1327	524	23.5		903	27	146	(92)	22	(9)	(14)	2	104	0	690	1	29
Partial Count (545 m)			Station No. ZMD75														
1 July	0845-0950	545			1035	52	124	(86)	3	(2)	(61)	2	39	0	140	1	17
Complete Count Part A (first 1,346 m)[a/]			Station No. ZME75														
1 July	0845-0930				827	15	109	(76)	3	(2)	(61)	2	22	0	100	1	13
	-1000	1,110			354	37	62	(39)	0	0	(13)	1	35	0	110	0	25
	-1030				384	0	33	(20)	0	0	(17)	0	41	1	260	0	15
	1045-1120	236	21 m	23 m	725	54	65	(36)	62	(37)	(140)	0	113	15	210	7	32
ubtotal	0845-1120	1,346 m			2,290	106	269	(171)	65	(39)	(231)	3	211	16	680	8	85

Table continued on next page

Table 8 continued

Part B (next 1.573 m)

Date	Time	L	H	W	TM	CM	BK	BK-N	RK	RKN	F(N)	RC	PA	CA	LA	TP	HP
25 July	1045-1100	166	15.5 m	22 m	522	0	5	(4)[1]	7	(4)[2]	(23)	2	49	0	15	1	10
	-1130	148	17	22	770	32	86	(56([38]	99	(50)[32]	(32)	0	40	4	40	0	22
	-1200	162	17	21	528	108	64	(48)[28]	19	(7)[5]	0	0	29	0	170	0	14
	1230-1300	148	18	19	756	41	27	(17)[12]	6	(1)[0]	0	0	37	1	160	0	12
	-1330	229	20	18	886	72	7	(5)[4]	0	0 0	(41)	0	65	3	270	5	34
	-1400	140	21	18.5	716	12	96	(40)[34]	43	(18)[24]	(66)	1	42	0	105	0	25
	-1430	113	18.5	17	670	0	53	(24)[17]	1	(0)[0]	(34)	0	40	0	50	1	13
	-1500	170	22	12	391	148	74	(40)[32]	0	0 0	(25)	1	54	2	50	0	32
	-1530	157	21	12	1,111	17	110	(72)[48]	21	(6)[4]	(57)	7(5)	22	0	30	0	13
	-1600	140	24	.9	1,388	8	12	(6)[6]	92	(39)[34]	(91)	1	18	0	20	0	17
Subtotal	1045-1600 Station No. ZPC75	1,573	-	-	7,738	438	534(312)[220]		288(125)[101]		(369)	12(5)	396	10	910	7	192
Total b/ For 21 and 25 July	- Station No. ZMR75	2,919	-	-	10,028	544	803(483)[110]		353(164)[101]		(600)	15(5)	607	26	1,590	15	277

a/ Includes 545-m area above.

b/ The total birds for all species was 14,858; when only nests are included for kittiwakes and cormorants, this drops to 14,349.

Station Numbers PPC75
3BC75

Table 9. Census Data--Strata B and C

Cliffs No. 9 and 11

Total length 0.468 and 0.460 km, by tape

Date	Time	L	H	N	BK BK-N	RK RK-N	F(N)	RC	FA	CA	LA	TP	HP
28 June Wind 7 knots SW	**Cliff No. 9**: from "trail down" (Kitasealogh to Pinnacle Pt.												
	1255-1420	468 m	59 m	783	K: 572	KN:(342)	-	111(82)	-	-	-	-	2
	Cliff No. 11 from "Pinnacle Pt." to "3 Boulders Pt."												
	1520-1750	460 m	61 m	4,382	K: 869	KN:(459)	-	35(20)	-	-	-	-	-
24 July	**Cliff No. 9**: from "trail down" (Kitasealogh) to Pinnacle Pt.												
light fog	1040-1205			1,093	556(310)	163(117)	14	(90)	49	11	250	-	9

Station No. MCL75 Table 10

Ledge Attendance Counts: Thick-billed Murres
Place: Murie Cove (Cliff divided into two groups of ledges: Upper and Lower).
Birds classified as sitting or standing. No common murres observed.

Date	Upper				Lower				Total (both)
	Time	Sit	Stnd.	Tot.	Time	Sit	Stnd.	Tot	
10 July	1000-15	approx.		125	1000-15	approx.		75	200
14 July	1050-1100	46	99	145	1103-10	20	74	94	239
	1130-40	55	83	138	1130-40	13	80	93	231
	1205-10	51	91	142	1205-10	24	70	94	236
16 July	930-35	64	136	200 a/	925-28	18	128	146	346
	949-1000	43	148	191 a/	945-47	20	104	124	315
	1005-10	55	152	207	1000-04	20	105	125	332
	1019-24	48	149	197	1015-18	14	114	128	325
	1032-36	61	134	195	1030-32	17	114	131	326
	1047-51	65	132	197	1045-46	21	107	128	325
	1103-08	63	126	189	1100-02	16	114	130	319
	1117-22	66	121	187	1115-17	15	104	119	306
	1134-38	64	132	196	1131-33	20	100	120	316
	1148-54	76	128	204	1145-47	24	86	110	314
18 July	1403-09	65	126	191	1400-02	21	99	120	311
	17-22	63	123	186	15-17	23	105	128	314
cloudy,	33-36	69	115	184	30-33	31	102	133	317
vis. fair	48-53	67	123	190	45-47	38	101	139	329
	1504-09	93	107	200	1500-02	27	102	129	329
	18-23	71	127	198	15-17	28	107	135	333
	33-38	76	120	196	30-32	33	106	139	335
	47-52	78	123	201	45-47	30	111	141	342
	1604-08	65	141	206	1600-03	37	106	143	349
	17-22	73	143	216	15-17	29	111	140	356
	34-38	72	145	217	30-33	16	129	145	362
	48-53	67	148	215	45-47	24	120	144	359
	1703-08	64	149	213	1700-03	26	97	123	336
	18-22	68	143	211	15-17	29	98	127	338
	35-40	62	117	179	30-35	19	116	135	314
	48-53	62	121	183	45-48	18	118	136	319
20 July b/	455-50	32	74	106	500-05	6	83	89	195
	515-20	54	81	135	20-24	10	91	101	236
cloudy,	33-37	57	76	133	30-33	11	91	102	235
fog,	48-53	64	69	133	45-47	16	85	101	234
drizzle	603-05	76	55	131	600-03	20	84	104	235
entire period	19-23	66	63	129	15-18	19	87	106	235
	33-38	58	79	137	30-32	13	95	108	245

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Date	Upper				Lower				Total (both)
	time	sit	stn	tot	time	sit	stn	tot	
20 July	640-53	65	60	125	45-48	22	87	109	234
	703-07	65	63	128	700-03	16	82	98	226
	18-21	66	64	130	15-18	11	81	92	222
	33-37	65	61	126	30-33	19	76	95	221
	48-51	69	65	134	45-48	18	74	92	226
	803-06	66	65	131	800-03	16	75	91	222
	18-22	72	57	129	15-18	14	84	98	227
	33-36	63	64	127	30-33	19	78	97	224
	48-51	70	58	128	45-48	22	77	99	227
	903-06	63	69	132	900-03	23	72	95	227
	18-22	67	54	121	15-18	16	79	95	216
	33-36	73	50	123	30-33	23	68	91	214
	48-51	63	63	126	45-48	20	70	90	216
	1003-07	61	61	122	1000-03	21	65	86	208
	18-23	68	59	127	15-18	22	60	82	209
	1034-38	64	68	132	1030-33	17	59	76	208
	48-54	64	68	132	45-48	18	65	83	215
	1103-08	68	64	132	1100-03	19	64	83	215
23 July	1740-45	36	172	208	1745-50	10	142	152	360
	1750-55	36	148	184	1755-1800	8	140	148	332
27 July	1815-20	40	140	180	1820-21	4	113	117	297
	30-34	43	133	176	35-37	5	110	115	291
sea 2	45-48	33	147	180	49-50	10	109	119	299
high ceiling	1900-04	46	131	177	1904-05	16	99	115	292
vis:good	15-20	45	120	165	20-21	12	101	113	278
	30-35	53	110	163	35-36	9	98	107	270
	45-48	43	104	147	49-50	9	92	101	248
	2000-05	43	98	141	2005-06	6	94	100	241
	15-18	44	97	141	18-19	10	89	99	240
	30-34	50	64	114	34-35	10	74	84	198
	45-48	40	55	95	48-49	10	57	67	162
31 July	1534-39	50	158	208	1530-34	19	125	144	352
	48-52	64	147	211	45-47	30	119	149	360
sea 0-1	1605-08	69	145	214	1600-03	34	120	154	368
vis:v. good	19-23	67	154	221	15-18	23	131	154	375
	35-37	67	149	216	30-32	34	120	154	370
	48-52	56	158	214	45-47	35	118	153	367
	1705-08	71	145	216	1700-04	35	114	149	365
	18-21	63	156	219	15-18	33	120	153	372
	34-38	59	159	218	30-33	25	133	158	376
	49-53	61	153	214	45-48	20	139	159	373
	1804-08	72	139	211	1800-03	23	131	154	365
	18-22	55	134c	/189	15-17	31	119	150	339
	34-37	52	131	183	30-33	25	111	136	319
	48-52	55	132	187	45-48	27	109	136	323
	1904-06	53	113	166	1900-04	21	119	140	306

continued on next page

Table 10 (cont.)

Date	Upper time	Upper sit	Upper stn	Upper tot	Lower time	Lower sit	Lower stn	Lower tot	Total (both)
31 July	19-22	50	113	163	15-18	22	105	127	290
	34-38	52	105	157	30-32	22	102	124	281
	49-53	43	107	150	45-48	23	88	111	261
	2004-08	47	99	146	2000-03	22	87	109	255
	18-22	46	91	137	15-18	25	79	104	241
	33-35	50	74	124	30-32	16	74	90	214
	48-51	45	55	100	45-47	13	57	70	170
	2103-08	54	27	81	2100-03	16	37	53	134
9 Aug.	1049-55	31	137	168	1045-48	23	101	124	292
	1103-06	35	130	165	1100-02	23	94	117	282
wind lt. from N. good vis.	17-21	35	120	155	15-17	22	92	114	269

a/ Shrouding fog.

b/ Cloudy, fog, drizzle entire period.

c/ Fox intrusion (compensated by adding flushed TM to "stn." col.)

Station No. PPL75

Table 11.

Ledge Attendance Counts: Kittiwakes, Murres and Cormorants with Supplementary Observations on Parakeet and Least Auklets.

Pinnacle Pt. Study Area (Part of Cliff No. 2)

Width: 50 m(68-18 m E. of Pinn. Pt.); ht: 15-16 m

		RK					BK						TM			RC		PA	LA
Date	Time	pr N	sN	Loose	Tot. N	Tot. indiv.	prN	sN	Loose	Tot. N	Tot. indiv.	K	Sit.	Stand	Tot.	at N	loose	No.	No.
9 July	1380-1410	11	70	22	(81)	114	1	38	10	(39)	50	3	85	70	155	12	7	10	11
"	1516-1550	10	66	21	(76)	107	5	33	16	(38)	59	3(3)	70	97	167b/	12	6	8	4
11 July	1000-1023	9	54	22	(63)	94	5	34	9	(39)	53	(7)a/	76	28	104	12	4	3	-
14 July	1630-1710	-	-	-	(64)	101	-	-	-	(30)	48	9(8)	60	75	135	-	-	6	-
"	1705- 35	7	55	24	(62)	93	3	26	16	(29)	48	6(6)	67	66	133	12	20	5	-
"	1805- 20	8	71	16	(79)	103	7	25	11	(32)	50	8(7)	83	68	151	12	22	1	-
15 July	1000- 30	18	59	33	(77)	128	2	30	18	(38)	64	-	81	71	152b/	14	16	1	-
"	1100- 30	14	61	30	(75)	119	4	33	21	(37)	62	-	67	59	126	-	-	-	-
"	1130- 50	11	65	22	(76)	109	6	37	15	(43)	64	-	78	65	143	12	15	2	3
"	1230-1300	13	64	34	(77)	124	7	28	18	(35)	60	-	63	73	136	12	13	6	3
"	1305-1320	11	68	36	(79)	126	6	33	12	(39)	57	3	72	61	133	12	13	2	3
22 July	0500- 30	-	41	0	(80)a/	41	-	24	1	(43)a/	25	-	36	113	149	-	-	-	-
"	0530- 50	-	42	-	(73)a/	42	-	23	-	(36)	23	-	91	78	169	-	8	-	-
"	0600- 17	-	39	-	(80)a/	39	-	26	-	(43)	26	-	69	82	151c/	-	8	-	-
"	0630- 45	-	53	-	(72)	53	1	27	1	(39)	30	-	72	35	107b/	-	6	-	-
"	0700- 15	-	60	5	(81)	-	-	-	-	-	-	-	69	35	104b/	-	7	-	-

Table continued on next page

Table 11 continued.

Date	Time	RK pr N	RK sN	RK loose	RK Tot. N	RK Tot. indiv.	RK pr N	RK sN	RK loose	RK Tot. N	RK Tot. indiv.	A	TM Sit.	TM Stand	TM Tot.	RC at N	RC loose	PA No.	LA No.
24 July	0935-1004	9	66	31	(76)a/	115	1	33	18	(35)	53	--	57	82	139b/	-	9	-	-
"	1030- 38	4	42	61	(46)d/	111	4	24	22	(29)d/	54	-	69	25	94	-	13	-	-
29 July	0930- 52	-	37	55	-	92	-	27	21	-	48	-	57	87	144	11	11	-	-
"	1000- 25	2	42	68	-	114	1	23	25	-	50	-	66	92	158	-	13	-	-
"	1030-1100	3	37	62	-	105	-	23	31	-	54	-	64	100	164	-	12	-	-
"	1100- 25	3	40	67	-	113	1	24	32	-	58	-	71	92	163	-	9	-	-
		brood/sit[35] chicks seen: 2					brood/sit[18] chicks seen: 8												
10 August	1930-2015	1	37	65e/	(38)d/	104	1	22	40f/	(23)d/	64	-	54	82	136 [11]	1	14 (10) g/	-	-

a/ Nest unoccupied

b/ Plus 1 common murre

c/ Plus 2 common murres

d/ Only completed nests counted; all others in the first 17 lines above defined as any nest site under construction

e/ Includes 56 adults at 45 incomplete nests

f/ Includes 24 adults on 17 incomplete nests

g/ the 10 nests had 21 chicks

Station No. FBA75

Table 12

Ledge Attendance Counts: Kittiwakes and Murres

Place: First Bluff--Center Study Area

Subsection A (face nearer observation pt.)

		RK					BK					K			TM		
date	time	pr N	sN	loose	tot. N	tot. indiv	pr N	sN	loose	tot. n	tot. indiv.	pr N	sN	tot. indiv	sit.	stn	tot. TM
10 July	1511-26	4	43	11	(47)	62	1	15	0	16	17	1	7	9	29	92	121
10 July	1600-16	9	27	10	(36)	55	1	12	0	13	14	3	9	17	43	107	150
12 July	1642-1703	5	24	14	(29)	48	2	15	2	17	21	1	13	15	28	97	125
"	1904-23	10	23	14	(33)	57	0	11	5	11	16	0	15	17	42	89	131
23 July	1115-31	6	49	17	(55)	78	-	13	-	13	13	-	-	-	28	56	84
"	1202-07	7	49	19	(56)	82	-	13	-	13	13	-	-	-	37	38	75
"	1230-40	5	43	20	(50)a/	73	-	12	3	12	15	-	-	-	52	38	90
"	1300-06	6	39	19	(47)a/	70	-	8	5	8	13	-	-	-	48	41	89
"	1330-37		time	spent		mapping	K	nests	-	—	-	-	-	-	40	50	90
"	1400-06	-	-	-	-	-	-	-	-	-	-	-	-	-	52	48	100
"	1430-35	-	-	-	-	-	-	-	-	-	-	-	-	-	61	51	112
"	1500-10	5	43	18	(48)	71	3	11	3	14	20	-	-	-	58	60	118
"	1530-42	4	44	19	(48)	71	1	13	3	14	18	-	-	-	69	58	127
27 July	1755-1812	5	38[31]	20	(43)	68	1	11[8]	3	12	16	-	-	-	51	61	112
"	1845-53	5	41	21	(46)a/	72	1	11	5	12	18	-	-	-	51	60	111
"	1915-26	4	40	16	(44)	64	1	11	4	12	17	-	-	-	58	49	107
"	1944-52	3	42	18	(45)	66	1	12	2	13	16	-	-	-	52	50	102
"	2005-10	1	42	14	(43)	58	1	12	4	13	18	-	-	-	57	42	99
"	2022-29	1	46	13	(47)	61	1	12	3	13	17	-	-	-	49	48	97
29 July	1500-20		44[46]	7	(48)a/	51		12[12]	3	13b/	15	-	-	-	47c/	25	72
very strong wind	1540-47		42	8	(47)b/	50		12	5	13b/	17	-	-	-	56c/	22	78
"	1612-20		43[41]	8	(47)	51		13[12]	4	13	17	-	-	-	65c/	17	82
"	1642-47		42[40]	9	(46)a/	55		13[12]	4	13	17	-	-	-	66c/	28	94
"	1710-17		44[41]	8	(47)b/	52	1	12[12]	2	13	16	-	-	-	51c/	37	88
"	1730-37		41[39]	11	(47)b/	52	1	12[12]	2	13	16	-	-	-	60	39	99

Table 12 (Cont.)

Subsection A (face nearer observation pt.)

		RK							BK							TM			
date	time	RK pN	sN	loose	tot. N	tot. indiv.	sit-ting	Nw/ chicks	BK pN	sN	loose	tot. N	tot. indiv.	sit-ting	Nw/ chicks	sit.	stn	tot.	brooding chick se
30 July	0930	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	61	90	-
"	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41	54	95	-
"	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39	54	93	-
"	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	54	97	-
"	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	48	91	-
"	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	64	104	-
"	1100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37	68	105	-
"	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	69	104	-
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46	54	100	
6 August	1400-13	3	44	13	(48)d/	63	-	-	-	13	4	(13)	17	-	-	32	50	82	-
"	15-25	2	44	18	(48)d/	66	-	-	-	12	3	(13)d/	15	-	-	30	58	88	-
"	30-36	2	43	20	(48)d/	67	-	-	-	13	2	(13)	15	-	-	42	52	94	-
"	50-55	4	41	12	(48)d/	61	-	-	-	13	4	(13)	17	-	1	29	63	92	-
"	1500-06	3	42	16	(47)d/	64	-	-	-	13	5	(13)	18	-	-	40	53	93	-
"	15-21	2	45	14	(48)d/	63	-	-	-	13	5	(13)	18	-	-	39	56	95	4
"	30-38	3	42	-	(47)d/	48	-	-	1	12	5	(13)	19	-	-	41	56	97	-
"	45-50	3	42	18	(47)d/	66	-	-	-	-	-	-	-	-	-	55	53	108	-
8 August	0615-25	-	38	5	(47)d/	43	[25]	-	-	11	1	(12)	12	[9]	3	31	67	98	-
"	0630-40	-	38	5	(47)	43	-	-	-	11	1	(12)	12	-	-	35	61	96	3
"	0645-50	-	39	5	(47)	44	[24]	-	-	11	1	(12)	12	[7]	-	35	56	91	-
"	700-06	-	39	3	(47)	42	[20]	-	-	10	-	(12)	10	[8]	-	28	63	91	-
"	0715-24	1	38	6	(47)	46	[26]	-	1	10	-	(12)	12	[6]	-	36	60	96	-
"	0730-40	1	37	8	(46)e/	47	[24]	-	-	12	-	(13)e/	12	[6]	-	38	58	96	3
"	0745-52	2	39	10	(46)e/	53	[27]	-	-	12	4	(13)e/	16	[8]	-	38	54	92	-
"	0800-07	2	39	15	(47)	58	[29]	-	-	11	4	(12)	15	[5]	-	37	55	92	4
"	0815-24	4	39	15	(47)	62	[27]	-	1	10	2	(12)	14	[5]	-	36	57	93	6
"	0830-36	4	38	16	(47)	62	[29]	-	1	10	4	(12)	16	[10]	-	38	53	91	7
August	1125-44	3	25	49f/	(28)e/	80	[23]	4	2	8	7g/	(10)e/	19	[8]	5	24	64	88	10
"	1200-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	74	96	-

Table continued on next page

Table 12 (Cont.) Station No. FBB75

Subsection B (farther from observation pt.)

date	Time	RK pr N	RK sN	RK loose	RK tot N	RK tot. indiv.	BK pr N	BK sN	BK loose	BK tot. N	BK tot. indiv.	K pr N	K sN	K tot. indiv.	TM sit.	TM stn	TM tot.	HP hole	PA hole	F/N
10 July	1530-45	3	20	20	(23)	46	-	-	-	0	0	1	9	11	76	243	319	2/1	5/0	1/(1)
"	1746-1800	3	24	15	(27)	45	-	-	-	0	0	1	7	10	80	269	349	5/1	13/0	1/(1)
12 July	1704-1730	7	11	13	(18)	38	-	2	-	2	2	-	7	8	74	249	323	8/2	14/1	2/(2)
23 July	1133-40	tot. k: 47, too foggy for further classification													41	121	162	6/	1/	-
27 July	1815-38	3	21 [17]	22	(24)	49	-	-	-	-	-	-	-	-	78	207	285	4/2	17/	2/(2)
"	1900-12	4	23	18	(27)	49	-	-	1	-	1	-	-	-	87	194	281	1/1	20/	2/(2)
"	1933-40	1	22	13	(23)	37	-	-	-	-	-	-	-	-	63	166	229	-	18/	2/(2)
"	1954-2000	1	24	10	(25)	36	-	-	-	-	-	-	-	-	57	172	229	3/	15/	1/(2)
"	2013-20	-	22	7	(22)	29	-	-	-	-	-	-	-	-	63	146	209	2/	22/	0/(2)
29 July	1525-38	2	27 [28]	10	(29)	41	-	-	2	-	2	-	-	-	43	202	245	1/	3/	1/(1)
"	1548-1600		28 [26]	4	(28)	32	-	-	-	-	-	-	-	-	52	179	231	1/1	1/	1/(1)
"	1622-34		26 [24]	8	(26)	34	-	-	2	-	2	-	-	-	54	199	253	1/1	1/	-
"	1658-1708	1	23	13	(24)	38	-	-	-	-	-	-	-	-	72	160	232	2/2	9/	1/(1)
"	1719-28	1	24 [20]	17	(25)	43	-	-	-	-	-	-	-	-	72	178	250	-	12/	1/(1)
6 August	1507-12	(foggy weather)				-	-	-	-	-	-	-	-	-	45	177	222	-	-	-
"	22-28	3	23	28	(26)	77	-	-	-	-	-	-	-	-	63	189	252	2/1	12/1	2/(2)
"	38-44	2	24	26	(26)	54	-	-	-	-	-	-	-	-	62	177	239	1/1	4/	2/(2)
1 August	1145-1200	2	22	23h/	(24)e/	49i/ [22]	-	-	-	-	-	-	-	-	40	161	201 brood: [7]	-	-	2/(2)

Table is continued on next page

Table 12. (concluded)

a/ plus 2 unoccupied nests

b/ plus 1 unoccupied nest

c/ strong winds

d/ some nests unoccupied

e/ complete nests with side walls

f/ also includes 22 adults at 18 incomplete nests

g/ also includes 4 adults at 3 incomplete nests

h/ also includes 2 adults at 2 incomplete nests

i/ 8 chicks seen

Station No. RFC75

Table 13.

Ledge Attendance Counts: Thick-billed and Common Murres, Red-legged and Black-legged Kittiwakes, and Fulmars. Place: Rosy Finch Cove

Date	Time	TM			CM			RK	BK	F
		stn	sit	total	stn	sit	total			
18 July	Normal observation point									
	1415	—	—	86	—	—	47	(1)	(5)	(1)
	1430	—	—	85	—	—	46	2 (1)		
	1445	—	—	86	30	21	51	4 (1)	—	—
	1500	—	—	96	24	22	46	2 (1)	—	—
	1515	—	—	107	20	24	44	3 (1)	—	—
	1530	—	—	97	31	17	48	—	—	—
	1545	—	—	100	20	24	44	2 (1)	—	—
	1600	—	—	112	28	21	49	—	—	—
18 July	On east of ledge--birds hidden in above count									
	1525	—	—	17	17	9	26	—	—	—
	1605	—	—	13	19	9	28	—	—	—
19 July	Viewing from beach below									
	1025	—	—	—	—	—	112[a]	—	—	—
19 July	Normal observation point									
	1045	28	45	73	30	17	47[b]	4 (1)	7 (6)	—
	1105	16	39	55	25	43	68	4 (1)	7 (6)	—
	1120	29	40	69	28	25	53	3 (1)	7 (6)	—
	1130	32	40	72	24	29	53	—	—	—
	1157	33	45	78	27	25	52	—	—	—
	1207	34	46	80	27	27	54	2 (1)	—	—
20 July	Normal observation point									
	0815	9	42	51	28	18	46	(1)	(6)	—
	0830	13	45	58	16	18	34	2 (1)	—	—
	0845	9	44	53	17	21	38	—	—	—
	0900	12	40	52	13	25	38	—	—	—
	0915	6	47	53	20	24	44	4 (1)	6 (6)	—
	0930	12	45	57	20	21	41	—	—	—
20 July	On east of ledge--birds hidden in above count									
	0940	—	—	9	—	—	18	—	—	16 (10)
20 July	Normal observation point									
	0945	14	41	55	20	22	42	2 (1)	—	—
	1000	14	40	54	24	18	42	3 (1)		—
	1015	12	46	58	18	25	43	3 (1)	7 (6)	1
	1030	10	47	57	11	31	42	2 (1)	9 (6)	—
20 July	On east of ledge									
	1040	—	—	10	—	—	18	—	—	—

Table continued on next page

Table 13 continued.

Date	Time	TM stn	TM sit	TM total	CM stn	CM sit	CM total	RK	BK	F
23 July	Normal observation point									
	1215	24	45	69	26	16	42	3 (1)	_	8
	1230	21	49	70	21	26	47	3 (1)	_	_
	1245	20	42	62	28	27	55	_	_	_
	1300	17	47	64	20	27	47	_	_	_
	1315	21	42	63	28	23	51	_	_	_
	1330	27	40	67	30	28	58	_	_	_
	1345	37	36	73	29	28	57	_	_	_
	1400	37	37	74	28	21	49	_	_	_
	1415	26	50	76	15	33	48	_	_	_
	1430	32	44	76	23	27	50	_	_	_
	1445	34	48	82	20	27	47	_	_	_
	1500	41	39	80	29	29	58	_	_	_
	1515	64	32	96	34	24	58	_	_	_
	1530	54	35	89	27	26	53	_	_	_
23 July	On east of ledge									
	1545	_	_	14	_	_	30	_	_	_
27 July	Normal observation point									
	1116	19	31	50	44	21	65	_	_	_
28 July	Normal observation point									
	1215	18	44	62	22	18	40	5 (1)	2 (7) [4]	_
28 July	On east of ledge									
	1230	3	3	6	12	6	18	_	_	_
28 July	Normal observation point									
	1245	15	42	57	16	22	38	7 (1)	9 (7)	_
	1300	18	42	60	22	16	38	6 (1)	8 (7)	_
	1315	26	46	72	17	17	34	5 (1)	8 (7)	_
	1330	29	44	73	23	20	43	9 (1)	9 (7)	_
28 July	On east of ledge									
	1335	0	4	4	16	9	25	_	_	_
28 July	Normal observation point									
	1345	29	40	69	16	21	37	11 (1)	10 (7)	_
	1400	30	44	74	16	25	41	8 (1)	12 (7)	
	1415	29	46	75	20	20	40	10 (1)	10 (7)	_
	1430	26	41	67	27	17	44	11 (1)	11 (7)	_
28 July	On east of ledge									
	1433	1	4	5	18	12	30	_	_	_
28 July	Normal observation point									
	1445	21	45	66	22	19	41	10 (1)	10 (7)	_
	1500	20	45	65	22	22	44	6	9	_
	1515	20	41	61	19	20	39	7	10	_
	1530	16	44	60	19	22	41	6	10	_

Table continued on next page

Table 13 continued.

Date	Time	TM stn	TM sit	TM total	CM stn	CM sit	CM total	RK	BK	F
28 July	On east of ledge									
	1532	1	4	5	23	9	32	—	—	—
28 July	Normal observation point									
	1545	16	39	55	24	19	43	5	9	—
	1600	16	43	59	21	19	40	4	10	—
	1615	13	20	33	22	20	42	5	11	—
29 July	Normal observation pcint									
	1630	19	38	57	18	15	33	—	—	—
30 July	Normal observation point									
	1100	31	41	72	24	26	50			
				+15 flushed			+39 flushed	3	8 (4) [3]	—
	1115	39	38	77	18	31	49	4	8	—
	1130	50	36	86	51	25	76	5	10	—
	1145	42	42	84	154	23	177	3 (1) [1]	(4) [3]	—
	1154	—	—	—	—	—	107 flew off		—	—
31 July	Normal observation point									
	1430	41	43	84	47	29	76	4 (0)	5 (4)	—
	1445	44	43	87	39	34	73	3 (0)	8 (4) [3]	—
	1500	38	49	87	52	27	79	1	5 (4)	—
	1515	47	48	95	50	26	76	5	5	—
	1530	45	45	90	51	34	85	5	3	—
	1545	49	38	87	55	34	89	3	4	—
	1600	51	38	89	46	37	83	3	4	—
31 July	On east ledge									
	1610	7	6	13	27	7	34	—	—	—
4 August	Normal observation point									
	1015	32	28	60	38	22	60	6	4	8
	1030	20	40	60	27	27	54	4	5	8
	1045	25	39	64	28	27	55	6	5	7
	1100	22	40	62	31	26	57	3	4	7
	1115	32	36	68	29	30	59	3	5	6
4 August	On east of ledge									
	1125	1	6	7	26	12	38	—	—	—
5 August	Normal observation point									
	1015	31	39	70 [6]	39	26	65 [7]	4	4	
	1030	33	35	68 [11]	37	22	59 [9]	3	4	7
	1045	33	39	72 [12]	34	24	58 [7]	3	4	5
	1100	31	42	73 [16]	38	25	63 [12]	5	5	—
	1115	36	39	75 [13]	31	28	59 [11]	—	—	—
5 August	On east of ledge									
	1125	4	4	8 [2]	49	5	54 [2]	—	—	—

Table continued on next page

Table 13 continued.

Date	Time	TM stn	TM sit	TM total	CM stn	CM sit	CM total	RK	BK	F
7 August	Viewing from beach below									
	1430	176	96	272 [11]c/	177	32	509	—	—	—
8 August	Normal observation point									
	0530	41	35	76 [5]	29	24	53 [3]	—	4	5
	0545	43	35	78 [4]	38	25	63 [1]	—	—	—
	0600	44	33	77 [4]	57	28	85 [1]	—	—	—
	0615	48	27	75 [5]	97	25	122 [2]	—	—	—
	0630	46	36	82 [4]	97	23	120 [2]	—	—	—
	0645	45	35	80 [4]	90	22	112 [2]	—	—	—
	0700	54	33	87 [5]	97	17	114 [2]	—	—	—
	0715	49	30	79 [4]	98	20	118 [4]	—	—	—
	0730	51	39	90 [7]	104	16	120 [4]	—	—	3
	0745	53	39	92 [9]	83	21	104 [3]	—	—	4
	0800	52	36	88 [3]	76	28	104 [3]	—	—	—
	0815	46	38	84 [3]	94	18	112 [0]	1	5	—
	0830	47	39	86 [3]	76	20	96	1	3	3
8 August	On east of ledge									
	0840	6	2	8 [0]	31	7	38 [0]	—	—	—

a/ 58 loitering on lower edge

b/ loiterers leave

c/ large numbers of loiterers present on lower edge

Station No. LAF75

Table 14. Flight Count--Least Auklets Flying Over Airstrip To Colony on Ulakaia Ridge July 1

Time	Flight Count		Percent
Start-0519	9		
0519-0556	379		
0556-0612	650		
0612-0700	2,628		
0700-0733	3,890		
0733-0800	4,750		
0800-0830	7,700		
0830-0905	10,200		
0905-0930	6,950		
0930-1003	7,200		
1003-1030	7,300		
1030-1100	5,100[a/]		
1100-1130	11,900		
1130-1200	8,100		
1200-1230	6,495		
1230-1300	12,285		
1300-1330	10,500		
1330-1400	9,140		
1400-1430	8,330		
1430-1500	5,830		
1500-1530	3,460		
1530-1600	2,125		
1600-1630	1,025		
1630-1700	586		
1700-1730	91		
1730-1800	8		
		136,631	63.2
1800-1830	66		
1830-1900	230		
1900-1930	770		
1930-2000	1,550		
2000-2030	8,550		
2030-2100	16,460		
2100-2130	24,180		
2130-2200	18,530		
2200-2230	8,820		
2230-2300	475		
2300-2330	--		
2330-2400	--		
		79,631	36.8
		216,262	100.0

a/ Involves a slight estimate for some minutes in which the observer was absent.

Station No. LAF75

Table 15

Flight Counts: Comparison of Evening Flights of Least Auklets over airstrip on 22 June and 17 July from 2040 to 2200 hours.

Time	Totals 22 June	Totals 17 July
2040-2050	15,410 (2040-2110)	8,110 (2040-2100)
2050-2100		
2100-2110		5,930
2110-2120	5,740	7,470
2120-2130	6,150	6,260
2130-2140	4,260	3,560
2140-2150	4,430	1,350
2150-2200	2,367	450
TOTALS	38,357	33,130

Station No. MNF75

Table 16.

Flight Counts: Murre Flights on North Side of St. George, as observed from Staraya Artil

Two observers with spotting scopes, counting in 10's unless otherwise noted.

	E to W					W to E				
Date	time	above horizon	below horizon	sum	count/min	time	above horizon	below horizon	sum	count/min
25 June	1655-1705	8,440	3,440	11,880	1,188	1710-20	220	1,980	2,200	220
	1730-40	6,700	8,900	15,600	1,560	1747-57	510	1,650	2,160	216
	1820-30	3,480	5,920	9,400	940	1820-30	data collected		682	68
	1840-50	6,950	5,320	12,270	1,227	40-50	by only 1 obser-		481	48
	1900-10	2,950	5,790	8,740	874	1900-10		ver	616	62
Total and mean				57,890	1,158					
30 June	1510-15	630	5,060	5,690	1,138	1520-21	2	430	432	432
wind 3-4	1522-27	580	4,750	5,330	1,066	1530-31	1	490	491	491
kt from						1542-43	10	350	360	360
SSW	1545-50	1,360	4,050	5,410	1,082	1550-51	20	440	460	460
vis. good	1553-58	720	4,410	5,130	1,026	1602-03	3	470	473	473
T 11°C	1605-10	160	4,610	4,770	954	1612-14	14	560	574	287
	1620-25	520	4,580	5,100	1,020	1622-23	6	300	306	306
	1630-35	610	4,140	4,750	950					
	1645-50	120	3,920	4,040	808					
Total and mean				40,220	1,005					
1 July						519-22	3,570	4400	7,970	2,657
	536-41	630	550	1,180	236	522-	by 10's	------	5,780	1,156
fog						27	by 25's	------	8,340	1,668
vis. 300 m.						546-47			3,000	3,000
effective:						652-	by 100's		15,600	3,900 a/
flying low						56			13,600	3,400 a/

Table continued on next page

Table 16 (cont.)

Date	E to W				
	time			sum	count/min
July 7	1015-25			9,900	990
	25-35			9,300	930
	35-45			8,800	880
	45-55			10,700	1,070
	1055-1105			7,700	770
	1105-15			8,200	820
	15-25			7,700	770
	25-35			6,600	660
Total and Mean				68,900	861

a/ consideréa to be best estimate by observers.

Station No. MNF75

Table 17

Flight Counts: Diurnal East-to-West Flight of Murres
on North Side of St. George Island in Early July
(Birds counted with 10-power, Zeiss binoculars
in units (flocks) of 80 every other 10 minutes.)

Hours	Date	No. of Flocks counted in 3 x 10-minutes	Flocks x 80	x 2 = Total Each Hour
5-6	4 July	8	640	1,280
6-7	"	76	6,080	12,160
7-8	"	83	6,640	13,280
8-9	"	255	20,400	40,800
9-10	3 July	372	29,760	59,520
10-11	"	380	30,400	60,800
11-12	"	680	54,400	108,800
12-13	"	301	24,080	48,160
13-14	"	223	17,840	35,680
14-15	"	79	6,320	12,640
15-16	6 July	99	7,920	15,840
16-17	"	58	4,640	9,280
17-18	"	17	1,360	2,720
18-19	"	44	3,520	7,040
19-20	"	-- a/	4,520	9,040
20-21	"	-- a/	3,860	7,720
21-22	"	12	960	1,920
Totals			223,340	446,680

a/ From 1950 hr. to 2050, birds were counted by another observer using a different method.

VII. DISCUSSION

Aerial Surveys of Ledge-nesting Species.--St. George during the summer period is more or less regularly serviced by Peninsula Airways by means of flights chartered by the National Marine Fisheries Service 2-3 times per month. The plane, a twin-engined Navaho, flies out of King Salmon almost exactly 500 miles (800 km) due East. In our brief experience, the plane was often late by at least a day (once, 4 days), and its arrival on St. George once was effected under conditions that could only be termed by we laymen as "hairy." The weather factor here is fog, and on St. George it can facetiously be said that the weather seemed to change every 2 hours on the hour. Fogs proved to be local. One part of the island at this time of the year would be fog-bound, the others clear; or the others fog-bound, and this one clear. We repeatedly set out on long hikes only to be frustrated by a developing fogbank that came in just before or just after we arrived. During the course of our 54 days on St. George, there appeared to be 6 days in which the island was seemingly free of fog; but on some of these 6 days we did not actually check the entire island for this condition.

Of course, there are no U.S. weather stations to the east of St. George, and there was no way that one could predict when a survey plane might find the cliffs reasonably free of fog--after the plane had flown something like 800 km from a place like King Salmon. We therefore came to conclude that aerial photographic surveys of ledge-nesting species on St. George will be extremely difficult to carry out, and it was no surprise to us that the U.S. Fish and Wildlife Service flight on 1 August encountered fog on the higher cliffs.

Bartonek (pers. comm.) has expressed to us his deep disappointment in the photos that FWS secured on this date. On two of our Reference Ledges (Station Numbers FBA75 and FBB75 at First Bluff), we can discern in the FWS photos on 1 August (under a 23-power binocular microscope) 34 and 9 birds respectively. On 6 August we counted the following on these areas:

	FBA75	FBB75
Time . .	1538-1544	1530-1538
Red-legged kittiwakes	54	66
Black-legged "	-	17
Thick-billed murres	239	82
Other species (3)	7	-
Total . . .	300	165

This difference occurs on one of the better FWS photographs.

Boat Photography.--On 14-16 January 1976 we reviewed the FWS photos with Dr. David N. Nettleship (Canadian Wildlife Service at Ottawa), discussed our photographic problems with him, went over CWS methods of analyzing aerial photos (see also below), and decided to have our own boat available for quick use of good weather in photographing ledge-nesting birds. (No national Marine Fisheries Service boats with motors were available to us in 1975, and the Aleuts' private boats were only occasionally available. We had actually contracted to use one such boat on a fine-weather day but lost out because the whole village decided to go fishing!) In early March 1976 we therefore shipped on the Pribilof, the Aleut vessel servicing the islands, a 13-foot Avon rubber raft equipped with a 25-HP Evinrude motor. This will permit us to have much flexibility in photographing at least the lower cliffs, but we may not be able to do a good job of photographing all the higher ledges on the highest cliffs.

Analysis of Photographs.--The errors inherent in census counts based on photographs of gulls have been reviewed by Kadlec and Drury (1968) and by Drury (1973) and for alcids by Nettleship (1975). Our conference in Ottawa yielded the following information:

CWS has found Hasselblad photos to be "not good" and has settled on Pentax 6 by 7 cm in photographing murre cliffs at 600-900 ft. with a 100-mm lens and trying to fill the cliff in each frame. Higher cliffs have to be photographed at a greater distance.

The CWS blows its photograph prints to 28 by 36 cm [about 10 1/2 by 15 inches] on glossy paper (for resolution and storage) and counts each carefully with the aid of gridded plastic overlays. The time involved varied from about 1,500 to 3,000 birds or nests per day in examples that we studied. Specific counting statistics provided us by Nettleship and his photo interpreter, Mike Channing, follow:

Great Island	23,229 nests	about 3 weeks to count
Degges Sound	89,647 murres	about 1 1/2 months

It is worth adding that the photo interpreter involved here is an experienced technician with a great deal of patience.

The Service assumes that 1 bird = 1 pair. It attempts to photograph murres before the nonbreeders come in. This ordinarily is late June but was early July on Funk Island. What it tries to do is standardize date and time of day--preferably in the second half of the incubation period.

It is obvious that the censusing of ledge-nesters on St. George by means of photographs can only be done, under CWS methodology, on a stratified sampling basis: it will be impractical to try and count say 400,000 murres on say 50 km of cliffs.

It is at least possible that the birds photographed on these cliffs could be counted mechanically by a particle-counter which is used in hematological labs. Dr. Don H. Anderson, director of the Industrial Laboratory of Eastman Kodak Company, Rochester, has found (pers. comm.) that a Quantimat counter is easily able to enumerate blackbirds (on the order of 3-5 thousand in a single picture) photographed against the sky as they approached a night-time roost. We are currently exploring the practicality of such a technique for the analysis of our St. George photos. The machine presumably will not distinguish between a bird on a ledge and one in the air; and it may not be able to distinguish between birds and rocks that have been whitened by fecal droppings. Nettleship (pers. comm.) feels that the variance in Alcid ledge numbers in Eastern Arctic colonies requires him to count 65 percent of the total number of ledges. This figure is clearly impossible to attain on St. George; its need would presumably be reduced by stratification. Mechanical counting impresses us as a practical necessity. Even with the limitations already envisioned (and there must be others), it would appear to have considerable utility as an order-of-magnitude estimate of the present population and as a year-to-year population index.

Flight Observations.--In personally discussing their St. George fieldwork with us last December, I. R. Gabrielson and M. C. Thompson (pers. comm.) maintained that the least auklet was the most abundant species on the island at the time of their visits (3 July 1940 and 3 other days on a later visit--IRG; 1964-68--MCT). This was not our impression in 1975, when murres were more numerous; we did not see Gabrielson's "swarming millions" (Gabrielson and Lincoln 1959:506). In the flight of least auklets over the village on 3 July, Gabrielson saw "many cresteds." In our all-day count on 1 July 35 years later we saw not more than 200. Thompson's impressions of the least auklet flight back up Gabrielson's, and we feel it probable that a significant decrease in this species took place on St. George sometime in the last 10 years. Aleut people who have for many years witnessed the auklet spectacle on this island all seem to agree that some diminution in numbers has taken place, but they place it earlier after the road was put through near the edge of the Ulakaia Ridge. This would be about 1950; but the Aleuts are not talking about a great reduction which we feel has taken place. There is at least some possibility that a pronounced change in auklet breeders could have taken place in 1975 as a result of the usually late snowfields to persist on Ulakaia Ridge. This will of course be watched for in 1976.

The least auklet flight into Ulakaia Ridge on 1 July dropped to a scant 8 birds between 1730 hr and 1800 (Table 14). We initially hypothesized that the 79,631 that then came in were females preparing to take over their nests for the night. If one is willing to accept an even sex ratio in the breeding population, it then follows that the morning flight consisted of 79,631 males and the remaining 57,000 birds (27 percent of those counted on 1 July) were nonbreeders. This 27 percent may be compared to the 30-35% that Bédard (1969) estimated as nonbreeders in the least auklet population on St. Lawrence Island. We did not attempt to test this hypothesis on St. George until 30 July when we collected 10 least auklets flying in from the sea between 2030 and 2130 hr. The sex ratio (Table 18) on this occasion was 5:5. We lack a good flight count for this late date in the season, and at present we regard the hypothesis as not yet adequately tested. George and Molly Hunt report (personal communication) that, in collecting least auklets on St. Paul this summer for their food-habits study, they found no evidence of a difference in sexual behavior such as we initially hypothesized. If the 79,600 evening fliers on 1 July were all and the only birds that would be incubating that night, it might still follow that 27 percent of the birds seen on 1 July were nonbreeders.

Flight counts do vary somewhat as the season progresses. For the period 2100-2200 hr, we counted 29,380 least auklets flying into Ulakaia Ridge on 22 June; on 1 July this number was 42,710.

Table 18

Least Auklets Collected

30 July 1975; 2030-2130 hr.; on St. George Island

#1	♂	Left testis 0.4 cm x 0.2 cm right testis not found food sample taken - skin saved
#2	♀	largest ova 1.5 mm burst follicle found food sample taken - skin saved
#3	♂	left testis 0.5 cm x 0.3 cm right testis 0.5 cm x 0.2 cm food sample taken - skin saved
#4	♀	largest ova 0.1 cm has collapsed follicle food sample taken - skin saved
#5	♂	left testis 0.8 cm x 0.3 cm food sample collected; rt. testis not found skin discarded since badly damaged
#6 92 g	♂	left & right testes both 0.4 x 0.2 cm food sample collected, skin saved
#7 87 g	♀	ova to 0.05 cm food sample collected, skin saved
#8 94 g	♀	ova to 0.05 cm skin saved, food sample collected
#9 87 g	♀	ova to 0.05 cm skin saved, food sample collected
#10 90 g	♂	left testis 0.5 x 0.2 cm, right testis 0.4 x 0.2 cm. skin saved, food sample collected.

The east-to-west flight of murres of the north shore of St. George was an impressive ornithological sight in 1976. Using spotting scopes, for 5 to 10-minute counts scattered over about 4 late afternoon hours on 25 and 30 June, we estimated this flight to involve about 1,000 birds per minute. This ran to about 900 per minute in a morning count on 7 July (Table 16). When a single observer "counted" these flocks with a 10-power binocular on 3-6 July (Table 17), there was good agreement between the morning counts (1000 vs. 900 per minute) but not at all for the afternoon counts (200 vs. 1000 per minute). We hope to make more direct comparisons of these two techniques in 1976.

We did carry out comparative side-by-side counts or estimates of least auklets on our full-day count of the flight going into Ulakaia Ridge on 1 July. These were independent estimates by J. J. Hickey and R. C. Squibb. Their estimates were invariably less than 10 percent apart, and no bias on the part of one man was evident. Auklet counting at this site is quite comparable to counting starlings as they fly into a roost.

Reference Areas.--In the field we delineated our reference cliffs and reference ledges by taking Polaroid pictures in color or black and white. These were immediately pasted into field note books against the need to replicate counts in subsequent days. It would have been preferable to have taken a duplicate set of these pictures for use in the present report. Conventional 2 x 2 pictures taken of the reference areas have not been entirely satisfactory, and efforts will be made this summer to remedy this situation.

Ledge Attendance.--It is now well-known that a diurnal rhythm in the ledge attendance of murres does take place (Tuck, 1960:120; Swartz, 1966:659), although no such rhythm was evident to Uspenski (1956) at Novaya Zemlya nor to Pennycuick (1956) at Spitzbergen.

Our ledge counts (Tables 10-13) were made for trial time periods of varying length whenever our work schedule and the weather permitted. Because of the patchy nature of these observations, confidence intervals can not be calculated and the counts can only be considered as a rough estimate. Preliminary analysis of these counts reveals a general trend during incubation: the lowest numbers of birds are present on the cliffs in the evening just before dark (presumably equals over night) and in the morning before it is light enough to make an accurate count; and the highest numbers are present in the afternoon, around 1630 hours. This is best seen in our most numerous set of counts--for Murie Cove, where we made 94 counts spread over 8-days from 10 to 31 July (Table 10). The behavior is illustrated in Figure 5. It appears that only those birds with very high motivation for breeding (i.e., those properly classified as breeding birds) are spending the night on land. Evening ledge counts may be valuable in correlating ledge counts with numbers of breeding pairs. This phenomenon is further discussed under Direct Counts (below).

Figure 5. Ledge attendance of thick-billed murres at Murie Cove Study Area (Station No. MCL75) 14 July-31 July. Each dot indicates one datum point. (First thick-billed murre chick seen August 2.)

We are considering doing systematic counts in the coming season at 1/2-hour intervals for one full day at regular intervals at each of the study ledges we will set up. This of course will be modified somewhat by weather conditions.

Direct Counts.--In 1975, we succeeded in counting from the beach a total of 6.67 km of the lower cliffs, most of them in Stratum A (Table 19). With more than half of this stratum thus censused, it would appear that the 10.6 km of this lowest stratum carried about 40,000 birds . . . and that the numbers present on the higher cliffs will in turn be much higher. These higher strata

Table 19. Effect of Cliff Height on the Numbers of Birds Present

Approx. Cliff Height (m)	Station No. (Table 2)	Length Cliff Counted (km)	No. of Counts[a]	Mean No. of Birds	Mean No. of Pairs[b]	Birds per 100 m	Table Ref.
Stratum A							
12.2	VWC75	1.2	2	2,763	2,173	230.3	5
12.2	VEC75	1.07	2	2,297	2,023	214.7	6
ca 18	ZBC75	0.55	3	1,613	1,530	293.3	7
24.4	ZMR75	2.92	1	14,858	14,349	508.8	8
Totals		5.74	8	21,531	20,075		
Stratum mean						375.1[c]	
Stratum B							
24.4-61	PPC75	0.47	2	1,852	1,576	394.0	9
Stratum C							
61	3BC75	0.46	1	5,286	4,861	1,149.1	9

a/ Where 2 counts were available, the numbers were averaged. Where 3 or more counts were available, the 2nd-, 3rd-, and 4-th highest counts for each species were averaged, the mean total of these was used to arrive at the mean numbers shown in the table.

b/ For "Pairs" here we substituted the actual number of nests or started nests for the numbers counted for kittwakes and cormorants.

c/ Weighted according to the length of cliff censused.

must be sampled by boat and aerial photography; they have little in the way of beaches at their bases, and the cliff-nesting birds there cannot be fully counted from the cliff tops.

The variables affecting this estimate appear to result, at least importantly, from differences in the number of nonbreeding birds present (1) throughout the day, as one might suspect from Figure 5, and (2) throughout the season, as one can infer from the work of Swartz (1964) at Cape Thompson on murres. Our census work on Stratum A was equally divided between morning and afternoon hours (Table 20). Morning counts on the whole were 24 percent lower than afternoon counts. Of this 24 percent, half was due to a difference in thick-billed murre counts, one-quarter was due to least auklet counts, and the remaining one-quarter was spread over the other nine species. The afternoon least auklet counts invariably included flocks of obvious nonbreeders on the beach or talus slopes. We believe that the difference of 25.8 birds between A.M. and P.M. birds of this species was produced by this segment of the population. If 44.6 least auklets in Table 20 are a reasonable index of the incubating half of the breeding population, the total population is represented by 44.6 + 44.6 + 25.8 = 115. This would mean that the nonbreeders were 22 percent of the population. This compares to an inferred 27 percent in the flight at Ulakaia Ridge and Bédard's (1969) estimate of 30-35 percent on St. Lawrence Island.

The major difference between A.M. and P.M. counts for a single species appears in the common murre. We interpret at least part of this to be due to an inadvertent increase in flat ledges in the higher cliffs of Zapadni Bay that we could reach only in the latter part of our field trips. Counting these higher cliffs in the afternoon (Station No. ZPC75) has probably biased our afternoon totals somewhat also. There were more birds per meter here than anywhere else in this stratum.

At Cape Hay, Tuck (1960:119) found the murre population to be increased about 10 percent by nonbreeders that appeared after 1 August. On the basis of extensive collecting during the incubation and early nestling period. Swartz (1966) did not consider nonbreeding murres to represent any significant fraction of the population at Cape Thompson. His diurnal cycle, obtained 30 August to 1 September involved a maximum of 250 birds on his study ledges. Our curve (Figure 5) compiled from data obtained on 14-31 July closely follows that of Swartz. This is a bit surprising since (1) Tuck (1960:120) found different rhythms for different parts of the nesting cycle, (2) Swartz's rhythm data in 1959 were obtained late in the nestling period, and (3) our curve holds only for the latter half of incubation. Swartz corrected all his ledge counts and census data to 100 percent of his afternoon maximum.

We have extrapolated the Table 20 data to 10.6 km for Stratum A in Table 21. The use of all our afternoon data instead of a correction factor based on the peak at 1630 hr gives a somewhat somewhat more conservative estimate than Swartz's approach, being 12.8 percent lower.

Table 20. Effect of Time of Day on Census Totals for Lowest Cliffs (Stratum A)[a]

Species	Mean no. birds (and nests) counted per 100 m		AM as Percent of PM
Time counted	0845--1200	1200--1630	
Total hours counted	8 hr 44 min	8 hr 43 min	
Thick-billed murre	185.6	234.8	79
Common murre	9.8	17.3	57
Red-legged kittiwake	12.7 (4.7)	19.1 (4.6)	66
Black-legged kittiwake	24.3 (15.3)	26.7 (15.2)	91
Fulmar	8.6	9.8	88
Horned puffin	4.7	4.8	98
Tufted puffin	0.3	0.4	75
Parakeet auklet	15.7	20.8	75
Crested auklet	0.4	0.6	67
Least auklet	44.6	70.4	63
Red-faced cormorant	0.8 (0.3)	0.9 (0.5)	89
Total birds per 100 m	307.5	405.6	76

[a] Counts of zero birds are included in the means shown.

Table 21. Estimated Breeding Population (Pairs) in Stratum A Cliffs[a]

Ledge nesters	
Thick-billed murre	25,000
Black-legged kittiwake	2,800
Red-legged kittiwake	2,000
Common murre	1,800
Fulmar	1,000
Red-faced cormorant	100
Hole nesters	
Least auklet	4,700
Parakeet auklet	2,200
Horned puffin	500
Crested auklet	60
Tufted puffin	40
Total	40,000 (40,200)

[a] Extrapolations to 10.6 km from AM figure for least auklet and from PM statistics for all other species in Table 20.

VIII. CONCLUSIONS

1. In 1975, the seabird numbers on St. George were considerably down from the "millions" reported in the past.

2. The cause of this change is not yet clear; some disturbance of the main least auklet colony may have taken place. Some instability induced by persisting snowbanks in 1975 also seems to have occurred.

3. The main least auklet colony held over 200,000 birds, of which as many as 27 percent may have been nonbreeders.

4. The lower cliffs on the island, extending for 10.6 km, held approximately 40,000 breeding pairs of 11 species. Higher densities undoubtedly occur on the 37.5 km of high cliffs, the highest of which held at least 400,000 murres on the north side of the island.

5. On the lower cliffs, the commonest species were thick-billed murres, least auklets, black-legged kittiwakes, parakeet auklets, red-legged kittiwakes, common murres, and fulmars in that order. Horned puffins, red-faced cormorants, crested auklets, and tufted puffins were also present in much reduced numbers.

6. Pelagic cormorants, formerly found on this island, were completely absent in the summer of 1975.

7. St. George now appears to be the main stronghold of red-legged kittiwakes in North America. (Their only other known nesting grounds, outside the Pribilofs, are in the Komandorskie Islands). If any species of seabird can be seriously threatened by petroleum exploration in the Bering Sea, it will be this one.

8. Conventional census-photography by aircraft on St. George is extremely difficult to carry out due to fog; boat photography of ledge-nesting birds will have to be substituted.

9. If conventional photograph-analysis is used, it would take an experienced technician 26-52 weeks to count 400,000 murres. This time can be reduced by stratified sampling. It will in turn be increased by the need to count other species. The search for a mechanical counting technique should be pushed.

10. The major threats to these seabird populations posed by petroleum exploration will be (a) disturbance of the ledge-nesting species by people or aircraft if St. George is ever used as a local or regional base of operations for petroleum drilling and (b) potential spillage at or near the birds' main (but not their only) feeding areas 13.7 km (less than 8 nautical miles) NE of the island at 56°37'30" N and 160°11' W. This is about 2-5 fathoms deep and involves about 1 km by 500 m.

IX. NEEDS FOR FURTHER STUDY

Most of our needs for 1976 have already been alluded to:

(1) We will need to take advantage of good weather, whenever we get it, to photograph ledge-nesting species. We expect to use a boat to do this.

(2) We need to jack up our ledge-attendance statistics for other species besides murres and for different parts of the birds' nesting cycles in which we will be photographing the cliffs.

(3) We will need to lay out the quadrat system on Ulakaia Ridge in order to get some confidence limits in estimating the main nesting population of least auklets. We will explore the possibility of revising our budget so as to put one man full time on this subprotect.

(4) We will have to run down the possible use of a mechanical counter for cliff photographs.

(5) We are considering the use of a miniature radio telemetry system to monitor the flight of least auklets and determine how often breeding birds approach and leave the colony.

(6) We need some new understanding from NOAA about how long it takes to write up a final report. If our field work runs well into August, we are appalled at an "absolutely firm" deadline for a final report on 1 October.

(7) A cooperative effort with Dr. George Hunt and his team on St. Paul is being worked out whereby (1) we will monitor kittiwake nests at two study areas on St. George and collect growth and reproductive data. (Molly Hunt will spend a month on St. George from mid-August until fledging in mid-September) and (2) they will photograph and census the cliffs of St. Paul and other Islands in the course of their work there. Plane schedules permitting, we will try to join them on some of this.

X. SUMMARY OF 4TH-QUARTER ACTIVITIES

(1) Field Trip Schedule

11-12-75 to 12-12-75
Pacific Seabird Group Meeting in Asilomar, California. Conference with NOAA personnel on research problems and data management.

14-01-76 to 16-01-76
Meeting with Dr. David N. Nettleship and Canadian Wildlife Service staff in Ottawa, Canada, to discuss and examine CWS techniques for censusing seabirds by means of aerial photography.

(2) Scientific Party
Dr. Joseph J. Hickey, Professor of Wildlife Ecology, University of Wisconsin, P. I.
F. Lance Craighead, Research Assistant, University of Wisconsin

(3) Methods
We received 306 aerial photographs of the cliffs of St. George Island from Dr. James C. Bartonek of the U. S. Fish and Wildlife Service. These were taken on 1 August 1975, from an FWS P2V. We examined these photographs and then conferred with Dr. David N. Nettleship who agreed that many of them were impossible to analyze for census information. It was concluded that much better-quality photographs could be taken by boat with a 6 X 7 cm Pentax as used by the Canadian Wildlife Service. This we have now secured.

We also conferred (by phone) with Dr. Don H. Anderson, director of the Industrial Laboratory of Eastman Kodak Company, Rochester, N. Y., relative to a mechanical counter for the birds we photograph on ledges. We are currently trying to find a Quantimat counter here in southern Wisconsin so that we can explore this further.

(4) Sample localities, etc.
None. A rubber boat and motor were shipped to St. George on the Pribilof early in March.

(5) Data analysis
Upon receipt of Data Management Formats 034 and 035, work was begun keypunching last summer's data for storage on magnetic tape. This should be completed by 1 April.

ANNUAL REPORT

Contract #
Research Unit #77
Reporting Period
7-1-75 to 4-1-76
Number of Pages 11

Ecosystem Dynamics - Birds and Marine Mammals

Co-Principal Investigator F. Favorite
Co-Principal Investigator W.B. McAlister
Northwest Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112

March 1976

ANNUAL REPORT

I. Summary of objectives, conclusions, and implications with respect to OCS oil and gas development

The long range objective is to develop an ecosystem model of the eastern Bering Sea, which will aid in multispecies and multidisciplinary decision making processes and specially depict the effects of man's activity (fishing, gas and oil developments, etc.) on the dynamic changes and balances in this marine ecosystem. A preliminary conceptual model is being developed for two dominant organisms within each of four major groups--plankton, fish, birds, and mammals--for which data on abundance are fairly complete. Specifically, these are icthyoplankton and macrozooplankton; herring and pollock; short-tailed shearwaters and murres; and bearded seals and fur seals. One of the purposes of this model is to ascertain the magnitude of food biomass required to keep the ecosystem in a equilibrium condition.

The formation of a useful ecosystem model for the eastern Bering Sea appears well within the present state of the art and preliminary results are extremely interesting. Of course, the degree of complexity to be achieved is a function of time, funds, and data required for verifications, but we envision that these studies will constitute a major scientific breakthrough in the understanding and prediction of interspecies interactions. Predicition of the effects of environmental changes will be done during next (1976/77) contractual period. A conceptual quantitative ecosystem model, with emphasis on trophodynamics and including limited interspecies interactions has been designed but not completely programmed and when fully developed, in continued studies, it will accomplish the following tasks:

(1) Serve as basis for directing further research on marine ecosystem (i.e. indicating gaps in existing knowledge and determining priorities of research to fill these gaps).

(2) Be the optimized system for condensing all essential knowledge on marine ecosystem (and resources) into numerical, easily accessible and reviewable form (including information on marine environment and effect of man).

(3) Provide a rapid evaluation of the effects of man (e.g. fishing) in any area and time on any living marine resource.

(4) Permit an effective evaluation of the effect of environment and interspecies interactions on any resource.

The prospective effects of OCS oil and gas development on marine mammals have not been fully quantitatively assessed, though some adverse effects could be expected (e.g. increased mortality of pups in case of oil spills; effects of drilling and ship traffic noise on repelling animals from their normal feeding and breeding grounds).

The extent to which some near-coast dwelling mammals might be subject to harm in case of oil spills can be much more quantitatively determined when the complete ecosystem model is completed.

Marine birds will be adversely affected by oil spills directly as well as indirectly by destruction of breeding grounds (e.g. new shore installations at or near known breeding grounds). However a comparative evaluation of "man made catastrophes" in relation to the effect on birds of natural catastrophes (e.g. heavy, long lasting storms; environmental anomalies affecting the availability of food etc.) can best be accomplished after the complete ecosystem model is available.

II. Introduction

A. General nature and scope of study.

The present project is a pioneering effort in dynamic marine ecosystem modeling. It encompassed five different research activities: (1) obtaining necessary data through field and laboratory work for input into trophodynamic type of upper trophic level ecosystem model (i.e. determination of food composition and its variability through stomach analyses); (2) obtaining pertinent quantitative data on the distribution of marine mammals and birds, their behavior and their food and feeding habits through literature search; (3) development of the concept and preliminary flow diagrams on a dynamic ecosystem model with emphasis on submodels as upper trophic levels; (4) programming and running of the initial submodel as feasibility study and for determination of requirements and priorities of future research, and (5) exploration of the reduction of quantitative and qualitative (descriptive) data into dynamic models for future easy access and utilization/manipulation.

B. Specific objectives

The first year introductory study of the dynamics of the upper levels of marine ecosystem (mammals and birds) was conducted as: (1) a feasibility study of designing and programming a complete dynamic ecosystem model which could be utilized for quantitative assessment of the effects of man's activities and interventions on the balance of marine ecosystem and the responses and internal readjustments within this system; (2) to determine the essential parameters and limiting and determining factors of the marine ecosystem; (3) to obtain the necessary input data for a conceptual dynamic ecosystem subroutine for plankton, fish, marine mammals and birds, and (4) to use this preliminary model for the determination of the utility of a dynamic ecosystem model and for direction of further research and research priorities.

C. Relevance to problem of petroleum development.

The research in the present project aims first at the determination of the initial state and behavior of a relatively undisturbed marine ecosystem as influenced by the forces of nature and by the past and present commercial fishery. The second use of the dynamic ecosystem model under the development is for an assessment of the possible effects of petroleum exploration and exploitation on the marine ecosystem and the quantitative comparison of the exploration/exploitation effects with the effects of natural causes, changes and fluctuations. And third, the ecosystem model under development would be easily adaptable to any coastal and continental shelf area of interest and concern.

III. Current state of knowledge

Although the marine mammals management and population control has been exercised for a number of years for eastern Bering Sea, the complete ecosystem approach has not been utilized in this activity in the past. The OCSEAP project has supported a total ecosystem approach and has thus aided the study of the seasonal behavior and feeding habits of the mammals, both through summary and synthesis of existing scattered information as well as new field studies. These studies have produced the food composition of different marine mammal species as well as their seasonal migrations, which often coincides with the optimum availability of food items.

One of the principal food items of marine mammals in Bering Sea is Alaska pollock, which is also subject of intensive fishery. The new concept of total quantitative ecosystem model has advanced the study of the throphodynamics of this species and has indicated needs for further information on behavior of pollock and of factors affecting its population size. The present studies have shown that more pollock is consumed by marine mammals than is caught by the commercial fishery.

As marine birds are not of commercial value, the available information on their abundance and behavior, as well as on factors affecting their abundance is scant indeed. The conceptual ecosystem model, developed within this project, will help the evaluation of many aspects of marine birds populations, specially as the latter have been affected in the past by well publicized accidental oil spills.

The full benefits of the present study can be reaped when the quantitative total ecosystem model in its numerical computerized form has been completed as a result of continued research associated with this project.

IV. Study area

The principal study area is eastern Bering Sea, though it is envisioned that the coastal areas around Alaskan Peninsula and Aleutian Islands must also be eventually considered, due to seasonal migrations of the mammals, birds and fish.

V. Sources, methods and rationale of data collection

No field studies conducted, data obtained from the literature and NMFS files.

VI. Results

The composition of food of marine mammals has been summarized and the feeding is being quantified in two aspects: (a) the total amounts of various food items consumed annually (computed as monthly means, for example see Fig. 1), and (b) the monthly consumption of pollock by fur seals as determined by quantitative distributions of fur seals as well as pollock (the latter inferred from monthly mean commercial catch statistics, for example see Fig. 2). Some of these results are summarized in a report to be presented at a marine mammal symposium in Bergen (Norway) in September 1976 (McAlister, W. B. and G.A. Sanger, NMFS, Preliminary Estimates of Pinnipeds - Finfish Relationship in the Bering Sea. MS).

The analysis of a limited number of stomach contents of pollock caught in the vicinity of the Pribilof Islands and Kodiak Island has been completed and the data summarized. The results show that the composition of pollock food changes materially with size (age) of the fish and also from area to area, apparently dependent on availability of various food items (see note on ecosystem model below). Rather surprising is the large percentage (>50) of unidentified digested content of pollock in the Pribilof area. Takahashi and Yamaguchi (1972)[1/] indicate that

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1/ Takahashi, T. and H. Yamaguchi (1972). Stock of the Alaska pollock in the eastern Bering Sea. Bull. Japan Soc. Sci. Fish., 38(4), 382-399, (in Japanese).

1

FUR SEAL

J	7,94	F	13,11	M	20,18	A	27,25	M	32,42	J	34,31
J	32,42	A	27,25	S	20,18	O	13,11	N	7,94	D	6,05

2

BEARDED SEAL

J	86,90	F	78,68	M	67,44	A	56,20	M	47,97	J	44,96
J	47,97	A	56,20	S	67,44	O	78,68	N	86,90	D	89,91

CONSUMPTION OF GADIDS

3

GAF

J	13,34	F	22,03	M	33,90	A	45,78	M	54,47	J	57,65
J	54,47	A	45,78	S	33,90	O	22,03	N	13,34	D	10,16

4

GA3

J	14,60	F	13,22	M	11,33	A	9,44	M	8,06	J	7,55
J	8,06	A	9,44	S	11,33	O	13,22	N	14,60	D	15,11

Fig. 1. Example outputs from a preliminary ecosystem model (from mammals subroutine). 1 and 2--monthly mean standing crops of biomass of fur seal and bearded seal, in kg/km^2. 3 and 4--monthly mean biomass of gadids (mainly pollock) consumed by fur seals and bearded seals respectively, in kg/km^2. (To obtain total monthly biomass of the above seal species and of total monthly amounts of gadid consumed by them in eastern Bering Sea, multiply the above numbers with 800,000.)

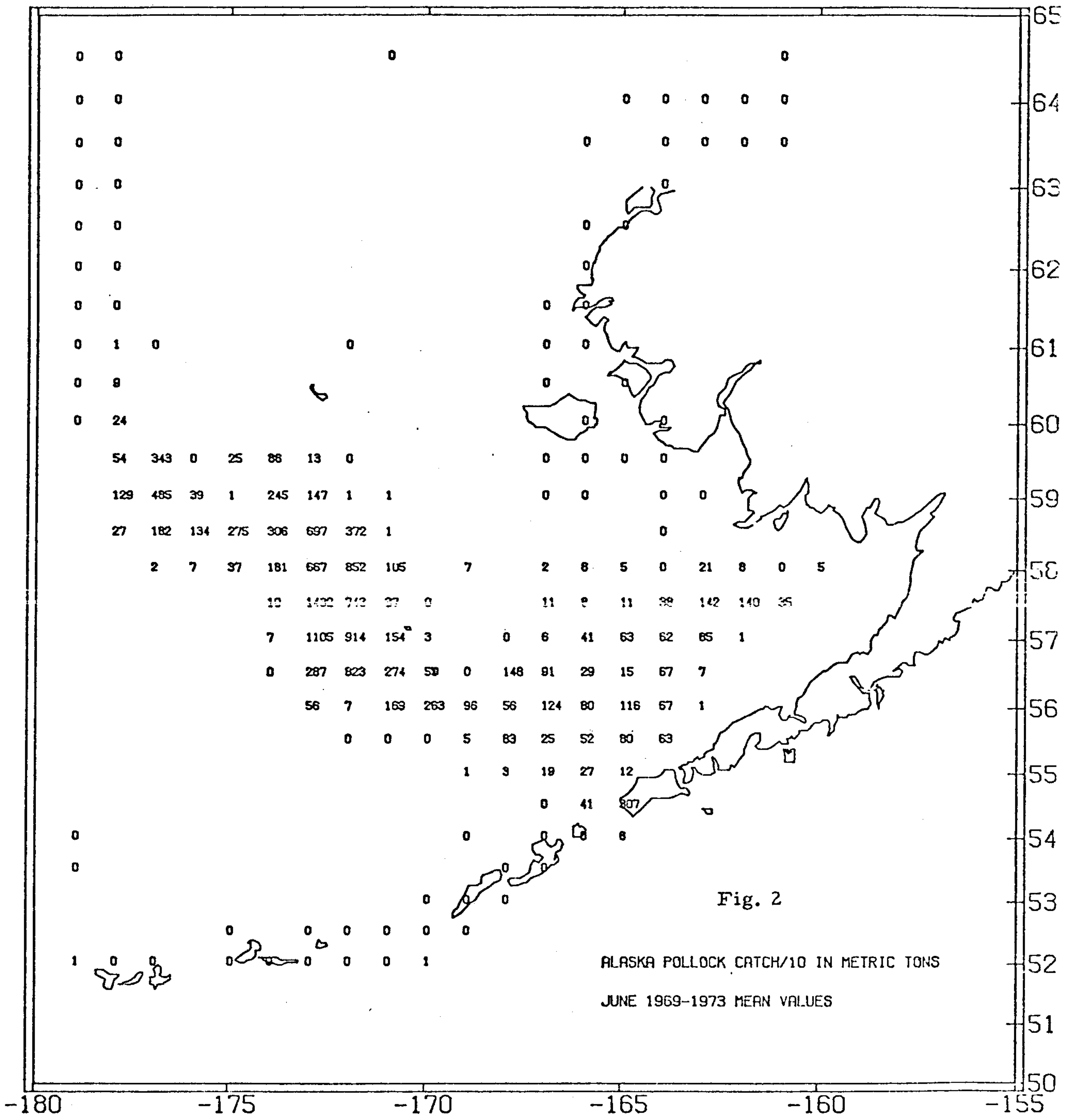

ALASKA POLLOCK CATCH/10 IN METRIC TONS
JUNE 1969-1973 MEAN VALUES
-180
-175
-170
-165
-160
-155
65
64
63
62
61
60
59
58
57
56
55
54
53
52
51
50

Fig. 2

much of this material is probably the result of cannibalism by larger pollock (ca 50% of stomach content consists of smaller pollock--Fig. 3). Near-bottom animals (shrimp, crabs, amphipods) comprise in general less than ten percent of pollock food.

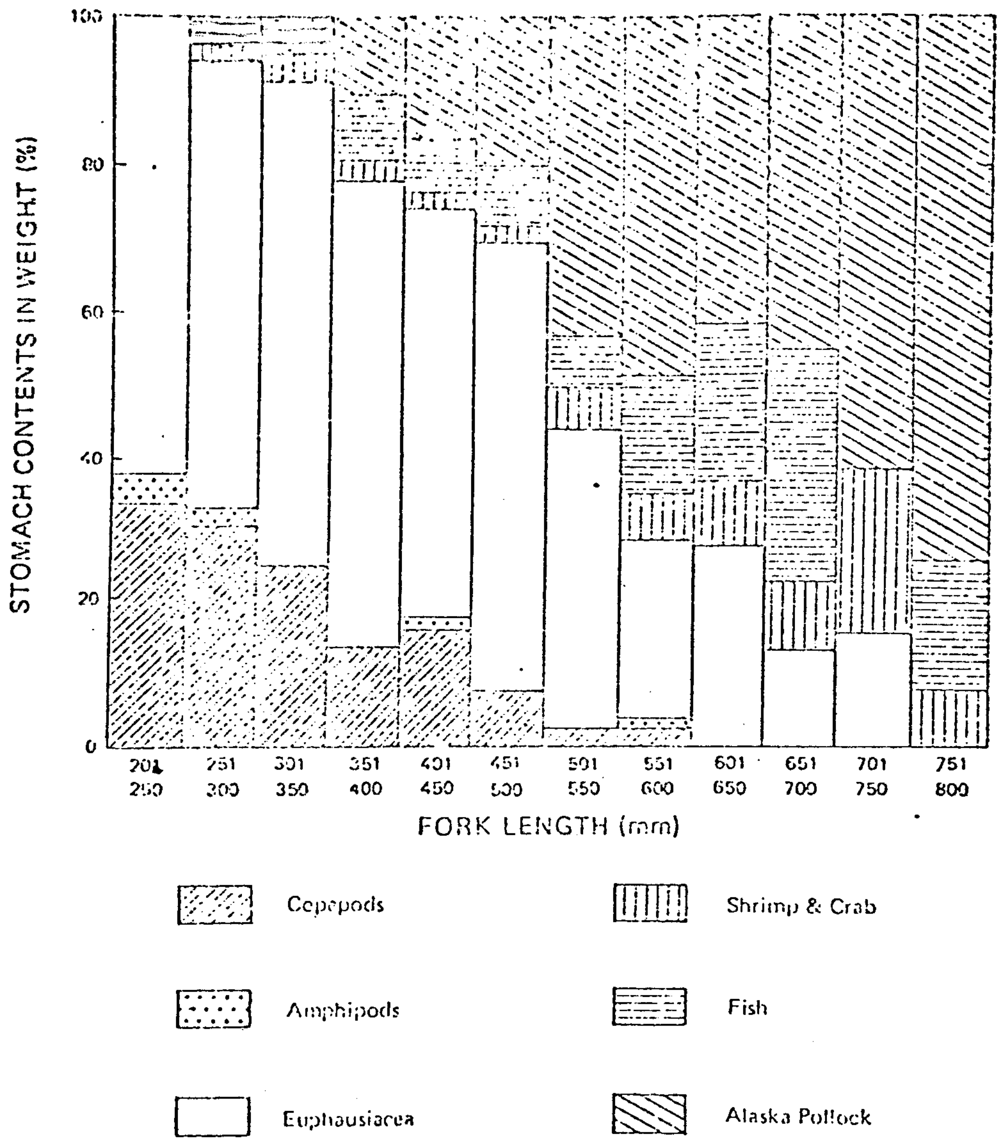


Figure 3. Relation between pollock growth (expressed as fork length) and feeding preferences (Takahashi and Yamaguchi, 1972).

Some knowledge on distribution, abundance and feeding habits of marine birds is available in a manuscript report (Straty, R.R. and R.E. Haight [NMFS), Interaction of Marine Birds and Commercial Fish in the Eastern Bering Sea MS). Another report on marine birds in the specified study area has been initiated by NWFC personnel and will be supplemented by studies conducted under contract to the Fish and Wildlife Service. As marine birds have no direct commercial value, the quantitative knowledge of them is scarce. Most of the marine birds in the eastern Bering Sea (shearwaters, puffins, fulmars and gulls) feed on pelagic fish, such as smaller herring, smelt and sand lance; squids and euphausids. One exception in food composition among birds are murres, who feed also on young salmon, pollock and cod. It is anticipated that severe, long-lasting storms have considerable effects on marine bird mortality in a multitude of ways. It is anticipated that these effects will be investigated next year under a continuing contract.

A submodel is being developed within this contractual period for two dominant organisms within each of selected four major ecological groups--plankton, fish, birds, and mammals, for which data on abundance are fairly available. Specifically these are: ichtyoplankton and macroplankton; herring and pollock; short-tailed shearwaters and murres; and bearded seals and fur seals. The purpose of this submodel is to ascertain the magnitude of additional biomass required to keep the ecosystem in a equilibrium condition.

VII. Discussion

The initial studies of the marine ecosystem dynamics under this contract have demonstrated the complex interactions and interdependence of various ecological groups, specifically the high competition for food. It has become clear that the effects of man's actions as well as the effects of natural environmental changes can be best understood, and in a form most useful for management decision when a complete quantitative interactive ecosystem model has been programmed. The preliminary conceptual model will be useful in itself to indicate the areas and subjects where further research is required.

VIII. Conclusions

(1) The monthly distribution of fur seal and its principal food item--pollock are closely related.

(2) The amounts of fish (pollock) consumed by marine mammals may exceed considerably the commercial catch of this species.

(3) The composition of pollock (and also mammals) food varies from area to area and season to season, apparently depending on the availability of food.

(4) The species composition of food for pollock changes materially with size (age) and area, and larger size groups conduct considerable cannibalism (ca 50%).

(5) Information on marine birds is relatively scarce. Several considerations indicate that severe long-lasting storms might effect the population sizes of several bird species.

(6) The preliminary dynamic ecosystem model indicates great utility in evaluating possible changes in this system caused by man, as well as pointing out where additional knowledge and research is required.

(7) Preliminary computations show that food (next lowest trophic level) is limiting factor for most population sizes.

IX. Need for further study

As indicated in conclusions above, a complete quantitative ecosystem model must be developed, programmed and verified. The study under present contract has shown the feasibility of this undertaking. A detailed proposal for continuation of this study in respect of the ecosystem development will be submitted at the appropriate time.

X. Summary of 4th quarter operations

(1) The necessary inputs for the submodel will be summarized and refined.

(2) The basis conceptual model is being programmed in FORTRAN.

(3) Preliminary draft description of the model has been prepared and modifications will occur as testing proceeds.

RU 77

APPENDIX

Ecosystem Dynamics--Birds and Marine Mammals

Progress Report on Submodel: Marine Mammals-Finfish

W. Bruce McAlister
M. Perez

March 1976

An important task of scientists associated with the Alaskan Outer Continental Shelf Environmental Assessment Program is to conduct research and analyze all known data to determine the structure and behavior of the Bering Sea ecosystem. This research is essential if we are to understand the impact on the environment of man's activities on the outer continental shelf. We now know very little about the dynamic behavior of this ecosystem, but we do have some information which helps to shed some light on the subject. Most of our information exists as individual population assessments, oceanographic analyses, and the results of food chain studies which have been undertaken by several research agencies. All of these independent studies should be integrated into a single unified concept describing interrelationships among marine organisms in the ecosystem.

For years, marine mammals have been hunted and populations reduced or eliminated to control assumed predation on commercial stocks of fish and shellfish. Yet actual mechanisms of the cause and effect relationship between pinnipeds and fish abundance remain largely unknown. Some information is available on direct relationships such as feeding, but the nature and extent of indirect relationships remain obscure. Many of the marine mammal species that occur in Alaskan waters are seasonal entrants whose range includes thousands of miles of coastal and pelagic waters of other nations. The commercial fishery off Alaska is both U.S. and foreign. Consequently, the status of marine mammals there is of concern and potential value to other nations. The Marine Mammal Protection Act of 1972 established a moratorium on the taking of marine mammals by all U.S. citizens except for certain Alaskan natives who may harvest certain species for subsistence, and for others who may take animals for display and scientific collection. The northern fur seal, a species regulated by international treaty with Canada, Japan, and the USSR, is harvested on land by the United States. All activities which will affect either marine mammals or their environment must be consistent with provisions of the Marine Mammal Protection Act, particularly with the requirement to maintain a healthy ecosystem. Major changes in mammal or fishery stocks will affect the several components of the ecosystem, but the magnitude, extent, and even direction of the effects of a particular management action are difficult to predict' in a complex ecosystem. In addition, impacts caused by environmental changes must be considered.

In order to improve our understanding of how fisheries and mammals interact in the Bering Sea, the Northwest Fisheries Center of the National Marine Fisheries Service has been examining some of the relationships between marine mammals and fisheries. Some of this research is being conducted as part of a study on the northern fur seal to fulfill obligations under the Interim Convention on the Conservation of North Pacific Fur Seals. In addition, research is being conducted on aspects of the ecosystem under the Alaskan Outer Continental Shelf Environmental Assessment Program. A detailed analysis of all eastern Bering Sea and eastern North Pacific pelagic data collected during research carried out on northern fur seals since 1958 on distribution, reproductive rates, and feeding has been started. Information on other marine mammals, fisheries stocks, and oceanographic data are also being combined with an analyses of fur seal data to determine the dynamics of the Bering Sea ecosystem.

Studies reported on in this paper represent the initial phase of the work within Research Unit 77 of the AOCSEAP to integrate and synthesize these data into a conceptual submodel of the ecosystem describing trophodynamic relationships in the eastern Bering Sea including interactions among northern fur seals, other marine mammals, marine birds, and several species of fish. The amount of food consumed by fur seals and other pinnipeds has been estimated and compared with the amount of fish caught by commercial fisheries in the same waters.

The Bering Sea Ecosystem

In terms of fishery exploitation and the distribution of marine mammals it is convenient to consider the Bering Sea as divided into two subunits: the eastern Bering Sea shelf and the Aleutian area (Figure 1). Pinniped stocks in the Bering Sea are large, including northern fur seals for which extensive research and population data are available,

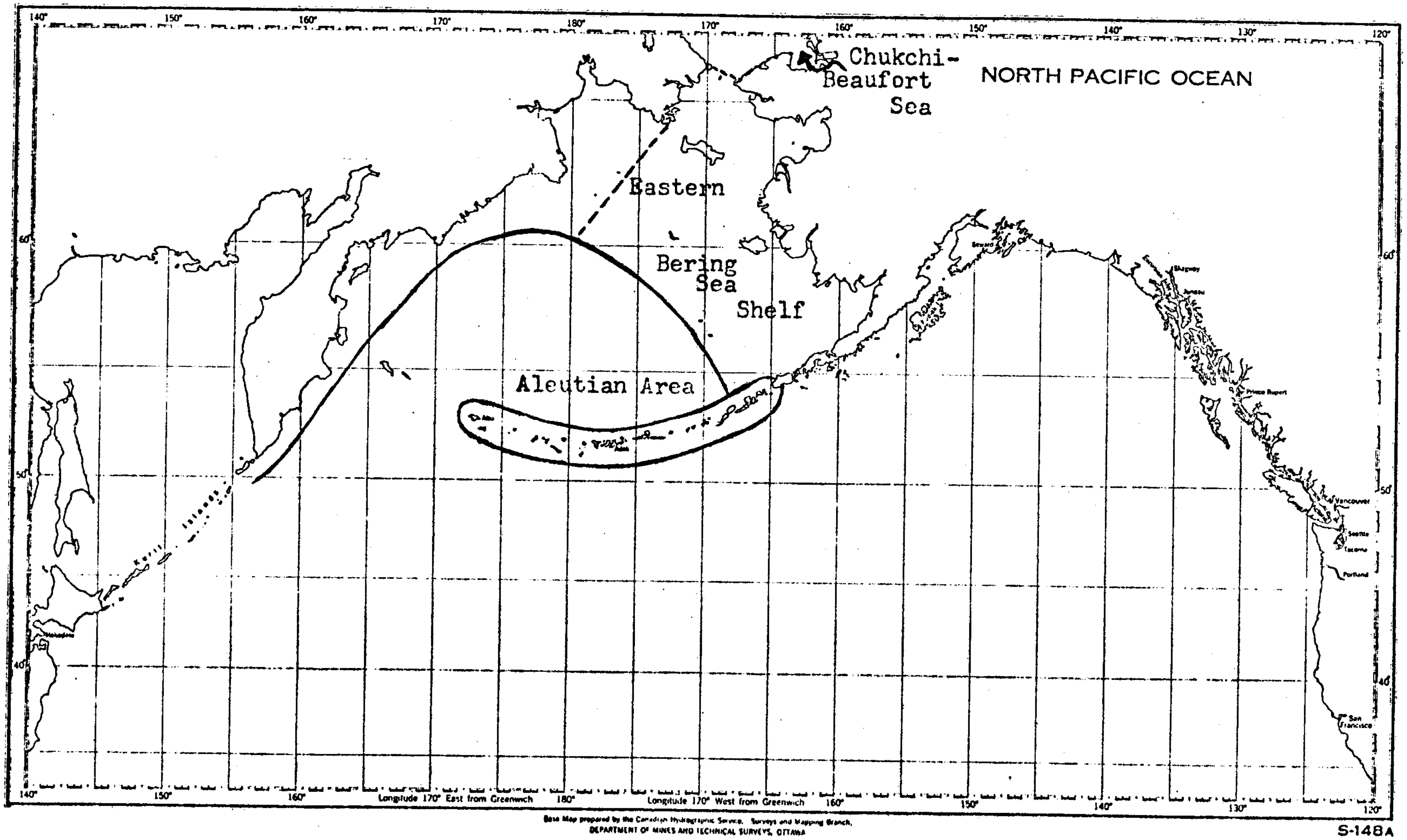


Figure 1. -- Oceanic areas adjacent to Alaska, based on the schematic Domains of Dodimead et al (1963).

and provide a basis for estimating biological parameters for other pinnipeds where direct observations are not available. The area is one of high overall productivity and of heavy commercial utilization with a good historic fisheries data base. Although not adequate to the degree one would like, data exist for estimating productivity at the upper trophic levels, and by inference at least, throughout the food web.

The food web is enormously complex in the ocean and the eastern Bering Sea is no exception. Although much of the primary productivity of phytoplankton takes place in the water column, blooms of algae in and beneath the sea ice in late winter, and eelgrass and epibenthic phytoplankton growing on mud flats in summer all contribute to the total primary production of the area (McRoy et al., 1972). Although progress has been made in understanding the amount of primary production in the water column which can be used as a basis to estimate overall productivity, the interrelationships between pelagic, in-ice, and epibenthic production remain to be properly identified. Sanger (1974) has reviewed the available data (Table 1), and obtained a value of 415 mg C/m^2/day as an estimate of primary production in the Bering Sea. Estimated production in the Aleutian area is lower, averaging near 100 mg C/m^2/day.

Table 1. --Recent estimates of primary production in the water column for oceanic waters contiguous to Alaska (Carbon-14 method).[1/]

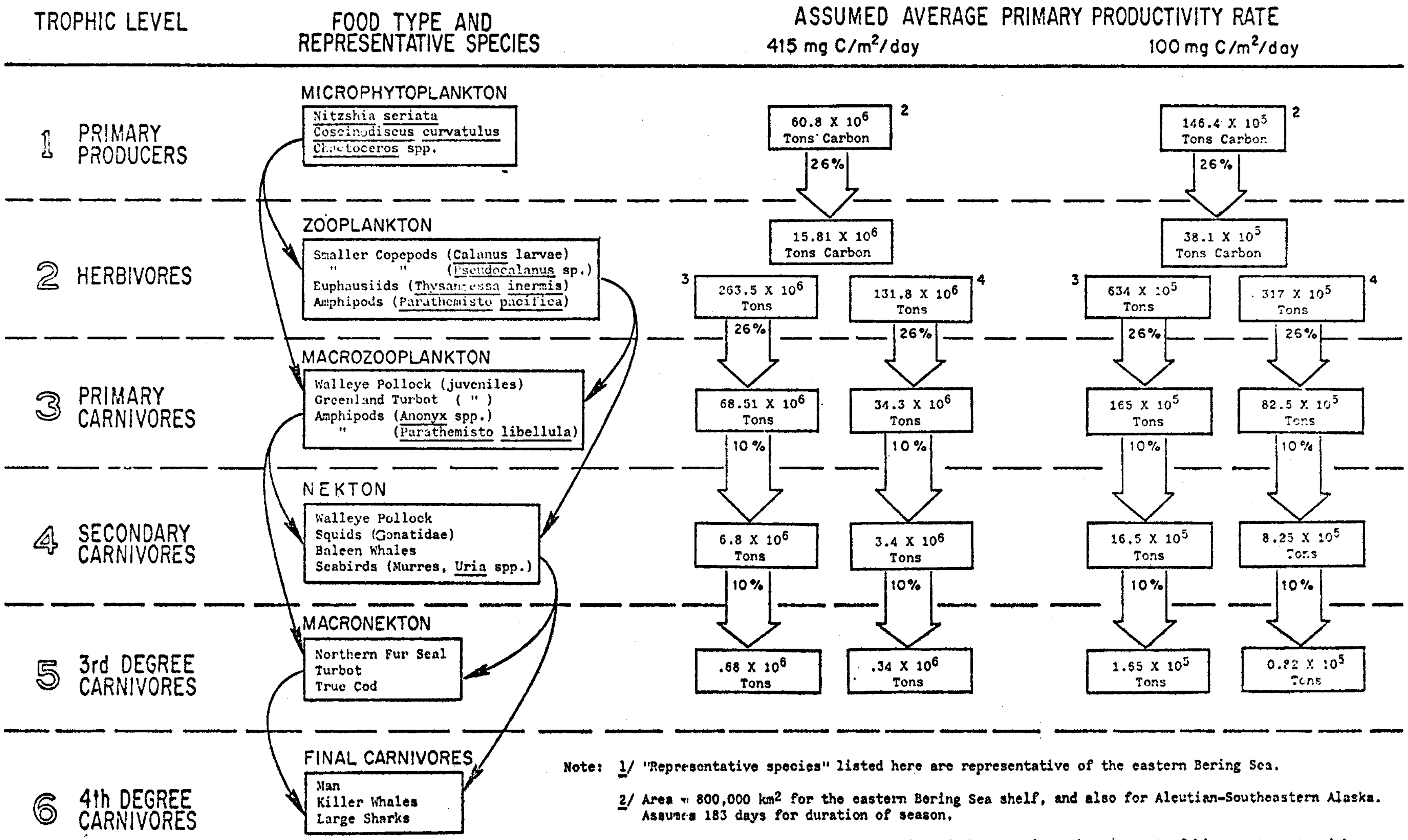
Region	Daily Rate (mg C/M^2/day)	Dates	Source
Bering Sea			
Bering Strait	4,100	June 1969	McRoy et al (1972)
Eastern Bering Sea	21	February 1970	McRoy et al (1972)
Aleutian Area			
Unimak Pass Area	243	June 1968 &1970	McRoy et al (1972)
	85	February 1967	McAlister et al (1970)
Amchitka Island Area	38-45	February 1968	McAlister et al (1968)
Adak Island Coast	686	June-July 1967	Larrance (1971)
	581	August 1967	Larrance (1971)
	404	September 1966	Larrance (1971)
Adak Bay	350-460	March 1966	Larrance (1971)
	840-2,400	late spring-summer	Larrance (1971)
Central Subarctic Domain			
Subarctic waters south to Adak Island	133	February	Larrance (1971) (Fig. 5, p. 604)
	325	March	Larrance (1971)
	280	May	Larrance (1971)
	327	June	Larrance (1971)
	250	July	Larrance (1971)
	207	August	Larrance (1971)
	240	September	Larrance (1971)

1/ Adapted from Sanger, 1974.

Figure 2 shows a schematic food chain for the eastern Bering Sea shelf area in summer (defined as June through November). Examples of representative species are given to show the kinds of organisms which would be expected to occur at the various trophic levels in the fur seal food chain. Karohji (1972), Hiroshi Kajimura (pers. comm.), and Donald S. Day (pers. comm.) provided suggestions for some of the representative animals used in Figure 2. Calculations of productivity at each trophic level are shown for average daily production rates of 415 mg C/m^2/day and of 100 mg C/m^2/day.

Because primary productivity is measured and expressed in terms of organic carbon production, estimates of organic carbon at the herbivore level were converted to biomass to relate production to stocks of organisms at higher trophic levels. Sanger (1974) has reviewed the literature and discussed possible energy transfer coefficients between trophic levels and conversion factors of organic carbon to biomass for zooplankton. Figure 2 shows calculations for values of 6% and 12% as the carbon content of zooplankton biomass to represent the possible overall range of values. The values of energy transfer coefficients (percent of the production at trophic level n produced at trophic level n+1) used to calculate productivity at the next higher level are also shown in Figure 2; however, it should be stressed that many uncertainties exist concerning conversion factors between trophic levels in the fur seal food

Figure 2. Schematic, simplified summer (June-November) food chain, applicable to the eastern Bering Sea.



Note: 1/ "Representative species" listed here are representative of the eastern Bering Sea.

2/ Area = 800,000 km² for the eastern Bering Sea shelf, and also for Aleutian-Southeastern Alaska. Assumes 183 days for duration of season.

3/ Assumes a factor of 6% for conversion of the organic carbon content of biomass to wet weight.

4/ Assumes a factor of 12% for conversion of the organic carbon content of biomass to wet weight.

web, and that the calculations shown in Figure 2 should be considered as rough estimates only.

Food Consumption by Pinnipeds

In order to calculate the amount of food consumed by pinnipeds, it is necessary to know the size of the population, the biomass of each pinniped species in the ecosystem, and consumption per pound of biomass. Table 2 lists the current data on standing stocks of pinnipeds and their average weight. Data for fur seals were obtained from pelagic observations by the Marine Mammal Division, NWFC, NMFS. Data on other pinnipeds are from reports by the Alaska Department of Fish and Game, except that the summer/winter distributions are estimates based upon observed seasonal migration patterns and given population sizes.

Many fishes and pinnipeds feed on either pelagic and benthic forms, or both. They also feed in migratory patterns, which makes it difficult to ascertain their actual impact on a given species in a particular area. A simple multiplication of estimated population numbers and average size gives only a very rough approximation of biomass. The accuracy of these estimates has been improved by taking into account the variable summer/winter distribution. Additional future improvements will consider size of different age classes and amount of time spent at sea.

Table 2. Population and biomass estimates for pinnipeds in Alaska

Species	Total Alaska Population Size ($x10^3$)	Population Size in the: 1/				Average Animal Weight, Kg.
		Aleutians		Eastern Bering Sea Shelf		
		Summer	Winter	Summer	Winter	
Northern Fur Seal	1,300 2/	37,000	97,300	55,000 3/	96,650	50.3 4/
Northern Sea Lion	225	41,000	62,000 5/	100,000	50,000	400 6/
Harbor Seal *Richardi*	270	85,000	85,000	65,000	65,000	140 6/
Harbor Seal *largha*	250	-	-	125,000	250,000	140 6/
Ringed Seal	250	-	-	125,000	250,000	65 6/
Ribbon Seal	100	-	-	50,000	100,000	80 6/
Bearded Seal	300	-	-	150,000	300,000	240 7/

1/ Population size for pinnipeds, except northern fur seal, based on status of stock reports in ITG, 1975, - ADFG, 1975.
2/ Northern fur seal numbers rounded to nearest 100,000 animals.
3/ Estimated summer distribution of northern fur seals based on pelagic observations by MMD, 1967-1973 and total population of 1,300,000 animals.
4/ Based on the following average weights: Pup=10Kg; males age 3 and older = 225Kg; all others (females age 1 and older; males age 1 and 2)=48Kg.
5/ ADFG, 1973 (b).
6/ Average weight based on ADFG (1973a), Nishiwaki (1972), and NMFS (1973).
7/ Adult bearded seals weigh up to 340Kg in winter.

Estimates of food consumption were made by multiplying biomass by number of days (assumes 183 days per season) by a daily consumption rate as percent of total body weight. The data collected by the Marine Mammal Division are extensive enough to provide reasonable data for fur seals. Where direct data were not available for other pinnipeds, rates determined for fur seals were used as a first approximation.

Estimates of food consumption for nothern fur seals are shown in Table 3. Annual consumptions derived for these seals assume a daily consumption rate of 7.5% of the body weight. Most consumption rates have been calculated for animals held in captivity; they have ranged from 6% to 8% (Scheffer, 1950; Sergeant, 1973; Geraci, 1972).

Estimates of the total annual or seasonal food consumption by northern fur seals in the North Pacific Ocean and waters off Alaska are given in Table 3. The average amount of food consumed annually by fur seals in the North Pacific Ocean is estimated to be nearly 1.1 million metric tons, based on a present population estimate of 1.3 million animals. This value is much larger than that of 689 thousand metric tons estimated by Scheffer (1950) when the population was larger. A. M. Johnson (pers. comm.) recently estimated that fur seals in the eastern Bering Sea annually consume 318-340 thousand metric tons. Using a consumption rate of 7.5% of the body weight, an average annual value of 442 thousand metric tons has been obtained for the eastern

Table 3.--Estimates of total annual or seasonal food consumption by northern fur seals from the Pribilof Islands

Estimated herd size (thousands)	Area	Season	Food consumption (thousands of metric tons)	Source
1,530	North Pacific	Annual	689	Scheffer (1950)
1,300	North Pacific	Annual	965.3	Sanger (1974)
550	Eastern Bering Sea	June-Nov.	304.0	Sanger (1974)
97	Eastern Bering Sea	Dec.-May	53.3	Sanger (1974)
90	Aleut.-Cent. S.E. Alaska	June-Nov.	49.4	Sanger (1974)
236	Aleut.-Cent. S.E. Alaska	Dec.-May	129.1	Sanger (1974)
1,300	Bering Sea	Annual	318-340	Ancel Johnson (pers. comm.)
37	Aleutians	June-Nov.	25.5	present exercise
97	Aleutians	Dec.-May	67.0	Do.
550	Eastern Bering Sea	June-Nov.	379.7	Do.
97	Eastern Bering Sea	Dec.-May	67.0	Do.
66 1/	Gulf of Alaska	Annual	91.1	Do.
849 2,3/	South of Alaska	Dec.-May	448.6	Do.
1,300	North Pacific	Annual	1078.9	Do.

1/ Average of summer and winter months. Population size from Sanger (1974).

2/ Sanger, 1974.

3/ Assumes age and weight composition of 25% yearlings at 10 kg, and 75% "other" at 48 kg.

Bering Sea (Table 3). Sanger (1974), using a consumption rate of 6.1% of the body weight, obtained an estimate of 357 thousand metric tons which is similar to the value obtained by A. M. Johnson.

