

ABSTRACT. Near shore waters along the entire coast of Katmai National Park were used by large numbers of 2 species of waterfowl, 3 species of cormorant, a large gull, a small gull, and 5 alcid species during the summer months of 1989. Numerous other species were observed in smaller numbers. Mixed species colonies of over 300 breeding pairs of seabirds were observed at 9 sites distributed throughout the Katmai coast; two of these sites, Ninagiak Is. and Shaw Is., were observed to contain a thousand or more breeding pairs. Smaller colonies were observed at 19 other sites. The common breeding seabirds, in decreasing order of abundance, were Glaucous-winged Gulls, Tufted Puffins, cormorant species, Horned Puffins, Pigeon Guillemots, and Black-legged Kittiwakes. Most oiled carcasses of seabirds collected along the Katmai coast were probably killed at sea far from shore. Murres, by far the most common seabirds found dead along the Katmai coast, were not observed to breed there.

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INTRODUCTION

On March 24, 1989, the oil tanker EXXON VALDEZ ran aground, spilling 11.3 million gallons of crude oil into Prince William Sound, Alaska. Piatt et al. (1989) state that approximately two million gallons (17% of oil escaped the relatively sheltered waters of Prince William Sound between March 31 and April 9 and entered the Gulf of Alaska. In the one month period immediately following the spill, weathered oil in the form of mousse, tar balls, and sheen was transported by marine currents and driven ashore by spring storm tides on beaches of the Kenai Peninsula, Barren Islands, lower Cook Inlet, Kodiak Archipelago, and Alaska Peninsula, including Katmai National Park and Preserve (Katmai NP).

Oil on the beaches of Katmai NP was first documented by National Park Service (NPS) field personnel near Cape Douglas on April 18. During the week of April 22-23, moderate to strong southeast winds combined with prevailing currents in the Shelikof Strait to drive oil southwest. An aerial survey conducted jointly by the Alaska Department of Environmental Conservation (ADEC) and the National Oceanic and Atmospheric Administration (NOAA) on April 28 confirmed that concentrations of mousse extended the length of Katmai NP along its Shelikof Strait coastline (Piatt et al. 1989). Within the boundaries of Katmai NP, oil impacted supratidal and intertidal coastal habitats, benthic substrates, and nearshore and offshore water columns.

The estimated 40.3 million seabirds found in Alaskan waters may equal or exceed the total number of seabirds present elsewhere in the remainder of the northern hemisphere; densest concentrations occur in the Aleutian Islands chain, the Bering Sea, the Gulf of Alaska, and along the Alaska Peninsula (Sowls et al. 1978, Gould et al. 1982, DeGange and Sanger 1986). This abundance of breeding seabirds constitutes an ecological resource of global significance.

Study area

The isolated wilderness coastline of Katmai NP extends from the mouth of the Kamishak River in Akumwarvik Bay (59° 01'N, 154° 10'W) in the northwest, through Cape Douglas at the mouth of Cook Inlet (58° 31'N, 153° 15'W) in the east, to Cape Kubugakli in the Shelikof Strait (57° 34'N, 155° 05'W) in the southwest (Figure 1). Portions of the coastline consist of steep-walled fjords and jagged headlands with offshore islands, sea stacks, and reefs. Other areas are dominated by wide bays, tidal lagoons, low-lying marshes, grasslands, or moist rolling tundra. The overall shoreline length, including the many islands and concave bays within the park totals approximately 612 km (382 mi).

A general description of the vegetation types of the Alaska Peninsula is found in Murie (1959) and detailed information on the flora of the

Katmai

NATIONAL PRESERVE

Northwest Camp

A

Summit

7082 ft

Case

Douglas

KOHAGIAK

W. T. S. 1947

region is available in Hulten (1968). The majority of seabird colonies are located on coastal islands which are quite variable in size and topography. Larger islands (e.g., Shaw, Kikpaalik, Teell) are gently undulating or flat-topped with berched freshwater wetlands. Smaller islets (e.g., Shakun Islets, Nukshak, Kulichkof) and sea stacks (e.g., Shakun Rock) are typically steeply sloped, irregular bedrock masses. Insular vegetation is dominated by grasses (Calamagrostis spp., Deschampsia spp., Elymus spp., and Festuca spp.), sedges (Carex spp.), and umbellifers (Angelica lucida, Conium maculatum, and Heracleum lanatum).

The remoteness of the Katmai NP coast has limited the availability of baseline data on its seabird populations. The first reconnaissance of seabird colonies in Katmai NP was conducted in June 1973 by Sowl (1982); several other investigators visited portions of the park later during the 1970s. Sowl et al. (1978) summarized existing colony data as part of their catalog of Alaskan seabird colonies. Bailey and Faust (1984) surveyed Katmai NP colonies during 1981.