The Marine Mammal Division, NMFS, has also collected extensive data on the amount and type of food found during examination of fur seal stomach contents. The proportionate weight by food type, based on data from pelagic research during the summers of 1968 and 1973 (NMFS, 1970; 1974), is shown in Tables 4 and 5. Finfish comprise nearly 90% of fur seal diets in the eastern Bering Sea (Table 4) and 70% of fur seal diets in the Aleutian area (Table 5). In both areas, walleye pollock represents over half of the finfish portion of the fur seal diet.

A length distribution of walleye pollock, unidentified fish belonging to the family Gadidae, and Greenland turbot found during examination of fur seal stomachs collected for pelagic research in the eastern Bering Sea in 1973 is shown in Figure 3, together with prerecruit limits for these fish. The minimum recruit size for fish entering the commercial fishery is 20 cm for walleye pollock and 22 cm for turbot (Bakkala, pers. comm.). It should be emphasized that fish eaten by fur seals are generally of prerecruit size, as evident in Figures 3 and 4. It should be noted that the data used to construct Figures 3 and 4 represent the

Table 4. --Estimated amount of food consumed by northern fur seals in the eastern Bering Sea, by food type, based on relative food consumption observed during July-September 1973.

Food type	Percent of total 1/	Proportionate weight of food consumed (in thousands of metric tons)		
		Summer	Winter	Annual
Walleye pollock	67	254.4	44.9	299.3
Unidentified gadid	15	56.9	10.0	66.9
Gonatid squid	11	41.8	7.4	49.2
Bathylagid smelt	4	15.2	2.7	17.9
Greenland turbot	2	7.6	1.3	8.9
All others	1	3.8	0.7	4.5
Totals		379.7	67.0	446.7

1/ NMFS, 1974.

Table 5.--Estimated amount of food consumed by northern fur seals in the Aleutian area of Alaska, by food type, based on relative food composition observed between Kodiak Island and Unimak Pass, May-August, 1968

Food type	Percent of total 1/	Proportionate weight of food consumed (in thousands of metric tons)		
		Summer	Winter	Annual
Walleye pollock	37.8	9.6	25.3	35.0
Gonatid squid	30.8	7.8	20.6	28.5
Atka mackerel	16.3	4.2	10.9	15.1
Capelin	7.4	1.9	5.0	6.9
Salmonidae	5.1	1.3	3.4	4.7
All others	2.6	0.7	1.7	2.4
Totals		25.5	67.0	92.5

1/ NMFS, 1970.

total amount of fur seal stomachs in a season containing fish of measurable size. A greater percentage of fur seal stomachs analyzed were in a state of digestion that did not permit measurement of the consumed fish. Also, the areas in which fur seal stomachs were collected varied throughout the season in each of two years.

Similar methods have been used to estimate food consumption by other pinnipeds. We have made a best estimate for each species of that percentage of total consumption which is finfish. Where data have been lacking or inconclusive, we have used rates observed for fur seals as a first approximation. Tables 6 and 7 show consumption figures and data sources for northern fur seals, northern sea lions, harbor seals, ringed seals, ribbon seals, and bearded seals in the eastern Bering Sea. Total food consumption by pinnipeds in this area is estimated to be 4, 223 thousand metric tons per year, of which fur seals account for approximately 447 thousand metric tons, or about 18% of the total finfish consumed. Northern sea lions account for over one-third of the total finfish consumption (Table 7).

Tables 8 and 9 show similar calculations for the Aleutian area of Alaska. Consumption in the Aleutian area is about one-third of eastern Bering Sea shelf values, with northern sea lions again being the largest single consumer of finfish.

Table 6.--Food consumption by pinnipeds in the eastern Bering Sea shelf (thousands of metric tons).

Pinniped	Rate (%)	Summer	Winter	Annual	Percent of total
Northern fur seal 1/ (*Callorhinus ursinus*)	7.5	380	67	447	11
Northern sea lion 2/ (*Eumetopias jubatus*)	7.5	549	275	824	19
Harbor seal 2/ (*Phoca* sp.)	7.5	365	605	970	23
Ringed seal 2/ (*Pusa hispida*)	7.5	112	223	335	8
Ribbon seal 2/ (*Histriophoca fasciata*)	7.5	55	110	165	4
Bearded seal 2/ (*Erignathus barbatus*)	7.5	494	988	1,482	35
Subtotals		1,955	2,268		
Total		4,223			

1/ Consumption (rounded) from Table 3.

2/ Consumption based on biomass from Table 2. Average rate of consumption 7.5% of body weight per day and a season of 183 days: (biomass in metric tons) x 183 days x $\frac{(0.075)}{\text{day}}$ = seasonal food consumption.

Table 7. --Annual food consumption of finfish by pinnipeds in the eastern Bering Sea (thousands of metric tons).

Pinniped	Food[1/] (thousands of metric tons)	Percent finfish (w=winter, s=summer)	Finfish consumption (thousands of metric tons)
Northern fur seal[2/] (*Callorhinus ursinus*)	447	84	375
Northern sea lion[3, 4/] (*Eumetopias jubatus*)	824	90	742
Harbor seal[3, 6/] (*Phoca* sp.)	970	50	485
Ringed seal[5/] (*Pusa hispida*)	112s/223w	90w/40s	246
Ribbon seal[4/] (*Histriophoca fasciata*)	55s/110w	90w/40s	121
Bearded seal[5/] (*Erignathus barbatus*)	1, 482	10	148
Subtotals	4, 223		2, 117

1/ From Table 6.
2/ NMFS, 1974.
3/ Spalding, 1964.
4/ Fiscus and Baines, 1966.
5/ Johnson et al., 1966.
6/ Fiscus, pers. comm.

Table 8.--Food consumption by pinnipeds in the Aleutian area (thousands of metric tons)

Pinniped	Rate (%)	Summer	Winter	Annual	Percent of total
Northern fur seal[1/] (*Callorhinus ursinus*)	7.5	26	67	93	10
Northern sea lion[2/] (*Eumetopias jubatus*)	7.5	225	340	565	57
Harbor seal[2/] (*Phoca* sp.)	7.5	163	163	326	33
Total				984	

1/ Consumption (rounded from Table 3).

2/ Consumption based on biomass from Table 2. Average rate of consumption 7.5% of body weight per day and a season of 183 days: (biomass in metric tons) x 183 days x $\frac{(0.075)}{\text{day}}$ = seasonal food consumption.

Table 9.--Food consumption of finfish by pinnipeds in the Aleutian area (thousands of metric tons).

Pinnipeds	Food 1/ (thousands of metric tons)	Percent finfish	Finfish consumption (thousands of metric tons)
Northern Fur Seal 2/ (*Callorhinus ursinus*)	93	69	64
Northern Sea Lion 3, 4/ (*Eumetopias jubatus*)	565	90	509
Harbor Seal 3, 5/ (*Phoca sp.*)	326	50	163
Sub-totals	984		736

1/ From Table 8.
2/ NMFS, 1970.
3/ Spalding, 1964.
4/ Fiscus and Baines, 1966.
5/ Fiscus, pers. comm.

Comparisons with Fisheries Catch Statistics

The eastern Bering Sea is the source of a major commercial fishery harvested principally by Japan, the USSR, and South Korea. Japan resumed fishing operations in the Bering Sea in 1954 after an interruption during World War II. A harvest of yellowfin sole, herring, and pollock, primarily by Japanese and Russian fishing fleets, exceeded 2.3 million metric tons in 1972. These totals were expected to decrease to slightly over 1.7 million metric tons in 1975. The total sustainable fishery harvest of groundfish in the Bering Sea and Aleutians in 1975 has been estimated to be between 1.4 and 1.7 million metric tons, under present harvesting and environmental conditions (Table 10).

An analysis of catch and effort statistics and biological data indicate that the present high harvest levels of pollock in the eastern Bering Sea are exceeding sustainable levels (Alverson, 1975), as shown in Table 10. From an examination of all available information, U. S. fisheries scientists have indicated that the pollock fishery for the eastern Bering Sea shelf should be limited to a harvest of about 1.0 million metric tons.

Values derived for food consumption by pinnipeds have been compared with the commercial harvest and standing stocks in Table 11. Because the best available statistical data on the commercial fisheries combined both the Bering Sea and the Aleutian areas, we have included

Table 10. --Expected fisheries catch in the eastern Bering Sea and Aleutians in 1975 (thousands of metric tons). 1/

Country	Pollock	Pacific Ocean perch	Yellowfin Sole and other	Herring	Totals
Japan	1,100	11	214	18	1,343
USSR	210	148	---	30	388
Other	3	---	---	--	3
Total	1,313	159	214	48	1,734
Estimated Sustainable Yield	1,000	350		40	1,390

1/ Letter Oct. 17, 1975, Dr. D.L. Alverson to Hon. Mike Gravel, U.S. Senate.

Table 11. --Consumption of fish in the eastern Bering Sea and Aleutian areas

	Thousands of metric tons
Estimated finfish consumed by fur seals 1/	439
Estimated finfish consumed by other pinnipeds 1/	2,414
Estimated finfish consumed by sea birds 2/	50
Estimated vertebrate predation	2,903
Estimated 1975 catch by commercial fishery 3/	1,734
Estimated total catch plus vertebrate predation	4,637
Estimated stock of all finfish 4/	17,000
Percent standing stock annually consumed by man and other vertebrates--approx.	27%
Percent consumed by fur seals--approx.	3%
Percent consumed by marine mammals and birds--approx.	17%
Percent consumed by fisheries--approx.	10%

1/ Table 7, Table 9.
2/ Sanger, 1974.
3/ Table 10.
4/ INPFC Documents 1680 and 1663 (Pruter, 1973).

both areas in the values for pinnipeds for comparison purposes. It can be seen that consumption of finfish by pinnipeds is of the same magnitude as the commercial fishery, which is presently in a state of overfishing. Total consumption of finfish by pinnipeds in the eastern Bering Sea is estimated to be between 2 and 3 million metric tons, which is approximately equivalent to or slightly larger than the present commercial fishery.

Under the following assumptions: (1) fur seals and man are direct competitors for the same species of fish, (2) a direct correlation may exist between the size of the fur seal herd and the amount of fish consumed as food, and (3) the ecosystem is presently in equilibrium (which is probably not the case, as it is currently overfished as mentioned above) (NMFS, 1975). Consumption values in Table 11 were calculated. These values show that fur seals account for approximately 3% of all fish taken annually in the eastern Bering Sea, an amount equivalent to approximately 25% of the amount taken by the fisheries. If the fur seal population were to increase by as much as 40% to 1.8 million animals, an additional 1% of the standing stock of fish would be consumed, requiring as much as a 10% reduction in the finfish catch if the above assumptions are valid. Furthermore, this 10% estimated reduction ignores any direct competition between fur seals and other marine mammals. Some of the increased food supply required by a larger fur seal population could be obtained from the diet of competing pinnipeds. Consequently, the above 10% reduction in man's finfish catch should be regarded only as an upper boundary for the possible effects upon the fishery of an increase in the fur seal population. As yet, not enough information is available to determine how portions of this 10% reduction might be allocated among the fur seal's competitors, if at all (NMFS, 1975).

The effects which fur seals may presently have on the commercial fishery are still not yet clear. As stated above, fur seals as well as other marine organisms may impact on the potential catch as competitors with man, but they may also affect the potential growth of the fish populations. As mentioned earlier, the data from 1973 and 1974 in Figures 3 and 4 show that fur seals generally consume juveniles of walleye pollock and Greenland turbot. However, pollock consumed by fur seals in 1974, as shown in Figure 4, were in a size range approximately equal to that of fish being recruited into the commercial fishery. Therefore, fur seals may not only compete with man directly in consuming fish of catchable size, but may also affect the potential population growth of the fish themselves because of their predation on juvenile fish. These interactions between fur seals and their fish prey need to be determined.

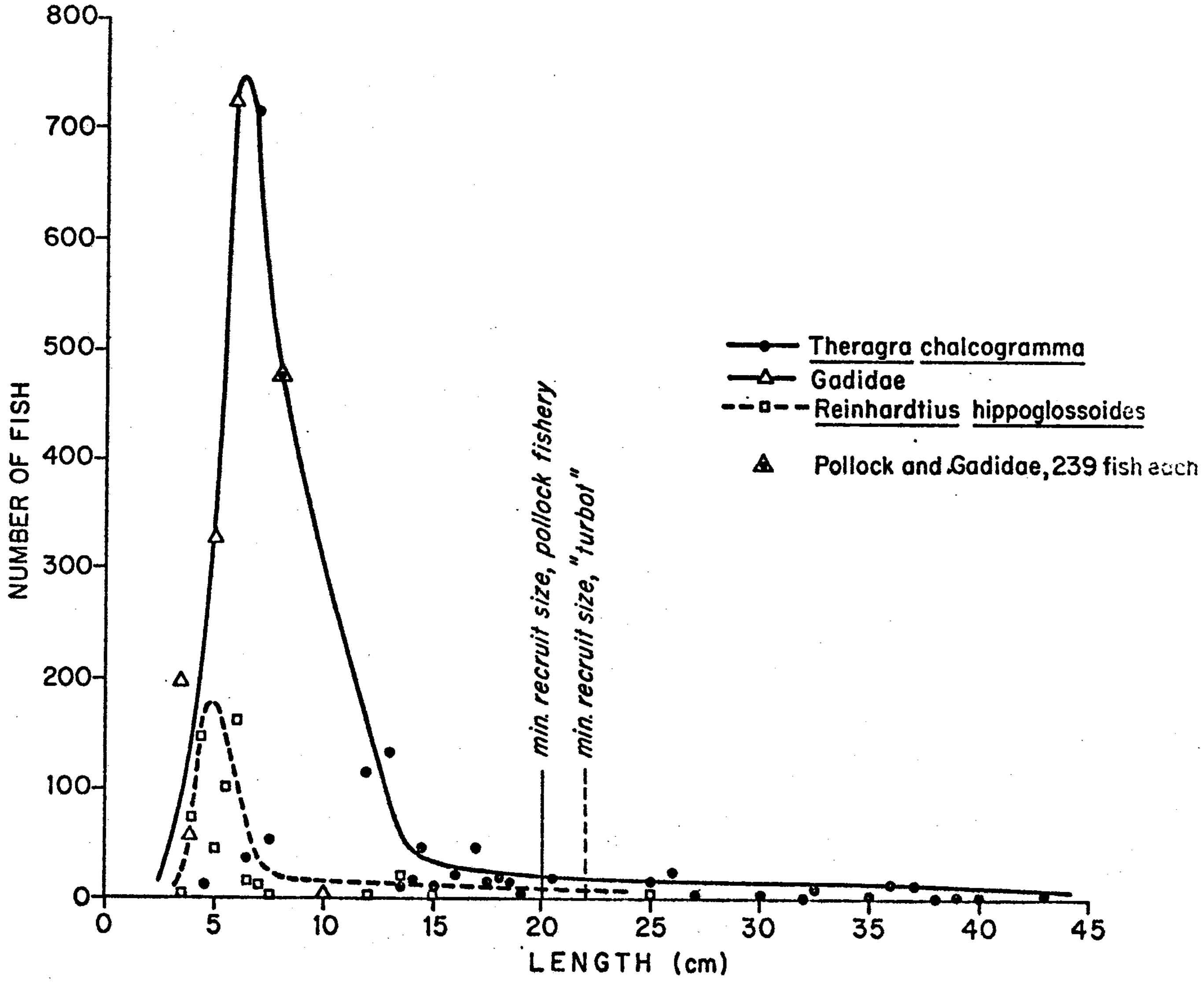
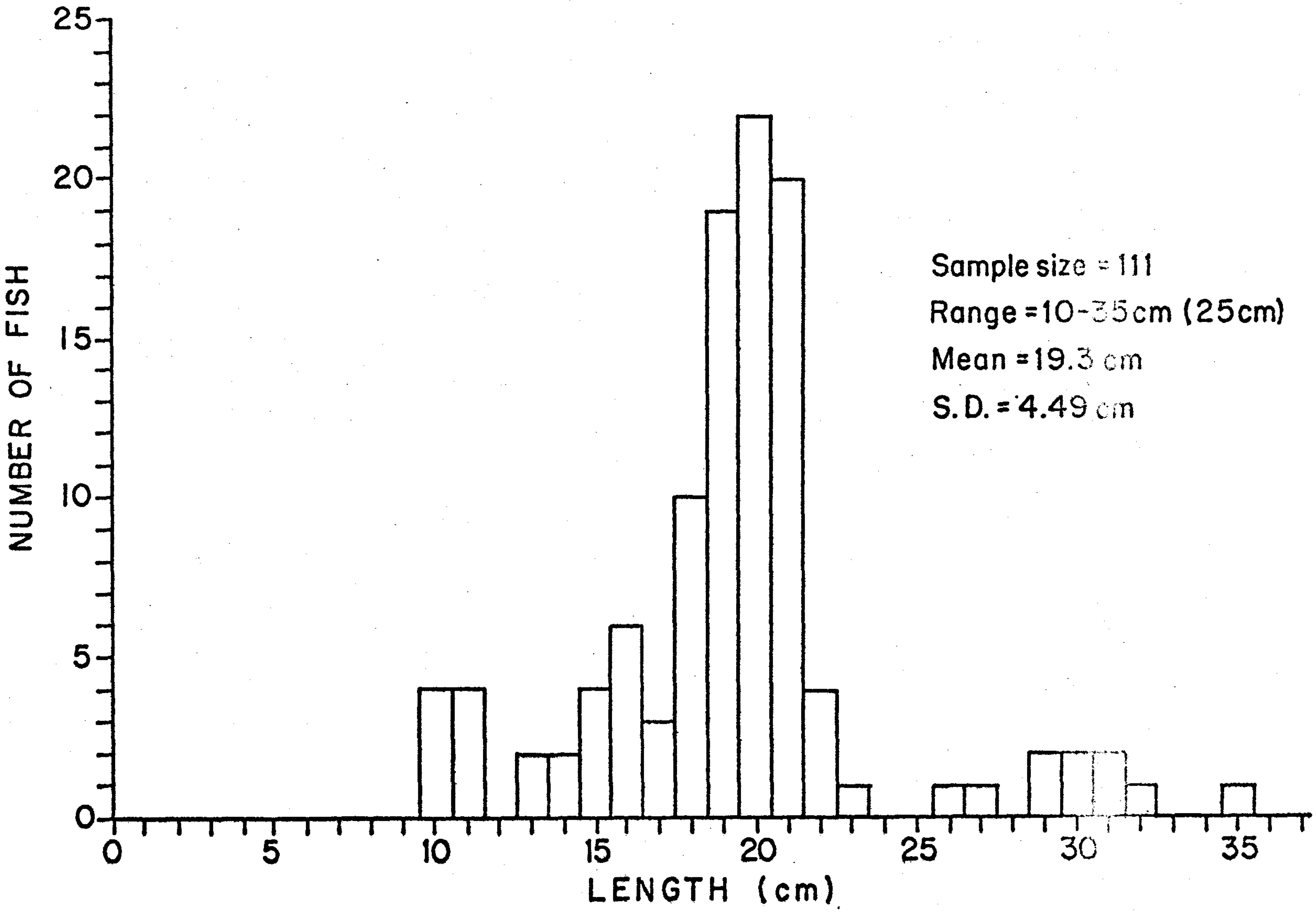


Figure 3. Approximate length distribution of pollock (Theragra chalcogramma), unidentified fish belonging to the family Gadidae, and Greenland turbot (Reinhardtius hippoglossoides) in fur seal stomachs from the eastern Bering Sea, July-September 1973. The minimum sizes the fish enter their respective fisheries are also noted ("turbot" here represents the minimum recruit size for the turbot fishery which includes arrowtooth flounder in addition to Greenland turbot; Bakkala, pers. comm.)

Figure 4. Length frequency distribution of walleye pollock, Theragra chalcogramma, in fur seal stomachs from the eastern Bering Sea, July-September 1974.



Conclusions

Although this report is preliminary and the first step in a detailed process of analyzing all known data on the feeding relationships of pinnipeds, it does appear to provide a good estimate of the range of finfish consumption by fur seals and other pinnipeds. Pinnipeds do consume a quantity of food consisting largely of fish, especially pollock, which is nearly as great as that of the commercial fishery; although, the impact of fur seals is apparently not as great as that of other pinnipeds such as the northern sea lion. Also, the fact that finfish consumed by fur seals are generally of prerecruit size can only mean that the potential size that the adult fish population can reach is affected. What effects present exploitations have on the fishery is not yet clear, but with overfishing by man at present and predation of juvenile fish populations by pinnipeds, fish, and other marine organisms, it may be difficult to achieve a maximum sustained yield in the fishery.

It must be emphasized that finfish are not the only food of pinnipeds. Squid actually forms a higher percentage of occurrences in fur seal diets than finfish, although not by volume. Because organisms change their diet from one species to another in their food web as a given species becomes increasingly difficult to find, it might be true that fur seals will consume a greater amount of squid as the standing stocks of fish decrease. The impact of fur seals on the fishery is a complex interaction, and further analyses of data on the ecosystem and trophodynamic relationships of pinnipeds and finfish is required before the system can be understood.

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The Reproductive Ecology, Foods, and Foraging Areas of Seabirds Nesting on St. Paul Island, Pribilof Islands

George L. Hunt, Jr.
University of California at Irvine

1 April, 1976

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I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

The objective of research detailed below was to obtain baseline data on the reproductive ecology of the eleven species of seabirds nesting on the Pribilof Islands of Alaska. To this end data on 1) seasonal timing of reproduction, 2) reproductive success, 3) growth rates, 4) food habits and 5) foraging areas were sought.

Data suitable for baseline use were obtained in the summer of 1975 for timing of reproduction for Black-legged Kittiwake, Red-legged Kittiwake, Common Murre and Thick-billed Murre. Measures of reproductive success were obtained for Red-faced Cormorant, Black-legged and Red-legged Kittiwakes and Common and Thick-billed Murres. We determined the growth rates of the young of Red-faced Cormorant, Black-legged and Red-legged Kittiwakes and Thick-billed Murres. Foods brought to the young Least Auklets, Black-legged Kittiwakes, Common Murre, Thick-billed Murre and Red-faced Cormorant were collected in sufficient number to give a reasonable impression of the foods used by these species in rearing their young. Preliminary indications of foraging areas for species other than the small alcids were obtained during an August cruise. On two occasions the effect of airplane movements close to seabird colonies were noted.

Because natural populations normally fluctuate from year to year in timing of breeding, reproductive success, growth rates and foods used, it is premature to draw conclusions as to what is "normal" for the seabird populations in the Pribilof Islands. Such conclusions can only be drawn after a three to five year study.

Although we have had very little direct experience with aircraft flying in the vicinity of the nesting colony, all indications are that both fixed wing aircraft and helicopters cause major disruptions of nesting birds and lowering of reproductive success in Murres. The implication is that in OCS oil development and in the coincident monitoring of natural populations, all aircraft should be restricted from flying near colonies. It is likely that, in terms of on-going oil production, disturbance by aircraft could be as damaging to bird reproduction as spilled oil. These tentative observations have the further implication that aircraft should not be used to monitor the reproductive output of Kittiwakes or the size of bird colonies if these operations require flying in the proximity of cliffs while Murres have either eggs or chicks.

II. Introduction

In the face of impending oil exploration and extraction in the outer continental shelf of Alaska, it is imperative that thorough baseline research be conducted on all aspects of the environment in potentially affected areas. One segment of the environment which is particularly sensitive to spilled oil is seabird populations. The Bering Sea is home to some of the greatest concentrations and the greatest diversity of seabirds in the world. Baseline studies of these populations are necessary in order to identify areas of particularly great sensitivity from which oil should be excluded, to identify areas in which special priority should be given to the clean up of spilled oil, and to provide evidence as to the effects of spilled oil on avian populations.

The following is an annual report on the first season's field work conducted in the summer of 1975. The purpose of this study was to obtain baseline data on the reproductive success, the food habits and the foraging areas of eleven species of seabirds breeding on St. Paul Island in the Pribilof Islands, Alaska.

In studying the reproductive success of each species the goal of the scientific party was to establish timing of breeding, number of eggs laid, hatching and fledging success, and growth rates and causes of mortality of young. All of these factors are indicators of the health of seabird populations. Knowledge of when and why the normal stresses in the reproductive cycle occur will facilitate predictions of the possible effects of oil spills on these systems. Nesting seabirds are particularly vulnerable to spilled oil, as they are tied to restricted areas by their need to incubate eggs or feed developing young. Young birds, newly departed from their nests, may also be unusually vulnerable to oil on the sea because of incomplete development of flying ability and inexperience in foraging. In addition, certain cliff nesting species may be vulnerable to disturbance by aircraft.

Data on the foods and foraging areas used by seabirds were collected in order to determine in which ocean areas oil spills would be particularly damaging to Pribilof Island populations. Knowledge of the food chains upon which the seabirds are dependent is also necessary to establish both the role the seabirds play in the marine ecosystem and the potential vulnerability of seabirds should certain other marine species be damaged by oil.

III. Current State of knowledge

At present a vast literature exists on the effects of oil pollution on seabirds. Vermeer and Vermeer (1974) provide an annotated bibliography of 232 entries through December 1973. Many of the papers listed, as well as others, document the numbers of oiled birds found after spills of various sorts. Other studies provide useful data for predicting the consequences of spills in general.

Several persons have noted differences in behavior of birds confronted by spilled oil. Curry-Lindahl (1960) has observed Oldsquaw (Clangula hyemalis), a species of sea-duck which breeds in small numbers on St. Paul Island (Preble and McAtee 1923 and pers. obs., this study), to be attracted to patches of oil at sea. When Common Murres (Uria aalgae) encounter oil, they have been noted to dive as they entered a slick (Bourne 1968). These particular birds resurfaced clear of the slick. In contrast a Herring Gull (Larus argentatus) and a Black-legged Kittiwake (Rissa tridactyla) upon encountering the same slick, rose into the air and flew away.

Differences in reaction to oil spills such as those mentioned above may account for differences in vulnerability of species to population loss when oil is spilled. Milou and Bougerol (1967 in Vermeer and Vermeer 1974) have documented changes in the populations of seabirds on the Ile Rouzic in France subsequent to the Torrey Canyon disaster. In less than a month's time the Atlantic Puffin (Fratercula arctica) population was reduced from about 5000 pairs to 600 pairs. Likewise Razorbilled Auks (Alca torda) were reduced from 800 individuals to 100, and Common Murres from 400 to 100.

In contrast gulls (*L. marinus*, *L. argentatus* and *L. fuscus*) decreased about 10% and of 40-50 Fulmars, only 2 birds were stained. Kittiwakes were not present at the time of the spill and suffered no apparent effect. Other studies similarly showed breeding alcids and gannets to be very vulnerable to oil spilled by the Torrey Canyon (O'Connor 1967, Phillips 1967, Monnat 1967). For lack of adequate baseline data on numbers and timing of breeding, Phillips (1967) was unable to determine what effect, if any, the oil had on other colonies.

The results of the Torrey Canyon and other studies, albeit fragmentary, provide an important lesson for OCSEP studies in Alaska. They show that alcids and sea ducks are especially vulnerable to spilled oil. The vulnerability of alcids is a critical problem in relation to Alaskan oil recovery, as the majority of the breeding seabirds congregated into massive colonies are alcids. In fall and winter sea ducks may occur in vast numbers, also creating the potential for the devastation of populations.

Oiling may affect the survival and reproduction of waterfowl in several ways. Experiments by Hartung (1965) have shown that waterfowl reproduction can be damaged both by the ingestion of oil, which may cause inhibition of egg laying and that oil transferred from the plumage of an adult to its egg will greatly reduce hatchability. Hartung and Hunt (1966) have shown that ingested oils also cause a number of toxic effects on waterfowl. Hartung (1967) and McEwan and Koelink (1973) have both showed that heat loss increased for ducks with oiled plumage. Hartung (1967) further showed that heat loss increased with increased dosage of oil and that death came after most fat reserves were exhausted. Since oiled birds usually refrained from eating, Hartung (1967) concluded that starvation, accelerated by rapid use of fat reserves for thermal maintainence, was often the cause of death. If during reproductive efforts a bird's fat reserves were drawn down, we might expect otherwise healthy adult birds to have an increased susceptability to death by even moderate to light oiling.

Although the seabird colonies of the Pribilof Islands are some of the largest in Alaska, surprisingly little is known about them. Palmer (1899) provides an annotated checklist of 69 species which contains little useful information on either numbers or phenology. Preble and McAtee (1923) list 137 species as known to occur in the Pribilof Islands, of which 23 are recorded as breeding. Their paper provides fragmentary information on numbers, timing of breeding and food habits, and somewhat more useful data on spring arrival and fall departure dates. While much of the data will provide useful for comparative purposes, virtually none are sufficient to provide a baseline comparison.

In recent sutdies, Kenyon and Phillips (1965) Sladen (1966) and Thompson and DeLong (1969) provide updates on the records of unusual species visiting the islands. The work of Kenyon and Phillips (1965) is of particular interest as it provides one of the few indications of changes in numbers of Red-legged Kittiwakes (Rissa brevirostris) a species endemic to the Bering Sea. Whereas Prentis (1902 cited in Preble and McAtee 1923) found in 1895 that Red-legged Kittiwakes "at the southwestern portion...form nearly one-half of the kittiwakes. ... on the north side of St. Paul they were numerous", Kenyon and Phillips estimated about 346 nests on St. Paul in 1954. Although we have as yet not attempted a complete count, we estimated there were no more than two or three hundred Red-legged Kittiwake nests on St. Paul in 1975, thus confirming the downward trend. Kenyon and Phillips also suggest that Red-legged Kittiwakes breed later in the year than Black-legged Kittiwakes and that the former species is left with less choice nest sites.

The population of a second species may have also declined. In view of the description in Gabrielson and Lincoln (1959, p. 501) it appears that the Crested Auklet (*Aethia cristatella*) population may also have decreased in numbers.

Finally, DeLong and Thompson in various reports of the Smithsonian Institution Pacific Ocean Biological Survey provide scattered data on the numbers and phenology of some of the nesting seabirds (see Thompson, 1964, 1965, 1966).

There exist several papers of a general nature which are relevant when considering the reproductive ecology of Pribilof Island seabirds. Belopol'skii's (1957) work on the seabirds of the Barents Sea provides a basis for comparison with work in the Bering Sea and some very useful insight about the ecology and behavior of seabirds. Shuntov (1972) gives a useful overview of pelagic birds in the Bering Sea as well as touching on relevant aspects of marine productivity and ocean circulation. Swartz (1966) in a chapter on the birds of Cape Thompson provides much interesting data on the numbers, phenology, and ecology of the seabirds.

However, in spite of a three year study, he has little on reproductive success of birds other than Kittiwakes. Food data were mostly restricted to Murres, Kittiwakes and Glaucous Gulls. Dick and Dick (1971) provide phenological data on the seabirds on Cape Pierce. These will be of interest to compare with the data from the Pribilof Islands, as both are at similar latitudes.

The spatial distribution of foraging activity by nesting seabirds is relevant to OCS oil production because the distribution of the foraging birds will affect their potential vulnerability in the event of an oil spill (Vermeer and Vermeer 1975, Clark 1973, Joensen 1972 and others). At present two schools of thought exist as to the dispersion of foraging activity. Cody (1973), on the basis of field work on the west coast of North America and Iceland, believes that alcids differ in their foraging zones at sea, and that colony size, chick growth rates and weight at fledging are related to the distance off-shore of the foraging zone. In contrast, other workers (Sealy 1973, Scott 1973) have emphasized the importance of large aggregations of seabirds into mixed species foraging flocks. These flocks apparently concentrate at "hot-spots" where food is particularly abundant. Bedard (1969a) studying the small auklets of St. Lawrence Island, Alaska, also emphasizes that the three species, Least Auklet (Aethia pusilla), Crested Auklet (Aethia cristatella) and Parakeet Auklet (Cyclorrhynchus psittacula), were usually found foraging together. Given this divergence of opinion and the importance of spatial distribution in determining vulnerability of seabirds to oil, determination of the actual distribution of the foraging activity of Pribilof Island seabirds is important for developing predictions on the potential impact of an oil spill.

Finally, a number of valuable papers shed light on various aspects of the reproductive biology and ecology of many of the species which nest on the Pribilofs. While these studies have been carried out on populations elsewhere than on the Pribilof Islands, the opportunity to compare the results of the present study with those of others will be most valuable. Information in the papers cited below will be compared with our own data in the final report.

Table 1 provides an annotated list of selected references which will provide comparative data of use in the compilation of the final report. Clearly, the data available varies greatly form species to species. While Fulmars (Fulmaris glacialis) have been studied extensively in Great Britain by Fisher (1952), very little has been written about Alaskan populations. Similarly, little information exists on the Red-faced Cormorant (Phalacrocorax urile). Black-legged Kittiwakes have been the subject of numerous studies in other parts of the world, and the Red-legged Kittiwake, a Bering Sea endemic, while poorly known, has drawn the attention of at least a couple of workers.

The Murres have been the subject of a wide variety of studies, some of which include work done in Alaska. These papers should provide particularly valuable comparative material. Likewise, the three Auklets (Aethia pusilla, A. Cristatella and Cyclorrhynchus psittacula) have been the subject of intensive studies on nearby

St. Lawrence Island. The studies on the Pribilof Islands should provide valuable material for comparison and for filling out details of the biology of these three species. The existance of the excellent studies of Bedard and of Sealy are of particular value as the auklets are difficult to work with in the Pribilofs. As for the two Puffins (Fratercula corniculata and Lunda cirrhata), Sealy's (1973) work will be of considerable value as will be the work of Nettleship (1972) on the Atlantic Puffin (Fratercula arctica).

Table 1. Selected references on the biology of individual species.

Fulmar (<u>Fulmarus glacialis</u>)

Author and date	Location	Presence	Ecology	Phenology	Reproductive success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	not present	-	-	-	-	-	-
	Walrus Is.	not present	-	-	-	-	-	-
	Otter Is.	abundant	-	egg dates	-	-	-	-
	St. George	abundant	-	egg dates	-	-	-	-
Bent, 1922	Pribilofs	present	poor	poor	-	-	fair	fair
Preble and McAtee, 1923	St. Paul	present	-	fair	-	-	-	-
	Walrus	-	-	-	-	-	-	-
	Otter Is.	present	-	-	-	-	-	-
	St. George	abundant	-	fair	-	-	19 stomachs	-
Fisher, 1952	various			have yet to check out in detail				
Gabrielson and Lincoln, 1959	Pribilofs	present	-	-	-	-	-	-
Thompson, 1966	St. George	census	-	poor	-	-	-	-
Coulson and Horobin, 1972	England	-	-	good	-	-	-	-
Shuntov, 1972	various	-	fair	-	-	-	fair	fair

Red-faced Cormorant (<u>Phalacrocorax urile</u>)

Author and date	Location	Presence	Ecology	Phenology	Reproductive success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	few	-	-	-	-	-	-
	Walrus	present	-	egg dates	-	-	-	-
	Otter	present	-	-	-	-	-	-
	St. George	present	-	-	-	-	-	-
Bent, 1922	Walrus	present	poor	fair	-	-	-	-
Preble and McAtee, 1923	Pribilofs	common	-	fair	-	-	6 stomachs	-
Gabrielson and Lincoln, 1959	Pribilofs	present	-	-	-	-	-	-
Thompson, 1964	St. Paul & St. George	common	-	poor	-	-	-	-
Thompson, 1965	St. George	common	-	poor	-	-	-	-
Thompson, 1966	St. George	present	-	poor	-	-	-	-
Dick and Dick, 1971	Cape Pierce	uncommon	-	fair	-	-	1 stomach	-

Black-legged Kittiwake (*Rissa tridactyla*)

Author and date	Location	Presence	Ecology	Phenology	Reproductive success	Growth rates	Foods used	Foraging Behavior
Palmer 1899	Pribilofs	abundant	-	fair	-	-	-	-
Bent, 1921	Pribilofs	common	-	fair	-	-	poor	poor
Preble and McAtee, 1923	Pribilofs	abundant	-	good	-	-	3 stomachs	-
Coulson and White, 1956	England	-	good	good	-	-	-	-
Belopolskii, 1957	Barents Sea	-	good	good	fair	good	468 stomachs	good
Gabrielson and Lincoln, 1959	Pribilofs	abundant	-	-	-	-	fair	fair
Coulson and White, 1960	England	-	fair	good	-	-	-	-
Thompson, 1964	Pribilofs	comparative data	-	fair	-	-	-	-
Kenyon and Phillips, 1965	St. Paul	partial census	-	good	-	-	-	-
Thompson, 1965	Pribilofs	-	-	fair	-	-	-	-
Coulson, 1966	England	-	good	good	good	-	-	-
Swartz, 1966	Cape Thompson	abundant	fair	good	good	-	115 adult stomachs 48 chicks	-
Thompson, 1966	Pribilofs	-	-	fair	-	-	-	-
Dick and Dick, 1971	Cape Pierce	abundant	fair	fair	fair	-	fair	good
Shuntov, 1972	various	-	fair	-	-	-	-	-

Red-legged Kittiwake (*Rissa brevirostris*)

Author and date	Location	Presence	Ecology	Phenology	Reproductive Success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	Pribilofs	present	-	egg dates	-	-	-	-
Bent, 1921	Pribilofs	present	fair	fair	-	-	-	-
Preble and McAtee, 1923	Pribilofs	some cam-parative data	fair	-	-	-	15 stomachs	-
Gabrielson and Lincoln, 1959	Pribilofs	present	fair	-	-	-	fair	fair
Thompson, 1964	Pribilofs	comparative data	-	poor	-	-	-	-
Kenyon and Phillips, 1965	St. Paul	partial census	fair	good	-	-	-	-
Thompson, 1965	Pribilofs	-	-	fair	-	-	-	-
Thompson, 1966	Pribilofs	-	-	fair	-	-	-	-

Common Murre (Uria aalge)

Author and Date	Location	Presence	Ecology	Phenology	Reproductive success	Growth rates	Foods used	Foraging Habits
Palmer, 1899	St. Paul	small #	-	-	-	-	-	-
	Walrus	abundant	-	fair	-	-	-	-
	Otter	-	-	-	-	-	-	-
	St. George	small #	-	-	-	-	-	-
Bent, 1919	Pribilofs	present	-	-	-	-	-	-
Preble and McAtee	Pribilofs	abundant	-	fair	-	-	18 stomachs	-
Belopolskii, 1957	Barents Sea	-	good	good	-	good	223 stomachs	-
Tschanz, 1958	Norway	-	good	-	-	-	-	-
Gabrielson and Lincoln, 1959	Pribilofs	common	-	-	-	-	-	poor
Tuck, 1960	various	-	good	good	-	good	44 stomachs	fair
Thompson, 1964	Pribilofs	uncommon	-	-	-	-	-	-
Kenyon and Phillips, 1965	Walrus	status report	-	-	-	-	-	-
Thompson, 1965	St. George	relative abundance	-	-	-	-	-	-
Swartz, 1966	Cape Thompson	-	good	good	fair	fair	84 adults 2 chicks	-
Thompson, 1966	St. George	common	-	-	-	-	-	good comment
Dick and Dick, 1971	Cape Pierce	abundant	fair	good	poor	-	-	good
Spring, 1971	-	-	good	-	-	-	-	-
Shuntov, 1972	various	-	-	-	-	-	-	-
Williams, 1974	Norway	-	good	-	-	-	-	-

Thick-billed Murre (Uria lomnia)

Author and date	Location	Presence	Ecology	Phenology	Reproductive Success	Growth rates	Foods used	Foraging Habits
Palmer, 1899	St. Paul	-	-	-	-	-	-	-
	Walrus	partial census	-	poor	-	-	-	-
	Otter	-	-	-	-	-	-	-
	St. George	partial census	-	-	-	-	-	-
Bent, 1919	Walrus	present	-	-	-	-	-	-
Preble and McAtee, 1923	Pribilofs	abundant	-	fair	-	-	6 stomachs	-
Belpolskii, 1957	Barents Sea	-	good	good	-	good	499 stomachs	-
Gabrielson and Lincoln, 1959	Pribilofs	present	-	-	-	-	-	-
Tuck, 1960	various	-	good	good	good	good	excellent	fair
Thompson, 1964	Pribilofs	abundant	-	poor	-	-	-	-
Thompson, 1965	St. George	counts	-	poor	-	-	-	-
Swartz, 1966	Cape Thompson	-	good	good	fair	fair	176 stomachs	-
Thompson, 1966	St. George	-	-	poor	-	-	-	fair
Dick and Dick, 1971	Cape Pierce	not mentioned - apparently not present (??)						
Spring, 1971	-	-	good	-	-	-	-	-
Shuntov, 1972	various	-	-	-	-	-	-	-
Williams, 1974	Norway	-	good	-	-	-	-	-

Parakeet Auklet (Cyclorrhynchus psittacula)

Author and date	Location	Presence	Ecology	Phenology	Reproductive success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	present	fair	-	-	-	-	-
	Walrus	present	fair	egg dates	-	-	-	-
	Otter	present	-	-	-	-	-	-
	St. George	abundant	fair	egg dates	-	-	-	-
Bent, 1919	Pribilofs	present	fair	-	-	-	poor	-
Preble and McAtee, 1923	Pribilofs	common	fair	good	-	-	1 stomach	-
Gabrielson and Lincoln, 1959	Pribilofs	abundant	-	-	-	-	-	-
Thompson, 1964	Pribilof	common	-	-	-	-	-	-
Thompson, 1965	St. George	uncommon	-	-	-	-	-	-
Thompson, 1966	St. George	uncommon	-	-	-	-	-	-
Bedard, 1969a	St. Lawrence Is.	-	-	-	-	-	good	good
Bedard, 1969b	St. Lawrence Is.	-	good	-	-	-	-	-
Sealy and Bedard, 1973	St. Lawrence Is.	-	good	good	-	good	-	-

Crested Auklet (*Aethia cristatella*)

Author and date	Location	Presence	Ecology	Phenology	Reproductive Success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	-	-	-	-	-	-	-
	Walrus	-	-	-	-	-	-	-
	Otter	present	-	-	-	-	-	-
	St. George	common	-	egg dates	-	-	-	-
Bent, 1919	Pribilofs	-	fair	poor	-	-	poor	-
Preble and McAtee, 1923	Pribilofs	fairly common	fair	good	-	-	7 stomachs	-
Gabielson and Lincoln, 1959	Pribilofs	incredible numbers	-	poor	-	-	-	-
Thompson, 1964	Pribilofs	localized not common	-	-	-	-	-	-
Thompson, 1965	St. George	fairly common	-	-	-	-	-	-
Thompson, 1966	St. George	abundant	-	-	-	-	-	-
Bedard, 1969a	St. Lawrence	-	-	-	-	-	good	good
Bedard, 1969b	St. Lawrence	counted	good	-	-	-	-	-

Least Auklet (Aethia pusilla)

Author and date	Location	Presence	Ecology	Phenology	Reproductive Success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	abundant	-	egg dates	-	-	-	-
	Walrus	-	-	-	-	-	-	-
	Otter	-	-	-	-	-	-	-
	St. George	abundant	-	egg dates	-	-	-	-
Bent, 1919	St. Paul	abundant	fair	-	-	-	poor	-
	Walrus	common	fair	egg dates	-	-	poor	-
	St. George	abundant	-	-	-	-	poor	-
Preble and McAtee, 1923	Pribilofs	excessively abundant	fair	good	-	-	-	-
Gabrielson and Lincoln, 1959	Pribilofs	abundant	-	poor	-	-	-	-
Thompson, 1964	Pribilofs	abundant	fair	-	-	-	-	-
Thompson, 1965	St. George	abundant	-	poor	-	-	-	-
Thompson, 1966	St. George	10 million	-	fair	-	-	-	-
Bedard, 1969a	St. Lawrence	-	-	-	-	-	good	good
Bedard, 1969b	St. Lawrence	courtship	good	-	-	-	-	-

Horned Puffin (<u>Fratercula corniculata</u>)

Author and date	Location	Presence	Ecology	Phenology	Reproductive Success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	present	-	-	-	-	-	-
	Walrus	-	-	-	-	-	-	-
	Otter	-	-	-	-	-	-	-
	St. George	abundant	-	egg dates	-	-	-	-
Bent, 1919	various	-	fair	-	-	-	fair	fair
Preble and McAtee, 1923	Pribilofs	abundant	fair	good	-	-	1 stomach	-
Gabrielson and Lincoln, 1959	Pribilofs	present	-	-	-	-	-	-
Thompson, 1964	Pribilofs	common	-	-	-	-	-	-
Thompson, 1965	St. George	common	-	-	-	-	-	-
Swartz, 1966	Cape Thompson	-	fair	poor	poor	-	17 stomachs	-
Thompson, 1966	St. George	common	poor	-	-	-	-	-
Dick and Dick, 1971	Cape Pierce	500-1500 pairs	fair	poor	-	-	-	-
Sealy, 1973	St. Lawrence	1,500 pair	good	fair	-	poor	-	-

Tufted Puffin (<u>Lunda cirrhota</u>)

Author and date	Location	Presence	Ecology	Phenology	Reproductive Success	Growth rates	Foods used	Foraging Behavior
Palmer, 1899	St. Paul	present	-	-	-	-	-	-
	Walrus	present	fair	egg dates	-	-	-	-
	Otter	present	-	egg dates	-	-	-	-
	St. George	-	-	-	-	-	-	-
Bent, 1919	St. Paul	-	-	-	-	-	-	-
	Walrus	numerous	fair	-	-	-	fair	fair
Preble and McAtee, 1923	Pribilofs	abundant	fair	good	-	-	-	-
Gabrielson and Lincoln, 1959	Pribilofs	-	-	-	-	-	-	-
Thompson, 1964	Pribilofs	common	-	-	-	-	-	-
Thompson, 1965	St. George	very few	-	-	-	-	-	-
Swartz, 1966	Cape Thompson	-	-	-	-	-	2 stomachs	-
Thompson, 1966	St. George	less common than horned	-	-	-	-	-	-
Dick and Dick, 1971	Cape Pierce	10,000 pairs	-	poor	-	-	-	-
Sealy, 1975	St. Lawrence	500 pairs	good	fair	-	-	-	-

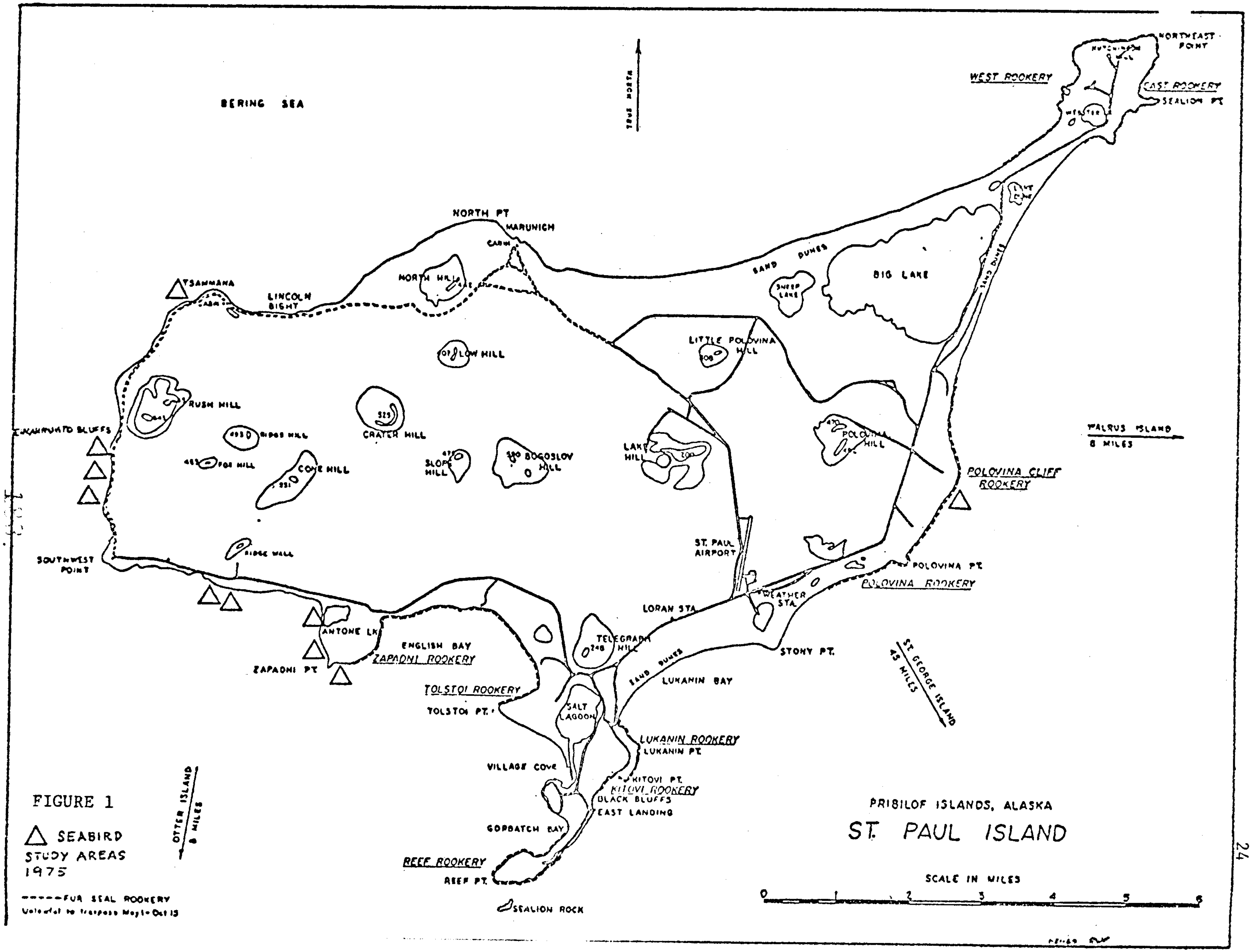
IV. Study Areas

The reproductive studies were conducted on St. Paul and St. George Islands in the Pribilof Islands, Alaska. The ten study sites on St. Paul and the one study site on St. George are marked on Figures 1 and 2, respectively. In Figure 1, the study areas between Southwest Point and Einahnuhto Bluffs are referred to as "Southwest Cliffs" in this study. Areas referred to as "Ridge Wall Cliffs" are coastal cliffs in the vicinity of Ridge Wall which itself is inland. In Figure 2, the Red-legged Kittiwake study area was located just east of the Staraya Artel Seal Rookery, which is not labeled on this map.

For the study of foraging areas at sea, a four day cruise was scheduled on the Discoverer.

The proposed ship track for the Discoverer cruise is presented in Figure 3. Once the cruise began a number of changes were made in the days that certain areas were covered and in some of the tracklines themselves, although in general the original plan was followed. As of this writing information on the exact route and timing of the ship's positions has not yet been sent to our group from Alaska.

An approximation of the route followed is possible, however, for the ship's position was recorded on many of the observation records. Figure 4 presents the areas covered by the ship. For the purpose of preliminary data analysis the area is divided into grid blocks 10' x 10'. These grid blocks are divided into three groups: Island, Continental Shelf and Continental Shelf Edge grid blocks. Island grid blocks are those in which the ship's course passed within



BERING SEA
TRUE NORTH
NORTHEAST POINT
HUTCHINSON HILL
WEST ROOKERY
EAST ROOKERY
SEALION PT.
NORTH PT
MARUNICH
CAIRN
NORTH HILL
TSAMMANA
LINCOLN BIGHT
SAND DUNES
SHEEP LAKE
BIG LAKE
LITTLE POLOVINA HILL
LOW HILL
RUSH HILL
CRATER HILL
RIDGE HILL
FOX HILL
CONE HILL
SLOPE HILL
BOGOSLOV HILL
LAKE HILL
POLOVINA HILL
WALRUS ISLAND
8 MILES
POLOVINA CLIFF ROOKERY
ST. PAUL AIRPORT
SOUTHWEST POINT
POLOVINA PT.
POLOVINA ROOKERY
WEATHER STA.
LORAN STA
ANTONE LK
ENGLISH BAY
ZAPADNI ROOKERY
ZAPADNI PT.
TELEGRAPH HILL
STONY PT.
ST GEORGE ISLAND
45 MILES
LUKANIN BAY
TOLSTOI ROOKERY
TOLSTOI PT.
SALT LAGOON
LUKANIN ROOKERY
LUKANIN PT.
OTTER ISLAND
6 MILES
VILLAGE COVE
KITOVI PT.
KITOVI ROOKERY
BLACK BLUFFS
EAST LANDING
GORBATCH BAY
REEF ROOKERY
REEF PT.
SEALION ROCK
PRIBILOF ISLANDS, ALASKA
ST. PAUL ISLAND
SCALE IN MILES
0 1 2 3 4 5 6
SEABIRD STUDY AREAS 1975
FUR SEAL ROOKERY
Unlawful to trespass May 1 - Oct 15

FIGURE 1

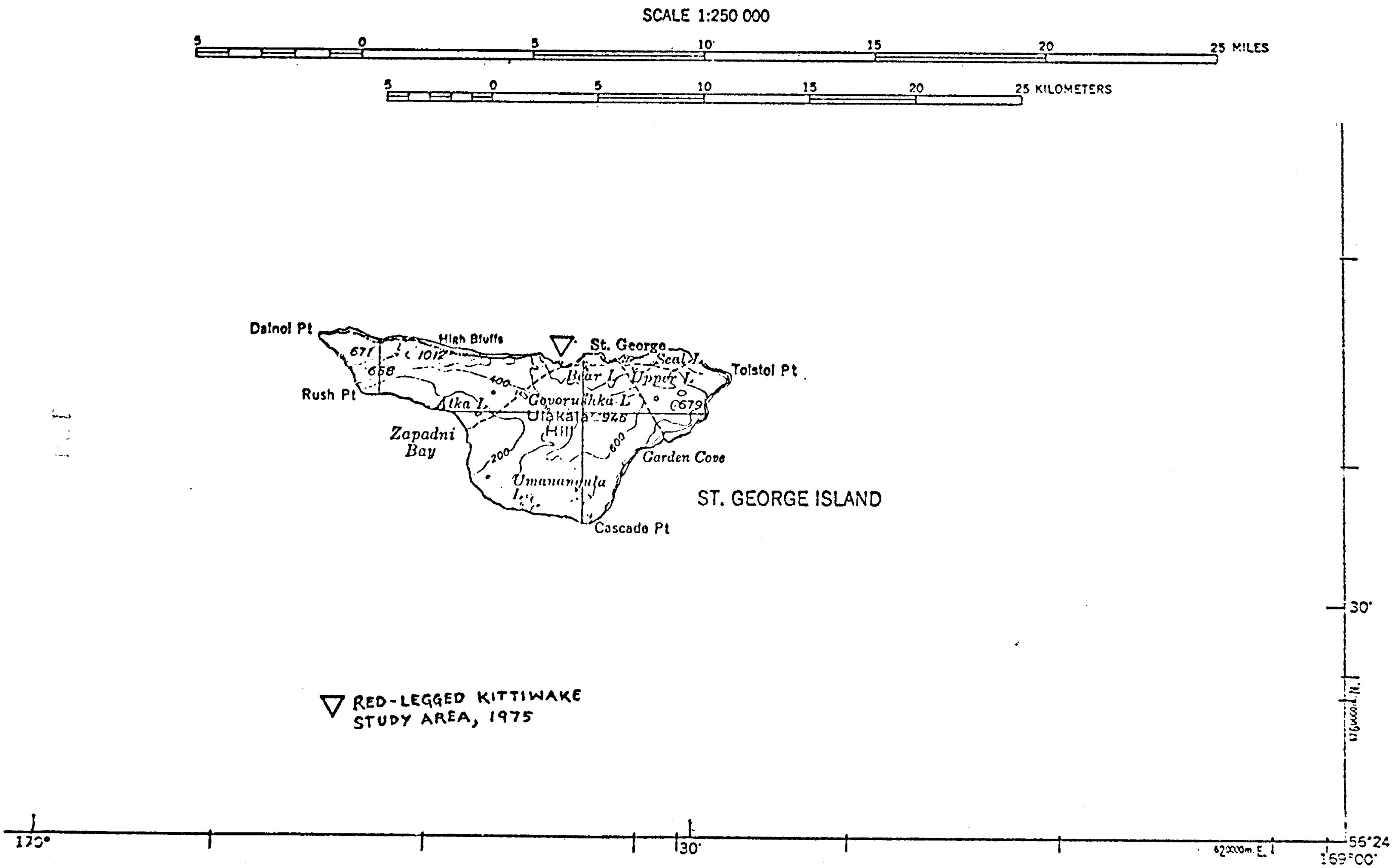

SCALE 1:250 000
25 MILES
25 KILOMETERS
Dalnoi Pt
High Bluffs
St. George
Tolstoi Pt
Rush Pt
Zapadni Bay
Garden Cove
Cascade Pt
ST. GEORGE ISLAND
RED-LEGGED KITTIWAKE STUDY AREA, 1975

FIGURE 2

FIGURE 3

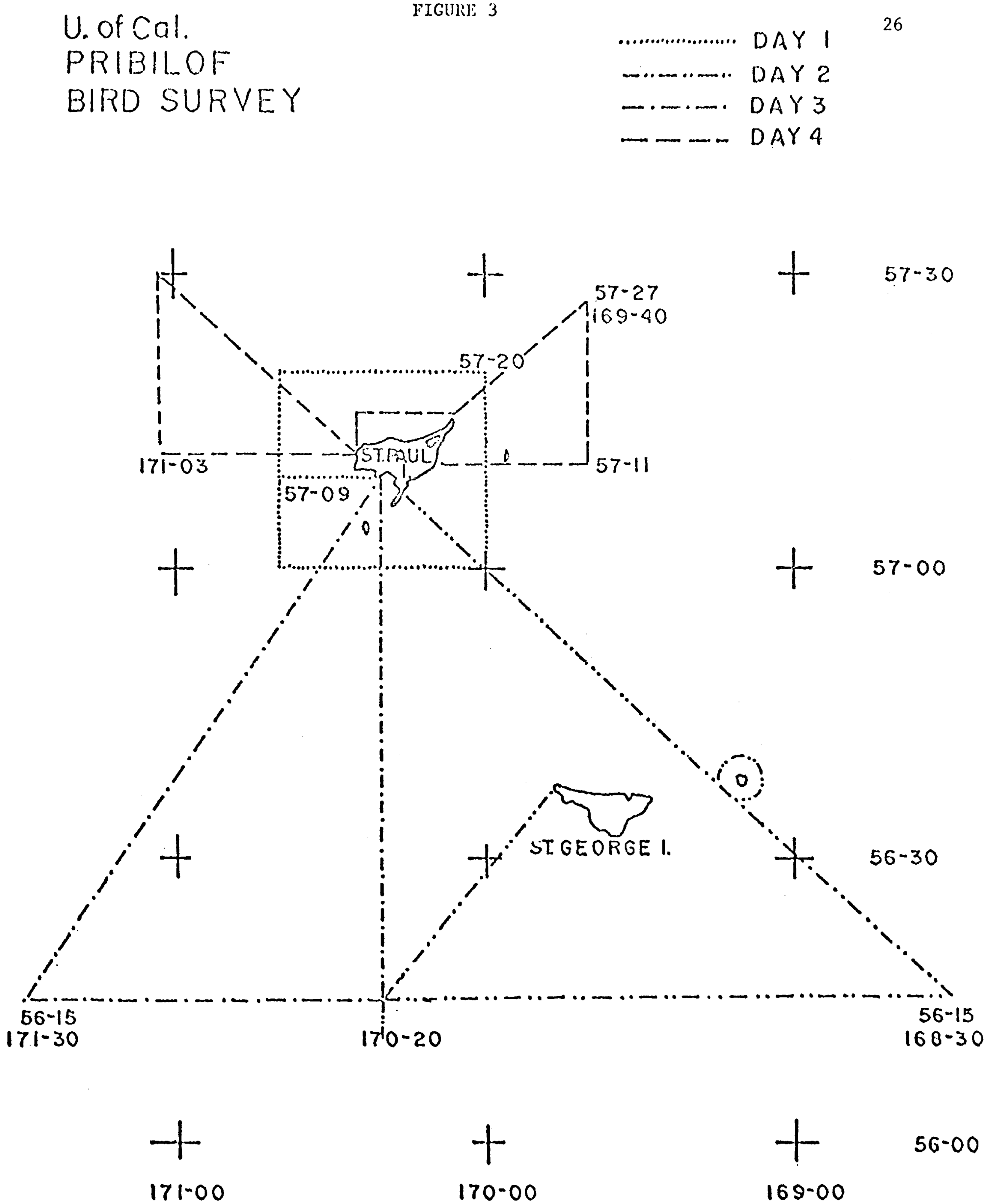
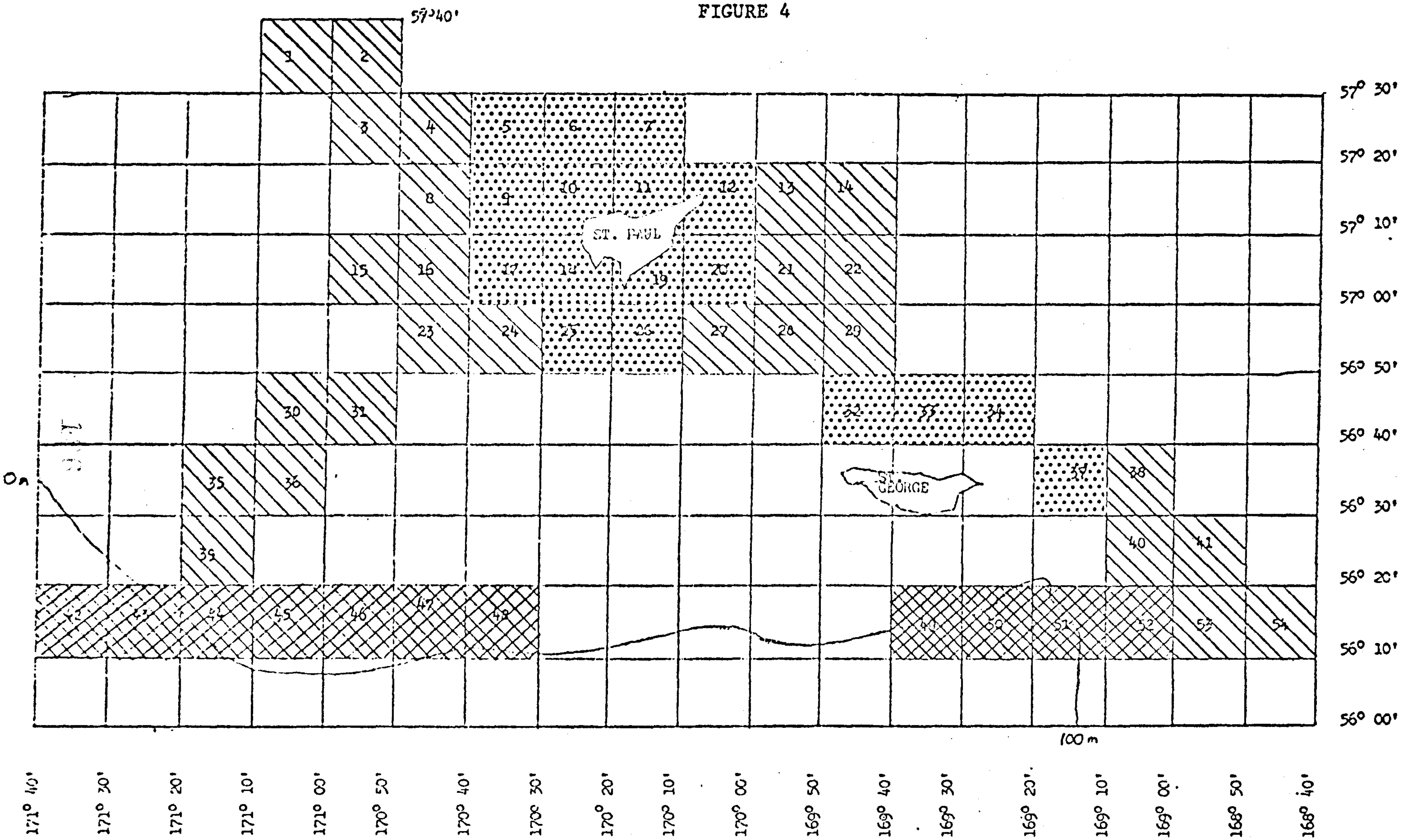

U. of Cal.
PRIBILOF
BIRD SURVEY
DAY 1
DAY 2
DAY 3
DAY 4
57-30
57-27
169-40
57-20
ST. PAUL
171-03
57-11
57-09
57-00
ST. GEORGE I.
56-30
56-15
171-30
170-20
56-15
168-30
56-00
171-00
170-00
169-00

FIGURE 4



Location and Numbering of Grid Blocks Visited on Cruise of U.S.C.G.S. Discoverer 20 VIII 1975 - 23 VIII 1975. All longitudes are west of the Greenwich Meridian.

Island Grid Block — Continental Shelf Grid Block — Continental Shelf Edge Grid Block

See text for explanation of grid block classifications.

10 nautical miles of St. Paul or St. George Islands. Likewise, Continental Shelf Edge grid blocks are those in which the ship came within 10 nautical miles of the shelf edge (the 100 m depth line in Fig. 4 is approximate). All remaining grid blocks were over the Continental Shelf itself.

V. Methods

1. Rationale

Several variables which influence reproductive success and growth rates impinge on any natural study. These variables include: 1) year to year changes in the ecosystem, 2) variations in the exposure of different nest sites, and 3) variations in the age and experience of the nesting individuals being studied.

Variable 1, year to year variation can only be understood by a multiple year study; one year's efforts represent but a single data point for understanding the input of this variable. The possible distortions that variables 2 and 3 might cause to a baseline study can be minimized within a single year's study by choosing a sufficiently large number of subsampling areas and by following the success of an adequate number of nests in each area. The number of separate sites to be chosen will depend on the dispersal of nests and on local conditions. The number of nests to be studied in each area should be at least 15-20, if possible, so that individual variations and chance events will not unduely distort the results obtained.

2. Reproductive Success

Seabirds breeding on St. Paul Island either nest on cliff ledges or raise their young in holes and crevices in the cliffs or below ground among the rocks of boulder beaches. For those species which breed in the open (Common and Thick-billed Murres, Black-legged and Red-legged Kittiwakes, and Red-faced Cormorant), data on reproductive success can be obtained relatively easily by observation of many nests at a time from locations at the top or bottom of the cliffs. Accurate data on the hole-nesting species (Fulmars, in shallow caves, Tufted and Horned Puffins, and Crested, Least and Parakeet Auklets) must be obtained by looking into each nest individually.

The basic techniques for obtaining data on the reproductive success of the five ledge-nesting species and the Horned Puffin were to locate nests, number them individually, and count the eggs or chicks contained in those nests usually every three to seven days, either until chicks fledged and left the nest or until total egg or chick loss occurred. In order to get a good count of eggs and small chicks of ledge-nesting species near the cliff tops, adult birds reluctant to leave their nests often had to be scared off by shouting or by dangling a rope over the cliff edge. In working with the two murre species it was imperative that the birds not be scared suddenly in order to minimize egg and chick loss. Murres were gradually alerted to our presence so that they would move slowly away from eggs or chicks before they left their nesting ledges. As a result of our using this technique very few eggs or chicks were lost due to our activities. Egg and chick counts for the Horned Puffin, for part of the Black-legged Kittiwake sample on St. Paul Island and for the sample of Red-legged Kittiwakes on St. George Island were made by using a ladder at the bottom of the cliff to reach into nests and nesting holes in the cliff.

For the two Kittiwake species and the Red-faced Cormorant the sample of nests included some which could only be viewed from below, and consequently counts of eggs and tiny chicks were impossible. However, data from these nests were used to calculate both fledging success and approximate egg-laying dates, as large chicks or incubating parents could be easily seen.

In addition to counts of eggs and chicks for individual pairs of Common and Thick-billed Murres, certain ledges were chosen for study on which many birds bred and where it was impossible to tell individual eggs or chicks apart. In these areas the largest number of eggs and chicks on each ledge was used to calculate hatching and fledging success. While these figures represent the maximum possible breeding success for those pairs rather than the exact percentages, the data provide a useful comparison with the sample of individual nests, particularly for the Common Murres. In this species nesting is usually in large aggregations on wide ledges and the individual nests which we had to work with in order to get accurate data may not have been entirely representative of the population as a whole.

All probable nest sites located for Fulmars, Tufted Puffins and Crested Auklets were inaccessible. While most Fulmar nests were located in shallow caves, six nests were found on open ledges and progress of chicks in these nests could be followed from the top of the cliff. No accessible nest sites of the Parakeet Auklet were located until the end of their breeding season in 1975, but we feel that in the 1976 season we will be able to document Parakeet Auklet reproductive success.

The most common nesting location for Least Auklets is one to two feet below the surface of the ground between the rocks of boulder beaches. In digging to check nest contents, it is inevitable that the nest itself is destroyed. We dug up only one such nest which was located by the noises made by the chick. Two other accessible nests located in small holes in a cliff could be reached by using a ladder.

Data were taken on colony attendance by cliff nesting species over a cycle of 36 hours by counting every three hours the numbers of Murres and Black-legged Kittiwakes present.

3. Growth Rates

Growth rates of young seabirds have been shown in past studies to be strongly correlated with fledging success (Hunt, 1972, Hunt and Hunt, 1975, in press).

Data on growth rates of the chicks of five species (Thick-billed Murre, Black-legged and Red-legged Kittiwakes, Red-faced Cormorant and Horned Puffin) were obtained by weighing chicks periodically, usually at least twice a week. Chicks were placed in cloth bags and weighed with Pesola spring scales (300 g to 5 kg capacity, depending on the species and the size of the chick). The weight of the bag and of any food regurgitated by the chick were subtracted from the total weight to obtain the weight of the chick.

In all of the above species with the exception of the Thick-billed Murre the typical growth pattern is a period of rapid and steady weight gain followed by either a plateau or a slight decline in weight prior to fledging. In these cases the growth rate for the straight-line portion of the growth curve was calculated by the formula: $$\frac{\text{weight}_2 - \text{weight}_1}{\text{day}_2 - \text{day}_1}$$

where the gain in weight between the first weighing and the peak weight is divided by the number of intervening days, yielding an average number of grams gained per day.

4. Food Sampling

Information on foods were obtained in four ways: (1) The birds were shot with a 16 gauge shot gun and their stomachs were removed and opened, (2) Chick regurgitation was collected, (3) Adult Least Auklets were captured in mist nets, and their regurgitation collected, (4) Photographs were taken of birds (principally the Common and Thick-billed Murres) that held fish in their bills prior to feeding their young.

Birds of several species were collected once or twice each week for 3-4 hours per session. On the average, 10-15 birds were killed each week. The stomachs were removed from each bird for future content analysis. Each bird was skinned for use as a study skin or museum skeleton. The skinning process was quite time consuming, requiring 1/2 - 3/4 hours per bird.

As the field season progressed and chicks began hatching, we were able to obtain food samples from Black-legged Kittiwake, Red-legged Kittiwake, and Red-faced Cormorant chicks. Chicks often regurgitated while being wèighted, and during August and September samples from these species were obtained entirely by this method of collection from chicks rather than by shooting. We continued to shoot puffins, murres, and Parakeet Auklets during this time, but collected samples from Least Auklets by mist-netting adults returning in the evening with food for their chicks. A bird containing food in its gular pouch would regurgitate as soon as it hit the net.

Food samples were preserved in plastic Whirl-pak bags in 70% ethanol, and labeled as to sample number, species, island and date collected.

5. Distribution of Foraging Seabirds

Two members of the research team participated in four days of pelagic seabird observations on board the USCGSS Discoverer (OSS 022). D. Causey and D. Schwartz conducted continuous censuses of seabirds from dawn to dusk from 20 through 23 August 1975.

Observations when the ship was moving were usually conducted by one observer who stood on the starboard side of the flying bridge (eye level 21 m above the water surface). The birds were recorded by numbers and location in one of three 100 meter segments parallel to the ship's course out to 300 meters from the ship. A course register and meteorological log were kept during all observations.

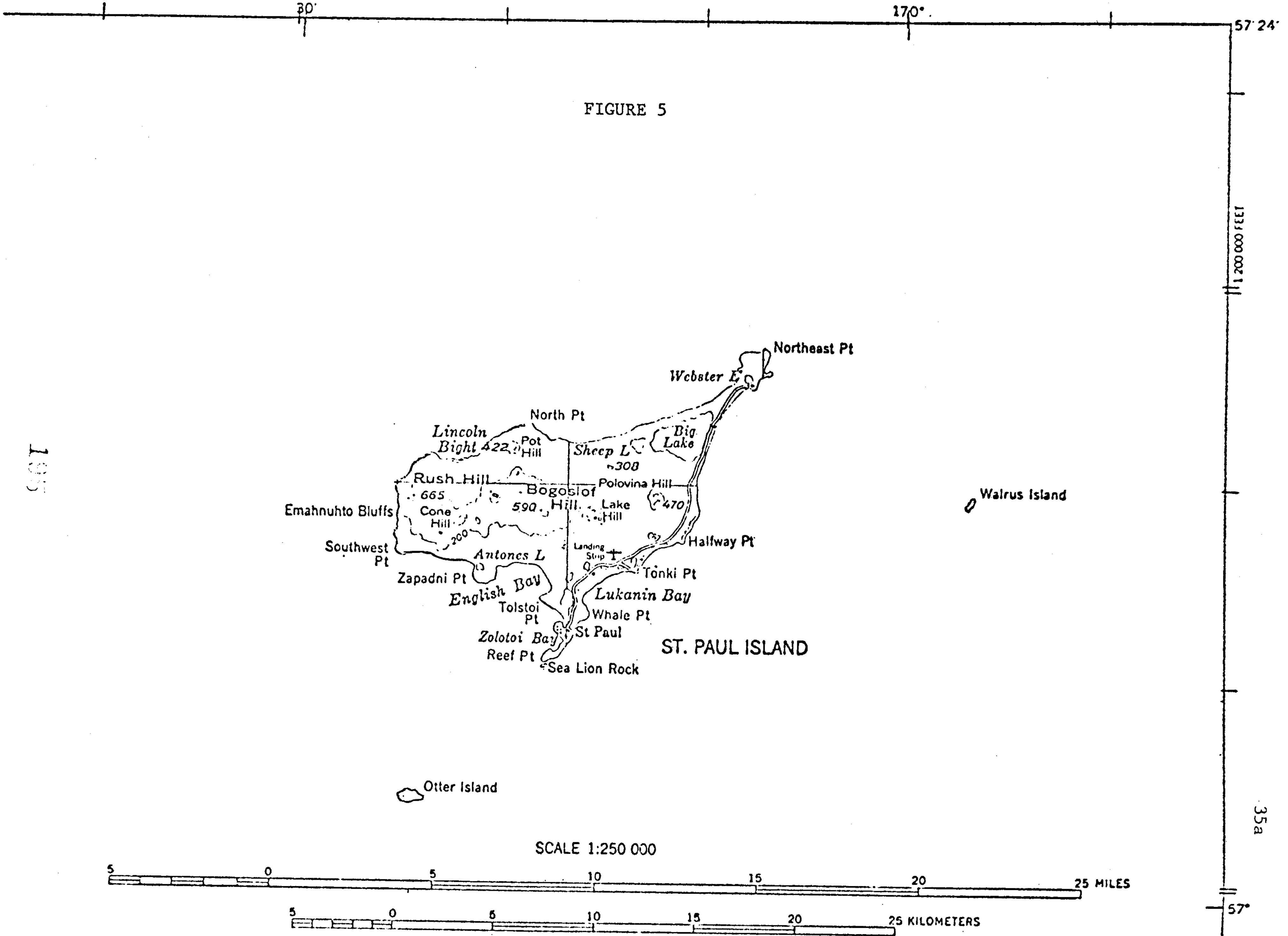
Oceanographic stations were made at the completion of a two hour transect segment and in most cases, a Vertical Plankton Tow with a one meter net and a Tucker Trawl were made by other scientists on the ship. These plankton samples will be analyzed by Dr. Ted Cooney at the University of Alaska, who has agreed to provide us with his results. During the oceanographic stations seabird observations were made from the middle of the flying bridge. The observer faced the bow of the ship and recorded birds by number and location in each of three concentric 100 meter wide semicircles around the ship's bow. A diagram of the viewing areas accompanied the observation sheet.

During all transects and stations, care was taken to ensure that observations were of a natural situation and not that influenced by the ship's presence in the water. Garbage and refuse was dumped only at the completion of the observations (23 August 1975), and a radar watch was kept for foreign and domestic fishing vessels within the radar range (50 nautical miles). Effort was made not to count circling or following birds more than once.

6. Survey of Otter and Walrus Islands

A brief survey of Otter and Walrus Islands (Figure 5) was conducted by M. Hunt and L. Holmgren using a Coast Guard helicopter on 9 August, an unusually bright and clear day. The main purpose of the flight was to census by photography a colony of Common Murres reported breeding in large numbers on Walrus Island early in the century, which had by 1954 declined in size due to crowding by Steller's Sea Lions. Each island was circled twice at an altitude of 800 feet with the helicopter staying approximately 500 feet out from the edge of Walrus Island and 1,000 feet out from the cliffs of Otter Island. Slides were taken using High-speed Ectachrome film in a Nikon camera with an 80-200 mm zoom lens.

FIGURE 5


30'
170°
57°24'
57°
Northeast Pt
Webster L
North Pt
Lincoln
Bight
422
Pot
Hill
Sheep L
Big
Lake
308
Rush Hill
665
Bogoslof
Hill
590
Polovina Hill
470
Lake
Hill
Emahnuhto Bluffs
Cone
Hill
200
Walrus Island
Southwest
Pt
Antones L
Landing
Strip
Halfway Pt
Zapadni Pt
Tonki Pt
English Bay
Lukanin Bay
Tolstoi
Pt
Whale Pt
Zolotoi Bay
St Paul
Reef Pt
Sea Lion Rock
ST. PAUL ISLAND
Otter Island
SCALE 1:250 000
5
0
5
10
15
20
25 MILES
5
0
5
10
15
20
25 KILOMETERS

VI. Results

A. Data Collected

Table 2 indicates the dates on which reproductive data were collected for each species at each study site. Included in this table are days on which counts were made of breeding birds on the cliffs as well as days of nest checks and chick weighings.

Table 3 provides a numerical summary of the different types of data gathered during the 1975 season.

B. Reproductive Success

1. Fulmar (Fulmarus glacialis).

Pairs of Fulmars on St. Paul nest almost exclusively in shallow caves on the high cliffs of the western end of the island. Observations from the clifftop of birds at 43 potential nest sites near the Einahnuhto Bluffs were begun in late June (see Table 2). These nest sites, all inaccessible to researchers, were located either on open ledges or, more frequently, in small caves in certain volcanic strata of the cliff face.

Two main problems encountered in this study were the lack of visibility into the caves and the fluctuations in both numbers of Fulmars seen and in their distribution in various areas of the cliff. On one large ledge numbers of Fulmars seen ranged from 8 to 18 on any given day, with birds usually in different positions from the previous observations. Other potential nest sites were occupied erratically. On the whole it was very difficult to ascertain which areas were actually nest sites. In 14 of the original potential nest locations, Fulmars were observed

TABLE 2

Dates and Locations of Colony Work

St. Paul and St. George Islands - 1975

All on St. Paul unless indicated otherwise	June 15	16	19	22	23	24	25	26	27	28	29	30
Red-faced Cormorant												
Tsammana							X					
Ridge Wall					X					X		X
Zapadni												
Polovina				X							X	
Black-legged Kittiwake												
Tsammana							X					
Ridge Wall												
Zapadni	X	X	X									
Red-legged Kittiwake												
Tsammana							X					
Southwest Cliffs			X						X	X		
Ridge Wall												
Zapadni	X	X										
Staraya Artel-St. George Is.												
Fulmar												
Southwest Cliffs												
Horned Puffin												
Tsammana						X	X					
Southwest Cliffs			X				X		X	X		
Ridge Wall					X							X
Zapadni	X	X										
Tufted Puffin												
Southwest Cliffs			X						X	X		
Ridge Wall					X							X
Zapadni	X	X										
Least Auklet												
Ridge Wall												
Zapadni	X	X			X			X				
Common Murre												
Tsammana												
Southwest Cliffs			X									
Ridge Wall												X
Zapadni	X	X	X									
Polovina												
Thick-Billed Murre												
Tsammana												
Southwest Cliffs			X									
Ridge Wall												X
Zapadni	X	X	X									
Polovina												

TABLE 2 (continued)

All on St. Paul unless indicated otherwise	July 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Red-faced Cormorant																															
Tsammana		X							X							X					X			X		X				X	
Ridge Wall			X				X			X				X				X			X							X			X
Zapadni						X						X																			
Polovina					X					X					X				X			X				X				X	
Black-legged Kittiwake																															
Tsammana		X							X							X			X		X			X		X				X	
Ridge Wall							X			X				X				X			X							X			X
Zapadni						X						X																			
Red-legged Kittiwake																															
Tsammana		X							X							X			X		X			X		X				X	
Southwest Cliffs					X					X								X			X										
Ridge Wall			X				X			X				X				X			X							X			X
Zapadni						X						X																			
Staraya Artel-St. George Is.																								X			X			X	
Fulmar																															
Southwest Cliffs										X								X			X										
Horned Puffin																															
Tsammana		X							X							X								X							
Southwest Cliffs					X																										
Ridge Wall			X				X					X		X			X		X				X								
Zapadni																															
Tufted Puffin																															
Southwest Cliffs					X																										
Ridge Wall			X				X					X		X			X		X				X								
Zapadni																															
Least Auklet																															
Ridge Wall														X			X														
Zapadni															X																
Common Murre																															
Tsammana		X							X							X			X		X		X	X		X				X	
Southwest Cliffs					X		X			X		X		X			X		X		X		X					X			X
Ridge Wall							X			X		X		X			X		X		X		X					X			X
Zapadni																															
Polovina					X					X		X			X				X			X	X			X				X	
Thick-Billed Murre																															
Tsammana		X							X							X			X		X		X	X		X				X	
Southwest Cliffs					X		X			X		X		X			X		X		X		X					X			X
Ridge Wall							X			X		X		X			X		X		X		X					X			X
Zapadni																								X				X		X	
Polovina					X					X		X			X				X			X	X			X				X	

TABLE 2 (continued)

All on St. Paul unless indicated otherwise	August 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Red-faced Cormorant																															
Tsammana		X					X						X					X		X			X					X			
Ridge Wall		X		X							X			X							X	X					X				
Zapadni																						X									
Polovina		X				X				X				X						X					X					X	
Black-legged Kittiwake																															
Tsammana		X					X						X			X		X		X			X					X			
Ridge Wall		X		X							X			X							X	X					X				
Zapadni																						X									
Red-legged Kittiwake																															
Tsammana		X					X						X					X		X			X					X			
Southwest Cliffs														X								X									
Ridge Wall		X		X							X			X							X	X					X				
Zapadni																						X									
Staraya Artel-St. George Is.		X			X					X						X				X					X					X	
Fulmar																															
Southwest Cliffs														X								X									
Horned Puffin																															
Tsammana							X						X					X		X			X					X			
Southwest Cliffs																															
Ridge Wall				X							X							X			X						X	X			
Zapadni																															
Tufted Puffin																															
Southwest Cliffs																															
Ridge Wall				X																											
Zapadni																															
Least Auklet																															
Ridge Wall																		X			X						X				
Zapadni																															
Common Murre																															
Tsammana		X					X		X		X					X		X							X		X				
Southwest Cliffs		X				X			X					X		X		X		X		X			X		X		X		
Ridge Wall		X				X			X					X		X		X							X		X		X		
Zapadni																															
Polovina		X				X			X					X		X		X		X		X			X		X		X		
Thick-Billed Murre																															
Tsammana		X					X		X		X					X		X							X		X				
Southwest Cliffs		X				X			X					X		X		X	X	X		X			X		X		X		
Ridge Wall		X				X			X					X		X		X			X				X		X	X	X		
Zapadni		X				X			X					X																	
Polovina		X				X			X					X		X		X	X	X		X			X		X		X		

TABLE 2 (continued)

All on St. Paul unless indicated otherwise	September																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Red-faced Cormorant																														
Tsammana																														
Ridge Wall																														
Zapadni	X										X														X					
Polovina																X							X							
Black-legged Kittiwake																														
Tsammana	X				X								X																	
Ridge Wall	X									X											X									
Zapadni	X										X														X					
Red-legged Kittiwake																														
Tsammana	X																													
Southwest Cliffs	X																													
Ridge Wall	X									X											X									
Zapadni	X										X														X					
Staraya - Artel-St. George Is.			X																											
Fulmar																														
Southwest Cliffs	X																													
Horned Puffin																														
Tsammana	X				X								X																	
Southwest Cliffs																														
Ridge Wall	X				X													X					X				X			
Zapadni																														
Tufted Puffin																														
Southwest Cliffs																														
Ridge Wall																														
Zapadni																														
Least Auklet																														
Ridge Wall	X																													
Zapadni																														
Common Murre																														
Tsammana																														
Southwest Cliffs	X			X		X		X																						
Ridge Wall	X			X		X		X																						
Zapadni																														
Polovina	X			X		X		X																						
Thick-Billed Murre																														
Tsammana																														
Southwest Cliffs	X			X		X		X																						
Ridge Wall	X			X	X	X		X																						
Zapadni																														
Polovina	X			X		X		X																						

TABLE 3

Types of Data Collected, Pribilof Islands 1975

1. Work on the Islands

Breeding Species	Number of Days of Observations at Study Sites: St. Paul Island: Tsammana	Southwest Cliffs	Ridge Wall	Zapadni	Polovina	Staraya Artel St. George Is.	Total days observation	Number of nests observed	Number of chicks for growth data	Number of food samples collected
Fulmar	-	6	-	-	-	-	6	43	-	1
Red-faced Cormorant	15	-	19	6	18	-	58	83	8	37
Black-legged Kittiwake	20	-	17	9	-	-	46	185	34	123
Red-legged Kittiwake	17	10	18	8	-	11	64	51	18	12
Common Murre	17	27	24	3	24	-	95	49	-	21
Thick-billed Murre	17	27	27	10	25	-	106	89	7	20
Horned Puffin	15	5	20	2	-	-	42	11	8	4
Tufted Puffin	-	4	10	2	-	-	16	-	-	2
Crested Auklet	-	-	-	-	-	-	-	-	-	6
Least Auklet	-	-	6	5	-	-	11	-	-	52
Parakeet Auklet	-	-	-	-	-	-	-	-	-	8

2. Pelagic Seabird observations aboard the Discoverer

Days of observations	Total species seen	Total numbers of birds seen	km^2 surveyed
4	23	28,000	203

on all days that observations were made. Although no eggs were ever seen, in six of these locations chicks appeared and were observed consistently through the last observation. Hatching most likely occurred during the last week of July and the first week of August.

Unless better means of access to nests can be found, data on the breeding success of Fulmars on St. Paul will be at best sketchy.

2. Red-faced Cormorant (Phalacrocorax urile).

Red-faced Cormorant nests on St. Paul Island tended to be clumped on certain cliffs despite the apparent availability of potential nest sites in other areas. While nests of "nearest neighbor" cormorants were sometimes separated by ledges of murres and kittiwake nests, it was unusual to find a single cormorant nest farther than twenty meters from another one.

The largest aggregations of cormorant nests that could be easily observed were at Polovina Rookery Cliffs, Zapadni Point, Ridge Wall Cliffs and Tsammana. Scattered nests not included in the sample were also located at Tolstoi Point and along the cliffs of the west end of the island. The 88 nests under observation may well represent a major portion of the breeding population on St. Paul, perhaps as much as 50%. In the recent past cormorants bred near the village (Max Thompson, personal communication) in areas where they did not breed in 1975. This species is considered quite good to eat by the native Aleuts and it is possible that the small population size may be the result of shooting.

TABLE 4. Red-faced Cormorant Reproductive Success

St. Paul Island - 1975

	Total 88 nests	79 - 81 laying eggs	38 nests with reliable egg data (including no eggs laid)	33 nests with known clutch sizes
% laying eggs	89.8-92.0%	(100%)	86.8%	(100%)
range of clutch size	-	-	0-4	1-4
average clutch size	-	-	-	3.00
hatching success	-	-	-	38.4-44.4%
average number of chicks hatched/ nest with eggs	-	-	1.00-1.16 chicks	1.15-1.33 chicks
% of nests where ≥ 1 chicks fledged	-	65.4-69.6% (53-55 nests)	-	45.5% (15 nests)
% chicks fledged/ chicks hatched	-	-	-	59.1-68.4%
average number chicks fledged per nest	1.20-1.24 chicks	1.31-1.38 chicks	0.68 chicks	0.79 chicks
average number of chicks fledged/ nest for nests that fledged chicks	-	1.98 chicks (45 reliable nests) 2.0-2.06 (53 nests, some dubious)	-	1.73 chicks (15 nests)

One tiny chick was kicked from the nest when the parent was scared off, and two small chicks died in their nests of unknown causes. A large chick that was nearly fledged died after losing 770 grams in two weeks from a peak of 2,300 grams. Two broods may have lost young to foxes.

Table 4a shows the breeding success of cormorants at the four study areas. Birds at Polovina fared less well than those at other areas due to the placement of nests. The cliffs at Polovina are very low, and many nests were destroyed by waves during a storm in June.

Growth rates were obtained for eight cormorant chicks from three nests at Polovina and one at Ridge Wall. Weight at hatching is about 30 grams. The average growth rate in the straight-line portion of the growth curve was 61.8 $\pm$ S.D. 10.21 grams per day (range 48.5 - 72.8 g/day). Peak weights of chicks (at about five weeks of age) ranged from 1,700 to 2,300 grams, probably depending on the sex of the bird.

3. Black-legged Kittiwakes (Rissa tridactyla)

The Black-legged Kittiwake nests in profusion wherever nesting space is available on the cliffs of St. Paul. This species is almost certainly the next most abundant of the cliff-nesters after the murres.

Black-legged Kittiwake nests in three study sites were chosen either because of the ease of reaching them with a ladder (at Tsammana), or because of their proximity to Red-legged Kittiwake nests (at Zapadni and Ridge Wall cliffs) which, in a

Table 4a. Red-faced Cormorant Reproductive Success
St. Paul Island 1975

	Polovina	Ridge Wall	Zapadni	Tsammana
# nests	23	35	13	15
# nests where adults incubated	20	33	11	15
# nests known clutch size	19	4	0	10
Total # eggs	59	12	-	28
Average clutch size	3.11	3.00	-	2.80
# chicks hatched known clutch size	17	10	-	10
% hatching success	28.8*	83.3	-	35.7
Total young seen	19	69	21	21
Average # chicks seen/incubated nest	0.8*	2.1	1.9	1.4
# chicks fledged	17	57	18	15
% of incubated nests where at least 1 young fledged	50.0	78.8	72.7	60.0
Average # chicks fledged/incubated nest	0.85	1.73	1.64	1.00
Chicks fledged per egg laid	0.24	0.42	-	0.25
Chikcs fledged per nest built	0.74	1.63	1.38	1.00

*Lower hatching success due to destruction of many nests by waves comparison of these two closely related species, would control for possible differences in envirionmental factors affecting their nesting success.

Nests at the three study sites were followed from prior to egg-laying in June and early July until the chicks left the nests in September (Table 2). Of the three sites, the Tsammana study area yielded the most satisfactory data because nests were low enough to reach with a ladder in one section and close enough to the top of the cliff in another section that adults could usually be scared off their nests long enough for us to get an accurate count of eggs and small chicks. At Ridge Wall we viewed nests from the cliff top but were not able to get good egg counts in all nests. At the Zapadni site we viewed nests from the bottom of the cliff and egg counts were impossible, but the data obtained from there on fledging success were comparable with other areas.

Nesting and timing of breeding success of the Black-legged Kittiwake are presented in Tables 5 and 5a and Figure 6. Although many pairs laid two eggs, in most cases only one egg hatched; however, in other cases whether the second egg hatched is not known. In all nests where two chicks hatched, one chick was gone before the age of ten days. Chicks that fledge remain in the nest for about 40 days.

Causes of egg and chick loss in the Black-legged Kittiwake were undetermined for the most part. A few eggs did not hatch and were not incubated after the normal incubation period.

TABLE 5

Reproductive Success of

Black-legged Kittiwakes

St. Paul Island, AK - 1975

	Total 185 nests	149 nests known to have laid eggs	87 nests with known clutch size
% laying eggs	80.5% (149)	100% (149)	100% (87)
range of clutch size	0-2	1-2	1-2
average clutch size	-	-	1.44
hatching success	-	-	56.8% (71) - 67.2% (84)*
average number of chicks hatched/ nest with eggs			.82-.97 chicks*
% of nests where ≥ 1 chick fledged	-	54.4% (81)	55.2% (48)
% chicks fledged/ chicks hatched	-	-	67.6-57.1%*
average number chicks fledged per nest	.44 chicks (81)	.54 chicks (81)	.55 chicks
chicks fledged per egg laid	-	-	.38 chicks

* Depending on whether some second eggs hatched, see text.

Table 5a. Reproductive Success of Black-legged Kittiwakes
St. Paul Island 1975

	Ridge Wall	Tsammana I	Tsammana II	Zapadni
# nests	26	58	52	49
# nests where adults incubated	23	48	52	49
# nests with eggs and known clutch size	3	47	38	0
Total # eggs	4	67	53	-
Average clutch size	1.33	1.43	1.39	-
# chicks hatched of known clutch	3	41	32	-
% hatching success	75.0%	61.2%	60.4%	-
Total young seen	15	42	35	22
Average # chicks seen per incubated nest	.65	.88	.87	.58
# chicks fledged	13	27	22	20
% nests of all with eggs where at least one chick fledged	56.5	56.3	55.0	52.6
Average # chicks fledged per nest	.57	.56	.55	.53
Chicks fledged per egg laid (known clutch)	.75	.39	.36	-
Chicks fledged per nest built (including ½ built)	.50	.47	.42	.41

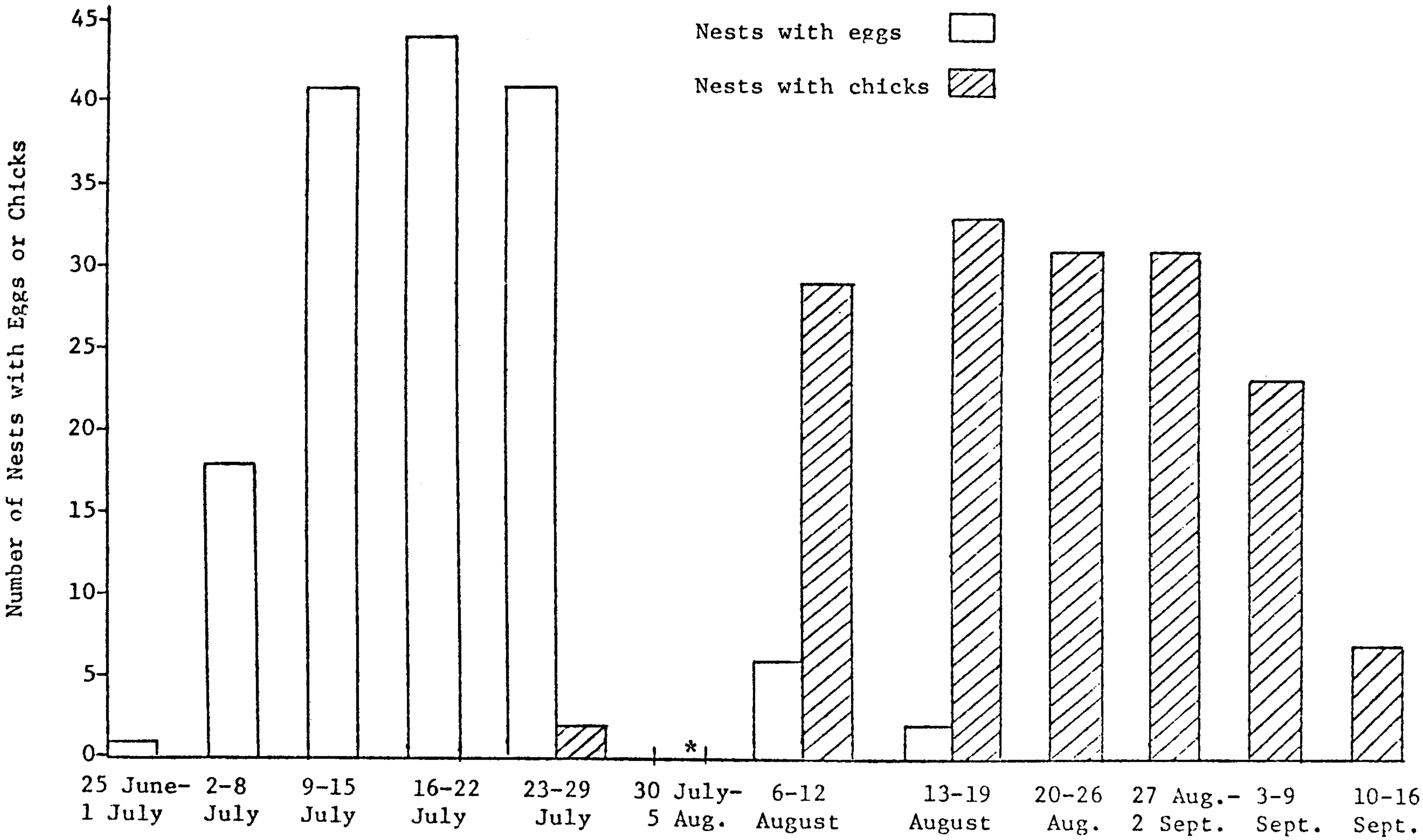
FIGURE 6

PRESENCE OF NESTS WITH EGGS OR CHICKS

BLACK-LEGGED KITTIWAKES

TSAMMANA STUDY AREA

ST. PAUL, ALASKA 1975

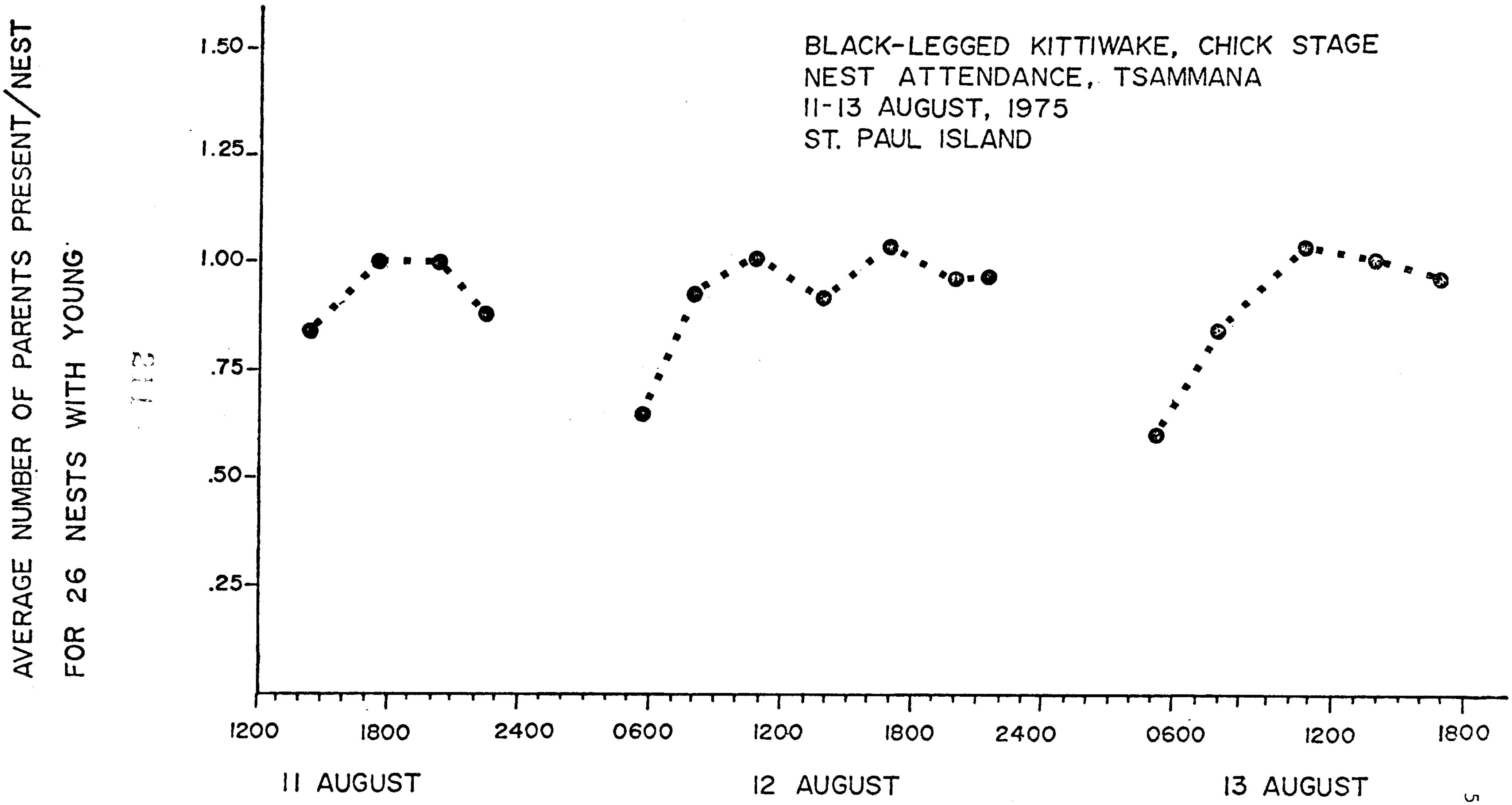


* Data from 30 July - 5 August is not available.

Some eggs disappeared before they should have hatched. A very few of these may have been taken by foxes in areas where the slope of the cliff was less than 90°. In several other cases the nest itself disintegrated and fell off the cliff. Chick mortality was probably due mostly to chicks falling out of the nest. In three cases chicks were found unhurt at the bottom of the cliff below their nests; these were counted as "dead" because they were unable to fly back to their nests and foxes soon would have found and eaten them. One chick died while being weighed.

The pattern of growth in the Black-legged Kittiwake chick is first a period of rapid weight gain from a hatching weight of 35-40 grams, followed by a plateau usually between 400 and 550 grams during which time most of the contour feather production takes place. Average peak weight is 484 grams (range 427-585 grams), and probably depends partly on the sex of the chick. The average growth rate during the straight-line portion of the growth curve for 34 chicks at Tsammana was 17.9 $\pm$ 3.4 grams/day gained (range 11.9 - 26.3 g/day). No statistical differences were found between the growth rates of chicks that survived (18.0 $\pm$ 3.7 g/day, n - 27) and those that died (17.7 $\pm$ 2.0 g/day, n = 7), principally because the chicks that died either disappeared when they were very small before a second weight for calculating growth rates could be obtained (n = 4), or died after reaching peak weight but before they were able to fly.

FIGURE 7



BLACK-LEGGED KITTIWAKE, CHICK STAGE
NEST ATTENDANCE, TSAMMANA
11-13 AUGUST, 1975
ST. PAUL ISLAND
AVERAGE NUMBER OF PARENTS PRESENT/NEST
FOR 26 NESTS WITH YOUNG
1.50
1.25
1.00
.75
.50
.25
1200
1800
2400
0600
1200
1800
2400
0600
1200
1800
11 AUGUST
12 AUGUST
13 AUGUST

Table 5a shows the reproductive success of Black-legged Kittiwakes in four study areas. Clutch size, hatching and fledging success are very similar throughout the colony. From this table it may be seen that our handling of chicks for growth rates and food samples (Tsamanna I) had little effect on reproductive success.

Figure 7 shows the daily colony attendance cycle for Black-legged Kittiwakes for three days in August at 26 nests in one colony. From these data it appears that a fairly constant number of adults are present during the daytime hours, about one per nest, and that numbers are lower in early morning and late evening.

4. Red-legged Kittiwake (*Rissa brevirostris*)

Red-legged Kittiwakes nests on St. Paul Island are scattered in clumps of two to ten among nests of the Black-legged Kittiwake. Whereas the latter species is very numerous, the Red-legs represent only a tiny fraction of all Kittiwakes breeding on the island.

Four study sites were chosen for the Red-legged Kittiwakes: Tsammana, Zapadni, Ridge Wall Cliffs and Einahnuhto Bluffs north of Southwest Point. At none of these sites could we reach Red-leg nests with a ladder; all data were obtained by observation alone. As with the Black-legged Kittiwakes, the most satisfactory data were obtained at the Tsammana site. Nesting success of this species on St. Paul is presented in Table 6. Table 6a compares the nesting success at the four study sites.

TABLE 6

Reproductive Success of

Red-legged Kittiwake

St. Paul Island - 1975

	Total 51 nests	33 nests known to have laid eggs	9 nests with known number of eggs
% laying eggs	64.7	(100%)	(100%)
range of clutch size	-	-	1.00
average clutch size	-	-	1.00
hatching success	-	54.5% (assuming a clutch size of 1.00) (18)	55.6% (5)
average number chicks hatched/ nest with eggs	-	.55 chicks (assuming a clutch size of 1.00)	.56 chicks
% of nests where ≥ 1 chick fledged	29.4% (15)	45.5% (15)	44.4% (4)
% chicks fledged/ chick hatched	83.3% (assuming a clutch size of 1.00)	83.3% (assuming a clutch size of 1.00)	80.0%
average number chicks fledged per nest	.29 chicks	.45 chicks	.44 chicks
chicks fledged per egg laid	-	.45 assuming a clutch size of 1.00	.44 chicks

Table 6a. Reproductive Success of Red-legged Kittiwakes St. Paul Island 1975

	Ridge Wall	Tsammana (site II)	Zapadni	SW Cliffs
# nests	10	12	13	9
# nests where adults incubated	7	10	10	6
# nests with eggs known clutch size	1	7	0	2
Total eggs	1	7	-	2
Average clutch size	1.00	1.00	-	1.00
# chicks hatched of known clutch size	1	6	-	0
% hatching success	100.0	85.7	-	0
Total young seen	4	9	4	0
Average # chicks hatched per incubated nest	.57	.90	.40	0
# chicks fledged	3	7	4	0
% of nests with eggs where at least 1 young fledged	42.9	70.0	40.0	0
Average # chicks fledged/nest	.42	.70	.40	0
Chicks fledged per egg laid	0	.86	-	0
Chicks fledged per nest built	.30	.58	.31	0

Egg-laying and fledging success varied between these sites, but since the samples are very small it is difficult to draw a meaningful conclusion from them.

Since we were not able to reach any nests to obtain growth rates of the Red-legged Kittiwake on St. Paul Island, we decided to sample Red-leg nests on St. George Island where the species is more numerous. M. Hunt spent two weeks on St. George from 24 July to 8 August. Using a ladder with the help of Dr. Joseph Hickey's two field assistants, she sampled 28 Red-leg nests once every three days (Table 2). In lieu of returning to St. George later in the season she hired John Francis, a student spending the summer on St. George working for Dr. Roger Gentry of the National Marine Fisheries Service, to check the nests every four to six days, weigh the chicks, and record the development of their plumage.

Timing of breeding and breeding success of St. George Red-legs are presented in Figure 8 and Table 7. In interpreting these results it must be remembered that work was begun later in the season than at St. Paul and ended shortly before most chicks should have fledged. Average growth rate for these chicks during the straight line portion of the growth curve was 13.7 $\pm$ 3.7 grams per day (range 4.0 - 19.1 g/day, n = 18). One small chick with the lowest growth rate (4.0 g/day) was found dead in its nest, while another chick with the second lowest growth rate (8.3 g/day) disappeared. Surviving chicks grew at an average of 14.7 $\pm$ 2.4 g/day (range 10.3 - 19.1 g/day, n = 16). The peak growth varied from 327 to 443 g with an average of

TABLE 7

Reproductive Success of

Red-legged Kittiwake

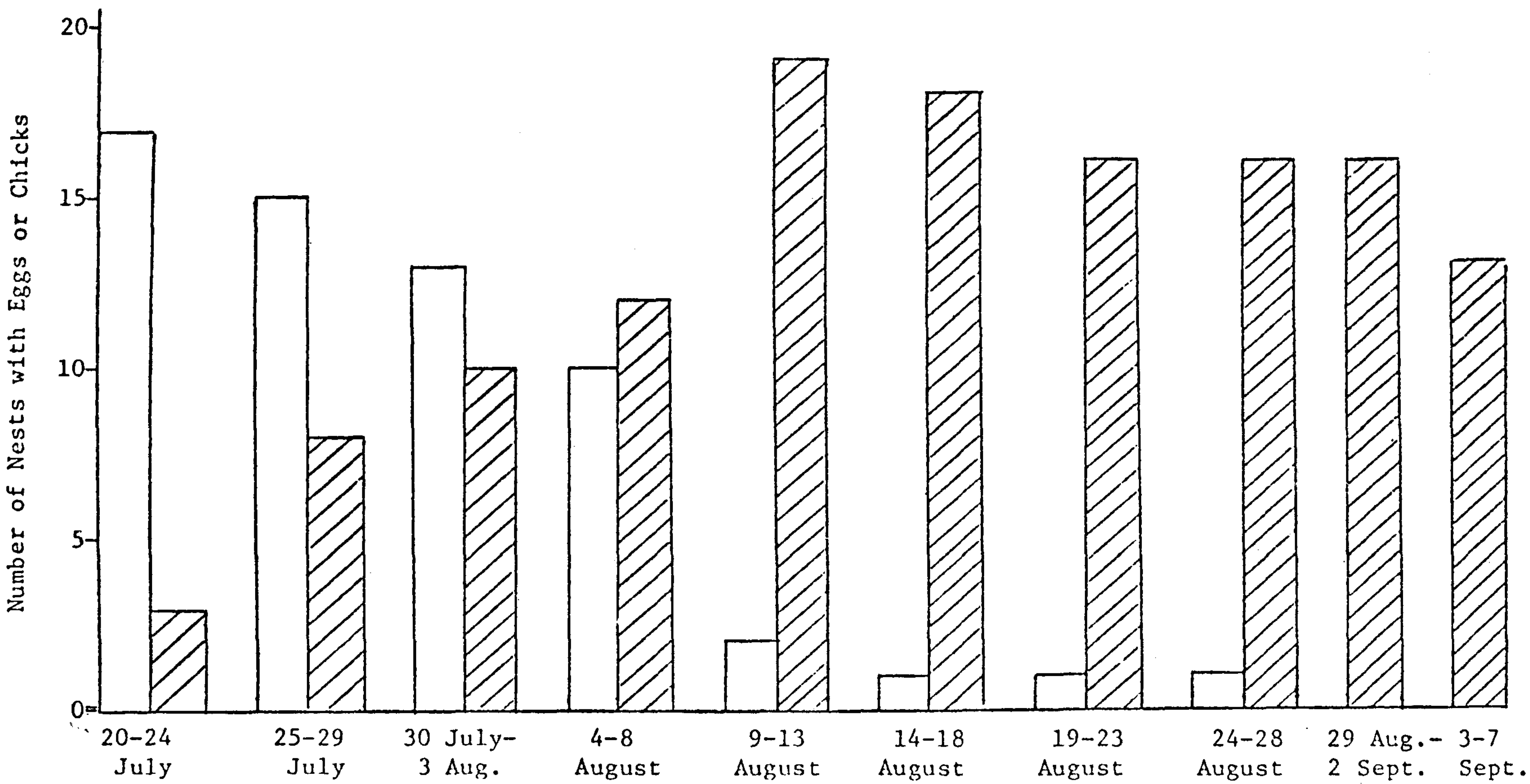
St. George Island 1975

	Total 28 nests	23 nests laying eggs	19 nests with known number of eggs laid
% laying eggs	89.3%(25)	100%(23)	100%(19)
range of clutch size	-	1.00	1.00
average clutch size	-	1.00	1.00
hatching success	-	82.6%(19)	78.9%(15)
average number of chicks hatched/ nest with eggs	-	.83 chicks	.79 chicks
% of nests where ≥ 1 chick fledged	57.1%(16)	69.6%(16)	63.2%(12)
% chicks fledged/ chicks hatched	84.2%(16)	84.2%(16)	80.0%(12)
average number chicks fledged per nest	.57 chicks/ nest	.70 chicks/ nest	.63 chicks/ nest
chicks fledged per egg laid	-	-	.63 chicks/egg

FIGURE 8

PRESENCE OF NESTS WITH EGGS OR CHICKS
RED-LEGGED KITTIWAKE, STARAYA ARTEL
ST. GEORGE ISLAND 1975

Nests with eggs ☐
Nests with chicks ▨



400 g. This weight then dropped slightly until chicks were able to fly (at about 40 days of age), usually a week to ten days after reaching peak weight.

5. Common Murre (Uria aalge)

Most of the Common Murres nesting on St. Paul Island breed on wide ledges on which many birds of the same species congregate in dense groups. A very small percentage of the Common Murres breed on narrower ledges six inches to a foot wide, often among pairs of Thick-billed Murres. No nest is built; the murres lay their single eggs on the bare rock and incubate by holding them on top of their feet against the brood patch in the stomach area. Chicks that "fledge" spend an average of 2½ weeks on the ledges before leaving to be fed at sea by the adults. During this short time on the cliffs their natal down is replaced by contour feathers, but chicks attain only about one-third of their adult weight before leaving.

It is often difficult for an observer to tell whether a murre is incubating an egg or brooding a small chick merely by the position of the bird. As with many of the other species nesting on the cliffs of St. Paul, the murres were reluctant to move away from eggs or small chicks long enough for an observer to count them. There were very few individual nests or broad ledges of Common Murres that were close enough to the top of the cliff for an observer to persuade the birds to move. In addition, large numbers of murres that frequented these ledges appeared to be non-breeders.

Table 8 shows the hatching and chick survival of Common Murres both in individual nests and on large ledges. Chicks were classified as "fledged: if they were observed until they were at least 15 days old. Calculations for breeding success on the broad ledges are based on the maximum number of eggs and chicks observed. In these areas it is impossible to tell whether eggs observed on a given day are the same ones observed previously, or whether chicks that are no longer there have fallen off the ledges prematurely or have "fledged". Therefore, percentages for the broad ledges are at best estimates. Data from the individual nests may not be representative of the Common Murre population of St. Paul, as these more accessible nest sites are perhaps in a suboptimal habitat. Excluded from the figures for individual Common Murres are one egg and one chick that were lost as a result of our presence.

Table 8 does show, however, that egg mortality is very high in the Common Murre, and that the number of chicks "fledged" per egg laid is very small. Judging from the number of broken eggshells at the bottom of the cliffs, a main cause of egg mortality is falling off the ledges. This happens normally, even when birds are not startled suddenly. Other eggs roll and become jammed into cracks where the adults cannot incubate them. Foxes take large numbers of murre eggs (presumably of both species), although it is not known whether this accounts for any egg mortality in our sample. Disturbance by aircraft may have accounted for part of the egg mortality (see Table 10, discussed under Thick-billed Murres).

TABLE 8

COMMON MURRE REPRODUCTIVE SUCCESS

ST. PAUL ISLAND - 1975

	Counts of Individual Nests	Counts of Ledges with Several Nests (numbers are maximum figures)
Number of eggs laid	18	≤ 31
Number of chicks hatched	2	≤ 9
Number of chicks fledged	0	≤ 6
Eggs hatched/eggs laid	.11	≤ .29
Chicks fledged/chicks hatched	0	≤ .66
Chicks fledged/eggs laid	0	≤ .19

PRESENCE OF EGGS AND CHICKS
COMMON MURRE NESTS
RIDGE WALL STUDY AREA
ST. PAUL ISLAND, ALASKA 1975

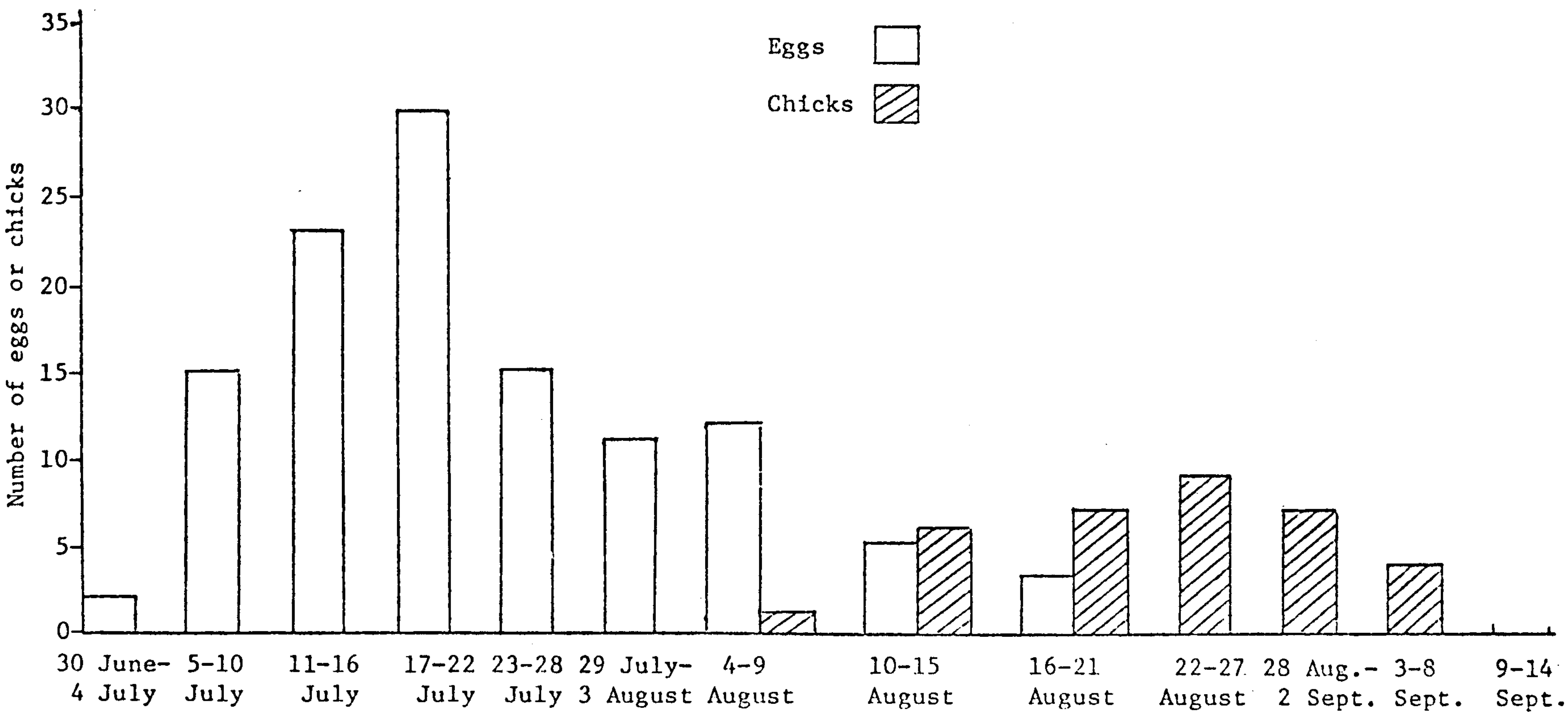


FIGURE 9

Figure 9 presents the dates when Common Murre eggs and chicks were observed on the communal ledges of the Ridge Wall Study Site. In cases where the area was censused more than once during each five-day interval on the graph, the maximum figures were used. While this figure indicates that the peak of laying in 1975 occurred around 17 July, this date is probably not an accurate representation of what occurred on the entire island. The Common Murre ledges that contributed data to this graph sustained heavy egging by the native Aleuts on 29 June, an acitivity that caused egg relaying and delayed chick hatching by 10-20 days.

6. Thick-billed Murre (Uria lomvia)

The most numerous of cliff-nesting seabirds on St. Paul, the Thick-billed Murre is found on all cliff areas of the island. Breeding biology of this species is nearly identical to that of the Common Murre, except that its preferred nesting habitat is narrow ledges where pairs breed in linear formation rather than in clumped groups. Individual nests close to the cliff top were much easier to locate than for the Common Murre.

Breeding success of Thick-billed Murres both in individual pairs and groups of pairs is presented in Table 9. Excluded from the calculations for individual pairs in Table 9 are one egg and one chick that were lost as a result of our presence. Table 9a compares reproductive success in different areas of the island. While causes of egg and chick mortality in this species are the same as for the Common Murre, it is possible that

TABLE 9

THICK-BILLED MURRE REPRODUCTIVE SUCCESS

ST. PAUL ISLAND 1975

	Counts of Individual Nests	Counts of Ledges with Several Nests (numbers are maximum figures)
Number of eggs laid	66	≤ 23
Number of chicks hatched	34	≤ 15
Number of chicks fledged	25	≤ 11
Eggs hatched/eggs laid	.51	≤ .65
Chicks fledged/chicks hatched	.73	≤ .73
Chicks fledged/eggs laid	.38	≤ .48

Table 9a. Reproductive Success of Thick-billed Murre - Individual "Nests" St. Paul Island 1975

	Polovina	Tsammana (site II)	SW Cliffs area 17A	SW Cliffs area 17B	SW Cliffs areas 17C, D & E
# eggs	10	14	10	11	21
# hatched	8	6	6	5	9
# fledged	7	3	4	3	7
# hatched/egg	0.80	0.43	0.60	0.45	0.43
# fledged/hatched	0.87	0.50	0.67	0.60	0.77
# fledged/egg	0.70	0.21	0.40	0.27	0.33

Reproductive Success of Thick-billed Murre - Ledges

	Tsammana	SW Cliffs areas A & B	SW Cliffs areas 17C, D & E	Ridge Wall
Maximum # eggs	13	16	20	23
Maximum # chicks	6	9	8	15
Maximum possible chicks hatched or fledged/egg	0.46	0.56	0.40	0.65

fox predation played a larger role in our sample of Thick-billed Murres than in the sample of Common Murres.

In addition to natural causes of mortality, disturbance by aircraft may have caused a significant portion of egg and chick deaths in both species of murre on St. Paul (see Table 10 for results of disturbance of 2 August). A second occasion for the observation of the effect of aircraft on nesting seabirds occurred in early August when M. Hunt was on St. George Island with Dr. J. Hickey's team. In this case a P2V aircraft flew close to the cliffs during a photographic survey of the nesting seabirds. Murres commenced departure from the cliffs before the aircraft was even with the birds on the face of the cliffs. At the closest approach of the plane huge numbers of murres left the cliffs and flew out to sit on the water about a half mile away. Due to the unexpected arrival of the aircraft and the terraced structure of the cliffs above the beach where the observers happened to be at the time, no estimate of percent damage to the eggs or young of the murres was possible.

Figure 10 shows the dates when eggs and chicks were observed. For this graph data from three study areas are combined, and in cases where sites were visited more than once during a five-day period, the maximum numbers of eggs or chicks were used. The data from Ridge Wall that are included in this graph were affected by egging activity by Aleut people on 29 June, effectively delaying the peaks of egg numbers and chick hatchings.

TABLE 10

CHICK AND EGG MORTALITY OF COMMON AND THICK-BILLED MURRES FOLLOWING AIRCRAFT ACTIVITY NEARBY*

ST. PAUL ISLAND 1975

	Common Murre	Thick-billed Murre
Number of individual nest followed	18	66
Number of nests losing eggs or chicks during the season	18 (100%)	41 (62.1%)
Number of nests losing eggs or chicks between 2 August and the previous observation	4 (22.2% of nests)	15 (22.7% of nests)
Percent of mortality occurring between 2 August and the previous observation	36.6%	22.2%

* On 2 August B. Easterday reported two or more Coast Guard planes flying in the vicinity of the bird cliffs around St. Paul Island, particularly around the Southwest Point study areas.

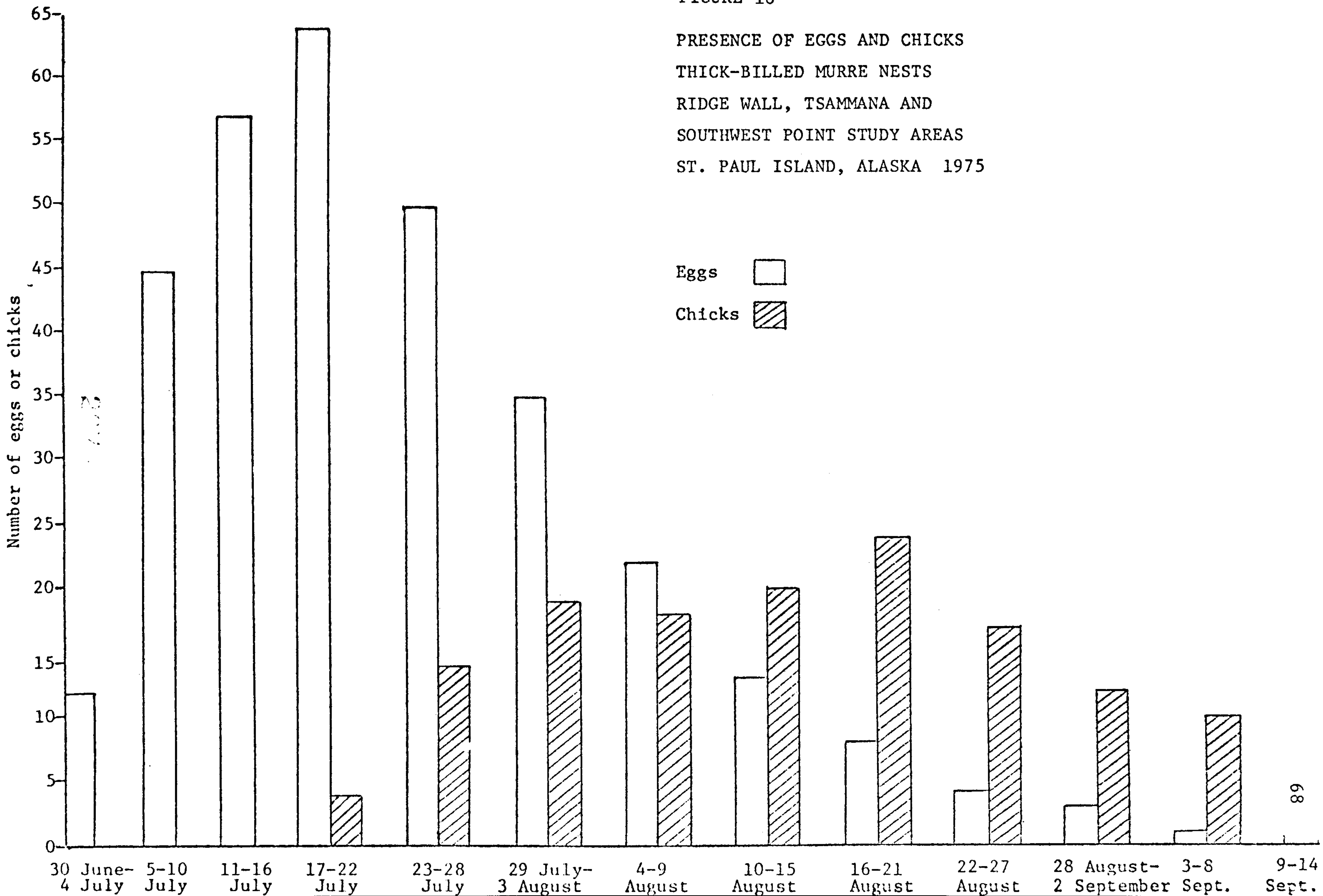


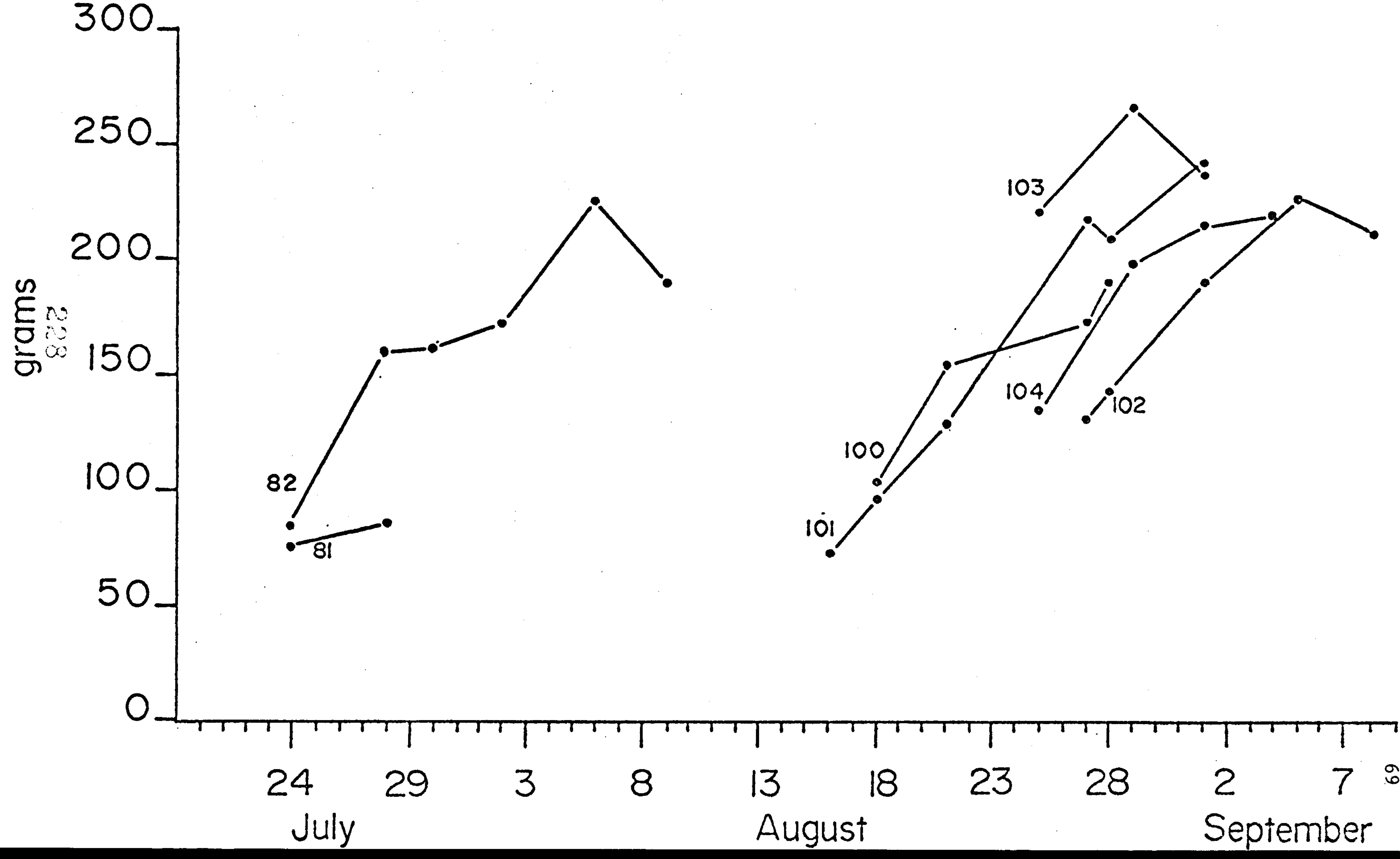
FIGURE 10

PRESENCE OF EGGS AND CHICKS
THICK-BILLED MURRE NESTS
RIDGE WALL, TSAMMANA AND
SOUTHWEST POINT STUDY AREAS
ST. PAUL ISLAND, ALASKA 1975

FIGURE 11

THICK-BILLED MURRE CHICK GROWTH RATES

ST. PAUL ISLAND - 1975



Growth measurements were obtained for seven Thick-billed Murre chicks which were accessible to researchers and either inaccessible to or overlooked by foxes (Figure 11). Starting from a hatching weight of about 75 grams the chicks gain roughly 20 grams per day until a short period of extensive feather development during which weight gain is slower. The chicks then gain more weight, which peaks and drops just before the chicks leave the cliff. Chicks that grow too slowly may not survive (see chick #81, Figure 11).

The results of three days of observations of the daily cycle of murres (Figure 12) shows that there are wide fluctuations in the numbers of murres present at different times of day. A nightly exodus is followed by a gradual build up in numbers throughout the day with maximum numbers present around 1600 h.

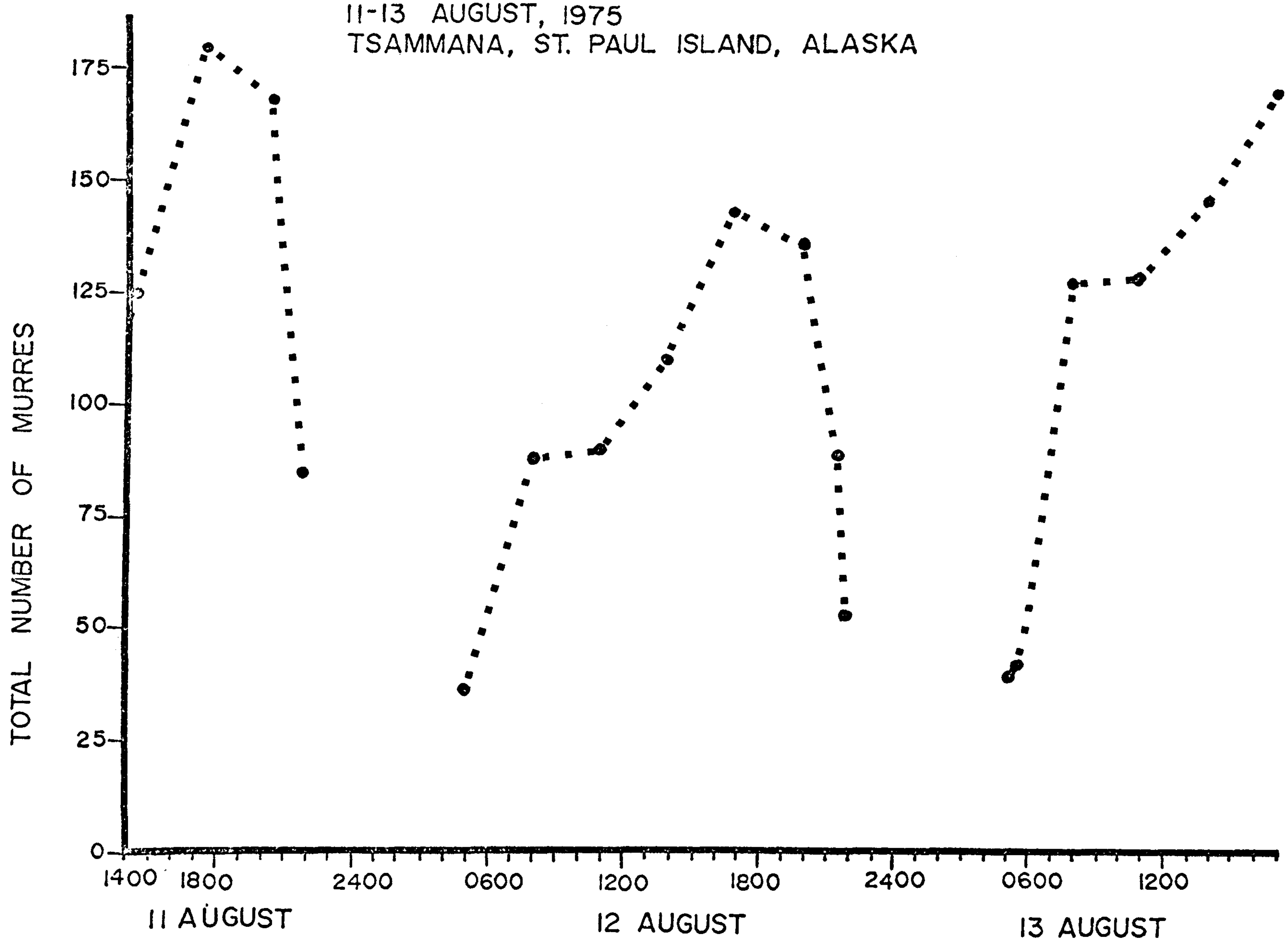
7. Horned Puffin (Fratercula corniculata)

Horned Puffins on St. Paul Island nest in holes in the cliff face, and lay their single eggs in nests constructed of grass and bits of seaweed. Due to the presence of foxes, these birds do not nest in burrows in the ground inland from the cliffs as they do in other parts of their range.

Observation of Horned Puffins from the cliff top to determine nest attendance and timing of breeding proved difficult and unsatisfactory. In addition to two accessible nests found at Tsammana in June, in August an area at Ridge Wall was located where nine Horned Puffin nests could be reached from the ground with a ladder. Exploration of this area proved that many holes

FIGURE 12

DAILY MURRE POPULATION CURVE
FOR COMMON AND THICK-BILLED MURRES
11-13 AUGUST, 1975
TSAMMANA, ST. PAUL ISLAND, ALASKA



thought earlier to be puffin nests were empty. Holes that did contain nests were approximately 10-15 inches high at the mouth and from 1 to 4 feet in width. Most of the grassy nests were located in an open "antechamber" 8-12 inches high towards the front of the burrow. Often the hole continued out of arm's reach, becoming deep and narrow towards the back.

All eggs in the 11 Horned Puffin nests hatched. Assuming an average incubation period of 42 days (Sealy 1973), egg laying was calculated to have taken place during the first two weeks of July with hatching in mid to late August. Puffin chicks which fledge at about 40 days of age (Sealy 1973), are the last seabird young to leave their nests in September.

Data on fledging success and growth rates proved somewhat difficult to obtain as the chicks tended to crawl out of reach to the back of the holes when they heard the ladder against the cliff. While at least five of the 11 chicks were believed to have fledged, six others either disappeared or may have hidden in the backs of the cracks out of sight when they heard us coming. This problem will be easily remedied next year by blocking the access to the back parts of the nesting holes with rocks before the eggs hatch.

The average growth of eight Horned Puffin chicks was 11.1 ± 1.3 grams per day (range 8.2 - 12.8 g/day) from a hatching weight of about 50 grams. Peak growth was attained 30-35 days after hatching.

8. Tufted Puffins (*Lunda cirrhata*)

While neither species of puffin on St. Paul is numerous, Tufted Puffins are far less common than Horned Puffins, possibly by an order of magnitude. Like the Horned Puffin the Tufted Puffin nests in holes in the cliff face. Most holes that we believe were occupied were located toward the top of the cliff, and all were well out of reach of a ladder. Some of these holes may possibly be explored next year with use of a rope ladder.

9. Crested Auklet (*Aethia cristatella*)

Crested Auklets are the rarest of all seabird species breeding on St. Paul Island, representing only an infinitismally small fraction of the total number of birds present. On St. Lawrence Island, where this species breeds in huge numbers, nests are located between large boulders of talus slopes. This type of habitat does not exist on St. Paul, and Crested Auklets must nest either in holes in the cliff or among the rocks of boulder beaches along with its smaller congener, the Least Auklet. Only one possible nest of the Crested Auklet was located during the 1975 season, and it was inaccessible by ladder. This species was not seen on St. Paul after the middle of August.

10. Least Auklet (*Aethia pusilla*)

Least Auklets, the smallest of the alcids, are by far the most abundant of the hole-nesting seabird species on St. Paul, and may be rivaled only by the murres in population size. Many of them nest in dense colonies among the boulders below the surface of three rocky barrier beaches (East Landing, Salt

Lagoon and Antone Lake). Others nest individually in small holes in the cliff face and probably also use the rocky rubble at the foot of the cliffs.

Least Auklets exhibited a regular attendance pattern at their breeding areas, and were either present in large numbers or almost totally absent depending on the time of day.

In the case of beach-nesting birds examination of nest contents effectively means destroying the nests: therefore, we did not attempt to get information on reproductive success by this method. However, we have evidence for the timing of breeding of the Least Auklet. The egg stage began in early to middle June. Two eggs collected by Aleuts on 15 June were measured and opened. One egg measured 4.09 x 3.08 cm and contained an embryo 0.76 cm long. The other egg was 4.03 x 2.97 cm and contained an embryo 1.08 cm long. With an incubation period of about one month, these eggs were less than a week old. Chicks were present from mid July to mid August. On 15 July we dug up a nest with a newly hatched chick (weight 15 grams). During the next month, in order to collect regurgitation samples, we mist-netted adults bringing food back to their young in the evening. From mid July to mid August we could hear the chicks chirping constantly among the rocks below the beach surface. By 14 August very few adults were present and most of the underground chirping had ceased. Least Auklets seen during the last two weeks of August represented only a tiny fraction of the numbers that had been present earlier.

Two Least Auklet nests were found in small holes in a cliff. In one of these a small chick that was first seen on 18 August was growing contour and primary feathers when last observed on 1 September. The hole was too small for us to reach the chick to measure its growth.

11. Parakeet Auklet (Cyclorrhynchus psittacula)

Parakeet Auklets are ubiquitous, although scattered, on the cliffs of St. Paul, nesting in small holes in the cliff face. We were not able to locate any accessible nests until the end of their breeding season in mid August. In three cases we found an egg that had rolled into such a position that it could not be incubated. Another egg, presumably laid by a Parakeet Auklet judging by its size, was found wedged behind the nest of a Horned Puffin. Next year suitable areas of cliff will be explored in June with ladders and we anticipate obtaining a reasonable sample of nests for data on reproductive success and growth rates of young.

C. Foods

Table 11 presents the number of birds collected for food samples and Table 12 summarizes the total number of food samples taken from both shot and non-shot birds. This latter category includes not only chick regrugitation samples, but also miscellaneous samples found on murre ledges and below the bird cliffs and regurgitations from adult Least Auklets caught in mist nets.

To date 211 of the 292 food samples have been sorted and items identified. Identifications have been made to species level when possible and voucher specimens sent to the Institute

TABLE 11. Numbers of Birds Collected for Food Samples

St. Paul Island 1975

Species	JUNE number collected	JUNE % with food	JULY number collected	JULY % with food	AUGUST number collected	AUGUST % with food	SEPTEMBER number collected	SEPTEMBER % with food	TOTAL number collected	TOTAL % with food
Least Auklet	20	60	12	83	0	0	0	0	32	69
Parakeet Auklet	2	0	7	29	7	86	0	0	16	50
Crested Auklet	2	0	4	100	2	100	0	0	8	75
Horned Puffin	0	0	7	29	2	100	0	0	9	44
Tufted Puffin	0	0	2	50	2	50	0	0	4	50
Black-Legged Kittiwake	5	80	21	90	1	100	4	100	31	90
Red-Legged Kittiwake	1	100	1	0	0	0	0	0	2	50
Common Murre	6	83	13	62	1	100	9	78	29	72
Thickbill Murre	2	100	18	72	0	0	1	100	21	76
Red-Faced Cormorant	1	100	4	75	2	50	0	0	7	71
Total	39	64	89	70	17	82	14	86	139	81

On a total of 25 days this summer, birds were collected for stomach contents analysis. On the average, it took 2 people, 2-3 hours to do a days collection. However, following a large killing of 10-15 birds, 10 or 12 man hours are required to do the initial processing of the birds.

TABLE 12. Total Food Samples Collected*
St. Paul Island, Alaska
Summer 1975

Species	Shot Birds JUNE	JULY	AUGUST	SEPTEMBER	Non-Shot Birds	TOTAL
Least Auklet	12	10	0	0	30**	52
Parakeet Auklet	0	2	6	0		8
Crested Auklet	0	4	2	0		6
Horned Puffin	0	2	2	0		4
Tufted Puffin	0	1	1	0		2
Black-Legged Kittiwake	4	19	1	4	95	123
Red-Legged Kittiwake	1	0	0	0	11**	12
Common Murre	5	8	1	7		21
Thickbill Murre	2	13	0	1	4	20
Red Faced Cormorant	1	3	1	0	32	37
Murre Spp.					3	3
Fulmar					1**	1
Fish Found on Cliffs					3	3
Total	25	62	14	12	179	292

* This is only a conservative estimate of the number of food samples that will probably be found to be useful.

** Non-Shot Red-Legged Kittiwake includes 10 samples from St. George Island and one at sea aboard the "Discoverer"; Fulmar from St. George Island; and the Least Auklet includes 10 samples from birds collected on St. George Island for Dr. Joseph J. Hickey.

of Marine Sciences Sorting Center in Fairbanks, Alaska, for confirmation of identifications. For the purposes of this interim report food items have been lumped into broad phylogenetic classes for presentation (Table 13).

A few preliminary comments are possible at this time. The data from the Red-faced Cormorants are misleading, in that in many other samples, yet to be worked up, a large variety of foods are present in addition to fish. While only 8 samples from Red-legged Kittiwake were available, it is interesting to note that this species appears more limited in its diet than does the Black-legged Kittiwake. During the coming summer we hope to greatly expand the data base for Red-legged Kittiwake in order to resolve this question. On the basis of the small amount of data available, it appears that Thick-billed and Common Murres may differ in their food preferences. Although both species bring fish to their young, it appears that adult Thick-billed Murres may also make use of a number of types of invertebrates in their own diets. Tuck (1960) refers to a number of studies which show that Thick-billed Murres take invertebrates. Unfortunatley little information on the foods of Common Murres is available. Differences in the foods used by the two species and by adults and chicks need to be examined further.

Due to predominately overcast weather, we were able to take only a limited number of useful photographs of murres holding fish in their beaks. However, we are optimistic that with use of a higher-speed film next season a larger number of useable slides of

Table 13. Synopsis of the results of the analysis of 211 food samples

Species	# samples with food	# occurrences	Cephalopoda	Copepoda	Amphipoda	Euphausiacea	Decapoda	Brachipoda	Fish	Debries	Plastic Spheres
			PERCENT BY OCCURRENCE								
Fulmar	1	1	100%	-	-	-	-	-	-	-	-
Red-faced Cormorant	2	2	-	-	-	-	-	-	100%	-	-
Black-legged Kittiwake	53	69	9%	-	14%	4%	1%	-	62%	6%	3%
Red-legged Kittiwake	8	8	-	-	-	-	-	-	88%	12%	-
Common Murre	22	22	9%	-	-	-	-	-	91%	-	-
Thick-billed Murre	19	19	5%	-	16%	-	5%	5%	68%	-	-
Parakeet Auklet	22	22	-	-	14%	5%	-	-	55%	14%	14%
Least Auklet	45	48	-	44%	8%	17%	6%	-	10%	15%	-
Crested Auklet	5	5	-	-	80%	-	-	-	20%	-	-
Tufted Puffin	2	2	50%	-	-	-	-	-	50%	-	-
Horned Puffin	5	5	-	-	-	-	-	-	80%	20%	-

foods used by murres and puffins will be obtained. Our results show that this technique has promise, and we feel that the expense of investment in camera gear will prove warranted.

Our data on foods used by the three small auklets are generally similar to those of Bedard (1969a). We also found the Least Auklet to specialize on Calanus spp. and that the Parakeet Auklet used more fish than the other two species. Our results suggest that fish may be more important to Parakeet Auklets than Bedard (1969a) indicated. In our sample of Crested Auklets we found Hyperiid amphipods to predominate, while Bedard (1969a) found Euphaseacea to be more prevalent. Whether this difference is an artifact of our small sample, the result of differences in the local abundance of food species, or due to differences in choice of foods cannot be resolved until we have larger samples.

These data on food habits will be useful in terms of O.C.S. oil development from two perspectives. First, once toxicity studies are completed, it may be possible to predict which food species will be affected by spilled oil and hence, which species of birds may have difficulty finding food, should the birds themselves escape becoming oiled. Second, bird reproductive success may be altered by natural fluctuations in food availability. To the extent that data on variations in food species abundances are available, it may be possible to separate out the effects due to fluctuations in food availability from the effects of oil or disturbance to bird colonies.

D. Distribution of Foraging Seabirds

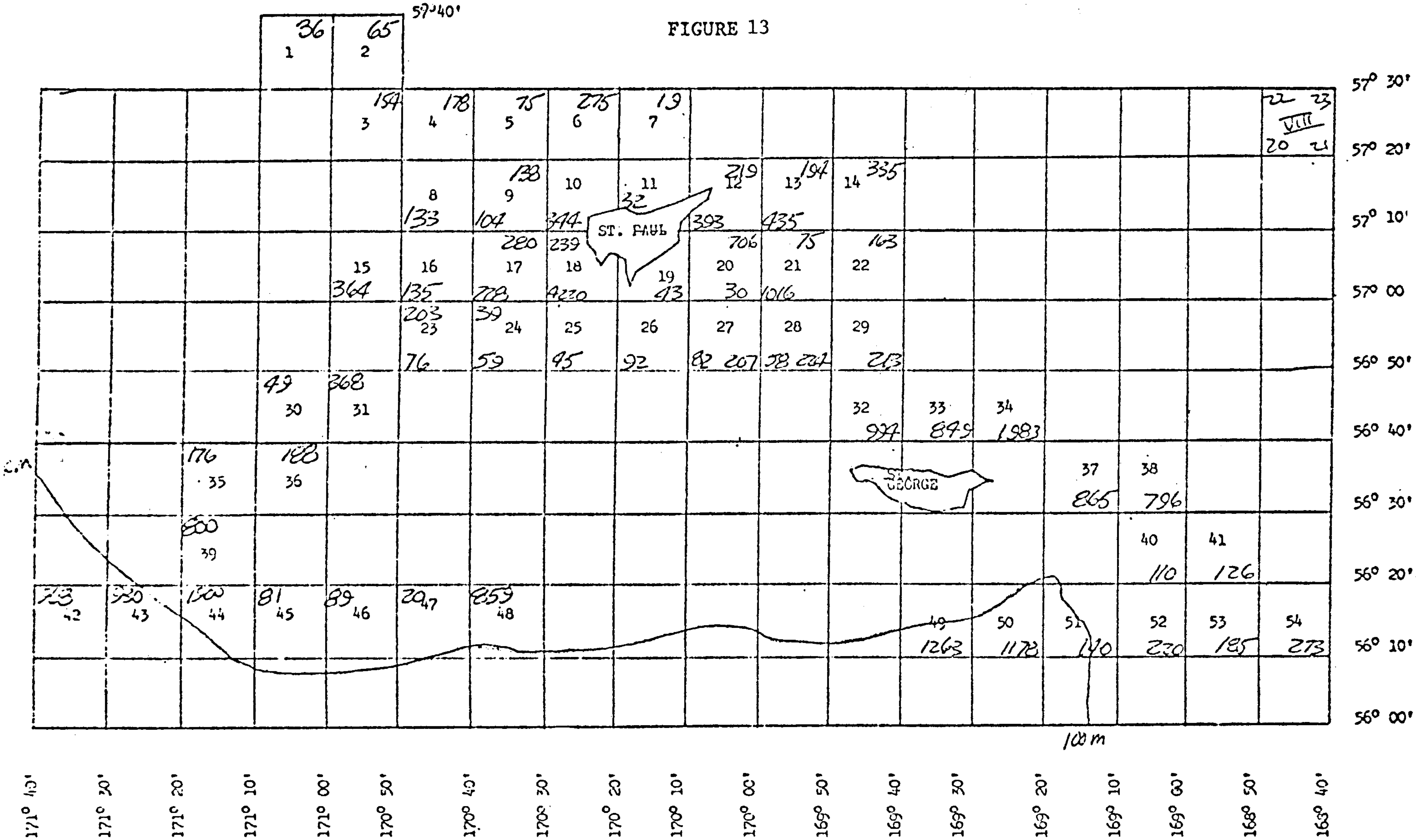
Approximately 28,000 seabirds of 23 different species were seen in the 203 km^2 viewed during four days of dawn to dusk observations. A detailed report containing such information as the number of transects and stations made and the density of each species per km^2 of transect will have to wait until records of the official Course Register and Ship's Log are sent to our project from Alaska.

For preliminary analysis prior to knowing the precise route of the Discoverer, the birds recorded during the cruise were grouped according to the 10' square of ocean in which they were observed (see Fig. 4). Figures 12 through 22 show the number of the most numerous seabird species seen in each 10' x 10' grid block. In these figures numbers of birds seen in the same block on different days have been separated.

Figures 15-22 suggest that some seabirds are found more commonly near land while others appear to congregate in largest numbers at the Continental Shelf edge. However, without the knowledge of the exact kilometers of trackline through each grid block these raw numbers may be misleading. In order to illustrate more accurately the tendency of species to gather in certain areas, Table 15 shows both the number of birds seen and the percent occurrence of species in each of three categories of ocean habitat.

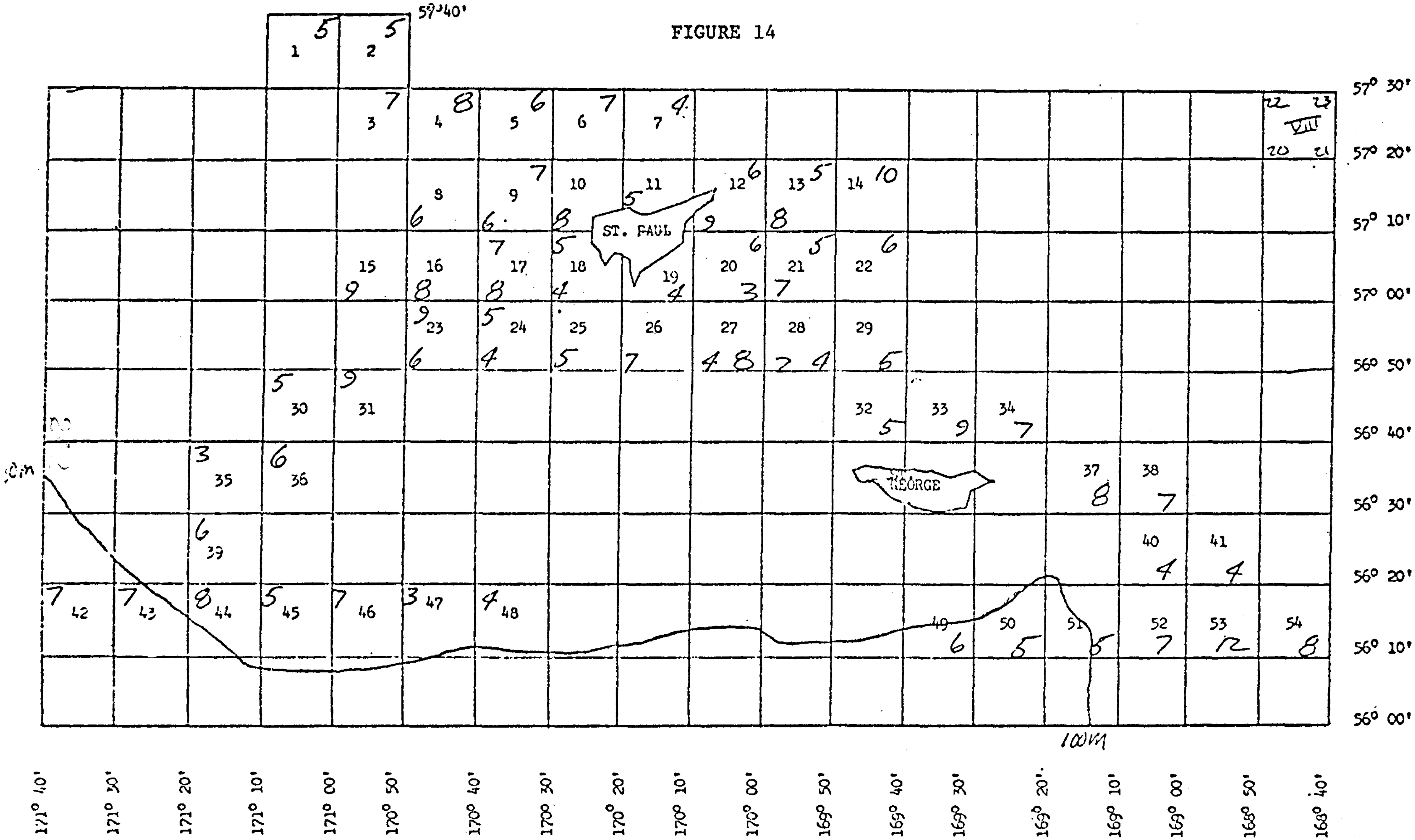
Of the birds breeding on the Pribilof Islands, the murres and kittiwakes were seen most frequently in all three habitat areas (Table 15). It is possible that not all of these birds were

FIGURE 13



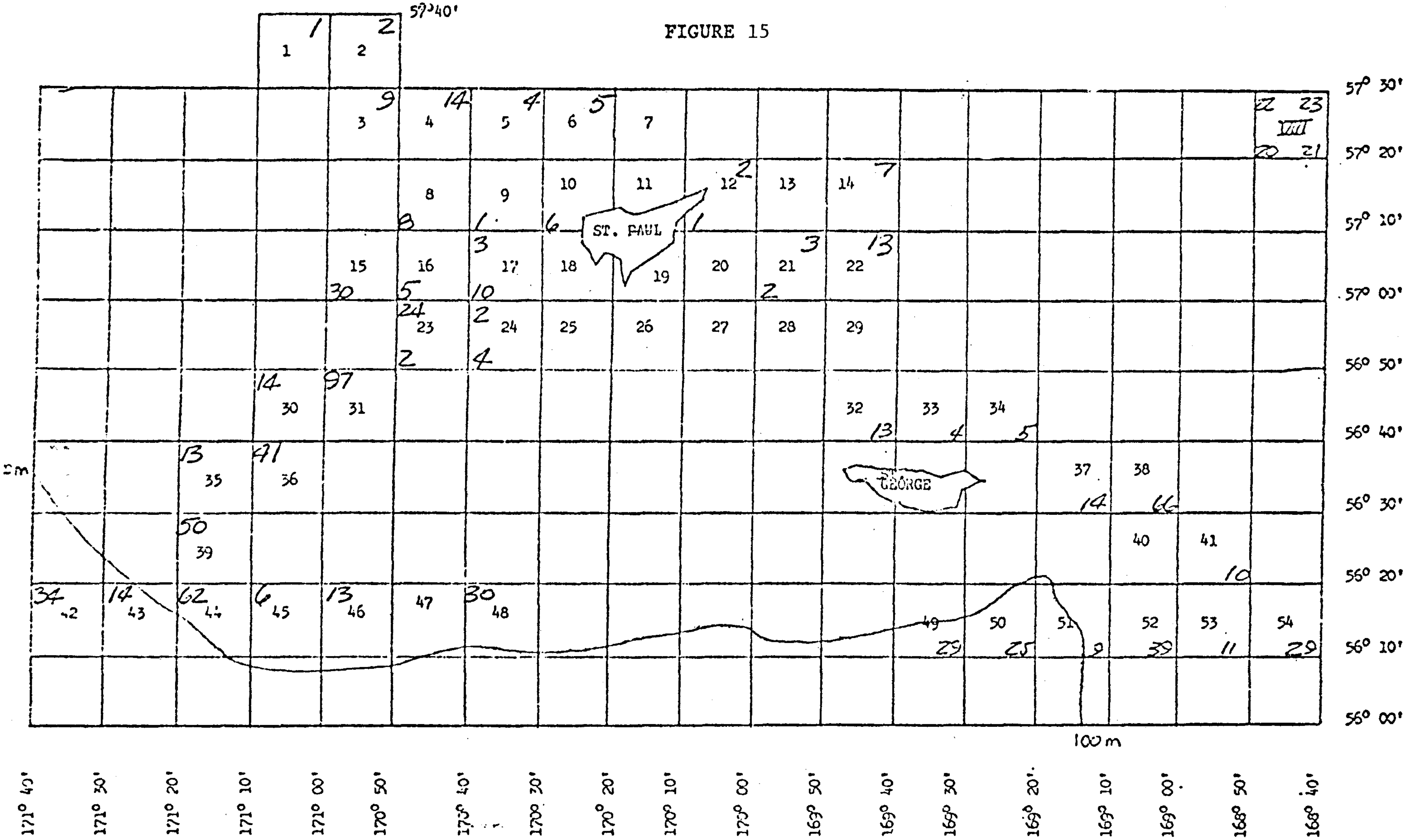
Total Birds Seen on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 14



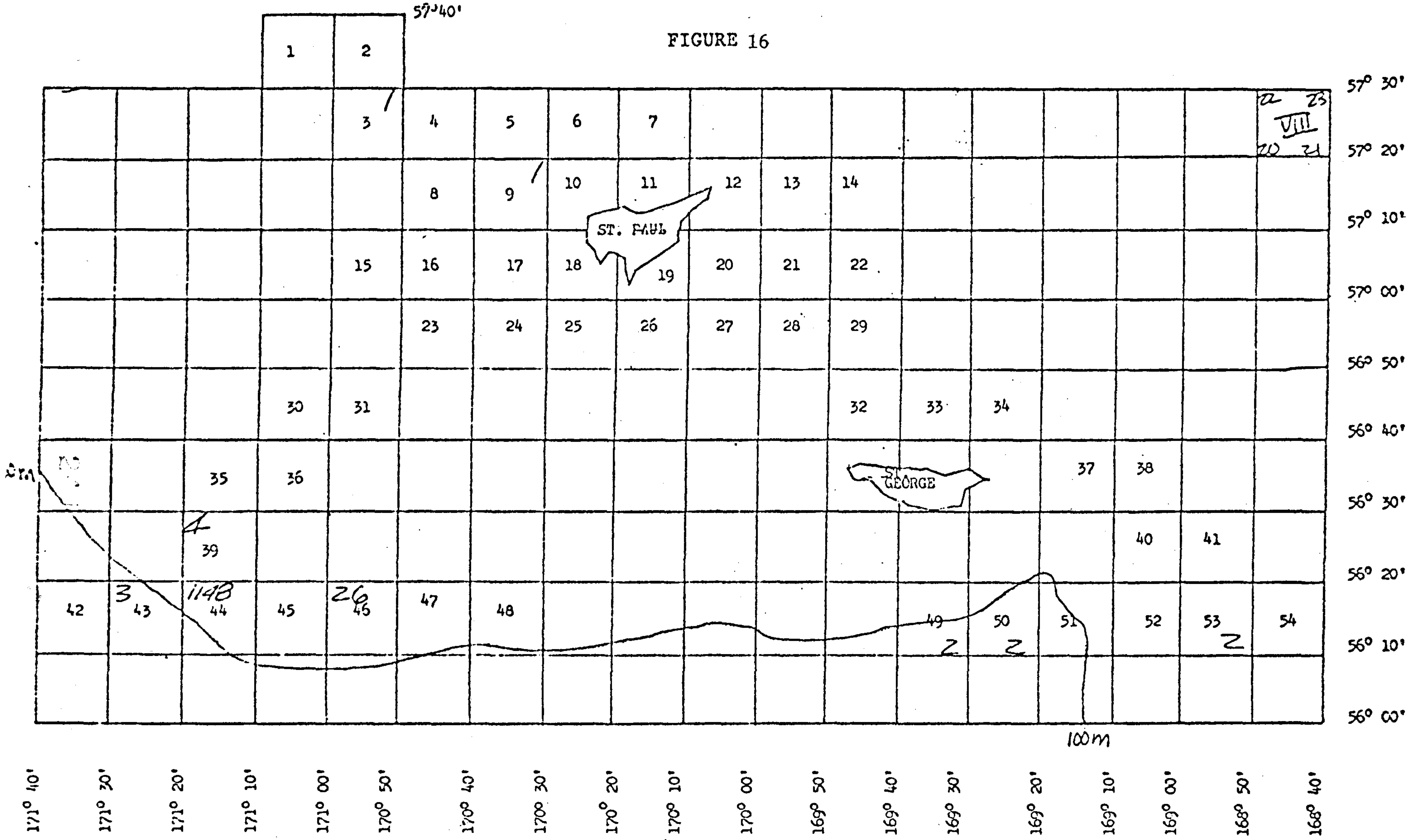
Number of Species of Birds Seen on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 15



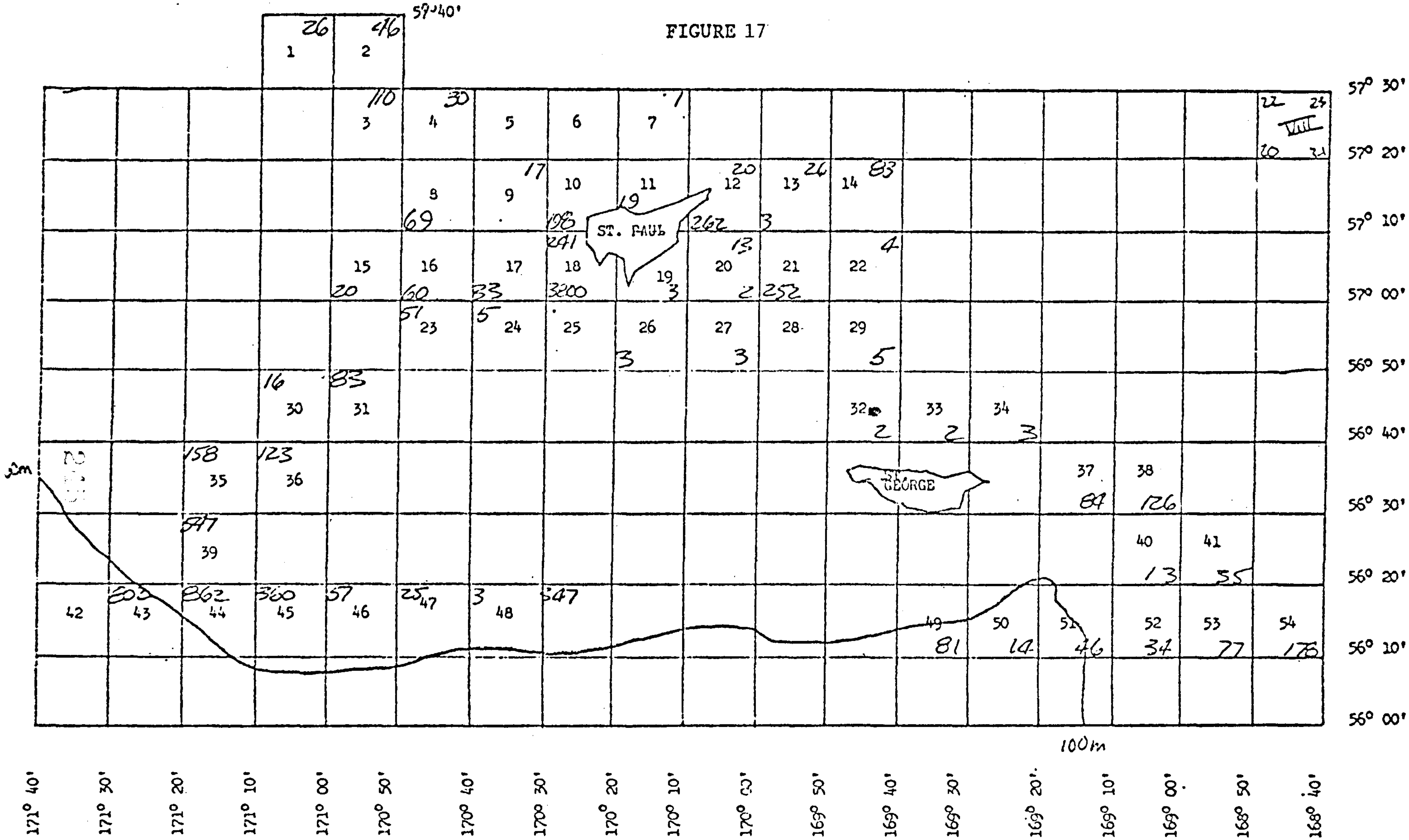
Fulmars Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 16



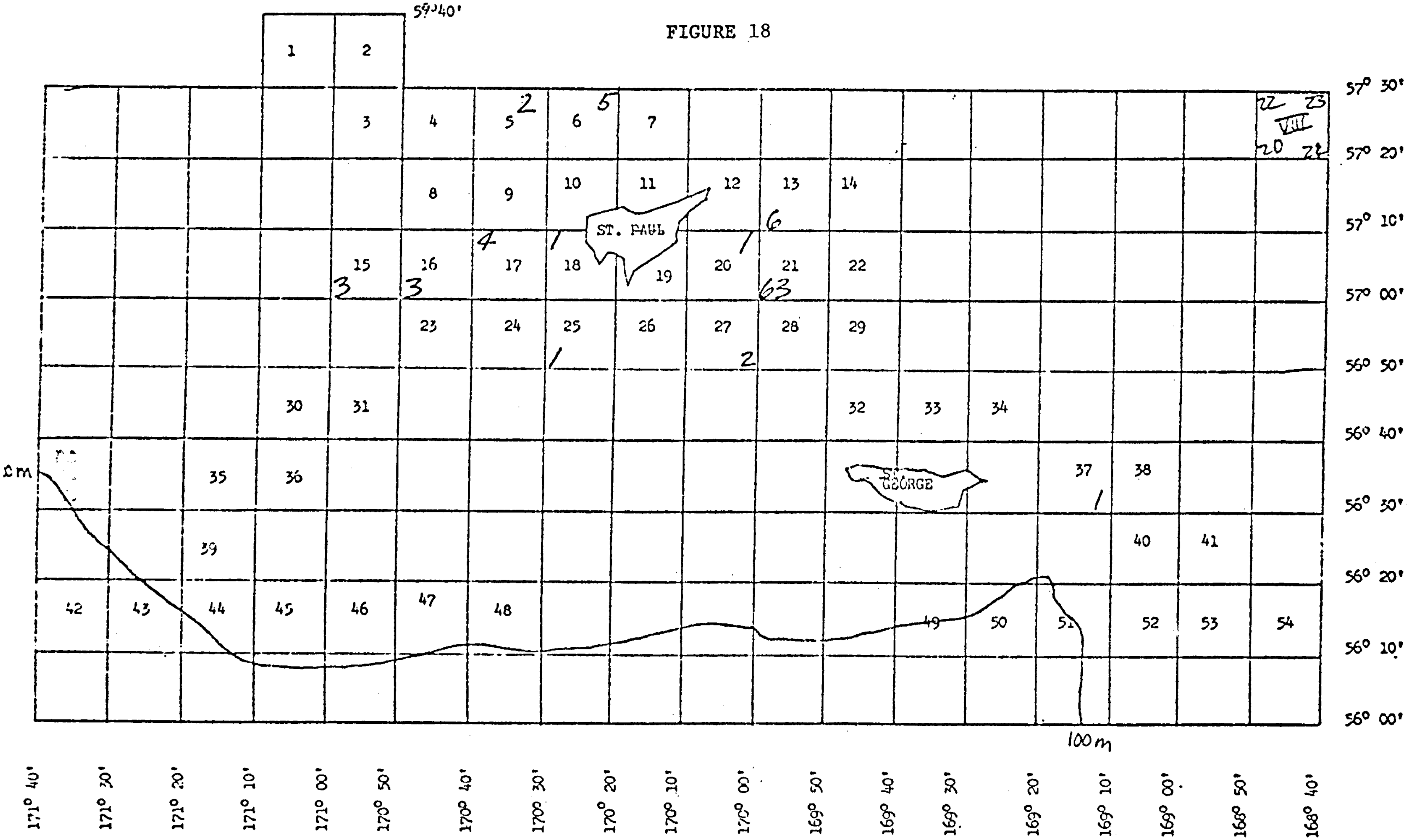
Petrels (total) Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 17



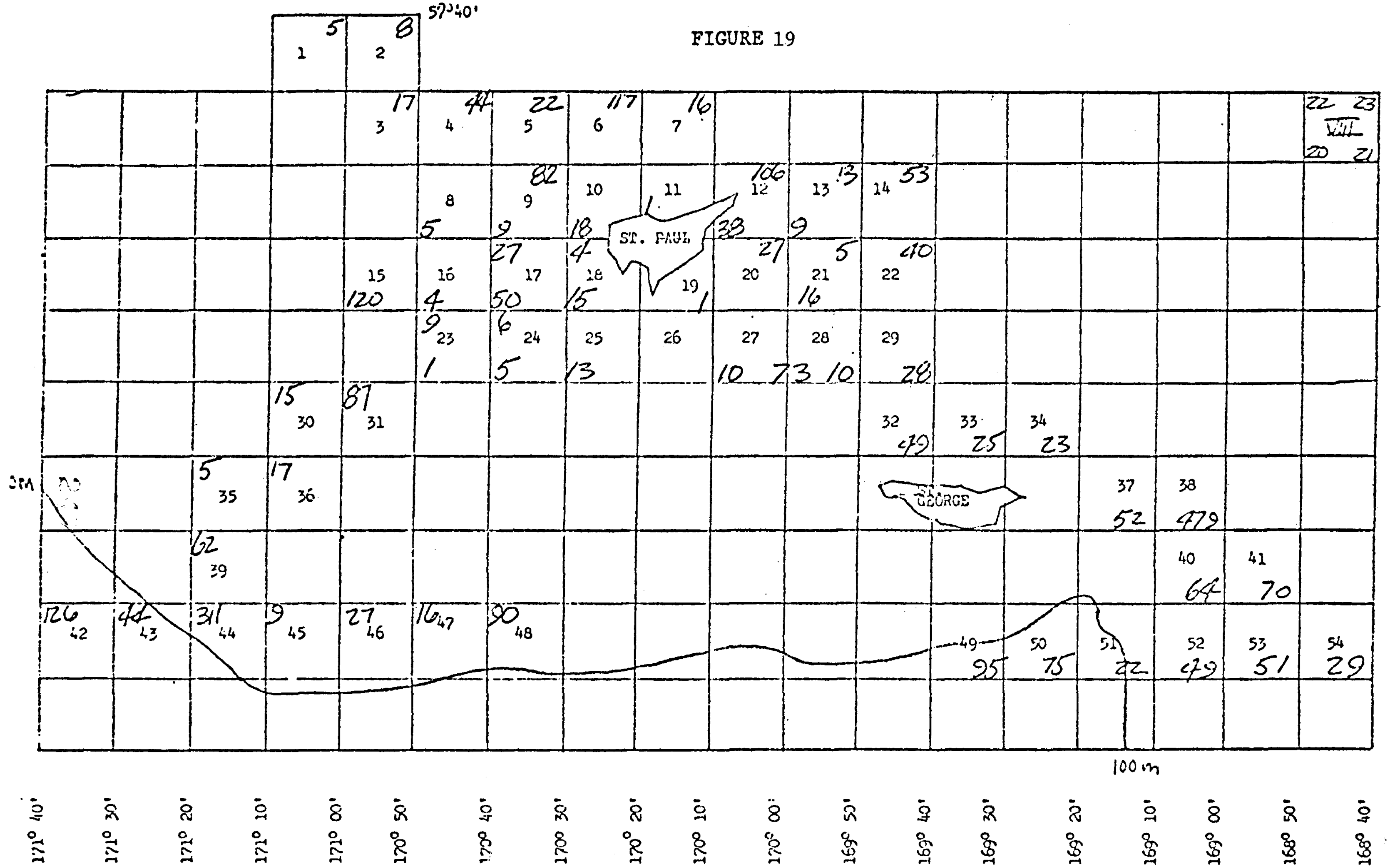
Shearwaters (total) Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 18



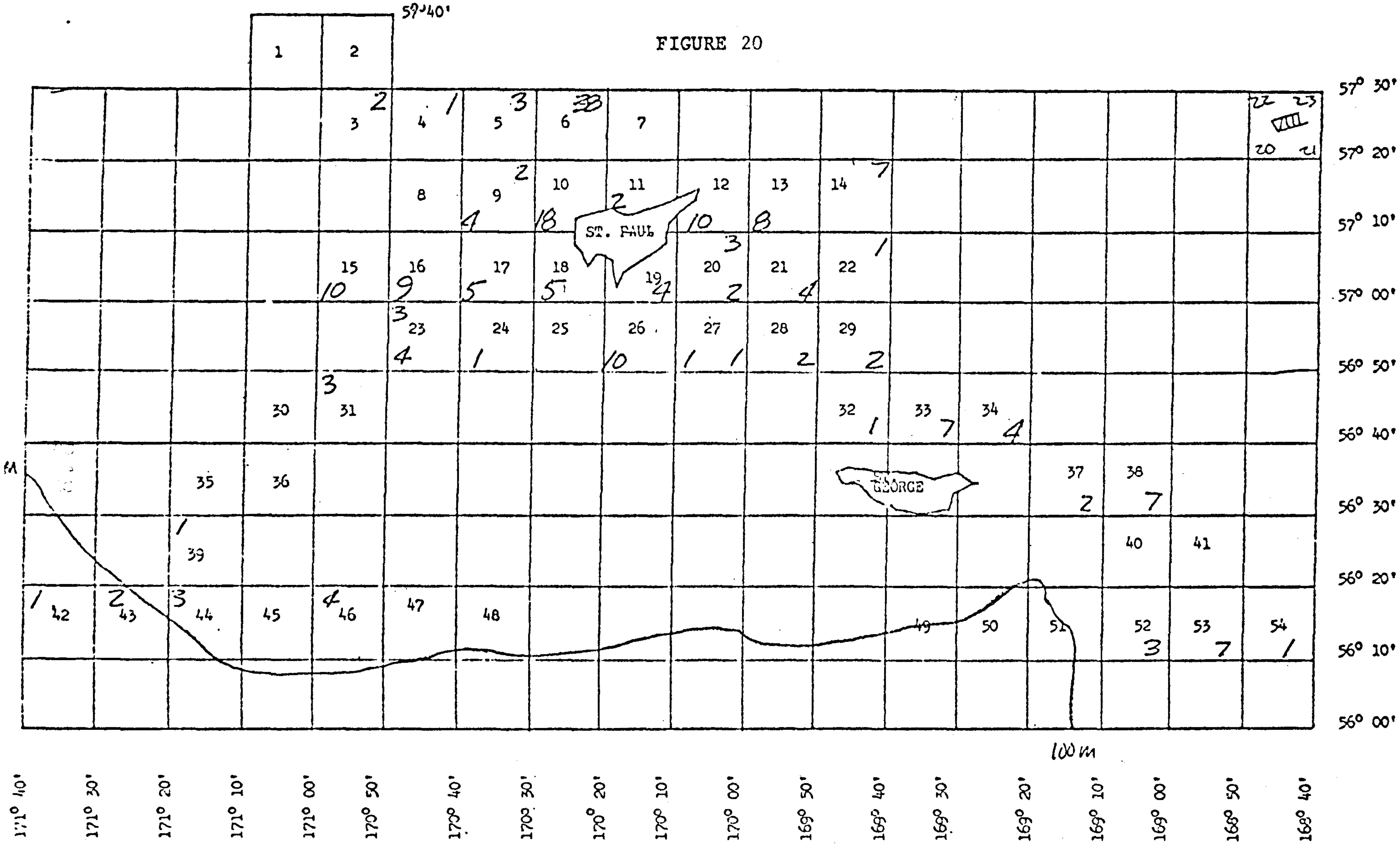
Red-faced Cormorant Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 19



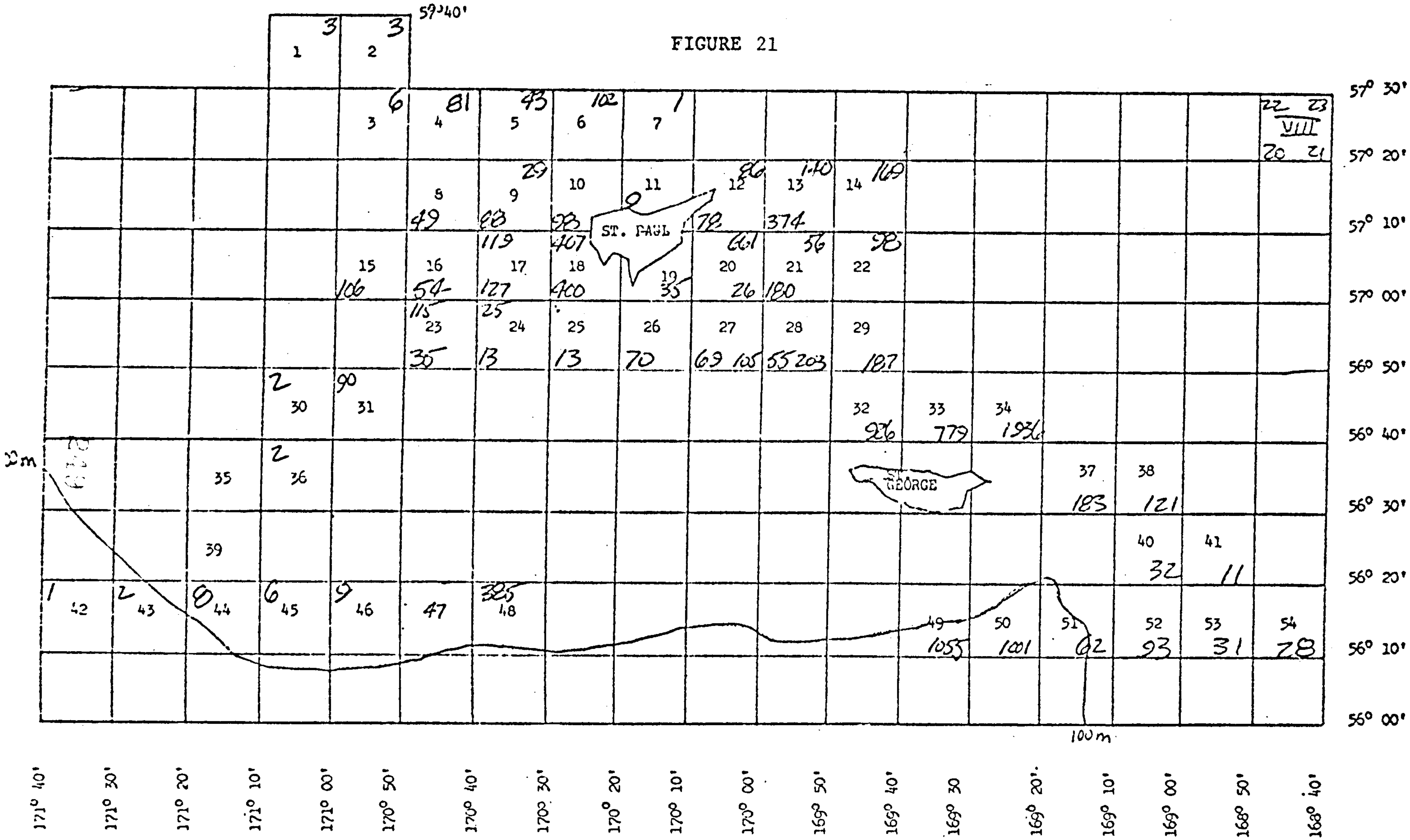
Kittiwakes Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 20

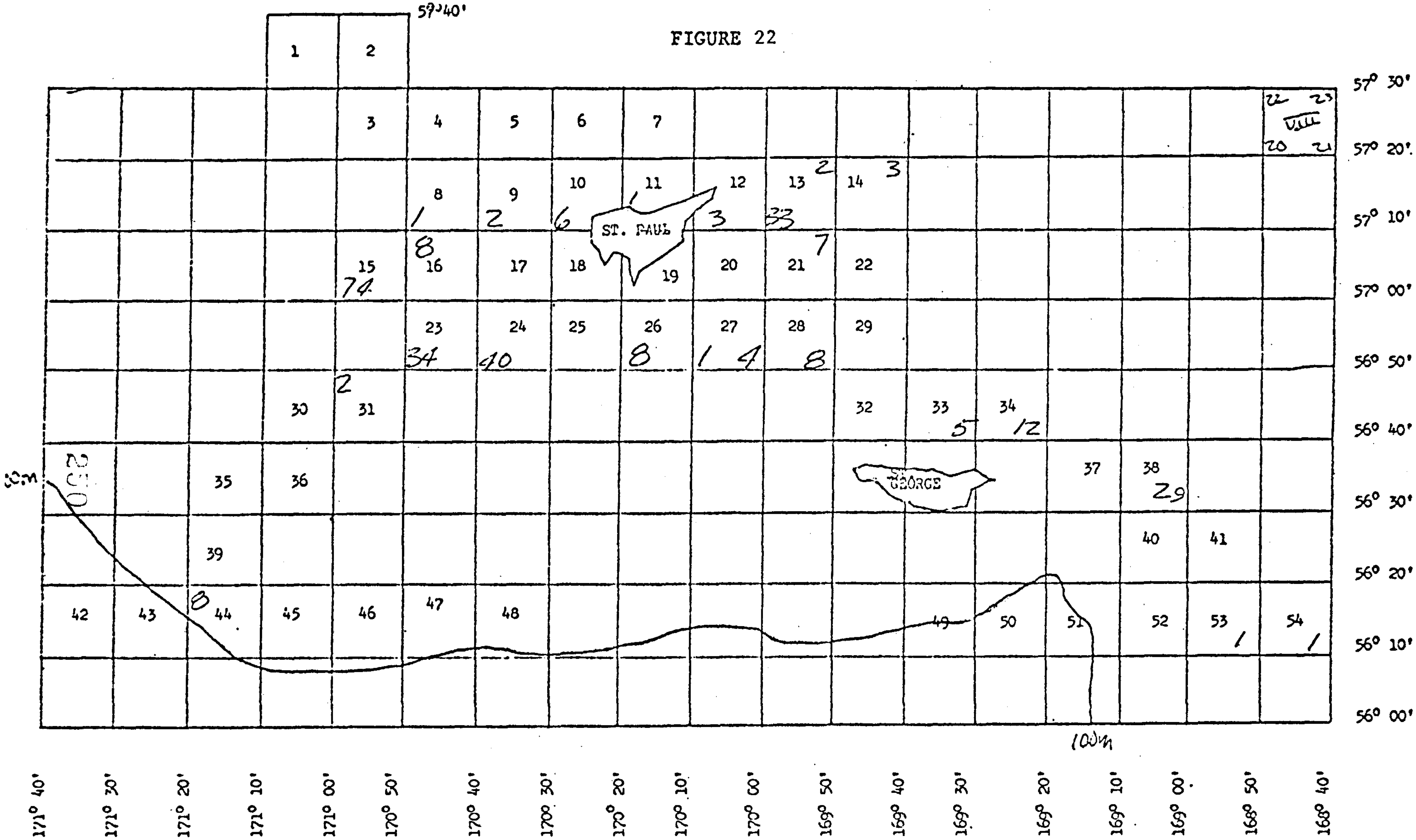


Puffin (total) Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975

FIGURE 21



Murre Counted on the Cruise of U.S.C.G.S. Discoverer, 20 - 23 August 1975



Small Alcid (total) Counted on the Cruise of U.S.C.G.S. <u>Discoverer</u>, 20 - 23 August 1975 breeding. While all of the alcids (murres, auklets and puffins) were seen more often near the islands, kittiwakes and fulmars occurred more frequently in continental shelf and shelf edge areas. The small number of Red-faced Cormorants seen occurred mostly in continental shelf areas. Auklets (including "small unidentified alcids") constituted a relatively small percentage of the total number of birds; by the time the cruise took place toward the end of August most had left their breeding grounds on the islands.

Of the birds seen that do not breed in the Pribilofs, the shearwaters far outnumbered all other species in all three area types. Petrels were concentrated in areas away from the islands and constituted approximately 20 percent of all birds seen in continental shelf grid blocks.

E. Survey of Otter and Walrus Islands

Examination of slides taken during the flight around Walrus Island confirmed observations made from the helicopter that the huge colony of Common Murres described in earlier literature was no longer present. The large flat top of the island was bare and bore no evidence of guano patches indicating where birds might have congregated. However, a small group of gulls or kittiwakes was seen resting on the shore at the northern end of the island, and a large flock of kittiwakes was seen feeding nearby. The low cliff areas of the island were partially white, indicating the presence of a small number of seabirds. Detailed analyses of the slides for the count of Steller's Sea Lions around the edges of the island indicated between 1,684 and 1,562 animals present. These data have been provided to the Seattle National Marine Fisheries, Marine Mammal Laboratory.

At Otter Island our view of the highest cliffs at the west end of the island was blocked by a fog bank. Although our observations of the lower south-facing cliffs were very brief, this area appeared similar both in physical structure and in the types of seabirds present to the cliffs of St. Paul and St. George Island.

Observers on the *Discoverer* survey were able to see murres near the tops of the low cliffs of Walrus Island in late August two weeks after the helicopter survey. The observers believe that these birds were not actually on the top of the island, and were not part of the former Common Murre colony.

VII. Discussion

Ideally a baseline study of nesting seabirds should provide data on: 1) where and when birds are nesting, 2) what kinds of birds are present, 3) how many birds are present, 4) how successful they are in raising young, and 5) where do they obtain food and what do they eat. With this information available, it is possible to ascertain the populations at risk if an oil spill occurs in a given area, and the magnitude of the effects of the spill on nesting population size and reproductive success. Additionally, if long term banding data are available, it may be possible to construct life tables for species and to predict the ability of a species to recover from a disaster.

In the present coordinated studies of Pribilof Island seabirds, Dr. J. Hickey and his team on St. George have concentrated on problems 1, 2, and 3, while we have concentrated on problems 4 and 5 on St. Paul. With cooperation between the two groups, we feel it will be possible to get a clear overall picture of seabird numbers and reproductive ecology in the Pribilof Islands.

In our work on the Pribilofs we have attempted to develop an overall understanding of processes and principles which govern seabird reproductive success and foraging behavior. There are too many remote colonies of seabirds in Alaska for all to be accorded the degree of study needed to establish realistic baselines. Therefore, it is necessary to concentrate on a limited number of important areas, and attempt to develop an understanding of seabird ecology which can be extrapolated to other areas. Predictions can then be made and tested, and if found reliable, used for estimating present baseline conditions, and also for advising government bodies on the sensitivity of areas to oil spills before lease sales are made.

The temporal distribution of nesting activities for seabirds on St. Paul Island in 1975 is summarized in Figure 23. The Red-faced Cormorants are the first to commence nesting activities in May, and the puffins are the last to finish, late in September. Thus, for at least 5 months nesting activities will bind one or more species of seabirds to the vicinity of the island.

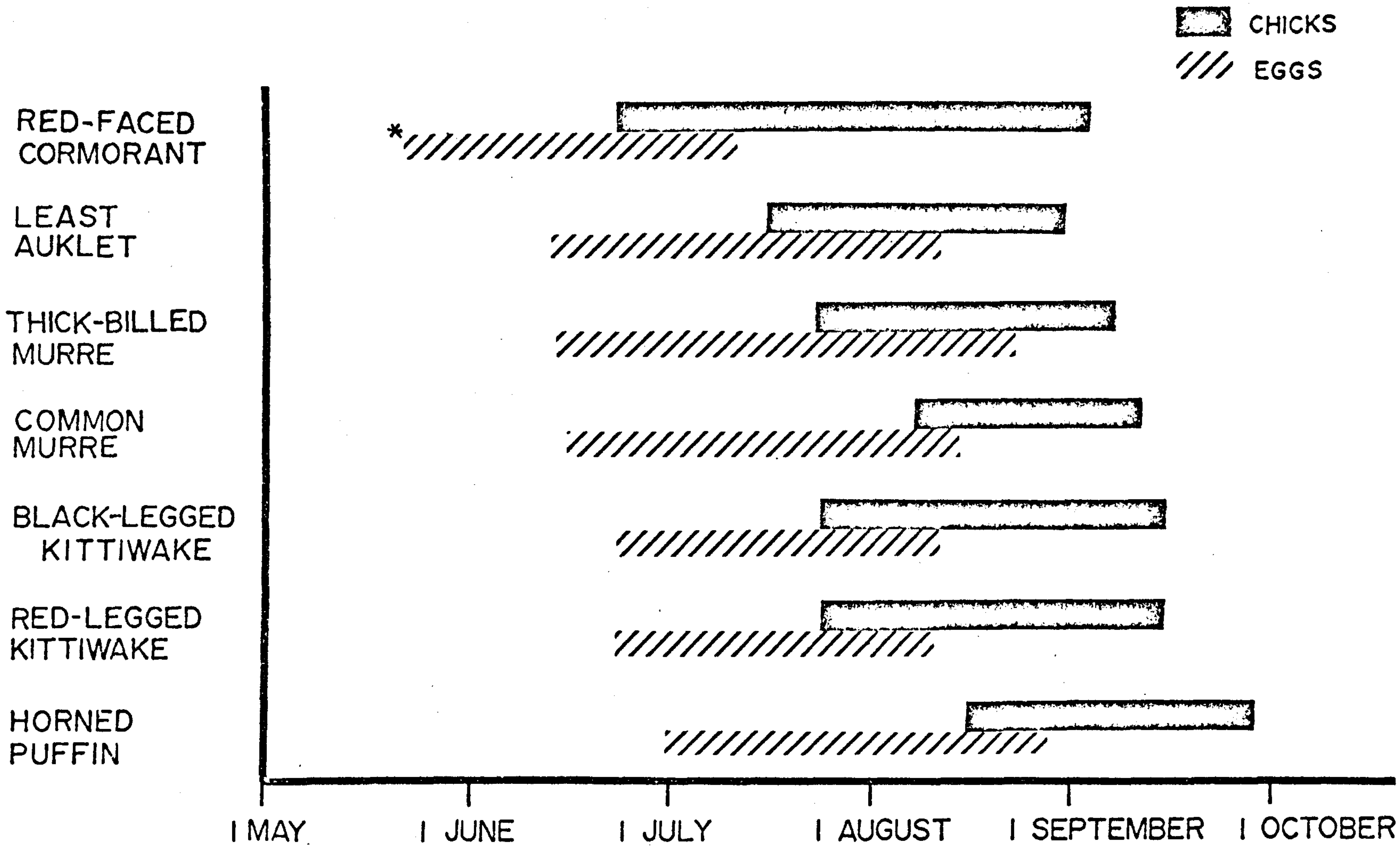
We have found that the spatial distribution of nesting activity for the 11 species of seabirds on St. Paul Island is determined by the availability of nesting sites on ledges and in holes in the vertical cliffs that border the island on the south and west sides. In addition, one of these species, the Least Auklet, also nests in large numbers on boulder beaches deep in holes between the rocks.

All seabird species on St. Paul were the potential prey of the Arctic Foxes which live by scavenging, catching birds and taking eggs. The foxes are small and agile and were often seen running easily up and down the crumbling cliffs where a person would soon perish. Consequently, the seabirds that bred successfully are those that nest in locations inaccessible to foxes and therefore also to ornithologists. Interestingly introduced cats, while common in the villages, did not appear to be a major threat to the cliff nesting seabirds.

In spite of these problems, we were able to obtain reasonably good data on reproductive success and growth rates of young of five species. Our results of .38 - .48 chicks/egg laid for Thick-billed Murre compares well with Tuck's (1960) figure of .41 for his study of a colony on Cape Hay in 1957. Our estimates of Black-legged

FIGURE 23

PRESENCE OF EGGS AND CHICKS IN NESTS OF SEVEN SPECIES OF SEABIRDS ON ST. PAUL ISLAND, 1975



*Extrapolated from hatching dates.

Incubation period = 1 month

255

Kittiwake nesting success (o.44 - 0.55 young/nest) were much lower than the 1.22 and 0.72 young fledged/nest found by Swartz (1966) at Cape Thompson in 1960 and 1961 respectively. However, in terms of a baseline study, we will need several years of comparable data before we will be able to say what is "normal" for these species in the Pribilofs. For this sort of work one year provides but one "sample".

Comparisons can, however, be made between similar species or populations within this year's sample. Comparisons between Black-legged and Red-legged Kittiwake on St. Paul and between Red-legged Kittiwake on St. Paul and St. George are particularly rewarding.

Earlier workers (Prentis 1902 in Preble and McAtee 1923) described the Red-legged Kittiwake and Black-legged Kittiwake as about equally abundant on some parts of St. Paul. At present, the Black-legged Kittiwake far outnumbers the Red-legged Kittiwake on St. Paul, while populations of the Red-legged Kittiwake appear large on St. George. Two possible reasons for the decrease in numbers of the Red-legged Kittiwake on St. Paul could be competition for food or nesting space with the Black-legged Kittiwake, or shooting by the Aleuts who find the Red-leg a particular delicacy. It would be extremely interesting if we could correlate differences in reproductive success between species and populations with major changes in population size. If changes in reproductive success can in turn be related to food habits or other quantifiable parameters, we will have not only a very important discovery, but also a tool for predicting future changes in kittiwake populations.

During the present year's study we found that on St. Paul Island, Black-legged Kittiwakes had larger clutches than Red-legged Kittiwakes and fledged more chicks per nest even though survival of young in relation to chicks hatched was lower overall for Black-legged Kittiwakes (Tables 5 and 6). Thus, the higher reproductive success of the Black-legged Kittiwakes is directly attributable to their larger clutch size.

When reproductive success within Red-legged Kittiwakes is compared between St. Paul and St. George (Table 6 and 7) it appears that Red-legged Kittiwakes enjoy greater reproductive success on St. George. This result may be biased by our starting work on St. George shortly before hatching was to commence, and thereby causing us to overestimate hatching success. Our results need to be carefully checked by future studies of these birds on St. Paul and St. George as they may provide an important clue about the changing kittiwake populations in the Pribilof Islands, a matter of no small interest since the Red-legged Kittiwake is endemic to the Bering Sea and nests on only a very few islands.

A comparison of the reproductive success of the Thick-billed and Common Murres on St. Paul shows that the more abundant Thick-billed Murre enjoys both greater hatching success and greater fledging success than the Common Murre. At present we do not know why this difference exists, but, during at least the egg stage, it seemed that on the broad, crowded ledges occupied by the Common Murres there was a greater chance for unattended eggs to be knocked off the ledge than was the case on the narrow ledges occupied by Thick-billed Murres, one observation at odds with those of Tuck (1960, p. 154).