Litch and Blackie (1988) conducted a seabird colony survey of approximately 60% of the Katmai NP coast during July-August, 1988. Their inventory data allows an opportunity to compare data from the breeding season immediately prior to the oiling of the Katmai NP coast with data gathered after the oil arrived. Pre-oiling assessment inventories carried out in April 1989 also provided a limited amount of useful data on seabird colony attendance (K. Heacox and M. Heacox, Katmai Coast Patrol Log, NPS files 1989).

Study objectives

This report documents the relative abundance and local population distribution of seabirds and their breeding colonies within Katmai NP during the summer of 1989. Most of the species discussed are highly mobile; both their abundance and their observability vary with time of day, weather, tidal stage, and breeding cycle. Because of these factors and other sources of variability, it is very difficult to identify and quantify with precision, changes in these populations. Nonetheless, baseline inventory data of this type are critically important in monitoring the status of seabird populations.

The objectives of this study were as follows:

- 1) document the summer seabird species composition and abundance in the nearshore waters of Katmai NP.
- 2) document colony locations and count the number of nesting birds present at colonies.
- 3) document impacts on seabird resources resulting from oiling of beaches and from oil damage assessments and clean-up operations.

- 4) compare 1989 seabird census results with baseline data available from previous surveys.
- 5) compare the present species composition and abundance of living seabirds in Katma NP to those of dead birds collected off park beaches throughout the summer.

Effects of oil on seabirds

Seabirds which initially survive direct exposure to oil in the environment may later die as a result of higher susceptibility to disease and predation. More subtle, long-term detrimental impacts on populations may also be anticipated, including decreased productivity and survival of young. According to Holmes and Cronshaw (1977), non-acute seabird mortality following an oil spill may occur due either to physical/external or systemic effects.

Physical/external effects include:

- 1) elimination of trapped air between feathers, resulting in loss of buoyancy, and/or increased body weight, leading to physical exhaustion and/or death by drowning.
- 2) contamination of flight feathers affecting aerodynamic properties of wings, impairing or preventing flight.
- 3) additional body weight and impaired mobility leading to reduced ability to forage, affecting nutritional status.
- 4) reduction in thermal insulation resulting in increased metabolic requirements, therefore increasing food intake necessary to maintain body temperature, resulting in death by starvation or exposure.

Systemic effects include:

- 1) toxic effects to adults brought on by ingestion of food and/or water containing petroleum or through preening activities.
- 2) inhibition or termination of embryo development as a result of oil contacting egg shell and impairing gas exchange and/or by penetrating egg shell and killing embryo directly.
- 3) inhibition of egg laying and/or reduction of hatchability of eggs laid through the ingestion of a single large dose of oil by breeding adults.

Annual productivity of seabird colonies may thus be affected by

- 1) increasing nest abandonment by adults due to physiological effects or changes in foraging conditions.
- 2) reduced hatching success resulting from oil transfer from incubating adults through eggshells to developing embryos.
- 3) increased chick mortality due to decreased food availability or decreased food quality.
- 4) increased disturbance by human activity associated with monitoring and recovery of oil spill through increased nest abandonment and increased temporary absences from incubation and breeding.
- 5) direct mortality from contact with oil.

U.S. Fish and Wildlife Service (USFWS) cumulative carcass recovery totals for the entire oil spill area (current as of September 13, 1989) included 34,434 dead birds and 1869 oiled, live birds, of which 895 subsequently died in captivity (P. Benson, USFWS Information Specialist, Alaska Maritime NWR, pers. comm. 1989). Approximately 35% of recovered birds were found outside of heavily-oiled Prince William Sound (Piatt et al. 1989).

Because they were present in nearshore waters at the time that oil was drifting through the Gulf of Alaska and Shelikof Strait and because they forage in concentrated flocks, diving species were heavily impacted by oil-related mortality. Of the total number of dead birds recovered by USFWS, 83% were members of the diving family Alcidae. Although they are Alcids, Tufted and Horned puffins were not initially heavily impacted; these species typically remain far at sea until after May 1, thus they comprised less than one percent of all dead birds recovered (Piatt et al. 1989).

Biologists estimate that the actual number of birds killed during an oil spill can be from 10-20 times greater than is indicated by the number of beached birds recovered; carcasses often sink, become buried in sand and debris on shore, or are carried away from beaches by predators, tides, and currents (Vequist and Nishimoto 1989).

METHODS

Assessment of the relative vulnerability of marine-oriented species to oil-related mortality is based on an extensive analysis of seabird biology conducted by King and Sanger (1979). Oil vulnerability indices for all species discussed in this report appear in Appendix A

Species observed during this study were occasionally consolidated into ecologically and/or phylogenetically related groups (e.g., Cormorant spp., Murrelet spp., Scoter spp.). Species and species group names are abbreviated using a four-letter taxonomic alphabetic coding system based on a system used by the USFWS (Appendix B).