The mortality of murre eggs and young associated with the passage of two or more airplanes close to breeding cliffs points to the need to restrict the movement of aircraft should oil leases be sold in the vicinity of seabird colonies. Frequent disturbance by aircraft could prevent successful reproduction and spell the doom of the largest of seabird colonies.

It is still premature to discuss in detail the results of the radial transect surveys for foraging birds at sea. We were somewhat surprised by the large numbers of shearwaters close to St. Paul Island (Figure 17). The distribution of petrels was much as we had expected. More important for the studies of breeding birds was the finding that both of the two species of kittiwakes (Figure 19) and the Fulmars (Figure 15) ranged far from the islands often near the continental slope. Away from the islands the numbers of kittiwakes and Fulmars appear to be closely correlated with one another. It will be valuable to collect these species at sea on future cruises, as time permits, in order to determine their food preferences in relation to food availability.

The alcids, which are notoriously vulnerable to oil on the sea's surface, were found primarily close to the islands, usually within 10-20 miles. Because the small alcids had largely completed their breeding cycle by the time we made our transects, we were unable to get much data on possible differentiation of feeding areas used by the different species. However, it did appear that the murres were not distributed evenly in a band around each island, but rather were clumped in a few areas of presumed abundance of food (Figure 20).

Our brief surveys of Otter and Walrus Islands suggest that these areas are deserving of future attention. Walrus Island, once reputed to be the home of one of the world's largest Common Murre colonies, no longer supports large numbers of these birds. Clearly we need to visit Walrus Island early in the season in order to determine what birds are still breeding there. Otter Island has in the past been a breeding area for the Red-legged Kittiwake (Kenyon and Phillips 1965) and it would be very interesting to know whether that population, free of shooting pressures from the Aleuts but not necessarily free of competitive pressures from Black-legged Kittiwakes, is holding stable.

VIII. Conclusions

Given the need to obtain data over the course of several years prior to determining what is "normal", any conclusions at this point would be premature. We have, however, demonstrated the feasibility of obtaining accurate data on the timing of nesting, reproductive success, growth rates and foods of a wide variety of seabirds in a demanding environment. Gathered over a sufficient time base, these types of data can provide the information necessary to detect changes due to environmental purturbations.

In terms of immediate application of our observations to O.C.S. development, two findings may be of particular significance. First, the cliff nesting species, particularly the murres, may be very sensitive to disturbance both by fixed wing aircraft and helicopters. Additional experimental study on this point is needed to determine the extent of the hazard and permissable distances of approach.

Secondly, from our one brief cruise, it appears that most of the birds nesting on St. Paul Island forage relatively close to the island. If subsequent cruises confirm this impression, then oil spilled within a zone 30-40 miles around an island will create an extremely serious hazard to sea birds breeding on that island. Note of this zone of extreme vulnerability of nesting birds to oil should be taken in any decisions concerning permits for drilling or transporting oil.

IX. Needs for further study

Additional required research falls into two categories, short term and long term studies. Needed long term (10-15 year duration) studies include banding programs to elucidate life-history information, and moratlity and replacement rates. The results of such studies should be generalizable for whole species and could be conducted in different locations for different species, depending upon their accessibility. Species in the Pribilofs which could profitably be studied for life-history information would be the Black-legged and Red-legged Kittiwake and the Red-faced Cormorant. The life-history information is essential if the impact of an oil related disaster is to be assessed in terms of the ability of a population to recover.

A second long term study making use of banding would be to determine the frequency of movement of individuals of various species of seabirds between colonies. If a given colony is destroyed or partly destroyed, the repopulation of the area may depend as much or more on immigration of individuals from adjacent populations as from population growth generated within the remenants of the local population. At present there is very little information on the extent of interchange between colonies.

Additional long term study is required to elucidate population trends. If the populations of Red-faced Cormorant and Red-legged Kittiwake are declining on St. Paul, effort should be made to determine the rate of this decline and its cause. These two species are endemic to the Bering Sea, and it will be critical in the development of oil production to prevent their extermination.

A number of short term studies are required which should be able to be completed within the 3-4 years remaining for the proposed baseline program. One such study would involve radio-tracking of birds on their foraging grounds. The present efforts, using large ships to conduct radial transects, is providing valuable information on the general distribution of birds in the vicinity of the Pribilof Island colonies. The implicit assumption is that the birds seen are nesting on the nearby islands. To test that assumption it is necessary to track birds from their nests to the foraging ground. We would like to commence radio-tracking studies during the third field season, after we have gained a second year's experience with the equipment and techniques in southern California.

A second short term study of value would involve determining the importance or the role of the apparent surplus of non-breeding Murres which occupy the nesting colonies. Dr. Drury and I have both noticed that for every egg on a given ledge there may be several adult murres present in addition to the pair which produced the egg. There are suggestions that some of these "extra" birds are in fact "helpers", which contribute food and perhaps protection to a chick of which they are not a parent. In order to determine the impact of a spill on the reproductive output of a colony, it will be important to know the extent to which these "extra" birds contribute to raising a chick. If "helpers" play a significant role in raising a chick, then the loss of even the "surplus" non-breeding birds could affect the reproductive output of a colony. During our second field season we intent to commence pilot studies of this problem using color-marked birds.

A final short-term study of great urgency is an investigation of the effects of aircraft disturbance on murres. With the likelihood of increased aircraft traffic with all phases of oil exploration and development, and with the use of aircraft for censusing birds or for estimating reproductive success as suggested by Dr. William Drury, it is essential that we determine the impact of aircraft operations near colonies. Observations of the effects of aircraft on seabirds should be gathered in carefully controlled experiments involving coordinated efforts between observers on the ground and in the plane.

X. Summary of 4th quarter operations

During the period 1 November 1975 - 1 April 1976 we have been operating on a skeletal staff of one 50% time graduate research assistant, and the senior investigator. In this period we have completed the identification of 211 food samples and have an additional 81 samples yet to be analysed. We have also been planning the field work for the second field season, purchasing supplies and equipment and arranging logistic support.

Work up of the at-sea transect data has not been possible, due to the lack of the ship's track data. This has been repeatedly requested. Likewise we have not put the data from the first year on code forms, as we have only just received the formats. It is perfectly clear that insufficient time remains between now and the beginning of the field season for this work to be completed before the end of the contract, 1 October 1976.

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BREEDING ECOLOGY OF THE GULF OF ALASKA HERRING GULL GROUP

(Larus argentatus x Larus glaucescens)

ANNUAL REPORT

1 April 1976

by

Samuel M. Patten, Jr., M.Sci.
Associate Investigator
Department of Pathobiology

The Johns Hopkins University

Linda Renee Patten
Research Technician
Department of Pathobiology

The Johns Hopkins University

An analysis of the 1975 and previous field seasons presented as a working copy to the

U.S. Department of Commerce
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and

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Fish and Wildlife Service

and

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as part of the

Environmental Assessment of the Alaskan Continental Shelf

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Samuel M. Patten, Jr.
M.Sci.

SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT IN THE NORTHERN GULF OF ALASKA:

This first annual report of Research Unit #96 is addressed to the following tasks:

TASK A-4 -- Summarize and evaluate existing literature and unpublished data on the distribution, abundance, behavior, and food dependencies of marine birds.

TASK A-5 -- Determine the seasonal density, distribution, critical habitats, migratory routes, and breeding locales for principal marine bird species in the study area. Identify critical species particularly in regard to possible effects of oil and gas development.

TASK A-6 -- Describe dynamics and trophic relationships of selected species at offshore and coastal study sites.

TASK A-28 -- Determine by field and literature studies the incidence of diseases presently existing in fish, shellfish, birds, and mammals for use in evaluating future impacts of petroleum-related activity.

This report provides information on the breeding ecology, including disease aspects of the Gulf of Alaska Herring Gull group (Larus argentatus x Larus glaucescens).

There are five known large gull colonies along the northeast Gulf of Alaska between Cordova and Juneau, in an area soon to be impacted by the development of oil resources. These colonies are located at Egg Island, Strawberry Reef, Haenke Island, Dry Bay, and North Marble Island. There is little information known about the reproductive biology of these colonies prior to this investigation. The goal of the current study is to assess the reproductive health of these gull populations. Reproductive indices are now available for two of these colonies, Egg Island and North Marble Island.* This information indicates these populations have the potential for rapid increase with access to human garbage, sewage and refuse associated with increased oil operations, but their colonies are sensitive to disturbance during the breeding season. Gulls are associated with canneries, fish-packing houses, garbage dumps, sewer outfalls and municipal water supplies along the coast of Alaska, and are clearly implicated with human bacterial and parasitic diseases in Alaska. As the availability of human-generated refuse increases with the development of oil resources in the Gulf of Alaska, populations of gulls previously more isolated may come into closer contact with one another. The gene flow between gull populations in the Gulf of Alaska may be further increased in coming years as a secondary influence of human activities, which may lead to a new adaptive peak in this commensal bird species, with consequences for municipal health and sanitation.

This investigation will continue with examination of the population structure, reproductive biology and disease aspects of this gull group. Dry Bay, Strawberry Reef, Egg Island and Middleton Island will be researched this season.

* Egg Island: 1.03 chicks/nest; n=153
North Marble Island: 1.77 chicks/nest; n=162 - 191

INTRODUCTION

The Larinae (gulls) have a world-wide distribution with 42 species. Gulls as a group may have evolved in the North Pacific and North Atlantic (Fisher and Lockley, 1954). Sixteen species of gulls are found in the North Pacific (Vermeer, 1970). Birds of this sub-family have been considered chiefly inshore feeders, and most coasts support a smaller scavenging species and a larger more piratical type (Cody, 1973). Recent evidence indicates that large as well as small gulls can behave as essentially marine species, feeding far out at sea and coming to land only occasionally or to breed (Lensink, pers. comm.). Most gulls live in flocks; they forage together in characteristic patterns the year around and nest in colonies during the breeding season (Tinbergen, 1960). These gregarious birds nest in a wide variety of habitats ranging from vertical cliffs to open marshes (Smith, 1966a). Gulls lend themselves to population analysis, especially productivity, because of their colonial breeding tendency (Kadlec and Drury, 1968).

An important reason for studying gulls is their use as indicators of the health of the environment (Vermeer, 1970). Chemical pollution of the environment poses an increasing and immediate threat to all organisms, including man. A recent survey conducted by the U.S. Fish and Wildlife Service (Ohlendorff, pers. comm.) of chemical residues in marine avifauna showed gulls to be among the most contaminated birds examined, probably due to their feeding habits. Since gulls nest in colonies, changes in breeding populations can be monitored and related to environmental conditions, among which are industrial development and the concurrent changes in food supply.

An additional reason for studying gulls is that the age structure, mortality rate, life expectancy and survival rates of gull populations aid in the general understanding of population mechanisms. The mere knowledge of the size of a population from year to year indicates little about population problems without such data (Paynter, 1949).

The size, age structure, growth or decline of a population are a result of fluctuations in time and space of the natality and mortality rate, and movement into or out of a population of a species. Breeding adults form the base of the population structure, because only by successful production of young can a population grow or maintain itself (Kadlec and Drury, 1968).

Reproductive rate has an important effect on the age structure and the growth of the population. The average number of young which a breeding pair can raise to fledging is a good measure of gull reproductive success. Meadow-nesting gulls are excellent subjects for a study of reproductive success because eggs and young are readily accessible. Information is available on the breeding biology and dynamics of gulls near large urban centers, or in recent post-glacial environments, but comparative base-line information on gulls along the southern coastline of Alaska prior to the development of oil resources is completely lacking.

This report presents the initial results of an ongoing study of meadow-nesting gulls in widely-spread colonies in the northeast Gulf of Alaska. These sites were selected for research because of the incipient development of oil resources in the vicinity, and the necessity to provide base-line information on marine birds along this relatively wild stretch of Alaskan coastline. The overall objectives of the study are to gain information on distribution, behavior, population dynamics, trophic relationships, and pathologies of the Gulf of Alaska Herring Gull group (Larus argentatus x Larus glaucescens). To assemble this information,we studied: colony sites, feeding areas, behavior of adults and chicks, aspects of breeding biology, calculated hatching and fledging success, and compared the data to knowledge of other Alaskan gull populations previously studied. We banded a large number of gulls, and color-marked, collected and removed blood samples from a smaller number of individuals. We carried out a concentrated investigation of the breeding biology of Larus glaucescens on Egg Island, at the mouth of the Copper River, Chugach National Forest, near Cordova, Alaska. Additional time was spent examing a mixed colony of Larus argentatus and Larus glaucescens at Dry Bay, mouth of the Alsek River, Tongass National Forest, near Yakutat, Alaska. Information previously gathered on a Larus glaucescens colony on Haenke Island at Disenchantment Bay (off Yakutat Bay), and from North Marble Island, south of the study area, is included in this report for comparative purposes (Figure 1).

The Glaucous-winged Gull (L. glaucescens), which breeds along the coast from Washington State to the Aleutians, is quite closely related to the Herring Gull (L. argentatus), a common and widely distributed species. Herring Gulls make up a low proportion of the breeding gulls in the northeast Gulf of Alaska, but occur more commonly in winter and offshore. The Herring Gull replaces the Glaucous-winged Gull in interior Alaska, British Columbia, and the Yukon. The Glaucous-winged Gull is morphologically similar to the Herring Gull except that the black pigment on the tips of the primaries is replaced by light grey that matches the rest of the mantle. Conversely, the iris of the Glaucous-winged Gull is darker than that of the Herring Gull. These two gulls are considered separate species in the A.O.U. Checklist of North American Birds (1957), but the taxonomic and ecological relationships between the two species have not been clearly defined. In some areas hybrids are common.

Information on other species of plants and animals inhabiting the

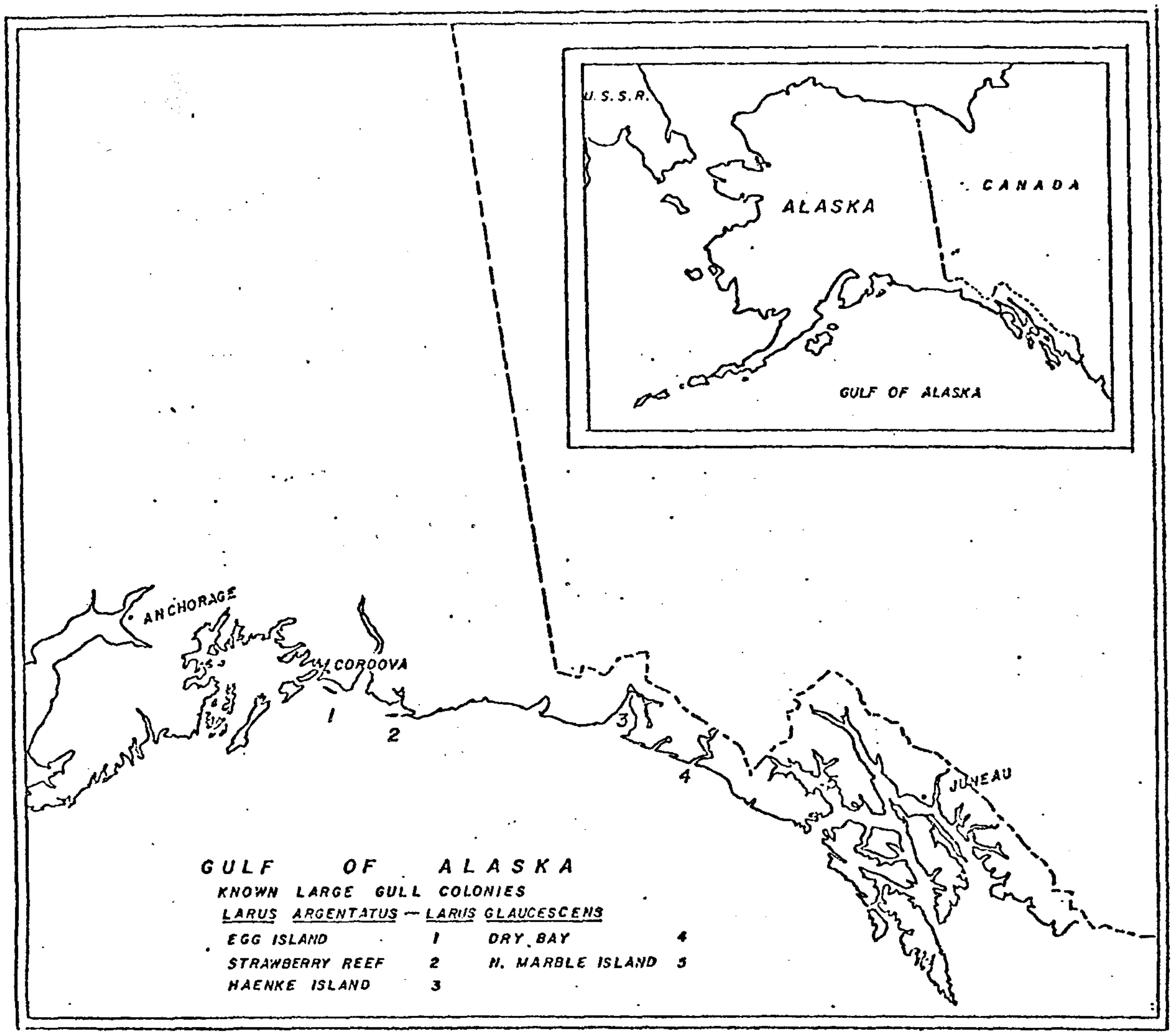

Figure 1. Map of the northeast Gulf of Alaska, showing known large gull colonies of the Larus argentatus - Larus glaucscens species group. (Inset: map of Alaska and northwest Canada showing Gulf of Alaska.)

Oil lease sales will take place offshore from colony (1) and between colonies (2) and (3).

coastal area of the northeast Gulf of Alaska was gathered to support the main objectives of this study. This first annual report presents the results and analysis of the data gathered during the 1975 field season, and is supported material gathered in previous years of research in this area. Banding returns, disease aspects, as well as relevant literature on gulls have been incorporated in this expanded and revised report, which follows the initial interim report of 1 November 1975.

SCOPE AND SIGNIFICANCE OF THE STUDY

The nature of this study was to examine the reproductive biology of several colonies of Herring and Glaucous-winged Gulls in the northeast Gulf of Alaska. This report covers information from the 1975 and previous field seasons. Several aspects of gull breeding biology were studied for comparative purposes. Such information is available in the literature for gull populations outside of Alaska and from Glacier Bay National Monument south of the study area. This comparison serves as a basis from which to draw some tentative conclusions. Definitive statements require further investigation. An important aspect of this report is the initial data on fledging success. As can be seen from a literature review, fledging success can serve as an index to the dynamics of an avian population. If fledging success is poor over a number of seasons, a population will decline through adult mortality and low recruitment of breeding adults. While this report presents 1975 fledging success from the largest gull colony in the northeast Gulf of Alaska, it is emphasized that no firm conclusions should be drawn regarding the state of this population without further study.

Results from this report provide the National Oceanic and Atmospheric Administration with specific information about the status of a marine-oriented animal population during one field season. More broadly, this report indicates additional areas to be investigated for a better understanding of an Alaskan marine bird species under environmental conditions certain to change with increasing human activity.

Task A - 4

CURRENT STATE OF KNOWLEDGE

The breeding biology of gulls, especially the Herring Gull, has been studied in detail by Goethe (1937), Paludan (1951), Tinbergen (1960), Harris (1964) and Ludwig (1966). Their results consistently indicate that Herring Gulls raise an average of one young per pair per year to fledging. Extremes of variation are shown to be 0.5 by Paludan (1951) and 1.5 by Ludwig (1966) (in Kadlec and Drury, 1968). The population dynamics of the Herring Gull in eastern United States and Canada have been reasonably well investigated by Kadlec and Drury (1968). Kadlec and Drury (loc. cit.) found the usual productivity is apparently 0.8 to 1.4 young per nest in the New England Herring Gull, averaging about 50 percent fledging success. They showed this to be a major factor in the structure of the New England Herring Gull population, which has been rapidly increasing since the turn of the century. In a later paper (Kadlec et al., 1969) they examined the critical period between hatching and fledging for mortality factors.

Their results indicate the average clutch size in the Herring Gull is nearly always three, and variations are small (Keith, 1966; Brown, 1967b; Paynter, 1949; Kadlec and Drury, 1968). Hatching success is usually 60 to 80 percent. Keith (1966) has discussed in detail the problems of accurately measuring success, which are due to predation or cannibalism of eggs and chicks before they can be counted. Critical factors effecting hatching and fledging rate are chick and egg loss through cannibalism, chick mortality due to aggressive behavior of adults, and weather conditions during the breeding season (Paynter, 1949; Paludan, 1951; Tinbergen, 1960; Brown, 1967b).

In contrast to the intensive investigations of Herring Gulls in Europe and eastern North America, few workers have studied gulls along the Pacific Coast of North America. Breeding biology of the Western Gull (*Larus occidentalis*) has been studied by Coulter (1969), Schreiber (1970), Harpur (1971) and Coulter, et. al. (1971). Aspects of the breeding biology are similar to those of the closely related Herring Gull, but nesting habitat selection and nest materials differ because of the drier conditions on California islands. Recently Hunt and Hunt (1973) and Hunt and McLoon (1975) have investigated supernormal clutches, aberrant pairing, and chick mortality in Western Gulls.

Vermeer (1963) published a major work on the breeding biology of the Glaucous-winged Gull, although Schultz (1951) reported on growth in this species. In most aspects the Glaucous-winged Gull is similar to the Herring Gull, including plumage sequences (Schultz, ms).

Other important papers on gulls are those of Coulson and White (1956, 1958, 1959, 1960) on the Kittiwake (Rissa tridactyla), in which they attempt to refute Darling's (1938) contention that egg-laying synchrony in the Herring Gull and the Lesser Black-backed Gull was related to social facilitation. Darling's (1938) hypothesis of social stimulation suggests that stimulation received from other birds in a colony produced greater synchrony of egg-laying within the colony. This in turn resulted in earlier egg-dates and a shorter spread of egg-laying in large colonies. Coulson and White (1956), however, showed that the difference in breeding times between colonies of the Kittiwake was not significant and that the spread of egg-dates increased with the size of the colony. Coulson and White (1960) observed that the greater part of the differences in time of breeding were correlated with density. They found that the spread of breeding was greatest in dense colonies of Kittiwakes, which does not support Darling's contention. Moreover, breeding occurred earlier in the more dense colonies. Hunt and Hunt (1975) have found in the Western Gull, which tends to nest on level ground, that territory size expands and agonistic interactions increase with the hatching of chicks. Apparently there are dynamics in gull breeding ecology which have not been explored.

Cullen (1957) reported on adaptations of the Kittiwake to cliff-nesting, which was followed by N.G. Smith's (1966a) work on adaptation to cliff-nesting in arctic gulls (*Larus*), and his more extensive study (1966b) on evolution in arctic gulls. Smith found four sympatric species on Baffin Island to be reproductively isolated due to such mechanisms as species recognition and nesting habitat selection. Ingolfsson (1970) noted rapid evolution in Icelandic gulls (*Larus argentatus* and *Larus hyperboreus*) since 1925, probably due to a secondary contact between these species associated with the development of large-scale Atlantic fisheries and the concurrent spread of the Herring Gull to Iceland.

In summary, one finds that the Herring Gull and relatives in North America lay a clutch of three from which they normally fledge one young per nest per year. Predation and attacks by members of the same species are the primary factors responsible for egg and chick loss. Gulls have increased rapidly in Europe and eastern North America within the last seventy years. The increase in gull population is associated with environmental deterioration, due to increases in refuse, fish scraps, and similar garbage.

THE STUDY AREA

The largest and probably most important gull colonies in the northeast Gulf of Alaska are located on sandbar islands off the Copper River delta. For millenia Copper River has flowed from interior Alaska through the Chugach Mountains (2000-3000 m) to the Pacific Ocean. The river carries a naturally heavy burden of silt, mud and gravels from montaine erosion and the heavy, ongoing glaciation of the higher peaks. This massive river system flows into the Gulf of Alaska south of Cordova, Alaska, and carries Gletschermilch, mud and gravel of the Scott, Sheridan and Sherman glaciers and other ice systems (USFS, 1975) (Figure 2).

The Copper and the confluent Martin River have deposited their sands and mud where they meet the sea. With the increasing salinity gradient the suspended inorganic matter precipitates out. A large, 50 kilometer-wide delta has been formed over the centuries. The rivers move across the delta, crossing tidal mudflats and passing through brackish sloughs. Shallow ponds are formed in sedgy or grassy marshes. Summers in the Copper Delta region tend to be cool and rainy, while winters bring extremely strong storms, intense cold, ice and interior winds which blow with incredible velocity.

The Copper River Delta has been one of the most productive and important migrating and breeding grounds for waterfowl on the North American continent (USFS, 1975). Millions of birds pass through the area in spring and fall, and tens of thousands of ducks, geese and swans remain to breed. Brown bears and moose roam the delta, while black bears, lynx, wolf, coyote, black-tailed deer and wolverine are found in forested areas of the delta nearer the mountains. Another indicator of the importance and productivity of the Copper River Delta is the sizable fishery on the "Copper Flats" for king, sockeye, and silver salmon. The king and sockeye salmon migrate up

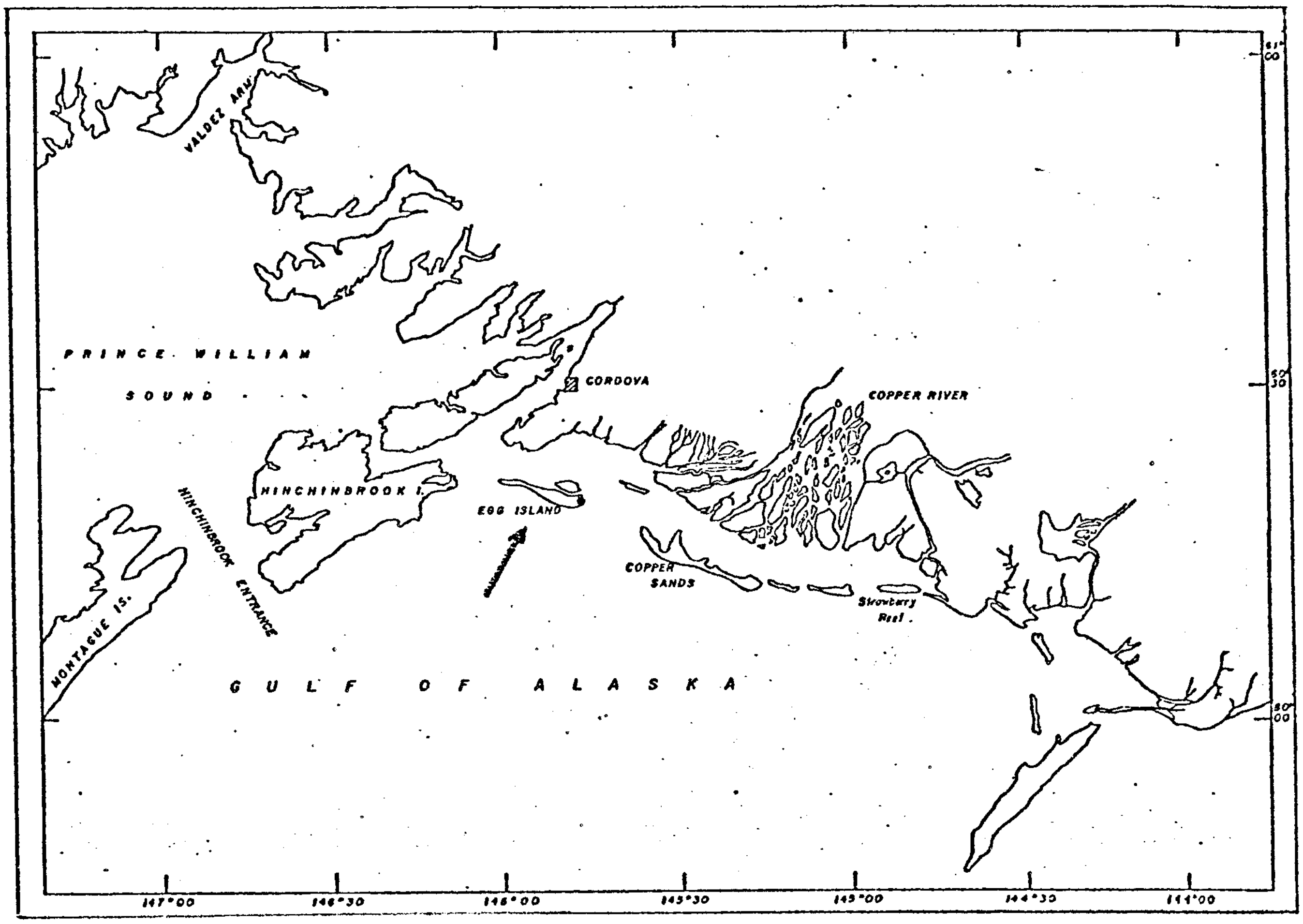

Figure 2. Map of the Copper River Delta region and Prince William Sound, showing location of Cordova, the Copper River, Egg Island (arrow), Copper Sands, and Strawberry Reef.

the Copper River into the interior to spawn, while the silver salmon breed in the smaller streams and tributaries of the delta. A Herring fishery is important and increasing in size in the Cordova-Copper River, Prince William Sound area. It is inevitable that this concentration of food resources should attract fish-eating birds such as eagles and gulls.

A series of low sandbar-dune islands located a few kilometers offshore, form a partial barrier at the mouth of the Copper River. Geologically these islands appear to have been entirely formed by the deposition of sand and mud from the Copper River, and to have been shaped by the counter-clockwise onshore currents of the Pacific Ocean.

Constant change is a characteristic of the interface between land and sea, especially where rivers enter the ocean. Sandy islands are formed, built up, and eroded away again in a relatively slow, uninterrupted process. However, the Copper River Delta and surrounding area have been marked by sudden geological changes that have been extremely important in affecting the local biota. The most severe earthquake recorded on the North American continent during modern times occurred in March of 1964. The whole Copper River delta and surroundings including offshore islands, were uplifted an average of two meters in a series of severe shock waves (USFS, 1975). This abrupt uplift disrupted the complex ecosystem of the Copper Delta and altered the balance between fresh and salt water. Nutrient imput from salt water to the delta was appreciably diminished; several species of intertidal invertebrates declined in numbers, and nesting populations of ducks changed much for the worse. Willows and alder began to replace grassy and sedgy marshes in certain areas on the delta. Tidal sloughs dried out.

The offshore sandbar barrier islands at the mouth of the Copper River underwent the same geological forces as the delta itself, but due to the nature of the islands and the marine bird species using them, the resulting changes were quite different. Shallow salt-water channels separating islets were eliminated, and new ridges of sand dunes formed, joining islets together. The actual land area of the islands increased due to the uplift. Because fresh water was limited on the islands before the earthquake, the small breeding populations of waterfowl were not affected to the degree on the Delta itself. The gulls, the largest breeding bird population on the outer islands, were influenced in the following manner. The long lines of dunes increased in height and area. Plant succession began on newly formed dunes, with *Elymus*, the beach rye, forming scattered tufts on the sandy surface. The beach rye spread from the older high dunes which were covered with grassy meadows, in which *Elymus* was the dominant plant species. A variety of other lesser grasses, mosses and forbs also occurred. Large colonies of gulls nest on these meadow-covered dunes. With the passage of time, more and more dunes become covered with meadows as succession continues. The actual area upon which gulls can nest is increasing. A few young alder and cottonwood trees are growing on the higher dunes of Egg Island. If this trend towards woody vegetation continues, in time the result could be displacement of nesting gull populations. The presence of important seafood packing canneries in Cordova is providing an increasing food supply for gulls, and the potential for discarded human food and industrial waste in the Cordova area incraases daily. Islieb (pers. comm.) sees an increasing gull population to this point. Additional factors now enter the picture(of unknown consequence). The trans-Alaska pipeline is being constructed from Prudhoe Bay on the North Slope to Valdez on Prince William Sound on the south. Valdez is less than 150 kilometers northwest of the delta. Tanker traffic will pass just offshore from the barrier islands through the entrance to Prince William Sound. The Copper River Delta itself is rich in both mineral and fossil resources. The first oil well in Alaska was developed just south of the delta at Katalla in 1901 (USFS, 1975). A consortium of oil companies is presently involved in exploratory research offshore. The first oil leasing is expected 13 April 1976 and will include an area offshore from the Copper River Delta near Middleton Island, and a large group of tracts offshore between Kayak Island and Icy Bay (see map), an area bracketed by large gull colonies at Egg Island, Strawberry Reef, Haenke Island, and Dry Bay. Banding returns and sightings of color-marked gulls from this study indicate this lease sale area is repeatedly traversed by gulls under current investigation (see below).

The following annual report should be understood as an analysis and predicition of some of the vector forces acting to change gull populations in the NEGOA.

MATERIALS AND METHODS

Colony Selection and Investigation Dates

We selected Egg Island as a principal location for this study because it has the largest meadow-nesting gull population in the northeast Gulf of Alaska. Kenton Wohl of the Bureau of Land Mangement, Dr. Pete Michelson, then of the Forest Service, and Pete Islieb of Cordova emphasized the importance of this colony to our study. The 1975 field season began on 16 June and continued through August 23. We selected a survey area southwest of Egg Island light, and spent considerable time on foot examining the rest of the island colony. There were 153 nests in the study area, which was fairly representative of conditions on the island. This study area is located on the windward, ocean slope of stabilized meadow-covered dunes of the east end of the island near the light tower. Egg Island Light is readily identified on nautical charts, and can be visually observed from some distance (Figure 2, 12).

We initially hoped for a survey area of about 100 nests in this facet of the study. We measured a 150m x 150m square with a tape, flagged the corners with survey markers, and counted nests a sequence of slow sweeps. Our final nest count considerably exceeded our original estimation, a fact to be remembered in future surveys. (Figures 12, 13).

Kadlec and Drury (1968) observed that a high level of disturbance will cause Herring Gulls to abandon efforts to breed. Coulter et al (1971) found reproductive success in a colony of Western Gulls to be inversely proportional to the amount of disturbance. Therefore we did not enter the survey colonies except when absolutely necessary.

Reproductive Cycle

We used a method devised in previous gull studies to mark the nests we were studying. We marked 153 gull nests with flagged wire stakes in the 22500 m^2 study area at the beginning of the investigation on Egg Island. Since growth of vegetation tends to obscure the stakes, each was marked with a additional numbered florescent streamer. The same method was used to mark 100 nests at Dry Bay, another study area south of Yakutat. Using the measure of territory defined by Harpur (1971) we used a steel tape to find the direct distance from every nest to the center of the nearest neighboring nest; one half this distance was assumed to be the radius of the territory. Nest diameter and depth were measured in Dry Bay and on Egg Island for comparative purposes.

Each time we visited a nest site we recorded the number of eggs or chicks. The highest number of eggs per nest was assumed to be the clutch size. Due to the short notice under which the investigation was begun, completed clutch size figures are lacking. Original clutch sizes were extrapolated from typical rates of egg loss from data gathered in our previous Alaskan studies. Egg loss was calculated at the end of the incubation period from the numbers of eggs remaining from the (calculated) completed clutch. We counted young chicks on Egg Island in the nest. We assumed older chicks to come from the nearest nest; such older chicks were banded with 657 series tall tarsal bands and released. At the end of the survey period in August, we made fledging counts of banded chicks for the entire survey area on Egg Island. The results were compared to North Marble Island and to other gull studies.

Data Analysis

As part of each sequential visit through the gull colonies we recorded the number of eggs and chicks from each nest site visited. The numbers were recorded on 80-column entry, and used to compute clutch size, egg loss, hatching success and fledging success.

A Monroe 1766 programmable desk-top calculator was used for the initial statistical analysis. Means and standard deviations are included in the data where applicable.

Raw data on 80-column entry was filed with Mr. Mauri Pelto (NOAA-OCSEP) in Juneau, Alaska, for later retrieval.

Specimens

We collected specimens from Egg Island, Haenke Island, and Dry Bay. Thirty-two Egg Island specimens were collected in July and August 1975. Ten Haenke Island specimens were collected in June 1974, and twenty-eight Dry Bay specimens were collected in June 1974 and 1975. Three Egg Island specimens were placed in the charge of Dr. David Norton, OCS Arctic Project Officer, for potential petrochemical assay. The other specimens are maintained in the Department of Pathobiology, The Johns Hopkins University, since analysis is presently only partially complete. At the close of this study, the specimens will be maintained in the U.S. National Museum and the American Museum of Natural History. Two hundred and fifty gull blood samples from chicks and adults were collected. Serum was collected from the samples with a centrifuge courtesy of Alaska Public Health Laboratories. Analysis of these sera is not yet finished.

Task A - 6

RESULTS

General Timing of the Reproductive Cycle

Exactly when gulls first arrive on Egg Island in the spring is not known, although Michelson (pers. comm.) reports seeing gulls on their nesting areas in May. Arrival dates may vary from year to year by several weeks due to weather conditions and snow cover. Gulls are present in the Cordova area through the winter, but nesting populations do not settle down in their colonies until snow melts (Islieb, pers. comm.). Streveler (pers. comm.) reports similar observations from Glacier Bay (Figure 3).

Incubation was well advanced at the time of our arrival on Egg Island in the middle of June 1975. The first chicks hatched around the middle of June, and most chicks hatched the last week of June. This year the peak time of fledging on Egg Island was the beginning of August. At Dry Bay, the general timing of the reproductive cycle was two weeks delayed from that of Egg Island, since the first eggs were pipping at the end of June. Brogle (pers. comm.) reported heavy snow fall and a late spring for the Yakutat area this year, perhaps accounting for the late nesting gulls. Extrapolating from the hatching dates, and assuming an incubation of 24-26 days, as has been reported by Patten (1974) for Glaucous-winged Gulls in Glacier Bay, Alaska, most egg laying took place in the last week of May 1975 on Egg Island. Gulls at Dry Bay laid most of their eggs in the first week of June.

Other investigators have reported the following: Western Gulls in southern California usually lay eggs at the end of the first week in May (Schreiber, 1970; Harpur, 1971). Herring Gulls in Rhode Island and Michigan, and Lancashire, England, have mean egg-laying dates usually around the end of the first week in May (Erwin, 1971, Keith, 1966; Brown, 1967a). Herring Gulls breeding on Kent Island, New Brunswick, Canada, have mean egg dates in the middle of May (Paynter, 1949). Glaucous-winged Gulls on Mandarte Island B.C., Canada, lay most of their eggs in the last week of May and the first weeks of June (Vermeer, 1963). Patten (1974) has reported egg dates of mid to late May in Glacier Bay. While egg-dates vary by several weeks in the

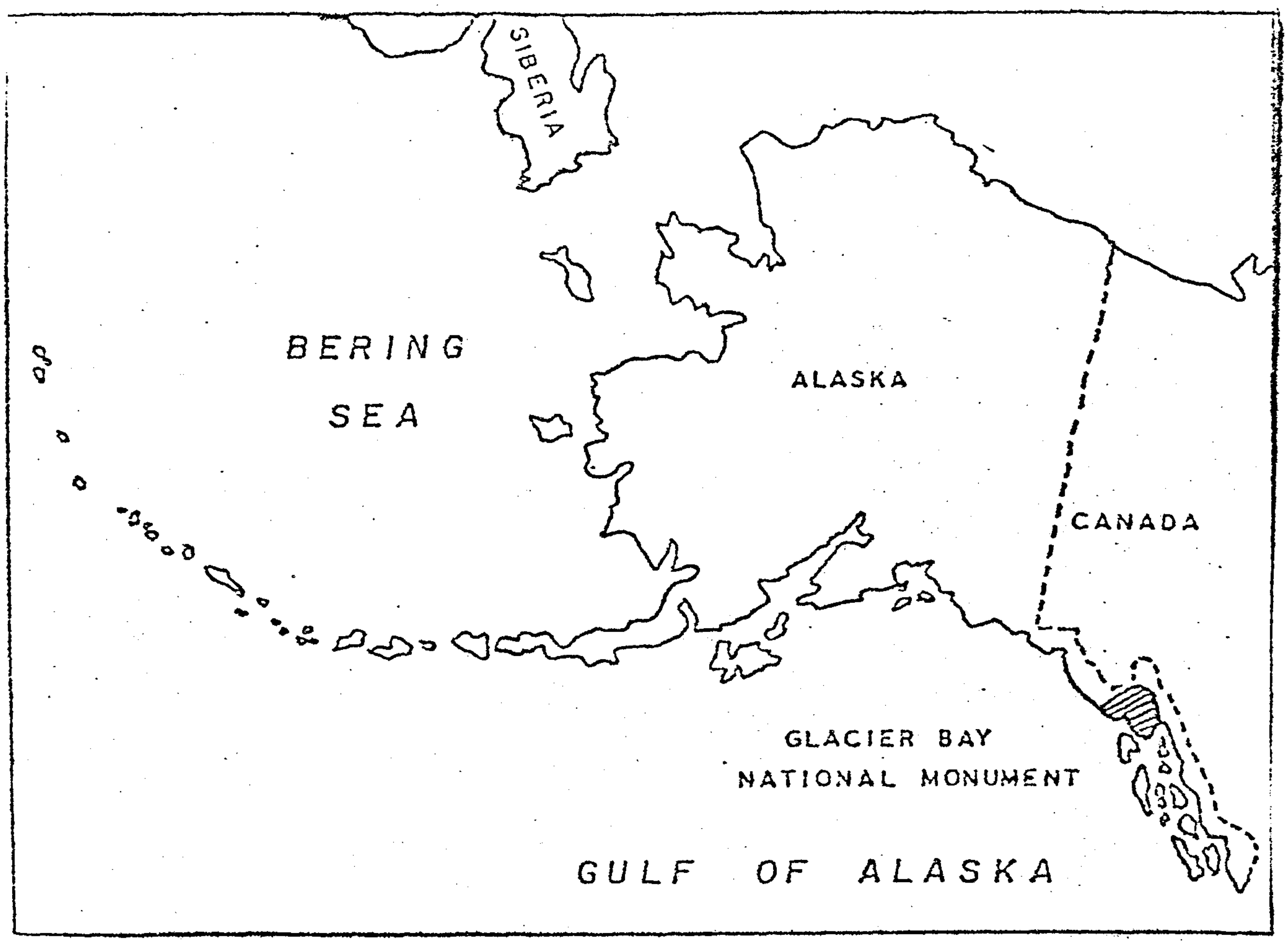

Figure 3. Glacier Bay National Monument (58° 10' - 59° 15' N. Latitude, 135° 10' - 138° 10' W. Longitude), located north of southeastern Alaska's Alexander Archipelago, is shaped as a parallelogram, with 104 and 120 km on a side.

northeast Gulf of Alaska, the general timing of the reproductive cycle most resembles that reported by Vermeer (1963) on Mandarte Island, B.C., and by Patten (1974) on North Marble Island, Glacier Bay, Alaska (Figure 4).

Territory Size

The definition of territory, as Hinde (1956) states, is "any defended area". Even if this definition does not necessarily imply that the defended area is sharply delimited, in practice many workers on territory (references in Hinde, 1956) imply the existence of such borders by measuring territory size. Using the measure of territory defined by Harpur (1971) we calculated the area of each nesting territory as a circle with a radius half the distance to the nearest active nest. We found the mean territory size on Egg Island was 28.9 m^2, while the Dry Bay mean territory size was 29.8 m^2. Mean distance to nearest neighbor at Egg Island was 6.066 m , while at Dry Bay the distance was 6.16 m. This suggests that there was no significant difference in the territory sizes in two widely spread colonies in the northeast Gulf of Alaska in the 1975 breeding season. Patten (1974) has previously reported a mean territory size of about 18 m^2 for gulls in two different seasons on North Marble Island, but that territory size varied from colony to colony and from year to year. In comparison, Vermeer (1963) found Glaucous-winged Gulls on Mandarte Island to have a mean territory size of 15.6 m^2. Harpur (1971) studying a small colony of Western Gulls near Santa Catalina Island, California, reported a small colony had a mean 22.0 m^2 territory size.

Patten (1974) has previously reported an inverse relationship between colony and territory size on North Marble Island in Glacier Bay. The inverse relationship could be due to the two kinds of predation pressure on gulls. Larger colonies of gulls, with smaller territories, have the

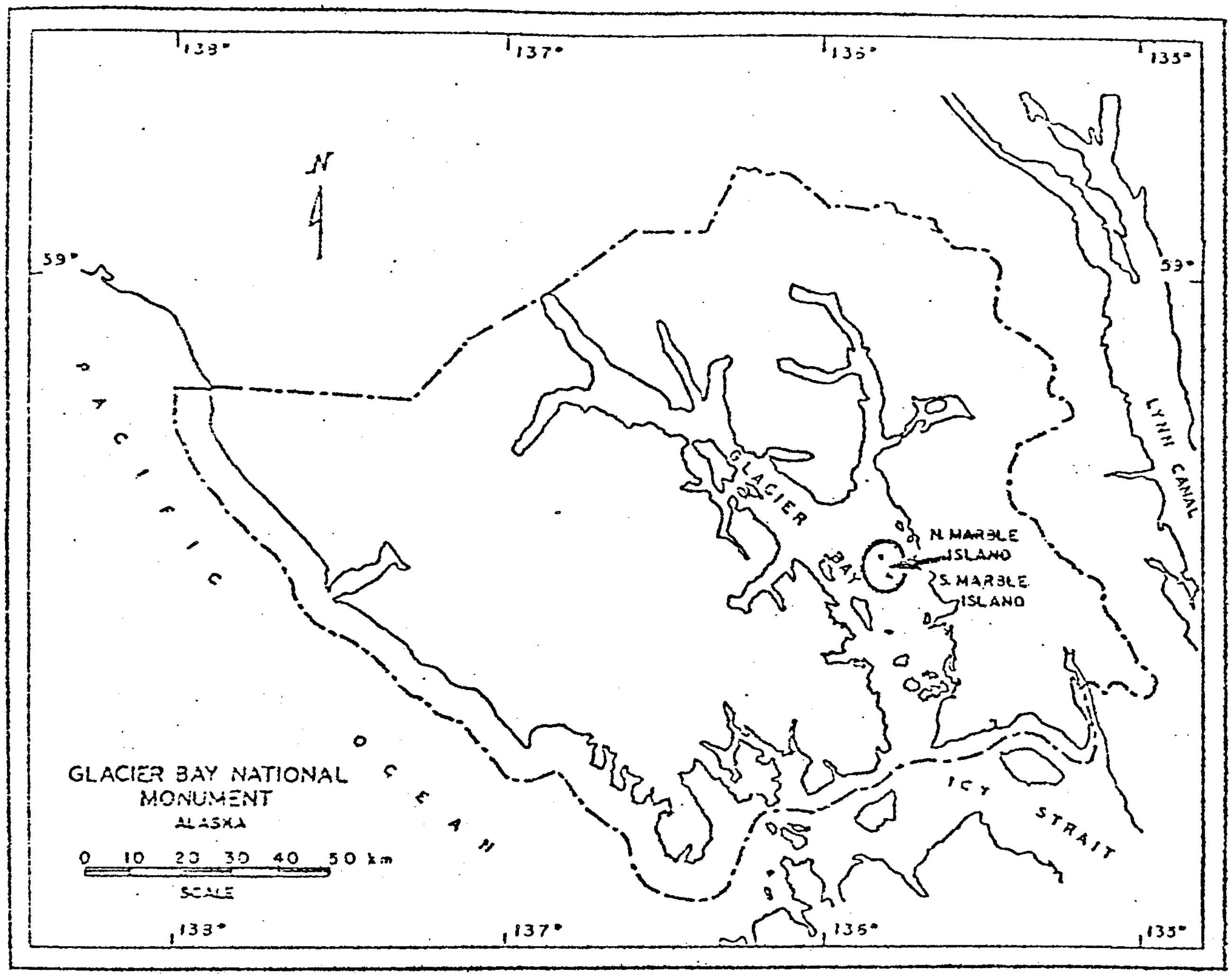

Figure 4. North Marble Island lies in the middle of Glacier Bay and contains large marine bird nesting areas. North and South Marble Islands, 2 km apart, are surrounded by cold, highly oxygenated waters and strong tidal currents.

advantage of behavioral mechanisms such as flight response to alarm calls and mass attack on predators (Kruuk, 1964), but large colonies suffer more internal cannibalization of eggs and chicks. Smaller gull colonies, with larger territories, have weaker defenses, more predation, and less cannibalism (Darling, 1938; Brown, 1967b). Selection may operate for a range of values around the optimum, and against both ends of the spectrum, although there are presumably more advantages to nesting closer together. In the field, this means one could expect gulls with very large territories or very small territories to produce fewer young over a long period of time. Since both Egg Island and Dry Bay survey areas contained 100 or more nest sites, it is not especially surprising that the mean territory sizes were quite similar; what is notable is the large territory size. This suggests the gull populations are not yet limited by the available nesting territory on their breeding islands. With increasing food supply, it is not unreasonable to expect increasing gull populations.

Table 1

CLUTCH SIZE, NUMBER OF FLEDGLINGS, & TERRITORY SIZE

IN ALASKA *L. argentatus* & *glaucescens*

Colony	Number of Nests	Mean Clutch Size	Mean Number of Fledglings	Mean Territory Size (m^2)
N. Marble	191	2.9	1.77	18 m^2
Dry Bay	100	(2.9?)*	---	29.8 m^2
Egg Island	153	(2.9?)*	1.03	28.9 m^2

* approximate calculations

The mechanism for establishing territory size is defensive behavior, according to Patterson (1956). The way in which this mechanism could produce dispersion of individuals or pairs has been discussed by Tinbergen (1957). He emphasizes that both attack and avoidance are involved in the maintenance of the territoral system. Both motivations are present in the threat displays of the territory owner and conspecific intruders almost always respond to these displays and to actual attack by fleeing. Degree of spacing between nests and territorial individuals will then depend upon the balance of attack and escape motivations in the established residents and intruding birds.

Two possible functions of the territorial system are: assistance to survival of adults, or insurance of their maximum reproductive success, or a compromise between the two functions. Data on mortality agents suggests that egg and chick predation was by far the most important cause of reproductive failure (Table 4). The most serious predation was gulls consuming eggs and chicks of their own species (see below); secondary in importance was crows, ravens, jaegers, and probably eagles (Vermeer, 1963) taking gull eggs and chicks. Darling (1938) suggested that the much larger territory sizes of the Lesser Black-backed Gull allow a higher overall reproductive rate than the Herring Gull. Large territories permit chicks to wander over a larger area before they stray into another parent's nesting region and are attacked. He also observed, however, that the young in large colonies has better survival than those in smaller colonies. He presumed this to be due to the greater degree of synchronization in large colonies leading to a smaller percentage of chicks or eggs taken by predators in any one period. However, Coulson and White (1958) challenged this conclusion by reporting the spread of Kittiwake breeding was greatest in larger colonies, with older birds laying sooner than young adults. Our evidence from Egg Island, a large colony, indicates a wider spread of breeding and a lower fledging success than North Marble Island, a much smaller colony under post-glacial conditions.

Another function of territory may be the spacing apart of nests. Tinbergen (1956) has stressed the importance of dispersion in cryptic prey in order to minimize the formation of search images in their predators. It would seem advantageous to have gull eggs and young spaced apart to some extent since they are cryptically colored. The arguments of spacing out as one of the main functions of territory have been summarized in the review by Hinde (1956) and by Tinbergen (1957). However, the upper limit of territory size would be influenced by the need for colonial nesting discussed above, and the lower limit influenced by the possibility of increasing intraspecific predation (see below). In addition, the spacing apart of nests in a gull colony is adaptive mainly against bird predators, normally the most important for gulls, which tend to nest on islands or cliffs (Patterson, 1956).

The most obvious factor in dense breeding populations of meadow-nesting gulls is that smaller territories increase the chances that wandering chicks will be attacked (see Ashmole,1963 for a similar argument concerning terns). Hunt and McLoon have recently (1975) argued that decline in food availability will lessen the ability of adult gulls to provide their chicks with food. When the begging chicks fail to receive food, their increased activity (wandering) will increase their chances of being killed by territorial neighboring gulls. This in turn suggests food as the ultimate limiting factor. If this sort of internal predation is combined with Darling's hypothetical effect of breeding synchrony, then there would be an optimum density for breeding. Whether gulls have reached this density in the northeast Gulf of

Alaska is not yet clear. Evidence indicates sufficient room for larger breeding populations on nesting islands.

Nesting Activities

Thousands of gulls on Egg Island nest on stabilized meadow-covered (Fig.6,8,10) dunes, usually in proximity to some additional cover of old drift logs or Sambucus bushes. Slope of the dunes is shallow, since the highest are only ten meters above sea level. Egg Island can be compared to North Marble, where highest densities of nesting gulls are found on completely open meadows. However, some sites on North Marble are precipitous, approaching 50 percent slope. Gulls tend to select breeding habitat where approaching predators can be easily detected. Gulls were not observed nesting in brush fringes on North Marble, but gull nests have been observed directly beneath bushes on Egg Island. Brush-nesting gulls have been previously reported by Vermeer (1963) for Mandarte Island, and Manuwal (pers. comm.) in the San Juan Islands, Washington State.

Dry Bay provides somewhat different conditions. About 500 gull pairs nest (Fig.5) on gravel bars at the mouth of the Alsek River. The low gravel islands there (Fig.9) are washed by high waters during spring melt-off and following summer storms. Vegetation as a consequence of unstabilized substrate plus flooding is sparse and consists of mainly *Salix*, spp., *Festuca*, *Achillea*, *Elymus* and *Epilobium*, which would indicate a combined maritime and fresh-water influence. Vegetation cover is important, since nests are clumped near drift logs, willow bushes, and grass patches. Fewer nests are located on exposed gravel. Nests are similar to those on Egg Island, although nest cups are more shallow, perhaps due to the lack of slope on the island and the lack of suitable vegetation. Some nests are hardly more than a depression in the sand with a few dry strands of *Elymus* around the edge.

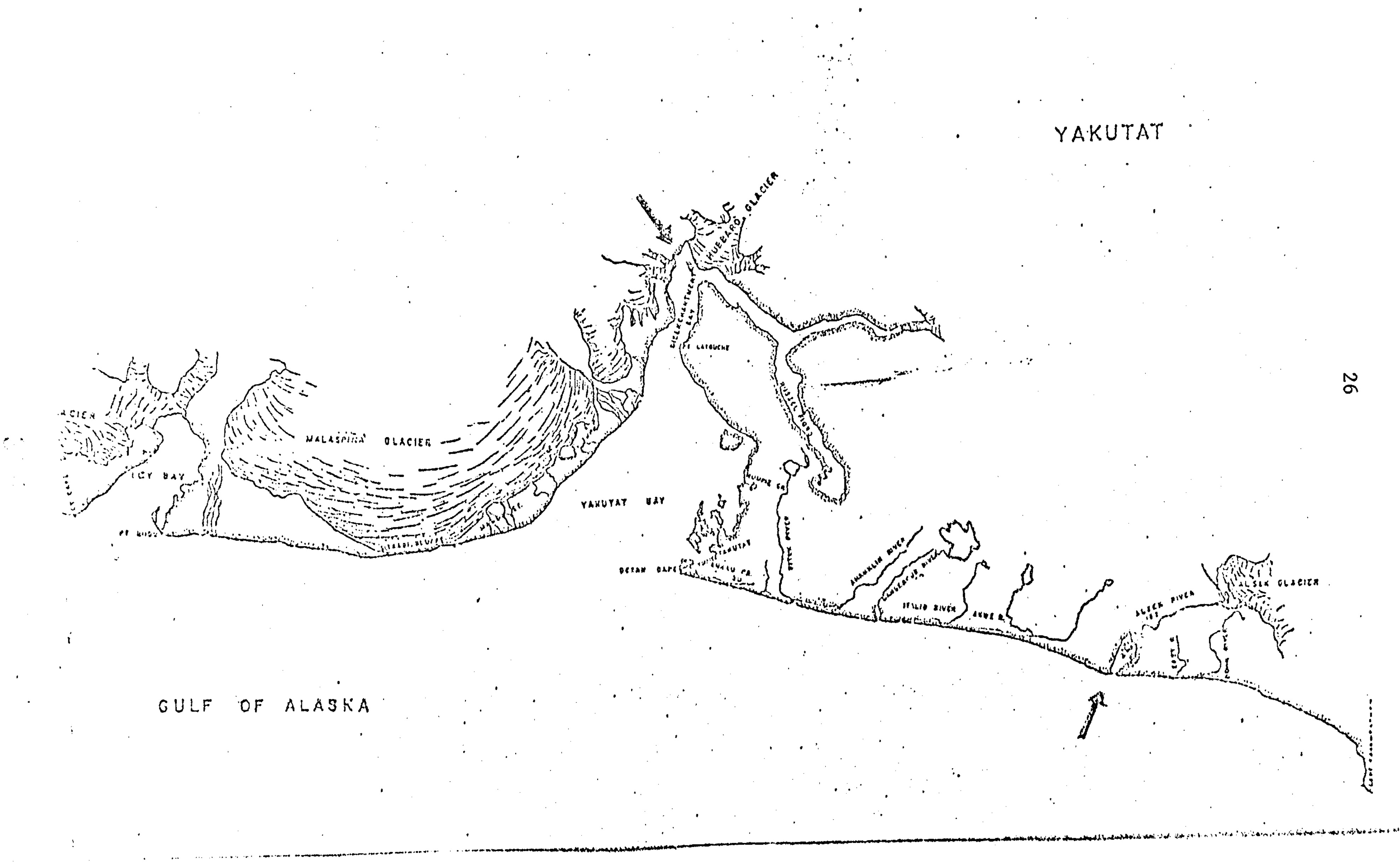

Figure 5. Map of the Yakutat area, showing location of gull colonies at Dry Bay, mouth of the Alsek River (lower arrow) and Haenke Island in Disenchantment Bay (upper arrow).

Gravel beds where no gulls nest separate parts of the island colony at Dry Bay. The reason for this distribution became evident when a strong summer storm followed days of brilliant sun. Apparently glaciers melted somewhat in the mountains. When the melt-waters combined with the heavy rainfall, the river rose, filled the gravel beds, sectioned off parts of the gull island and the entire area. Gulls on the gravel beds or on the periphery of the island must find their nests washed away under these conditions (Figure 9).

Glaucous-winged and Herring Gulls nest together at Dry Bay. These gulls are flexible in nesting habitat selection (Patten and Weisbrod, 1974; Patten, 1974). Western and Glaucous-winged Gulls also nest in a variety of habitats (Vermeer, 1963; Coulter, et al 1971). Nesting habitat selection apparently does not serve as an isolating mechanism between these species.

About 200 pairs of Glaucous-winged Gulls nest at Haenke Island off (Fig.5,7) Yakutat Bay. Haenke Island is about 1 km wide and 1 km across. The east side of the island, facing the Hubbard Glacier, gradually inclines up to a large 150-200 m westward facing cliff, which then slopes precipitously down a series of shallow terraces bordered by vertical cracks. Vegetation on the terraces is composed of alders and meadows. Sambucus and Ribes bushes border grass and forb meadows on the face. The dominant grass in the nesting areas was Hordeum sp. Mosses, fireweed and forbs made up the steeply sloping meadows where gulls did not nest. Glaucous-winged Gulls breed on the meadow-covered terraces. Gull nests in 1974 were widely spaced, approximately 20 meters apart on the average. We observed many "false" nests. The Glaucous-winged Gulls did not nest close to the water; the closest nest was about 25 m above the high tide mark.

Gulls in all colonies studied in southcentral and southeastern Alaska built nests of material available in the immediate vicinity of the nest site,

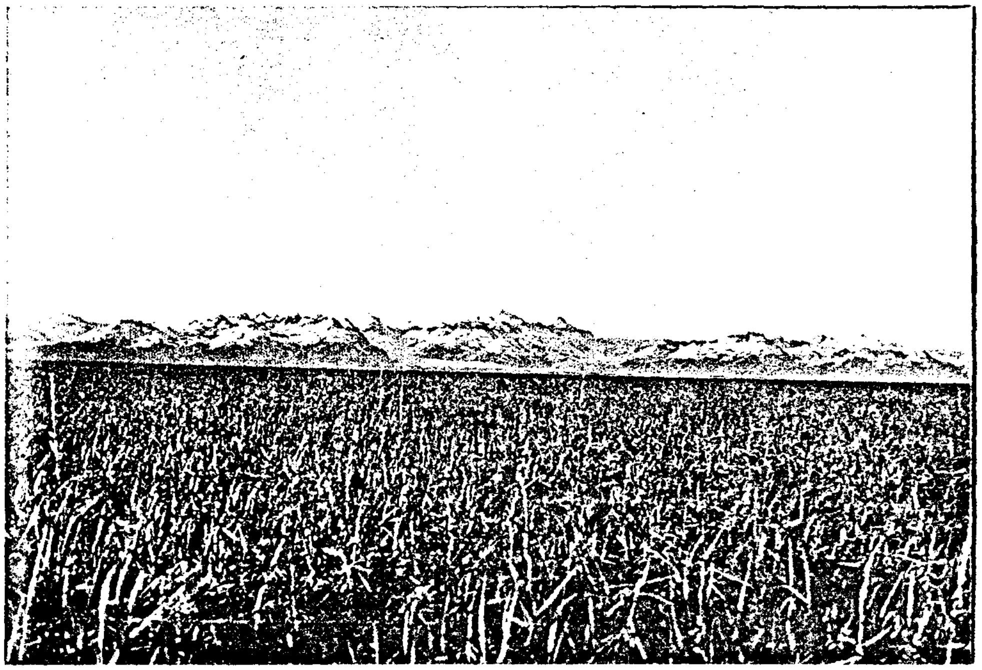

Figure 6. View from Egg Island, June 1975, showing Elymus meadows, Egg Island Channel, part of the Copper River Delta, and the Chugach Mountains.

Figure 7. Haenke Island (center) is located in Disenchantment Bay, off Yakutat Bay, near the active front of the Hubbard Glacier at the foot of the St. Elias Range.

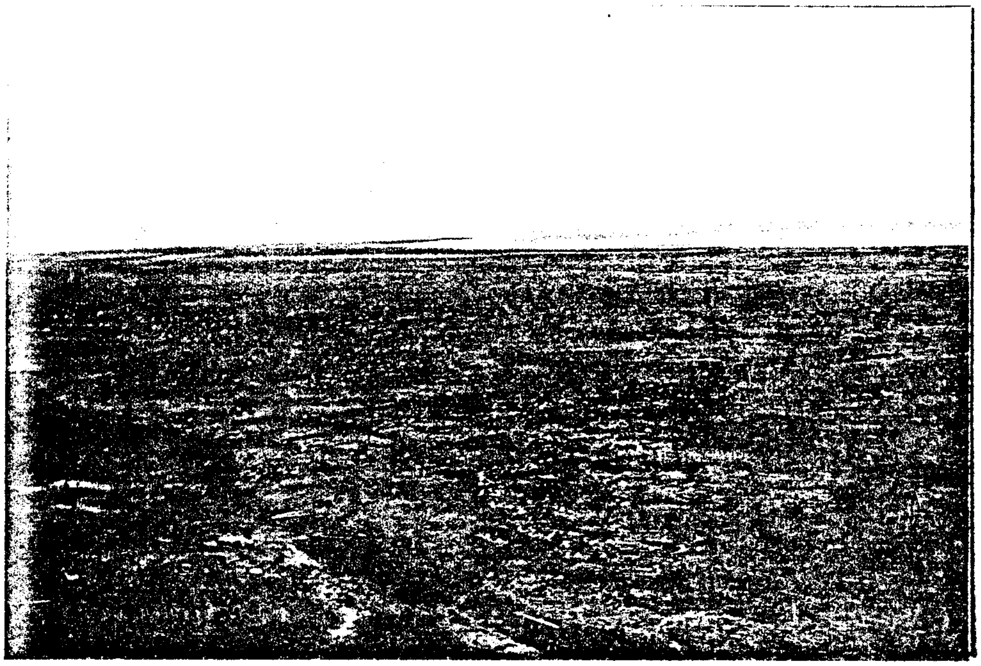

Figure 8. Egg Island viewed from a small aircraft at 100 m, showing hundreds of gulls flying over meadow-covered dunes with scattered old drift logs providing partial cover for nests.

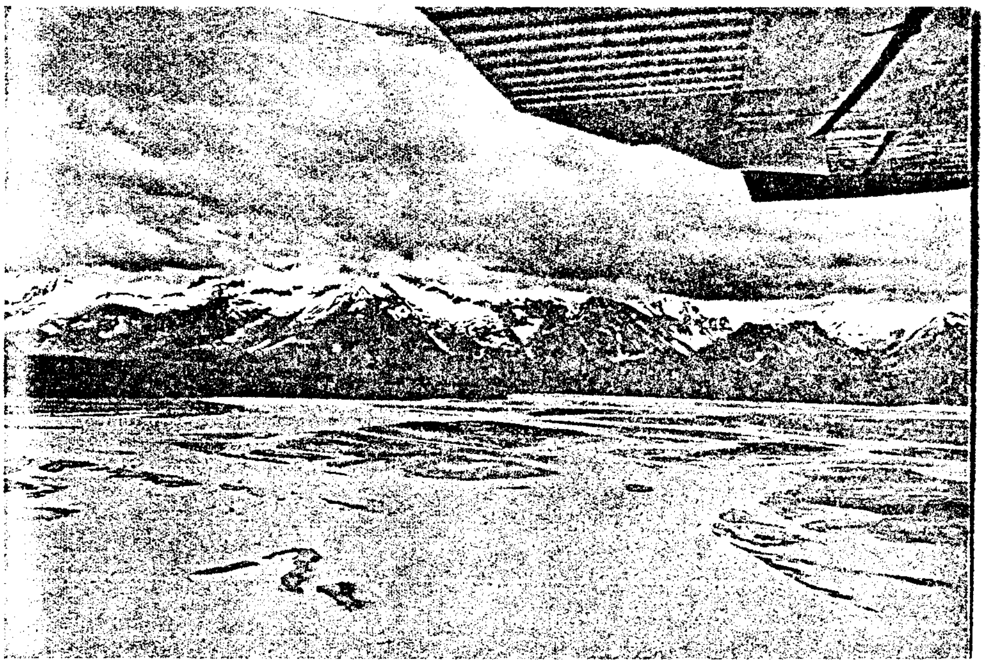

Figure 9. Dry Bay from a small aircraft at 200 m + elevation showing gull colony (center) on low gravel bars with sparse vegetation.

that is, usually within the territory. Colonies located on different vegetation substrate show the corresponding structural material in the nests. Thus, the predominant nest material on Egg Island is Elymus and (Fig. 10) mosses, on Haenke Island most material is Hordeum, Epilobium and mosses (Fig. 11); at Dry Bay Salix twigs, Epilobium and detritus, and on North Marble Hordeum, Festuca, Epilobium, Elymus and mosses depending upon colony location. Similar use of vegetation close to the nest site has been reported by Harpur (1971) and Strang (1973).

We measured 100 nests at Egg Island and 100 nests at Dry Bay for comparative purposes, the dimensions of which are presented along with North Marble data in Tables 2 and 3. The inner (nest cup) diameters along two perpendicular axes had respective means of 19.63 cm and 19.91 cm at Egg Island, and 19.92 cm and 20.06 cm at Dry Bay. The outer nest diameters along two perpendicular axes had respective means of 39.75 cm and 39.11 cm at Egg Island, while at Dry Bay the respective dimensions were 40.16 cm and 39.42 cm. (Table 2). Note that the standard deviations indicate that the nest cup dimensions, or inner diameters, are less variable than the outer nest dimensions (Table 2). This is due to the method of nest construction, in which the gull turns its body to form the more rounded uniform interior of the nest. Mean nest cup depth was 6.98 cm at Egg Island, while Dry Bay mean nest cup depth was 5.94 cm (Table 3). Egg Island nests tended to be deeper and more built up than those at Dry Bay. Note that nest cup dimension at North Marble was appreciably deeper than either Egg Island or Dry Bay, probably due to the large amounts of vegetation available on North Marble and possibly related to the greater slope. The nest dimensions given here resemble those of other large white-headed gulls (Patten, 1974).

Vermeer (1963) stated that either male or female Glaucous-winged Gulls

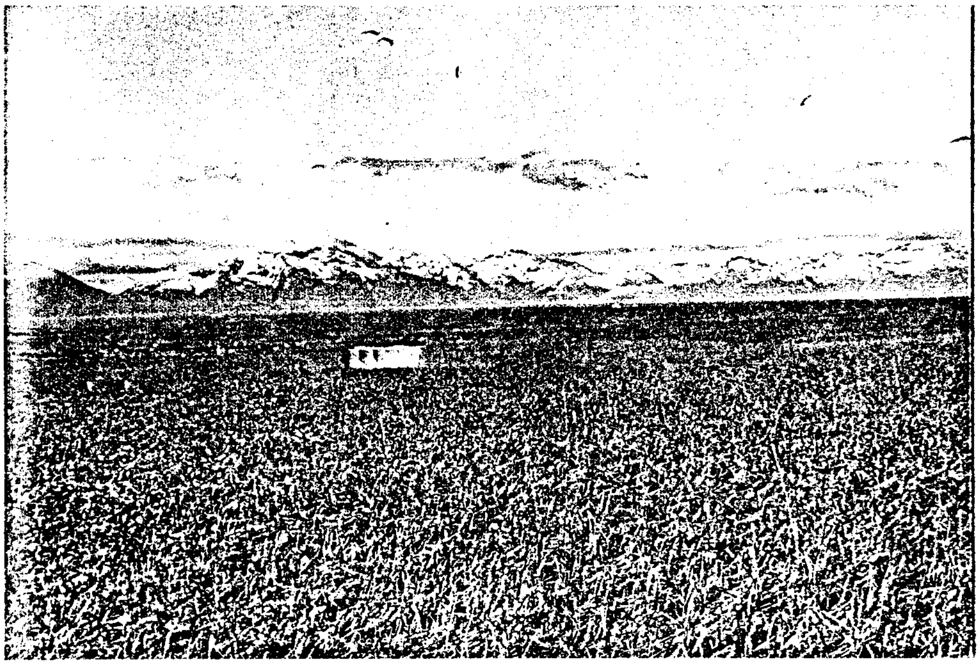

Figure 10. Campsite on Egg Island, June 1975 with Egg Island Channel and the Chugach Range in the background.

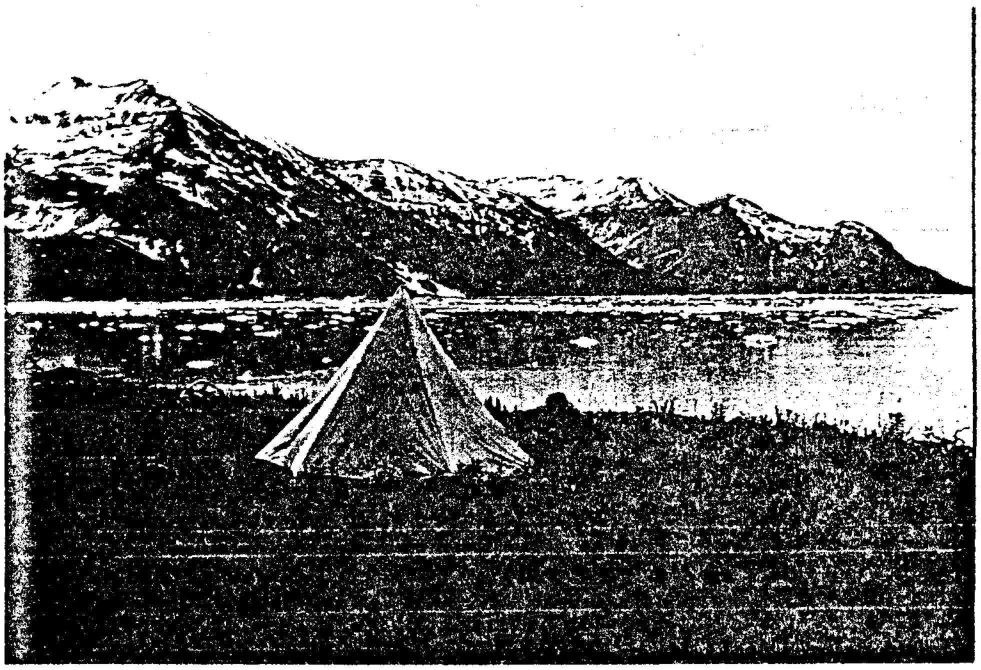

Figure 11. Campsite on Haenke Island, June 1974, at the foot of the gull colony on the cliff (not visible). Pack ice from the Hubbard Glacier in the background. Gulls feed on seal placentae scavenged on the ice.

may initiate nest building. After the beginning of nest construction, apparently both sexes share equally in building, in contrast to Herring Gull males, which collect more material than females (Tinbergen, 1960; Goethe, 1937). Nests are maintained until chicks hatch, after which the nests begin to disintegrate and rarely survive the winter storms.

We observed the construction of "false" or "play" nests at Egg Island, Haenke Island, Dry Bay and North Marble, as did Goethe (1937), Paynter (1949), and Tinbergen (1960) elsewhere. Construction of "false" nests may relate to the amount of available vegetation. Supernumerary nests may prevent the formation of search images in predators (Tinbergen, 1960). Reasons otherwise for the construction of supernumerary nests are not apparent. False nests may simply result from the release of the nest-building drive (Nisttrieb), but the effect can be the utilization of a large amount of vegetation. A colony of 500 gull pairs on North Marble removes about a metric ton of vegetation in one season. Added to the effects of trampling, fertilizing and physical damage done to the meadows during spring and summer, the total gull activity may act to retard herbaceous succession in the meadows in which they nest. Tree reproduction, however, around the edges of the meadows in gull colonies may eventually displace the gulls. For a discussion see Patten (1974). (See Figures 12, 13.)

Table 2

Inner and Outer Diameter of <u>Larus argentatus</u> - <u>Larus Glaucescens</u> Gull Nests at Egg Island, Dry Bay and North Marble Island, Alaska

	Egg Island Inner Diameter (cm) X axis	Y axis*	Outer Diameter (cm) X axis	Y axis*
Mean	19.63	19.91	39.75	39.11
Standard Deviation	0.97	1.22	3.90	3.74
Minimum	16.00	18.00	28.00	29.00
Maximum	21.00	25.00	46.00	48.00

sample size: 100 nests

	Dry Bay Inner Diameter (cm) X axis	Y axis*	Outer Diameter (cm) X axis	Y axis*
Mean	19.92	20.06	40.16	39.41
Standard Deviation	1.19	1.35	5.65	5.94
Minimum	18.00	18.00	30.00	30.00
Maximum	24.00	25.00	56.00	70.00

sample size: 100 nests

	North Marble Inner Diameter (cm) X axis	Y axis*	Outer Diameter (cm) X axis	Y axis*
Mean	21.55	21.53	38.59	37.69
Standard Deviation	2.92	2.48	4.92	2.04
Minimum	7.00	12.00@	23.00	5.00@

sample size: 100 nests

* Nests are nearly circular in both inner and outer diameter; X and Y axes are chosen at random, 90° from one another.

@ Small figures indicate incomplete nests.

Table 3

Nest Depth for Egg Island, Dry Bay and North Marble Island Colonies

	Egg Island	Depth (cm) Dry Bay	North Marble
Mean	6.98	5.94	10.57
Standard Deviation	1.07	1.35	2.04
Minimum	5.00	3.00	5.00
Maximum	10.00	14.00	16.00

sample size: 100 nests for each colony

Egg Laying

The gulls on North Marble begin to lay eggs in mid to late May (Patten, 1974). A remarkable degree of synchronization was apparent when comparing percentages of eggs found on sequential dates of observation through the nesting period. Egg-laying on North Marble both years was very closely synchronized in all colonies, although peak egg-laying was two weeks earlier in 1973 than 1972. Darling (1938), Coulson and White (1956), Coulter, et al (1971) and Brown (1966b) have reported synchronous egg-laying in gulls. There is considerable debate, however, about the relation of colony size and density to egg-laying synchrony (see above).

The northeast Gulf of Alaska gull study was not funded early enough this year to provide sufficient data on egg laying synchrony. However, evidence suggests a wide spread of egg dates on Egg Island. This may be due to the amount of egg predation from the large numbers of other gulls and consequent re-nesting. Smaller colonies at Haenke Island and Dry Bay may show less spread of egg dates, although evidence is currently incomplete.

Figure 12. Study area southwest of Egg Island Light, showing gulls on territories and nest survey markers, June 1975.

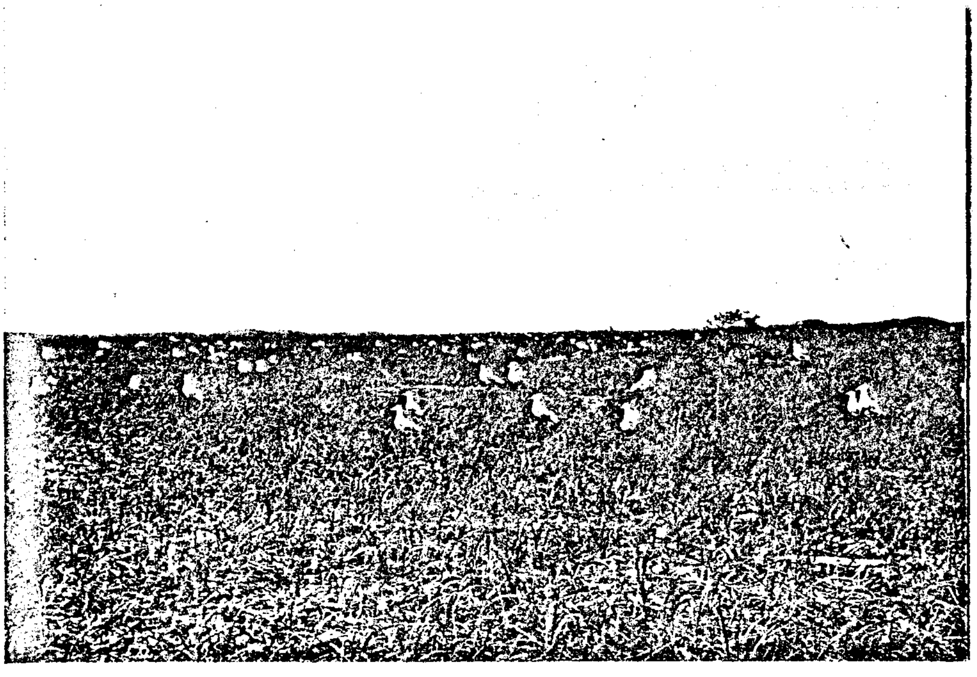

Figure 13. Survey Area, Egg Island, West View, June 1975.

Egg synchrony will be investigated further; we include a general discussion here.

Both colonial nesting and synchronization of egg-laying have an anti-predator function. The mechanisms through which these two phenomena reduce predation on the population have been discussed by Darling (1938) and Kruuk (1964). They suggest that the concentration of gull reproduction into the shortest possible time will reduce egg and chick losses since the number of predators is limited by the amount of food available.during the rest of the year, and by intra-specific aggression. Brown (1967b) suggests a possible mechanism for synchronous laying. He suggests that "social attraction" in gull colonies functions beyond colonial defense, and that this function increases efficiency. Brown (1967b) postulates that in gulls copulation may be the key factor stimulating ovulation, and that copulation by one pair stimulates others to do the same. Judging from Coulson and White's (1960) records on the effect of density on breeding in the Kittiwake, the result would probably be a local synchrony, rather than the colony-wide one suggested by Darling (1938); presumably the birds in the denser areas would be the first to breed. Either way, their breeding is likely to be more efficient than birds in less dense areas or colonies. The evidence from North Marble (Patten, 1974) indicates not only a colony-wide synchrony, but a synchronous egg-laying in four partially contingent colonies. This in turn suggests that the gulls on North Marble are acting as one large colony. It should be pointed out that North Marble contains about 500 breeding pairs of gulls. Egg Island pairs vastly outnumber this figure.

Incubation in Alaskan Glaucous-winged Gulls does not begin until after the clutch of three is completed, usually about a week after the first egg is laid (Patten, 1974). On North Marble the onset of incubation was quite synchronized, and began immediately after the peak egg-laying week. This meant that gull eggs are subjected to ambient temperatures for a week. Gull eggs, however, apparently tolerate temperature fluctuations, even after incubation commences (Baerends, 1959; Vermeer, 1963). Gull eggs were left uncovered during the time we examined the survey area on Egg Island, about once every three days. Weather ranged from cold drizzle to brilliant (Fig.10) sunshine. We found no adverse affect on eggs hatching resulting from interrupted incubation due to our presence. Vermeer (1963) found gull eggs to be resistant to nocturnal exposure in a series of experiments. He found no adverse effect on hatching and fledging rate in an experiment which involved preventing gulls from incubating during the night.

Clutch Size

A total of 339 eggs was found in the 153 nests under study on Egg Island within the observation period of 16 June to 18 August. At Dry Bay, 237 eggs were found in the 100 nests examined in late June. These are not completed clutch size figures. In both colonies the modal number of eggs per clutch was three. At Egg Island, the mean was 2.2 per clutch on 17 June, and at Dry Bay the mean was 2.37 on 28 June. Both dates are late in the incubation period. The clutch size data are within the range of other studies of Glaucous-winged, Herring and Western Gulls in North America and Europe (reference in Patten, 1974). Patten (1974) has previously reported a mean clutch size at the beginning of the incubation for Alaskan Glaucous-winged Gulls of 2.9. This leads to the question: "Why do Alaskan gulls lay this number of eggs rather than fewer or more?". As Lack (1968) has stated, the factor limiting clutch size is not the number of eggs a bird is potentially capable of laying and incubating, but rather the number of young a pair of birds is able to rear to fledging age with success. The upper and lower limits of clutch size have been determined by natural selection which acts through several channels. The lower limit of clutch size in gulls has been influenced by predation, and the upper limit presumably through the inability to feed young in abnormal years, although gulls in the _Larus argentatus_ group have only three brood patches. Harpur (1971) has previously reported no gulls were successful in experiments involving the ability to brood clutches larger than three. We report, however, two (Fig. 17) supernormal clutches of four eggs each on Egg Island this season. Sample size was 750 nests observed. At least one of these clutches hatched normally, producing 4 chicks of normal weight (Table 6). Such an occurrence is quite rare, and has not been previously reported for Alaska. No clutchss larger than three were observed in Glacier Bay; sample size was 500 nests. Hunt and Hunt (1973) have reported supernormal clutches in Western Gulls in southern California (see below); currently Pierotti (pers. comm.) is investigating the possibility that supernormal clutches are the result of female-female pairs (fertilized by males otherwise paired). The presence of supernormal clutches in the study area requires additional research. The optimum clutch size in Herring, Glaucous-winged and Western Gulls is evidently around three but as in other species there is probably some variation in the optimum number from locality to locality as well as from year to year.

Among the determinants of clutch size is the age at which birds breed. (Paynter, 1949). Coulson and White (1956) have demonstrated that in the cliff-nesting Kittiwake (_R. tridactyla_) the female's age, breeding experience and the time of breeding all effect clutch size. There is colonial and geographic variation in the percentage of complete clutches, and this has direct effect on the population reproduction rate. Another agent which at times has been suggested as modifying clutch size is the availability of food (Paynter, 1949; Ward 1973). While this may be effective in species with a more restricted diet than Glaucous-winged or Herring Gulls, it seems that judging from the castings on Egg Island, that food is not usually scarce. Fish and other animal populations may fluctuate from year to year, but gulls feed on so many forms, including human garbage, that there is little probability that in any one breeding period all types of food would be difficult to find (Paynter, 1949).

Another factor enters into the discussion of clutch size. Harris (1964) in Wales, Keith (1966) in Wisconsin, Kadlec and Drury (1968) in Massachusetts, and Vermeer (1963) in British Columbia have independently decided that with repeated egg counts the closer the mean clutch approaches three. Most single counts will show only 60 to 80 percent three-egg counts, because egg loss is widespread, in some cases occurring even during laying, and egg-dates of females in the same colony may be spread over several weeks, so that there is no one day on which all nests have the full number of eggs. Gulls do not re-lay unless the completed clutch is destroyed.

We report the occurrance of "runt" eggs on Egg Island. In the same sample of 750 nests examined above, we found four nests with strikingly (Fig. 14,15,16 subnormal eggs in size and weight (Table 5). These nests contained one "runt" egg each, in addition to one or two other "normal" eggs. The "runt" eggs were not viable, did not hatch, and contained little tissue or fluids. Ohlendorff (pers. comm.) informs us of "runt" eggs in museum collections. Female gulls laying for the first time may lay smaller eggs than usual but the reasons for the occurrance of "runt" eggs are otherwise obscure and will be investigated further.

Egg Loss

Patten (1974) has previously reported a mean clutch size of 2.9 for Alaskan Glaucous-winged Gulls. For purposes of demonstration, we will assume a mean clutch size of 2.9 at the beginning of the 1975 incubation period on Egg Island and Dry Bay. One hundred nests examined on June 17th at Egg Island contained a mean 2.2 eggs per nest. Hatching started within two days. Thus approximately 75 percent of the eggs in this smaller survey area were remaining near the end of incubation. However, both egg loss and egg-laying continued. At the end of the season, our figures indicated we had observed 339 eggs in the enlarged study area of 153 nests. Of these 339 eggs, 254 had hatched. Of the remaining 85 eggs, 9 were apparently infertile or pipped but failed to hatch (see below). Therefore, 74 eggs (19 percent) were "lost" from the study area after we had seen them. Assuming a completed clutch of 2.9 eggs per nest and 153 nests, then total eggs laid in the study area amounted to 444. If our assumptions hold true, then 105 eggs (24 percent) were lost before our arrival on Egg Island. Total egg loss amounted to 179 eggs or nearly 43 percent in the study area (Table 4). This is an island with 10,000-12,000 nesting adult gulls.

At Dry Bay on June 28th, 100 nests contained a mean 2.37 eggs per site. Granted the above assumption of 2.9 eggs per nest at the beginning of incubation, the colony at Dry Bay had about 82 percent eggs remaining near the end of incubation on an island with about 1,000 adult gulls. This would indicate in general about 20-40 percent egg loss to predation from other gulls, ravens, crows and jaegers in the northeast Gulf of Alaska.

This roughly follows a normal pattern of 60-80 hatching success reported by Kadlec and Drury (1968) for Herring Gulls in New England.

Hatching failure can be conveniently divided into three classes (Paynter, 1949): egg disappearing (lost) from the nests during incubation; eggs which remained in the nests but did not hatch (dying); and eggs which were pipped but in which the chick died before emerging. Gulls would occasionally be seen to swoop down on unguarded nests of their own species and eat or carry away eggs. We also saw raven and crows on Egg Island and North Marble taking gull eggs. At Dry Bay we observed Parasitic Jaegers eating gull eggs. However, in all three places the gulls appear to be the more serious predators simply because of their overwhelming numbers. The loss of eggs through predation was the principal factor influencing hatching and fledging rate on Egg Island in 1975 and in both years on North Marble (1972-73) (Table 4,9,10).

L. argentatus loses eggs most commonly through predation from conspecific adults, according to Paynter (1949) and Paludan (1951). This is the opposite of which Vermeer (1963) reported for L. glaucescens. More eggs in his study failed to hatch than were taken by predators. However, Keith (1966) reported that in a population of Lake Michigan Herring Gulls, contaminated by DDT, the chief cause of egg mortality was embryonic death. Hunt and Hunt (1973) located a colony of Western Gulls on Santa Barbara Island, California, in which many clutches containing four or five eggs were found. It is particularly interesting that in these large clutches not only was hatching success low but also eggshell thickness was reduced. The authors suggested that the eggs may have been contaminated with pesticide residues.

Table 4

Numbers of "Lost", "Infertile" and "Pipped" Eggs Which Did Not Hatch in the Study Areas on Egg Island, 1975; Dry Bay, 1975 and North Marble Island, 1972,1973.

Colony & Year	Total Eggs	Lost Eggs	Infertile Eggs	Pipped, but Did not Hatch
Egg Island 1975	444*	179*	8	1
Dry Bay 1975	290*	53*	-	-
North Marble 1972	455	125	22	2
North Marble 1973	566	150	26	1

* Calculations assuming a clutch size of 2.9.

A very low cause of non-productivity in the 1975 gull breeding season on Egg Island was failure to hatch. Incubation and other influences seemed normal from gross field examination. Examinations of the few decayed eggs did not reveal developed embryos or any specific reason for mortality. We have tentatively concluded the eggs were infertile since the relative percentage of unhatched eggs was very low, and eggshells showed no signs of fragility or pesticide contamination. Ohlendorff (USF&WS Patuxent) is currently examining a small sample of eggs from Egg Island for biocide residues. A larger sample will be collected for biocide residue analysis next year. Paynter (1949) and Brown (1967) have also reported low numbers of "infertile" gull eggs in their studies.

The last cause of failure to hatch occurred when the chick pipped the shell but failed to emerge and died. There was only one case of this in in the Egg Island study area this year, and only three cases in the two years of Patten's (1974) previous study. These are insignificant figures.

Pigmentation of eggs on Egg Island was observed to be quite variable, ranging from virtually no coloration (pale blue with no spots) to dark olive with many spots. Variation in eggshell pigment has been widely reported and is not directly involved with hatching or fledging success, although light-colored eggs in grassy meadows may be more susceptible to predation (Kruuk, 1964); (Tinbergen, 1960).

Table 5

Weights and Measurements of "Runt" Eggs on Egg Island, 1975, Compared to "Normal" Range. One "Runt" Egg Each from Four Clutches.

Egg	Weight (gms)	Length (mm)	Width (mm)
A	8.5	44	28
B	10.0	40	29
C	34.8	48	38.5
D	5.0	46	37
"Normal" Range *	60.0 - 110.0	70 - 80	50 - 60

* Weight varies with the state of incubation.
All "runt" eggs were inviable.

Table 6

Supernormal Clutches, Egg Island, 1975

June 17 Clutch A Weights (gms)	July 9 Clutch B Weights (gms)	Size (mm)
1. 80	68	76 x 57
2. 83	70	76 x 57
3. 85	68*(chick less than 1 day old)	--
4. 79	68 (chick 1 day old)	

*Eggshell weighed an additional 7.5 gms.

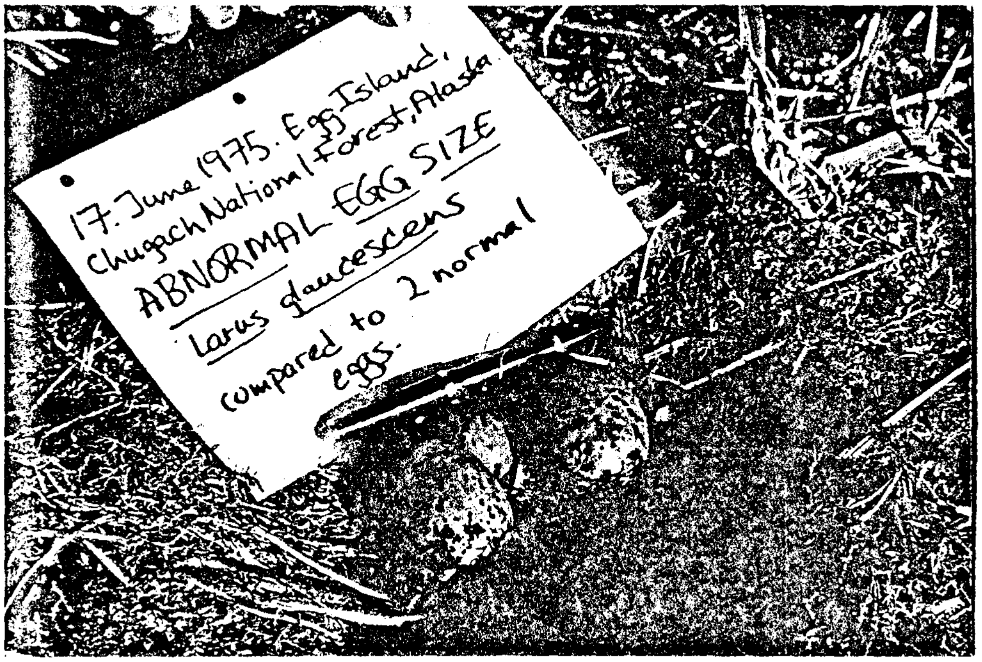

Figure 14. Abnormal Egg Size, Example # 1.

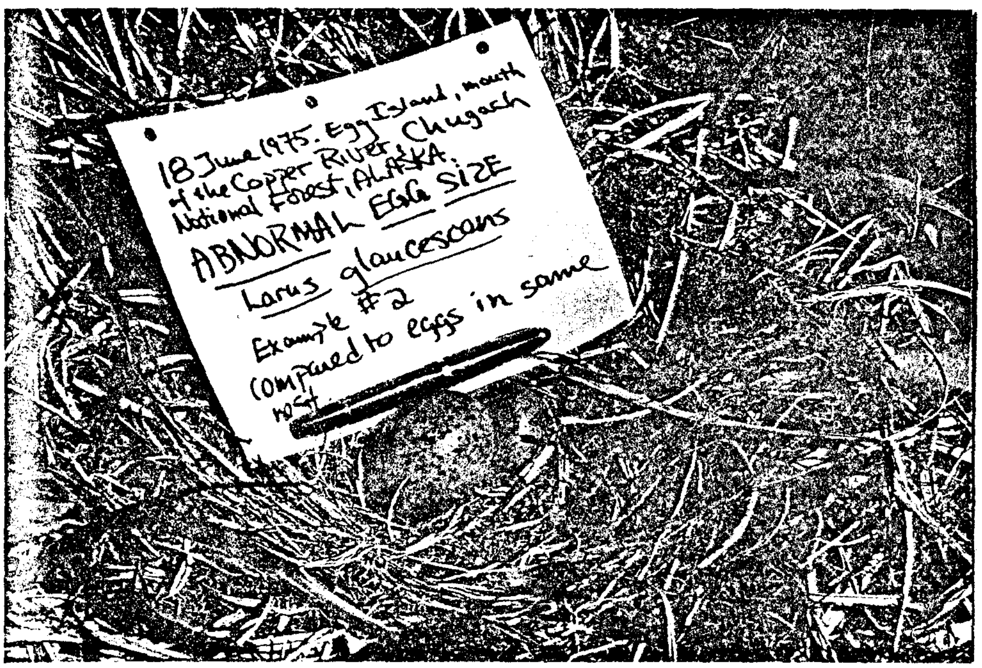

Figure 15. Abnormal Egg Size, Example # 2.

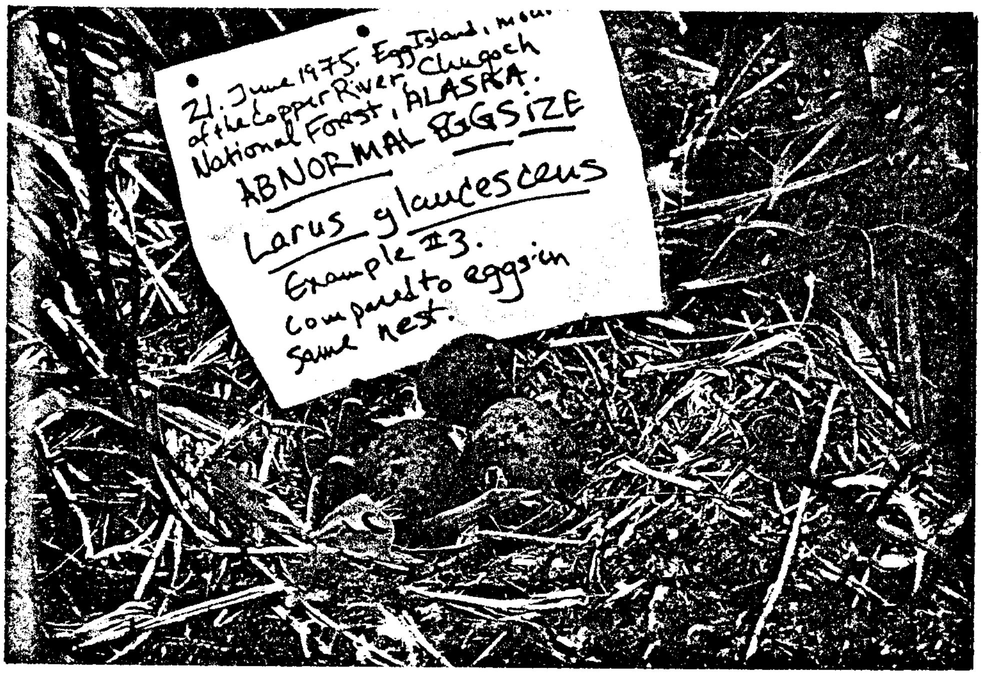

Figure 16. Abnormal Egg Size, Example # 3.

Figure 17. Supernormal Clutch, Example # 1.

Egg and Clutch Replacement

Replacement clutches seem to be important only when large disturbances occur to colonies (Vermeer, 1963). Paludan (1951) recorded Herring Gulls laid replacement clutches after a snowstorm. Such a large disturbance was not noted this summer on Egg Island or in either year of Patten's (1972-73) study on North Marble. However, our figures show some egg-laying still going on in early July 1975. Whether this indicates replacement clutches following predation, or simply a wide spread of breeding is yet unknown. Loss of the entire clutch after sufficient brooding to suppress the fourth follicle results in a replacement clutch in Larus argentatus and L. fuscus in 11-12 days (Paludan, 1951) and in L. ridibundus in about the same time (Weidmann, 1956). Vermeer (1963) found a similar occurrence in Larus glaucescens to take a slightly longer time, probably due to his experimental procedure (trapping). If we are allowed to speculate, egg-laying in late June or early July could indicate previous clutch loss to predation in early to mid June. This is entirely likely.

Loss of eggs as they are laid enables four eggs to be laid, as evidenced by L. argentatus and L. fuscus (Paludan, 1951) and L. ridibundus (Weidmann, 1956). Vermeer (1963) demonstrated similar phenomenon for L. glaucescens and also that the egg-laying interval between eggs was similar to undisturbed clutches. The reason for egg loss in Vermeer's (1963) study was crow predation resulting from human disturbance. In spite of predators, Vermeer found that in both years of his study, more eggs failed to hatch (addled) than were taken by predators.

Attempts have been made to control the New England Herring Gull population by treating eggs with a mixture of formaldehyde and oil (Gross, in Drury and Nisbet, 1973). An egg destruction program was planned to inhibit the growth of the gull population. During the first years of the gull control program, Gross (USF&WS) punctured eggs. However, the eggs so treated then rotted, burst, and the gulls again laid complete clutches in the usual pattern. Gross then shifted to spraying eggs with formaldehyde and oil. The formaldehyde is of course cytotoxic, but we wish to point out that the oiling of the eggs also acted to inhibit the respiration of the developing embyro by sealing the egg. If adult gulls resting on contaminated water become oiled about the breast feathers, then oil could be transferred to the eggs during incubation, causing embryonic mortality. If the embryos died, and the oil prevented much bacterial action, then the adult birds would continue to brood the eggs for long periods and not re-nest during the season. Drury and Nisbet (1973) reported Gross found the numbers of gulls nesting on treated (oiled) islands decreased more rapidly than could be attributed to adult mortality, indicating a net emigration of adults from these colonies. We wish to indicate the possibility of such occurrances in the NEGOA, with unfortunate consequences for marine birds including gulls.

Incubation Period

Incubation was nearly complete at the time of our arrival at the gull colonies in June 1975. Patten (1974) has previously reported a range of onset of incubation on North Marble from 29 May to 10 June. Beginning of incubation in colonies at Dry Bay, Haenke and Egg Island apparently falls within this time range. The beginning of incubation was synchronized in all colonies on North Marble; most gulls began brooding at about the same time, despite of larger spread of egg-dates from colony to colony. The abrupt synchrony of chick hatching both years of the North Marble study reflected the synchronized onset of incubation. The wide spread of chick ages on Egg Island may reflect less synchrony in onset of incubation as well as a greater spread of egg-laying.

Median dates from onset of incubation to hatching established a incubation period of 24 to 27 days on North Marble. Modal hatching dates indicate the usual eggs were incubated for a period of 26 days. Similar incubation periods have been reported by Tinbergen (1960), Vermeer (1963), Keith (1966), Schreiber (1970) and Harpur (1971).

Near the end of the incubation period, on 29 June 1975, 115 gull eggs at Dry Bay weighed a mean 87.2 ± 7.3 gms (Table 7). Eggs from North Marble in 1973 weighed 80.5 gms at the end of incubation. Eggs on North Marble lost about 18 percent of their weight during incubation, beginning incubation at a mean 97.6 gms/egg. The usual incubation period on North Marble is 26 days, and the average gull egg loses 0.67 percent of its weight per day. Assuming an equal incubation period 75 percent completed with equivalent weight loss at Dry Bay, the usual weight for gull eggs there at the beginning of incubation is about 100 gms. Eggs thus hatch at a hypothetical mean 82.7 gms, which would indicate a mean hatching date of 5 July 1975. Indicated onset of incubation at Dry Bay Bay was thus 10 June 1975.

Table 7

Egg Weights At Beginning and End of Incubation Period, North Marble Island, 1973; Dry Bay, 1975

(means)

Sample Size (Eggs)	Beginning of Incubation (gms)	75% of Incubation (gms)	End of Incubation
Dry Bay 115	100*	87.2 ± 7.3	82.7*
North Marble 142	97.6	84.8	80.5

* Calculations assuming 75 percent incubation completed on 29 June 1975.

Chick Stage

A chick, as here designated, is a bird from time of hatching until departure from the nesting island (Schreiber, 1970).

Chick hatching was not especially synchronous on Egg Island this year. Two peaks of chick hatching were observed: the majority of chicks hatched in late June, while a smaller group of chicks hatched in mid-July. Presumably, synchrony of egg and hatching dates provides better protection from predators, which can take only a certain percentage of eggs and chicks at any one time (Darling, 1938).

When chicks hatched adult gulls gave long (territorial) calls more frequently than during incubation. Adult gulls also became more aggressive when chasing other gulls or corvids from their territories (similar observations reported by Vermeer, 1963). Parental gulls continued incubation during hatching, although the intensity of the drive apparently diminished rapidly, correlated with the development of homeothermy in the chicks. Adult birds removed eggshells up to 20 meters away from nests by picking them up and dropping the eggshells in flight. Presumably there is a strong selective pressure for removal of eggshells from the nest as an anti-predator device. Gulls were extremely wary with young chicks in the nest, and flew up at the slightest alarm. Defensive adult gulls defecated on us or repeatedly struck us with lowered feet across the back of the head.

Adult gulls react to all newly born young on the territory in the first few days after hatching by directing by directing parental behavior towards them (Tinbergen, 1960). Soon afterward, gulls learn to know their own young, and hostile behavior towards strange chicks develops within a week (Tinbergen, 1960). Gull parents react to the call of their own chicks, even when they cannot see them (Goethe, 1956), while they do not react to strange chicks under similar circumstances. Goethe (1956) concluded that voice is an important factor in adults recognizing young. In addition, the cryptic pattern of dark vs. light on the chick's head may be important for individual recognition by the parents (Tinbergen, 1960). In this context we wish to emphasize the results of some of our color-marking experiments this summer on Egg Island. We originally planned to color-dye all chicks produced in our study area in order to trace their movements. In accordance with the plan we completely dyed 21 chicks with nyansol, a purple-black dye. Immediately thereafter (in two days) we found seven of the 21 chicks dead, a 33 percent mortality (Table 8). The parents may not have continued to feed the young due to non-recognition, or the young birds may have died from exposure resulting from the evaporation of the isopropyl alcohol which is the solvent for the dye. The complete color-dyeing program of young gulls was immediately dropped due to the mortality rate. Outside the study area proper on Egg Island, we dyed 80 chicks with nyansol on the tail, rump, abdomen, and axillaries, in other words parts of the body that probably are not important for individual recognition. Dying the parts of young birds unrelated to individual recognition led to no observed mortality. With this background in mind we wish to point out that if young gulls are oiled for whatever reason about the head, individual recognition of chicks by parents may be destroyed, leading to mortality of the young.

Table 8

Analysis of Seven Mortalities
Associated With Color-Marking
(Complete) With Nyansol Dye.
Egg Island, 1975

Chick	Mortality Reasons (apparent)
A	intrusive skull fracture posterior to orbital region
B	acute inflammation of distal portion of the left wing
C	consolidation of upper left lung
D	unknown; had been feeding
E	unknown
F	unknown
G	unknown

Sample Size: 21 fledglings completely color-dyed in study area. None had blood samples taken. 80 chicks outside study area proper were partially color-marked on lower portions of body: no observed mortality. Most of these had 3 - 5 cc blood removed from wing vein.

We also wish to point out that if chicks become oiled on other parts of the body, the development or maintenance of homeothermy may be prevented, leading to death from exposure (McEwan and Koelink, 1973). Since chicks have little energy reserves, and often die in periods of bad weather (see below) impairment of homeothermy through oiling must be regarded as a possibility.

The period of hatching is a critical time in the gull reproductive cycle. In this period, adults must shift their behavior from incubating to brooding, gathering food and feeding the young (Vermeer, 1963). Some parents do not make this shift, or are inept at it. Paynter (1949), Paludan (1951) and Harris (1964) agree that major chick mortality occurs within a few days of hatciing.

Even while still in the egg, chicks ready to hatch can be heard squeaking. But chicks stop peeping when hearing alarm calls from the adults. Tinbergen (1960) is sure that the alarm stimulus is auditory; in experiments involving visual isolating of chicks, chicks crouched upon hearing alarm notes.

The physical characteristics and boundaries of the territory are learned by chicks through experience as they develop. Chicks run to accustomed hiding places when adults give alarm calls. Fortunately this made the chicks easier for us to locate. For about two days after hatching, chicks remained in or next to the nest and made no consistant attempts to hide other than remaining quietly on the bottom of the nest. Then for several days chicks hid behind grass tussocks near the nest. Later, chicks wandered further from nest sites and were more difficult to locate. Chicks began to swim on their own at about two weeks of age, and with increasing mobility and coordination they attempted to move down and away from the main colony sites when disturbed. Chicks close to the edge of the island fled into the water. However, water apparently does not provide the proximate stimulus for this behavior, since chicks from the high dunes at the center of Egg Island moved out into open sandy areas at the foot of the dunes when disturbed. While swimming, chicks from the edge of the island started to group together. Small groups of chicks swam back to the island and crept in submissive posture, with heads down, back up to their nest sites after disturbance. If aquatic borders of island colonies become heavily oiled, at this time normal avoidance behavior of chicks would lead them into oil slicks.

Nearly fledged chicks wandered extensively in and out of less defended territories towards the end of the breeding season. A flightless chick with a tall tarsal band, indicating origin in the Egg Island study area near the light, was found in late July one km further west along the main dune line. Wandering chicks formed small flocks at the base of the dunes near the water, or if no water was nearby, the chicks formed small flocks at the edge of sandy open areas. Southern (1968) noted response to disturbance of Ring-billed Gull chicks (*Larus delawarensis*) that were similar to other observations (Patten, 1974) of Glaucous-winged Gull chicks in Alaska.

Mortality Factors

Observed chick mortality was low (28 chicks) this season in the Egg Island study area. Most chicks (76) that failed to fledge simply disappeared (Table 9). Chicks surviving to banding at two weeks amounted to 221 individuals. One hundred fifty banded chicks were counted in the study area at the close of the fledging period. If we include the seven chicks mortalities associated with color-dying, then productivity in the study area on Egg Island was 157 individuals. Twenty-one tall tarsal banded chicks observed were natural mortalities, including one found over 300 meters away from the study area. Therefore, 43 banded chicks were "lost" from the study area and probably failed to survive. Thirty three chicks were lost before banding. Banded chicks, flightless but still alive, were found as much as one kilometer away from their natal area, suggesting that a few wandering chicks may have lived to fledge. Their chances were not good since they had to forage on their own in the meadows.

Egg Island chick mortality was 23 percent in 1975. Chick mortality was lower (5 to 8 percent) in both years of Patten's (1974) Glacier Bay study under conditions considerably different (Table 10). Coulter et al (1971) reported a mean 11 percent chick mortality for Western Gulls on Southwest Farallon Island, California. Harpur (1971) found mean chick mortality in the Western Gull on an islet near Santa Catalina Island, California, to be 37 percent but he stated that except for human disturbance, chick mortality might have been as low as 7 percent. Harpur (1971) suggested that chick mortality may be more a function of crowding than of absolute colony size.

The rise in mortality in crowded colonies could be due to the increased probability that small chicks wander into nearby territories and are killed (see above). The high average (about 85 percent) from the larger colonies reported by Harris (1964) support this hypothesis. However, Patterson (1956) working with the Black-headed Gull and Vermeer (1963) working with the Glaucous-winged Gull could find no significant difference in chick mortality as related to various colony sizes.

Table 9

Chick Mortality Egg Island, 1975,
North Marble Island, 1972-73 ($\bar{x}$)

Study Area	Chicks Hatching	Observed Mortality	Disappeared	Fledged
Egg Island (153 nests)	254	28	76	150
North Marble (162-191 nests)	347	36	--*	311

Table 10

Percent Chick Mortality Egg Island,
1975, North Marble Island 1972-73 ($\bar{x}$)

Study Area	(%) Hatching	Observed Mortality	Disappeared	Fledged
Egg Island (153 nests)	57	6	17	34
North Marble * (162-191 nests)	68	7	--*	61

* We were able to account for chick mortality on North Marble, a much smaller island.

As indicated in previous discussions above, one of the main factors affecting chick mortality and fledging rate in this and other gull studies was the habit of adults to attack strange chicks (Paynter, 1949; Tinbergen, 1960; Vermeer, 1963; Patten, 1974). It was not unusual to note adult gulls attacking chicks that had wandered from their natal territories into neighboring areas. We found most dead chicks on Egg Island about three weeks of age, in contrast to North Marble, where most dead chicks were found during the first week after hatching. Killing at North Marble does not seem confined to any particular age group, but is greatest when chicks are small, unable to retreat rapidly, or give appeasement displays. On Egg Island chick mortality seems most related to the age at which chicks begin to wander widely.

The dead chicks on Egg Island and North Marble were usually away from any nest site, and typically exhibited head injuries. Small chicks were easily swallowed by adult gulls (Brown, 1967b), perhaps accounting for some chick disappearance. Vermeer (1963) noted that most chick mortality on Mandarte Island, B.C., occurred in the first week after hatching. Paynter (1949) and Paludan (1951) also ascribe most of the chick mortality in Herring Gulls to aggressive behavior in adults.

There has been much speculation about the reasons for this killing (Paynter, 1949). Tinbergen (1960) believes that it may be due to the highly developed territorial defense of breeding adult gulls towards any moving object. It may be that selection is operating so that chicks remaining strictly on their natal territory will have a better chance of survival.

Weather was also a factor affecting chick mortality in this study. June and July 1975 on Egg Island were favorable months, with periods of a day or two of rainfall and moderate winds followed by stretches of fair, calm weather. There was excellent cover in the gull meadows due to growth of vegetation, and air temperatures were moderate. A week of quite poor weather occurred in early August, with cooler temperatures, very strong winds, and heavy rainfall. Vegetation in the meadows began to die down after the growing season. The main group of chicks had fledged and were foraging on their own around the island beaches. However, a second group of chicks was still in the meadows and there was heavy mortality of the smaller chicks after the stretch of poor weather. The mortality may have two reasons, although they are related. Partially fledged chicks in poor cover may have died from exposure. Secondarily we observed much cannibalism, and we found many chick bodies picked clean. The inclement weather may have prevented both adults and juveniles from foraging efficiently, and the half-grown chicks accordingly suffered. Whether the chick mortality was due directly to attacks from other hungry gulls, was related to their weakened condition, or was only indirectly related to other gulls scavenging on chicks dead from exposure, is unclear. The effect was the same: chicks hatched later than the main group apparently had much lower survival. A selective pressure for egg and chick synchrony maybe due to weather, predation, cannibalism, and lack of food. Michelson (pers. comm.) pointed out that for several years a severe storm has occurred in the Cordova area early in August. Our observations of chick mortality after the August storm were made in meadows outside the study area. By August 10th only few adult gulls were left. The productivity figure for the 1975 study area thus may not include the weather-induced mortality affecting other parts of Egg Island.

The unseasonably dry July of 1972 on North Marble resulted in poor protective cover for chicks. Several chicks were found dead, apparently from exposure, after several days of cold rainy weather ended the dry spell. Coulter et al (1971) found chick mortality to be affected by the degree of exposure to weather and salt spray. Tinbergen (1960) stated gull chicks were quite sensitive to temperature changes. Vermeer (1963) suggested that the proximity of cover may be important for survival of young chicks in a hot, dry summer. Thus weather, through abrupt temperature changes and increasedvulnerability to adult gulls and other predators, may have an effect on survival of chicks.

We compared the results of our investigation of factors influencing reproductive success on Egg Island and North Marble with data from other colonies and from other species of gulls, since so little is otherwise known of Glaucous-winged Gulls in Alaska. Natality, or hatching success, was calculated to be approximately 57.3 percent on Egg Island, and about 68 percent for North Marble (Table 11). These figures can be compared to Western Gulls, in which hatching success has been reported to be 55 percent by Schreiber (1970), 78 percent by Harpur (1971) and 78 percent by Coulter, et al. (1971).

The mean combined mortality from egg to fledging on Egg Island was about 66 percent. This compares to 34 percent on North Marble, to 30 percent combined egg and chick loss for Western Gulls on Southeast Farallon Island (Coulter, et al. 1971). Egg loss was higher but chick loss was lower on North Marble compared to Southeast Farallon. On Egg Island, egg loss was 42.7 to 26.5% and chick loss was 23.4 to 6.5% compared with North Marble. In both cases there was higher mortality on Egg Island.

Total reproductive success was about 33.7 percent on Egg Island. Egg Island can be compared to North Marble, which had a total fledging success of 61 percent under post-glacial conditions. The fledging success of eggs hatched (59%) on Egg Island in 1975 compares favorably with the usual 50 percent reported by Kadlec and Drury (1968) for Herring Gulls in New England; however, one year's data is no indication of a trend.

On North Marble, hatching and fledging success were not significantly different from colony to colony and from year to year, suggesting the gulls on North Marble may be acting as one large colony, and that environmental conditions were relatively static for the two study years. The exception was a small, newly colonized area at the top of the island, which had significantly larger territory sizes and lower fledging success. Egg loss on North Marble plotted against territory size showed increased loss with smaller territories, indicating that on eggs, intraspecific predation was more important than interspecific predation. Thus, the larger average territory in the new small colony could not directly account for higher egg loss and resultant lower fledging success. However, the enclosed location of the small colony, and the lack of water nearby to which chicks could flee, suggested strongly that chick predators had an important effect. In 1975 perhaps the larger numbers of other gulls on Egg Island resulted in a greater rate of chick predation, although the situation there is complicated by the large territory size.

Table 11

Hatching Success, Mortality, Reproductive Success
Egg Island, 1975; North Marble Island, 1972-73 ($\bar{x}$)

Colony	Hatching Success (%)	Egg and Chick Combined Mortality (%)	Total Reprod. Success (%)
Egg Island (153 nests)	57	66	34
North Marble (161-192 nests)	68	34	61

Avian predators other than gulls were not uncommon on Egg Island or North Marble, although relative to gulls, their numbers were low. No terrestrial predators were noted on any gull island examined. Gull alarm calls were due, in order of importance, to the frequent appearance of Bald Eagles (Haliaeetus leucocephalus), Ravens (Corvus corax) and Crows (Corvus brachyrynchos). Parasitic Jaegers (Stercorarius parasiticus) took gull eggs at Dry Bay and perhaps at Egg Island. Alarms in the gull colonies were good indicators of breeding intensity (Vermeer, 1963). Broody gulls remained on the nest and did not repeat the alarm call until the disturbance was close. Gulls gave two kinds of alarm calls, high and low intensity, as reported by Tinbergen (1960). Gull chicks hid at both high and low intensity alarm calls.

Eagles disturbed the Egg Island and North Marble colonies repeatedly, especially early in the season before salmon were in the nearby mainland streams. The approach of an eagle caused immediate high-intensity alarm calls and flight of entire colonies at once. We found some gull remains that had been picked completely apart except for the cranium. A dead gull was found in an eagle nest near North Marble. Smoker (NMFS) reports a successful attack by an eagle on a gull at Kitoi Bay, Agfognak Island. Our conclusion fromthis evidence is that eagles take gulls whenever possible.

Tinbergen (1960) never saw a Herring Gull actually attacked by a predator, although he found remains of Herring Gulls probably killed by a Peregrine Falcon (Falco peregrinus). No Peregrines were observed this season on Egg Island, although Peregrines were seen occasionally on North Marble in previous years. The falcons caused no alarms in the gull colonies, and no attacks were observed.

Fledging Success

We determined the median length of the nestling period to be 40-45 days on Egg Island, similar to that on North Marble. Other investigators also have reported similar fledging periods for Herring Gulls in Michigan (Keith, 1966), Western Gulls in California (Schreiber, 1970; Harpur, 1971), and Glaucous-winged Gulls in British Columbia (Vermeer, 1963).

At the end of the fledging period, counts were made to determine fledging success. The fledging success, while a difficult measurement, (Keith, 1966; Schreiber, pers. comm.) is crucial in understanding the reproductive biology of birds. The fledging rate of 1.03 chicks per nest is normal when compared to other gull species, but much lower when compared to a colony in recent post-glacial surroundings (Table 12). Paynter (1949) found a production of 0.92 chicks per pair per year sufficient to maintain a stable population of L. argentatus on Kent Island, New Brunswick. Ludwig (1966) reported a recruitment rate of 0.63 is sufficient to maintain a stable population of Ring-billed Gulls (L. delawarensis) on the Great Lakes. Ludwig (1966) also found that between 1960 and 1965, L. argentatus populations increased at an annual rate of 13 percent with a mean fledging rate of 1.47. This was due to the unusal abundance of the alewife (Alosa pseudoharengus), a major food source. At the same time, L. delawarensis populations on the Great Lakes were increasing 30 percent per year with a mean fledging rate of 1.74, which is practically identical to the gulls on North Marble. Glaucous-winged Gulls studied by Vermeer (1963) on Mandarte Island, B.C., fledged 1.0 and 1.7 chicks per nest in his two-year investigation. Harpur (1971) published fledging rates of 1.33 and 0.96 per nesting pair of Western Gulls. The highest mean fledging success encountered in the literature has been the 2.00 chicks per nest reported by Coulter, et al. (1971). Other fledging successes, as summarized by Keith (1966) ranged from 0.3 to 1.17. The gulls on Egg Island in 1975, in comparison with the above studies, fledged roughly in a "normal" pattern. This rate , if continued, would indicate a slowly expanding population, similar to that of Herring Gulls in the eastern United States and Canada, and due to a similar reason, that of an increasing food supply due to man's activities.

Table 12

Comparative Index of Gull Reproductive Success
In Chicks Per Nest (Productivity)

Colony Location	Species	Chicks Produced Per Nest	
California	(*L. occidentalis*)	2.00	(Coulter et al, 1971)
North Marble (1972-73)	(*L. glaucescens*)	1.77	(Patten, 1974)
Great Lakes	(*L. delawarensis*)	1.74	(Ludwig, 1966)
Great Lakes	(*L. argentatus*)	1.47	(Ludwig, 1966)
British Columbia	(*L. glaucescens*)	1.35	(Vermeer, 1963)
California	(*L. occidentalis*)	1.14	(Harpur. 1971)
Egg Island (1975)	(*L. glaucescens*)	1.03	(this report)
New Brunswick	(*L. argentatus*)	0.92	(Paynter, 1949)
Michigan	(*L. argentatus*)*	0.35*	(Keith, 1966)

* Population contaminated by DDT

Task A - 5

Banding Recoveries and Sightings of Color-marked Gulls

We banded 1521 Glaucous-winged Gull chicks on Egg Island in July and August 1975. 1300 of these young birds were ringed on their left tarsi with aluminum USF&WS "short" bands of the 1047 series, size 7A. These birds were captured on dunes outside the survey colony proper. Inside the survey colony (150m x 150m) southwest of Egg Island Light, we also captured every chick surviving to two weeks of age, which totaled 221 individuals, and enclosed their left tarsi in stainless steel "tall" bands of the USF&WS 657 series, size 7A. Of these 221 banded chicks in the survey area, 150 survived to fledge.

One of these recently fledged young gulls, banded in the survey colony on Egg Island on August 1, 1975, was recovered at the end of Sunny Point, 8 km west of downtown Juneau on October 4, 1975, after it had been shot by a small boy. Mr. Jim King, Waterfowl Investigations, USF&WS, managed to convince the boy into retrieving the gull from the woods where he had hidden it. The immature Glaucous-winged Gull wore band #657-67383, which indicated it had been banded as a flightless individual of unknown sex at Egg Island near Cordova.

All other recoveries to date have been from gulls banded outside the survey colony proper on Egg Island. These are the following: two recently fledged juveniles, banded on Egg Island in July, were hit by an airplane at Valdez on August 22, 1975. Another Egg Island juvenile wearing a band was found dead on the road at Valdez on August 29, 1975. On September 1, 1975, an additional banded juvenile from Egg Island was found 17 km east of Cordova on the Copper Delta, being eaten by an eagle. On January 20, 1976, a large juvenile gull was recovered on the beach in Ketchikan near where oil had been reported. Mr. Bob Wood of ADF&G kept the partially incapacitated bird overnight until it recovered somewhat, and then released it after noting the band number. The number was reported to Mr. Jim King in Juneau. Our records indicated the bird had been banded as a flightless chick of unknown sex on Egg Island on July 25, 1975. (Table 13).

We color-marked over 100 young gulls in two different patterns with nyansol, a purple-black dye, at the close of the field season on Egg Island. (See above discussion.) Mr. Pete Isleib noted dark-pigmented young of the year in and near Cordova during September. None were reported after the third week of September and the highest number observed at one time was three at the Cordova dump on September 7, 1975 (Isleib, pers. comm.). Nyansol-dyed birds have not been seen so far in the spring of 1976, according to Isleib. Such reports are unlikely due to the juveniles molting twice since being color-marked. The nyansol program may be phased out due to the poor visibility of the dye on the immature plumages.

We were able to capture nine adult gulls in the summer of 1975 and mark them with picric acid, a brilliant yellow feather dye, which gradually oxidizes to orange color with time. The first gull was captured at the Cordova docks, dyed on the head and upper breast, and released after a blood sample was taken. Our subsequent observations indicated that this bird remained in the Cordova for most of the summer, feeding on the effluent of the seafood-packing canneries, and resting on Eyak Lake or on the Ocean Dock. When the canneries were not operating, this individual bird was seen at the dump. Isleib (pers. comm) continued to observe this bird in the general Cordova waterfront area until the first week in October. Most observations of this bird were between Ocean Dock and Observation Island, that is, in front of the canneries and the small boat harbor. Isleib's last noted observation of this bird in 1975 was on October 9th.

The local movements of this bird lead us to the suspicion that it may be part of a summering non-breeding population exploiting concentrated food resources opportunistically. (Table 14).

Eight other adult gulls were captured on Egg Island, banded, weighed, and dyed yellow on the lower breast feathers, belly, axillaries, and tail, so as to preclude the hypothetical possibility of breaking pair bonds through disruption of individual recognition patterns of the birds. Our initial observations indicated that these birds, which were breeding adults with eggs or chicks when captured, remained close to the colony in July. In August we observed these birds progressively further from Egg Island, first at the mouth of the Eyak River a few kilometers away, then in Cordova 30 kilometers away at the dump or around the docks, and then as far away as Deep Bay, Hawkins Island, 40-50 kilometers from Egg Island.

In October 1975 we received notification from Mr. King of "canary yellow" to "golden" gulls seen by various parties in the Juneau area in early September. Through the efforts of Mr. King, the Alaska Department of Fish and Game informed the public in the Juneau area of the presence of color-marked gulls during a radio broadcast from station KINY.

Isleib (pers. comm.) has recently informed us of heavy movement of Larus gulls into the Cordova area during the period of March 7-10, 1976. Snow cover at the time was 1-1.3 m but weather and snow conditions southeast along the coast were good and many migrant species and population shifts were occuring in the area. Isleib & Isleib (pers. comm.) report four observations of orange-color-dyed gulls in the Cordova waterfront from March 10 to March 19, 1976. Between mid-October 1975 and early March 1976 no color-dyed gulls were seen or reported in the Cordova-Orca Inlet area.

We are indebted to the observations reported to us by the Isleibs and Jim King. With this information we are able to suggest local and then southeastern movements of both adult and juvenile Glaucous-winged Gulls from Egg Island along the Gulf of Alaska coastline in post-breeding dispersal. Egg Island gulls apparently leave the Cordova area in October and return in March. Wintering areas are currently unknown. (Ketchikan?)

The USF&WS has provided us with additional information which suggests gulls may return to the Cordova canneries year after year. A gull was observed at the St. Elias Floating Cannery, at the Cordova Ocean Dock, on July 11, 1975 by Mr. Joel Schilmoeller and Mr. Mike Lettis of the United States Forest Service. The bird was an adult Glaucous-winged Gull with a USF&WS band on the left tarsus. The band number was #0937-70444; the outer left web on the left food had been cut in a "V" fashion as an additional marker. The bird was in a feeding flock with other gulls around the cannery effluent, and was an apparently healthy individual not marked in any other way. The Office of Migratory Bird Management, Bird Banding Laboratory, Laurel MD has indicated to us that this gull was banded by personnel of the Denver Wildlife Research Center on July 19, 1970, near Cordova, as part of research directed towards the gulls around the Cordova canneries. The gull was at least one year old when banded.

We are hopeful of additional reports of adult and juvenile gulls from our Egg Island study. The initial reports indicate this is a highly promising aspect of this research. We are deeply grateful for the assistance we have received from other biologists to date in reporting banding recoveries and sightings of color-marked gulls.

Table 13

Banding Recoveries of Juvenile Gulls
from Egg Island

Location	Date	Reason
1) Valdez	22 Aug 75	aircraft strike
2) Valdez	22 Aug 75	aircraft strike
3) Valdez	29 Aug 75	dead on road
4) Copper Delta	1 Sept 75	eaten by eagle
5) Juneau	4 Oct 75	shot by boy
6) Ketchikan	20 Jan 76	oiling (?)

Table 14

Observations of Color-marked Gulls

Location	Date	Activity
1) Cordova docks-canneries	July-Aug 75 Sept-Oct 75	feeding
2) Cordova dump	July-Aug 75 Sept-Oct 75	feeding
3) Egg Island	July-Aug 75	breeding
4) Eyak River, Copper Delta	Aug 75	resting
5) Hawkins Island, Prince William Sound	Aug 75	flying
6) Juneau	Sept 75	resting
7) Cordova docks-canneries	March 76	resting

Sympatry and Interbreeding of Herring and Glaucous-winged Gulls

Rand (1948) suggests that several populations of gulls became separated during Pleistocene glaciation. Populations resembling Herring Gulls may have been pushed back by the continental glaciation to an interior refugium along the Yukon-Kuskokwim-Bering Sea land bridge. Other populations of gulls may have been forced to retreat southward along the Pacific coastline to the Puget Sound area. While these gulls may have shared a common gene pool at one time, enough evolution has occurred to account for certain observed morphological differences between the Herring and Glaucous-winged Gulls, for instance in the amount of melanin in mantle plumage, in primary feather pigmentation, in the iris and orbital ring color. These gulls are now expanding their ranges from Pleistocene "refuges" and where the populations are in contact, hybridization occurs.

As the availability of human-generated refuse increases with the development of oil resources in the Gulf of Alaska, populations of gulls previously more isolated may come into closer contact with one another. The refuse associated with increased oil operations may result in genetic changes in the gull populations (Hunt, per. comm.).

Williamson and Peyton (1963) collected a series of specimens intermediate between the Herring and Glaucous-winged Gulls from Cook Inlet, near Anchorage, Alaska. They suggested that sympatry between breeding Herring and Glaucous-winged Gulls occurs in southeastern Alaska. This section will document briefly current knowledge of sympatry and interbreeding of Herring and Glaucous-winged Gulls in southcentral and southeastern Alaska, and follows information presented by Patten (1975) at the Pacific Seabird Group meeting at Asilomar, California.

Glacier Bay, Alaska, just to the south of the current study area is quite recently deglaciated (less than 200 years). Gene flow between previously isolated populations in this area must be as recent as the deglaciation. Herring and Glaucous-winged Gulls have been found nesting together in at least three colonies in Glacier Bay. The colonies are found on (1) a near vertical cliff; (2) a flat low gravelly island; and (3) sloping grassy hillsides. During the summer of 1971, suspected intermediates were observed at a cliff colony. These gulls showed intergradation from one form to the other in primary feather pigmentation. During the next two summers, mixed, conspecific, as well as 'intermediate' to Glaucous-winged Gull pairs were observed on North Marble Island in Glacier Bay, which contains a colony of 500 pairs. Relative numbers of Herring Gulls in relation to Glaucous-winged Gulls were low. The mixed, apparent backcross and 'pure' pairs successfully fledged young. Some individual birds proved impossible to categorize. Primary feather pigmentation varied in both amount and pattern. Iris color also varied apparently independently of primary feather pigmentation.

Dry Bay, mouth of the Alsek River, approximately 75 km south of Yakutat, that is, within the boundaries of the current study area, contains about 500 pairs of Herring and Glaucous-winged Gulls nesting sympatrically on low gravel bars at the mouth of the River. Dry Bay has apparently never been glaciated but may have been the location of catastrophic flooding from glacially dammed lakes in the interior Yukon within the last 1000 years. The Alsek River is a known migration route connecting coastal with interior populations of vertebrates through the St. Elias Range (5000m - 6500m). Collections of specimens in June 1974 and June 1975 revealed both Herring Gull and Glaucous-winged Gull types as well as a wide range of variation in primary feather pigmentation. Relative proportions of Herring Gulls to Glaucous-winged Gulls are considerably higher in Dry Bay than Glacier Bay, reflecting influence from interior Yukon.

Haenke Island lies off Yakutat in Disenchantment Bay and has about 200 pairs of Glaucous-winged Gulls nesting on a 100m grassy cliff. The St. Elias Range and the Malaspina Glacier prevent the influence of interior conditions in the area. The gull population here is currently less variable in primary feather pigmentation than the population at Dry Bay.

Apparently the largest Glaucous-winged Gull colony in the northeast Gulf of Alaska is located on Egg Island near the mouth of the Copper River near Cordova. Conditions on this island have been previously discussed in this report. Gull specimens collected in the summer of '75 show a limited range of variability. The large number of glaucescens may serve to "swamp" argentatus-type genes.

N.G. Smith (1966) suggests there are insufficient isolating mechanisms between the Herring and Glaucous-winged Gulls. Field evidence from this portion of the study indicates that the Larus argentatus - Larus glaucescens species group is in an exceptionally fluid state evolutionarily, with populations at least partially isolated by glaciation and mountain ranges now interbreeding where in contact, and producing a variety of morphological types in a geologically rapidly changing environment. Superimposed upon the geological forces will be the future explosive industrial development. The gene flow between gull populations in the Gulf of Alaska may be further increased in coming years as a secondary influence of human activities, which may lead to a new adaptive peak in this commensal bird species, with consequences for municipal health and sanitation.

Task A - 28

The Role of Gulls (*Larus argentatus* & *Larus glaucescens*) in the Transmission of Human Parasitic and Enteric Diseases in Alaska: A Review

Part 1. Human Parasitic Diseases and Gulls

The exposure of untreated or poorly treated sewage to gulls in coastal regions of Alaska may lead to potential human health hazards from helminth and bacterial infections. One of the traditional safety factors relied upon for the prevention of the dispersal of pathogens which may be present in the effluent of sewage treatment has been the dilution of the effluent with an abundance of river or sea-water (Silverman and Griffiths, 1956). Overloading, however, or construction of new sewage plants with outfalls into already heavily polluted waters, e.g. Cordova dockfront area (USDI, FEIS, 1976), reduces the dilution factor, and certain organisms, such as gulls, may actively concentrate human pathogens through their foraging patterns. For instance, in sewage treatment plants there is little evidence that continuous aeration adversely affects helminth ova, nor is rapid sand filtration an effective means of removing helminth ova from sewage effluents (Silverman and Griffiths, 1956). Varying percentages of viable helminth eggs (*Ascaris*, *Trichurus*, *Enterobius*, *Diphyllobothrium*, and *Taenia* - all human pathogens) have been found in raw sludge from sewage treatment plants (Silverman and Griffiths, *loc. cit.*). Eggs may persist in a viable state in the sludge for up to two years.

The role of birds in the dissemination of helminth ova is difficult to evaluate, but is highly suggestive (Silverman and Griffiths, 1956). Götzsche (1951) suggested that gulls might be responsible for dissemination of tapeworm eggs from sewage outfalls. Gulls may come into contact with sewage at every stage of treatment, and it is well known that gulls frequent canneries, fish-packing houses and garbage dumps as well along the coast of Alaska, in addition to roosting on municipal water supplies (e.g. Ketchikan, Cordova) (Wilson and Baade, 1959; USDI FEIS, 1976). Dumping of raw sewage from coastal towns and villages in Alaska attracts gulls such as Glaucous-winged and Herring Gulls, which being natural scavengers, forage on the fecal matter (e.g. Juneau; Williams, pers. comm.) Silverman and Griffiths (1956) found gulls attracted to sewage outfalls especially in winter. These authors reported that feeding experiments with Herring Gulls revealed that tapeworm eggs (*Taenia saginata*) can pass through the alimentary tract of gulls and still retain their infectivity. The eggs pass through the intestinal canal of unstarved birds and appear in the feces about an hour after injestion. Mature eggs may hatch in the gut of the gull, and the activated hexacanth embryo may be found in the droppings. In experimental situations, if the tapeworm species *T. pisiformis* and *T. saginata* eggs are fed to gulls, infections in rabbits and cattle develop when gull feces are injested by the respective host animals. If gulls injest or become contaminated with tapeworm eggs at sewer outfalls, the gulls may transport the eggs elsewhere and deposit them at places inopportune for human health. Thus gulls can deposit *Taenia* eggs, which have been acquired from human feces, on pastures, where they are injested by cattle, which then develop *Cysticercus bovis*, the infective larval stage of a human tapeworm. The potential for this cycle exists in the cattle raising areas on Kodiak Island if sewage treatment is not carefully monitored. Other Alaskan tapeworms are discussed below.

The problems involved in the treatment and disposal of sewage from small groups of buildings and dwellings, particularly in isolated areas, are varied and complex (Silverman and Griffiths, *loc. cit.*). Soil and water pollution resulting from the inadequate disposal of human excreta is a potential source of human health problems along the coast of Alaska, currently where human habitations are isolated and undeveloped. These problems are complicated by by the scavenging nature of the abundant Alaskan gull populations. Additional aspects of these sewage-gull related problems are discussed below.

Part II. Naturally Occurring Human Helminth Infections Associated with Gulls in Alaska

The Eskimos of western Alaska depend upon fishes of several species for much of their food. These fishes are often eaten raw and thus transmit to humans certain helminth worms for which the fish serve as intermediate hosts, for example species of Diphyllobothrium tapeworms (Rausch et al, 1967). In the Kuskokwim Delta region of western Alaska, Eskimos usually eat raw or partially frozen smelt (Osmerus), blackfish (Dallia), and sticklebacks (Pungitus), which often contain diphyllobothriid plerocercoids, which are larval tapeworms, and it is assumed that these fishes are an important source of infection for man (Rausch et al, 1967). The rate of infection with diphyllobothrium tapeworms reached the highest level in winter and early spring, after the greatest consumption of blackfish and sticklebacks (Rausch et al, loc cit.). Uncooked fishes comprise 38% of the diet of these Eskimos (Heller and Scott, 1967). Levels of infection in these people by tapeworms of this genus ranges from 16% to 30% (Rausch et al,loc cit.). Among the tapeworms identified by these authors is D. dalliae, which is found in the adult stage in man and dogs. This cestode is one of the most frequently found in this region, and early life stages of the species inhabit the blackfish, Dallia pectoralis, which is an abundant and economically important species in the Kuskokwim River region of Alaska (Rausch et al, loc. cit.) Rausch (1956) obtained infectious tapeworm plerocercoid larvae from blackfish trapped on the lower Kuskokwim River. At the laboratory at Anchorage, adult tapeworms derived from these larvae were raised in Glaucous-winged Gulls which had been hatched in an incubator and maintained parasite-free until the experimental infection. Rausch (1956) stated that the occurrence of the tapeworm *D. dalliae* is to be expected in gulls in Alaska. Gulls are implicated in the dissemination of this parasite, transporting eggs to various aquatic areas where the eggs develop through several life stages to plerocercoid larvae in fish infective for humans.

Another cestode commonly found in man in Alaska is a *Diphyllobothrium* species undetermined. This type appears identical with a tapeworm species reared experimentally in man, dogs, and Glaucous-winged Gulls from plerocercoids (infectious larvae) encysted on the stomach of salmonid and coregonid fishes (Rausch *et al*, *loc. cit.*). Glaucous-winged Gulls have also been found to be naturally infected with this tapeworm parasite in Alaska. Rausch (1956) collected other adult cestodes resembling *D. dendriticum* in morphological details from various species of gulls in Alaska. Kuhlow (1953) established infections in gulls by feeding encysted tapeworm plerocercoids from the stomach of *Osmerus eperlanus*, the smelt. Chizhova (*in* Rausch, 1956) observed a tapeworm parasitizing Herring Gulls as well as man and dogs on an island in Lake Baikal. Specimens apparently of the same species were found in both man and gulls (Rausch, 1956). The Herring Gull is also common inland on Alaskan lakes during the summer, and along the south coast in the winter. Rausch (1954) observed specimens of still another *Diphyllobothrium* tapeworm species in dogs, foxes, cats, and gulls in Alaska after feeding plerocercoids from infected steelhead (rainbow) trout. Rausch (1954) experimentally infected Glaucous-winged Gulls with the tapeworm *Diphyllobothrium ursi*, a parasite of brown bears. Since Glaucous-winged Gulls often feed on the same salmonids as the bears in Alaska (e.g. McNeill River), the possibility of the same species of cestodes naturally parasitizing both bear and gulls cannot be ruled out, the hosts cross-infecting each other and potentially man.

Thomas (1938) reported the life cycle of the tapeworm *Diphyllobothrium oblongatum* involved Herring Gulls, herring (*Leucichthys* sp.), and copepods. Tapeworm eggs were deposited in the feces of the gulls. Thomas (1938) reported that freezing the tapeworm eggs solid in ice for a month did not destroy their ability to hatch normal coracidia (early developmental stages). This suggests that tapeworm ova can survive through the Alaskan winter to continue their life cycle in the spring.

Although the pernicious-like anaemia associated at times with human *Diphyllobothrium* tapeworm infection in Eurasia has not been observed in Alaska, the potential for such disease has been examined by Rausch *et al*, (1967). These authors reported that there was no evidence that infection of Alaskan natives by diphyllobothriid tapeworms contributed to the development of microcytic anaemia. However, in view of the often poor nutritional level of these people, the infection by these tapeworms may be detrimental (Rausch et al, 1967). Caucasians, however, especially those descended from northern European stock, may be genetically susceptible to anaemia associated with *Diphyllobothrium* tapeworm infections (Tötterman, 1947).

In addition to tapeworms, gulls have been demonstrated to be part of the marine cycle of trichinosis, a roundworm parasite which infects Eskimos in arctic Alaska. Marine animals may become infected through the consumption of encysted trichinae in the feces of carrion feeding birds such as gulls (Schwabe, 1964). Eskimos may become infected with trichinosis when they consume the raw flesh of marine mammals, including polar bears, seals, walrus, and beluga whales, all of which have been discovered to carry *Trichinella spirialis* (Rausch *et al*, 1956).

Part III. Gulls and Enteric Disease in Alaska

Reports of human gastroenteric diseases associated with high fever, marked diarrhea, and dysentery have been received by the Alaska Department of Health and Social Services from time to time. These reports have originated from all parts of Alaska (Williams, 1950). Outbreaks of enteric or intestinal diseases occur frequently in Alaska where water supplies are not protected (*anon.*, Alaska's Health, 1954). Studies conducted by Alaska Public Health Laboratories have implicated sewage disposal, water supplies, and Glaucous-winged Gulls in the spread of *Salmonella manhatten* from sources of infection to healthy human beings. Salmonellosis is the term applied to any infection caused by any one of a group of more than 1,100 microorganisms (Steele and Galton, 1969). Salmonellosis usually occurs as an intestinal infection which may result in enteritis and diarrhea, and may terminate in some cases in septicemia and death (Steele and Galton, 1969).

The bacterial genus *Salmonella* is composed of gram-negative, aerobic, non-spore-forming microorganisms that grow well on artificial media and reduce nitrate to nitrite.(Edwards and Galton, 1967). There is considerable disagreement regarding taxonomy of this group. All members of the genus are potentially pathogenic for man and animals. It is known that salmonellae inhabit most species of warm-blooded animals (Steele and Galton, *loc. cit.*) For instance, *Salmonella typhimurium* has been recovered from gulls found dead at a cannery in Denmark (Nielson, 1960). *S. paratyphi* B has been discovered in Herring Gulls and other avian species (Wilson and MacDonald, 1967). *S. derby* has also been isolated from Herring Gulls in the United States (Faddoul and Fellows, 1966). Gulls carry many other kinds of *Salmonella* as well (Steele and Galton, *loc. cit.*). In gulls, enteritis may be the only sign of infection, thus increasing the probability of the transmission of the disease (Nielson, 1960).

Gulls became suspect in a Salmonella outbreak at Ketchikan because of their scavenger feeding habits along the shore at the edge of that city where sewers discharge above the waterline at low tide (anon., Alaska's Health, 1954). Gulls have been observed for many years to leave the Ketchikan waterfront with the coming of winter storms, and to fly back approximately four kilometers to Ketchikan Lake, which is the municipal water supply for the town (Wilson and Baade, 1959). Epidemics of gastrointestinal disease have occurred at this time of year. Literally thousands of gulls roosted on the lake at the time of the 1953 epidemic, and the water showed gross contamination that could not be explained from any other source (Wilson and Baade, 1959). Specimens from gulls collected at the lake proved positive for Salmonella manhatten organisms. Cultures from gulls as well as from patients hospitalized with gastroenteritis were verified by the Center for Disease Control, Atlanta, Georgia. Chlorination of the water supply has drastically reduced the incidence of this disease in Ketchikan, but the situation must be monitored to assure constant levels of chlorination. A similar situation exists at Cordova (Morley, Alaska Environmental Health, pers. comm.), where gulls roost on the lake forming the town water supply.

Pollution of reserviors by aquatic birds has been recorded from Massachusetts, New York City, San Francisco, Los Angeles, Vancouver, B.C., and London, England (Wilson and Baade, loc. cit.). Typhoid bacillus has been isolated from gull excreta collected in the vicinity of a town in Scotland where typhoid epidemics had occurred (Wilson and Baade, loc. cit). Salmonellae were recovered from 78% of gull droppings collected near sewage disposal works at Hamburg, Germany. Samples taken from sewage-free areas were consistantly negative (Muller, 1965).

According to Pauls (1953), providing safe and adequate water supply and sewage disposal systems is a vital problem intricately linked with the outbreak of enteric diseases. The role of gulls is an added phase in the study of enteric and parasitic diseases in Alaska. The Ketchikan _Salmonella_ epidemic emphasizes the need for proper and adequate sewage disposal systems to prevent contamination of gulls with disease producing organisms which can be carried to public water and food supplies. In many smaller communities in Alaska, the disposal of sewage is taken care of through single premises systems, _scavenger systems_ (underlining mine) or dumping of collected wastes on the surface of the ground in areas not especially distant from dwellings (Pauls, _in_ Alaska's Health, 1954). Contaminated water supplies and improper sewage disposal have historically been the major causes of outbreaks of gastrointestinal diseases in Alaska (Pauls, 1953). In all of the outbreaks since 1807, the first reporting date, poor sanitation has played an important role, whether the epidemic was water-borne or food-borne.

The influx of people into locally crowded areas of Alaska will increase the health hazards already complicated by unsanitary basic sanitary facilities, since newcomers will bring with them their own diseases, and carriers of typhoid fever and parasitic infections are undetected within this group (Pauls, 1953). The present explosive immigration to Alaska and the projected rapid industrial growth in offshore oil operations may lead to conditions where gulls act as vectors for rapidly spreading human diseases.

Newcastle Disease Virus Antibody Assay (Task A - 28)

Newcastle disease virus (NDV) is considered a pathogen for most avian species (Hanson, 1972). Newcastle disease can be a mild illness with transient respiratory signs or it can be fatal with severe respiratory and neurological symptoms (Beard and Brugh. 1975). It can also cause hemorrhage and necrosis of the intestinal tract (Beard and Brugh, loc. cit.). Bradshaw and Trainer (1966) gave evidence of NDV infection in wild ducks and Canada geese by demonstrating hemaglutination-inhibiting (HI) antibody in 14-17% of birds tested. Palmer and Trainer (1970) reported 31% of Canada goose sera contained antibody to NDV. Rosenberger et al. (1974) described isolation of NDV from several species of migratory waterfowl. The cloaca or feces may be a prime site of virus isolations in migratory waterfowl, with implications for dissemination (Rosenberger et al., 1974).

We observed three dead or dying immature Black-legged Kittiwakes and many Glaucous-winged Gull chicks in the meadows on Egg Island; the kittiwakes and some gull chicks showed no external injury (see Chick Stage and Mortality Factors, above.). The kittiwakes were totally unexpected in the meadows since they are cliff-nesters and pelagic feeders. In the Hopkins laboratories we are examining an adequate sample (250) of sera from Egg Island gull chicks for evidence of common virus diseases, among which is NDV. We are using the HI test, which is the most convenient, rapid and economical method for evaluating antibody titer to NDV (Beard and Brugh, 1975).

Our procedures are as follows: all sera are heat-treated at 56^{o} C for 30 minutes to remove non-specific inhibitors; positive control is NDV hyperimmune chicken antisera; negative control is normal chicken serum (both controls heat-treated 56^{o}C, 30 min.). HI tests are performed on microtiter plates using 0.5 or 1.0% chicken red blood cells in buffered saline. In the initial screening antibody activity has been detected in 8 of 125 sera(6.4%). We are continuing our examination of these sera and suggest an NDV strain in this gull population.

SUMMARY AND TENTATIVE CONCLUSIONS

We carried out a concentrated investigation of two gull colonies located hundreds of kilometers apart in the northeast Gulf of Alaska in the summer of 1975. We compared the results of our investigation to data gathered in our previous Alaskan research and to other studies in the literature.

Egg Island lies a few kilometers offshore from the mouth of the Copper River, near Cordova, Alaska, and contains the largest Glaucous-winged Gull colony in the northeast Gulf of Alaska. Some 5000-6000 pairs nest on meadow-covered dunes on Egg Island. Mean territory size was 28.9 m^2. The gull population may not be limited by available nesting space due to the uplift of the island and the surrounding area in the '64 earthquake. Nests averaged 19.6 by 19.9 cm across the inside, and 39.7 by 39.1 cm across the outside, and averaged 7 cm deep. Most egg-laying took place in late May or early June; there was a wide spread of egg dates. Observed clutch size at the end of incubation suggests a 43 percent egg loss to predators, mostly other gulls. Hatching success was high other than those eggs predated. There were no signs of eggshell weakness. However, "runt" eggs and supernormal clutches were noted on Egg Island. Considerable chick mortality occurred when chicks began to wander at about three weeks of age; the large territory size may slow the rate of earlier mortality. Death of many wandering chicks was due to attacks from other adult gulls. Bad weather was associated with much mortality of younger chicks later in the breeding season. Fledging took about 40-45 days, and overall productivity was moderate, averaging about 1.03 chicks produced per nest, or 59 percent fledging success of chicks hatched.

About 500 pairs of Herring and Glaucous-winged Gulls nest sympatrically in a mixed colony on low gravel bars at Dry Bay, mouth of the Alsek River, south of Yakutat, Alaska. Hybrid gulls are common in the area. The reproductive biology of this colony was examined in late June 1974 and 1975 in a sample of 100 nests. Territory size averaged 29.8 m^2, practically identical to that on Egg Island and also suggesting room for population expansion. Nests at Dry Bay averaged 19.9 cm by 20.06 cm inner diameters, and 40.16 cm by 39.42 cm outer diameters, and averaged 1 cm shallower than nests on Egg Island, probably due to the lack of suitable nest material. One hundred and fifteen eggs at this colony showed a usual mean weight for a late stage in incubation. No runt eggs or supernormal clutches were observed in this smaller sample size. The reproductive cycle at Dry Bay was about two weeks behind Egg Island, probably due to heavy snowfall and late spring in the Yakutat area. The gravel bars at Dry Bay may be flooded on occasion, disturbing the gull reproductive cycle. The gull population at Dry Bay indicates strong influence from interior Yukon.

The North Marble Island gull population, which is technically outside the borders of the current study area, but which forms part of the Gulf of Alaska, has been investigated in 1972-73 for the National Park Service. This population shows a quite high reproductive rate under post-glacial conditions, averaging 1.77 chicks fledged per nest in the two-year study.

This information indicates the gull populations in the Gulf of Alaska have the potential for rapid increase with access to human garbage, sewage, and refuse associated with increased oil operations. Gulls are associated with canneries, fish-packing houses, garbage dumps, sewer outfalls, and municipal water supplies along the coast of Alaska, and are clearly implicated with human bacterial and parasitic diseases in Alaska. As the availability of human-generated refuse increases with the development of oil resources in the Gulf of Alaska, populations of gulls previously more isolated may come into closer contact with one another. The gene flow between gull populations in the Gulf of Alaska may be further increased in coming years as a secondary influence of human activities, which may lead to a new adaptive peak in this commensal bird species, with consequences for municipal health and sanitation.

Banding returns and sightings of color-marked gulls indicate that breeding birds depart from the Cordova area in October and return in March. Juveniles disperse widely from Valdez to Ketchikan. There may be a southward shift of this population in the winter along the coast of the Gulf of Alaska.

This report examines some of the factors influencing gull reproductive biology in the northeast Gulf of Alaska during the 1975 and previous field seasons, and indicates a gull population reproducing at a good to normal rate under relatively wild conditions. However, we suggest this gull population is already responding to human influence in the area, notably around the Cordova canneries. The moderate reproductive rate of the large population breeding on Egg Island could account for, if continued, and expanding number of gulls, due to increasing availability of food resulting from human activity. The development of oil resources could effect gull reproduction positively through access to this food supply, or negatively through disturbance of colonies at certain crucial periods in the breeding cycle, detailed herein.

NEEDS FOR FURTHER STUDY

Population studies become more valuable for management decisions as well as for scientific knowledge directly in proportion to the number of reproductive cycles studied. Gull productivity analysis, as with any other species, requires at least two breeding cycles to determine the absolute minimum trend of the population reproduction. The gull population at Egg Island has been examined through one breeding season; the study will continue through the 1976 season.

The Environmental Protection Agency has requested an almost total ban on effluents from the Cordova canneries by December 1975 (Michelson, pers. comm.). The Cordova dump, another gull foraging area, should be phased out during the spring of 1976, as well as a sanitary landfill utilized at Mile 17, Copper River Highway, in line with the Cordova airport at Mile 12. Gulls nesting at Egg Island, the nearest colony, may not be able to forage as they have in years past on the effluent of the Cordova seafood packing canneries. This effluent has perhaps accounted for the gull increase (Isleib, pers. comm.). In addition, gulls will not have access to as much garbage if the Cordova dump and the Mile 17 landfill are closed. Artificial food will thus decrease in availability, which may influence the reproductive success of the colony at Egg Island (Ward, 1973). Similarly, recently fledged juveniles will be forced to rely on natural food in the intertidal rather than scavenge around the canneries or in the dump. Thus colony size may stabilize or decline in the long run if gulls are relying on artificial food sources (Michelson, pers. comm.). The results of the 1976 studies may provide a comparison of breeding success in a year with abundant artificial food (1975) versus a year of low artificial food availability (1976), testing under natural conditions the hypothesis that garbage attendant upon increased oil operations will result in increasing numbers of gulls.

The Egg Island colony will be examined further for evidence of such reproductive abnormalities as "runt" eggs and supernormal clutches. Blood samples will be collected from chicks and adults for assessment of disease in this population (Task A-28).

An additional protocol has been devised to test the effects of North Slope crude oil on gull eggs (see Egg and Clutch Replacement above). Oil in a variety of mixtures and under different conditions of application will be delivered to a sample of eggs in marked nests, thus simulating pollution conditions as discussed in the section above. The hatching success of the experimentally oiled eggs will be compared to a sample control of undisturbed clutches.

We will also investigate the gull population at Dry Bay to obtain an initial index of reproductive success for this mixed colony at the southern border of the study area. We will obtain precise dates of egg-laying and chick hatching to ascertain reproductive synchrony, study growth rates in a sample of chicks, and collect food remains for subsequent identification. Chicks will be banded and adults color-marked at this colony.

Two additional colonies are important for the scope of this investigation. These colonies are Middleton Island and Strawberry Reef, which have not yet been visited during this study. Middleton Island is the closest gull colony to the northernmost GOA lease sale area, and Strawberry Reef is the nearest onshore colony to the larger lease sale area between Kayak Island and Icy Bay. It will be important to provide at least a preliminary picture of the conditions at these colonies during the 1976 field season.

Oil seeps at Katalla may already contaminate the Copper Delta environment, but evidence is lacking. Egg collections will be made from Strawberry Reef, a particularly important site, since it is the closest gull colony to Katalla. The USF&WS Patuxent research laboratory, in a program under the direction of Dr. Harry Ohlendorff, will examine these egg tissues for base-line evidence of petroleum hydrocarbons.

The data on fledging success in the above colonies will provide the basis for future assessment of population changes. A further long-term banding scheme is necessary to detail the age structure, mortality rates, survivorship, critical habitats and migration routes of these gull populations. We will continue to band as many gulls as possible at Egg Island and Dry Bay this season, because many more banding returns are needed to complete life tables for analysis of population changes. Complete life table data will require further effort during successive breeding seasons. Determination of migration routes and seasonal densities requires large-scale banding returns as well over a number of years and the development of such information will of necessity be slow. Alaskan gull banding returns made elsewhere previously to this study will be included in the Fall 1976 report.

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COMMUNITY STRUCTURE, DISTRIBUTION, AND INTERRELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA

John A. Wiens

Research Assistants: Wayne Hoffman
Dennis Heinemann

Department of Zoology
Oregon State University
Corvallis, Oregon, 97331

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT.

The objectives of this study are to determine geographical areas of critical importance to seabird populations, to assess the degree of interdependency among various species of flock-forming seabirds, and to calculate the energetic demands which the seabirds place upon the marine environment. To date, we have found that the distributions of many seabird species in the Gulf of Alaska are only qualitatively and approximately known. Our distributional data include several records of birds in unexpected places, and unexpected concentrations of birds. Our flock studies indicate that flock feeding is a common and important phenomenon in shallow near-shore ares. Considerations of the relationship of the birds to their food resources indicate that increased mortality, such as might result from petroleum development is unlikely to be buffered by increased production. Further, for the flock-feeding birds, a threshold density may exist for efficient foraging, and if oil-related or other mortality brings the population below this threshold, the rate of production of young may actually decrease.

II. INTRODUCTION

This annual report summarizes activities in R. U. #108 from project initiation in 1975 to 31 March 1976. While field studies during 1975 were conducted according to schedule, analysis of the data obtained in these studies has lagged far behind initial schedules for two reasons. First, the compiling, analysis, and storage of large quantities of data such as are being gathered in OSCEAP demands computer interfacing. To do this with any hope of standardization and long-term useability of the data requires that the data be compiled in accepted formats using standardized coding processes. These are not easily developed, and our study did not receive copies of final data formats and codes until early March 1976. Prior to that time the data we gathered could not be prepared for analysis. Entry of the 1975 data onto keypunching forms has been progressing since early March, but the completion of the files for transmittal has been delayed because we have not yet received copies of the Surveyor's "rough smooth-plot" of the ship's trackline. We must use these smooth-plots to make accurate determinations of our positions and course and speed in the frequent cases where the ship's written log is not sufficiently accurate. Copies of these smooth-plots were requested October 20, 1975. We have repeated this request several times in January, February and March of this year.

Second, once the data are entered in the proper formats they must be keypunched and verified before computer analyses can be initiated. The OCSEAP project office in Juneau originally assumed responsibility for key-punching our data, but by early December, it was apparent that they were not equipped to handle the volume of data being generated in the program. We then presented this office with several alternatives to accomplish the keypunching necessary to handle our data. At the time of submission of this report, we have received no word of action upon our suggestions.

For these reasons, it has proven impossible to conduct quantitative analyses of material gathered during 1975 studies for inclusion in this report. Our emphasis instead is upon a qualitative review of our activites and major findings to date.

A. General Nature and Scope of Study. This study is designed to examine the interactions of marine birds in the Gulf of Alaska with each other and with their food resources. Emphasis has been placed upon the larger fish-eating birds. In the examination of interactions between marine bird species we are concentrating upon feeding flocks and other at-sea interactions. Nesting colony interactions are not being considered. Our studies of seabird interactions with food resources are focused upon the modes of communal or interactive food location, on the behavioral responses of the food organisms, and upon the energetic and numerical roles of the birds in marine resource webs.

B. Specific Objectives.

1. Patterns of seasonal abundance and distribution are being studies because of their direct relevance to oil development and transport activities, and also to use in our analysis of marine bird energetic impact.

2. The dynamics of feeding flocks are being studied to determine the degrees and directions of dependency and/or interference between seabird species. This involves a description of the roles of different species in flock formation and development and an analysis of their contribution to the efficiency and performance of the system as a whole.

3. The energetics analysis is designed to estimate the impacts of marine birds on oceanic ecosystems, and to predict the effects on those systems of major changes in bird populations, such as may occur from oil development and transport accidents.

C. Relevance to Problems of Petroleum Development. Floating oil, whether crude or refined, poses major health problems to marine birds. It destroys the insulative properties of their feathers and causes considerable mortality from exposure. Birds frequenty ingest oil while trying to preen fouled feathers. Apparently most petroleum fractions are toxic to seabirds, but the amount of refinement i.e. the volatility of the fraction, appears to be directly correlated with the toxicity.

It is likey that the impact of a particular petroleum development or activity can be minimized by seasonal restrictions. In this way, impact could potentially be greatly reduced without seriously restricting development. For example, tanker routes could be specified, and could be required to vary seasonally, to avoid seasonally sensitive areas.

The flock investigations will provide predictive information on the secondary impacts of petroleum development on bird communities. If single species-populations are directly affected by development, there may well be indirect or secondary affects on species which interact with the affected species.

The energetics analysis will estimate the role of the seabirds in Gulf of Alaska marine ecosystems, and will allow prediction of the effects on the system energetics of alterations in bird populations which may result from oil development. If suitable data are available from productivity, zooplankton, and fisheries studies, the effects of oil-related alterations of productivity on bird populations may also be predicted.

III. CURRENT STATE OF KNOWLEDGE.

A. Distribution. The oceanic distribution of most Alaskan seabirds is known only very generally. Areas of concentration and patterns of seasonal movement of the birds are not well known, especially in the detail necessary for estimation of vulnerability to oil development. This is reflected in the amount of new and amplified information on distribution and abundance generated in the 1975 field season by ourselves and by other bird research teams in the OCSEAP program. For the widespread species general ranges of occurrance have been described (i.e. Gabrielson and Lincoln 1959, Murie 1959) but densities and areas of greater or lesser importance within the ranges have generally not been described. Sanger (1972, 1974) has discussed in general terms the abundance of marine birds in Alaskan waters but he did not identify local areas of concentration.

B. Density Estimation. Estimation of seabird density has generally been done using a technique of counting along transects by ships or low-flying aircraft.

King (1970) reported on the method of density estimation used in the POBSP program in 1964-65. They counted all the birds they could see, and assumed that they could see all birds of each species out nearly to the greatest distance to which any individuals of that species could be seen. They thus generally underestimated actual numbers (they were aware of this discrepancy, but they felt that it was safer to estimate numbers conservatively.) A group of Canadian and English seabird investigators, including W.R.P. Bourne, R.G.B. Brown, and D.N. Nettleship, have concluded that density estimtion of seabird numbers is so subject to error that it is unsafe, and have decided to mrerely publish counts of birds seen per minute. Sanger (1972, 1970) used a method similar to that of the POBSP, in which the total number of birds seen was multiplied by an intuitive estimate of the species specific average distance at which a bird could be detected.

Emlen (1971) devised a method for calulating densities of terrestrial birds which includes zonal estimates of the distances of all birds seen from the transect line. This allows an internal calculation of the distance at which birds can be detected. Our methodology is an adaptation of the Emlen technique with some analytical refinements to improve the statistical validity of the method.

C. Energetics. Swartz (1966) and Sanger (1972) have attempted to analyze marine bird dynamics and energetics in Alaska waters. Swartz lacked sufficient information on energy balance to document caloric and chemical impacts of the birds quantitatively. His study applied to the Cape Thompson region only. Sanger attempted to relate bird biomass to biological productivity. His estimates of bird standing stocks apparently tend to be low in coastal areas because his sampling scheme (largely on ship-of-opportunity basis) may have missed many nearshore concentrations of seabirds. His sampling scheme was also deliberately constructed to give conservative estimates of bird numbers.

Wiens and Innis (1974) provide a more complete rationale and methodology for calculaitng bird energetic demands. Wiens and Scott (1975) applied this methodology to Oregon seabirds. The present study is designed to analyze marine bird energetic importance and impact in Alaskan ecosystems using this latter approach.

D. Feeding Flock Dynamics, and Interspecies Dependencies. The POBSP conducted extensive studies of feeding flocks of seabirds in the tropical and subtropical central Pacific (King 1974). They described the formation of flocks, and the species' positions and behavior within these flocks. Hatch (1975) explained group kleptoparasitism by laughing gulls in a way that seems to apply very well to the behavior of jaegers in the Gulf of Alaska and elsewhere. Sealy (1973) briefly described feeding flocks off the Queen Charlottes of British Columbia. The flocks described were similar to some of these which occur in Alaskan waters but averaged smaller. He was unable to quantitatively judge the importance of flock feeding to the birds involved. Nettleship (1972) discussed interactions of puffins and gulls on the nesting colonies but didn't consider interactions at sea. Hoffman (unpub. data) studied the formation and structure of feeding flocks on the Washington coast in 1974. He found that the structure and composition of flocks varied seasonally and with the fish species involved as prey.

IV. STUDY AREA.

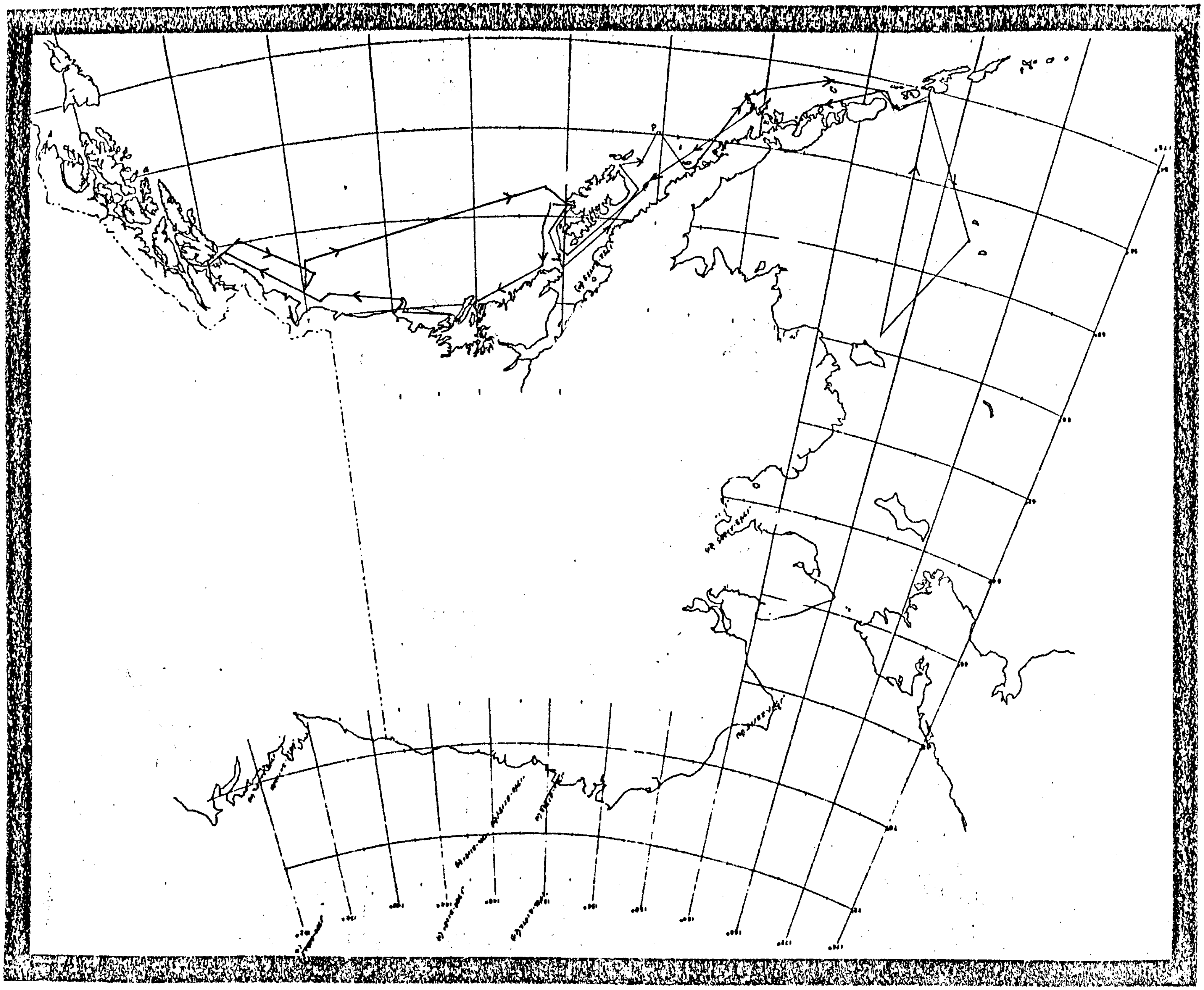
This study is being conducted on the continental shelf and adjacent oceanic areas of the Gulf of Alaska. Because of our ship-of-opportunity status in 1975, we spent several days in the southeast Bering Sea. Our 1975 tracking is indicated in Figure 1. The intensity of transect sampling in these areas is indicated in table 1.

TABLE ONE

REGION	NUMBER OF TRANSECTS	NUMBER OF MINUTES	NUMBER OF BIRDS	NUMBER OF SPECIES
1.	5	107	661	22
2.	71	1601	5155	35
3.	21	390	1477	16
4.	11	200	13800	16
5.	16	355	6540	20
TOTALS	91	2895	24733	54

Regions:

1. Inside Passages East of 137° W
2. Gulf of Alsaka East of 152° W, excluding the Inside Passages
3. Gulf of Alsaka Between 152° and 157° W
4. Gulf of Alaska and North Pacific, between 157° and 166° W
5. Eastern Bering Sea, area from Unalaska to Nunivak I.



V. SUMMARY OF METHODS AND RATIONALE OF DATA COLLECTION.

A. Distribution of Seabirds. Observations are made at all periods of the day, but proximate decisions on observations are largely dependent upon weather, visibility, and ships' activity. Observations are made as follows: the observer places himself on the Flying Bridge or elsewhere high on the forward part of the ship. Observation is normally limited to one quadrant, from the bow to one beam. The side of the ship to be used is chosen on the basis of visibility and weather. Observations are made for periods of 15 minutes or more while the ship is travelling at a constant course and speed. We collect data on the behavior, position, distance, and identification of each bird seen. These data will allow us to calculate area-specific densities of seabirds to a greater level of accuracy than has previously been accomplished.

B. Multispecies Feeding Assemblages. During 1975, flock observations were made from the Surveyor as flocks were encountered, and from the Surveyor's launches when the ship was in port in Kodiak and Dutch Harbor. Data were collected on species' roles in flock formation and development, on arrival and departure times and patterns, on flock dimensions and characteristics, and on time-specific species composition and behavior. During the 1976 field season flock studies will be supplemeted with observations by spotting scope from suitable sites on land at several locations in the Gulf of Alaska. Ocean-based data will also be collected as in 1975, but the land-based observations will allow more precise determinations of the importance of flock feeding to particular bird populations.

C. Energetics. Data collected in the field on distribution and abundance of birds and on their food habits will be used, along with energetics, productivity, meteorological and breeding biology data from the literature, as inputs to the BIRD model (Wiens and Innis, 1974) to calculate the population energetics of the marine birds in Gulf of Alaska ecosystems. We will then be able to conduct computer simulations, modifying model inputs to predict the energetic consequences of various possible patterns of oil-related disturbances.

VI-VII. RESULTS AND DISCUSSION.

A. Marine bird distribution in the Gulf of Alaska. Although extensive quantitative analysis of the data gathered has not yet been done, pending development and authorization of computational procedures, qualitative conclusions can be drawn from preliminary inspection of the data.

Loons. Yellow-billed loons (Gavia adamsii) appear to winter in numbers off the Trinity Islands, in shallow water, but at times on banks 10 nautical miles or more offshore. Additional observations will be necessary to determine their abundance to the south and west in the Gulf of Alaska. Apparently a major part of the North American population may winter within the OCSEAP study areas. Loons are at times very susceptible to floating oil (Joensen 1972).

Albatrosses. As noted elsewhere, the two Albatross species tend to stay beyond the continental shelf margin. They were noted to follow the ships into 100 fathom water but never closer. They were seldom encountered in water of less than 1000 fathoms on outward runs. Laysan Albatrosses were found in greater than expected numbers in the northeastern gulf in late September. Albatrosses and other soaring seabirds are apparently less susceptible to oiling than diving birds, but the impact of oil on them through food chain disturbance is not known.

Shearwaters. Two unuusal northerly records of shearwaters were made in August and September, 1975. A Manx Shearwater (Puffinus puffinus) was seen near Kodiak August 5, and Buller's Shearwaters (P. bulleri) were seen

September 18 and 19 off Yakatat. These observations, together with the Laysan Albatross sighting mentioned above, may be indicative of unusual oceanographic conditions in the gulf in the late summer of 1975. The apparently widespread occurrence of "red tide" organisms in the Gulf during the summer may reflect the same phenomenon. Sooty and Slender-billed Shearwaters (P. griseus and P. tenuirostris, respectively) were the most abundant birds recorded in summer. Almost all of these birds moved out of the area during October.

Petrels. Fork-tailed storm-petrels (Oceanodroma furcata) were the only petrels regularly seen. They occurred both over deep water and close to shore. They are apparently permanent residents of the Gulf and Prince William sound. The susceptibility of storm-petrels to oil is not well known, because in most areas they occur only well offshore for most of the year, and any oil mortality which may occur has not been detected.

Cormorants. Little new or unusual was discovered about the distribution of cormorants in 1975. Red-faced cormorants were found to occur farther offshore than the other species.

Ducks. Ducks were seen regularly but in small numbers at sea in the eastern Gulf in September and November, which suggest the possibility of regular transgulf migrations for several species. Species seen included Mallards, Pintails, Shovelors, Goldeneyes, Scotors, and Mergansers.

Phalaropes. Northern Phalaropes were abundant on the ocean throughout the areas covered in early August, and were present in smaller numbers in September. Red Phalaropes were seen occasionally in early August. The effects of oil on Phalaropes are not known.

Jaegers. Pomarine, Parasitic and Long-tailed Jaegers were seen regularly in the Gulf of Alaska in August and September. Pomarine Jaegers were by far the commonest, and long-tailed the rarest. Jaegers depend on Kittiwakes, other gulls, and terns to capture much of their food, and so are susceptible to changes in the numbers or distribution of these species. In all of the jaeger species light-phased individuals were much more common than dark-phased ones.

Gulls. The Black-legged Kittiwake was the most common gull in the Gulf of Alaska in August. It was also regularly observed well offshore in September. Glaucous-winged Gulls and Mew Gulls are present throughout the study area. In the eastern Gulf, Glaucous-winged gulls, Herring Gulls and Glaucous-winged X Herring Gull hybrids were common far from shore. This had been noted previously (Sanger 1973) but there was some question as to the relative abundance of Herring and Thayer's Gulls (then considered a subspecies of Herring Gull). Our observations indicate that at least in September and November, Thayer's Gulls are very rare in the offshore zone of the Gulf of Alaska, and that the "Herring Gulls" present there are in fact mostly Herring Fulls. Gulls are generally considered less susceptible to floating oil than other seabirds (Bourne 1975) but Kittiwakes and probably other Gulls living offshore are apparently more susceptible than the near-shore populations observed by Bourne (Hoffman pers. obsn. from Oregon).

Terns. Arctic terns were abundant in August around Kodiak and regular to common elsewhere in the Gulf. They don't normally sit in the water, so they may be relatively unsusceptible to oiling by floating crude, or other heavy oils. They do frequently sit on floating logs, kelp, and other debris. If droplets of heavy oil adhere to such objects, terns may be severely affected. Further, they feed by plunging after fish from considerable heights, and may be vulnerable to floating slicks of light oils.

Alcids. The alcids include may of the bird species most susceptible to oil. They have been shown (Bourne 1975) to be less adept at avoiding floating oil than most other birds. The various species of alcids are common summer residents and regular winter residents of the entire continental shelf area of the Gulf. In addition several species also were found regularly out beyond the shelf margin. Pigeon Guillemots (Cepphus columba) are normally shallow water benthic feeders, but we found them occasionally in the midst of feeding flocks apparently feeding on mid-water schooling fishes. Rhinoceros Auklets (Cerorhyncha monocerata) were noted regularly in September east of Kodiak in water ranging from 50 to 1500 fathoms in depth. Rhinoceros Auklets (Cerorhyncha monocerata) were not known from this part of Alaska prior to 1975 but were seen by various people throughout the area during 1975. They were found nesting on the Barren Islands by USFWS personnel. Adult Marbled Murrelets (Brachyramphus marmoratum) were found regularly along the Alaska Peninsula and at Unalaska Island in August. They were previously (Binford et al 1975) thought to nest west only to Kodiak, Otherwise we found alcid distributions largely conforming to the literature.

B. Energetics. The energetics calculations will begin when we have completed collecting the data needed as inputs. These data relate chiefly to distributional patterns and abundances, oceanographic conditions (primarily surface temperatures, to be gathered by other investigators), and trophic functions. The model structure necessary to conduct these calculations is now operative at Oregon State University, and awaits revision to add greater specificity in marine bird population energetic analyses. We thus have no results to report at this time.

C. Feeding flocks. Multispecies feeding flocks were found to be very common in shallow water close to shore through the summer. They were much less frequent offshore. Species composition varied markedly seasonally and from area to area, but most of the birds could be catagorized by their tendency to join flocks. Table 2 lists the species regularly seen in such flocks. One group, including the gulls, shearwaters, jaegers, and cormorants, is composed of species which feed in the flocks apparently whenever the opportunity arises. Another includes three species which regularly and actively join flocks during their breeding season, but which were observed ignoring the flocks after the breeding season. (A fourth species, Uria lomvia, probably also fits in this category.) These species are all members of the family Alcidae.

Those species which join the flocks regularly feed readily upon schooling fishes. Those which don't join the flocks feed primarily on other food sources, such as macroplanktonic crustaceans, benthic invertebrates, or perhaps squid.

Possible dependencies. The study of flock dynamics is important to considerations of the possible impact of oil development because knowledge of species interdependencies is necessary to predict the effects of an incident affecting one species directly. We have not collected enough data to measure the degrees of interdependency which exist, but we can qualitatively indicate where dependencies may be found.

Jaegers. When not breeding, Jaegers apparently susbsist largely upon food obtained by robbing (kleptoparasitising) gulls, kittiwakes, and terns. In the Gulf of Alaska, non-breeding individuals are present throughout the summer, and the breeding adults and their young appear on the Gulf during August and September. They migrate south out of the Gulf for the winter. If the gull, tern, or Kittiwake populations were reduced by oil development, less food would be available for the jaegers. They might be able to respond to this problem by migrating south earlier, but there is some indication that they follow the Alaskan terns and kittiwakes, and parasitize them throughout their migration.

Table 2. Species occurences in mixed-species foraging flocks.

Frequently join flocks if present	Frequently join flocks in summer	Occasionally join flocks	Present but seldom/ never join flocks	Likely participants but not enough data
Sooty Shearwater	Common Murre	Arctic Tern	Marbled Murrelet	Red-legged Kittiwake
Short-tailed Shearwater	Horned Puffin	Pigeon Guillemot	Kittletz' Murrelet	Sabine's Gull
Red-faced Cormorant	Tufted Puffin	Fork-tailed Petrel	Cassins Auklet	Long-tailed Jaeger
Pelagic Cormorant		Fulmar	Ancient Murrelet	Thick-billed Murre
Pormarine Jaeger		Black-footed Albatross	Parakeet Auklet	Double-crested Cormorant
Parasitic Jaeger				Rhinoceros Auklet
Glaucous-winged Gull				
Herring Gull				
Mew Gull				
Black-legged Kittiwake				

Larger Diving Birds. The Murres, Horned Puffins, Tufted Puffins, Cormorants and perhaps the non-breeding loons appear to depend on the Gulls and Kittiwakes and perhaps to some extent the Shearwaters for fish school location. These birds are highly adapted for diving, and are inefficient (although rapid) fliers. The gulls and Kittiwakes are more adept at locating fish school near the surface because they are slower and very efficient at flying. The diving birds are attracted to the gulls and Kittiwakes by (perhaps unintentional) behavioral signals, and join the flock. It appears that during the breeding season, when the alcids have by far their greatest energy requirements, they depend on the gulls and Kittiwakes for food location. It is not yet clear why the alcids do not extensively utilize the gull flocks out of the breeding season; apparently they don't need them, but it is not apparent that they would not gain advantage from using them.

The gulls and Kittiwakes apparently tend to be less susceptible than the diving birds to floating oil, so the direct effects upon the diving bird populations are likely to be greater than the secondary effects, unless the Kittiwakes or gulls are affected at a time of year when they are geographically separated from the diving birds. In any case, the gull and Kittiwake colonies need to be protected, not only to maintain their own populations but to maintain the cormorant and large alcid populations as well.

Data on the flock interactions, although far from conclusive at this time, suggest the possibility of a reciprocal dependency, or at least a reciprocal advantage, to the gulls and Kittiwakes. Since they can feed only at the surface, they can exploit a fish school only until it dives out of their reach. It may be that the activity of the diving birds, in attacking the school from the sides and probably from below, drives portions of the school back toward the surface and into the reach of the gulls, If so, the effects of oil development on the divers would also adversely affect the gull and Kittiwake populations.

Very large numbers of shearwaters (Puffinus griseus and P. tenuirostris), largely from New Zealand and Australian breeding colonies, spend their nonbreeding season in the Bering Sea and Gulf of Alaska. They frequently feed in large flocks, sometimes with, and sometimes separted from, the local breeding birds. Their morphology is such that they are both efficient at flying and capable of swimming under water, so they are apparently capable of efficient flock feeding by themselves. The data gathered to date are not detailed enough to demonstrate dependencies between the shearwaters and any of the breeding birds, but they do suggest that puffins and kittiwakes may at times be attracted to flocking shearwaters, and that at other times shearwaters may interfere with puffin feeding.

One final result emerges from considerations of flock feeding. Theoretical analysis of the relationships of seabirds to their resource base (Hoffman, in prep.) indicates that a density-dependent population response to increased mortality from oil is very unlikely. In other words, if mortality increases, production of young is not likely to increase to make up for it. Further, for those species which feed in flocks, a threshold density of birds may be necessary for efficient foraging, and if oil-related or other mortality brings the population below this threshold, the rate of production of young may actually decrease.

VIII. CONCLUSIONS

As noted elsewhere in this report, we can offer only tentative conclusions at this time.

Our 1975 distributional studies demonstrated that present knowledge of seabird distribution in the Gulf of Alaska is insufficent to predict the effects of oil spills. More detailed study of most areas is necessary, especially in the winter months.

We have found that feeding flocks are an important phenomenon inshore, at least in summer, and that the potential for significant species inter-dpendencies exists.

Jaegers are certainly dependent upon the gulls, Kittiwakes, and Terns for much of their food. It is likely that the diving species are to a large degree dependent upon the gulls and Kittiwakes for food location, at least in the breeding season. The gulls and Kittiwakes typically locate the fish schools, and the diving birds follow them. In addition, the activities of the diving birds may aid the gulls and Kittiwakes in exploiting the fish schools. Since the composition of the community varies somewhat throughout the Gulf, studies need to be continued in several areas. The nature of the foraging behavior suggest that efficiency in foraging for these birds may be a function of density. This means that reductions in the populations by oil-related or other developments may not be buffered by increased production of young. In fact, we would suspect that a threshold level may exist for efficinet feeding, and that when the population of one of the component species drops below that level, its production of young may actually decrease. In addition, such a reduction would adversely affect the other dependent species in the assemblage.

IX. NEEDS FOR FURTHER STUDY.

The measurement of bird densities at sea is still an art rather than a science. As noted in the "Current State of Knowledge" section of this report, there is little agreement in the literature on censusing techniques. We have proposed (See attachment no. 1) to do a computer simulation of seabird transect counting techniques. This would allow us to evaluate the various methods for accuracy and also help in determining the suitable information to be collected. It would also point out the likely sources of error in existing methods, and allow sensitivity analyses of "permissable" levels of uncertainty.

Another problem which warrants close study is the bird fauna of the eastern Aleutian passes such as Unimak and Akutan passes. These passes will almost certainly be used for transport of any oil discovered in the eastern Bering Sea. They also have been historically recognized as some of the world's greatest seabird concentrations. In order to predict accurately the impact of oil transport on the pass ecosystems, including the bird communities, the energy and nutrient flow patterns of the whole system must be understood. The system is apparently extremely productive, and this productivity is presumably related to the mixing of Pacific and Bering Sea water masses of differing temperatures and nutrient concentrations. The curent patterns would need to be known, seasonally and in great detail. The patterns of primary and secondary production through the passes needs to be determined, and the critical foraging areas for the birds and mammals discovered. As in the Gulf of Alaska, the patterns of flock foraging need to be understood in detail to be able to assess possible interspecies patterns of dependency.

If this ambitious pattern of comprehensive study is beyond the scope or powers of organization of the OCSEAP program, a general understanding of the marine bird community dynamics could be obtained if sufficiently detailed ship-board observations were carried out in the passes, and if the immediate relationships of the birds to their food supplies were determined by frequent trawls and plankton tows in the areas of bird concentration.

X. SUMMARY OF FOURTH QUARTER OPERATIONS.

1. Ship schedule. No time was spent at sea during the 4th quarter.

2. - 4. Inapplicable.

5. Data analysis.

Most of the fourth quarter was spent waiting for completion of coding and format standardization by DODC/EDS (see attachments 2-7). Since receipt of the formats in early March, encoding of data and transferral to pre-punching froms has been progressing. However this activity has been delayed pending receipt of the "rough smooth-plots" of the Surveyor's August, September, and November tracklines. Presently data are being coded but the station positions are being left blank. Upon receipt of the "rough smooth-plots" the data files already coded will be completed and ready for transmission.

In the absence of the formats, and thus of computer analyses, a non-rigorous inspection of the data was undertaken to produce the tentative results listed in this report.

Estimated Funds Expended - 31 March 1976

Budget Category	Amount Budgeted	Spent to Date	Balance
Salaries	$14,420	$ 4,703	$ 9.717
Payroll Assessments	2,163	660	1,503
Indirect Costs	6,839	2,125	4,714
Materials & Services	6,700	908	5,792
Equipment	4,600	4,248	352
Travel	4,000	2,835	1,165
TOTAL	$38,722	$15,479	$23,243

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Attachment 1.

Department of Zoology Oregon State University Corvallis, Oregon 97331 (503) 754-3705

Date: January 27, 1976

To: Bob Meyer, OCEAP Juneau Project Office

From: J.A. Wiens, Principal Investigator (RU #108) JAW

Subject: Proposal for computer simulation of transect counting of Marine Birds

Our semiannual report of autumn 1975 included a proposal for a computer simulation of transect counting techniques for Marine Birds. If we are to use the results of this simulation to improve our methodology for the 1976 field season we will need to start working with it rather promptly.

We feel that our present methodology is representative of the state of the Art, but we also feel that room exists for substantial improvement. Thus while the performance of this simulation is not essential to the completion of our particular contract, we believe that it holds the most promise for providing the OCSEAP program with a rationale for choosing a standard transect technique to be used throughout the program.

We are now working on the specifics of methodology for the 1976 field season, so we need to know the status of that proposal.

Attachment 2.

Department of Zoology
Behavioral Ecology
Laboratory

Oregon State University

Corvallis, Oregon 97331 (503) 754-3705

Oct. 20, 1975

Mauri Pelto
Outer Continental Shelf Energy Program
Juneau Project Office
P. O. Box 1808
Juneau, AK 99802

Dear Mauri,

We need full-size copies of the smooth-plots of the Surveyor's trackline for the period we were on board. I assume that this material can be classed as data, and thus requests should be made through you. If not, please advise us of the proper channels to use. Smooth-plotting of the trackline was started as per directive from PMC in late August and continued as long as we were on board. We are thus requesting the smooth plots for the period from initiation until Sept. 23. We will be making similar requests for all of our future cruises.

Sincerely,

Wayne Hoffman

Wayne Hoffman

Attachment 3.

Department of Zoology | Oregon State University | Corvallis, Oregon 97331 (503) 754-3705

Date: January 27, 1976

To: Bob Meyer, OCSEAP Juneau Project Office

From: Wayne Hoffman (RU #108)

Subject: Request for smooth-plots for ship's tracklines

In october 1975 I wrote to the Juneau office and requested the smooth-plots of the trackline of the Surveyor for the period from late August 1975 to September 23, 1975, to use for verifying position data. While I was on board the Surveyor in Nov. 1975, the Field Operations Officer told me that a copy of my request had been forwarded to the ship. He also told me that besides the "rough smooth-plots" which the ship's survey crew produced, PMC eventually produces "final smooth plots" with computer plotting routines. The "rough smooth-plots" are suitable and in fact preferable for our purposes. Since that time I have received neither smooth-plots nor even acknowledgment of my request from the Juneau office. Could you look into this matter and see if you can expedite the delivery of this material?

At this time I would also like to request "rough smooth-plots" for the period October 29 - November 10, when I was also on board. We want to use these smooth-plots to check our position recordings, since they are the most accurate records of ship's position available for those cruises.

Attachment 4.

Department of Zoology | Oregon State University | Corvallis, Oregon 97331 (503) 754-3705

Date: 27 January, 1976

To: Robert Meyer
OCSEAP Juneau Project Office

From: John Wiens, PI Research Unit #108

Subject: Keypunching of marine bird data

Our program Work Statement (RU # 108) states that we are to supply the data we collect on forms ready for keypunching, and that "further preparation of this material for archiving will be the responsibility of central offices." At the time this contract was negotiated it was agreed by OSCEAP personnel that keypunching of these data was done by NODC. However, in our discussions with you at Asilomar in December, 1975, it was clear to all of us that the volume of data we have collected to date and that anticipated during the 1976 field season will put a severe strain on NODC capacities. Our analyses of data require a relatively rapid availability of punched data following collection, and the Freedom of Information Act of 1974 places additional restrictions on the time required to insure proper storage and availability of verified data.

Since it appears unlikely that NODC can handle our data with a reasonable turnaround time, we suggest that this service be conducted at Oregon State University for the data generated by our activities. In addition to providing more ready access of our investigators to the data during the process of keypunching, this would substantially reduce the extra processing time involved in mailing data forms to NODC for punching and subsequent mailing for proofreading and validation. Since the conduct of our 1976 studies will be defined to a degree by the analyses of 1975 data as well as ongoing data analysis during the field season, reduction of unnecessary time delays in data processing is essential.

The attached budget details our estimates of the funding necessary to provide these services at OSU. We could arrange for processing of data for the entire contract period, according to our anticipations of total volume, or for punching at this time of data from 1975 studies only. If the latter option is selected, plans will need to be made rather promptly for defining responsibilities for punching of the 1976 data. The budget estimates attached are based upon current and projected service costs at the OSU Computer Center; an alternative, of course, is for keypunching to be handled by NODC, as originally agreed. If this is the case, we will require some assurrances that turnaround time between receipt of field data in a formated form and return of a keypunch listing for proofreading will be no longer than one week.

Please consider the alternatives and notify us of your decision as promptly as possible. We must begin punching and analysis of 1975 data within a couple of weeks.

Proposed Keypunching Budget, RU #108

I. 1975 Data to be punched :30,000 Cards at ∿ 65 strokes/card.

OSU computer center rates - est. 8000 strokes/hour

= 244 hours

\$7.75* per hour = \$1889.06

*Punching rates are presently \$7.75 per hour; we expect them to be around \$9.00 per hour by the end of the project.

II. Total estimated 1975-1976 data set

:180,000 cards at ∿ 65 strokes/card

= ∿ 1500 hours

@ \$7.75/hour = \$11625.

@ \$9.00/hour = \$13500.

Attachment 5.

Department of Zoology Oregon State University Corvallis, Oregon 97331 (503) 754-3705

Date : Feb. 24, 1976

To : Robert Meyer, OSCEAP Juneau Project Office

From : Wayne Hoffman (representing J. A. Wiens, R. U. #108)

Subject : "Rough smooth-plot" of Surveyor's trackline

You requested in your letter of February 4 that I let you know if I haven't heard from PMC about the "rough smooth-plots". I have not received any information from them, nor any acknowledgement of the request. Could you please remind them of the matter?

Also, do you have any estimate of when we will receive the formats for our data?

Attachment 6.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
OUTER CONTINENTAL SHELF ENERGY PROGRAM
JUNEAU PROJECT OFFICE
P. O. BOX 1808
JUNEAU, ALASKA 99802

Date : February 4, 1976

To : Wayne Hoffman

From : Robert Meyer
Juneau Project Office-OCSEAP

Subject: Data Management. RE: Your letter of January.

1. SURVEYOR smooth plots--your request has been passed on to PMC (again). If you don't receive the information by February 18, 1976 please let me know.

2. Computer simulation--I will have to check woth Jay Quast on this one. Unfortunately Jay is in Boulder and won't be in until next week. I will get back to you as soon as I learn something.

3. Key punching--your request is in EDS. We should have a decision on this by the end of this week. Again, I will contact you as soon as I learn something.

As an aside, would you explain to me why the 5-fold increase in data between 1975 and 1976?

4. To reiterate--please contact me if you don't hear from PMC.

Attachment 7.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL DATA SERVICE
NATIONAL OCEANOGRAPHIC DATA CENTER
Washington, D.C. 20235

February 27, 1976 D781/ARP

TO : Distribution

FROM : Code D781, NODC

SUBJECT: OCSEP Formats

Enclosed are copies of data formats and codes that you will require for submitting OCSEAP data to NODC. These are a portion of the formats referenced by Mauri Pelto's memo of January 6, 1976.

It is requested that the data of the formats and codes used for your data be noted on the DDF for each data set. It is emphasized that nothing be added or modified on the enclosed formats and codes without contacting NODC or the Juneau Project Office.

If there are any questions pertaining to this material, please contact Jim Audet (202-634-7441) or Robert Stein (202-634-7505) at the National Oceanographic Data Center.

Enclosures

Shorebird Dependence on Arctic Littoral Habitats

Annual Report, R. U. 172, March 1976

Research coordinator: Peter G. Connors
Bodega Marine Laboratory
Bodega Bay, California 94923

Principal investigator: Robert W. Risebrough

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I. Summary of Objectives, Conclusions, and Implications

Shorebirds (sandpipers, plovers, and their relatives) are a major and important component of the Alaskan arctic avifauna. Past work on this large group of species in the arctic has concentrated on events on the tundra, where they nest, and has largely been confined to the brief breeding period. Almost no information is available concerning the use of littoral zone (shoreline) areas by shorebirds within the arctic. Our study has begun now to fill in this serious gap, providing quantitative data of three major types:

1. Seasonal occurrence of shorebirds by species, in a variety of arctic littoral and near-littoral habitats. This receives major effort and consists of repeated intensive transect censuses of many habitats near Barrow, backed up by less regular, more extensive observations there and elsewhere in the Beaufort and Chukchi, continued throughout the entire period of shorebird presence in the arctic.

2. Foraging habitat preferences of shorebirds within the littoral zone, by species.

3. Diets of shorebirds in the arctic littoral zone, by species, as these change through the season.

The ultimate objective of our study is the assessment of the degree and nature of dependence of each shorebird species on arctic habitats which are susceptible to perturbation from offshore oil development activities.

It must be stressed repeatedly that one of the most striking characteristics of the coastal tundra ecosystem is the pronounced annual variation in environmental conditions which causes huge fluctuations in the timing and magnitude of biological events from year to year. The first year of this study, therefore, permits only tentative conclusions, to be amplified and adjusted as subsequent investigation dictates.

Population density and habitat use information for individual species are presented in Parts VI and VII (Results and Discussion). In general, four periods of shorebird littoral zone use, overlapping to some extent, can be recognized. Differences in seasonal importance of shoreline areas must be viewed in light of seasonal changes in littoral habitat availability to shorebirds. Since the ocean shorelines are free of ice for only a relatively brief period in late summer, heavy use of these habitats cannot be expected in early summer. Nevertheless, in early and middle June at Barrow, pre-breeding adults of a few species, especially sanderlings, Baird's sandpipers, and semipalmated plovers, occur in early-opening gravel and mud areas on some beaches and at pools near lagoons. From late June through early July, a movement of non-breeding and post-breeding adults of several species occurs, with flocks and individuals utilizing habitats at the edges of small coastal lagoons and nearby brackish pools.

In late July and early August, adults of both sexes of most species are released from nesting duties as young birds fledge and become self-sufficient; these flocking adults, beginning their southward migration, move into littoral areas. At Barrow in 1975, heaviest use began at mud margins of small inner lagoons, tidal sloughs, and brackish ponds. Prey of most species were chiefly larvae and late emerging adults of dipteran insects.

The phase of heaviest use of littoral areas occurred during the entire month of August, stretching into September for some species. Juveniles left the tundra areas where they had fed before fledging and flocked in littoral habitats, beginning their southward movements independently of, and later than, the adults. Types of littoral habitats used and duration of this period varied between species. For example, a very brief peak of high density of juvenile semipalmated sandpipers occurred in early August along inner lagoon margins and brackish pools, whereas the period of juvenile red phalaropes' littoral zone use extended from about August 12 to September 15, and was concentrated mostly along ocean and outer lagoon beaches. Diets vary also; the semipalmated sandpipers fed primarily on insect larvae and adults, and the phalaropes became zooplankton predators, taking a variety of small crustacea and some chaetognaths from shallow water along the shorelines. Red phalaropes, frequently occurring at densities exceeding 500 per kilometer of gravel beach on portions of Barrow Spit, moved between nearby shores almost daily in response to changing conditions of wind, surf, ice, and possibly prey availability. Sabine's gulls, black-legged kittiwakes, and arctic terns, feeding on fish and zooplankton in the same areas during August, also changed their preferred foraging locations in response to fluctuating conditions.

The post-breeding season movements of adults and juveniles to littoral zone foraging areas precede migration, and it is therefore probable that this phase in the cycle of annual activities represents an important and possibly critical period of energy storage to meet the demands of migration. For inexperienced and presumably less efficient juveniles, especially, a high level of energy reserve in the form of deposited fat is probably a critical factor in determining survival during migration.

The several implications of these situations for OCS oil development along the arctic coast vary. We do not know how uniformly distributed or widely used are the particular littoral habitats selected by species at Barrow or at the few comparison sites checked in this study. It is possible, for instance, that the unique geographical position and unusual conformation of gravel spits at Pt. Barrow produce in some way a concentration area for migrating shorebirds, giving this location a special importance to be considered in any planned development. Limited observations suggest that densities of red phalaropes along some other beaches to the east and west were lower in August, 1975. However, comparably high concentrations were observed near at least one Barrier Island (Cooper Island: R. Bokelheide, personal communication) east of Barrow.

Until many other gravel beach areas are checked in several seasons, it would be premature to assume that Barrow densities do not occur at many points along the arctic coast. Distribution of utilized littoral habitats is not uniform along the coast, however. In addition to the gravel beach habitat found along barrier islands and some other shores, mudflats, inner lagoon and tidal slough shorelines, and brackish ponds are areas of high use. These habitats occur especially in regions of river mouths and very low tundra areas along the Beaufort coast. Mapping efforts in progress by Dr. A. C. Broad (R.U. #356), Alaska Department of Fish and Game (R.U. #3/4), and this study are locating and identifying these areas. Some of these locations (Smith River slough, near Lonely, identified in this report) are also apparently important for flocks of waterfowl, including Canada geese and black brant. Regions of dirt cliffs or eroding tundra banks appear to provide less usable foraging habitat.