Inventory data were recorded on Colony Status Record sheets which are commonly used by the USFWS for seabird counts (Appendix C).

Coastal survey units

For comparative purposes, the Katmai NP coast was subdivided into 15 coastal survey units. Numbers of seabirds observed were grouped for analysis according to these units. Units were defined on the basis of prominent geographic features of the coastline (Table 1). The positions of unit boundaries are shown on the set of 11 topographic maps (1:63,360 scale) which accompany this report (see attached maps).

Harbor counts

Harbor counts of seabird populations present in nearshore waters were conducted by two NPS field personnel from June 26 through September 3, 1989, using a 5 m inflatable boat equipped with a 30 hp outboard motor.

During harbor counts, the observers ran the boat under power parallel to shorelines at distances of 50-250 m offshore at speeds of 3-5 kt. Observers counted all seabirds seen (flying, on the water, or on shore) in a roughly linear transect approximately 200 m wide bisected by the path of the raft. Counts were attempted only during periods of favorable weather (relatively calm winds, good visibility) between 0900 and 1800 hrs. Two or more individuals participated in all observations; identification of species was made using 7x binoculars or the unaided eye.

Individuals vary in their ability to rapidly and accurately assess large numbers of seabirds. Our use of the same two primary observers throughout the study should have reduced errors associated with multiple observers.

Colony counts

For the purposes of this study, a "colony" was defined as any site where more than one pair of one or more species of seabirds nest. Counts of individuals present at colonies were conducted from June 26 through August 26, 1989. Using a 5 m inflatable boat equipped with 30 hp outboard motor, two NPS field personnel completely surveyed all colonies, counting numbers of individuals present and numbers of individuals in incubation posture. Unless access was prohibited by rough seas or cliffs, landings were made at all colonies.

Observations were made from the water surface or from land, whichever gave the better perspective for a given species and colony. Islands were walked whenever possible for nest counts of ground-nesting Glaucous-winged Gulls.

Data were collected on species composition, number of nests, presence and status of eggs, chicks, and evidence of activity by predators or humans. Counts were attempted primarily during periods of favorable weather (relatively calm winds, good visibility) between 1900 and 1800 hrs. Oiled specimens were collected in chemically clear glass jars with Teflon-coated lids for hydrocarbon analysis.

All species had distinct nesting habits; thus, different procedures were necessary for each species in order to obtain a best estimate of the number of breeding pairs. Burrow and crevice nesting species were especially difficult. The following definitions were used to estimate numbers of breeding pairs.

Cormorants. Counts of occupied nest-sites; on very high ledges on which nests could not be seen, occupancy by adults was used to identify nest-sites.

Glaucous-winged Gulls. When ashore, strip censuses of nests; from the inflatable boat, counts of sitting adults; loiterers were not counted.

Black-legged Kittiwakes. Counts of occupied nest-sites.

Pigeon Guillemots. Counts of birds perched within suitable nesting habitat, i.e. exposed rocky faces.

Parakeet Auklets. Counts of birds perched on rocks.

Puffins. Counts of every adult seen both on land at a colony and on the water within 500 m; these are certainly minimum estimates of the number of breeding pairs.

Black Oystercatchers. Counted pairs of adults, often attached; young were visible.

TABLE 1. Description of coastal survey units.

Unit	Code	Boundaries and total shoreline length
KATMAI	(KATM)	Cape Kubugakli to Sec. 24 SE of Mt. Pedmar: total shoreline distance of 44.6 km
OKAYAK	(OAKA)	Sec. 24 SE of Mt. Pedmar to Cape Ilktugitak, excluding Ilktugitak I.: total shoreline distance of 22.4 km
TAKLI	(TAKL)	Cape Ilktugitak to Cape Atushagvik, including Ilktugitak I.: total shoreline distance of 14 km
MISSAK	(MISS)	Cape Atushagvik to Cape Kuliak: total shoreline distance of 20.8 km
KULIAK	(KULI)	Cape Kuliak to Cape Gull: total shoreline distance of 28.8 km
KAFLIA	(KAFL)	Cape Gull to Cape Ugyak: total shoreline distance of 27.2 km
KUKAK	(KUKA)	Cape Ugyak to Cape Nukshak, excluding Nukshak I.: total shoreline distance of 88.0 km
HALLC	(HALL)	Cape Nukshak to Cape Chiniak, with Nukshak I.: total shoreline dist. of 40.0 km
SWIKSHAK	(SWIK)	Cape Chiniak to Sec. 9 NW of Kiukpalik I.: total shoreline distance of 33.6 km
SHAKUN	(SHAK)	Shakun Islets and Shakun Rock: total shoreline distance of 1.5 km
KIUKPALIK	(KIUK)	Kiukpalik I.: total shoreline distance of 6.4 km
FOURPEAK	(FOUR)	Sec. 9 NW of Kiukpalik I. to Cape Douglas, including Douglas Reef: total shoreline distance of 40.0 km
DOUGLAS	(DOUG)	Cape Douglas to Douglas River, including Sukoi Bay and Douglas R. delta islands: total shoreline dist. of 84.6 km
SHAW	(SHAW)	Shaw I.: total shoreline distance of 3.2 km
KAMISHAK	(KAMI)	Douglas River to Kamishak River: total shoreline distance of 30.4 km