Two possible alterations of existing conditions associated with development may have adverse affects on the foraging of phalaropes, gulls and terns in August and September. If construction activities on barrier islands or along shorelines produce high turbidity in waters close to shore, the foraging efficiency of these visual predators on fish and zooplankton may be reduced, even if the densities of prey are not changed. Second, if gravel removal or movement is great enough to alter the spatial array of shorelines in a barrier island or gravel spit area, the existence of necessary protected shores under different wind and wave conditions might be affected. A third potential impact of development, the disturbance of birds, through noise and activity during construction, is not considered serious in most areas, provided that undisturbed similar habitats are available nearby. Non-nesting shorebirds are not especially sensitive to noise disturbance. Activities in waterfowl staging areas would cause more severe problems.

Finally, the effects of any oil spillage could be quite serious, depending upon timing as well as magnitude of the spill and upon the dispersal behavior of oil under varying conditions of ice coverage. During open water periods of August and September, oil carried to near shore areas would probably cause extremely high mortality in juvenile red phalaropes and other swimming birds, including gulls, waterfowl, and alcids. Immediate effects would not be so severe on most other species of shorebirds, which walk along shores or on flats and wade in shallow water but do not usually swim. However, any drastic reduction in prey densities of plankton or infaunal invertebrates in these areas would reduce the foraging efficiency and probably the survival of these other species. Finally, it should be noted that these potential effects of oil spillage might persist through successive seasons (Carter, 1966).

II. Introduction

Shorebirds (suborder Charadrii: sandpipers, plovers, and their close relatives) constitute a major and prominent segment of the Alaskan arctic avifauna, contributing nine regular and seven irregular breeders to the Barrow community (Pitelka, 1974). These, as well as several other shorebird species which do not breed locally, occur at Barrow and elsewhere along the arctic coast as migrants, wintering in temperate and tropical regions of both northern and southern hemispheres.

Considerable effort has been expended on studies of the ecology of tundra nesting shorebirds near Barrow, Alaska (see Appendix A for references). These studies have dealt almost exclusively with conditions on the upland tundra, primarily during the short arctic breeding season. It has been noted, at Barrow and elsewhere in the arctic, that densities of several species of shorebirds increase near the shoreline as the summer progresses, resulting in a net increase in use of littoral habitats (Holmes, 1966; Bengtson, 1970). This movement begins with non-breeders and is augmented progressively by a shoreward movement of local and also inland birds, especially after the young have fledged. However, the importance of this habitat shift in the breeding cycle of arctic shorebirds has not been adequately evaluated.

This study attempts to provide detailed and quantitative information which is necessary to assess the dependence of any species of shorebirds on littoral habitats along the Alaskan arctic coast. We are addressing three aspects of shorebird ecology essential to evaluating the significance of the littoral zone for shorebirds: seasonal occurrence of shorebirds, by species, in different habitats; habitat patterns of foraging preferences, by species; and determination of invertebrate prey taken in littoral habitats.

The relevance of this investigation to problems of OCS petroleum development is clear. To the extent that shorebirds and other birds utilize and depend upon shore and nearshore habitats, any perturbation of these habitats can affect them. Use of littoral habitats in the arctic appears to be heaviest by juveniles moving from inland nesting areas to the coast in late summer, prior to their long-distance migrations. Since post-fledging mortality of juveniles is a significant factor in determining reproductive success, alteration of required habitat conditions for these birds could affect population levels over wide areas. Specific petroleum development implications arising from this study were presented in Part I.

III. Current state of knowledge

As already mentioned, no quantitative studies have concentrated on shorebird use of arctic littoral areas. Available information is rather sparse and general, usually gathered by observers in the course of other studies. Detailed information on breeding activities on the tundra is available for many species, however. A partial list of publications dealing with Alaskan arctic shorebird ecology, mostly done near Barrow, is appended. These studies provide a valuable basis for interpreting littoral zone and post-breeding activities of many shorebird species in the context of the entire summer reproductive cycle.

IV. Study area

The bulk of field activities took place near Barrow, Alaska (latitude 71° 17' North; Longitude 156° 46' West), utilizing logistic support provided by the Naval Arctic Research Laboratory (NARL). Within the coastal area extending 22 kilometers southwest and 6 kilometers southeast of Point Barrow, the northernmost point of land in Alaska, a variety of littoral and near littoral habitats are being studied. These include tundra-backed open lagoon beach (Elson Lagoon); open lagoon estuary (Central Marsh Slough); tundra-backed ocean beach (near Nunavak Bay); ocean estuary (Nunavak Bay); closed brackish lagoon (North Salt Lagoon) and peripheral estuary mudflats (Voth Creek, Middle Salt Lagoon); brackish storm-flood pools (Britton ponds and Barrow Spit ponds); and gravel spit beaches (Barrow Spit and Plover Spit: Chukchi, Beaufort, and Elson Lagoon shores).

Two supplementary study areas, at Lonely near Pitt Point (latitude 70° 55' North, longitude 153° 15' West), 140 km east of Barrow and at Wainwright (latitude 70° 38' North, longitude 160° 02' West), 140 km to the west, were visited on three occasions in July and August for comparison of shorebird littoral zone events on a more extensive scale, supplementing the intensive efforts at Barrow. Flights to these areas permitted some assessment of habitats on the intervening coast, and one trip along the Beaufort coast to Prudhoe Bay extended these observations.

Littoral habitats at Wainwright are similar to those studied near Barrow, but the Smith River slough and Kolovik slough, near Lonely, provide much more extensive tidal mudflats than are found at Barrow.

V. Methods: data collection and analysis

It is necessary within this study to establish some criteria for delimiting the littoral zone in the arctic. Definitions for other shores have been established (as reviewed in Ricketts et al., 1968), but the Alaskan Beaufort coast presents some special problems. The mean tidal range at Barrow is a scarcely noticeable .3 feet (9 cm). However, during periods of open water near the coast (August and September principally), storms may produce tides up to a few feet above normal, inundating considerable areas of low-lying tundra. This affects the vegetation and presumably the invertebrate biota of these areas, and would under conditions of oil spills adversely affect a zone extending well beyond the mean tide level. For the purposes of this study, then, the arctic littoral zone is considered to extend from lowest tide level up to the limits of the regions likely to be inundated by storms at least once every few years. The impreciseness of this operational definition results from our inability to establish the area-frequency

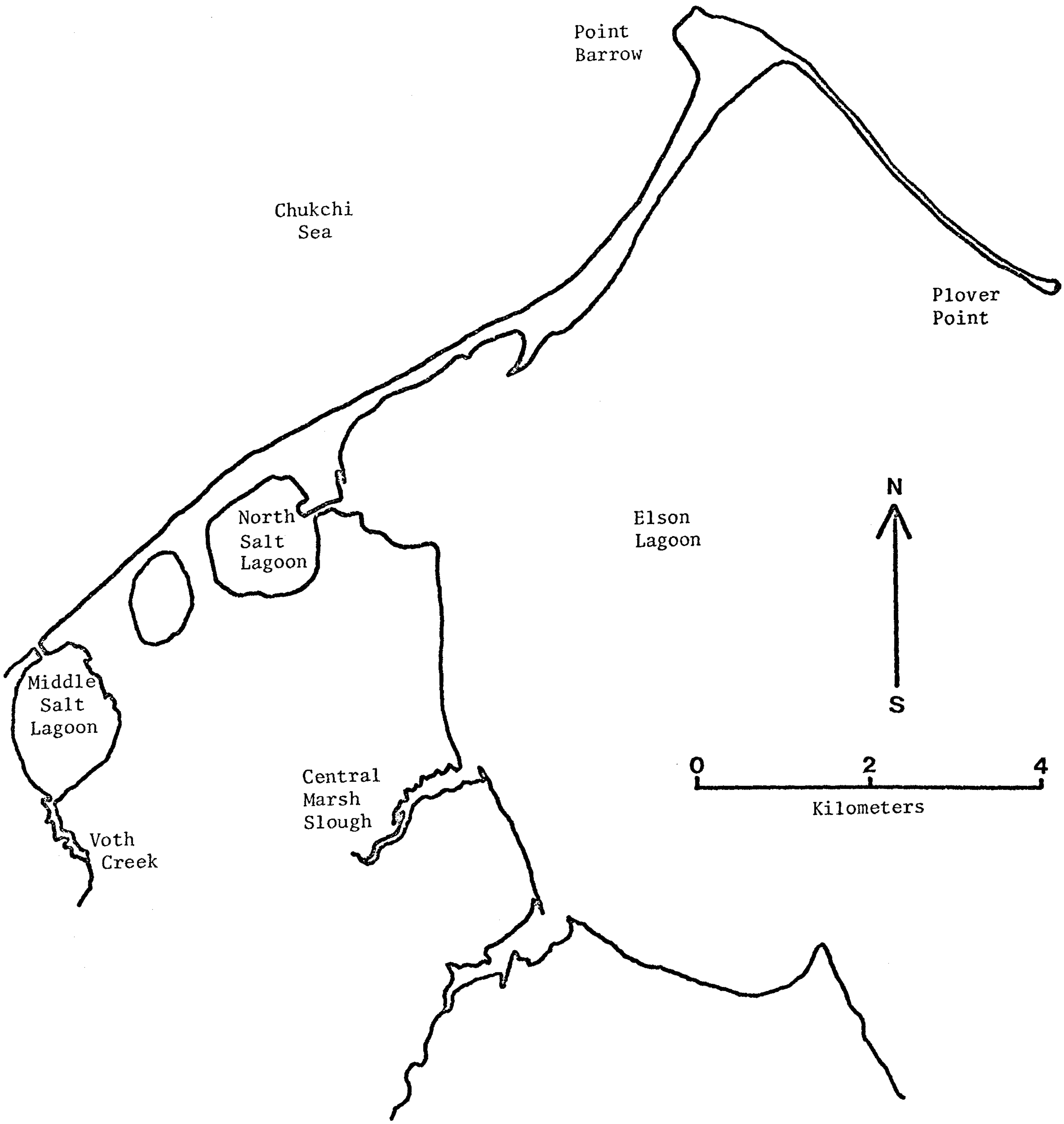


Figure 1. Prominent shoreline features near Point Barrow, Alaska.

contours necessary for a more precise definition. In practice, this littoral zone can be recognized by the elevated salinity of standing water in flood pools, by the presence of salt-tolerant vegetation (species of grass Puccinellia and sedge Carex), and by the distribution of storm drift material. In some regions of the Beaufort coast, driftwood lines, up to a few hundred meters inland, probably represent very infrequent storms. Extensive areas of low tundra with dead vegetation may also derive from these occasional extremely high storm tides.

Within this study, the nearshore water surface is also of interest, since it is obviously susceptible to oil spills and is used by many species of birds, including especially the phalaropes. Most shoreline transects include both littoral and nearshore water areas.

This discussion will be divided into three sections corresponding to the principal classes of data gathered.

A. Shorebird seasonal interhabitat distribution

Primary effort was focused on a permanent transect method. Transects were marked with stakes at 50 meter intervals following shorelines in each of the habitats listed at Barrow in Part IV, and at several locations on tundra within the Barrow study area. Upland transects are necessary for comparison with littoral transects to assess seasonal changes in habitat use by shorebirds. In narrow shoreline habitat areas, stakes defined a single row of square census plots, 50 m on each side. In areas of more extensive continuous habitat, such as mudflats or upland tundra, the stakes defined a double parallel row of 50 m plots. Estimate of 50 m distances to each side of the staked row, necessary during the census, is possible to a sufficient level of accuracy. Total lengths of transects within single habitats ranged from .3 km to 1.0 km. Total area of Barrow shoreline transects included 300 .25 hectare plots (equals 75 hectares) in 8.5 km of shoreline transects; tundra transects included 158 .25 hectare plots (equals 39.5 hectares) in 3.95 km.

Transects were censused repeatedly and regularly, within the limitations of weather and other field requirements, at least once every 4 to 9 days from June 30 to September 2, and less regularly before and after these dates. During periods of high shorebird densities, several censuses were made within a single period, and these counts are averaged in the analysis.

Rates of progression along a transect during the census were approximately 3 minutes per 50 m of tundra transect and 1.5 minutes per 50 m of shoreline transect. All birds within each census plot were recorded, as well as any birds within 200 m on the water side of shoreline transects. Although shorebirds were of primary interest, other species, including gulls, terns, and waterfowl, were always recorded.

At Wainwright 3 km (15 hectares) of shoreline transects were established on ocean beach, river lagoon beach, and river slough shores, and 1 km (10 hectares) of upland transects were chosen. At the

Lonely study area, 4.5 km (45 hectares) of littoral transects (tidal slough and estuary mudflats, brackish flood pools) were established. At both these study areas, field visits were limited to 3 brief periods in July and August, diminishing the usefulness of the permanent transect census method. Instead, these data are treated with the non-transect census data described next.

Permanent transects, regularly censused, provide data which are easily analyzed to record seasonal changes in population density, as illustrated in Part VI (Results). To obtain more extensive coverage of littoral areas near Barrow and elsewhere on the arctic coast, and to increase the prospect of observing very transitory or localized phenomena, the transect method was supplemented with censuses recorded as numbers of species in a known or estimated length of shoreline or area of suitable habitat. This approach provides flexibility in treating all observations, and results can be used to explain and complement the transect results. For example, a large population of juvenile red phalaropes on the Barrow Spit-Plover Spit complex in August shifted almost daily its foraging area in response to changing environmental conditions, primarily wind direction. Thus, a particular transect would change from very high to very low density overnight, with no loss of birds from the Barrow area. Our extensive non-transect observations provide the explanation for this phenomenon, which will be developed at length later in this report.

B. Foraging microhabitat preferences

During this first field season, we considered two approaches to collecting data which would allow us to characterize the littoral zone foraging microhabitats so as to distinguish the preferences of different shorebird species. Major emphasis was given to relatively detailed measurements of 10 variables of the habitat where individuals were observed feeding. These variables are listed in Table 1.

We also explored an alternate, simpler, set of variables, including distance to water, depth of water, and type of substrate in general categories. These determinations are made by visual estimation, sacrificing some accuracy of measurement for a considerable gain in the rate at which data can be collected. Limitations of time restricted the number of data points which could be collected by the first method, which received principal attention in the field. Total numbers of microhabitat points, by species, taken by each method, are listed in Table 2. Based on analysis of these sets of data, described below, we intend to continue microhabitat investigations with a slightly expanded set of easily estimated variables.

Two statistical methods have been employed in the analysis of the first data set. One, principal component analysis, views all the data points as a scatter plot in multidimensional space, the n axes corresponding to the n measured variables. The first principal component (PC1) is the linear combination of these n variables which defines a new axis passing through the scatter plot in the direction of maximum variance of the set of data points. The original set of n variables is thus combined into one variable which expresses a greater

Table 1. Foraging Microhabitat Variables

Variable Name	Description of Measurement
DIST	distance (cm) from foraging point to nearest standing water
DEPTH	depth of water (cm) at foraging point
PENET	penetrability of substrate (cm), measured by standardized dropping of guided rod
TOPO	topographic variation (cm): difference is elevation between highest and lowest points within 1 meter
The last 6 variables express the fractions of the substrate in each category within a 10 cm x 10 cm square around the foraging point.	
CSAND	coarse sand
FSAND	fine sand
GRAV	gravel
MUD	mud
DETRI	detritus
WATER	water

Table 2. Collection Schedule for Microhabitat Data

Species	Beginning Date	Ending Date	Median Date	Total Samples
Semipalmated Sandpiper	23 Jul	27 Aug	1 Aug	38
Dunlin	24 Jul	27 Aug	8 Aug	31
Western Sandpiper	23 Jul	31 Aug	22 Aug	17
Red Phalarope	24 Jul	27 Aug	1 Aug	30
Baird's Sandpiper	24 Jul	13 Aug	3 Aug	11
Pectoral Sandpiper	24 Jul	22 Aug	24 Jul	11
Ruddy Turnstone	24 Jul	23 Aug	3 Aug	16

separation of the data points than did any of the measured variables. The relative weighting of the original variables along the principal axis allows interpretation of the relative importance of these variables in distinguishing the measured microhabitats and the corresponding preferences of the different species (James, 1971). The analysis selects subsequent principal components (PC2, PC3, etc.) in orthogonal directions in multidimensional space defining the directions of maximum remaining variance. The reduction of many original variables to a few principal components allows graphic treatment of microhabitat preferences, as shown in Results.

The second statistical method, discriminate function analysis, produces similar information, constructing a linear combination of the measured variables which maximally separates the species sets of data points along the discriminate function axis (Green, 1971; James, 1971). Interpretation of the importance of measured variables is similar to the interpretation of principal component analysis. This technique, however, allows prediction of the species most likely to forage at any point in discriminate function space.

C. Shorebird diets in littoral habitats

To appreciate the seasonal changes in preferred foraging habitats and the sensitivity of species to perturbations in environmental conditions, we need some understanding of the major invertebrate prey of shorebirds in different littoral habitats. The most reliable method of determining prey species requires collection of foraging birds for subsequent stomach analysis. Efforts in this first season were directed toward discovering the range of prey types for common shorebirds.

Birds were collected by shotgun, and digestion was arrested by immediate injection of standard formalin fixative solution through a syringe and narrow plastic tubing inserted down the esophagus into the stomach. Volume of fixative was determined by the capacity of stomach plus esophagus. Analysis can take place at any time subsequently in the laboratory. To test the efficacy of this method of preservation, four red phalaropes were collected from a single foraging flock. Two individuals (samples no. 21 and 22, table 5 in Part VI) were treated as described above; stomachs of the remaining two birds (samples no. 19 and 20) were immediately removed in the field, opened, and preserved in formalin. The comparison did not indicate any differential deterioration of stomach contents preserved in the entire bird. This method has the advantage of saving the collected bird for museum specimen preparation.

Additional, somewhat less definite determinations of shorebird prey items were made occasionally through observation of foraging birds combined with sampling of potential prey in or on the substrate. Results of both methods are presented in Part VI.

VI and VII. Results and Discussion

These two sections are combined for convenience in presentation. Three categories of results will be treated.

A. Phenology of shorebird littoral habitat use

A series of seasonal population plots for littoral and upland habitat transects at Barrow are presented in figures 2-12, for all common shorebird species. Data are presented as bar graphs, with height of each bar equal to the recorded total population on all shoreline or tundra transects during the census period. Length of census periods varies from 4 to 9 days, and multiple counts for any transect within one period are averaged, so that each total population number represents the mean population on all grouped transects within the period. Total area of shoreline transects is 75 hectares in 8.5 km; area of tundra transects is 39.5 hectares in 3.95 km. Note that population axis scales often differ between plots.

All shorebird species recorded in littoral habitats are discussed in this section. Records of uncommon species refer only to littoral zone sightings.

1. Semipalmated plover (*Charadrius semipalmatus*).

Several individuals were seen in early opening gravel areas near lagoons in early June. Three nests or broods located (2 at Barrow, 1 at Lonely) were all in areas of gravel and mud bordered brackish pools near beaches or lagoons. No individuals were seen distant from the littoral zone.

2. Golden plover (*Pluvialis dominica*). Figure 2 A, B.

The major movement of post-breeding adults and juveniles occurred in late July, with some juveniles staying through August. This species was essentially restricted to tundra habitats, occurring on shoreline transects usually only where tundra occurs close to lagoon shores.

3. Black-bellied plover (*Pluvialis squatarola*).

This species was not recorded in the littoral zone at Barrow in 1975, but was fairly common on mudflats near Lonely July 19 and on river delta flats at the mouth of the Ikpikpuk River, 60 km southeast of Barrow, on July 21. These appear to be post-breeding adults, flocking in littoral mudflat areas prior to southward migration.

4. Ruddy Turnstone (*Arenaria interpres*). Figure 3 A, B.

Rarely recorded on our tundra transects, although they nest at Barrow, turnstones exhibited a broad population peak in littoral areas, beginning with adults in late July and changing to juveniles in August, as young fledge and move to the coast and adults migrate southward. Prior to August 8, 1975, all individuals of this species recorded in littoral areas were on those transects classed as "inner shores" (closed lagoons, sloughs, brackish pools) as opposed to "outer shores" (ocean beaches, open lagoon shores). After this date, corresponding to increasingly open (ice-free) outer shores, about half the turnstones were found on outer shore transects. This shift toward shoreline

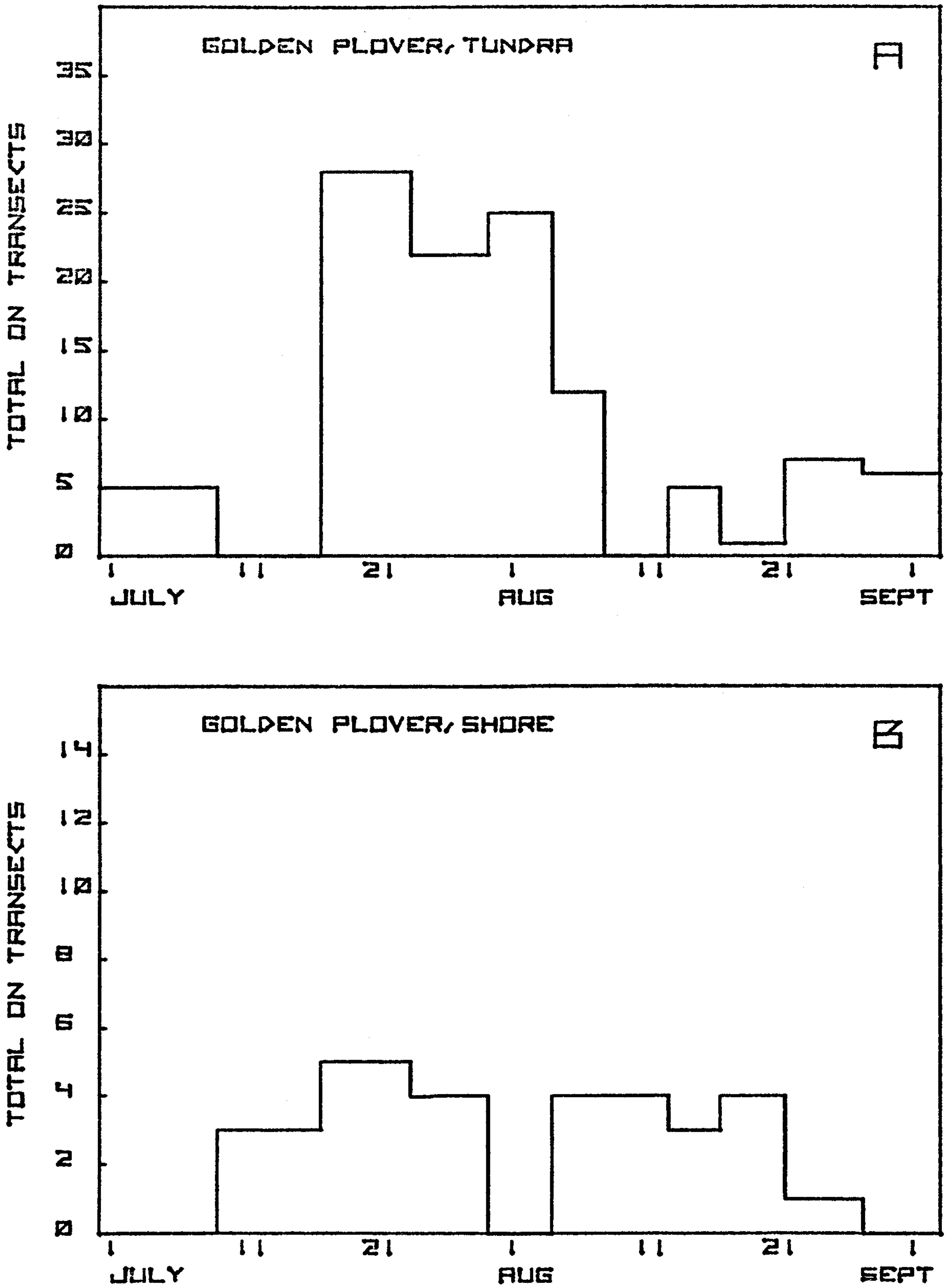


Figure 2. Seasonal population change, golden plover.

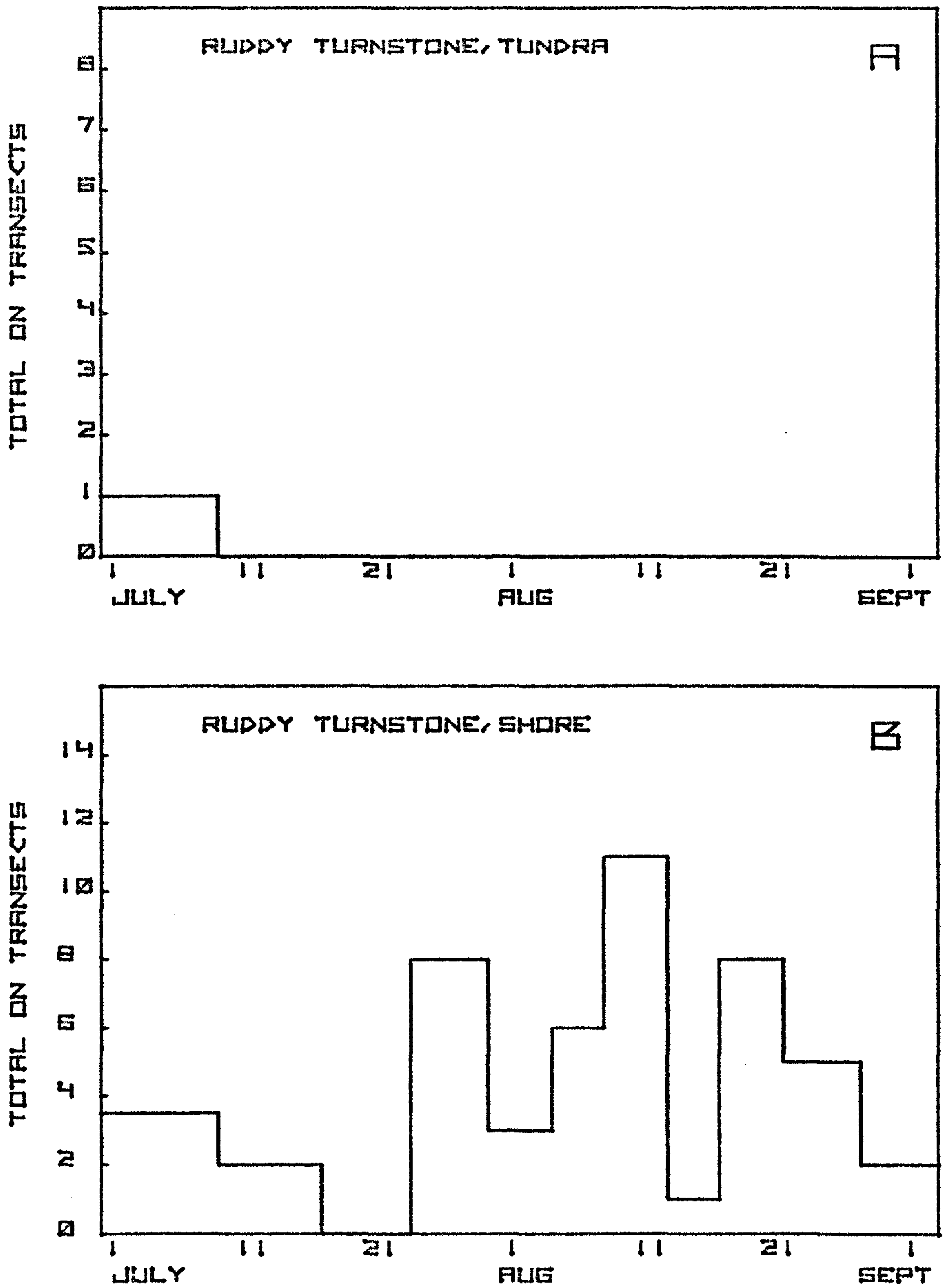


Figure 3. Seasonal population change, ruddy turnstone.

habitats in late summer agrees with a report by Nettleship (1973) for an area in the Canadian arctic, where juveniles began foraging on the shores of a large cold lake.

A flock of 30 adults of this species was recorded around muddy brackish pools near a tidal slough at Lonely, July 19.

5. Curlew sandpiper (Calidris ferruginea).

This species, a fairly common breeder in some years at Barrow, was represented by only 2 individuals in 1975, foraging on mudflat and inner lagoon shores on August 3 and August 5.

6. Sanderling (Calidris alba). Figure 4.

Groups of up to 6 sanderlings were frequently seen in littoral habitats in early to mid-June. Birds fed at the margins of inner, closed lagoons, around early melting pools near lagoons and beaches, and in open areas on gravel beaches. They were not seen at this time on the tundra, which was still mostly snow-covered. Sanderlings were seen in frequent displays apparently involved in pair bond formation, and may have been using these littoral areas for initiating the breeding effort before moving inland or eastward to nesting areas. Only one resident sanderling was located after this early activity, with a nest on the gravel spit extending north to Point Barrow. Sanderlings were never recorded on tundra transects.

In mid-August juvenile birds became fairly common along gravel beaches and lagoon shores, with populations on Barrow Spit and Plover Spit approximating 20-50 individuals from August 14 through August 30. Juveniles were seen also on beaches at Lonely on August 14. Sanderlings were still present as late as September 19, when our field season ended.

7. Semipalmated sandpiper (Calidris pusilla). Figure 5 A, B.

This species is a regular breeder at Barrow, and adults were recorded on tundra transects regularly in early July. These breeding birds foraged frequently in mud areas near lagoons and estuaries. A sudden striking influx of juvenile migrating birds reached Barrow on August 3, 1975, appearing on most inner lagoon shores, mudflats, and brackish pools. We observed a similarly high density of these juvenile sandpipers at a small pond at Deadhorse Airport (Prudhoe Bay) on August 2. Peak densities declined sharply within a few days, and all birds of this species were gone by August 31.

8. Western sandpiper (Calidris mauri). Figure 6.

This small sandpiper, considered a regular breeder at Barrow by Pitelka (1974), apparently did not nest there in 1975, and was never recorded on tundra transects. A movement of non-breeding adults passed through Barrow during late June and early July, foraging along inner lagoon edges and mudflats. A second movement, consisting primarily or entirely of juveniles, arrived in mid-August, reaching higher densities

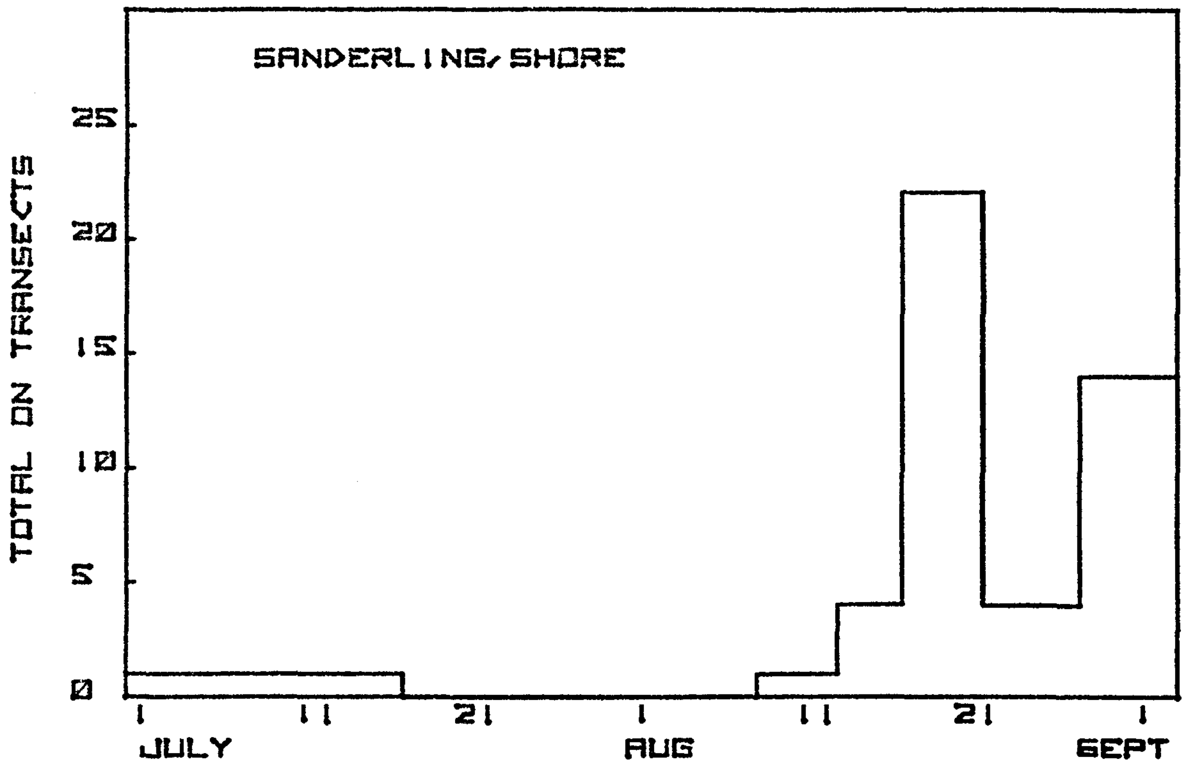
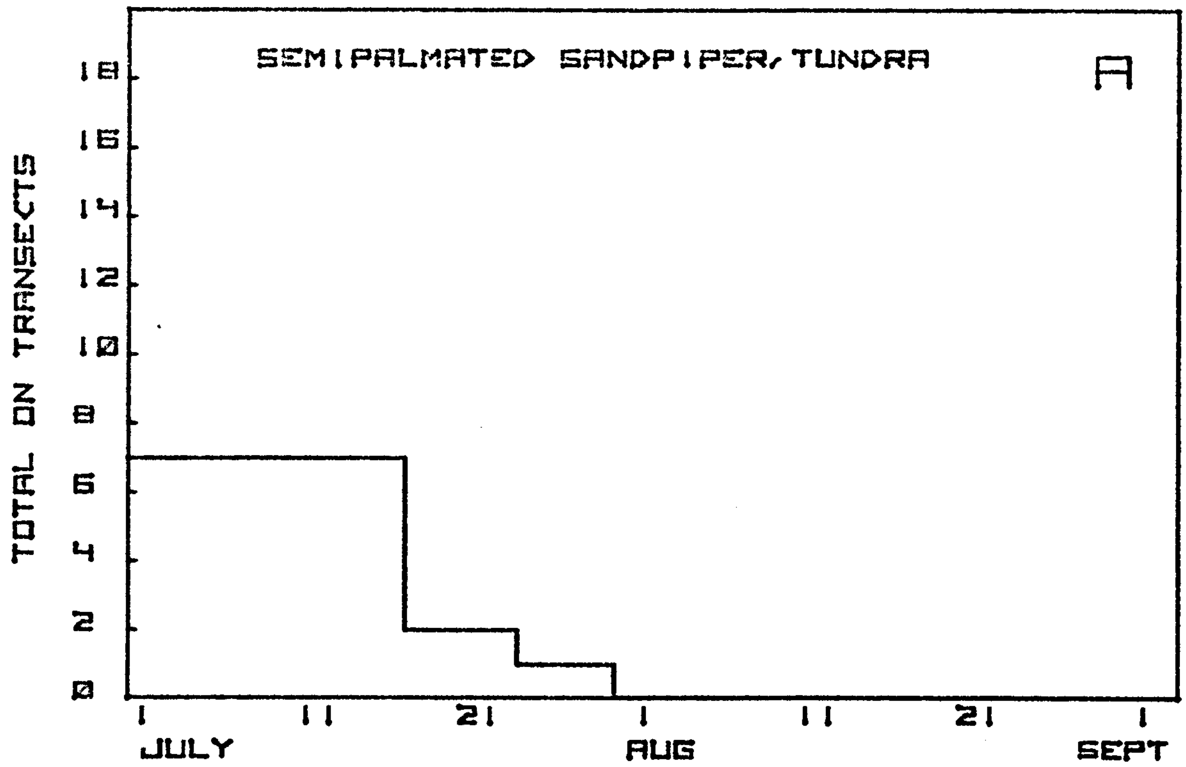


Figure 4. Seasonal population change, sanderling.



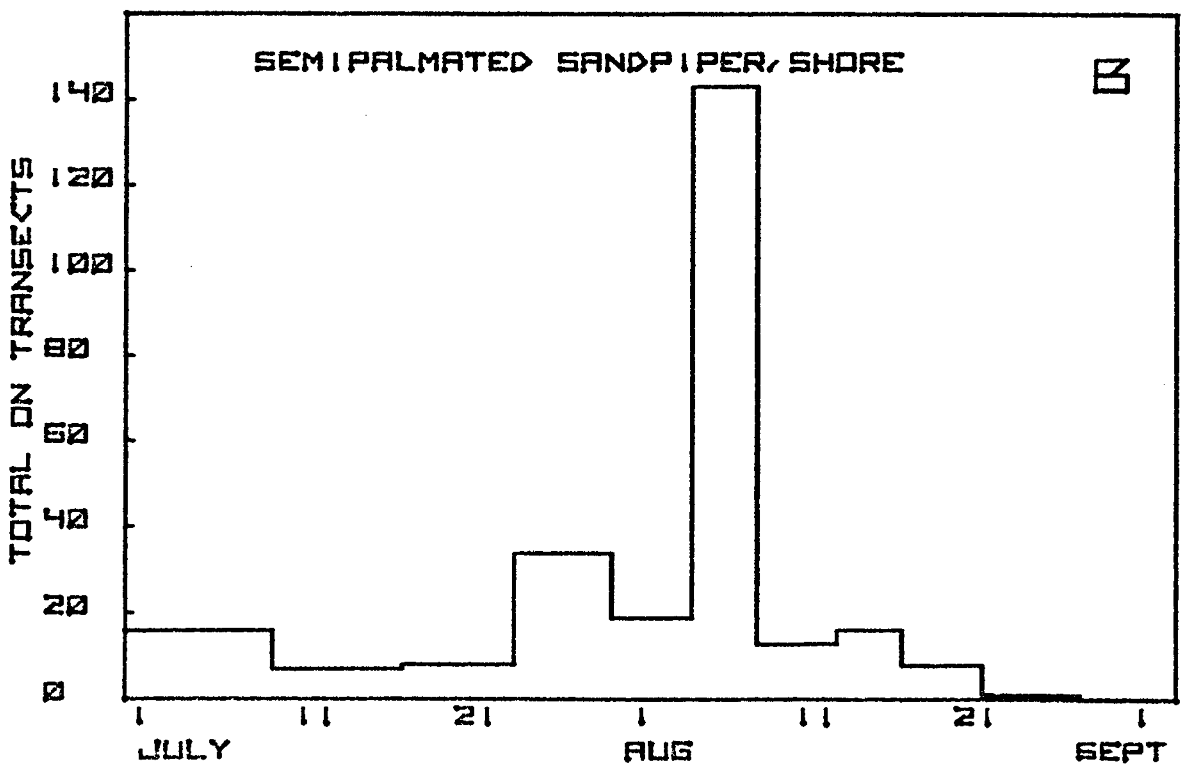


Figure 5. Seasonal population change, semipalmated sandpiper.

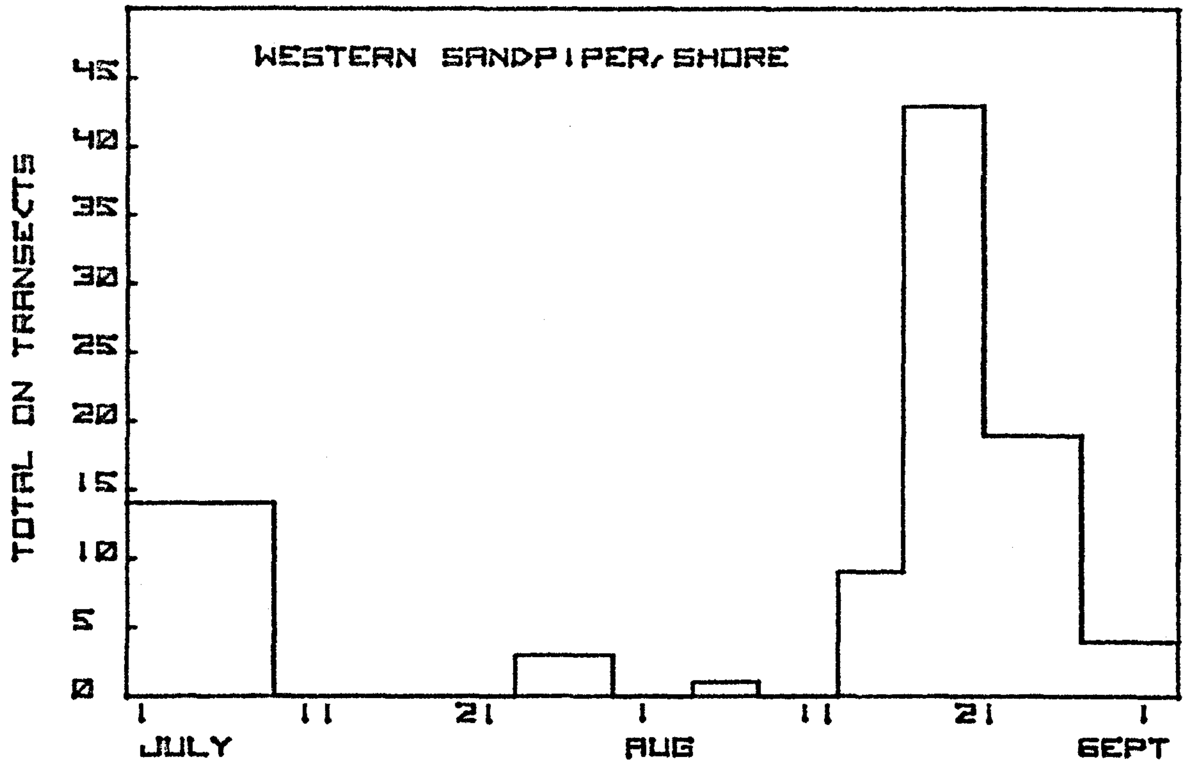


Figure 6. Seasonal population change, western sandpiper.

in the same habitats.

9. Rufous-necked sandpiper (Calidris ruficollis).

This Siberian shorebird, rare anywhere in North America, has been recorded as a straggler at Barrow only a few times (Pitelka, 1974). In 1975 we located the first recorded nest of the rufous-necked sandpiper in North America east of Cape Prince of Wales. The nest was at Point Barrow, where both adults and subsequently the young foraged around brackish pools susceptible to flooding during storm tides.

10. White-rumped sandpiper (Calidris fuscicollis).

Although a few pairs nested near Barrow in 1975, birds were seen in littoral areas only twice, foraging on mudflats near Middle Salt Lagoon on July 6 and July 31.

11. Baird's sandpiper (Calidris bairdii). Figure 7.

Similar to the prebreeding occurrences of sanderlings, this species was common in open areas of gravel beaches in mid-June, apparently moving to tundra nesting areas soon afterward. Only two individuals were actually recorded on tundra transects, both in early July, but nesting adults whose territories bordered lagoons and estuaries were regularly recorded on these shoreline transects. There was no heavy movement of migrating juveniles through littoral areas as in Western and semipalmated sandpipers, and Baird's sandpipers did not utilize gravel beach areas in July and August where they had been found in June.

12. Pectoral sandpiper (Calidris melanotos). Figure 8 A, B.

Of the several common sandpipers at Barrow, this species occurred least often along open shores; littoral habitats most commonly utilized by pectoral sandpipers consisted of grass-bordered inner lagoon and brackish pool shores. A conspicuous movement of non-breeding adults or post-breeding males was evident in late June and early July, with flocks of birds occurring in these littoral habitats and on wet tundra. After this population declined, although birds were present on tundra transects through August, no other significant population movements were noted at Barrow. At Lonely on July 19, we encountered 40 to 60 Pectoral sandpipers in a small area of grassy brackish pools near a tidal slough.

13. Dunlin (Calidris alpina). Figure 9 A, B.

This species was common throughout the summer on tundra transects, with a gradual increase in density in August as young birds fledged. During this same period a marked increase in density in littoral areas occurred at Barrow. Most birds foraged along inner shores (mudflats, sloughs, closed lagoon margins, brackish pools) but a few birds were present on gravel beaches from mid-August to at least September 19. Differences in movements of adults and juveniles are not clear; by late

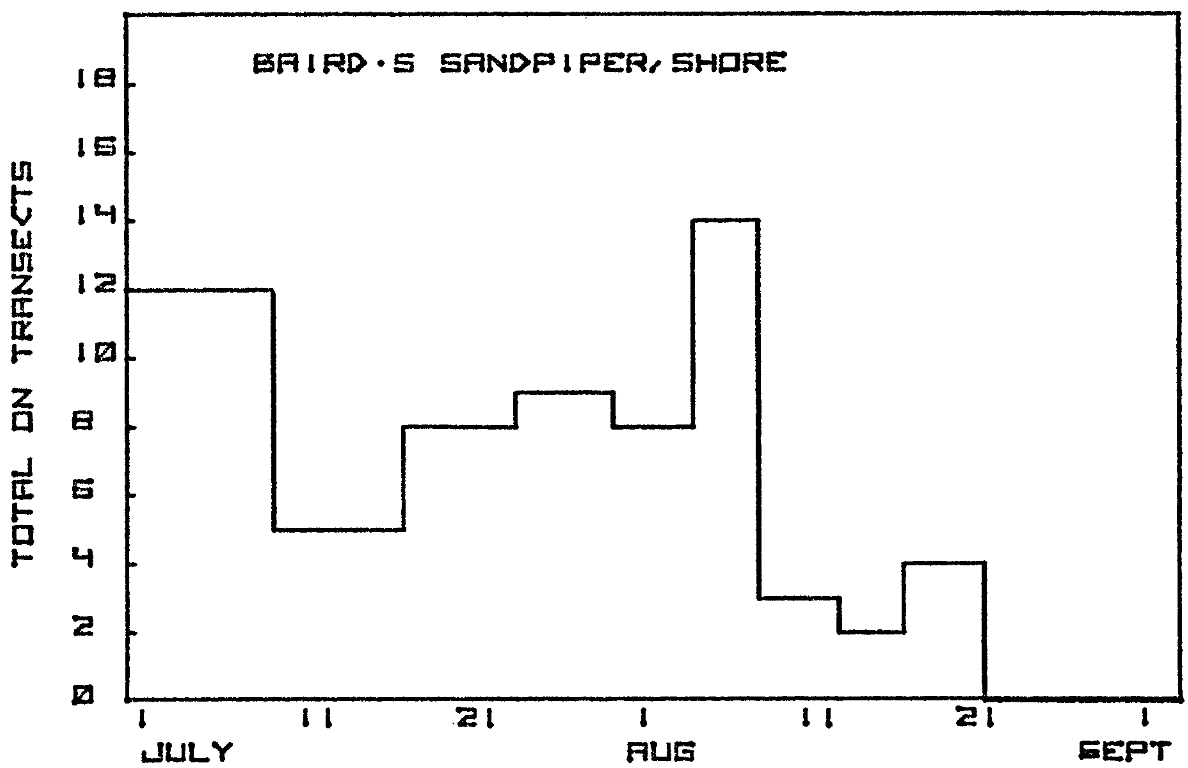


Figure 7. Seasonal population change, Baird's sandpiper.

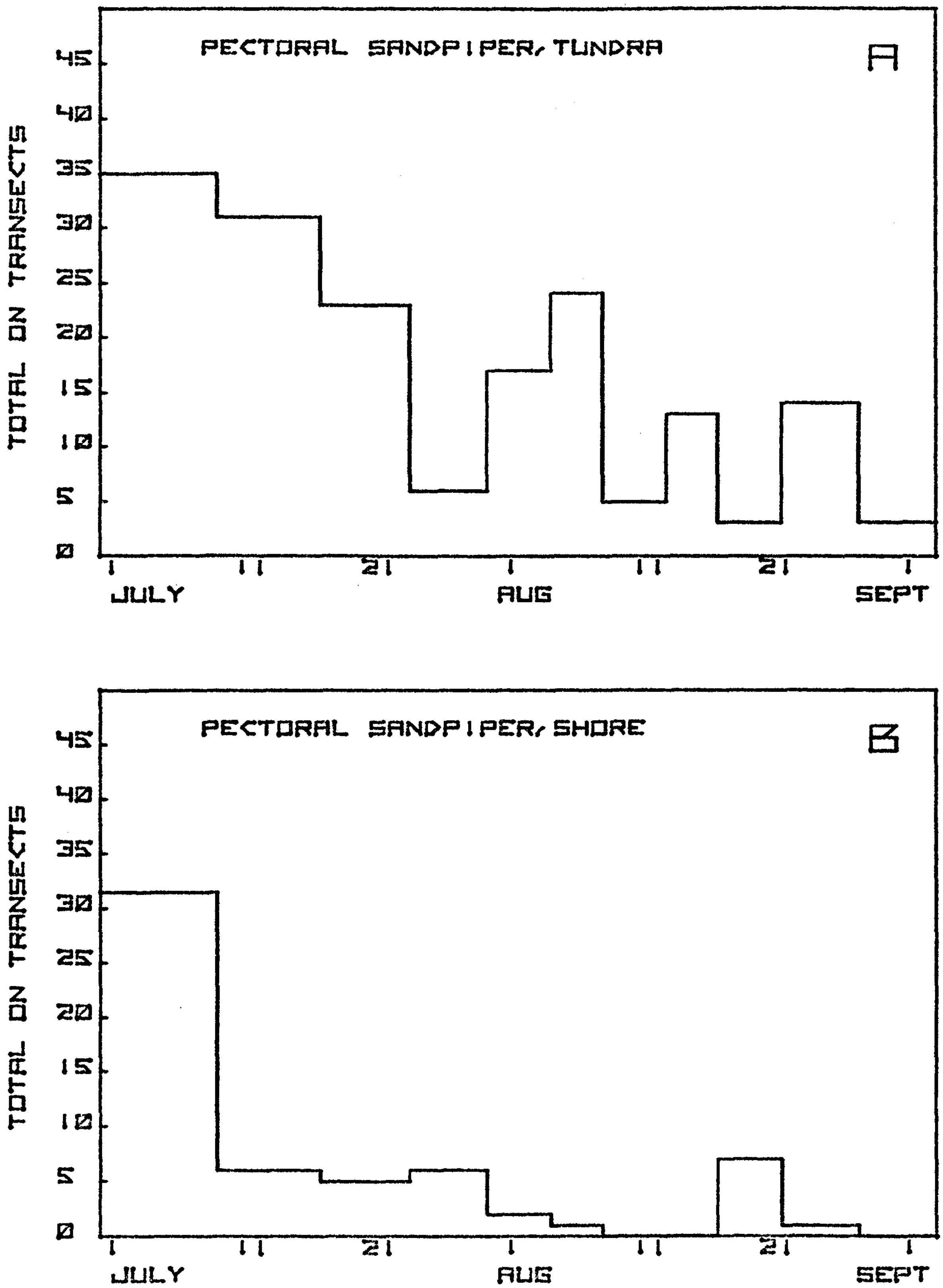


Figure 8. Seasonal population change, pectoral sandpiper.

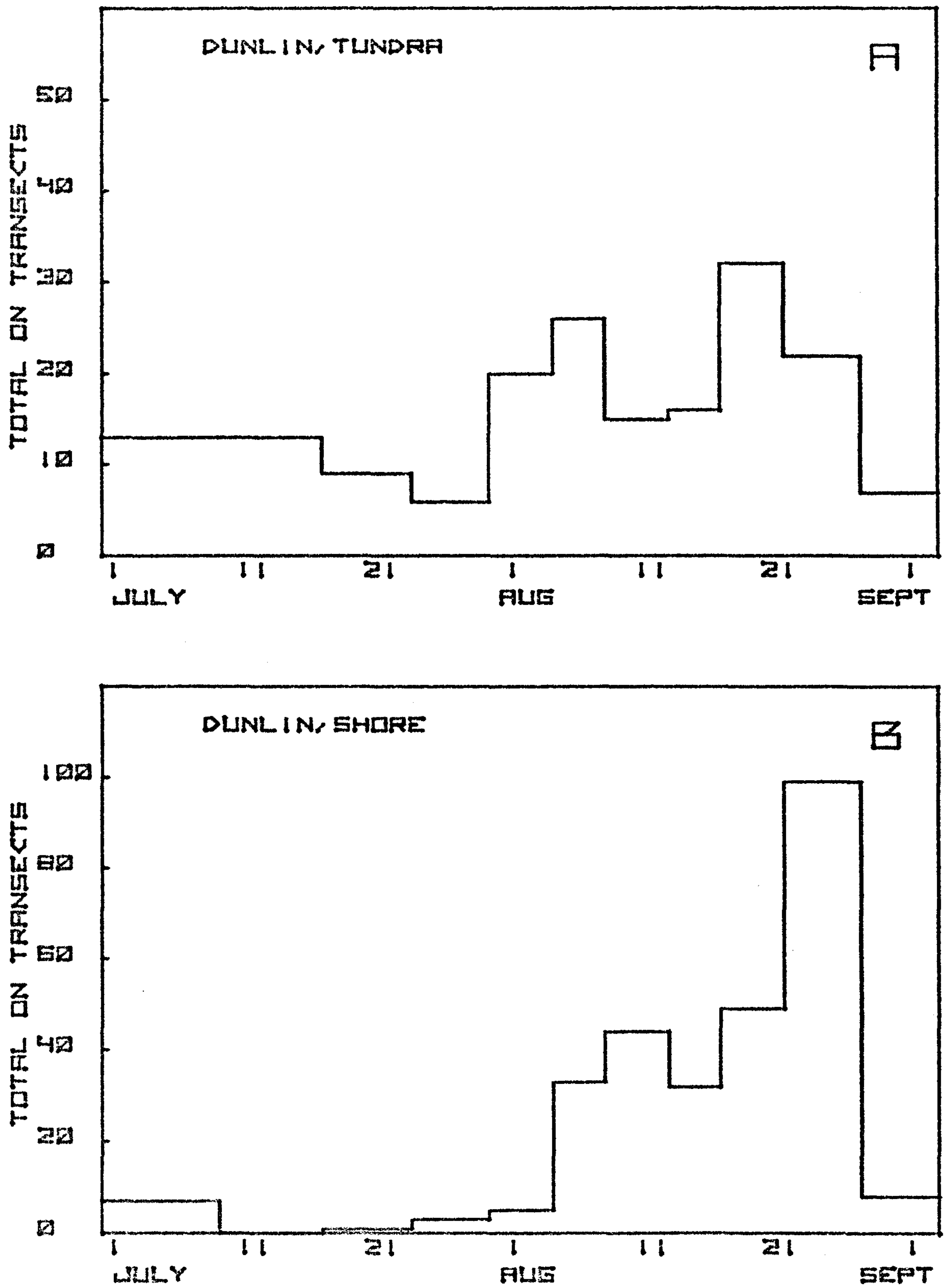


Figure 9. Seasonal population change, dunlin.

August juveniles were more common than adults at Barrow, but inconsistent differences in age ratios between groups in tundra vs. littoral habitats obscured the picture. Age ratio in a group of 400 Dunlin near Lonely on August 12 was still 5 adults:1 juvenile at a date when adults were much less common in most other species. Adult Dunlins are known to remain in the arctic longer than most other adult calidridine sandpipers; however, they have previously been noted to join juveniles in late summer shoreline movements only rarely (Holmes, 1966a, b). Movements of this species near Wainwright appeared similar to activities at Barrow, but the study areas at Lonely provided some contrasts. On July 20, we observed 2 flocks of adults on gravel beaches. None of the birds was feeding, and we interpret this as a movement of non-breeders, or birds which failed in nest attempts, since the early date does not suggest that these birds had already left fledged young. In addition, during a subsequent visit on August 11-14, we found Dunlins to be the most common shorebird in mudflat, tidal slough, and brackish pool littoral areas. In one pool region of particularly high density, 430 birds were counted in 9 hectares (300 m x 300 m).

14. Stilt sandpiper (Micropalama himantopus).

A few individuals, all juveniles, were observed feeding near brackish pools at Lonely (August 11, 12) and at Barrow (August 14-17).

15. Long-billed dowitcher (Limnodromus scolopaceus). Figure 10 A, B.

No dowitchers were encountered on any transects until August 24, when they suddenly became common on tundra and on mudflat and shallow pool habitats. The movement consisted entirely of flocks of migrating juveniles, and by August 29 few birds of this species remained near Barrow.

16. Hudsonian godwit (Limosa haemastica).

One individual of this uncommon straggler was seen beside a brackish pool near Middle Salt Lagoon at Barrow, August 21.

17. Bar-tailed godwit (Limosa lapponica).

A few juveniles were seen on an ocean beach August 14 at Barrow and in a brackish pool on August 11 at Lonely.

18. Red phalarope (Phalaropus fulicarius). Figures 11 A, B and 12 A, B.

This species was an extremely common nester at Barrow in 1975, and the most abundant late season migrant. Figures 11 A and 11 B present the census data for tundra and shoreline transects. In figures 12 A and 12 B, the shoreline transect data are separated into inner shores (lagoons, estuaries, and brackish pools) and outer shores (ocean and open lagoon beaches). Several distinct movements can be recognized. In late June and through mid-July, adult females, having completed their participation in nesting activities, formed flocks near tundra pools and inner shore littoral areas. Soon after these females left

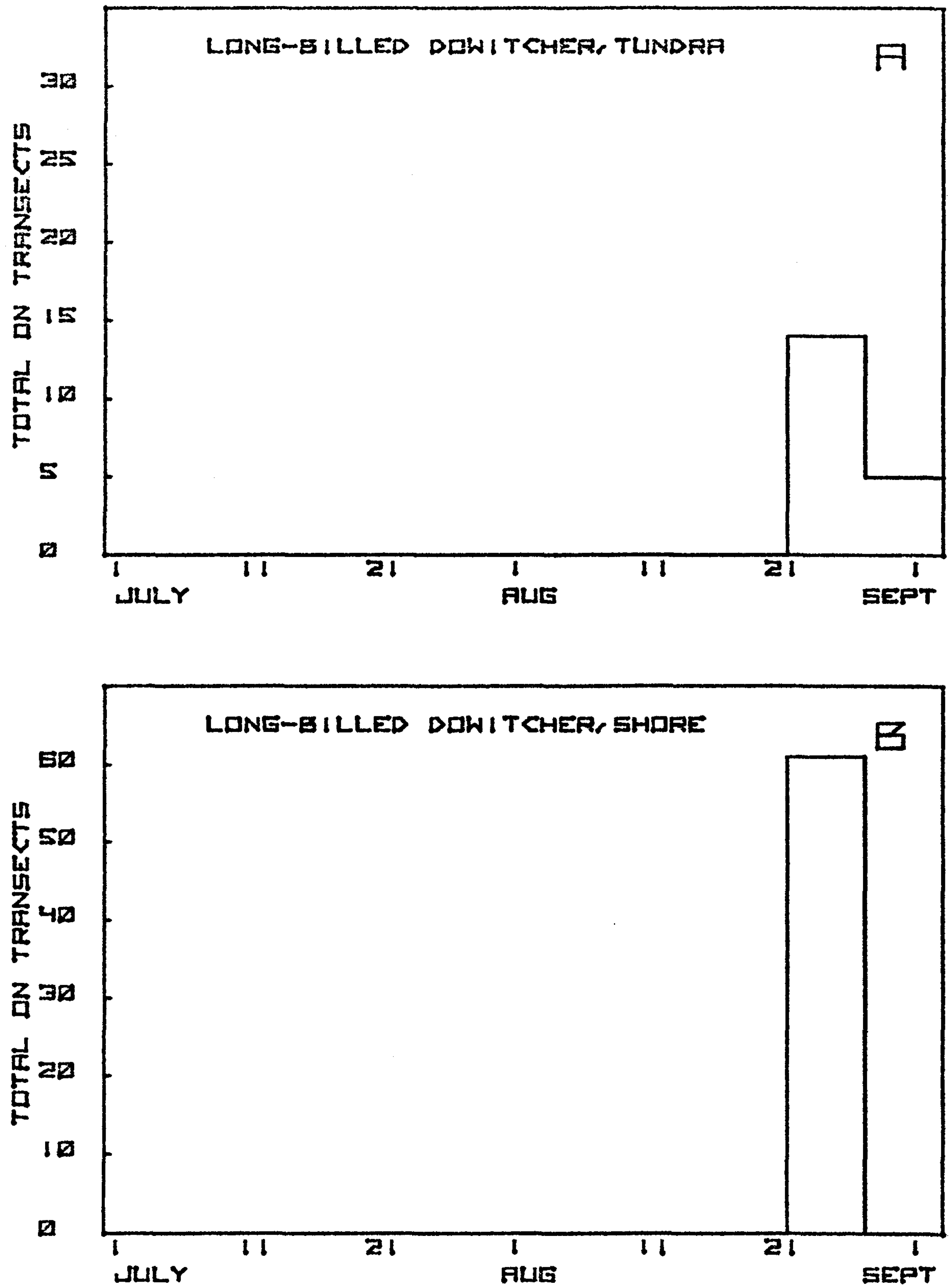


Figure 10. Seasonal population change, long-billed dowitcher.

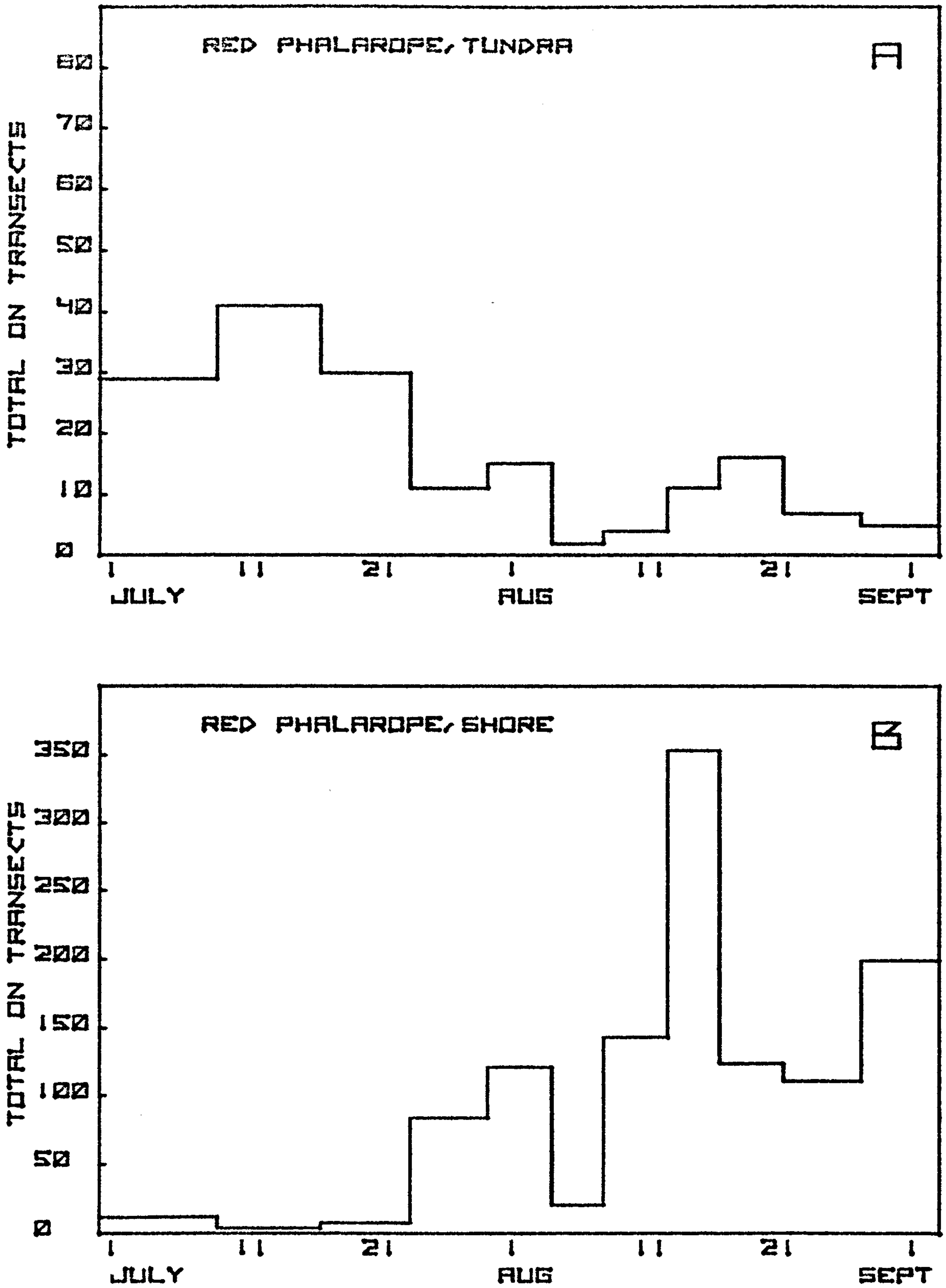


Figure 11. Seasonal population change, red phalarope.

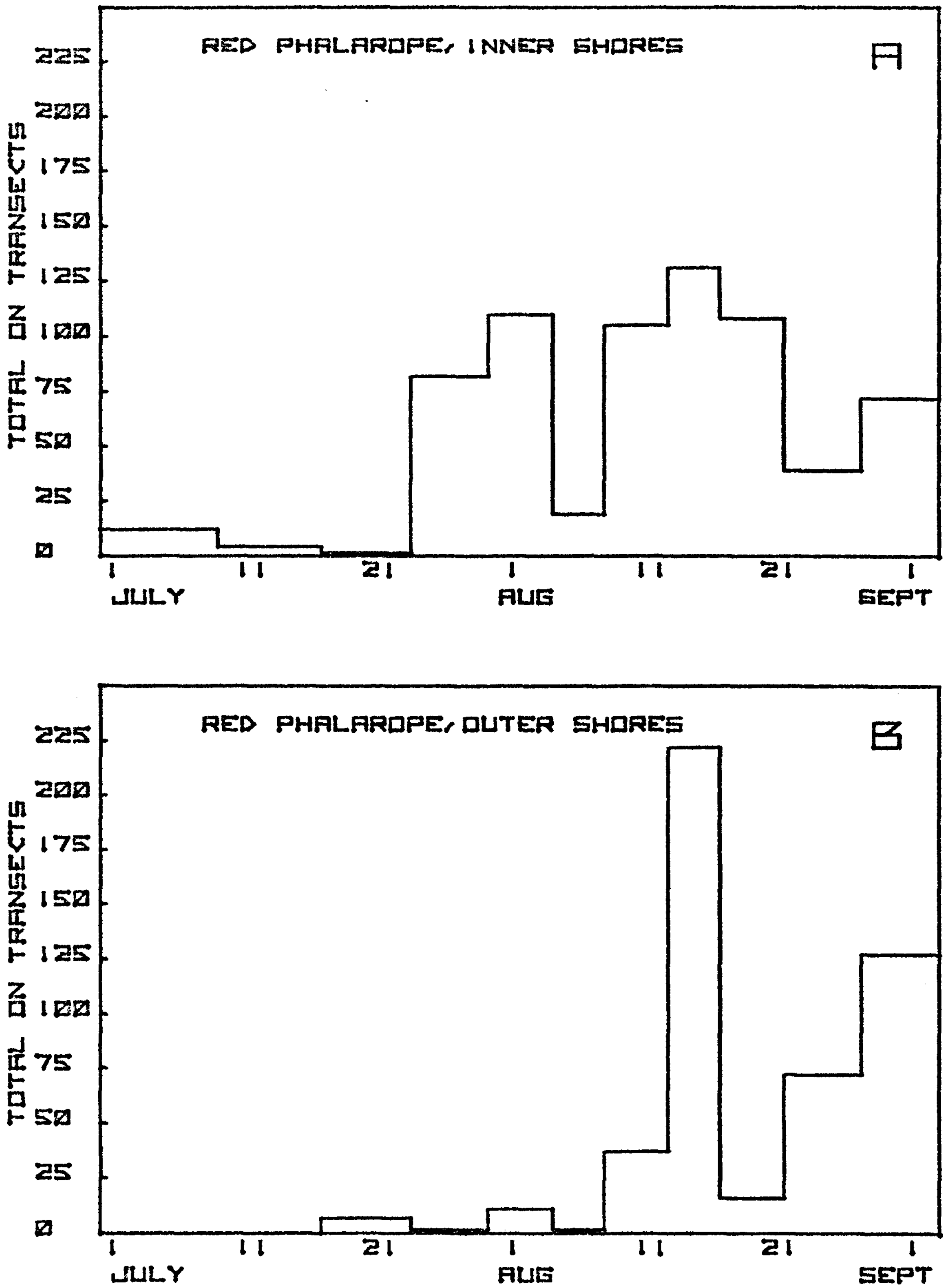


Figure 12. Seasonal population change, red phalarope, shores.

the Barrow area, post-breeding males began appearing in flocks primarily in inner shore littoral areas. This movement lasted mainly from July 22 to August 6.

About August 8 to 14, flocks of juveniles appeared along both inner and outer shorelines, eventually reaching densities in excess of 500 per kilometer along the gravel beaches of portions of Barrow Spit, in a narrow zone at the water's edge. Total populations within the Barrow Spit-Plover Spit complex peaked at approximately 4000 birds on August 14, and another peak of 3500 birds occurred on August 26. On August 15, and for several days thereafter, 1400 birds fed in Middle Salt Lagoon.

Juvenile phalaropes probably moved to the coast at approximately the same time at our other study areas. Approximately 150 red phalaropes, mostly juveniles, were feeding on plankton near the beach south of Wainwright village on August 7, and about 100 were foraging near the gravel beach at Lonely on August 14.

Census results for both shores of Barrow Spit, and less often for both shores of Plover Spit, are presented in Table 3. Percent of birds counted on each of 2 or 4 shores, as well as total populations, are listed. Average wind speed and direction are also given. It appears that the distribution of phalaropes among these four shores is affected by the speed and direction of the wind. Since the birds are feeding on zooplankton in shallow water within 2 m of shore almost exclusively, wind conditions may affect foraging efficiency, probably by altering surf and ice conditions and possibly through differences in plankton availability. To test the hypothesis that phalarope distribution is affected by wind direction, the 7 sets of census data for all four shores taken on days with wind speed above 10 knots were treated as follows: First, the absolute value of the angle in degrees between the actual wind direction and the direction of a full onshore wind was determined for each census day for each shore. Second, the percent of birds occurring on each shore was plotted against this parameter (Figure 13). The very restricted scatter of these data indicate simply that phalaropes seldom forage on beaches with onshore winds (angles less than 90°) if alternative shores are available. The complex arrangement of shores around Point Barrow, which always provides a protected shore, may be much more attractive to migrating phalaropes than single shores along the mainland. Barrier islands, by providing at least 2 opposite shores, would also provide protection in most wind conditions, and might be heavily used. Approximately 2000 red phalaropes fed near the shore at Cooper Island, 30 km east of Point Barrow, on August 26 and 300 birds were counted at Gurak Island 55 km east of Point Barrow, on August 28 (R. Bokelheide, personal communication).

19. Northern phalarope (*Lobipes lobatus*).

A few individuals, probably breeding adults, were seen near brackish pools at Barrow and Lonely during July. Northern phalaropes were never seen along outer shores, and no movement of this species was

Table 3. Distribution of Red Phalaropes near Point Barrow

Date in Aug. 1975	Wind direction, degrees	Wind speed, knots	Barrow Spit		Plover Spit		Total birds
			NW shore	SE shore	NE shore	SW shore	
10	280	13	5%	95%	--	--	320
14	160	12	90%	0	10	0	4000
15	260	7	60%	40%	--	--	2500
16	350	14	10%	90%	--	--	1000+
17	60	13	10%	0	0	90	1000+
19	70	16	90%	0	0	10	1000+
22	10	7	50%	0	50	0	500
26	260	18	0	0	100	0	3500
27	270	16	0	40%	60	0	1600
30	80	13	45%	0	0	55	1200
31	10	10	0	0	0	100	1200

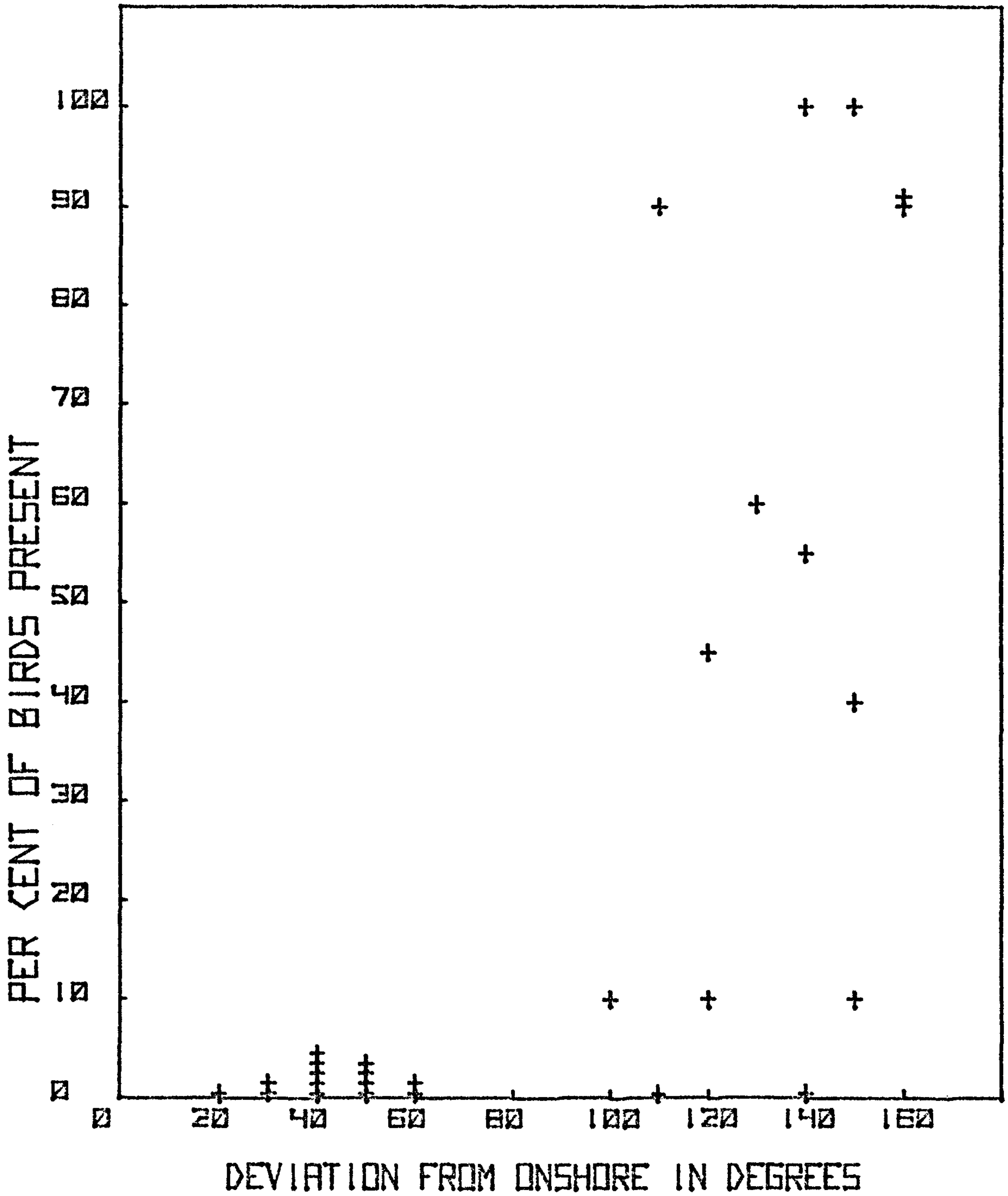


Figure 13. Red phalarope distribution in relation to wind direction.

detected at any of the study areas, in contrast to the report of Vermeer and Anweiler (1975) of a very heavy migration in August along the Yukon coast of the Beaufort Sea in western Canada.

On all shoreline transects, non-shorebird species were also recorded, in a 200 meter zone extending out from the shore. The more common of these species are discussed here.

20. Arctic loon (Gavia arctica). Figure 14.

The censuses record a broad population peak for this species in late July and early August. During the first week in September, a major movement of Arctic loons, flying westward singly or in small flocks, passed through the Barrow area, with 66 birds counted during two hours along the shore of Elson Lagoon on September 4.

21. Oldsquaw (Clangula hyemalis). Figure 15 A.

22. Eiders (all). Figure 15 B.

The plots for these waterfowl show peaks in mid-July, probably representing chiefly post-breeding males, with lower numbers for the remainder of the summer. This is somewhat misleading, since large numbers of both groups were present offshore through most of August, and flocks in excess of 1000 Oldsquaws were present into early September. The failure to record these birds probably results from late summer changing ice conditions which allow birds to move farther from our shore-based transects.

23. Glaucous gull (Larus hyperboreus). Figure 16 A.

The plot shows a population peak in mid-August at Barrow. The population center at that time was the Barrow dump near South Salt Lagoon where 1500-2000 Glaucous gulls were present on August 19.

24. Black-legged kittiwake (Rissa tridactyla). Figure 16 B.

This species, which does not nest east of Cape Lisburne in Alaska, showed no pronounced migratory population peak, although some birds were present throughout the period. Kittiwakes were most common near shores under conditions of grounded ice floes intermixed with water areas.

25. Ross' gull (Rhodostethia rosea).

A small movement brought a few juveniles and adults to Barrow the second week of August. During this period, Ross' gulls foraged by walking or swimming along gravel beach shorelines, feeding on plankton with red phalaropes and Sabine's gulls. Another influx occurred in early September, with as many as 60 birds seen in one day; they foraged by plunging amid ice floes, and remained until the ice became shorefast in late September.

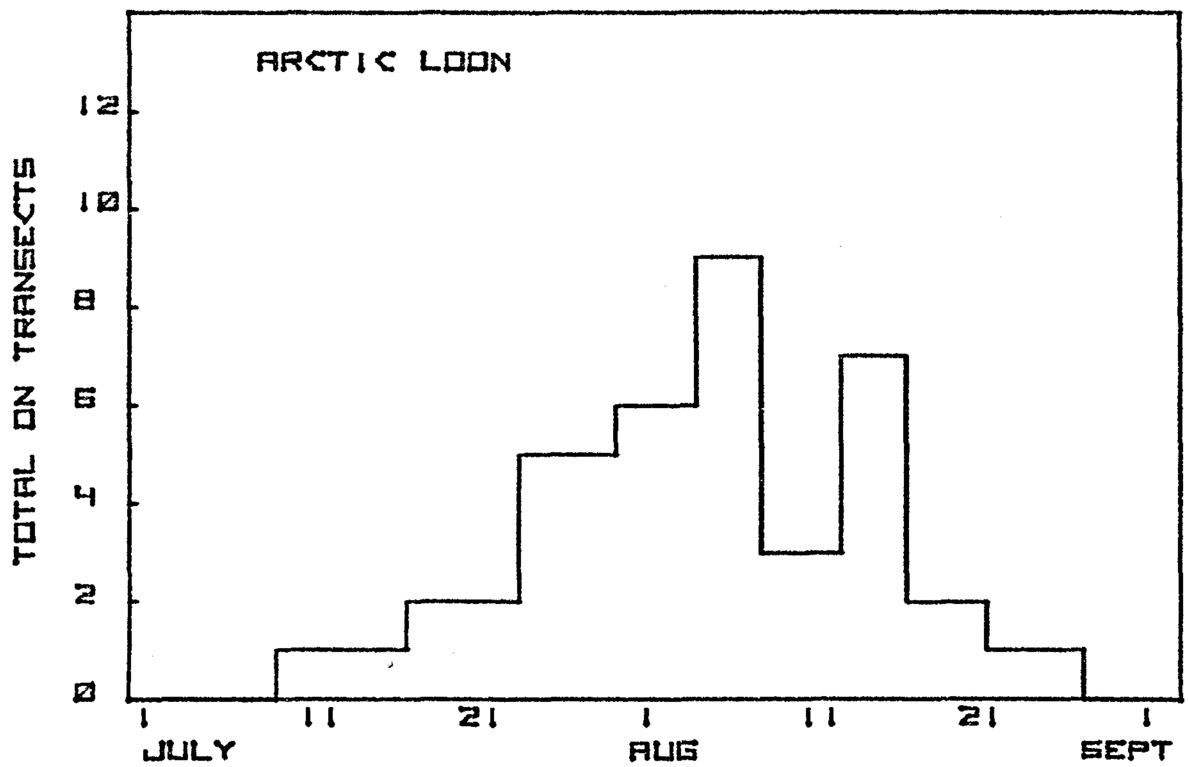


Figure 14. Seasonal population change, arctic loon.

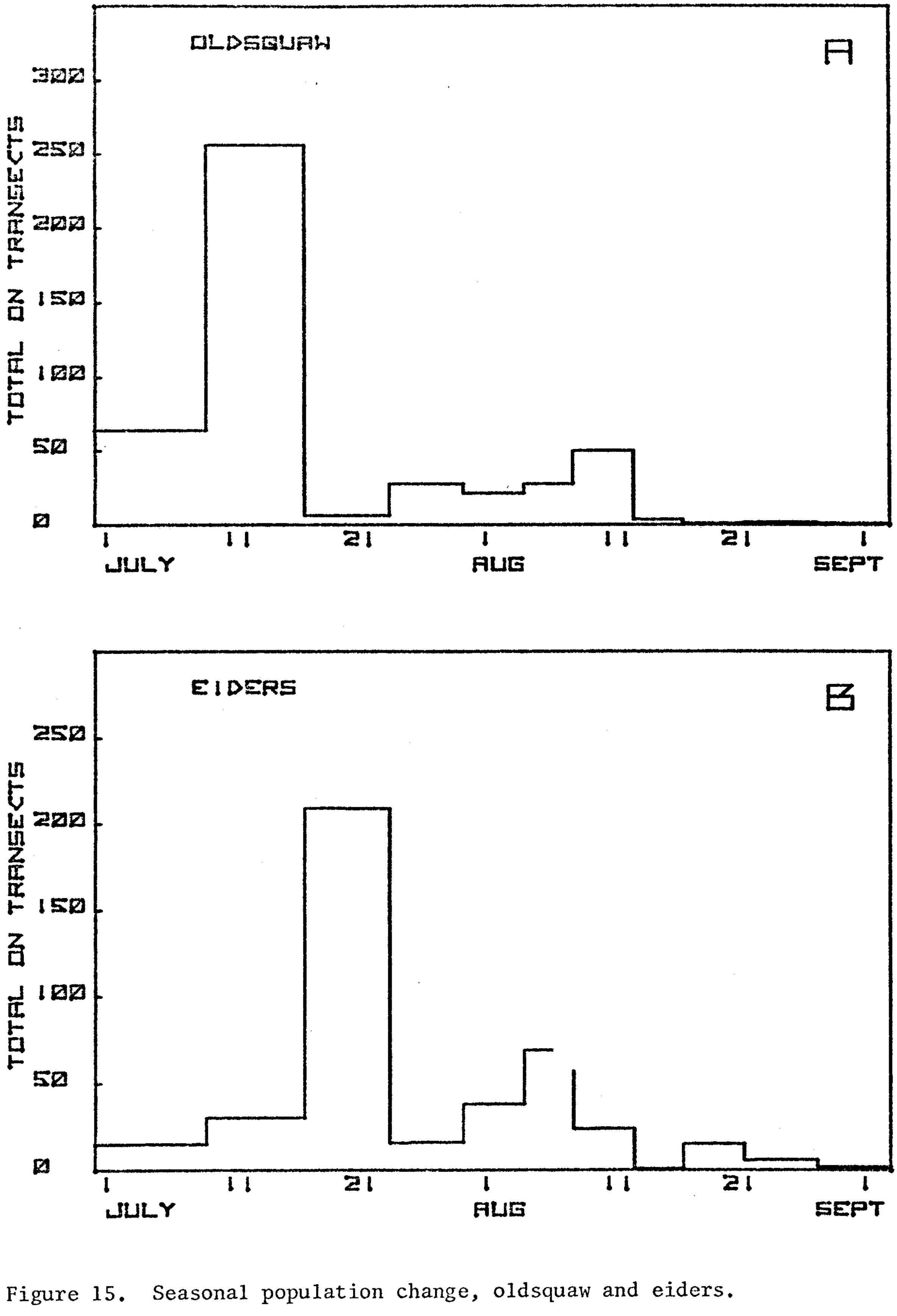


Figure 15. Seasonal population change, oldsquaw and eiders.

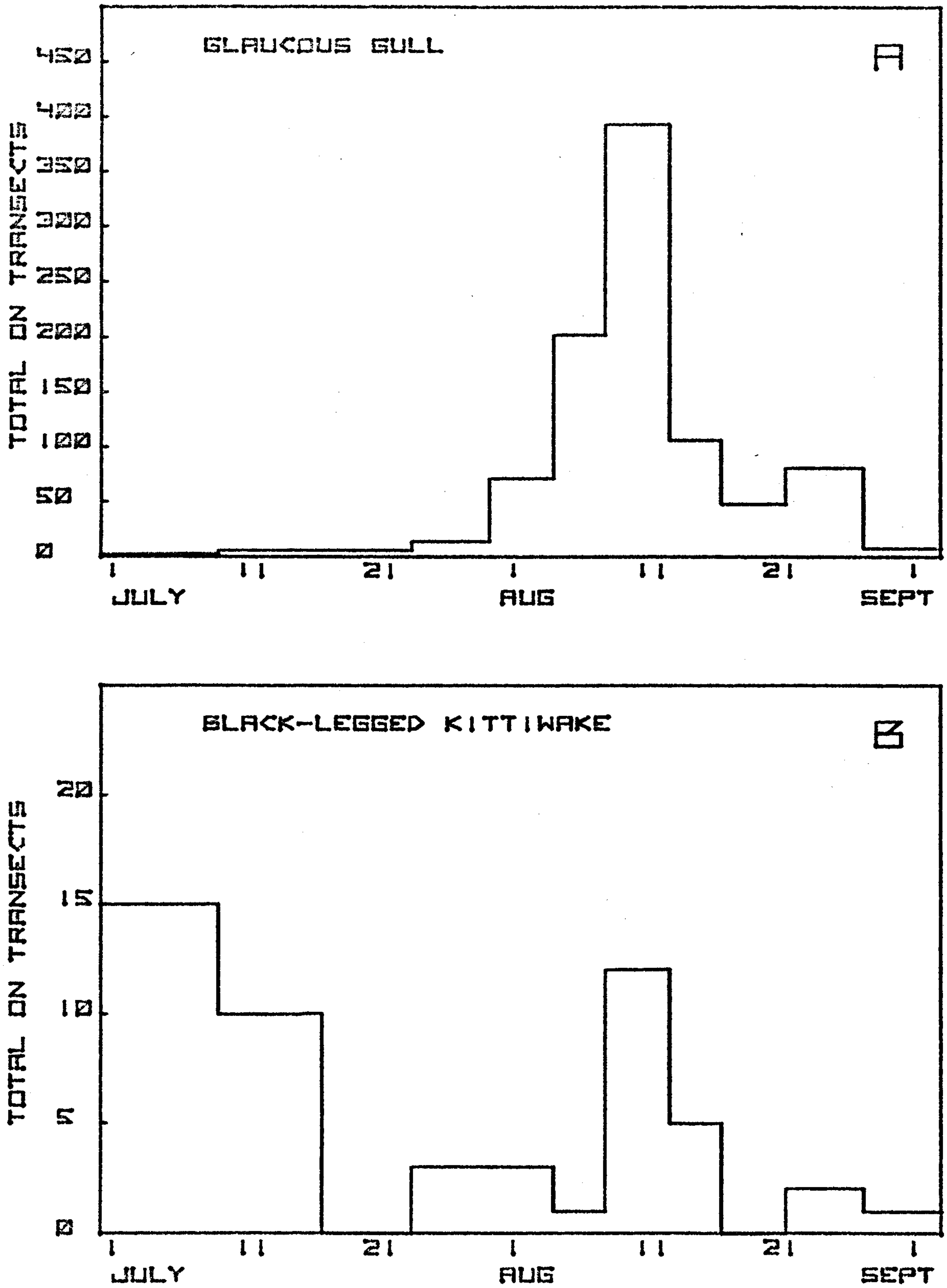


Figure 16. Seasonal population change, glaucous gull and black-legged kittiwake.

26. Sabine's gull (Xema sabini). Figure 17 A.

The transect censuses recorded a peak in mid-August. High concentrations of this species were seen sporadically and somewhat locally throughout August, with flocks still migrating past Point Barrow on September 5.

27. Arctic tern (Sterna paradisaea). Figure 17 B.

Movements of this species were also sporadic through much of August, with flocks of 50 at Wainwright on August 7, and a heavy movement at Barrow on August 8 and 9. Five hundred were counted at Brant Point on Elson Lagoon August 9. Approximately 700 to 1000 birds were feeding near Point Barrow on August 26 and 27, but few birds were sighted during September.

28. Alcids.

Large flocks of several species of these seabirds, principally thick-billed murres (Uria lomvia), were present in Elson Lagoon and the Chukchi near Barrow from July 28 to 31.

29. Canada geese (Branta canadensis) and Black brant (Branta nigricans).

We include these species principally to identify the area near Lonely as an important staging area for geese. Both species were present in large flocks at the mouth of the Smith River and the nearby tidal slough in early August. We counted 410 Black Brant and 145 Canada Geese on August 12 and 600 Black Brant and 200 Canada Geese on August 14. The low brackish areas surrounding the river and slough were densely covered by goose droppings, and edible plants had been cropped extensively.

B. Foraging microhabitat data

Table 2 lists the numbers and dates of foraging microhabitat data points collected for each common species. A principal component analysis was made with this data set. This technique reduces the original variables (Table 1) to a set of principal axes which reflect major components of variation in the data set. Biologically, these can be interpreted to reveal significant environmental gradients present in the habitat used by the birds, and they provide a convenient way to ordinate bird species in terms of their habitat use.

The original variables and their weighting coefficients for the first three principal components selected by the analysis are presented in Table 4. These coefficients reflect the correlation of each variable with the principal component axes. The space defined by the principal components can then be interpreted by considering the weighting coefficients for each measured variable. PC1 can be interpreted as representing an axis in the direction of decreasing depth of water and increasing distance to water, defining a habitat gradient from water on the left to upland on the right. PC2 runs from mudflat

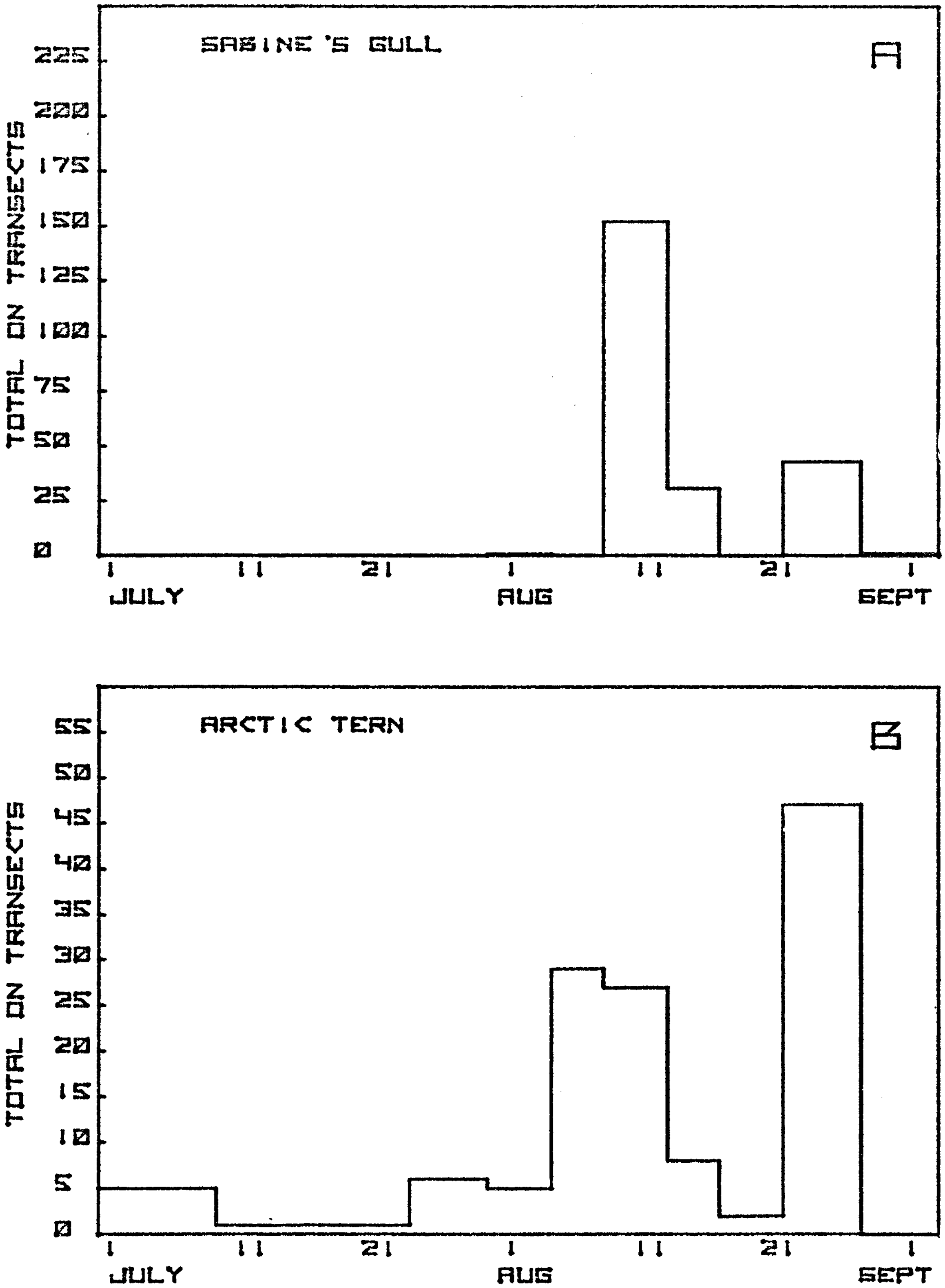


Figure 17. Seasonal population change, Sabine's gull and arctic tern.

Table 4. Principal Component Weighting Coefficients

Variable Name	PC1	PC2	PC3
DIST	.85	-.09	-.13
DEPTH	-.71	-.01	.04
PENET	.05	-.31	.67
TOPO	.24	.64	.21
CSAND	.03	.10	.05
FSAND	.10	.21	.16
GRAV	.12	.06	-.76
MUD	.61	-.64	.15
DETRI	.38	.67	.23
WATER	-.92	-.04	.05

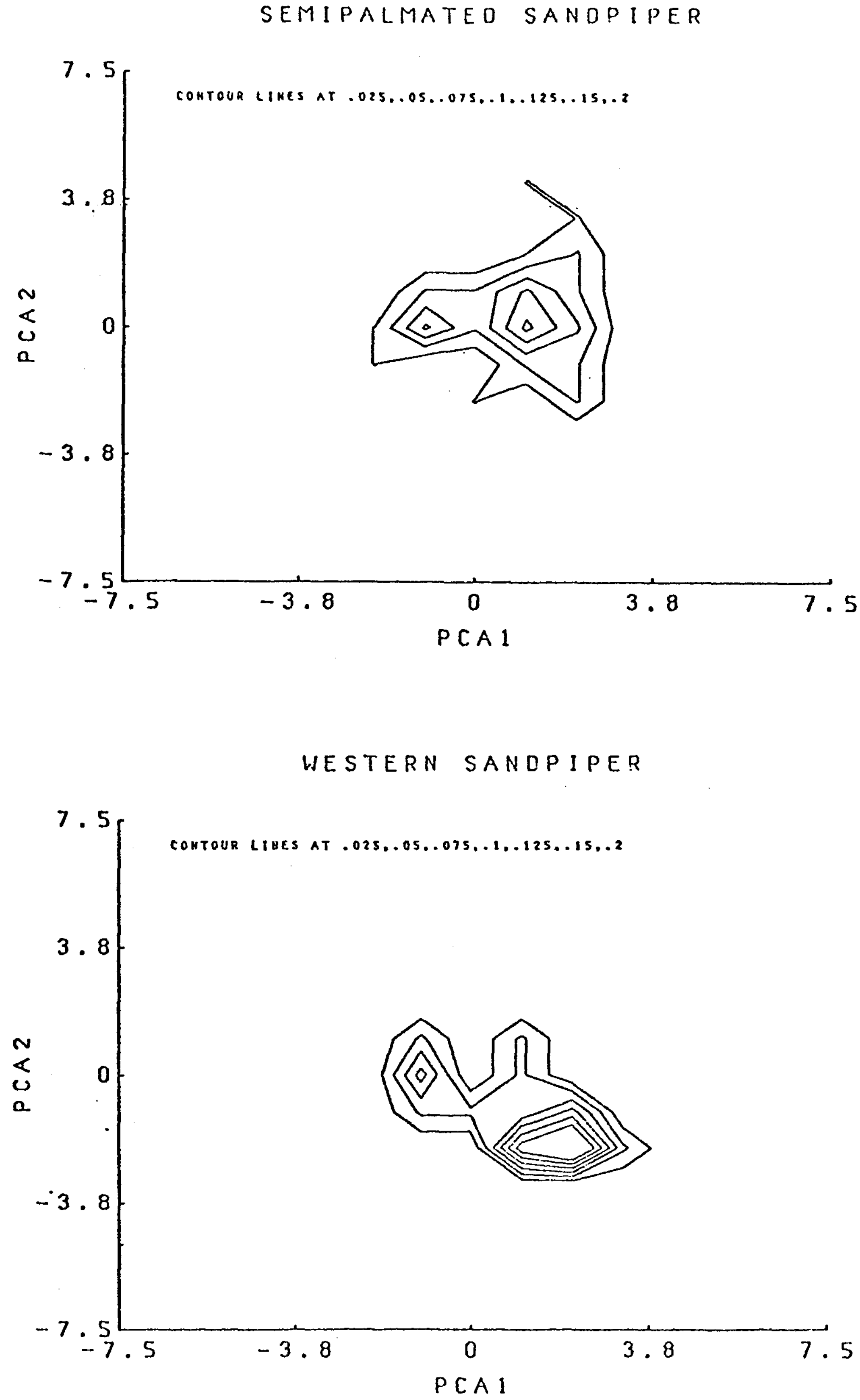
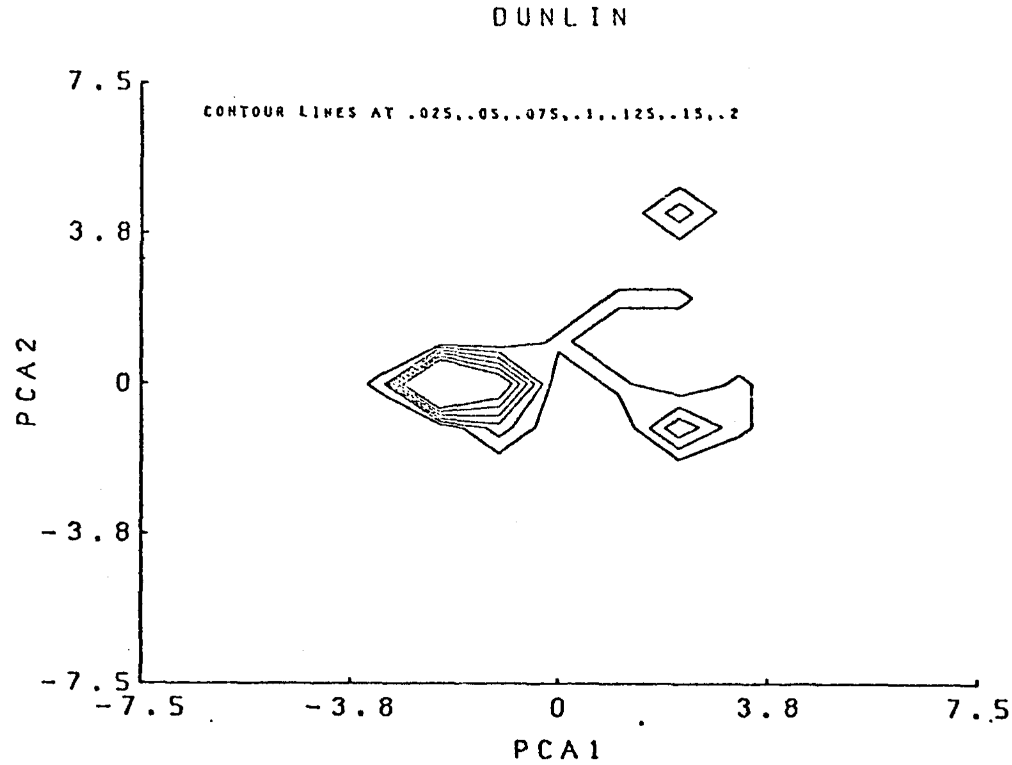


Figure 18. Foraging microhabitat principal component plots, semipalmated sandpiper and western sandpiper.



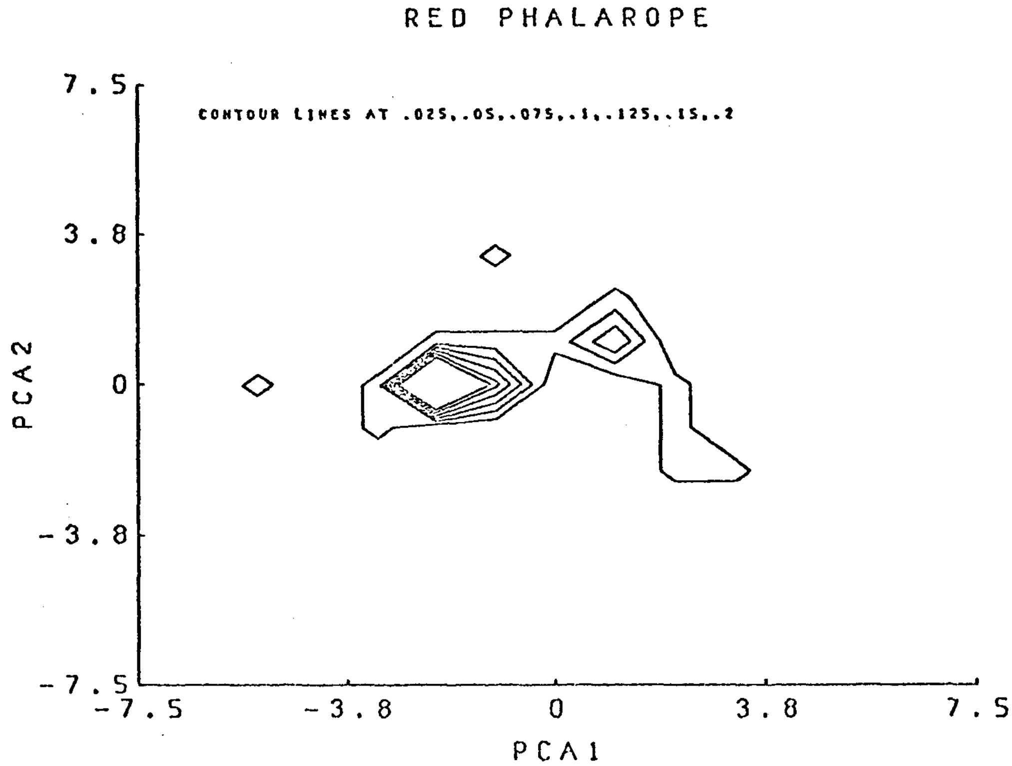


Figure 19. Foraging microhabitat principal component plots, dunlin and red phalarope.

surfaces to more variable surfaces with increasing topographic variation and small piles of detritus. PC3 represents the axis from gravel substrates to the most penetrable substrates.

In Figures 18 and 19 we present the frequency contour in a microhabitat space defined by PC1 and PC2 for four species. Differences between these species are not great. Western sandpipers seem to prefer more uniform mudflat surfaces than do semipalmated sandpipers or dunlin, and dunlin forage in much deeper water. The comparison between dunlin and red phalaropes, which appear very similar in this treatment, seems surprising until we note that most of the red phalaropes were measured in late July, a period when they are feeding principally on emerging adult chironomid flies along lagoon and brackish pool shores. At this time their foraging behavior is very similar to that of dunlins. Data collected in mid-August on juvenile phalaropes foraging on plankton on outer shores would presumably show markedly different contours in this space. Next season we will examine these intraspecific seasonal comparisons in foraging microhabitat.

Discriminant function analysis of these data is currently in progress, and will be used to refine our methods of data collection for future seasons.

C. Shorebird diets

Tables 5 and 6 present the food data collected from stomach samples and through observation and substrate sampling. The last two columns require explanation. (1) Under Food Items, only entire or nearly entire specimens are listed. This decreases the bias resulting from differential rates of digestion of soft and hard-bodied prey, since it probably includes only recently ingested items. Fortunately, no molluscs were encountered in any samples, and even extremely soft-bodied chaetognaths were found entire in several samples (see especially sample #32). (2) Within a sample, taxons are listed in order of decreasing abundance by number of specimens. (3) An asterisk (*) denotes any taxon comprising more than 70% of the total number of specimens in a stomach sample. (4) For samples with few specimens, the number of specimens is indicated in parentheses; length of specimens is occasionally noted. (5) The results from plankton and occasionally infaunal samples are presented in the last column. These samples were always taken at the time and place of the corresponding stomach sample. Relative abundance of different taxa is designated as approximate number of specimens.

Most samples can be placed in two broad categories of food sources: birds feeding on inner shores, usually of low salinity, depend upon insects, principally chironomid flies, in both larval and emerging adult stages. Individuals feeding on outer shores are oceanic plankton feeders, capturing prey in the nearshore water column (phalaropes) or washed up on beaches (sanderlings, ruddy turnstones, occasionally dunlin).

A few other generalizations can be made. Within one habitat in

Table 5. Food Items: Stomach Samples

Sample no.	Species	Age class	Coll. date	Location	Habitat	Food Items	Plankton or Infaunal Samples
1	Ruddy Turnstone	Juv	3 Aug 1975	Barrow Spit, Elson side	low salinity pool	Chironomid emerging adults	
2	Ruddy Turnstone	Juv	13 Aug 1975	Kolovik Slough, Lonely	ocean gravel beach	Amphipod: *Paramethisto libellula* (1) Insect parts	
3	Baird's sandpiper	Juv	3 Aug 1975	Barrow Spit, Elson side	low salinity pool	Chironomid adults and emerging pupae	
4	Dunlin	Ad	13 Aug 1975	Kolovik Slough, Lonely	med. salinity shallow pool	*Chironomid larvae	
5	Dunlin	Juv	13 Aug 1975	"	low salinity shallow pool	Chironomid larvae	
6	Dunlin	Juv	22 Aug 1975	Barrow Spit, Elson side	low salinity pool	*Chironomid larvae	Oligochaetes-from surface mud Copepods-in shallow water
7	Dunlin	Juv	25 Aug 1975	Voth Creek, Middle Salt Lagoon, Barrow	low salinity, estuary, mud-flats	*Chironomid larvae	
8	Dunlin	Juv	25 Aug 1975	"	"	*Chironomid larvae	
9	Sanderling	Juv	15 Aug 1975	Barrow Spit, Chukchi Sea	ocean gravel beach	Euphausiid: *Thysanoessa longipes* (1)	
10	Sanderling	Juv	22 Aug	"	"	no identifiable items	
11	Sanderling	Juv	23 Aug 1975	"	"	Euphausiid (1) Calenoid Copepod (1) Amphipod (1) Decapod Zoea (1)	Barnacle cyprids 650 Decapod Zoea A 230 Chaetognath: *Sagitta elegans* 160 Calenoid Copepod 80 Barnacle nauplii 50 Hydromedusa: *Aglantha digitala* 30 Fish 1 Euphausiid 1

Sample no.	Species	Age class	Coll. date	Location	Habitat	Food items	Plankton or Infaunal Samples	
12	Semipalmated Sandpiper	Juv	4 Aug 1975	Barrow Spit, Elson side	low salinity	Dipteran adult	Copepods (1 mm)	
13	Semipalmated Sandpiper	Juv	5 Aug 1975	Voth Creek, Middle Salt Lagoon, Barrow	low salinity estuary mudflats	Chironomid larvae	Collembolids	
14	Semipalmated Sandpiper	Juv	13 Aug 1975	Kolovik Slough, Lonely	mud near tidal slough	Oligochaetes		
15	Long-billed Dowitcher	Juv	25 Aug 1975	Voth Creek, Middle Salt Lagoon, Barrow	low salinity estuary mudflats	*Chironomid larvae		
16	Long-billed Dowitcher	Juv	25 Aug 1975	"	"	*Chironomid larvae		
17	Red Phalarope	Ad	30 Jul 1975	North Salt Lagoon, Barrow	low salinity closed lagoon shallow water	*Chironomid emerging adults		
18	Red Phalarope	Juv	9 Aug 1975	Barrow Spit, Elson side	open lagoon gravel beach, shallow water	*Decapod zoea A Calanoid copepod Chaetognath: *Sagitta*		
19	Red Phalarope	Ad	15 Aug 1975	"	"	*Copepods: *Calanus* sp. Barnacle cyprid	Barnacle cyprids Chaetognaths Decapod zoea Calanoid copepods	400 70 10 5
20	Red Phalarope	Juv	15 Aug 1975	"	"	Decapod zoea A Copepod: *Calanus* sp. (3 mm) Oligochaete	refer to preceding sample	
21	Red Phalarope	Juv	15 Aug 1975	"	"	*Calanoid Copepods Decapod zoea A	refer to preceding sample	

Sample no.	Species	Age class	Coll. date	Location	Habitat	Food Items	Plankton or Infaunal Samples	
22	Red Phalarope	Juv	15 Aug 1975	Barrow Spit, Elson side	open lagoon gravel beach, shallow water	Copepods: Calanus sp. Decapod zoea A Chaetognaths	refer to preceding sample	
23	Red Phalarope	Juv	20 Aug 1975	Middle Salt Lagoon, Barrow	med. salinity closed lagoon shallow water	*Calanoid copepod A (with many eggs) size: range 0.9-1.4 mm, mean 1.2 mm	Calanoid copepod A size: range 0.7-1.4 mm mean 0.9 mm	
24	Red Phalarope	Juv	20 Aug 1975	"	"	*Calanoid copepod A size: 1.1 mm	refer to preceding sample	
25	Red Phalarope	Juv	23 Aug 1975	Barrow Spit, Chukchi side	ocean gravel beach, shallow water	*Copepod: Calanus glacialis Euphausiid	Barnacle cyprids Decapod zoea A Chaetognath: Sagitta elegans Calanoid copepods Barnacle nauplii Hydromedusa: Aglantha digitala Fish Euphausiid	650 230 160 80 50 30 1 1
26	Red Phalarope	Juv	31 Aug 1975	Plover Spit, Elson side, Barrow	open lagoon gravel beach, shallow water	*Chaetognath: Sagitta elegans Calanoid copepods: >2 mm Calanoid copepods: <2 mm Barnacle cyprid	Chaetognath Copepods: <2 mm Barnacle cyprids Copepods: >2 mm Ctenophores	400 400 90 30 2
27	Red Phalarope	Juv	31 Aug 1975	Plover Spit, Elson side, Barrow	open lagoon gravel beach, shallow water	*Chaetognath: Sagitta elegans Copepod: Calanus sp. >2 mm Decapod zoea A	Copepods <2 mm Chaetognaths Barnacle cyprids Copepods >2 mm Ctenophores, hydrozoans	450 170 130 12 7

Sample no.	Species	Age class	Coll. date	Location	Habitat	Food Items	Plankton or Infaunal Samples	
28	Red Phalarope	Juv	19 Aug 1975	Barrow Spit, Chukchi side	ocean gravel beach, shallow water	Euphausiid (1)		
29	Red Phalarope	Juv	19 Aug 1975	Barrow Spit, Chukchi side	ocean gravel beach shallow water	Chaetognaths (3)	Copepods Barnacle cyprids Chaetognaths Ctenophores Decapod zoea	10 10 5 5 5
30	Red Phalaraope	Juv	13 Aug 1975	Kolovik Slough, Lonely	low salinity pool	Cladoceran ephippea size: 1.0-1.5 mm Cladoceran adults size: 2 mm		
31	Sabine's Gull	Juv	20 Aug 1975	Chukchi Sea, Barrow	ocean, 50 m from gravel beach	Fish		
32	Sabine's Gull	Ad	30 Aug 1975	Plover Spit, Elson side, Barrow	open lagoon, 1 m from gravel beach	*Chaetognaths (580) Calanoid copepod (1)	Barnacle cyprids Copepods <2 mm Chaetognaths Copepods >2 mm Ctenophores Sipunculid Annelid	310 65 61 22 2 1 1
33	Arctic Tern	Juv	14 Aug 1975	Beaufort Sea, Lonely	ocean, 3 m from gravel beach	*Euphausiid: *Thysanoessa raschii* Amphipods: *Paramethisto libellula* and *Paramethisto abyssorum* Copepod		
34	Arctic Tern	Juv	20 Aug 1975	Chukchi Sea, Barrow	ocean, 50 m from gravel beach	Fish		

Table 6. Food Items: Observations

Observation no.	Species	Date	Location	Habitat	Probable Food Items
1	Semipalmated Plover	9 Jun 1975	Britton area, Barrow	low salinity pools, mud	Oligochaetes
2	Semipalmated Plover	11 Aug 1975	"	"	Oligochaetes and/or Chironomids
3	Pectoral Sandpiper	30 Jul 1975	North Salt Lagoon, Barrow	low salinity closed lagoon	Chironomid emerging adults
4	Baird's Sandpiper	4 Aug 1975	Barrow Spit, Elson side	low salinity pool	"
5	Dunlin	4 Aug 1975	"	"	"
6	Dunlin	30 Jul 1975	North Salt Lagoon, Barrow	low salinity, closed lagoon	Chironomid emerging adults
7	Sanderling	12 Jun 1975	Chukchi Sea, Barrow	ocean gravel beach	Amphipod: *Paramethisto libellula* (dead)
8	Sanderling	20 Aug 1975	Elson Lagoon shore	open lagoon, mud-sand beach	Diptera larvae at decaying mammal carcass
9	Semipalmated Sandpiper	4 Aug 1975	Barrow Spit, Elson side	low salinity pool	Chironomid emerging adults
10	Semipalmated Sandpiper	30 Jul 1975	North Salt Lagoon, Barrow	low salinity, closed lagoon	"
11	Red Phalarope	4 Aug 1975	Barrow Spit, Elson side	low salinity pool	"
12	Red Phalarope	30 Jul 1975	North Salt Lagoon, Barrow	low salinity closed lagoon	"
13	Arctic Tern	1 Aug 1975	Nunavak Bay, Barrow	ocean estuary	Fish

a given time period, several species may prey upon the same category of food items, as adult chironomids near brackish pools August 3 and 4 (ruddy turnstone, Baird's sandpiper, semipalmated sandpiper, red phalarope); chironomid larvae on low salinity estuary mudflats August 5 and 25 (semipalmated sandpiper, dunlin, long-billed dowitcher); planktonic crustacea on or near ocean gravel beaches August 13-23 (ruddy turnstone, sanderling, red phalarope).

Most of these conclusions are based upon too few samples to assess accurately the range of foods taken by species, or the differences between species feeding in littoral habitats. Efforts in this direction will continue in future seasons. Nevertheless, data for red phalaropes during the 1975 season suggest seasonal trends in prey exploited by this species. During the movement of male red phalaropes in late July and early August, the important food source appears to be late emerging adult chironomid flies along low salinity littoral areas (inner shores). Near the end of this movement, and as juveniles became common in early to mid-August, a shift to outer shores became evident, and plankton became the important food source for juveniles storing energy in preparation for migration. The large number of phalaropes feeding in Middle Salt Lagoon during mid-August were also plankton feeders, taking a small calanoid copepod at a very high rate.

From the comparison of actual prey in stomachs with available prey in plankton samples, some conclusions regarding prey selection by red phalaropes are possible. From the single taxon prey base in Middle Salt Lagoon August 20 (samples 23, 24) larger individuals appear to be selected. This has not been tested statistically. Selection for large size prey also seems to occur in the presence of more diverse prey communities (samples 19-22, 25) except that large chaetognaths, fairly common in the plankton samples, were almost absent from stomachs. Differences in nutritional value between chaetognaths and crustaceans, especially oil-rich copepods, may account for this selection of the latter groups. However, an individual collected August 31 (sample 26) had been preying principally upon chaetognaths, and a Sabine's gull taken at the same site the previous day (sample 32) was clearly selecting these prey.

Two Sabine's gulls and two arctic terns were collected, since these species frequently fed together with red phalaropes in near-shore waters in August, the three species occasionally forming dense mixed foraging aggregations with black-legged kittiwakes. These minimal samples establish that both fish and invertebrates figure within Sabine's gull and arctic tern diets.

Finally, we should remark on the unusual prey observed for a small flock of sanderlings foraging on open patches of gravel beach in early June (Table 6, sample 7). These birds were searching through beach debris recently uncovered by melting ice, and were occasionally taking dead amphipods probably deposited on the beach by storms during the preceding autumn.

VIII. Conclusions

A striking characteristic of the coastal tundra ecosystem is the pronounced annual variation in environmental conditions which cause significant fluctuations in the timing and magnitude of biological events from year to year. Results from the first year of this study, therefore, do not permit more than tentative conclusions, to be amplified and adjusted as investigations during subsequent seasons dictate.

In general, four periods of shorebird littoral zone use can be recognized. Differences in seasonal importance of shoreline areas must be viewed in light of seasonal changes in littoral habitat availability to shorebirds. Since the ocean shorelines are free of ice for only a relatively brief period in late summer, heavy use of these habitats cannot be expected in early summer. Nevertheless, in early and middle June at Barrow, pre-breeding adults of a few species, especially sanderlings, Baird's sandpipers, and semipalmated plovers, occur in early-opening gravel and mud areas on some beaches and at pools near lagoons. At the end of June and in early July, a movement of non-breeding birds of several species and post-breeding adults of a few species (especially male pectoral sandpipers and female red phalaropes, which have completed their breeding participation) occurs, with flocks and individuals utilizing habitats at the edges of small lagoons and nearby brackish pools.

As young birds fledge in late July and early August, adults of both sexes of most species are released from parental duties, and these flocking adults, beginning their southward migration, move into littoral areas. At Barrow in 1975, heaviest use began at mud margins of small inner lagoons, tidal sloughs, and brackish ponds. Prey of most species were chiefly larvae and late emerging adults of dipteran insects.

The phase of heaviest use of littoral areas occurred during the entire month of August, stretching into September for some species. Juveniles left the tundra areas where they had fed before fledging and flocked in littoral habitats, beginning their southward movements independently of, and later than, the adults. Types of littoral habitats used, diet, and duration of this period varied between species, and the importance of littoral habitats also must vary between species.

These movements of adult and juveniles to littoral zone foraging areas precede migration and therefore it is probable that this phase in the cycle of annual activities represents an important and possibly critical period of energy storage to meet the demands of migration. For inexperienced and presumably less efficient juveniles, especially, a high level of energy reserve in the form of deposited fat is probably a critical factor in determining survival during migration.

It is possible that densities of some species in littoral habitats near Barrow are affected by the unique geographical position of Point Barrow, but movements of most species here seemed to correspond with movements observed near Wainwright and Lonely. The behavior of red phalaropes along outer shores in August with respect to changing wind conditions suggests the strong possibility that migratory populations of this species should favor the Point Barrow area over other mainland shores. For the same reason, barrier islands, which also provide a protected shore under most wind conditions, should be attractive to this species and to Sabine's gulls and black-legged kittiwakes, which often forage and respond to wind direction in a similar manner.

Implications of these conclusions with respect to OCS petroleum development were discussed in Part I, Summary.

IX. Needs for Further Study

We consider the 1975 summer season's work to be a successful first look at a fairly complex and potentially highly variable situation. The extreme annual variation shown by many biological events in the arctic is especially noticeable in the breeding densities and distribution of several species of shorebirds and lemming predators. Therefore, a single season population density and distributional study of these species should be regarded as an initial reconnaissance and only the first step in a long-term baseline study. We feel that the wide variety of littoral habitats near Barrow and the relative ease of logistics provided by NARL argue in favor of continuation of these intensive studies primarily at the Barrow study area. Concurrent measurement of population densities on the nearby tundra has proved extremely valuable in interpretation of littoral zone events, and should be continued. In fact, it would be valuable to have information regarding densities and movements well inland from the coast through the entire season.

In addition to these intensive studies, it has become clear that more area-extensive information is required to assess the generality of results obtained at Barrow, and to understand the coastal movements of these birds over large areas of the Alaskan arctic coast. In particular, barrier islands should be visited during the period of major juvenile movement in August. We plan to increase our attention to other areas over a larger distance scale this season, and are working to optimize the usefulness of information gathered by other researchers.

Diet studies must be continued, including studies of the relationship between prey selected and prey available, and of prey densities in response to variation in wind, surf, ice conditions, and season, within different habitats. Information about the relative nutritional value (caloric content) of different invertebrate prey, not easily obtained within our study, would be helpful in interpreting our results. One particular aspect of shoreline foraging especially intrigues us. Throughout August, sporadically and locally, assemblages of gulls, terns, and phalaropes have been observed foraging within small areas, usually 10-200 m offshore. We suspect locally high concentrations of fish or invertebrates such as under-ice amphipods are responsible, but do not know what factors influence these phenomena.

To better interpret the dependence of species on littoral habitats, we need to understand their migration routes before and after their passage through the Barrow area, since different migration routes and rates of travel influence the energetic requirements of birds which the littoral zone must supply. The migratory routes chosen and the degree of use of littoral areas in the spring may be determined for some species in part by the comparative phenology of melting between shoreline and tundra habitats throughout western Alaska. Observations by other researchers which reflect on these conditions and events will be helpful in interpreting the dependence of shorebirds on littoral habitats throughout the arctic.

X. Fourth quarter operations.

1. Field Schedule.

No field activities during this quarter.

2. Scientific party.

Dr. Peter G. Connors, University of California Bodega Marine Laboratory, research coordinator.
Mr. Russell Greenberg, University of California, Berkeley, research assistant.

3. Methods.

Laboratory analysis:

(1) Summary and computer plotting of shorebird seasonal distributions.

(2) Computer statistical analysis of foraging microhabitat data.

(3) Final analysis and identification of invertebrates in stomach samples.

(4) Interpretation of results and preparation of annual report.

4. Sample localities.

None

5. Data analyzed.

(1) Analysis of 154 microhabitat data sets.

(2) Analysis and identification of 63 invertebrate samples.

XI. Appendix: Published studies of shorebird ecology near Barrow, Alaska.

Holmes, R. T. 1966 Breeding ecology and annual cycle adaptations of the red-backed sandpiper (Calidris alpina) in northern Alaska. Condor, 68: 3-46.

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Holmes, R. T., and F. A. Pitelka 1964 Breeding behavior and taxonomic relationships of the curlew sandpiper. Auk, 81: 362-379.

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Norton, D. W. and U. N. Safriel 1971 Homing by nesting semipalmated sandpipers displaced from Barrow, Alaska. Bird Banding, 42: 295-297.

Norton, D. W. 1973 Ecological energetics of calidridine sandpipers breeding in northern Alaska. Ph.D. Dissertation, University of Alaska, Fairbanks. 163 pp.

Pitelka, F. A. 1959 Numbers, breeding schedule and territoriality in pectoral sandpipers of northern Alaska. Condor, 61: 233-264.

Pitelka, F. A. 1974 An Avifaunal review for the Barrow region and north slope of arctic Alaska. Arctic and Alpine Res., 6: 161-184.

Pitelka, F. A., R. T. Holmes, and S. F. MacLean, Jr. 1974 Ecology and evolution of social organization in arctic sandpipers. Amer. Zool., 14: 185-204.

XI. Literature cited.

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Carter, L. J. 1976 Oil drilling in the Beaufort Sea: leaving it to luck and technology. Science 191: 929-931.

Green, R. H. 1971 A multivariate statistical approach to the Hutchinsonian niche: bivalve molluscs of central Canada. Ecol. 52: 543-556.

Holmes, R. T. 1966a Breeding ecology and annual cycle adaptations of the red-backed sandpiper (*Calidris alpina*) in northern Alaska. Condor 68: 3-46.

Holmes, R. T. 1966b Feeding ecology of the red-backed sandpiper (*Calidris alpina*) in arctic Alaska. Ecology 47: 32-45.

James, F. C. 1971 Ordinations of habitat relationships among breeding birds. Wils. Bull. 83: 215-236.

Nettleship, D. N. 1973 Breeding ecology of Turnstones *Arenaria interpres* at Hazen Camp, Ellesmere Island N.W.T. Ibis 115: 202-217.

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XIII. Research Personnel, 1975 Season

Peter G. Connors, research coordinator

Russell Greenberg, research assistant

Carolyn S. Connors, research assistant

Frank A. Pitelka, consultant

J. Peterson Myers, consultant

James T. Carlton, consultant

Robert W. Risebrough, consultant

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AVIFAUNAL UTILIZATION OF THE OFFSHORE ISLAND AREA NEAR PRUDHOE BAY, ALASKA

George Mueller, Director
Marine Sorting Center
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701
SS#: 534-40-9671

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ANNUAL REPORT

I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

The objective of this study is to document changes in numbers and activity patterns of avifauna over time and space. This study was restricted to a 10.2 km^2 area surrounding Egg Island, Alaska. Mean densities were greatest on 24 June (171 birds/km^2) and on 20 July (148 birds/km^2) These figures correspond to the peaks of spring and summer migration, respectively. Spring migration is concentrated almost entirely at sea. The bay is used increasingly by birds from early July through August. The most numerous birds in the area (Common Eiders, Somateria mollissima: King Eiders, Somateria spectabilis, and Oldsquaw, Clangula hyemalis) are all highly susceptible to oil spills. Common Eiders and, to a lesser extent, King Eiders breed on Barrier islands. Oil development on these islands could interfere with nesting. Oil spills during the summer could adversely affect a significant number of birds.

II. Introduction

A. General nature and scope of study

This study was designed to provide supplemental data on bird numbers and use of barrier islands, in conjunction with a more intensive study of breeding birds on a single island (Schamel 1974).

B. Specific objectives

The main objectives of this study are to document:

1. Seasonal numerical changes
2. Daily and seasonal trends in spatial distribution
3. Diurnal activity patterns

III. Current state of knowledge

Only two studies have dealt with the bird utilization of the offshore islands along the Beaufort Sea coast (Schmidt 1970, Schamel 1974). Numbers of eiders using this coast have been estimated at Barrow, Alaska (Thompson and Person 1963, Johnson 1971) and in Canada (Barry 1960, 1968). Flock (1973) has used radar to describe the temporal and spatial aspects of spring migration at Barrow and Oliktok, Alaska. Bergman (1974) studied breeding waterbirds on the tundra immediately inland from the site of the present project. Bartels (1973) reported aerial surveys along the Beaufort coast.

IV. Study area

Egg Island, Alaska, is a barrier islet located at 70° 26' N and 148° 43' W, on the Beaufort Sea coast (Fig. 1). It lies 8 km northwest of Prudhoe Bay and 4 km northeast of the Kuparuk River delta, an area mentioned by Anderson (1913) as supporting large colonies of breeding eiders on sandspits. During a preliminary survey of islands in this area in July 1971 Egg Island was found to have the greatest concentration of nesting eiders.

The island is relatively small (7.5 ha) and flat (maximum elevation: 1.7 m) and is comprised of sand and gravel. Vegetation is extremely sparse, both in species and coverage. Only four species were found: Honckenya peploides (Sandbeach Sandwort), Mertensia maritima (Oysterleaf), Elymus arenarius mollis (Lyme Grass), and Puccinellia phryganodes (Alkali Grass). Overflow water from the break-up of the Kuparuk River inundates low areas of the island, creating temporary ponds. These are utilized for loafing, bathing, and drinking by eiders and other birds until July, when the ponds disappear.

During the winter and early spring, the island is icebound. After spring break-up the north shore becomes susceptible to the action of waves and ice. The extreme instability of Egg Island was first noted by Leffingwell (1919); erosion washed away his beacon in less than 3 years. Two half-buried oil drums indicated that major changes are still occurring. Although tide fluctuations for this area average 15 cm, changes in wind direction and velocity can cause noticeable variations in water level. The influences of wind, ice, and currents constantly rework the island during summer and fall. These probably have the greatest long-range impact on the size and shape of the barrier islands. Fall storms are capable of effecting very rapid and short-term changes (Hume and Schalk 1967). As storm water recede, scattered sticks and logs are left behind. This material, important to nesting eiders, is deposited at a higher elevation than the high tide mark of late spring and summer, when storms are rare.

In addition to Common Eiders, King Eiders, Arctic Terns (*Sterna paradisaea*), Glaucous Gulls (*Larus hyperboreus*), and Black Brant (*Branta nigricans*) nested on Egg Island.

V. Sources, methods and rationale of data collection

This study is based upon information gathered during the summer of 1972. Two observers were based on Egg Island, Alaska from 20 May through 12 August. Census data were collected from 12 June through 7 August using a 20X spotting scope from an elevated blind. All birds within a 1.8 km radius were identified (when possible) with respect to species, sex, location, and activity and then recorded. The count required two individuals: one observed and dictated while the other recorded the information on data sheets. Eighty-four hours of census and activity data are stored on computer tape.

VI. Results

The average number of species seen during an observation period increased from 12 June through 17 June (8 to 11 species). This figure then decreased on 18 June (8 species) and remained at this level until 10 July. From 11 July to 7 August, the average number of species dropped from 7 to 3.

Bird numbers peaked on 24 June (1750 individuals, 171 birds/km^2). Numbers then dropped to about 500 individuals (49 birds/km^2). From 1 July through 7 August, bird numbers generally fluctuated between 600 (59 birds/km^2) and 1100 (108 birds/km^2) individuals. They showed a general increase over this period.

The distribution of birds (sea, island, and bay) has also been examined. Bird numbers in the sea show a bimodal distribution seasonally. The peaks of 1675 (316 birds/km^2) and 840 (158 birds/km^2) occur on 24 June and 20 July, respectively. By August, the number of birds seen at sea had dropped to 100-200 (19-38 birds/km^2). Bird numbers on the islands also showed two peaks, one on 9-10 July (113 individuals, 565 birds/km^2) and one on 7 August (119 individuals, 595 birds/km^2). Less than 100 birds (21 birds/km^2) were seen in the bay until 5 July. After this time, numbers increased steadily through early August (to about 700 individuals, 149 birds/km^2).

Several species occurred in large numbers, at least seasonally, or were ubiquitous. These include: the Yellow-billed Loon (*Gavia adamsii*), Arctic Loon (*Gavia arctica*), Red-throated Loon (*Gavia stellata*), Common Eider, King Eider, Oldsquaw, Glaucous Gull (*Larus hyperboreus*), and Arctic Tern (*Sterna paradisaea*). These species are being analyzed separately with respect to distribution over space and time.

At large distances and under adverse weather conditions, Arctic and Red-throated loons are difficult to identify. For this reason, all species of loons have been lumped into one category. More loons used the sea ($\bar{x}$=8.3, 1.6 loons/km^2) than the bay ($\bar{x}$=2.6, 0.6 loons/km^2). This relationship is not significant (X^2=2.5, $0.10<P<0.25$). Although numbers of loons in the study area fluctuated with the time of day, their preference of habitat did not. More loons were almost always seen at sea. On a seasonal basis, loon numbers peaked on 16 June (40 individuals) and thereafter decreased steadily. On 7 August, only one loon was observed in the study area.

Common and King eiders showed similar trends over both time and space and will be considered together. Their numbers rose dramatically, peaking on 19 to 22 June (Common Eider: ca. 146, 14 birds/km^2; King Eider: 365, 36 birds/km^2), then decreased rapidly. By 27 June, only 29 Common (3 birds/km^2) and 141 King (14 birds/km^2) eiders were seen. Numbers continued to decrease, though more slowly, throughout the remainder of the season. On 7 August, no birds of either species were seen. The eiders, like the loons, were most numerous in the sea. Only a small number (usually less than 20 of each species, 4 birds/km^2) were found in the bay. Numbers of eiders on the island gradually increased through the first week of July, leveled off at about 15 Common (75 birds/km^2) and 5 King (25 birds/km^2) eiders through mid-July, then decreased to zero by August.

Oldsquaw seem to show three separate influxes of birds. The first is a gradual increase from 12 June ($\bar{X}$=0.4, 0.04 birds/km^2) to 22 June ($\bar{X}$=126.5, 12 birds/km^2). The second is a rapid increase from 27 June ($\bar{X}$=35, 3 birds/km^2) to 3 July ($\bar{X}$=428, 42 birds/km^2), with numbers decreasing to 268 (26 birds/km^2) by 12 July. The influx started on 16 July ($\bar{X}$=629.7, 62 birds/km^2) and fluctuated at large numbers through 7 August ($\bar{X}$=1056.9, 104 birds/km^2). Until 1 July, few Oldsquaw were seen anywhere but the sea. After this date, their numbers in the bay grew steadily through 7 August, at which time 778 (166 birds/km^2) were counted here. Meanwhile, their numbers in the sea fluctuated strongly during July and diminished by 7 August (160 individuals, 30 birds/km^2). The number of Oldsquaw on the island peaked on 10-12 July (ca. 60, 300 birds/km^2) and again in early August (ca. 100, 500 birds/km^2).

Summaries for Glaucous Gulls and Arctic Terns have not yet been compiled. Information on activity patterns is not available at the time of this writing.

Figures to accompany the results outlined above have not been prepared in their final form. They can be made available, in rough form, to other Principal Investigators upon request.

VII. Discussion

The peak of both numbers of species and individuals in mid-June corresponds with the end of spring migration. During this time, many birds are moving laterally along the coast, from west to east. The decrease in numbers of species using the island area may be attributed, in large part, to the absence of loons during late summer.

Following a sharp decrease in total bird numbers in late June, this figure again increases. This is due primarily to the large influx of Oldsquaw into the study area. According to Bergman (1974), most of the male Oldsquaw in this area have moved to the coast from inland breeding areas by 14 to 21 July. This agrees well with the data presented here.

Although more open water is available in the bay than in the sea in early June, the vast majority of birds are found at sea. This probably is related most strongly with food availability. In arctic waters, species diversity, numbers, and biomass all tend to increase with increased water depth (Ellis and Wilce 1961, Sparks and Pereyra 1966, Crane and Cooney 1973, Feder and Schamel, in press). The Gwydyr Bay is quite shallow (maximum depth: ca. 2.5m) while the corresponding section of the Beaufort Sea is at least twice as deep. The differential habitat use by birds may also be related to the migratory pathways of the birds. At Oliktok, approximately 30 km west of the study area, Flock (1973) recorded many birds migrating at sea during early June of the same year.

The peaks of bird numbers on the islands in mid-July and early August corresponds with : (1) the peak of the incubation period by eiders and (2) molting Oldsquaw resting on the island, respectively. The number of birds using the island in mid-July is greater than the number of incubating birds. This is due to the presence of immature or failed-breeding females.

The steady rise in bird numbers inside the barrier islands is due primarily to an influx of Oldsquaw. By late July, most of these birds are molting. They are closely associated with the islands, feeding on both the seaward and bay sides, as well as in the tidally-affected areas between the islands.

The disappearance of loons from the study area in late July and

August may relate to the breeding stage of these birds. At this time, the eggs are beginning to hatch (Bergman 1974) and the parents must attend the broods closely. Inland lakes are rich with invertebrates at this time and lengthy trips to the coast to procure food may be prohibitive.

VIII. Conclusions

Birds were present in the study area from our arrival on 20 May through our departure 12 August. Thompson and Person (1963) and Johnson (1971) recorded eider migration past Point Barrow through early September. Birds probably commonly occur in the study area from mid-May through late September.

Numerically, Common and King eiders and Oldsquaw were the predominant species in the study area. Eiders were most numerous during June and early July. They used primarily the sea for feeding and resting. Oldsquaw numbers increased steadily after 1 July. Until late July, these birds were about equally abundant in both the sea and bay. In August, they were more numerous in the bay.

IX. Needs for further study

This study establishes the numerical distribution of birds over space and time. No effort was made to examine why this distribution exists. This should be looked into. Such a study would require extensive and intensive sampling of prey items (invertebrates and fishes) to correlate with bird observations.

The present study is limited to a single, very small, area. Useful comparative information from other areas along the coast is limited to one study (Schmidt 1970). Additional census sites may prove valuable, even if data were limited in scope to seasonal counts (instead of daily or weekly).

X. Summary of 4th quarter operations

A. Ship or laboratory activities

1. Ship of field trip schedule

N.A.

2. Scientific party

N.A.

3. Methods

See "Methods" section of this report.

4. Sample localities

N.A.

5. Data collected or analyzed

a. Number and types of samples/observations

N.A.

b. Number and types of analyses

See the section pertaining to loons in this report.

c. Miles of trackline

N.A.

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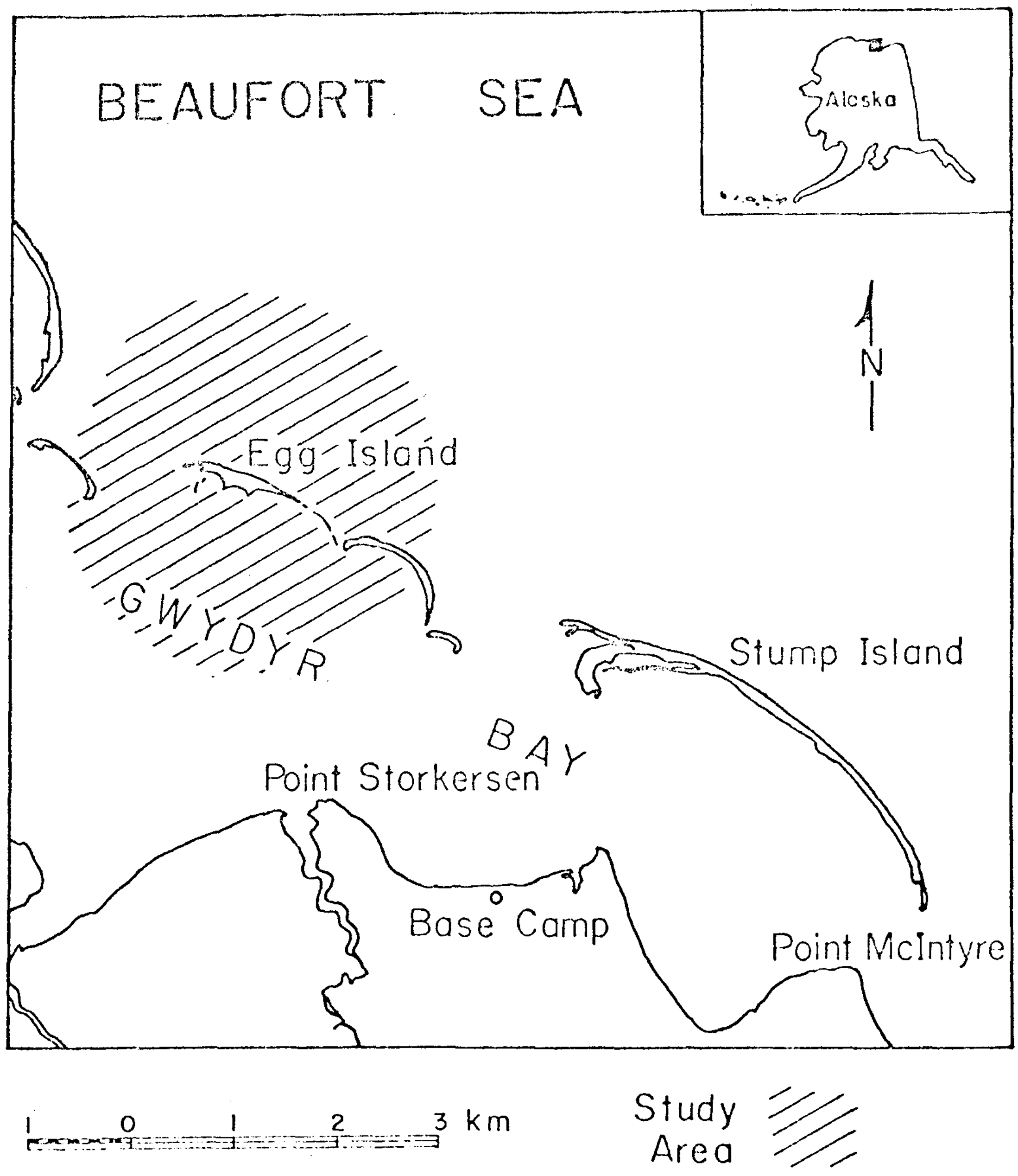

Figure 1. Map of study area.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 11 R.U. NUMBER: 215

PRINCIPAL INVESTIGATOR: Mr. George Mueller

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Dat nagement Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 11

PRINCIPAL INVESTIGATOR: Mr. George Mueller

Period April 1, 1975 - March 31, 1976* (12 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	1,202.00	-0-	1,202.00
Staff Benefits	204.00	-0-	204.00
Equipment	-0-	-0-	-0-
Travel	-0-	-0-	-0-
Other	1,850.00	1,237.94	612.06
Total Direct	3,256.00	1,237.94	2,018.06
Indirect	688.00	-0-	688.00
Task Order Total	3,944.00	1,237.94	2,706.06

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 215 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Project Title:	Avifaunal Utilization of the Offshore Island Area Near Prudhoe Bay, Alaska
Contract Number:	03-5-022-56
Task Order Number:	11
Principal Investigator:	Mr. George Mueller

I. Task Objectives

The main objectives of the present study are to document:

A. Seasonal numerical changes by species and sex.
B. Daily and seasonal trends in spatial distribution, by species and sex.
C. Diurnal activity rhythms, by species and sex.

II Field and Laboratory Activities

None.

III. Results

Seasonal numerical changes of three key species have been determined and graphed. Seasonal trends in spatial distribution for these same three species have been determined and graphed. Programming for the remaining analyses is underway and should be completed soon.

IV. Problems Encountered

None.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 11 R.U. NUMBER: 215

PRINCIPAL INVESTIGATOR: Mr. George Mueller

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data management plan was submitted to NOAA in draft form on October 9, 1975 and University of Alaska approval given on November 20, 1975. We await formal approval from NOAA.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 11

PRINCIPAL INVESTIGATOR: Mr. George Mueller

Period April 1 - December 31, 1975* (9 mos)

	Total Budget	Expended	Remainin
Salaries & Wages	1,202.00	-0-	1,202.00
Staff Benefits	204.00	-0-	204.00
Equipment	-0-	-0-	-0-
Travel	-0-	-0-	-0-
Other	1,850.00	5.94	1,844.06
Total Direct	3,256.00	5.94	3,250.06
Indirect	688.00	-0-	688.00
Task Order Total	3,944.00	5.94	3,938.06

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

NOAA OCSEAP
Contract No. 03-5-022-77
Research Unit No. 237

SEABIRDS ON THE SOUTH SHORE OF SEWARD PENINSULA, ALASKA

PRINCIPAL INVESTIGATOR

William H. Drury
College of the Atlantic
Bar Harbor, Maine 04609

March 1976

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS.

A. The objectives of our task include 1) to learn the species composition, the numbers, the schedule of breeding, the reproductive success, and the food of the seabirds breeding on the south shore of the Seward Peninsula in northwestern Alaska; 2) to record the regional and annual variations in these biological characteristics; and 3) to use these data to understand the structure and operation of the biological communities of which these seabirds are a part.

B. Our major conclusions are as follows:

1) The seabird cliffs at Bluff are critical to the maintenance of the seabird populations of Norton Sound.

2) The species composition of the seabird colonies in Norton Sound differ in major ways from those in the Chirikov Basin to the west.

3) Reproductive success in the species we studied appeared to be low.

4) The birds at Sledge Island and Bluff Cliffs largely depend upon a very narrow food base -- two species of fish (*Ammodytes hexapterus* and *Lumpenus sagitta*). The dozen or more additional fish species found were used only to a minor degree.

5) It may be possible to use measurements of the breeding success of kittiwakes as an assay of the general level of breeding success of the other seabirds on a nesting cliff in order to expend a minimum of time in a monitoring program. Further tests are needed. (See Section IX -- Needs for further study.)

C. Implications with regard to OCS oil and gas development.

1) Our observations suggest that materials released into Norton Sound can be expected to move westward along the south shore of Seward Peninsula collecting in sheltered bays. These sheltered areas are frequented by seafowl. Materials can be expected to move from the Yukon Delta and Norton Sound northwest into the Chirikov Basin, but not in the reverse direction.

2) Cormorants, murres, auklets and puffins are very vulnerable to oil spills. Gulls appear to be relatively invulnerable. Several of the endemic seabird species of the Bering Sea (auklets and murrelets) are especially vulnerable.

3) Seabirds gather at breeding cliffs and would be very vulnerable to oil spills there. Ninety percent of the seabird population of Norton Sound gathers in front of the cliffs at Bluff and Cape Denbigh during June, July and August. A spill at Bluff could kill a third or a half of the seabirds of Norton Sound. Seabirds also concentrate over shoals of food fishes.

4) The seabirds of the area have a number of special social values. The Bering Sea has not only one of the highest seabird and waterfowl species diversities in the world but has one of the world's largest seabird populations. The entire world's population of Red-faced Cormorants, four species of auklets, Kittlitz's Murrelets and Red-legged Kittiwakes are limited to western Alaska. Peregrines, an endangered species of special social significance, nests on the seabird cliffs in the Bering Sea.

5) As regards the secondary effects of oil development, our observation that the cliffs at Bluff have persisted while closely associated with

a large gold-mining operation suggest that if proper precautions are taken to avoid destructive activities, seabirds can coexist with economic development. Land use and habitat planning for the Norton Sound-St. Lawrence Island waters, Chirikov Basin, and Bering Strait can and should include guarantees for the persistence and health of the seabird cliffs as a resource whose values must inescapably increase in the future.

II. INTRODUCTION

A. General nature and scope of the study.

The goal is to learn the seabird species composition, their distribution at different times of year and their feeding biology so as to assess present conditions and to predict the impact of development. Given sufficient knowledge and the will to do so on the part of governmental administration we should be able to mitigate undesirable secondary effects of oil development.

B. Specific objectives.

1) Determine seasonal density, distribution and breeding locale for principal seabird species.

   a) Establish species numbers and schedule of reproduction.

   b) Compare species and numbers at major seabird colonies (for 1975 at Sledge, Topkok, Bluff, Cape Denbigh, and Egg Island).

2) Describe dynamics and trophic relations of selected species.

   a) Measure reproductive success (for 1975: Pelagic Cormorant, Glaucous Gull, Black-legged Kittiwake, and Common Murre).

   b) Determine where nesting seabirds feed and what food they bring to their young.

   c) Examine whether the relatively even distribution of fish-eating murres, puffins and kittiwakes, in contrast to the concentrated distribution of auklets in the St. Lawrence Island water, Chirikov Basin-Bering Strait area, is coincidental or related to the characteristics of these water masses and their trophic structures in a cause-and-effect way.

3) Predict the effects upon seabird populations of contamination and disturbance associated with proposed mineral development.

C. Relevance to problems of petroleum development.

We need to have answers to the following questions (among others) in order to assess the possible impact of oil development, to estimate its social effects and to suggest ways to allow development to be compatible with a wide spectrum of social values. The research undertaken will be relevant to the problems of oil development to the degree that it supplies answers to these questions.

1) If oil spills occur in the Norton Sound-Chirikov Basin area, where will the oil move and collect? How fast and under what conditions will it congeal into "chocolate mousse" -- a condition in which oil is less damaging to waterfowl?

2) What species of waterfowl and seafowl are especially vulnerable to oil spills? Where and under what conditions are they vulnerable?

Where are major seafowl resources concentrated at the several seasons: on arrival in early spring; when breeding and feeding young; when migrating and when wintering?

3) What species are perceived as having significant social importance to humans?

4) What impacts are oil development and its secondary effects (such as onshore and at sea construction, transportation and oil spills) likely to have on the seafowl and their food resources? What species are most vulnerable to human disturbance associated with oil development? Where are they vulnerable and under what circumstances?

5) What levels of coexistence of seafowl and development are possible? What constraints or what standards of performance might be set to ensure survival of seafowl resources during development?

III. CURRENT STATE OF KNOWLEDGE.

A lot is already known about the relation of the seafowl fauna to the oceanographic structure of the northern Bering Sea:

A. Patterns of distribution of the seabirds of the northern Bering Sea.

Shuntov's work on seabirds and our observations so far suggest that a striking contrast exists in the density and kinds of seabirds in the Chirikov Basin and Norton Sound. The density of seabirds is, according to Shuntov, very much higher in the Chirikov Basin. According to available information, the predominant species of murre there is the Thick-billed Murre, while the predominant murre in Norton Sound is the Common Murre. In addition there are large numbers of Least Auklets, Crested Auklets and Parakeet Auklets in the Chirikov Basin while these auklets are virtually absent from Norton Sound. There appears to be a more or less even distribution of the remaining species: Pelagic Cormorants, murres, puffins, kittiwakes and Glaucous Gulls. However, the murres and kittiwakes are very much more numerous than the other three species -- cormorants, puffins and Glaucous Gulls.

B. Relation of trophic structures to geographic distributions (review of published material).

Several sets of facts may be relevant to the marked difference in distribution of auklets as compared to the kittiwakes, murres and puffins. First, the kittiwakes, Common Murres and puffins feed upon fish. Thick-billed Murres are reported to feed somewhat more frequently on zooplankton than do Common Murres. The three species of auklets are primarily plankton feeders (Copepods, Euphausids and Amphipods). I can find little about the distribution and abundance of the primary bait fishes in the northern

Bering Sea, but according to material published in "The Oceanography of the Bering Sea", the distribution of zooplankton corresponds to the pattern of distribution of auklets and predominance of Thick-billed Murres. Zooplankton is dense off the Pribilof Islands (a center of auklet breeding) and in the St. Lawrence Island waters, and is less than half as dense in the Norton Sound area. Further indication of rich biological productivity is given by the exceptionally high density of benthos in the Chirikov Basin. In the southeastern part of the Bering Sea continental shelf (Bristol Bay), it has been reported that zooplankton are much more abundant in the waters offshore with higher salinity and less abundant in the waters dominated by fresh water runoff. In that area apparently salmon smolt when they go to sea move rapidly through the low salinity areas and begin to feed where zooplankton density increases. It seems presumptuous to refer to Coho Salmon smolt as bait fish, but murres and puffins are known to occur in large numbers in the same waters where the salmon begin to feed.

C. Relevant aspects of physical and chemical oceanography (review of published material).

The area of study -- the northeastern continental shelf waters of the Bering Sea (including Norton Sound, the Chirikov Basin, and St. Lawrence Island waters) -- is shallow. Norton Sound is in general less than 10 fathoms deep (20 meters) and its waters are relatively warm, of low salinity; they have high partial pressure of CO_2 and are poor in nitrates.

The waters flowing out of the basin in the Gulf of Anadyr north past the western end of St. Lawrence Island into the Chirikov Basin (despite the fresh water flowing out of the Anadyr River) are cold, more highly saline, of low partial pressure of CO_2 and are nitrate rich. The western side of the area has high primary productivity, 600 mg C/m^2 - day which is balanced by an increased contribution of deep source water rich in both nitrate and CO_2.

In general there is an inverse relation between phytoplankton production (including the rate of nutrient uptake) and P CO_2. There appears to be a sharp drop in P CO_2 west of Nome (Gordon et al., 1973) along the line between Sledge Island and the eastern edge of St. Lawrence Island west of which is the sharp increase in numbers of auklets.

D. Currents and interactions among the water masses.

The north and northwest trending gravel spits on Sledge Island, at Point Spencer, and at Cape Prince of Wales suggest that the major translocation of sediments is northwestward out of Norton Sound into the Chirikov Basin and northward out of the Chirikov Basin through the Bering Strait. We could see a northwesterly current of one to two knots flowing past Sledge Island during June and July 1975.

Large driftwood logs are abundant all along the treeless southern shore of Seward Peninsula. These logs were presumably carried down the several rivers flowing into Norton Sound, especially the Yukon River. The distribution of these logs, together with what little is published about currents and sediment transport reported from Landsat photos, suggest that outflow of fresh water from the Yukon River may influence all of Norton Sound. The impact of fresh water should be especially large when spring freshets pour melt water into Norton Sound in early summer. One would expect this influx to affect the schedule of melt of sea ice, the turnover of the water column, and the presence of nutrients and oxygen. This dominance by fresh water should be especially powerful in a shallow body of water such as Norton Sound.

E. Water masses and productivity.

It is known that there is a peak of productivity and other biological activity at the edge of ice as the pack ice breaks up and retreats north in spring. It may be that the energy born in the oxygenated waters of the spring freshet coming out of the Yukon and Anadyr Rivers plays an important part in spring turnover and the turbulent flow of the waters in this northern Bering Sea region. The thrust of fresh Yukon water mass can be expected to displace westward the cold saline water flowing out of the Gulf of Anadyr. One might expect the result to be two rather well defined water masses. The areas where these water masses meet and the ensuing turbulence should be highly productive. It has been noted elsewhere (Hardy's work in the Antarctic) that where fresh melt water merges with up-welling cold salt water, high productivity occurs. Russians investigating the whaling grounds southeast of Cape Navarin have found that the whales gather where deep salt and surface fresh water masses sheet against each other. One expects and many observers have seen seabirds gather in such waters.

This discussion implies, at a minimum, that the events in Norton Sound and off the Yukon River will have effects in the waters well to the west. If these speculations are valid, then any pollution, such as oil spills which may occur in the Norton Sound area and the area between Sledge Island and St. Lawrence Island, can be expected to contaminate the Chirikov Basin and flow north through the Bering Strait.

IV. STUDY AREA

The area is shown in Figure 1. We made air surveys of the coast between Point Spencer and Teller (approx. 65°15'N and 166°30'W) on the northwest, and Egg Island and Klikitarik (approx. 63°30'N and 161°31'W) on the southeast. Our work was concentrated at two seabird cliffs -- Sledge Island (approx. 64°28'30"N and 166°12'-13'W) and the Bluff cliffs (approx. 64°33'30"N and 163°40'-45'W).

V. SOURCES, METHODS AND RATIONALE OF COLLECTING DATA.

We have reviewed published materials on the oceanography of the area and on the species of seabirds which we observed. Published information is available on the most important species -- Glaucous Gull, Black-legged Kittiwake, Common Murre, Thick-billed Murre, and Horned Puffin -- despite the fact that most of the data were gathered in geographical regions remote from the Bering Sea. The general outline of the biology of these species has been sketched.

Our own field work consisted of 1) censuses of species and their numbers at the cliffs, 2) observations at study sites to define the schedule of reproduction and to measure breeding success, and 3) observations of movements of birds and monitoring of the prey items brought in. We use these observations to define feeding areas and species used for food.

These observations are relevant to finding how large the seabird resource is, where it is concentrated, where it feeds, what resources it depends upon, and something of the structure of the biological communities of which the seabirds are a part. Hence we can interpret what species will be vulnerable to oil spills, where they will be, and why.

A. <u>Methods</u>

1) Surveys

a) Air reconnaissance was made of the major seabird nesting areas on Egg Island, Besboro Island, Cape Denbigh, Rocky Point, Square Rock, Bluff, and Sledge Island as well as small groups of nesting seabirds in between. Surface censuses were made of the seabird nesting areas at Bluff, Topkok and Sledge Island.

b) During travel, attempts were made i) to identify and count species observed, and ii) to discover why the areas were being used. While camped en route or at nesting cliffs, we made standardized 15-minute watches over the inshore waters. During these watches we recorded species present, their numbers, directions of flight, and feeding or other activities.

2) Studies at bird cliffs.

a) Censuses of the entire cliffs area were made by boat at different times of day and several times during the season (13 complete or partial censuses). During the period when eggs were being incubated, two complete photographic records of the cliffs at Sledge Island were made, and one complete record was made at Bluff. A photographic record was made of each study site at Bluff at three different times during the breeding season.

b) Study sites were established (two at Sledge Island and 14 at Bluff) where repeated counts and observations of all species present were made. The purpose of the observations was to establish the sequence of events in the breeding schedule. Counts were made of nests, their contents and, later in the season, the number of chicks that reached fledging age (that is, were ready to leave the nest) (320 visits). Additional counts were made from a spot overlooking the face of the main cliffs: of the birds at the cliffs, those flying to the cliffs, those flying away from the cliffs, those resting on the water, and those flying along the cliff face (23 counts at Bluff cliffs).

c) During each visit to the study sites, observations were made on birds seen carrying food or regurgitating it for their young. Special watches were made to look for food brought in, but it proved impractical this year to measure the time that individual birds were absent on feeding trips, or the frequency with which young were fed. Searches were made for food regurgitated for young and dropped on the ledges accessible from the beaches and lower cliffs (12 visits).

d) At five study sites, maps of the nests of kittiwakes were made and each nest assigned a number. The contents of each of these nests was recorded at regular intervals until the end of September (38 site visits).

e) Maps of the location of individual murres were made during August and a continuing attempt was made either to locate young or eggs or to locate adults in postures that indicated they were incubating an egg or brooding a chick. During the period when chicks were leaving the cliffs and going to sea, timed watches were made between sunset and dark at one site to count the number of chicks seen to leave a cove having about 150 meters of shoreline below the cliffs.

f) Counts of the numbers of puffins perched on cliff faces were made at the study sites and attempts were made to locate burrows where birds incubated or to which they brought food.

B. Data collected.

We spent parts of four days flying reconnaissance, made 26 trips in small boats, 20 trips censusing seabird cliffs by boat, 12 trips to cliffs collecting food samples (collecting a total of 48 fish samples). We carried out 63 15-minute watches for seafowl on the beaches. We made 320 visits to study sites including taking 17 samples for clutch-size and 38 checks of study areas where nests were mapped.

We took 60 irregularly spaced and timed samples of the proportion of adult kittiwakes to chicks on the cliffs at Bluff to measure reproductive success outside of study sites. We made surveys during about 300 miles of small boat travel, 300 miles of road travel, 1000 miles of reconnaissance in small aircraft, and about 200 miles on foot.

These mileages are for the party as a whole. Approximately half of the time three persons were involved in these watches, and during the other half four persons were involved.

VI. RESULTS

While most of the information is presented in the species accounts, a few general remarks may be helpful.

A. At the colonies.

1) Species composition and numbers.

Table 1 presents estimates of the numbers of breeding pairs at the breeding sites which we surveyed. Some species nest as a few individuals in widely scattered places while others aggregate into large "bazaars" of several different species.

In the estimates that follow we have given the lower and upper limits to the population size as we estimated them. We took photographs of the cliffs at Sledge and at Bluff in order to test our powers of estimating birds. We compared our visual estimates made on the site with a) estimates made by examining a mosaic of the cliff photographs, and b) with counts of the birds on the mosaic. The results were satisfactory for kittiwakes but unsatisfactory for murres. (Table 2)

We also asked two, and in a few cases four, observers to count or estimate the kittiwakes on given sections of the cliff in order to calibrate our observers.

The results we got from these exercises are similar to those we got under other tests made on Herring Gulls in New England:

TABLE 1. Estimates of breeding pairs -- seabird cliffs of Norton Sound.

	Pelagic Cormorant	Glaucous Gull	Black-legged Kittiw	Common Murre	Thick-billed Murre	Pigeon Guillemot	Horned Puffin	Tufted Puffin	Parakeet Auklet
Point Spencer		35							
Cape Douglas		75-90							
Feather River-Woolley									
Sledge Island	60-80	4	750-1000	750-1250	100-300	4	75-100	10	20
Quartz Cr.-Sonora Co.									
Cripple River									
Snake River									
Home River									
Safety Lagoon									
Washout									
Ferry									
Sunset-Sunrise		30							
Bonanza									
Taylor Lagoon									
Topkok Head	75-125	40				10	40-50	10-15	
Tonok Head	1	2			500-1000		5		
Bluff	20-25	30	4250-7250	30000-50000	500-1000		600-800	5-15	
Square Rock		4	800	1500-2500			100-150		
Rocky Point area	5-10	20	50						
Cape Darby	50	15	100-125						
Cape Denbigh	20-30	25	500-700	4000-5000					
Besboro Island	40-50	15					150-200		
North of Egavik	10-12						6-8		
Unalakleet									
Klikitarik		4					10-15		
Egg Island		4	200-300	750-1250			50-150		

TABLE 2. Comparison of field estimates, photo estimates, and counts on photographs.

Kittiwakes

Area -- Bluff between "Thumbstack" and "The Arches"

	3 July	1 August	Photo estimate	Count
Observer A	920	800		
Observer B	990			
Observer C		760		
Observer D			900	1225

Kittiwakes

Area -- Bluff "outer corner" to "low promontory"

	3 July	1 August	Photo estimate	Count
Observer A	500	640		
Observer B	450			
Observer C		430		
Observer D			530	810

Kittiwakes

Area -- Sledge Island

	20 June	23 July	Photo estimate	Count
Observer A	1250	950		
Observer B	970			
Observer C	1220-1260		1000	1210

Murres

	Counts - Cliff	Photo estimate	Count
Area A	6300, 7150, 9800	2800	3040
Area B	6200, 8050	900	1280
Area C	8050	110	141
Area D	6200	300	960
Area E	1485 (count)	200	360

a) Observers vary widely on any short section of cliff but their totals average out to be similar over a large sample.

b) Observers who get the largest counts are closest to correct.

c) The group we worked with was consistently 20-30% low in their estimates.

In the estimates for kittiwakes given in the tables and discussions which follow, we give as the minimum the smallest number estimated. The higher number, given as the probable upper limit, is the largest estimate made, +20%.

The results of a similar test for murres is less satisfactory in that our photographs show only a fraction of the murres estimated in the field. On several occasions in the field we estimated the number of birds on the cliff and then counted the birds by two's. Our estimates were generally 10-20% low. Without further work we conclude that the numbers of murres were low on the cliff when the pictures were taken. We did not estimate at the time we took the photographs.

Species composition of the murres could be sampled only at Sledge Island and at Bluff cliffs. At Sledge Island, 15% were Thick-billed Murres; at Bluff fewer than 2 in 100 murres were Thick-billed. The proportion of Thick-billed Murres was higher on small ledges and on outer faces. There were virtually no Thick-billed Murres on crowded, broad ledges or tops of stacks. Sheer rock faces 1) east of Chiukak and 2) west of Rocky Point supported perhaps 20 pairs of Pelagic Cormorants, 30 pairs of Glaucous Gulls, and in one spot a group of less than 50 Black-legged Kittiwakes. There is a small colony of Glaucous Gulls and Pelagic Cormorants on Rocky Point and a somewhat larger mixed colony on Cape Darby. A small nesting group of Glaucous Gulls and Pelagic Cormorants is found on a sheer rocky face about 4 miles northeast of Cape Darby.

On 18 August a reconnaissance flight was made searching the shore from Cape Denbigh to Egg Island. A small group of nesting Horned Puffins was seen near Kliktarik Point and a group of Glaucous Gulls at Tolstoi Point.

The rest of the bluffs on the east shore of Norton Sound are of unconsolidated sediments and unsuitable for crevice or cliff-nesting seabirds, except for one spot north of Egavik.

2) Breeding schedule.

We were not at the colonies when birds came in the spring. When we made our first visit to Sledge Island in late June a small number (perhaps 20%) of the kittiwakes were incubating and about 10% of the murres acted as though they might have eggs. It is local tradition that the peak of egg-laying of murres is during the first week of July.

On 3 July at Bluff, 40-50% of the kittiwakes were incubating and about 20% of the murres were closely attached to their ledges.

Murre eggs began to hatch in late July and early August and murre chicks began to leave by 10 August. Many murres left after a large storm on 25 August. A few murre chicks left the cliff after 10 September, and almost all murres were gone by 15 September.

Kittiwake eggs hatched in early August and the first fledglings were on the wing by September 1st. Many fledglings left the cliff to feed for themselves by 15 September but large numbers of kittiwakes were still occupying territories on 25 September. Horned Puffins were incubating eggs on 4 July and at least one had hatched several days before 8 August. This chick had left by 18 September. After mid-August the number of Horned Puffins perched on ledges and inspecting crevices increased and the numbers reached a peak in mid-September. Cliff prospecting occurred when southerly winds made updrafts along the cliff faces.

The number of Tufted Puffins visiting the cliffs also increased during September.

Although both puffins decreased markedly after 15 September, they had not deserted the cliffs on 22 September when we left.

3) Trophic relations: measurement of reproductive success.

We have counts of the number of young in successful nests of Pelagic Cormorants at Sledge Island and Topkok Head. These data are approximate because of a) the difficulty of deciding whether each consistently used ledge and its "flag" of guano constitutes a nesting attempt, and b) the difficulty of establishing from a dancing small boat whether any given nest platform had young lying flat on it. We made counts after the young were half the size of adults in order to minimize the chance of missing chicks.

We have estimates of the number of breeding pairs and young produced for Glaucous Gulls at Topkok and Bluff. The estimates of breeding success are from 1/2 to 2/3 of a young per nest. We also have estimates upon which to base a life table for the gulls seen between Point Spencer and Bluff. However, it appears that many immature and non-breeding subadult gulls summer on Seward Peninsula and we cannot be sure of the general applicability of the age structure we observed: 73% adults, 14% subadults, and 13% first-year birds.

We have data on 125 mapped nests of kittiwakes at 4 study sites. At Bluff We have data on clutch-sizes at Bluff and Sledge Island. At Sledge Island 45% of the nests contained 2 eggs, 40% contained 1 egg, and 15% were empty. At Bluff 5% contained 2 eggs, 55-60% contained 1 egg, and 35-40% were empty. On average, nests produced one-half a chick per nest at Bluff and less than 5% of the nests produced 2 chicks to fledging. Twenty-three "capriciously" selected samples taken along the cliffs at Bluff showed variation from .2 to .8 (1.0) young per nest and averaged .5 (.48), i.e., a total of 604 chicks in 1281 nests sampled (see Table 2). Data taken from photographs taken from a small plane suggest that success was lower at Sledge than at Bluff, and higher at Cape Denbigh than at Bluff.

We established 9 study sites at Bluff for murres. We did not have a satisfactory method of measuring breeding success in murres although we can say that between 20% and 40% of birds present in early August appeared to be incubating or brooding and that no more than 20% of the birds present appeared to produce fledged young.

4) Identification of food.

We have about 46 samples of fish collected on ledges where murres and kittiwakes nest, and several dozen identifications made by 40X telescope of food fish brought in by murres. We have 6 samples of fish regurgitated by kittiwake chicks.

B. Away from colonies.

Our coastal watches showed the directions in which birds were flying to and from feeding areas.

1) Feeding melees were of special interest (scores of kittiwakes and puffins gathered over schools of bait fish, together with Spotted Seals, Finback Whales or Dall Porpoises). In mid-July we saw four feeding melees off Sledge Island; in mid-August 4-6 melees were to be seen on relatively calm days in the shallow water within a few miles of the barrier beach at Safety Lagoon. In mid-September on calm days, 4-8 feeding melees could be seen within three miles of shore from east of Square Rock to Topkok Head.

2) Kittiwakes and puffins were observed to commute between the cliffs at Bluff and the feeding melees. Before the feeding melees were

visible from Bluff, the major movement of kittiwakes away from and back to the cliffs was along the beaches. We did not get enough observations of puffins to chart their movements, but they appeared to feed in shallower water closer to shore than did the murres.

3) Murres apparently "fanned out" in all directions southward from Bluff. Although some flew and returned from the southeast and south, the large majority appeared to fly toward 215° magnetic. Skeins of scores of birds returned from that direction from as far as we could see with 16X binoculars.

C. Species list, including comments on special studies.

04040105 Pelagic Cormorant *Phalacrocorax pelagicus*

Cormorants were seen in small numbers all around Norton Sound, from Unalakleet on the east to Cape Spencer and Teller on the west. They were seen only on salt water. One hundred and twenty fed in the open water in lead at Teller on 10 June. Small groups (1-5) were seen flying past during 12 beach watches between Sledge Island and Cape Nome in June. Flocks of 2 to 15 individuals were seen perched on rocks every few miles along the coast.

Sledge Island. We estimated that there were 250-275 Pelagic Cormorants at Sledge Island and about 80 nests. The nests were scattered in several smaller groups. Four were in an isolated group on the east side of the island and 24 in another isolated group on the southwest corner of Sledge Island.

Five sample counts were taken to measure reproductive success. Some of these were made from observation points on land and some from a small boat.

Using our best judgment in order to eliminate duplication, we selected a combined total of 58 nests. These included 12 empty nests and 111 chicks. The date indicates a breeding success of 1.9 chicks per nest. If we total all out counts we get a similar result:

TABLE 3

Nests	Empty nests	Chicks
12	1	27
15	3	30
17	10	36
21	1	54
10	1	21
75	15	168

In the area of 21 nests which we could count from the land, two observers made the following counts of nest contents:

TABLE 4

	4 chicks	3 chicks	2 chicks	1 chick	Empty
Observer a –	1	14	4	0	2
Observer b –	0	9	15	1	1

The results indicate primarily that it is difficult to count the number of chicks huddled together in a nest.

Topkok Cliffs. We counted totals of 152, 235, 285, and 302 individuals. We estimate that there were between 75 and 125 nests divided into three areas. Most nests in two subsections had been abandoned -- one of 14 abandoned nests, the other of 6. In the main nesting area on 6 August we found 44 nests with chicks, 8 empty nests, and 82 total chicks. This indicates a breeding success of 1.6 chicks per completed nest.

Bluff Cliffs. We counted 62 individual cormorants at Bluff and estimated that there were between 20 and 25 nests. Five of these nests produced two chicks; two produced 3 chicks; and four appeared to be empty.

This averages 1.5 chicks per nest, but the sample is small. Nests were hard to examine at Bluff. We saw a cormorant chick being fed by parents on 6 September at Bluff.

Other Cliffs. Pelagic Cormorants nested in small groups of 5-10 pairs at two sites just west of Rocky Point and at Rocky Point. There were 50-75 birds at Cape Darby, 20 pairs both at a rocky ledge east of Cape Darby and south of Chiukak. There were 75-100 birds at Cape Denbigh, 12 on earth bluffs north of Egavik, and 50 nesting pairs on Besboro Island. There were 25 birds on cliffs on a rounded promontory southeast of Egg Island.

As with cormorants in other regions, there appeared to be many non-breeding individuals perched on the edge of breeding colonies and on rock faces in other places. We did not make detailed comparative counts but estimate that 30-40% of the population of Norton Sound may be non-breeding birds.

Cormorants stayed in numbers at the cliffs until we left in late September, e.g., there were 185 at Topkok on 22 September. Mr. Olson of Golovin remarked that the cormorants persist at the cliffs well after the kittiwakes leave in late September.

10080101 Glaucous Gull *Larus hyperboreus*

This was one of the most conspicuous and ubiquitous of the seabirds because gulls are attracted to man's refuse and concentrate their food search along the shore.

Census. We attempted a census of the breeding and non-breeding population between Teller on the northwest and St. Michael's on the southwest. But because individual gulls move readily, search large areas for food, and large groups gather where food is found, there is danger of duplication in censuses. Our total was 3000 birds which is probably the high limit. There were at least 2000 Glaucous Gulls in the area. The major concentrations were between the base of Cape Spencer and Cape Woolley (975), and between eastern Safety Lagoon and Topkok (750).

We found evidence of breeding at 13 places:

TABLE 5

1)	An island in a tundra lake at the base of Cape Spencer	35 pairs
2)	An island in a tundra lake inland from northwest of Woolley Lagoon	75-90 "
3)	Sledge Island	4 "
4)	An island in a lake northwest of Sunset-Sunrise Safety Lagoon	30 "
5)	Topkok Cliffs	40 "
6)	Tonok Cliff	2 "
7)	Bluff Cliffs	30 "
8)	Rocky Point	20 "
9)	Cape Darby	15 "
10)	Cape Denbigh	25 "
11)	Besboro Island	15 "
12)	Egg Island	4 "
13)	Point near Klikitarik southeast of Egg Island	4 "

The estimates of the breeding gull colonies totals 310 pairs, but could easily be 400 pairs. The estimates were made in late August at the largest colonies, however, and are probably not reliable estimates. By late August (19 & 29 August) many, if not most young that will fledge may have left the colonies accompanied by adults. The Glaucous Gull chicks were still at the Bluff cliffs in these weeks, however, so we cannot be sure.

Even if we double the size of the colonies found on islands in tundra lakes the combined totals account for only 1000 breeding adults. There are several observations which may explain the inconsistency between 1000 breeding adults and 2000-3000 adults found on air censuses.

It was clear that groups of gulls spent the summer months (July and August) loafing on the beaches or near seabird cliffs on the south shore of the Seward Peninsula. 1) There were usually 250-350 along the beaches which form Safety Lagoon, many of which were immatures. We saw only 15-35 birds, all adults, in the waters of Safety Lagoon. 2) A flock of 80-100 gulls, mostly immatures, was seen regularly at the body of a dead Gray Whale east of Nome. 3) A flock of 75-200 gulls, 1/2-2/3 adults, was seen regularly on sand flats at the mouth of the Nome River. 4) Fifty to 100 gulls loafed or fed at the breakwater at Nome. Many of these were immatures, some were young Herring Gulls, some may have been immature Glaucous-winged Gulls, some were unidentifiable.

We conclude that many gulls which may breed in other parts of the Bering Sea spend non-breeding months on these shores.

Schedule of reproduction. We saw no gull chicks at Sledge Island in late June but when we arrived at Bluff on 5 July we saw chicks which by their size and plumage development were 10 days to two weeks old. We saw other chicks that were three weeks old on 11 July. On 13 July at Topkok we saw 6 chicks that were four weeks old and one that may have been nearly five weeks old. At Sledge Island on 24 July we saw a chick just over three weeks old. By 3 August chicks were fully feathered except for an extensive area of down on their napes. Spots were still visible on the tops of their heads. On 6 August Glaucous Gull chicks were fully feathered at Topkok but we saw none on the water. We saw the first few fully fledged chicks on the water below the cliffs at Bluff on 14 and 15 August. Some were still on the cliffs on 16 August.

In the afternoon of 20 August there was a noisy chorus of Long-calls. Such a chorus is, among Herring Gulls in New England, associated with the first fledging flights of chicks. Because Herring Gull chicks usually leave their nesting island ten days or two weeks after they move down to the shore from their parents' territories, we think that our air censuses were barely within the period when adults and young still occupy the colony.

Reproductive success. We failed to make careful counts of the Glaucous Gull nests at Bluff. We tried to locate adult territories and compare these to the number of chicks in mid-August. The results suggest that most nests failed. Of those that succeeded, many lost young after they were three weeks old. We estimated that slightly under half a chick was produced per nest: 12-15 chicks for 30 territories.

At Topkok we counted 27 small chicks and 7 broods of 2. This count compared to our estimate of 40 nests suggests production of .67 young per nest. When we estimated 40 territories, 13 July, there were 165 adults present on that part of the cliff.

It is very difficult to count the number of nests at a gullery such as Bluff or Topkok unless one can do so while the parents are incubating eggs.

Counts contributing to preparing an age structure. We recognize that many birds from other regions may summer on Seward Peninsula, but we counted the proportion between adults and young in the local Glaucous Gull population anyway.

During censuses we counted age groups by plumage for 2100 birds. We got the proportion of 1650 adults to 440 subadults in 35 counts; that is, 20% subadults. Constructing an age structure from counts is difficult because most small flocks of gulls seen along the beach have a high proportion of subadults among them. A few large flocks (200-500 birds) which are 90% adults affect this in the regional totals. Hence sample counts taken along the beaches are partially misleading if applied to the whole. We have, however, 9 counts taken on the beach at Bluff in the second week of September totaling 755 birds. The age proportions came out to be 73% adults, 14% subadults and 13% first-year birds (Table 6).

During the third week of August there was a movement of adult and subadult Glaucous Gulls eastward along the beach and past the Bluffs.

TABLE 6. Counts and estimates of age categories in Glaucous Gulls

ESTIMATES

Air Census 29 August

	Adults	Subadults	
	7	1	
	3	2	
	38	6	
	3	15	
	15	7	
	20	20	
	20	3	
	6	2	
	30	3	
	50	20	
	8	5	
	15	4	
	60	25	
	11	8	
	32	6	
	20	9	
	30	6	
	8	4	
	25	1	
	15	8	
Total	416	155	571
	73%	27%	

Surface Estimates August

Adults	Subadults	
600	50	
275	80	
80	20	
60	40	
30	30	
1045	220	1265

COUNTS

Early September

	Adults	Subadults	
	21	8	
	80	12	
	109	52	
Total	210	72	282
	75%	26%	

11-18 September

	Adults	Intermediates	Chicks	
	82	17	24	
	32	3	7	
	42	6	1	
	73	11	12	
	52	12	8	
	48	16	14	
	63	18	13	
Total	392	83	79	554
	71%	15%	14%	

Food and feeding. Glaucous Gulls fed primarily at the sea's edge. Ingolfson in his study of Glaucous Gulls in Iceland found them to be more active in the intertidal area than Great Black-backed Gulls, Herring Gulls, Lesser Black-backed Gulls or Iceland Gulls.

The attachment of Glaucous Gulls to the sea's edge was surprising because there was so little tide (1-2 feet) and tide changes occurred only once in 24 hours.

To offset the lack of tide there was a surprising number of marine mammal carcasses washed up on the beaches and each carcass was attended by 20-100 gulls. We found carcasses of baby and adult Walrus, Spotted Seal, Beluga and Gray Whale. Most were more or less deeply buried in gravel when they washed up but on their periodic visits, Grizzly Bears dug parts of the carcass out and renewed the surface where Glaucous Gulls, Ravens and Red Foxes could feed.

Glaucous Gulls also gathered at the mouths of rivers especially those which meander extensively before they empty into the sea. In these places mud and sand flats are exposed or covered according to the direction the wind blows. A north wind lowers the sea and exposes flats. An east wind raises the water level in the ocean and in the lagoons.

In September Glaucous Gulls fed on crowberries and blueberries which they found on the wet tundra within a mile of the coast. At Bluff and at Bonanza the gulls alternated between exposed flats, mammal carcasses and the berries on the tundra.

10080301 Black-legged Kittiwake <u>Rissa tridactyla</u>

<u>General remarks on occurrence</u>.

In June kittiwakes were seen in small groups or small flocks (up to 25) feeding offshore wherever we looked. They were less conspicuous from shore in July and August. In July off Sledge Island and then in late August and September off Bluff and Safety Lagoon they were conspicuous feeding in milling flocks over schools of fish.

We saw flocks of 50-75-250 drinking at the mouths of rivers or in the shallow waters of drained lagoons (250, lagoon east of Sinruk River, 22 June; 250, west end of drained lagoon at Bonanza River mouth, 3 July; 175, Taylor Lagoon, 11 August; 180 in fresh water at mouth of Topkok Creek, 11 August; 75-100 in pond at the mouth of Daniels Creek, Bluff, 3-12 July.

Kittiwakes gathered to loaf in tight flocks on the gravel beaches (50 on the bar at Cripple River 20 June; 45 on the spit at Sledge on 18 June; 600-700 on the bar at the mouth of the Sinruk River 29 August; 350-450 on the beach by the Woolley Lagoons on 29 August; 250 on the beach by Topkok Creek on 19 September).

A. <u>Census</u> - Nesting Cliffs

TABLE 7

Location	Estimated Number of Nests	Estimated Number of Birds
South end of Sledge Island	750-1000	950-1500
Bluff Cliffs	4250-7250	4000-8000
Square Rock	500-700	800
Cape Darby	100-125	150
Cape Denbigh	500-700	600-1000
Egg Island	200-300	300-500

B. <u>Schedule of breeding</u>.

On 19 June at Sledge Island some kittiwakes were carrying nesting materials. At between 20% and 30% of the nests, the adults appeared to be incubating eggs. On 23 and 24 July at Sledge Island, kittiwakes were still incubating eggs and we saw no signs of hatched chicks although we examined 120 nests from which the adults had been frightened.

Kittiwakes had eggs and most were incubating when we got to Bluff on 3 July. Several pairs were seen to copulate on 7 July. A new nest was built between 13 July and 1 August. When we returned to Bluff on 1 August, kittiwake eggs were hatching. On 1 August chicks were observed in 15 nests of 36 at the study site, Stake 3. On 4 August 5 chicks had the primary pinfeathers erupted (Category 3a, Table 8). Thirteen others were downy showing first traces of pinfeathers (Categories 2a and 2b). In several nests the chicks were barely able to raise their heads (Category 1).

On 15 August at Stake 3, four chicks showed only primary pinfeathers just erupted; 15 chicks had primary and tail feathers erupted. On 16 August 6 chicks in 45 nests at Stake 10 were showing the first traces of pinfeathers; 11 chicks had erupted primary pinfeathers; 10 chicks showed erupted tail feathers (Category 3b). On 30 August 15 chicks at Stake 10 were fully feathered but had short tails, and 7 chicks had tails 2/3 of the full length. These last chicks were ready to fly. On 30 August at Stake 3, 12 chicks were fully fledged but for short tails, and 3 were ready to fly.

We saw the first flying chicks 31 August and 1 September. Most chicks began to fly in the next week. At Stake 3, 4 chicks left before 6 September, 7 left between 5 and 10 September, and 7 were still at their nests on 18-20 September. Flocks of chicks began to gather on the water below the cliffs on 9 September. On 16 September we observed chicks flying away from the cliffs to feed over shoals of fish with the adults.

TABLE 8. Descriptions of age classes.

	Herring Gull			Kittiwake
1a	Downy young newly hatched; short, pink, fat legs; no pinfeathers.		1-2a	Downy young lies flat.
2a	Legs long, dark; chick walks; no pinfeathers.	1 week		
2b	Pinfeathers appear on hand.	2 weeks	2b	Downy young stands in nest.
3a	Downy young, pinfeathers on hand conspicuous; tips burst, showing feathers.	3 weeks	3a	Chick downy; can see first signs of feathers on hand.
3b	Downy with some back feathers; hand feathers elongating; tail pinfeathers burst and are less than 1 inch.	4 weeks	3b	Can see stubby tail feathers; feathers on back and scapulars conspicuous; tail less than 1 inch.
4a	Becoming feathered out; extensive down on nape, rump and flanks; tail feathers over 1 inch long.	5 weeks	4a	Mostly feathered out; down on nape, flanks and rump; tail clearly evident -- over 1 inch.
4b	Feathered out; tail extends to end of wing tips.	6 weeks	4b	Full tail, all feathered except for down on nape.
5	Lost down on nape; flying.		5	No down; free flying.

Kittiwake — Seen on:

Earliest	3a	4 August
"	3b	9 August
"	4a	15 August
"	flying	30 August

We recorded a sudden increase in mortality of kittiwake chicks on 4 September. During the next 10 days we found between 65 and 70 dead chicks. Then the mortality seemed to diminish during the last six days we were at Bluff.

We saw many young kittiwakes flying away from the cliffs 5-15 miles west of Bluff on the morning of 22 September. On 26 September kittiwakes were still at the cliffs in large numbers.

C. Reproductive success.

Reproductive success can be measured against many measurements of the breeding population. Upon what segment of the adult population should one choose to relate to the number of chicks that fledge? One can use the total number of birds which spend the breeding season at the cliff, the number that defend territories, the number that build nests, the number that lay eggs, the number that hatch any young (the number of successful nests). We have some data on several of these categories.

a) Measures of population of reproducing adults.

1) At most cliffs there are numbers of birds which occupy and defend sites on the cliffs but do not build nests. These regularly occupied sites are made conspicuous by a "flag" of droppings. Some sites are occupied by a pair of birds, others by a single individual. Sample proportions are given in Table 9. These samples suggest that 20-25% of the birds at the cliffs did not advance to the stage of building nests.

2) Our nest checks suggested that some pairs built nests but did not lay eggs. First, we were able to examine some nests closely on those parts of the cliffs to which we could climb. Second, we took some other samples by the slow and much less reliable process of watching nests until the parents stand up or exchange places, allowing the observer to see into the nest cup. Samples of nest contents and clutch-sizes are given in Table 10.

TABLE 9. Proportion of non-nesting territory holders to pairs that built nests -- Kittiwakes 1975.

Sledge Island

Place		Nests	Non-nesting Pairs	Non-nesting Single Birds	
Stack		38-40	3	12-19	
Stake 1 (near face)		26	4	12	
(middle face)		30	4	5	
(far face)		41	9	20	
Stake 2 (near)		18	5	21	
		43	?	6	
	Pairs	(197)	(25)	--	
	Birds	394	50	80	Total 524
					Non-breeders = 25%

Bluff Cliffs

Place		Nests	Non-nesting Pairs	Non-nesting Single Birds	
Stake 1		85	15-18	12-22	
" 3		36	3	2-7	
" 4		74	7-8	16-19	
" 8		64	?	37	
" 9		40	?	15	
	Pairs	(299)	(28)	--	
	Birds	598	56	100	Total 754
					Non-breeders = 21%

TABLE 10. Clutch-size at Sledge Island and Bluff cliffs -- Kittiwakes 1975.

Directly Examined

Place	Date	Nests Empty	Contain 1 egg or chick	Contain 2 eggs or chicks
Sledge 1	July 26	3	10	11
" 2	"	0	8	7
" 3	"	10	24	21
" 4	"	6	8	17
		19 (15%)	50 (40%)	56 (45%)
Bluff (castellated promontory)	Aug. 4	5	16	2
	" 13	17	38	2
		22 (28%)	54 (67%)	4 (05%)

Examined by Telescope

Place	Date	Nests Empty	Contain 1 egg or chick	Contain 2 eggs or chicks
Bluff Stake 3	July 13	11	18	5
" 3	Aug. 5	12	20	2
" 4	Aug. 5	24	21	0
" 10	Aug. 5	9	26	2
		56 (37%)	86 (57%)	8 (05%)

These observations indicate that there are many fewer empty nests and more nests with two eggs at Sledge than at Bluff. The samples at Bluff are few and those taken directly are not readily comparable to those taken with a telescope; but they suggest that we missed eggs in a certain number of the nests which we examined by telescope from the tops of the cliffs.

Even at Sledge Island, where clutches were largest (1.3 eggs) the clutch-sizes are not comparable to those of the Atlantic kittiwakes studied in England by Coulson (2 and 3 eggs). We found the average clutch at Bluff cliffs to be .7 or .8.

3) Measurements of breeding success according to the number of fledglings produced per nest.

TABLE 11. Summarizing nesting success

Study Site	Place	Nests	Successful Nests	
	Stake 1	84	23	
	" 3	35	18	(1 nest with 2 chicks; both fledged)
	" 4	48	20	
	" 4B	17	7	(1 nest with 2 chicks; both fledged)
	" 10	42	26	(1 nest with 2 chicks; 1 survived to 16 August; the other fledged)
		226	94	= .42 young per nest.

The nests at Stake 3 were studied in detail over the longest period. At that site we found that 11 nests never had eggs; 4 contained eggs which did not hatch; 2 hatched eggs but the chicks did not fledge; all nests (5) which contained 2 eggs produced at least 1 chick but of them 4 nests contained only 1 chick after hatching; one nest raised 2 chicks to fledging; the remaining 12 nests contained 1 egg which hatched and the chick fledged.

On 16 August we took 23 counts of the number of nests and the number of chicks visible on sample cliff faces. The samples were chosen by making a count everywhere we found a good prospect along the western half of the cliffs; that is, between "the mine entry" and the western limit of the cliffs at Daniels Creek. These samples are shown on Table 12, arranged in order of success from 1.0 to .21, average .48.

The precision of the estimates of breeding success is not very high. If one person counts the nests and chicks on the same cliff three times, the counts will vary by 0-4 in the number of nests and 14 in the number of chicks (Table 13). The accuracy of our counts probably allows us to estimate only to one decimal place.

Even granted rather wide margin of error, it is clear that there was wide and presumably biologically important variation in the level of success at different parts of the cliffs. We did not collect enough data on the location of each sample to establish the variables associated with higher or lower success. Our impressions were that birds on outer and higher cliffs did better than lower and inner cliffs. This was complicated by the fact that pinnacles of rock close off the cliffs or the promontories which were almost separated from the cliffs seemed to be preferred sites and the birds nesting on such sites did well.

In summary we found, as did Coulson in his studies on British colonies of Atlantic kittiwakes, that different parts of the colony had marked differences in reproductive success.

4) The effects of a storm in late August.

On 25 August 1975, southeast winds over 60 knots blew in Norton Sound. Our impression was that many nests on the lower part of the bird cliffs at Bluff were washed away in this storm. We can record the effects at only one of our study sites, Stake 1. Table 14, however, does not give the impression made on the site that the two top sections of the cliff were unaffected while the bottom was "washed out". Several areas on the cliffs which were sheltered from the wind, i.e., faced west, showed little effect.

TABLE 12. Kittiwakes -- Bluff, August 1975.

Sample Estimates of Reproductive Success.

	Nests	Chicks	%.Success
	17	17	1.0
	67	54	.8
	47	32	.68
	87	54	.62
	100	58	.58
	37	21	.57
	31	17	.55
	106	58	.55
	79	43	.54
	17	8	.47
	46	21	.46
	47	22	.46
	52	24	.46
	10	4	.40
	43	17	.40
	70	28	.40
	71	28	.39
	83	31	.37
	47	17	.36
	25	8	.32
	49	15	.31
	93	25	.27
	57	12	.21
Total	1281	614	.48

TABLE 13. Comparisons of counts to indicate variation in one individual's counts.

20 August 1975	Nests 10X	Nests 16X	Chicks 10X	Chicks 16X
Station 1	32	29	14	16
2	43	42	20	26
3	19	23	10	11
4	32	28	23	21
5	22	25	13	16
6	43	43	33	33
7	41	42	22	26
8	40	36	19	19
9	42	42	26	30
	314	310	180	198
			20	22

TABLE 14. Effect of storm of 25 August on nest contents of kittiwakes at Stake 1.

		3 July	11 July	1 Aug.	12 Aug.	30 Aug.	1 Sept.	2 Sept.	6 Sept.	During absence 19-29 August
Cliff Top	Nests	35	28	28	31	31				
	Chicks				19	14	14	14	14	Lost 5 chicks
Cliff Middle	Nests					20				
	Chicks					8	6	6	7	Est. lost 1 chick
	(nests)	65	56	45	45					
Cliff Bottom	Nests					25				
	Chicks				20	1	1	1	2	Est. lost 10 chicks

D. Departure of fledglings from the cliffs.

The first chicks were seen flying at the cliffs both at Stake 4 and at Stake 10 on 31 August and 1 September. The number of chicks fledging rapidly increased over the next week so that after 5 September we could not use counts of chicks at the nests to measure reproductive success.

Some of the chicks which flew from their nests attempted to land on neighbors' nests or amongst territorial adults and were pecked. Many young birds tried repeatedly to land in several parts of the cliff. This suggests that they could not find their way back to their own nests. A number of chicks landed on parts of the cliff somewhat removed from the main area of kittiwake nests and roosted for the night in those places. One assumed that a number of such birds did not live through the transition period.

We found a total of 67 dead kittiwake chicks at the top of the bluffs or along the beaches below the cliffs or west of the cliffs. Many were pecked and had blood matted on the plumage on their heads.

Many chicks flew out from the cliff during the day and gathered on the water in a loose flock. By 10 September about half of the chicks appeared to spend most of the day away from the nest. On 16 September we saw chicks flying with the adults commuting several miles away from the cliffs to feed on shoals of fish.

E. Alternative calculations of reproductive success.

1) We used estimates of the number of chicks in flocks on the water to make a second calculation of the breeding success of the kittiwakes at Bluff. We did so as follows in the area between the western edge of the Bluff and the rock structure we called The Arches.

a) Number of nests.

i) We counted adults in the area as follows:

TABLE 15

On 3 July	Low count	3630	High count	4235
On 4 July	" "	4220	" "	4490
On 1 August	" "	3130	" "	3740

ii) To estimate the number of nests from these data we used data taken at study sites:

TABLE 16

	Number of Adults	Number of Nests
1-12 August at Stake 1	155	84
3 August at Stake 11	59	35
	56	41
20 August, 9 areas, Stakes 5-12	489	339
	759	499

This proportion of adults to nests is 3/2.

iii) Using our estimates of adults on the cliffs,

taking low estimates, adults 3700 x .67 = 2500 nests

taking high estimates, adults 4225 x .67 = 2850 nests

b) The number of chicks alive in mid-September.

i) Between 18 and 20 September we made two counts of the chicks on the water in the area: 560 and 620.

ii) We compared the number of chicks still on the cliffs on 9-20 September with the total we knew fledged, assuming that the rest were in the flock off the cliff:

TABLE 17

		On the cliff	Total which fledged
20 September	Stake 1	16	27
	Stake 3	6	16
	Stake 4	26	40
	Outer Face	25	66
	Totals	73	149

During this period, 9-20 September, there was regularly (6 counts) a flock of (88)-150-165-(203) chicks on the water off these study area cliffs on the western end of the Bluffs.

iii) On 18 September we counted 129 chicks on the cliffs between stakes 5 and 11 on the eastern end of the area being considered and 125 on the water below the cliffs.

The results of these two comparisons of chicks on the cliffs with those on the water suggest that in the period 15-20 September about 1/2 of the chicks were on the water.

c) We take the low count of nests to be 2500 and the high count to be 2850; we double each of the two counts of the total number of chicks seen in the sample areas -- 618 and 560 -- this gives a high count of chicks as 1240 and a low count of 1120.

Low counts: 1120 chicks - 2500 nests = .45 chicks/nest

High counts: 1240 chicks - 2850 nests = .44 chicks/nest

These values of .44 and .45 young per nest are very close to the value of .46 found at study sites and .48 found in the 23 samples taken on 16 August wherever possible along the cliffs (Table 12) in the same area. It is tempting to observe that there is a slight decrease in the value as if reflecting the mortality of chicks which could not find their parents' nests after early flight (a loss of 150-200 chicks). Furthermore, the storm of 25 August came in the period and we know that the storm killed many nestlings. But the low precision of our data does not justify drawing such a conclusion.

2) Using pictures taken from a small airplane.

When kittiwake chicks are about to fledge they have a black nape, black bar on the secondary coverts and black tip on the tail. These marks are conspicuous from a distance and can be recognized on a photograph of the cliffs. We decided to photograph the cliffs to see whether we could use this technique to measure breeding success -- by "remote sensing".

On 1 August Donald Olson, using a Cessna 175, flew two of us close by the cliffs at Sledge Island, Bluff (Stakes 4 and 10) and Cape Denbigh. I took photographs out of an open window as we flew close to the cliffs, using 135 mm and 400 mm lenses. There were many technical difficulties, e.g. 1) as we slowed down the window often closed, 2) as we turned when closest to the cliff the wing strut got in the way, 3) the wind was off the cliffs at Bluff and produced bad turbulence, and 4) I could not set the focus of the 400 mm lens on infinity because it is a Novoflex hand-focussing. These difficulties can be mostly solved if the technique appears to be justified.

Of the many pictures taken there are 9 usable ones and 3 good ones taken at Sledge, 9 barely usable ones taken at Bluff, and 15 adequate and 4 good ones taken at Denbigh.

The interpretation of most of these pictures is at best an art rather than a science. The storm of 25 August had washed off the flag of droppings below occupied nests. In many cases I had to use judgment as to whether a dark blob was a nest by whether the site resembled a nest site. Of course identifying a nest by the presence of a young bird introduced an element of circularity and bias toward too many nests with chicks.

The results (Table 17) appear to be cleaner and more consistent than the technique justifies. I believe, however, that they support a

TABLE 18. Counts of nests and fledglings made from photographs taken of cliff faces in flight.

Sledge Island

Adults	Chicks
34	14
58	25
30	6
23	6
26	11
24	9
5	1
18	7
15	5
233	84

.36 = .35

Less than 2% twins

Bluff

Adults	Chicks
22	10
20	5
22	10
18	9
16	9
10	4
14	6
21	12
27	10
170	75

.44 = .45

No evidence of twins

Cape Denbigh

Adults	Chicks
41	25
43	18
30	11
29	9
20	11
23	12
39	19
35	19
58	30
37	18
32	16
26	13
9	5
28	12
470	227

.48 = .50

Evidence of 10-15% of nests with 2 chicks conclusion that kittiwakes at Sledge Island produced fewer young per nest than did those at Bluff in spite of beginning with a larger clutch.

I believe that one can conclude that the kittiwakes at Cape Denbigh did better than did the kittiwakes at Sledge or Bluff. There was suggestion of twin chicks at a few nests at Sledge Island. There was no evidence of twins in nests at the Bluff cliffs. There was evidence of many nests containing twins on the cliffs at Cape Denbigh.

3) Because these studies of the photographs taken with a 35 mm camera from a light plane indicate that it is often difficult to identify nests precisely, it would be useful to find some consistent relation between the number of adults on a photograph and the number of nests. If we can find such a relationship, one could simply count the adults and chicks and get a measure of breeding success by applying a correction.

Seeking for such a solution, we investigated the relation between the number of adults on a cliff face and a) the number of nests as well as b) the number of chicks. We have three sets of counts by which to see whether some transformation can be applied to give us a measure of reproductive success.

The first is Table 19 -- counts of totals of adults, nests and chicks at the study sites. These data suggest that a reasonable approximation of reproductive success can be found by dividing the number of chicks by the total of the number of both adults and chicks. This method is reasonable because one observes at the study sites that both parents tend to be away from successful nests, presumably seeking food. Only the chick is at the nest. At unsuccessful nests, however, there is nearly always one adult defending the nest site. Thus there is, as it were, an inverse relation between the number of adults at nests and the number of chicks at nests.

TABLE 19. Counts of numbers of adults, numbers of nests, and numbers of chicks at study sites at Bluff.

	Date	Nests	Adults	Chicks		
Stake 1						
	19 Aug.	84	131	39		
	1 Sept.	77	141	20		
	2 Sept.	77	180	21		
	4 Sept.	77	50	27		
	5 Sept.	77	103	19		
	6 Sept.	77	22	23		
Total		385	496	110	C/N .29	C/A .22
Stake 3						
	2 Sept.	34	35	16		
	5 Sept.	34	11	15		
	6 Sept.	34	22	14		
Total		102	68	45	C/N .44	C/A .66
Stake 4						
	15 Aug.	48	16	19		
	30 Aug.	48	22	18		
	2 Sept.	48	78	13		
	5 Sept.	48	38	18		
	6 Sept.	48	15	15		
Total		192	153	64	C/N .33	C/A .42
Stake 10						
	31 Aug.	42	36	25		
	4 Sept.	42	18	25		
	6 Sept.	42	11	26		
Total		126	65	76	C/N .60	C/A 1.17

Unfortunately weather factors and seasonal factors seem to play an important role in any given day's count. Sample counts were made on 20 August (Table 20). These counts chosen by chance at localities away from study sites included total number of adults, total number of nests and total chicks. In order to adjust the proportion of chicks to adults so that it corresponds to the proportion of chicks to nests, one would have to subtract the number of chicks from the total number of adults (not add them as was the case at the study sites). In this case nearly all adults were on the cliff whether successful or not.

Fourteen sample counts were made on 8 September, again at capriciously chosen sites in the same area of the cliffs (Table 20). By 8 September some chicks were flying and away from the nests. In Table 20 one gets a best fit of the data by dividing the number of chicks directly by the number of adults. We conclude that we do not yet know enough about daily and seasonal patterns of behavior of adult kittiwakes to use the techniques suggested. Several complicating factors in adult kittiwake behavior will have to be examined:

i) One parent tends to stay at the nest with small chicks.

ii) When the chicks are full grown both parents are often away.

iii) Early in the morning the number of adults at a site is very low.

iv) Adults usually return to the cliffs in numbers about 1600-1900.

v) On days when feeding flocks can be seen from the cliffs, many adults can be seen loafing at the nest with chicks even at noon.

vi) On stormy days and late in the season most adults are away from the cliffs all day until the evening.

vii) After the first week of September 1975 the number of adult kittiwakes at the cliffs at Bluff sharply increased and there

TABLE 20. Numbers of adults, numbers of nests, numbers of fledgling chicks. Sample counts in the area Stake 5-12, period 15-20 August, 15 August-8 September.

20 August

	Nests	Adults	Chicks
	32	47	13
	43	58	20
	19	37	10
	32	40	23
	22	43	13
	43	65	33
	41	62	20
	40	64	19
	42	73	24
Total	314	489	175

Rate:
Chicks to nests .56
Chicks to adults .36

16 August

	Nests	Chicks
	47	22
	47	17
	71	28
	52	24
	47	32
	57	12
	10	4
	93	25
	70	28
	25	8
	49	15
	79	43
	83	31
	46	21
Total	776	310

8 September

	Adults	Chicks
	93	34
	194	82
	93	39
	26	7
	84	46
	44	15
	47	13
	39	19
	58	26
	67	28
	48	9
	49	29
	149	56
	86	33
Total	1077	436

Rate:
Chicks to nests .40
Chicks to adults .40

was an increase on territorial activities including long fights for nesting ledges. It suggests that all adults were asserting their claims to establish territories for the next breeding season (1976) and that subadults were trying to establish territories which these subadults would use in 1976 as new breeders.

In summary we have observed that certain consistency exists in the relations between the number of chicks and the number of adults, but we do not yet understand the consistencies. We also need to know more about changes in adult behavior (successful parents, unsuccessful parents, and prospective breeders) in the course of the season.

F. Feeding.

1) The evidence we gathered on food is as follows:

Assistants collected food items on the ledges where kittiwakes nest, both at Sledge Island and at Bluff in July and August. They also collected food regurgitated by kittiwake chicks. On about 15 occasions we saw adult kittiwakes carrying food back towards the cliffs from nesting areas.

We saw many dense flocks of kittiwakes hovering, diving and sitting on the water between Sledge Island and Bluff. Occasionally we saw Spotted Seals, Finback Whales and Dall Porpoises associated with these feeding flocks. Puffins were active in each flock we saw, but only a few murres were seen associated with the feeding melees.

All the food which we collected from ledges where only kittiwakes nest and all the food which the kittiwake chicks regurgitated was sand launce *Ammodytes*.* The food items we saw adult kittiwakes carrying was

* Fish samples collected at Sledge Island and at Bluff were identified by Karsten Hartel of the Fish Department, the Agassiz Museum, Harvard University, Cambridge, Mass.

also sand launce. The food which puffins brought to the cliffs was 90% sand launce and we saw a few murres bring back sand launce.

All this evidence is consistent with the conclusion that sand launce is the staple food of kittiwakes.

2) Variation in food.

Most of the sand launce found on ledges was about 10 cm long, but the sand launce in the food regurgitated by chicks was 2-4 cm long.

On cliffs where murres as well as kittiwakes nested we found a few Capelin (Mallotus), Smelt (Osmerus), Salmon (Onchorhynchus), small Cod (Gadus and Boreogadus), and many specimens of Lumpenus, a blennioid bottom-dwelling fish which we know murres fed on extensively.

3) Feeding techniques.

We saw many kittiwakes commuting away from the cliffs to the south and southwest. They flew steadily, close over the water, 1-2 meters or moderately high, 15-20 meters.

When feeding the birds hawked over the water dipping to the surface and often settled as if catching crustacea. In the feeding melees many sat on the surface pecking but the main melee was made up of birds which hovered and dove like terns. The gulls went into the water with wings bent back as do Gannets. They dove out of sight and stayed down 1-3 seconds.

When the feeding melees were seen at Sledge Island in July, the number of kittiwakes around the nesting cliffs increased by 30-50%.

Our observations of birds which we judged to be commuting suggest that the kittiwakes from Bluff flew regularly as far as 50-75 miles to feed. In July many fed regularly on shoals just east of Safety Lagoon where we saw two melees during one trip. The shoals evidently came closer to Bluff so that on 22 August we saw two feeding melees between Topkok and Bonanza River and four between Bonanza and the ferry crossing.

In early September the shoals of fish were close to Bluff and on still days we might see two to eight melees at once from one outlook on the Bluffs to the west.

10100301 Common Murre *Uria aalge*

A. General comments on occurrence.

The great majority of murres on Norton Sound are Common Murres. Eighty-five percent of the murres at Sledge Island were Commons. Ninety-seven percent or higher of the murres at Bluff were Commons except for one nearly flat face with tiny ledges. On that face the proportion was 65 percent Commons.

We saw murres in small numbers everywhere we looked out to sea. Birds from Sledge Island flew as far as Nome and birds from Bluff flew in groups of 3-5 at least as far as Cape Nome. We saw birds off the beach at Safety Lagoon flying in skeins toward Bluff. Murres were seen alone or in small groups except that they could be seen flying in skeins of 20-35 at 20-30 meters off the water toward their colony.

Feeding birds were usually scattered but on 11 August we saw about 500 feeding in a large, loose group between Bluff and Topkok.

B. Numbers.

At Sledge Island when we approached the cliffs on 20 June there were about 300 birds on the water. About 800 left the cliffs as we came and about 300-450 stayed on the eastern cliffs and 250 stayed on the southwestern cliffs. On 23 July we estimated 2200-3000 birds on the cliffs.

On the outer ledges and among those flying at Sledge Island about one murre in 6-8 was Thick-billed. However, among the murres crowded on the broad ledges or tops of rock pinnacles there were no Thick-billed visible.

At Bluff the murres are most concentrated on the western end of the cliffs. They are numerous in patches on the east side of the middle and there is a stretch of about 1 1/2 miles with almost no murres between the eastern edge of the main cliffs at Koyana Creek and Square Rock.

At Cape Denbigh the murres are concentrated on the western part of the southern point. From the air we estimated 12,000-15,000 birds to be present. We could not distinguish between the two species.

At Egg Island the murres were all nesting on low cliffs on the northern end. From the air we estimated 2000-2500 and could not distinguish between the two species. The top of Egg Island is flat and would appear to be an ideal place for large numbers of Common Murres to breed. It may well be that human predation or foxes prevent this because the island is a traditional egging place for the Eskimos of St. Michael. There are tent frames above the beach on the northwest side where it is easy to land a boat.

C. Schedule of breeding.

The tradition of the Eskimo is that the time to take fresh murre eggs is the weekend of the 4th of July. Our observations indicate that only a few of the murres at Sledge Island had laid eggs by 20 June, but our observations at Bluff indicated that even at the height of the incubation period barely a third of the birds present on the ledges were incubating eggs (see Table 21).

On 2-5 August we saw small murre chicks; these were probably over 10 days old according to Tuck (1960). Murre chicks were still on the cliffs on 15 September. If we take the incubation period as 33-34 days and take the nestling period to be 15 up to 20 or 25 days (Tuck 1960; Uspenski 1956) our observations indicate that the first eggs were probably laid about 15-20 June and the last were probably laid about 15-20 July.

TABLE 21. Calculations of proportion of numbers of Common Murre adults to numbers of incubators according to sample size.

Less than 35	40 - 95	100 - 200	Over 200
56 - 19	483 - 179	267 - 101	577 - 124
135 - 57	283 - 124	267 - 101	
208 - 59	209 - 78	455 - 113	
137 - 37	277 - 90	434 - 100	
100 - 42	179 - 53	577 - 124	
	257 - 85		
	292 - 75		
636 214	1980 684	1733 438	
35%	35%	25%	

We saw birds on 8 August which, to judge by their actions, probably left the cliffs in one or two days, i.e., they stood separate from their parents for an hour or more at a time.

We left Bluff on 22 August to try to go to Sledge Island. We got back to Bluff on 29 August and found that the majority of murres had left the cliffs. This suggests that most of the murre chicks produced on the cliffs at Bluff left or were blown off the cliffs between 15 and 28 August.

D. Reproductive success.

We persisted in our attempts to estimate the number of eggs or young on ledges we studied.

First: In some cases we could count the number of adults from a distance; then frighten off the majority by approaching in a boat and counting the remaining birds. On 20 June at Sledge 800 birds left and 300-450 remained. On 3 July at Square Rock 2500 left and 3600 stayed; on 14 August at Square Rock 2600 left and 3300 stayed. Finally we climbed to the cliff and counted eggs. We could only do this on a very few places and concluded that between 25 and 35 percent of the birds on a ledge would have eggs. The proportion was much lower (18-23%) on wide ledges with thickly crowded birds, and the proportion was higher, as high as 45-50% on long, narrow ledges where only a few birds could stand.

Second: We recognized a posture with breast and wings lowered which was assumed by adults we observed to have an egg or chick. Although in many cases a bird in such a posture stood up and left without uncovering an egg, we assumed that most birds in this posture were incubating or brooding. We made many counts of the totals of adults and of incubating adults at twenty different sections divided among our 13 study sites. Table 21 indicates that the smaller sample counts tend to have a higher proportion of adults in the incubating posture than do the sample counts from larger, more crowded ledges.

Using these observations and our census data, it seems safe to assume that 15,000-25,000 eggs were laid at Bluff during 1975.

A family of five Ravens fed on murre eggs regularly and the discarded eggshells littered the barren places at the crests of the bluffs. At most the Ravens could have eaten 200-500 eggs. We saw Glaucous Gulls take a few eggs but the heaviest gull predation came when the murre chicks were jumping from the ledges to join adults on the water. Eskimos from Golovin visited the cliffs twice in late June and early July and took between 350 and 400 eggs.

Glaucous Gulls were able to take about 1 in 3 of the chicks which jumped without an adult closely associating with it. We saw one Glaucous Gull at the western end of the Bluff cliffs take 3 or 4 chicks in one evening during a week when large numbers of chicks jumped each night. The way the gulls spaced themselves out on feeding areas during August and early September it is doubtful that more than 30 Glaucous Gulls were actively hunting for chicks. We saw 10-15 chicks jump accompanied by an adult for every chick that jumped alone. One can estimate that under conditions favorable to the gulls they might take 2000 chicks. We recorded 7 chicks as killed by Glaucous Gulls in the one cove where we watched for chicks leaving in the course of eight nights.

At the same time that the murre chicks were leaving the cliffs there was a Beluga, two Walrus and a seal carcass on the beaches within 10 miles of the cliffs and most of the Glaucous Gulls fed on these carcasses daily.

We do not know how many chicks were killed by the storm. However, when we came back to Bluff on 29 August the cliffs were wet and nearly empty.

Many chicks stood alone on ledges at the study sites. We presume that they had been left by their parents who had become hungry after almost a week of storms.

In early September it was striking that the murres still on the cliff were in patches. Certain sections of the cliff or ledges were still occupied and other areas were abandoned. The timing of departures suggest that egg-laying may be synchronized over small sections of the colony.

E. Behavior.

1) Johnson observed that adults which are not parents will adopt an abandoned egg. Russian author Gorbunov commented that parent murres feed only their own chicks and recognize them by sound. Uspenski contradicted this, saying that he had observed more than two different adults feed the same chick. Fish and Lockley (1954) and Tuck (1960) observed that chicks may leave the cliff in company with an adult which is not their parent.

These observations could be interpreted as contradictory and confusing, but if subadult birds accompany their parents on the breeding ledges and share in incubation, brooding and feeding of their siblings, the observations would be consistent with contemporary understanding of "helpers at the nest".

We observed that "additional" adults accompanied incubating and brooding birds on the ledges right up until the last chicks left. Then the "additional" adults abandoned the ledge after a few visits on two or three days after the chicks jumped. This suggests that there are adults which associate with the ledge as long as there are breeding activities in progress even though their degree of participation is not clear.

2) Murres have an interesting adaptation in the behavior of the chicks. At about 10-20 days, well before they can fly, the chicks leave

the cliffs. The chicks jump off the ledge beating their stubby wings vigorously and fall along an arc down to the water. It has been suggested that this behavior is why nearly all murre cliffs rise directly out of deep water.

Nearly all the murre chicks we watched jump were closely followed by an adult which had been perching next to the chick. The two landed on the water together and soon swam off directly out to sea where reportedly the adult moults in the course of migration toward the wintering grounds.

The chicks which were alone on the ledges and the chicks which found themselves,alone on the water gave a loud chirruping call which one could hear a hundred meters away. When a chick gave such a call on the water, 20-30 adults would swim toward it from the flotilla of adults which usually was to be seen swimming a couple of hundred meters off the foot of the cliffs.

F. Food.

Many murres dove as if feeding within a few hundred meters of the cliffs. We saw large aggregations feeding within 5 and 15 kilometers of the cliffs. However, large numbers could be seen returning from far at sea at the limit of visibility with 16X binoculars. These birds flew in flocks 20-30 meters above the sea and nearly all had the tail of a fish sticking out between the mandibles. We seldom saw murres associate with the milling flocks where kittiwakes and puffins fed. Indeed the fish they brought back were entirely different.

We estimate that 75-85% of the fish brought in were a Blennioid fish Lumpenus sagitta. The remaining percent included a few each of Capelin (Mallotus), Smelt (Osmerus), Salmon (Onchorhynchus), Cod (Boreogadus), Sand Launce (Ammodytes), and small numbers of several others we could not recognize and for which we found no specimens.

The fish we picked up on or below ledges occupied by murres may be a sample biased toward those fish which the murres rejected. The numerical representation of these samples is shown in Table and is consistent with our observations of what adults were carrying.

Lumpenus is reported to live on mud bottoms in 10-30 fathoms of water.

10100302 Thick-billed Murre *Uria lomvia*

Of the murres flying around the cliffs at Sledge Island on 20 June about 1 in 6 to 8 were Thick-billed. We made the following counts of cliffs from the boat:

TABLE 22

	Common Murre	Thick-billed Murre	
	24	8	
	7	5	
	5	1	
Total	36	14	28%

On July 24 we made two counts of the cliffs which we could see from our look-out above the cliffs:

TABLE 23

	Common Murre	Thick-billed Murre	
	45	15	
	92	0	
Total	137	15	.9%
Grand Total Tables 22 & 23	173	29	14%

Apparently the Thick-billed Murres were aggregated on the seaward sections of the cliffs. We saw no Thick-billed Murres among the closely crowded birds on the broad ledges or tops of the stacks (rock pinnacles).

On this basis we estimate that there were 300 to 450 Thick-billed Murres at Sledge Island.

We looked for Thick-billed Murres at several places along the cliffs at Bluff and found very few. Typical proportions are indicated:

TABLE 24

	Common Murre	Thick-billed Murre	
Stake 2	237	11	
Stake 1B	270	3	
Stake 4	410	14	
	1017	28	.03%

The only exception to this low proportion was a flat face with very small ledges where the counts indicated 150 Common Murres and 80 Thick-billed Murres.

In early August a disproportionately large number of the chicks visible were Thick-billed Murres. On 8 August, for example, at Stake 2 we saw 15 Common Murre chicks and 5 Thick-billed Murre chicks. We cannot be sure that the Thick-billed Murres laid earlier because the chicks may have been more conspicuous because they were on small narrow ledges. However, we saw no Thick-billed Murres after we came back to Bluff on 29 August. They may have finished breeding earlier and left or their reproductive season may have covered a smaller spread in time because of the smaller sample.

We could not estimate reproductive success in Thick-billed Murres, but the impression given is that their success was at least as high as that of Common Murres.

We saw 8 fish brought to the cliffs by Thick-billed Murres: 7 were Lumpenus and 1 was Ammodytes.

10100502 Pigeon Guillemot *Cepphus columba*

We saw 36 on the open water around the spit at Teller on 10 June and estimated that the entire patch of open water might have three times that number. This was the largest gathering we saw.

On 18 June we saw 9 individuals on the east shore of Sledge Island. On 23 June we saw one individual between the Cripple River and Nome. On 31 July on a still evening (which is the best condition to see a maximum number) we saw 20 at Topkok cliffs.

We saw none at Bluff or at other cliffs during the air survey. One would expect Pigeon Guillemots to breed at Besboro Island because of the rock slides.

10100602 Kittlitz's Murrelet Brachramphus brevirostris

We saw one east of Sledge Island on 17 June and a pair north of Sledge on 20 June.

10101001 Parakeet Auklet Cyclorrhynchus psittacula

On 17 and 18 June we saw 5 from the spit on the north end of Sledge Island but we saw none at the cliffs where we found them later. We saw 30 between Sledge Island and the mainland on 20 June.

On 23 July there was a flock of 32-38 on the east side of Sledge Island. On 27 July we counted 19 on the small face on the northeast corner of Sledge Island where Horned Puffins and Pelagic Cormorants nest. We saw 4 on the water below this face and a flock of 55-65 on the water east of the island.

At Bluff in August we saw 1, 4, then 8 birds together on the eastern end of the main cliffs. This place was about 1/2 mile west of the eastern edge of the main cliffs, Koyana Creek.

10101101 Crested Auklet Aethia cristatella

We saw several groups of 2 or 3 from Sledge Island and between Sledge and the mainland 17-20 June. We saw them at Sledge again on 23 July. In the evening of 5 July we saw 3 at sea about 6 miles south of Bluff. We saw an immature at Tonok in early September.

10101102 Least Auklet *Aethia pusilla*

We saw 6-8 between Cripple River and Sledge Island on 17 June, and 4 from the spit at Sledge on 18 June. We saw an immature at Tonok Point (Bluff) on 19 September.

10101302 Horned Puffin *Fratercula corniculata*

A. General comments on occurrence.

On 10 June we saw 50 on the east side of the spit at Teller and there were probably twice as many present on the open water.

During June and July we saw a few (2-5) up to as many as 15 at a time feeding within a mile or so of the shore from Cape Nome, Nome breakwater, Cripple River, or Sledge Island. They were occupying burrows when we got to Sledge Island on 17 June and were present in large numbers at Bluff in early September; but by mid-September their numbers had begun to drop and be variable at Bluff. We saw none at Topkok on 22 September.

B. Numbers.

1) We estimated that there were 100-150 birds at Sledge Island in late June.

2) At Bluff in the western part of the cliffs, east to Koyana Creek we counted 500-600 on 4 July and 12 July. In the same area we counted 1000 on 1 August and 14 August. There were between 100 and 175 in the eastern section of the Bluff cliffs, between Koyana Creek and Square Rock in early August.

On 12 September we counted 3000 birds in the updraft in front of the Bluff cliffs between the western end Daniels Creek and Koyana Creek. There were 560 in this area on 21 September.

3) At Topkok we estimated 50 birds present on 3 July in the early morning and counted 65 on 13 July in the evening.

There were 5 birds on the point between Topkok and Tonok and 5 at Tonok on 13 July.

On the air transects we estimated there to be: very few Horned Puffins or none at Cape Denbigh; 200-300 birds at Besboro Island; 50-200 birds at Egg Island; 20 birds on a round point southeast of Egg Island; 8 birds on an earth cliff north of Egavik.

C. Schedule.

Horned Puffins were incubating eggs at Bluff on 5 July. We saw two adults carrying sand launce on 3 August, and on 5 August we found a small puffin chick on a rock stack at Bluff. This chick was large yet completely downy on 5 September and had disappeared on 19 September. A parent was seen to carry food into a nest at Stake 1B on 9 September and into a nest at Stake 4 on 14 September.

D. Relation of numbers of birds seen to nests.

We searched for active burrows at each study stake (1, 1B, 2, 3, 4 and 4B) and also counted loafing puffins under ordinary weather and favorable conditions. Many times there would be no loafers so the figures in Table 25 are reasonable maxima.

The total of nests found in our study area was 15 and the average number of loafers was 10-15-25-35, growing to 50-100 on fine days. In September the prospecting birds in this area amounted to about 160, and on 19 September we counted a maximum of 186. Because the usual number of puffins counted on an ordinary day was 15-25, we believe that a count of birds over several miles of cliff may be close to the actual number of breeding pairs.

TABLE 25. Horned Puffins -- Bluff.

Burrows: loafers on ordinary and fine days.

	Burrows	Loafing Birds July-August		Loafing Birds September	
		Ordinary	Fine Days	Ordinary	Fine Days
Stake 1	4	5-9	19-12	5-10	20-26
near cliff			9-15		14-19
Stake 1B	1	2-4			16-17
Stake 2	2	3-5	13-18		9-15 (30)
near cliff		6-13			12-15 (27)
Stake 3	0	2-6			
far cliff		6-10			
Stake 4	7	5-10	10-19 (26)	10	30-43
Stake 4B	2	2-3	8-14		14-18 (34)

In September there was an influx of prospecting birds. Not only did we count 3000 flying along the cliffs on the western section (Koyana Creek to Daniels Creek) but we counted 186 birds in the study area. It seems prudent to use the count of 500-600 taken on 4 July and 12 July as representing the number of breeding pairs between Daniels Creek and Koyana Creek.

E. Food.

We do not have as many observations of food brought in as we would like, because puffins returned with food rarely. One had to wait 1-3 hours at a good spot to get one sighting. It was clear also that adults were hesitant to go to their burrows if we were at the top of the cliff.

All the food we saw was a blue-backed sand launce *Ammodytes*. The fish brought in averaged 2-3 bill lengths.

We saw puffins feeding on the water more often than we did murres. This suggests that puffins were feeding in places where they could be seen from shore, i.e., shallow water.

We saw groups of 30-150 puffins feeding intensively with each milling melee of kittiwakes. These flocks were seen in shallow water 1/2-3 miles from shore. Although we could not ourselves get far offshore, we gained the impression that the feeding flocks were concentrated in shallow water.

The agreement in the place and type of feeding together with the items of food brought in reinforce the idea that kittiwakes and puffins were feeding on the same prey -- sand launce.

10101401 Tufted Puffin *Lunda cirrhata*

Other than one group of 5 which we saw off the breakwaters at Nome in early June, we saw these birds only at the bird cliffs.

At Sledge we saw 17 birds on the water and 5 on the cliffs on 18 June.

At Bluff we estimated 5-8 pairs in July. In August we counted 15 birds in the western section plus one pair near Square Rock.

On 12 September, during the great influx of Horned Puffins, we counted 45-50 Tufted Puffins between Koyana Creek and the western end of the Bluffs.

At Topkok we counted 29 birds on 13 July and 21 on 6 August. We saw 4 at Topkok on 22 September.

At Bluff a pair of Tufted Puffins occupied a site at Stake 2. There were two pairs active at Stake 4. An adult came in carrying sand launce on 8 September and entered a burrow at Stake 4. During early September in the evenings, 5 birds loafed in the cove overlooked by Stakes 3, 4 and 4B.

VII. SELECTED OBSERVATIONS AND DISCUSSION

A. Species distribution.

1) From the information available, it appears that Black-legged Kittiwakes and Horned Puffins are relatively uniformly distributed over the northern Bering Sea area.

2) Common Murres were much the more numerous of the two murre species in Norton Sound. This was not expected because in general Thick-billed Murres are more numerous in sub-Arctic waters. The Thick-billed Murre is the more abundant of the two species of murres in the St. Lawrence Island to Bering Strait waters. The Parakeet, Crested and Least Auklets were virtually absent from Norton Sound, although numerous in the western waters.

3) Sledge Island, although it has suitable talus slopes, has only a small colony of Parakeet Auklets and no Crested or Least Auklets. King Island (which is within sight of Sledge Island) has hundreds of thousands of breeding auklets of all three species. Besboro Island in easternmost Norton Sound, has talus slopes which appear to be ideal for nesting auklets, yet none has been seen there. The presence of apparently suitable nesting sites and the absence of breeding auklets suggests that their distribution may be related to oceanographic conditions.

B. Species density.

1) There were significant changes in the numbers of murres (30,000-60,000) and Horned Puffins (750-3000) at the cliffs from day to day and in response to changes in weather. We got unsatisfactory results from the photographic record we took of the bird cliffs at Sledge Island and Bluff as far as a record of murres is concerned. There were less conspicuous

daily changes in the numbers of kittiwakes and our photographs supplied a satisfactory record for this species.

Several counts taken over several weeks are needed to indicate normal variation in the numbers of murres, but these problems do not appear to be serious with kittiwakes.

2) A few cliffs (Sledge, Bluff, Denbigh, Egg) are occupied by the great majority of nesting murres and kittiwakes of Norton Sound. There were other cliffs where a few kittiwakes nested and several sites where small numbers of Pelagic Cormorants, Glaucous Gulls, and Horned Puffins nested. The significance of the lesser sites, should a population disaster occur, is not known; but one presumes that the few primary colonies (in this case at Bluff and at Cape Denbigh) are critical to the persistence of seabirds in Norton Sound.

3) Glaucous Gulls were found to occupy their usual nesting sites scattered along the tops of rocky cliffs at Sledge, Bluff, Topkok, Cape Denbigh, Besboro Island, and Egg Island. However, we also found three colonies on small grassy islands in coastal lakes. This type of nesting site is more characteristic of Glaucous-winged Gulls or Herring Gulls. The Glaucous Gulls in Norton Sound appear to be able to benefit by increased association with man.

C. Breeding Schedule.

1) The breeding schedule of the seabirds at Sledge Island and Bluff was as we expected.

2) The main departure of murres from the cliffs took place in late August and appeared to be associated with early autumn storms. The murres had abandoned the cliffs long before there was any probability of sea ice

forming. Cormorants, kittiwakes and puffins, on the other hand, were still visiting the cliffs in late September. The numbers of kittiwakes and puffins at the cliffs in September were larger than were their numbers at the height of the breeding season. The reason for this is presumably competition for nesting sites. Young birds were prospecting for potential breeding sites the year before they will first breed.

D. Trophic relations.

1) Murres fed close to the cliffs and also returned from long distances to the southwest in conspicuous flocks. They fed primarily on a blennioid fish, *Lumpenus*, a fish whose biology is little known. Kittiwakes and puffins fed on sand launce *Ammodytes*, a genus which is an important food for many seabirds in many parts of the northern hemisphere. Its biology is also little known.

2) We found it difficult to measure reproductive success in murres and puffins.

Measurement of success was easy with kittiwakes. We believe we have developed a technique of photographing nesting cliffs from a small airplane in late August. This technique may allow us to assay the general success of a seabird cliff with perhaps only one visit, and that by air.

E. Impact of development.

1) The seabird breeding colonies at Bluff appear to be critical to the existence of seabirds in Norton Sound. Although the birds may be able to rest in some neighboring portions of the present cliffs, it is unlikely that they will move to other cliffs.

2) Our observations are consistent with those of Tuck (1960) who remarked that native communities at the seabird cliffs of Digges Island,

Akpatok, etc., in the Canadian Eastern Arctic, which had once been thriving centers of Eskimo populations, are now abandoned. King Island was abandoned in 1966; Sledge Island was apparently not visited in 1975, and Bluff, where one site is called Akpuluit (native name for "murre place") was visited only twice by eggers and they were collecting eggs as a delicacy.

The seabird cliffs do not now play an essential role in the Eskimos' economy, even though fowling and egging may remain a symbolic and recreational exercise. With continuing economic development, the value of the birds nesting on these cliffs will shift from a commodity category to an esthetic one, and the primary call of the native population on them will become complicated by the interests of a broad segment of the American public.

If, however, economic development stalls it may be that some segment of the native population will return to a subsistence economy, in which case bird cliffs will again play an important part.

3) It is not apparent why development of mineral resources should necessarily lead to damage of the wildlife resource. I believe that enough is known about the habitat needs of the species to anticipate damaging effects. Eskimos have lived for many generations at seabird colonies on Little Diomede, King Island, St. Lawrence Island, etc., without destroying the resource. An intense gold-mining operation was carried on at Bluff for fifty years without evident reduction in the number of birds at the cliffs.

VIII. CONCLUSIONS

1) The bird cliffs at Bluff support the great majority of nesting seabirds in the area. These cliffs, the waters in front of them, and the feeding grounds of the nesting seabirds will need to be protected if the

seabird population is to survive in its present numbers.

2) There is a skewed distribution in the species of seabirds. We believe from present evidence that the large number of plankton-feeding auklets in the Chirikov Basin as compared to Norton Sound reflects oceanographic conditions.

3) The number of young produced was small relative to the number of adults at the cliffs in all species studied. There appeared to be large differences in breeding success between different parts of the cliffs at Bluff.

4) The food base of the species of seabirds we observed was narrow; over 85% of the food items we saw brought to the cliffs consisted of two species of fish.

5) As regards the primary impact of oil spills, the birds at Bluff may be vulnerable to spills nearly anywhere in Norton Sound because a circulation of water within the Sound is indicated by the presence of driftwood from the Yukon River all along the south shore of the Seward Peninsula. According to these lines of evidence, oil spilled in Norton Sound will move northwestward past King Island and possibly through the Bering Strait.

IX. NEEDS FOR FURTHER STUDY

A. Reconnaissance surveys of species distribution and numbers.

1) We should repeat our survey of numbers and breeding schedule at Bluff in 1976 in order to check annual variations. We should visit Sledge Island, Cape Denbigh and Egg Island in order to confirm estimates of species numbers.

2) Further air searches should be made for cliffs or colonies on the south shore of Norton Sound in the St. Michael area and on the west shore of the Seward Peninsula between Teller and Cape Prince of Wales.

3) We should survey the major seabird colonies in the Chirikov Basin and Bering Strait (Little Diomede Island, Fairway Rock, King Island, and the three large colonies on St. Lawrence Island: near Savoonga, near Gambel and on the Southwest Capes).

The major points of the survey are: first, to establish the distribution and numbers of kittiwakes, murres and puffins; second, to establish the relative proportions of Common and Thick-billed Murres; third, to find the relative proportions of Least, Crested and Parakeet Auklets in each region. Good information on auklets on St. Lawrence Island is available, but the rest of the data needs to be gathered.

4) Pursuing the suggestion of the effect of the spring freshet, we should investigate spring conditions in eastern Norton Sound where melt water from the rivers should open leads early in the season. What effect does this have on seabirds? Do they arrive off Cape Denbigh early in May, earlier than at King Island or Bluff? Would large numbers be vulnerable to oil spills because they are concentrated?

B. Reconnaissance investigations of trophic relations.

1) Biological studies should include measurements of reproductive success (including growth rates of chicks). Data should include measurements of variation between sites on one nesting cliff, variation between cliffs (such as King Island, Sledge Island, Bluff, and Cape Denbigh) and variation from year to year.

Although it appears practical to measure reproductive success in Pelagic Cormorants, Glaucous Gulls, and Black-legged Kittiwakes, measuring reproductive success in murres is laborious and imprecise. We do not know what population elements are represented by the approximately 60% of the birds on the cliffs which do not appear to be directly associated with eggs. There are practical limitations (access to nesting crevices) to measuring reproductive success in puffins and auklets.

2) For the purposes of monitoring we need to develop an efficient technique for measuring breeding success at several bird cliffs. Kittiwakes have several characteristics which suggest that it may be practical to measure reproductive success from a distance in these gulls. The fledglings are boldly marked with black nape, wing-bars and tips of their tails, while the parents are white or pale gray with black wing-tips.

If (as is possible) annual variations and inter-colony variations in breeding success of murres, puffins and auklets run parallel with variations in breeding success in kittiwakes, we might be able to use kittiwakes as indicator species of breeding success in cliff-nesting species. We could thereby circumvent the practical limitations of the time involved in using other species for the purposes of the OCSEP.

a) We should test the consistency of the correlation between kittiwake breeding success and that of murres and puffins as breeding success varies between colonies and from year to year.

b) We should test the practicality of identifying nests, adults and fledgling kittiwakes on photographs taken from light aircraft.

In late August 1975 we took sample photographs of the nesting cliffs at Sledge Island, Bluff and Cape Denbigh to see whether we could measure breeding success by counting nests and chicks directly from the photographs. Our results were only moderately successful but are encouraging.

For most cliffs it will be necessary to use a twin-engine plane for safety reasons. The most promising plane is the Cessna "push-pull" twin-engine Sky Hawk. For the cliffs in the Norton Sound area the last ten days of August and the first five days of September appear to be the most suitable because the kittiwake chicks are large and have not left the cliffs. Furthermore, most murres will have left the cliffs.

c) We should test and where possible measure the impact of photographic flights on reproductive success in other birds such as murres. It is known that large aircraft, and especially helicopters, cause panic among murres and a close "fly by" might cause major mortality if it took place when many small chicks were on the cliffs.

3) We should repeat our collections of food dropped on the nesting ledges at Sledge Island and Bluff. We should make similar collections at other cliffs, primarily King Island and Cape Denbigh. It is important to observe whether there are regional and annual variations in the fish species and relative proportions.

4) We need to find the general distribution, density and locations of concentrations of seabirds feeding at sea in Norton Sound and the Chirikov Basin. We can do some of that and George Divoky's transects will supply more information, especially in the Chirikov Basin and Bering Strait.

We need to have facilities to make transects of feeding areas and to sample the waters where the birds are feeding, for fish population. It would be an important contribution to our work if we could develop means for sampling the populations of Sand Launce through the summer season. Hopefully, as the fisheries research related to NOAA, OCSEP move into the area, we will be able to get data on small fish and on shelf waters less than 20 fathoms (40 meters).

C. Investigations of population structure.

It is not clear the degree to which it will be worthwhile (strictly from the point of view of OCSEP) to enter onto the next more sophisticated level of understanding (rates of mortality, rates of population turnover, age structure, inter-colony movements, etc.) relevant to detailed biological monitoring.

1) In order to examine age at breeding, mortality rates and population turnover, we will need to expend a large amount of effort to catch and band adequate numbers of birds at the cliffs. It is evident already that accessibility to the ledges varies greatly between different bird cliffs.

2) We need to measure variations in breeding success from year to year in order to discover whether these seabirds depend upon certain outstandingly successful years to maintain high populations. Are there "year classes" as there are in some species of fish?

3) We need to see whether it is possible to detect and measure the impact of periodic die-offs of seabirds such as those during the last decade among the murres in the area of Bristol Bay-Alaska Peninsula and in the area of the Irish Sea. One presumes that only a small percentage of affected birds are reported and one would like to know whether such die-offs seriously deplete the populations either of certain local nesting cliffs or of the whole region.

4) For an adequate understanding of the ecosystem of which the seabirds are a part, it will be necessary to investigate the biology of the crustacea and fishes used as food. It will be important to find a) the annual variations in distribution, abundance and growth rates, b) the spawning grounds, and c) the rates and means of dispersal of the food organisms over the Basin and the Sound. Understanding the biology of the organisms will in its turn depend upon descriptive studies of chemical and physical oceanography, primarily the movements and interactions of ocean currents.

D. Geographic and oceanographic aspects.

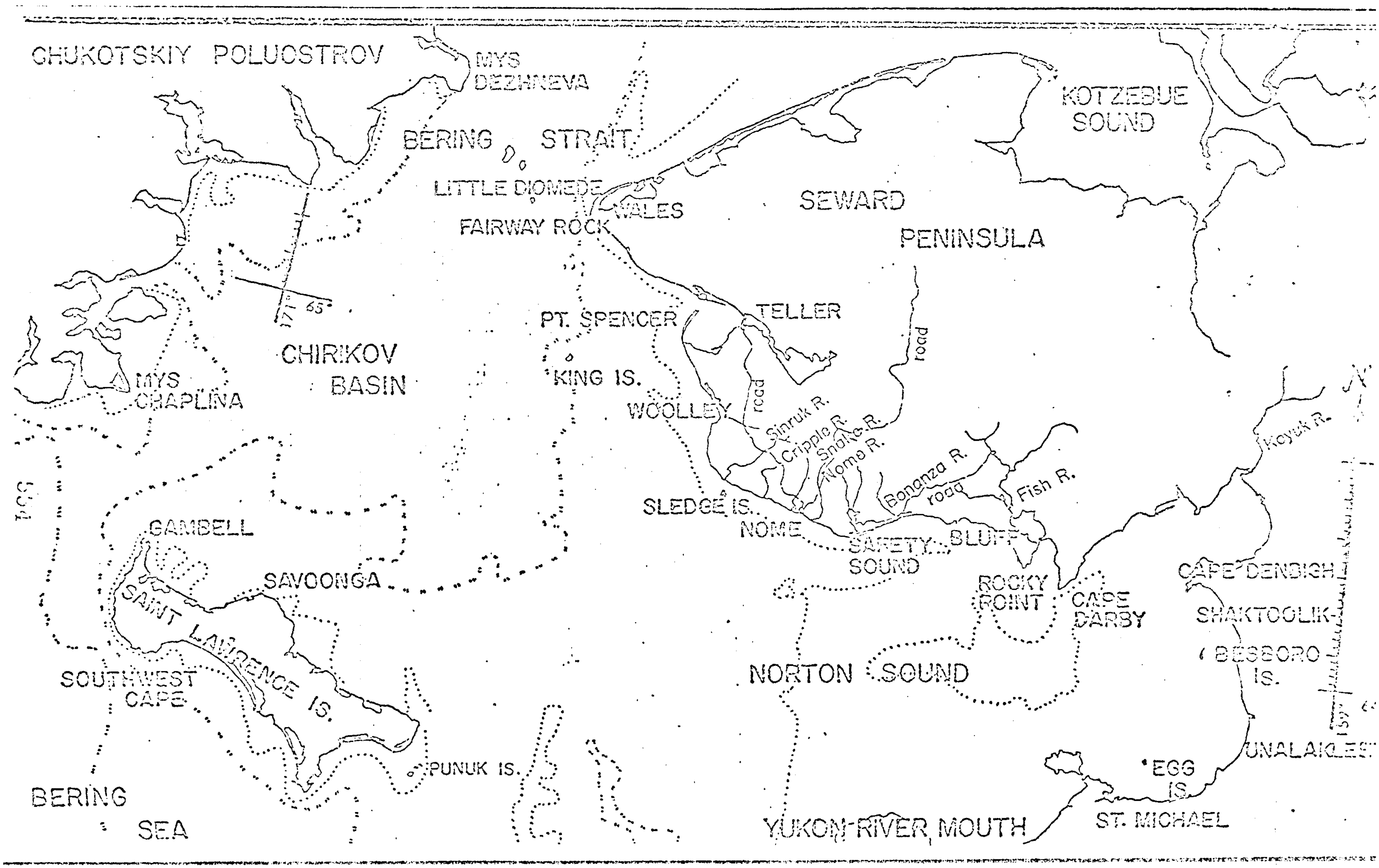
Is a skewed distribution of plankton feeders (auklets) in fact superimposed on a more or less uniform distribution of fish-eaters (Pelagic Cormorants, murres, puffins, kittiwakes, and Glaucous Gulls)? How does the distribution of these species relate to oceanographic conditions vis-a-vis nesting habitat?

1) Steps toward answers to these questions include investigating whether the distribution of the species of murres is controlled, as has been suggested, by the availability of suitable ledges (broad ledges are preferred by Common Murres and narrow ledges are preferred by Thick-billed Murres). An examination of factors influencing auklet distribution is also needed. Is auklet distribution controlled by presence or absence of suitable nesting habitats (coarse boulder slide-rock) by human and fox predation, or is their distribution controlled by the distribution and abundance of planktonic crustacea (Copepods and Amphipods)? Important work describing the food and nesting requirements of auklets on St. Lawrence Island has already been published (Bedard, Sealy).

2) If, as I expect, the question of auklet distribution has a more complicated answer than simply the distribution of suitable breeding sites, then it will be useful to investigate the structure of local water masses. We believe that the absence of auklets in Norton Sound is related to the presence of low saline, less productive water masses. Fortunately in several places comparisons can be made between relatively shallow, rather fresh water to relatively deep, rather saline water.

Comparisons should be made of a) the seabird colonies of Norton Sound with those of the Chirikov Basin; b) the seabird colonies on Cape

Newenham and Togiak Bay (shallow, low-saline waters) with those on the Pribilov Islands (deep, saline waters); c) the seabird colonies on Nunivak Island (shallow, low saline) with those on St. Matthew Island (deep, saline). If the relation between the water conditions, productivity and seabird distributions prove to be similar in these areas, a cause-and-effect relationship is suggested.


CHUKOTSKIY POLUOSTROV
MYS DEZHNEVA
BERING STRAIT
LITTLE DIOMEDE
FAIRWAY ROCK
WALES
SEWARD PENINSULA
KOTZEBUE SOUND
CHIRIKOV BASIN
MYS CHAPLINA
PT. SPENCER
TELLER
KING IS.
WOOLLEY
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Bonanza R.
Fish R.
Koyuk R.
SLEDGE IS.
NOME
SAFETY SOUND
BLUFF
GAMBELL
SAVOONGA
SAINT LAWRENCE IS.
ROCKY POINT
CAPE DARBY
CAPE DENBIGH
SHAKTOOLIK
BESBORO IS.
SOUTHWEST CAPE
NORTON SOUND
PUNUK IS.
EGG IS.
UNALAKLEET
BERING SEA
YUKON RIVER MOUTH
ST. MICHAEL
171°
65°

ANNUAL REPORT

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Research Unit No. 238

WATERFOWL AND SHOREBIRDS OF COASTAL HABITATS ON THE SOUTH SHORE OF SEWARD PENINSULA, ALASKA

PRINCIPAL INVESTIGATOR

William H. Drury
College of the Atlantic
Bar Harbor, Maine 04609

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OUTER CONTINENTAL SHELF OIL AND GAS DEVELOPMENT.

A. The objectives of this study are:

1) To find what use waterfowl and shorebirds make of which parts of the coastal zone on the south shore of the Seward Peninsula, Alaska.

2) To identify the areas of especial importance to waterfowl and shorebirds.

3) To develop conceptual models of how waterfowl and shorebirds respond to the patchy patterns of resources on the coastal tundra in order to estimate what habitat resources and what patterns in them are necessary to keep the coastal ecosystems going.

4) To describe the relation between human activities and the patchy distribution of wildlife relative to the effects of economic development.

B. Our conclusions are as follows:

1) At least two areas on the southern Seward Peninsula conform to the usual category of critical ecological areas. These are the mudflats at Safety Lagoon and those at the mouth of the Fish River in Golovnin Bay. Most of the flats in these two areas were covered by ice during the spring migration and their chief use by wildlife was during low-water periods in September.

2) The mossy lowland tundra and the associated small ponds are widely used by breeding shorebirds, cranes, ducks, geese, swans and loons. Certain areas, whether of tundra or lakes, are densely populated by mixed populations of several species; others are sparsely occupied or empty.

3) Migrants and non-breeding birds gathered in certain restricted places:

a) Early in the season waterfowl were found in flocks feeding in shore leads and the mouths of rivers.

b) A few of the coastal lakes (those held in by a beach ridge) were almost completely drained early in the season after the spring thaw. These lakes attracted large numbers of waterfowl, gulls and shorebirds. Because ocean currents had rebuilt the beaches and blocked the outlets of these lakes later in the season, we expect that the pattern of drained/undrained lakes will differ from year to year; so will their use by waterfowl and shorebirds.

4) The way wildlife uses the mossy tundra and associated lakes conforms to a model of interactions between an exploiter and an unpredictable or patchy resource.

a) Wildlife tends to aggregate rather than being evenly dispersed.

b) Although wildlife gathers consistently at some places, the aggregations of waterfowl usually move from place to place from season to season and from year to year.

c) We presume that many independently varying forces and processes make the habitat attractive. Wildlife gathers in those places where a maximum number of factors are favorable.

d) The habitat "needs" to have redundancy built into it to increase the odds of survival of the populations that use it.

C. Implications with respect to outer continental shelf oil and gas development.

1) Our observations of where drifting ice and driftwood collect suggest that materials released in southern or eastern Norton Sound will move

westward along the south shore of the Seward Peninsula and come ashore in the sheltered places where waterfowl seek shelter. These observations, together with the form of the gravel spit on Sledge Island and Cape Spencer suggest that materials released in Norton Sound and off the Yukon Delta will move northwest into the Chirikov Basin ~~but not~~ more than in the reverse direction.

2) Waterfowl and shorebirds habitually congregate at certain areas in their preferred habitats. Each of these gathering places deserves special consideration in developing land use plans.

3) Certain wildfowl species have special human or social values. These include:

> a) Waterfowl, b) sandpipers and plovers, c) species of special geographic distribution which include both those species of northwestern Alaska whose distribution is primarily in Eurasia and those 20-25 bird species which are endemic to the Bering Sea area.

4) As to the effects of oil spills: the waterfowl that are most vulnerable to oil spills are loons, grebes, eiders, scoters, Harlequins, Oldsquaws, and mergansers. Oil released into lagoons such as Safety Lagoon or into Golovnin Bay would be a serious hazard to the waterfowl and shorebirds which gather there. Several species of special biogeographic interest such as Steller's Eiders and Spectacled Eiders are especially vulnerable to oil on the sea. Other endemic species such as Emperor Geese, Small Canada Geese, Black Brant, Western Sandpiper, and Long-billed Dowitcher would be vulnerable to oil spilled on lagoons or estuaries.

5) As to the effects of secondary development: shorebirds will accept rather high levels of human presence at their gathering areas. Waterfowl are easily disturbed because they are hunted and therefore human disturbance promises to reduce or eliminate the value of coastal lagoons to waterfowl as human traffic increases.

6) The Eskimos were hunters and food gatherers before the invasions of the Europeans, and consequently their traditional village sites are at seabird cliffs, at waterfowl habitats or at sites convenient for hunting marine mammals. This situation creates a conflict between the land claims of the natives and the needs for habitat maintenance of waterfowl and shorebirds.

7) One major difficulty will relate to pressures for development of habitat when only a portion is occasionally used by wildlife. Developers may argue that any one portion of the region is not critical.

If our model for the use by wildlife of the coastal area is valid we can predict that reduction in the total area of tundra and number of coastal lakes reduces the odds that suitable habitat will be available [even though only a portion of the tundra and a few lakes are used in any year] . Loss of habitat redundancy increases odds of population reduction and makes it less likely that a population once reduced will readily regain its previous abundance. The effects of this reduction can be mitigated by management of water levels in the remaining lakes or ponds. But to the degree that the local population depends upon management, it is partly domesticated. Such partial domestication of wildlife may be a cost of mineral development but if so, it should be counted.

II. INTRODUCTION

A. General nature and scope of the study.

Most of the data were gathered by reconnaissance surveys. The scope of our study is to learn the uses made by waterfowl and shorebirds of coastal habitats of the Seward Peninsula, Alaska, to identify areas of special importance, to anticipate the impact of oil development and its associated increase in human population, to identify human activities that will be especially damaging to wildfowl, and to suggest possible ways of mitigating the effects.

B. Specific objectives.

1) To determine distribution and density of waterfowl and shorebirds by seasons on inshore waters and coastal lowlands; to locate and identify species and count numbers of individuals, recording the changes from season to season.

2) To make comparisons of types and intensity of use between regions; to identify why gatherings occur, whether they be feeding or resting (on migration or when breeding); and to identify movements relative to water conditions, tides, winds and storms.

3) To predict the impact of development (increase in human disturbance, roads, pollution, and alteration of habitat).

C. Relevance to problems of petroleum development.

In order to assess the possible impact of oil development, we need to identify areas where waterfowl and shorebirds gather and where, as a result, they will be vulnerable to oil which is carried to shore by ocean currents or driven by winds.

We need the conceptual materials and substantive information including quantitative data to be used by those developing ecosystem models to predict environmental effects of proposed oil and gas development.

We need to develop techniques to estimate the social effects of damage to waterfowl and shorebirds caused by oil and secondary development. We must suggest ways to allow development to be compatible with a wide spectrum of social values.

We need to have answers to these following questions (among others):

a) If oil spills occur in the Norton Sound-Chirikov Basin area, where will the oil move and collect? How fast and under what conditions will it congeal into "chocolate mousse" -- a condition in which oil is less damaging to waterfowl?

b) Where are major concentrations of loons and marine ducks at the several seasons: on arrival in early spring, when breeding and feeding; when migrating and when wintering? What species of waterfowl and seafowl are especially vulnerable to oil spills? Where and under what conditions are they vulnerable?

c) What species are perceived by members of the concerned public as having significant social importance to humans?

d) What impacts are oil development and its secondary effects (such as construction on shore or at sea, transportation and oil spills) likely to have on the food resources of the seafowl? What species are most vulnerable to human disturbance associated with oil development, where are they vulnerable and under what circumstances? What levels of coexistence of seafowl and development are possible?

e) What constraints or what standards of performance might be set to ensure survival of seafowl resources during development?

III. CURRENT STATUS OF KNOWLEDGE

In comparison with other species (seabirds and shorebirds) waterfowl have been well studied over wide areas. Furthermore, the changes in the distribution and numbers of their breeding populations have been followed over a number of years. Transects have been made to monitor waterfowl relative to setting bag limits and fixing hunting seasons. One such transect traverses Safety Lagoon.

In contrast, with a few exceptions (e.g., Western Sandpipers and Dunlin), knowledge of shorebirds is sparse and what there is reflects short-term local studies. A few ornithologists have recorded the species present at scattered sampling sites on the Seward Peninsula.

IV. STUDY AREA

The area is shown in Figure 1.

We concentrated our efforts at the mouths of rivers because we saw waterfowl gathered there. We also visited the lakes or lagoons we could walk to from the shore. We traversed Safety Lagoon in small boats and surveyed from small aircraft most of the coastal area between Cape Spencer on the northwest (65°10'N, 166°45'W) to south of Unalakleet on the southeast (63°50'N, 163°50'W).

V. SOURCES, METHODS AND RATIONALE OF COLLECTING DATA

A. Methods

1) We made air reconnaissance of marshes, lagoons, river estuaries and lakes within about ten miles of the coast in the coastal region which we surveyed.

We made surface reconnaissance of the coastal area at Teller, the Cape Woolley Lagoons, the coastal lakes between Cripple River and Sinuk

River, the mouths of the Snake and Nome Rivers, and the shoreline from Cape Nome eastward as far as Bluff -- that is, the area between a point 20 miles west of Nome to an area about 70 miles east of Nome.

We made surface visits to rivers where they are crossed by the roads to Teller, and to the Kougarok River and Taylor.

We used small boats to travel between Sledge Island and Nome eastward from Safety Lagoon to Bluff and Square Rock east of Bluff.

2) During these reconnaissance visits, species present were identified; individuals were counted and interpretations made as to the uses of the area by these species and individuals.

In addition (during reconnaissance travel or while camped at nesting areas) standardized 15-minute watches were made of the inshore waters recording species and numbers present, directions of flight, and feeding or other activity.

We gave special air and surface attention to Safety Lagoon, the mouth of Bonanza River and the lagoons between Bonanza (Solomon) and Topkok.

B. Data collected

We spent parts of six days flying reconnaissance, made 26 trips in small boats, 14 coastal and inland reconnaissances in auto, and carried out 63 15-minute watches for waterfowl.

We made surveys of waterfowl during 200 miles of travel by small boat, 520 miles of travel on roads, 750 miles of air travel, and 180 miles on foot.

C. Rationale

We undertook to identify and count the species of waterfowl and shorebirds to discover what species are most numerous and to locate rare or endangered species if they occur.

We visited all terrain types in the course of our surveys, so as to identify the species precisely.

The air surveys gave us an overall picture of the places where species occurred, their relation to landscape types, to vegetation and to the distribution of people.

We took ground surveys at different seasons to find the differences in use of coastal areas from month to month.

During the first summer's reconnaissance we searched widely in order to identify those areas which should be studied in more detail in later field seasons.

VI. RESULTS

A. Surface reconnaissance.

1) The standardized watches and observations made during travel supply reliable data on species present and numbers at the times of observation. These data have already indicated, however, that variation is high.

a) The species occurring in small numbers may vary widely from spot to spot and from day to day.

b) The numbers of individuals in flocks vary widely so that the precision of our counts is much greater than is necessary to establish expected usage.

Thus we can be confident of the occurrence and abundance of the common species. However, the presence of many wandering individuals of less common species and the large variation in flock size indicated that only general statements are supportable.

2) Sample size (number of sample watches and reconnaissance trips). Many areas were visited too few times to allow us to do more than make

general statements about the use of the area by waterfowl. Some areas are used heavily in mid- to late September but were very little used in June. A lagoon that is crowded with waterfowl when its water level has dropped because it has been drained may be empty of birds if the water level rises to the usual shorelines.

3) Some of our data are not representative because we only learned of important areas late in the season. We learned that certain areas, often of small areal extent, get unusually heavy usage. During other years these places will need to be visited more frequently.

4) We have data from a few visits at a few times during the summer for the fresh water areas visitable by car between Teller and Safety Lagoon. These include Teller, Woolley Lagoons, Sinuk River to "Washout" on Safety Lagoon, Bonanza River and Taylor Lagoon.

B. Air reconnaissance

1) We have made only one full reconnaissance of the shoreline of Norton Sound. Part of the reconnaissance was made on 18-19 August and the rest on 29 August. We have more than half a dozen air transects at low altitude of Safety Lagoon and these suggest that the general pattern found on one survey is consistent, even though details change.

2) We have counts of waterfowl including cranes, ducks, geese, swans and gulls from the air. The identification of these is reliable with the exception of separating the small-sized Canada Geese from Brant, and the identification of some species of diving ducks in eclipse plumage. We have some counts of shorebirds but species identifications in many cases are not reliable.

C. Species list, including comments

The species are reported in the order listed in Report USF&WL No. CE 002-75 (Computer Codes for Birds of North America, NOAA OCSEAP Research Unit 339".

01010102 Yellow-billed Loon *Gavia adamsii*

One individual was seen feeding at the mouth of the Cripple River on 22 June 1975. At that time the large inland lakes were still ice covered. Yellow-billed Loons have been reported to nest on Salmon Lake which is about 75 km (45 miles) north of Nome.

01010103 Arctic Loon *Gavia arctica*

These migrated from east to west along the south shore of Seward Peninsula all during June. During the month we have 11 reports of single birds or small groups of up to 5 individuals. Six individuals were feeding in open water at Teller when most of the sea was frozen on 10 June. A peak in the movement occurred in the evening of 23 June when 40 were seen flying west during a period of one hour. They were still moving west on 2 July when we saw flocks of 60 and 45.

When the ice on lakes and lagoons thawed these loons became much less evident on inshore waters. Nevertheless 2 Arctic Loons were seen between the ferry at Safety Lagoon and Bluff during trips in August and September.

In early September Arctic Loons were still on nesting lakes on the base of Point Spencer. They nested in lakes that were perhaps three times larger than those occupied by Red-throated Loons.

We saw an Arctic Loon at the point between Topkok and Tonok on 19 September.

01010104 Red-throated Loon *Gavia stellata*

Red-throated Loons seemed to arrive later than Arctic Loons and were less frequently seen at the mouths of rivers during June than Arctic Loons. Nesting Red-throated Loons were perhaps ten times as common as Arctic Loons on coastal lakes, and 1 to 3 could be heard in flight "songs" at each place where we stopped along the coast during July. Their nesting lakes were primarily within ten miles of the sea.

They were still on coastal lakes in late August and were seen on perhaps 5% to 10% of the lakes examined from the air.

Air transects suggested that Red-throated Loons were more common than elsewhere at two places: the thaw lakes inland from Safety Lagoon and the similar lakes between Cape Spencer and Cape Douglas.

In late June Six to ten were seen feeding on the sea during the hour's trip (about 10-15 miles) along the beach west of Nome to Cripple River. Eight were seen in the eastern half of Safety Lagoon on 2 July.

02010101 Red-necked Grebe *Podiceps grisegena*

Single birds were seen on the sea at Nome and at Sledge Island in June. One was seen in Salmon Lake in late June.

This small sample suggests that the species is not numerous and nests on lakes which are many miles from the sea.

We saw no Fulmars, Shearwaters or Petrels.

06010202 Whistling Swan *Olor columbianus*

Small flocks of Whistling Swans were seen flying along the valleys of major rivers in June. They were also seen on large inland lakes such as Salmon Lake. A flock of 10-30 birds could be seen during June, July and

August in a coastal lagoon between Bonanza and Topkok. This flock increased to 52 birds on 2 September.

We saw no spring migration that we recognized as such. Swans were seen flying east along the coast after the middle of August. There were still large flocks, e.g., 1200 adults on mudflats and shallows at the mouth of the Fish River in late September.

Swans bred on many lakes formed by thawing of frozen ground -- in the Fish River, Safety Lagoon and on the coastal lowlands west from Nome to Cape Spencer. In August we saw broods of 2, 2, 3 and 5 on the ponds north of Safety Lagoon.

On 29 August we were able to make counts of pairs or single adult swans on nesting lakes and counts of cygnets in families. These counts were made in the coastal area west from the Cripple River to Cape Spencer. We counted 49 parental sets and 43 cygnets indicating a breeding success of .9 cygnets per pair. Brood sizes of successful nests were observed as:

3 cygnets -- 7 2 cygnets -- 10 1 cygnet -- 2

On 26 September we counted a gathering of swans at the mouth of the Fish River. There were 850 adults and an uncounted number of cygnets which could fly. In addition we counted the following broods of still flightless young:

Brood size:	5 cygnets	4 cygnets	3 cygnets	2 cygnets	1 cygnet
Number seen:	1	4	6	5	2

The upper part of Golovnin Bay is an important gathering area for swans before freeze-up forces them to leave the area.

0601030108 Lesser Canada Goose <u>Branta canadensis leucopareia</u>

There was a pair on the river meadows and a flock of 6 flying at the northern end (about Mile 90) of the "Kugarok Road" on 24 June.

By August flocks were assembling. We estimated flocks of 12, 15, and one of 50-60 in Safety Lagoon on 19 August. On 29 August we estimated flocks of 40, 70 and 300 flying over the coastal lowlands between the Sinuk River and Cape Woolley. Also on 29 August we estimated flocks of 250, 175, 60 and 15 flying over the lowlands between Cape Douglas and at the base of Point Spencer.

On 18 September we saw 75 flying eastward over Bluff. On 23 September we saw a flock of 1500 feeding in the shallow water of Safety Lagoon.

0601030110 Cackling Canada Goose *Branta canadensis minima*

We saw two or three small flocks of very small-dark-bellied Canada Geese in September at Safety Lagoon and at Bluff.

06010303 Black Brant *Branta nigricans*

We did not see this species until the evening of 20 June when we saw flocks totaling 280 birds flying west between Nome and the Sinuk River. We saw a flock of 50-60 flying west near Cripple River on 23 June and a flock of 26 in Safety Lagoon on 26 June. On 29 June we made the comment that Black Brant were still migrating west.

We saw a single Black Brant during the air survey of Safety Lagoon on 19 August. We saw 2 between the Sinuk River and Cape Woolley during the air transect on 29 August. On the same 29 August we saw 300 Black Brant flying over the base of Cape Spencer.

We found it very difficult to judge the size of flying geese from the air. Furthermore, we found it very difficult to differentiate between flying Brant and Canada Geese from behind (whether above or below). We cannot therefore be sure of the identifications of geese made from an airplane.

06010401 Emperor Goose <u>Philacte canagica</u>

We saw a few, less than 6, flocks of 3-8 individuals, mostly flying west along the beaches in early June.

06010601 Snow Goose <u>Chen caerulescens</u>

We saw 3 at the base of Cape Spencer on 29 August.

06010907 Pintail <u>Anas acuta</u>

Pintails were, with Oldsquaw, the most common ducks on coastal areas. We saw pairs and groups of three at 5 small lakes along the Kougarok Road from Nome north to Salmon Lake and 40 on Salmon Lake and small lakes between there and the Kougarok River on 7 June.

Most of these ducks were seen on shallow coastal lagoons, e.g., 35 on a lagoon east of Sinuk River on 22 June. We have the comment on 22 June that more than half of the Pintails then appeared to be incubating. We saw 15 in Safety Lagoon on 2 July, 150 in the east end of Taylor Lagoon, and 700 at the west end on 11 August. We saw 300-350 in the lakes north of Safety Lagoon on 19 August, and 335 on the lakes south of White Mountain (Fish River) on 18 August.

We saw 50-75 in the lagoon east of Bonanza River on 2 September, 75 at the mouth of Bonanza River on 22 September and 450 in Safety Lagoon north of Port Safety on 23 September.

06010910 Common Teal <u>Anas crecca (carolinensis)</u>

We saw 4 along the Kougarok Road as far as Mile 24 on 7 June. On 24 June we saw 8-10 on small lakes between Salmon Lake and the Kougarok River.

Teal were widespread in the lakes behind coastal beach ridges. We saw two on a lake east of the Sinuk River. A flock of 20-35 seemed to move around among several patches of fresh water between the mouth of Bonanza

River and Taylor Lagoon between 11 August and 22 September.

Fifty teal were seen on the lakes near Flambeau River on the air survey of 19 August. Fifteen teal were seen from the air on large lakes behind the beach between Cape Douglas and Cape Woolley.

06010916 Baldpate *Anas americana*

We saw one on a small lake near the Kuzutrin River on 24 June. One hundred were seen on 11 August in shallows at the west end of Taylor Lagoon. Twenty were seen from the air on lakes near the Flambeau River north of Safety Lagoon on 19 August. Several hundred were seen south of White Mountain near the mouth of the Fish River on 26 September.

06011106 Greater Scaup *Aythya marila*

These were widely scattered in small numbers. We saw one flying west past Nome on 13 June and one in a lake behind the beach east of the Sinuk River on 20 June. We saw a pair on small ponds near the Kougarok River on 23 June.

They gathered in deeper coastal lagoons in August and September. We saw flocks of 55, 35, 30, 25 and 8 in lakes north of Safety Lagoon on 19 August, and we saw 125 on Safety Lagoon north of Port Safety on 23 September.

06011201 Common Goldeneye *Bucephala clangula*

We saw two between Salmon Lake and the Kuzutrin River on 24 June.

06011301 Oldsquaw *Clangula hyemalis*

Early in June we saw small groups of Oldsquaws at the mouths of rivers and off rocky shores between Cape Nome and Sledge Island. There were 15-20 pairs in the open water around the gravel spit at Teller. On 24 June we saw 15 pairs on lakes around Salmon Lake. On 22 June we have the comment that 95% of the Oldsquaws seen are single males.

Between then and 1 July we saw flocks of male Oldsquaw (70, 50, 30, 20, 15) on the sea close to the beaches between Cripple River and Bluff.

On 22 July we saw a female with 9 ducklings on a coastal lake east of Sonora Creek.

During the air surveys on 19 August we saw 35 on lakes north of Safety Lagoon. On 29 August we saw 115 along the beach between Sinuk River and Cape Woolley, 25 in the lagoons by the beach between Cape Woolley and Cape Douglas, 215 on the lakes at the base of Cape Spencer, 4 on the lakes some distance inland between Cape Douglas and Cape Woolley and 30 on tundra inland lakes between Cape Woolley and the Sinuk River.

By mid-September Olsquaw were moving from fresh water lakes to the shallow sea. On a boat trip from Bluff to Port Safety on 22 September I saw 75-100 between Bluff and Topkok; 250 from west of Topkok to Bonanza, 200 off the mouth of Bonanza River; and 100 between Bonanza and the ferry crossing.

06011401 Harlequin Duck *Histrionicus histrionicus*

Harlequin Ducks were seen in pairs flying up the rivers 20-30 miles from the sea until 15 June. We saw one or two pairs at each river where we stopped for half an hour or more. A flock of 3 pairs and a male were seen at Cape Nome on 6 June, and two pairs and a male at the Cripple River on 16 June.

At Sledge Island we saw 12 males and 3 females on the east side of the island and 14 males and 1 female on the west side on 18 and 19 June. We saw a flock of 90 males at the south end of Sledge Island on 18 June. On 22 June we saw a flock of 8 males and 1 female at the mouth of the Cripple River.

We saw a flock of 55 males at Topkok on 3 July and a flock of 35 males on the point between Topkok and Tonok on 11 July.

In July we saw small groups, 4-20, feeding and loafing at rock outcrops between Square Rock and the Sinuk River.

We saw very few Harlequins on the air surveys of 29 August, and we saw 4 Harlequins at the point between Topkok and Tonok on 19 September.

06011601 Steller's Eider *Polysticta stelleri*

We saw a pair at Cripple River on 16 June and a pair at Sledge Island on 18 June. We saw a flock of 5 males off Cripple River on 22 June, and a male off Topkok on 14 July.

06011701 Common Eider *Somateria mollissima*

We saw small numbers of this species, 1-6, on the sea between Cape Nome and Sledge Island in late June.

06011702 King Eider *Somateria spectabilis*

We saw 14 flocks of 12-20 individuals and one of 50 individuals flying west along the beach during late June. On 20 June we saw 50 in three groups at Cripple River. On 18 June and 23 July we saw small flocks, 4-12, at Sledge Island.

On 19 September we saw a female at Bluff and on 22 September I saw 155 between Bluff and Topkok and 150 between the west end of the Topkok cliffs and the mouth of the Bonanza River.

06011703 Spectacled Eider *Somateria fischeri*

We saw one female at the point west of Tonok on 19 September.

0601170001 Eiders -- unidentified

We saw a number of eiders which we could not identify to species during air reconnaissance. We saw 7 at Cape Denbigh 18 August. On 29 August we saw 110 close to the beach between the Sinuk River and Cape Woolley and 15 between Cape Woolley and Cape Douglas.

06011802 White-winged Scoter _Melanitta deglandi_

We saw two from the beach at Nome on two occasions on 12 June. We could not be sure that these ducks were not Velvet Scoters _Melanitta fusca_.

06011804 Black Scoter _Melanitta nigra_

On 6 June we saw a flock of 40 in drifting sea ice at Cape Nome. We saw about 15 flocks of 20-35 birds flying west along the coast in June. We saw flocks of 5, 8 and 20 at Sledge Island, and Cripple River in late June.

On 3 July we saw 20 on the sea between the ferry crossing at Safety Lagoon and the mouth of the Bonanza River.

On 22 September I saw 50 on the sea between Bluff and Topkok and 50-60 on the sea between the west end of the Topkok Cliffs and the Bonanza River.

06012102 Red-breasted Merganser _Mergus serrator_

We saw these in flocks at Cape Nome and on the Nome River in the first two weeks of June. After that we saw them in small numbers at nearly all places.

We saw 30 between Nome and Mile 25 on the Kougarok Road, and 4 pairs on the ponds between Salmon Lake and the Kuzutrin River. There were still some pairs together on the rivers on 28 June, i.e., later than Pintail, Harlequins and Oldsquaw.

On 14 July we saw 4 on the sea between Topkok Cliffs and the mouth of the Bonanza River.

On 11 August we saw 9 in two groups at Taylor Lagoon. On the air transects 29 August, we saw 42 on the coastal lagoons between Cape Douglas and Cape Woolley.

09010102 Sandhill Crane *Grus canadensis*

Cranes nested on the wet coastal tundra west of the Nome Airport and several nests were robbed.

Flocks were moving in mid-July. We saw 8 at Bluff on 12 July and 9-10 at Bonanza River on 14 July. An Eskimo at Woolley Lagoon reported that he had seen "lots of" cranes on the lowlands during the week of 11-18 July.

The eastward autumn migration occurred in the first three weeks of September. Flock sizes were usually 20-125. Although we could occasionally hear young cranes calling in flocks passing over, we could not estimate the proportion of adults to young.

On September	2	we saw	8
"	6	"	52
"	9	"	235
"	11	"	2800
"	16	"	1100
"	18	"	250 in a snowstorm
"	18/19		Several flocks flew over in the moonlight
"	19	"	4500-5000
"	21	"	525

Eastward movements were associated with clearing weather and perhaps a drop in temperature. Those moving on 19 September (a clear, cold morning with 20-25 knot north wind) were several miles out over the sea. The temperature on 20 September was 19-26°F. and a 15-knot north wind blew.

In addition to those we saw and counted, we heard many other flocks by day and at night by moonlight. I doubt that we saw more than 20-30%

of the small flocks that passed. We do not know whether there were other major movements to compare with those of 11 and 19 September.

10030200 Ringed or Semipalmated Plover *Charadrius hiaticula/semipalmatus*

The Ringed Plovers which we saw differed noticeably from Semipalmated or Ringed Plovers we have seen in eastern U.S. or in Europe. They had almost no white above and behind the eye. Instead the black eye stripe was conspicuously wide behind the eye. The birds did not have the wider breast band which seems to separate *hiaticula* from *semipalmatus*.

We saw Ringed Plovers at 10-12 places along the river gravels on the road to the Kougarok River. We saw them at two places on river gravels on the road to Teller (at the Feather River and at Eldorado Creek south of Teller).

10030402 American Golden Plover *Pluvialis dominica*

This was one of the most conspicuous and widespread shorebirds. I estimated 50-75 pairs along the road to Teller; 30-40 pairs along the road north to the Kougarok River and 20-30 between the Nome River and Cape Nome along the road to Safety Lagoon. They were present on the mossy tundra around Cripple River, Sonora Creek and the lowlands to the west. We saw three pairs near the airstrip at Bluff.

We saw the first chicks a few days to a week old at Bluff on 3 July. We saw four pairs with 1 to 1½ week old chicks on the road to Woolley Lagoon on 18 July.

Adults disappeared about 10-20 August but young were present through September.

On air transects we saw 30 on the flats of the Fish River (Golovnin Bay) 18 August; 10 on tundra lowlands north of Safety Lagoon on 19 August.

On the air transects on 29 August we saw 6 at the base of Point Spencer and 100 around the Woolley Lagoons. Fifty were seen while we were on the ground on the beach at Woolley Lagoons. All these were in winter plumage.

On 2 September we saw a total of 85 from the air over Safety Lagoon and the mouth of the Bonanza River.

We saw three birds in winter plumage at Port Safety on 23 September.

There may be several Golden Plovers with white axillar feathers in the Feather River-Woolley Lagoon area. These birds would be Eurasian Golden Plovers (*Pluvialis apricaria*) if indeed they do have white axillars.

10030403 Black-bellied (Gray) Plover *Pluvialis squatarola*

We saw two pairs each with two $1\frac{1}{2}$ week old chicks on the upper lichen or dry tundra part of the road to the Woolley Lagoons on 18 July.

10040101 Ruddy Turnstone *Arenaria interpres*

We saw these in five places, both on river gravels and on barren, dry or lichen tundra at passes between drainages along the road to the Kougarok River on 7 June and 24 June.

10040102 Black Turnstone *Arenaria melanocephala*

We saw three together on the stone "rip-rap" at "Washout" on Safety Lagoon in early August. We saw about 5 single birds at Bluff in September.

10041301 Surfbird *Aphriza virgata*

We saw a single bird feeding on the beach near Sonora Creek 22 July. We saw single birds three times at Bluff in September.

10040401 Common Snipe *Capella gallinago*

During the display period when males are "winnowing" and calling in flight, Snipe seem to occur almost everywhere on the wet or mossy tundra.

One can hear 2-3 different males displaying at most places of lowland, rich tundra. We counted 8 between Nome and Anvil Hill, and 28 between Nome and Cape Nome. We saw them at 25 different places along the road to the Kougarok River. They seemed to be present at each place we stopped between Nome and Teller -- that is, about 20 stops. They became much less conspicuous when the displaying period passed.

We saw one in the evening of 17 September at Bluff.

10040604 Whimbrel <u>Numenius phaeopus</u>

This is a conspicuous and widespread yet only moderately numerous shorebird. We estimate that in June they were in 12-15 places between Nome and Cape Nome which is favorable habitat -- wet lowland tundra. They were also present in June on the tundra north of the mouth of the Cripple River.

On 30 June we saw the first newly-hatched chicks about Mile 8-9 east of Nome towards Cape Nome.

Whimbrels were inconspicuous in July and early August; then we began to see small flocks: 20-30, 14 August, 15 August, 23 August, 31 August, 2 September.

10040801 Spotted Sandpiper <u>Actitis</u> (<u>Tringa</u>) <u>macularia</u>

In June we saw single birds on river bars at Mile 25 of the Kougarok Road and at the Kuzutrin River on the same road.

10041001 Wandering Tattler <u>Heteroscelus incanus</u>

These were conspicuous and widespread. We saw them at most places where the highways cross rivers, either on the road to the Kougarok River (10-15 birds) or the road to Teller (8-12 birds). We also saw them at the mouth of the Cripple River.

We did not visit their habitat in July or August. On 16 September we saw a single bird feeding on a cobbly beach at Tonok, west of Bluff.

10041200 Unidentified "peep" sandpipers *Calidris* sp.

From late August until late September we saw flocks of sandpipers at a distance or from the air and were not able to identify the species. Many were on mudflats near the mouth of the Bonanza River on the east end of Safety Lagoon., viz., 2 September -- 300; 22 September -- 175.

10041201 Red Knot *Calidris canutus*

On 20 June we saw 8-10 in a drained lake behind the beach east of the mouth of the Sinuk River.

10041204 Rock Sandpiper *Calidris ptilocnemis*

On 10 June we saw a pair on a barren lichen-vegetated ridge crest about 8 miles south of Teller.

On 16 September we saw 3-5 on the cobble beach at Tonok.

10041206 Pectoral Sandpiper *Calidris melanotos*

We saw one clearly at Bluff in early September and another at Port Safety on 23 September. However, I think that many of the other peep sandpipers we saw flying singly at Bluff or in flocks at Bonanza River were this species.

10041207 White-rumped Sandpiper *Calidris (Heteropygia) fuscicollis*

On 11 August we saw a sandpiper with a white rump on the mud of Taylor Lagoon. We saw it flying in a flock of Western Sandpipers and heard a "mouse-like squeek" but cannot be sure that the bird was not a Curlew Sandpiper.

10041208 Baird's Sandpiper *Calidris bairdii*

On 21 July we saw two on rocky outcrops along the beach between Sonora Creek and Quartz Creek north of Sledge Island. On 24 July we saw 5 in a flock on the flat top of Sledge Island.

We saw one individual on mine tailings on the edge of a pond at Daniels Creek at Bluff in early September.

10041212 Rufous-necked Sandpiper *Calidris ruficollis*

We saw one on several days during the first ten days of June on the mud of the shore of Safety Lagoon at "Washout".

1000414 Dunlin *Calidris alpina*

We saw small flocks,2-8, of these on mud shores, from the drained lagoon east of the mouth of Sinuk River to Safety Lagoon during June. In September we saw flocks of about a dozen at several places on mud shores, e.g., at Port Safety on 23 September.

10041216 Semipalmated Sandpiper *Calidris pusilla*

In June we saw 25 displaying males on territories on the vegetated dunes along the beach at Safety Lagoon. We saw 50-75 at other places on sandy shores, on mudflats, at river mouths, and at Safety Lagoon. We saw a few on tundra ponds behind beach bars between Sonora Creek and Quartz Creek north of Sledge Island.

On 11 August we saw two on the mud shores of the drained lagoon east of Taylor Lagoon.

10041217 Western Sandpiper *Calidris mauri*

These sandpipers were widespread and numerous on the low, mossy tundra near the coast. They were aggregated into groups which nested on contiguous territories. Each group was separated by several hundred yards or miles from the next aggregation.

One aggregation nested northeast of Nome; another was just east of the Nome River. In addition there were individual Western Sandpipers at nearly every place one stopped on the mossy tundra in June. We would estimate about 300 pairs nesting in the area extending 8-10 miles from west of Nome to Cape Nome. We found them nesting also in the lower creek valleys along the road to Teller, such as Washington Creek and Yellowstone Creek. They preferred mossy tundra with poorly developed hummocks and little if any willow shrubs. They were still to be seen on wet tundra into late July.

By early July they gathered in flocks of 50-200 on mudflats such as those at the mouth of Bonanza River or the drained lagoon east of Bonanza River mouth on 3 July.

We observed a sexual dimorphism that was so conspicuous as to suggest two species. One sex has much more and brighter red on the crown, earpatch and scapulars, as well as a longer bill thicker at the base.

10041402 Long-billed Dowitcher *Limnodromus scolopaceus*

We saw perhaps 20 Dowitchers in 2's and 3's during August and September in the area between Safety Lagoon and Bluff. We saw and heard three single birds at Bluff in late August and September which gave the Long-billed Dowitcher's call.

10041702 Bar-tailed Godwit *Limosa lapponica*

These were widespread and conspicuous because of their size and behavior. We estimate that there were 20 pairs between the Nome River and Cape Nome. There are probably one or two to be seen in each valley along the road to Teller and we saw about a dozen pairs along the road to the Kougarok River.

On 20 June we saw 150-160 in a drained lagoon east of the Sinuk River mouth and we saw a flock of 30 in a drained lagoon east of the mouth of the Bonanza River on 3 July.

10060101 Red (Gray) Phalarope Phalaropus fulicarius

These were widespread but not numerous, gathering on melt water ponds and muddy lake shores in June. We saw 35 at Safety Lagoon on 6 June and several feeding near shore on the sea at Cape Nome the same day. We saw them in three valleys along the road to Teller and a pair by the Kuzutrin River also in June.

When we next saw Red Phalaropes, they were in winter plumage feeding in the surf at Bluff in mid-September.

10060301 Northern (Red-necked) Phalarope Lobipes lobatus

We saw four at Safety Lagoon in June but this species was widespread on sedgy ponds along the coast from the Sinuk River to Cape Nome. There were 28 in the drained lagoon east of the Sinuk River on 20 June. We saw them at 12 places between Nome and Salmon Lake on the road to the Kougarok River.

Northern Phalaropes were more numerous and widespread than were Red Phalaropes.

10070101 Pomarine Jaeger (Skua) Stercorarius pomarinus

We saw a few small flocks (3-9) at Safety Lagoon, Cape Nome, off the town of Nome and at the spit at Teller in June.

10070102 Parasitic Jaeger (Arctic Skua) Stercorarius parasiticus

We saw these in pairs at 5 places between Sledge Island and Safety Lagoon in June. We also saw one at Teller and a pair inland at Eldorado Creek south of Teller on 10 June.

Parasitic Jaegers stayed near places where there were flocks of gulls or terns.

10070103 Long-tailed Jaeger (Skua) Stercorarius longicaudus

These were less numerous than Snipe and Golden Plover but were as widespread and more conspicuous. We would estimate 15 pairs between Nome and Cape Nome; we also estimated 15 between Nome and Mile 25 on the road to the Kougarok River.

We estimate 35-70 pairs between Nome and Teller on 9 and 10 June. By mid-July they had disappeared.

10080100 Gulls Larus sp.

We saw several gulls which we could not identify. One was an adult larger than a Glaucous Gull with a dark but not black back and pink legs. Its bill was larger than that of the Glaucous Gulls it was with.

We saw 12-15 immature gulls similarly larger with coarser bills than Glaucous Gulls. Their background color was pale and they were marked with discrete chevron-shaped spots on their backs, resembling a young Lesser Black-back or first plumage European Herring Gull. The tail was all slaty gray. The legs were pink. Most of these were seen along the beaches east of Nome.

We saw 10-15 immature gulls of a Herring Gull-Glaucous-winged type at the breakwater at Nome.

10080103 Glaucous-winged Gull *Larus (argentatus) glaucescens*

We saw one adult at the Snake River and several adults near the Koyuk River (Norton Bay) in June.

Several of the immatures summering on the beaches near Nome may have been of this species.

10080108 Herring Gull *Larus argentatus*

We saw perhaps 6-8 adults and 10-12 immature Herring Gulls for whose identification I would vouch. The first adults were seen 12 June. Most were seen in August between Nome and Safety Lagoon.

10080113 Mew Gull *Larus canus*

We saw a few adults at the waterfront at Nome in June and July. We saw adults at two places along the Nome River inland, at two places near the Kuzutrin River. We saw adults where the Teller road crosses the Cripple River about 15 miles from the coast. On 25 June we saw 30 Mew Gulls on the mud at the mouth of the Koyuk River, Norton Bay. In September we saw a few adults at the mouth of the Bonanza River.

10080117 Bonaparte's Gull *Larus philadelphia*

We saw one at the beach at Nome on 12 June.

10080501 Sabine's Gull *Xema sabini*

We saw one immature at several places between Topkok and Square Rock in September. At times it fed flying low over the surf the way a tern does. At other times it fed just outside the breaking waves or wading where wavelets lapped on the shore, pecking the way phalaropes do. Red Phalaropes were feeding in the same places.

10080704 Arctic Tern *Sterna paradisea*

In June these terns were evident wherever there was open water on the sea among the ice, at the mouths of rivers, along rivers 50 miles inland, and flying over the tundra.

There were 10-30 that fed near the breakwaters at Nome. There were usually 8 but at times 30 feeding at the mouth of the Cripple River. In late June we saw 12 on one trip and 40 on another trip between Nome and Salmon Lake.

Arctic Terns bred as single or a few pairs on many coastal lakes and on gravel bars far from the sea.

A colony of Arctic Terns nested on a mud and grass island just inside the main outlet of Safety Lagoon at the ferry. We saw 20-40 birds on this island on each trip before August.

On 31 July we saw several flocks totaling 175 Arctic Terns roosting on the sandbars by the outlet of Safety Lagoon. These were probably gatherings of migrants because Arctic Terns begin to migrate in the first week of August in many parts of their range.

On 22 and 26 August we saw two adults and a single young Arctic Tern in Safety Lagoon.

Terns that nested on gravel bars or coastal lakes fed primarily in the sea even when the ice had left the lakes. We saw parents carrying sand launce to their chicks at Sonora Creek in late July.

10080706 Aleutian Tern *Sterna aleutica*

A colony of Aleutian Terns nested with the Arctic Terns on the island near the outlet of Safety Lagoon. We counted 10, 14, 16, and 20 individuals on several visits. The species was still present in full numbers on 22 August when all but 3 Arctic Terns had left.

We saw Aleutian Terns fishing between 5 and 7 miles offshore in early July.

On 17 September we saw a tern fishing in the surf at Bluff and presume that it was this species.

VII. DISCUSSION

A. The occupation of habitat by waterfowl and shorebirds.

1) We observed that migrant waterfowl gathered in restricted areas in shore leads and at the mouths of rivers in the spring.

Waterfowl (primarily ducks and loons) move north in spring as early as it is likely for leads to open up along the shore. They push as far north as they can find open water (in many cases at the mouths of rivers) and linger there making excursions and testing conditions up river and further north.

The earliest birds at a breeding site have a big advantage in establishing desirable territories, hence the pressure of natural selection to move north early. It is known that successful breeders in many species tend to migrate earlier and to take up territories earlier than usual. It is also known that the earlier, hence older and more experienced breeders, are usually responsible for the majority of reproductive success. All of these factors lead us to assign special importance to the patches of water that are first open in spring and to any factors or activities which may affect waterfowl on them.

2) We observed that a few coastal lakes (those held in behind a ridge of beach sand and gravel) were largely drained in June and early July. These drained lakes attracted large numbers of waterfowl, gulls and shorebirds. Evidently when the spring thaw filled these lakes and they overflowed, some had enough water overflow to cut a channel through the beach ridge. In that case the pond was drained as the thaw passed. We would expect the identity of the drained lakes to change from year to year according to accidental events in the development of drainage channels. We presume,

furthermore, that the benthic fauna of a lake bed kept drained so as to be attractive to waterfowl would soon be "over-fished". The area would need to lie under water for several years for populations of food species to build up.

3) We observed that breeding waterfowl and shorebirds were aggregated into certain areas on the tundra. Some patches of tundra seemed filled with birds; others were almost empty. Many ponds had no waterfowl; some included individuals of several species. We could not see any obvious reasons why the waterfowl or shorebirds were aggregated into these placed. It has been the experience of many other observers (as well as our own) that birds usually occupy their breeding habitats on the tundra in this patchy way.

4) We observed that the mudflats at the mouth of the Bonanza River by Safety Lagoon and the Fish River by Golovnin Bay were frequented by large numbers and a good variety of waterfowl and shorebirds when northerly winds lowered sea level during September. There were few waterfowl at other similar places such as Moses Point, Shaktoolik or Unalakleet.

Most of the flats in Safety Lagoon were covered by ice during the spring migration. The narrow areas of mudflats exposed at this time were visited by many shorebirds. During the summer, July and August, the lagoons were little used except by Glaucous Gulls, Arctic and Aleutian Terns. When in late August and September water levels dropped, swans, geese and ducks, as well as many sandpipers and a few plovers, clustered in the lower reaches of the rivers.

5) Wildlife tends to aggregate in portions of the habitat rather than being evenly dispersed, even in the small area used. The aggregations

tend to be in different places in different years. A number of varying factors combine to make habitat attractive. In those places where in any year a maximum number of factors are favorable, wildlife gathers. Because the factors vary independently of each other, at least in part, the places differ from year to year where favorable conditions coincide.

B. Human use.

1) Our observations suggest intense local use of waterfowl by Eskimos.

a) The clearest correlation on our air and surface reconnaissance was that wildlife was very sparse in a zone a mile to several miles wide around human settlements.

b) It appeared that exploitation by Eskimos was unlimited. Furthermore, exploitation appeared to be heavier by those Eskimos who work in Nome than by those on a subsistence economy.

We interpret this as indicating that if the present level of per capita human use continues as the population increases with development, we can expect the reduction or elimination of the wildlife value of coastal lagoons within easy reach of towns such as Nome.

2) We have observed that wildlife in general and waterfowl in particular will accept a high level of coexistence as long as people avoid specifically disturbing or destroying them. An extreme case is that of Killdeer nesting between the ties of a commuter train track in New York. If, however, wildlife is harassed by dogs, hunting, walking or climbing among nests, birds flee and soon learn to avoid the area.

We interpret this as suggesting that probably the most serious human disturbance is hunting, especially spring hunting of waterfowl.

a) Hunting will drive birds away from those few areas where survival is possible especially in early spring. This disturbance results in mortality much greater than that caused directly by the shooting.

Discharge of firearms causes alarm because the sound carries far and spreads panic in a much larger number of birds than would result from the actions of people with sticks or nets.

b) Furthermore, the intense fear stimulated in hunted populations makes them flee in panic from all humans and hence denies enjoyment of the species as a recreational resource by non-consumptive users. This problem exists at certain localities, obviously those where natives and waterfowl congregate.

c) In general over the Arctic it is unlikely that spring hunting by natives has a serious impact on population levels. I think that spring shooting can have a serious effect around a community such as Nome or smaller villages, however, because the people who enjoy waterfowl or wildlife for other than hunting, congregate in these places too.

d) Hunting is an important economic and social endeavor and large areas of land should be open to hunting. However, these areas should be matched by large areas of land which are closed to hunting so that wildlife can lose its terror of humans with absence of disturbance. The purpose of such an arrangement is to see that non-consumptive uses (study, watching, photography) are not in competition with and lessened by the consumptive uses (hunting).

4) Social values of waterfowl and shorebirds.

a) The waterfowl have an outstanding commodity value. Waterfowl as a national resource have been valued by hunters in the lower 48 states, who number approximately 12-14 x 10^6 people according to information available from the National Wildlife Federation.

b) The sandpipers and plovers nesting widely over the wet tundra are an esthetic resource vaguely acknowledged by many people. If a measurable disaster occurred to these species, the most concerned segment of society would be bird-watchers, who now number 8-12 x 10^6 according to information available from the National Wildlife Federation.

c) There is an important geographic element: the species of northwestern Alaska whose distribution is primarily in Eurasia. These species are an economic resource in the sense that perhaps a dozen tourist excursions visited Nome and St. Lawrence Island during June 1975 to see these and other High Arctic bird species.

d) There are over 20 species of birds endemic to the Bering Sea area, such as Emperor Geese, Steller's and Spectacled Eiders, Bristle-thighed Curlews, Western Sandpipers, etc. These are acknowledged as a valuable resource by bird-watchers, environmentalists and a certain number of biologists.

e) Many traditional native villages were located near prime waterfowl habitat, near seabird cliffs and close to good hunting grounds for marine mammals. With the settlement of native land claims, a disproportionate amount of the best wildlife habitat has been awarded to private interests. Conflicts between proper native rights and proper public interests are likely to occur unless steps are taken to find equitable resolution for the conflicting claims. Surveys such as the present one, to identify the important wildlife habitats are first steps in that direction.

VIII. CONCLUSIONS

A. Distribution

1) Feeding and gathering areas.

a) We found that river mouths were very important gathering areas early in the season when the sea ice was melting. River mouths continued to attract aggregations of ducks and gulls throughout the season.

b) Lakes and lagoons that had been drained as a result of overflow and subsequent stream erosion during spring melt water runoffs, attracted large numbers of shorebirds, ducks and gulls all during the summer.

c) The shallow waters just offshore from barrier beaches were visited by sea ducks much more frequently than the rest of the shoreline.

d) In September shallow water and mudflats in lagoons such as Safety Lagoon and at the mouth of the Fish River attracted large numbers of ducks, geese, swans and shorebirds.

2) Breeding areas.

Waterfowl and shorebirds bred a) widely over the wet, mossy tundra in the coastal area, b) in sloughs and marshes along rivers inland, and c) by coastal lagoons and ponds on coastal tundra.

Some areas are much more heavily used and within favorable habitat the breeding birds appear to gather together in patches. Although only a portion of the whole habitat is used at any time, it appears that duplication of habitat may be one of the characteristics needed to maintain healthy populations.

3) Vulnerability to oil spills.

Among waterfowl the loons, grebes and sea ducks will be most vulnerable to oil spilled on the sea. The waterfowl, such as geese, swans, goldeneye and scaup which, together with shorebirds, frequent fresh water, will be vulnerable to oil spilled in shallow coastal bays and lagoons.

Waterfowl and shorebirds will also be affected by secondary effects of onshore development related to oil and gas extraction. Filling wetlands, draining or polluting breeding sites, or contaminating river mouths disturbs and degrades essential habitat. Increased human population and recreational activities promise to disturb the restricted areas where large numbers gather to feed or rest.

B. Human relations.

The human population now makes rather free use of waterfowl resources but as the human population is small and sparse there is plenty of undisturbed habitat to maintain the populations of wildlife. As the human population increases with economic development it will be necessary to establish large areas to support reservoirs of breeding wildlife populations which export croppable surplus. When that time comes, conflicts between one set of needs (the long-term needs of population maintenance and non-consumptive uses) and other needs (consumptive uses such as hunting for recreation, for subsistence economy) will develop and agreements with those who administer native land claims may become critical.

IX. NEEDS FOR FURTHER STUDY

1) We need surface and air reconnaissance work in late May-early June to find where open water is, where early migrant waterfowl gather, and what the impact is of spring hunting by natives. We need surface surveys to identify how shorebirds move in and occupy territories and where they feed before the tundra thaws.

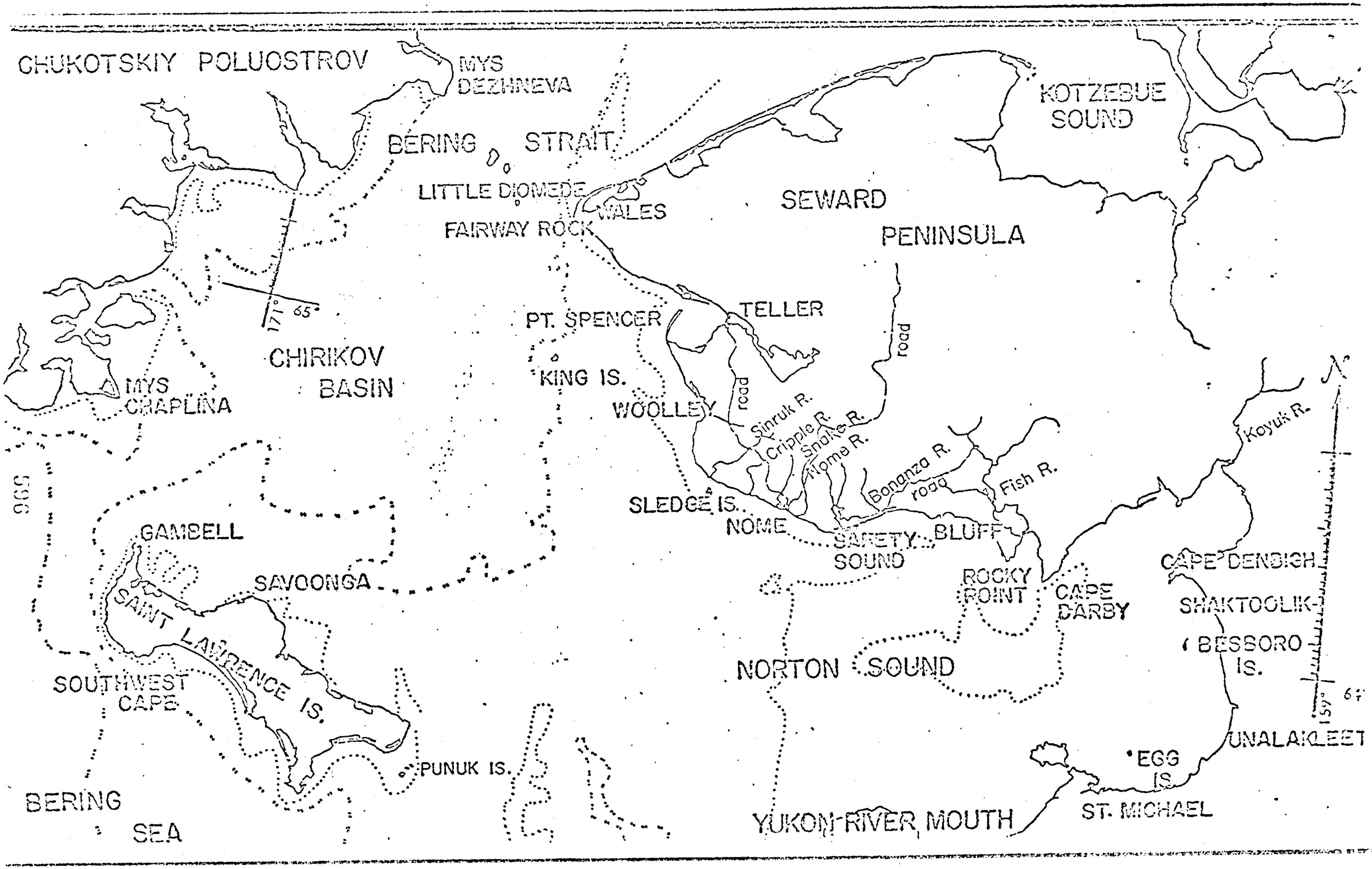
2) We need to sample several predetermined transect routes (e.g., three minutes at each 1/2 mile for 25 miles by car) in order to get quantitative data on the numbers and distribution of shorebirds, etc., nesting on the lowland tundra.

3) The mudflats of the lower reaches of several rivers were heavily used by waterfowl and shorebirds in September when north winds lowered the water level. We need to know what the species of shorebirds are and to trace out the generalizations and details of waterfowl use in September and October.

4) We need to continue and expand the reconnaissance survey, both surface and air, in order to find areas which we don't know about, and to confirm the observations we have made. The survey should be expanded to include the south shore of Norton Sound and the area between Teller and Wales.

5) We have sketched a model of the changing use of coastal lakes according to accidents of stream channel cutting. Using this idea, we have emphasized the importance of redundancy in the resources used by waterfowl and shorebirds. The observations and applicability of the model need to be tested because the usefulness of our predictions of the impact of oil and gas development depend on the validity of these conclusions.

6) We need to develop techniques for defining more precisely the areas of mossy tundra, of lakes, of inland sloughs, etc., that are used by waterfowl and shorebirds so that we can recommend areas to be protected from the impact of secondary development and the growth of the human population.



CHUKOTSKIY POLUOSTROV
MYS DEZHNEVA
BERING STRAIT
KOTZEBUE SOUND
LITTLE DIOMEDE
WALES
FAIRWAY ROCK
SEWARD PENINSULA
TELLER
PT. SPENCER
171°
65°
CHIRIKOV BASIN
KING IS.
MYS CHAPLINA
WOOLLEY
road
Sinruk R.
Cripple R.
Snake R.
Nome R.
Koyuk R.
Bonanza R.
Fish R.
SLEDGE IS.
NOME
SAFETY SOUND
BLUFF
GAMBELL
SAVOONGA
ROCKY POINT
CAPE DARBY
CAPE DENBIGH
SHAKTOOLIK
SAINT LAWRENCE IS.
NORTON SOUND
BESBORO IS.
SOUTHWEST CAPE
159°
PUNUK IS.
UNALAKLEET
EGG IS.
BERING SEA
YUKON RIVER MOUTH
ST. MICHAEL
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Quarterly Report

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Name of Principle Investigator William H. Drury

Affiliation College of the Atlantic
Bar Harbor, ME 04609

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Data analyzed are the data collected during the field season of 1975 and listed in the semi-annual report made on November 1, 1975.

Data have been extracted from field notes and recorded on 169 tables. These transformations have been made as part of the data to be formatted and archived.

Preliminary plans for preparing the data for archiving have been submitted.

Two annual reports totalling about 100 pages, 30 tables and maps were submitted on 28 March 1976.

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