Locations of colonies are plotted on a set of 11 topographic maps (1:63,360 scale) which are attached. Pigeon Guillemots often did not nest colonially; therefore, their counts were lumped into the nearest colony site of any species for purposes of reporting.

Beached bird counts

Dead birds which had been washed onto beaches in Katmai National Park were collected by NPS field personnel, and Exxon-contracted catcher boats and clean-up crews. Bird carcass data from the A-P district, which includes Katmai NP, were compiled and made available to the NPS for this report by personnel at the USFWS, Kodiak.

RESULTS AND DISCUSSION

Harbor counts

Harbor counts were conducted over a distance of 576 km (360 mi), or 94%, of the Katmai NP coast. A total of 35 species of seabirds (including loons, grebes, shearwaters, ducks, sandpipers, plovers, and others) was identified; this figure represents a large proportion of the seabird species known to occur in coastal portions of Katmai NP.

Seabird species count data for 1989 by coastal survey unit are presented in Table 2. A grand total of 15,834 individuals was obtained during our observation periods. Seabird density was quite variable from one unit to another. Table 3 presents the observed density of seabirds ranked by survey units.

Particular species were especially abundant or scarce in certain coastal survey units, while other species were evenly distributed throughout the entire study area:

Cormorant spp. were most numerous in TAKL and KATM units, but were not recorded in six other units;

Harlequin Ducks were recorded in 13 of 15 units; their absence in KIUK and KAMI units is likely a result of a lesser amount of counting time spent in those units;

Scoter Spp. were recorded in 13 of 15 units and appeared to favor relatively sheltered, shallow bays. Flocks of 50-100 individuals were commonly observed; large rafts of 400-800 individuals were noted in MISS and SWIK units;

TABLE 2. Seabird species counts for 1989 by coastal survey units

Unit	Seabird Species Present											
	UNCO	HADU	UNSC	GWGU	BLKI	PIGU	SRMU	TUJU	HOPU	BLOV	MISC	TOTAL
KATM	383	50	36	299	0	105	60	24	33	0	24	1064
DAKA	0	37	199	800	200	56	29	0	0	20	23	1364
TAKL	571	98	11	507	125	47	85	76	7	33	177	1737
MISS	70	94	400	100	40	10	12	0	0	6	80	812
KULI	10	68	233	188	650	20	9	12	18	12	223	1443
KAFL	30	203	263	82	20	14	10	13	20	12	12	679
KUKA	40	138	134	142	70	56	23	0	4	17	25	649
HALL	0	10	50	449	0	173	97	612	318	25	30	1764
SWIK	0	139	765	100	100	2	41	78	28	0	26	1279
SHAK	155	60	0	190	79	163	7	155	130	6	36	951
KIUK	0	0	0	140	0	106	3	7	48	13	44	361
FOUR	0	73	145	0	0	2	77	0	4	50	291	642
DOUG	109	267	28	67	0	25	18	160	78	0	23	725
SHAW	0	123	48	600	0	29	0	634	33	2	90	1579
KAMI	170	0	63	200	0	1	0	12	1	0	301	755
ALL	1538	1360	2375	3864	1284	809	471	1790	772	196	1405	15234

TABLE 2 Observed density of seabirds ranked by survey unit.

Coastal survey unit	Total length of shoreline	Seabird density (in birds/km)
SHAK	1.5	654.0
SHAW	3.2	493.1
DAKA	22.4	60.9
KIUK	6.4	56.4
KULI	28.6	50.1
HALL	40.0	14.1
MISS	20.8	39.0
SWIK	33.6	38.1
KAFL	27.2	25.0
KAMI	30.4	24.8
KATM	44.8	23.8
FOUR	40.0	16.1
TAKL	140.8	12.4
DOUG	84.8	8.5
KUKA	88.0	7.3
PARK	612.7	25.8
TOTALS		

Glaucous-winged Gulls were the most numerous species observed during harbor counts. A total of 3864 individuals was obtained and this species was recorded in 14 of 15 units, being absent only from the FOUR unit;

Black-legged Kittiwakes were noted in 8 of 15 units and were counted in numbers > 200 individuals only in KULI unit;

Pigeon Guillemots were observed in every survey unit and were most numerous in HALL and SHAK units. This species is widely distributed, but not abundant, throughout coastal waters of Katmai NP;

Brachyramphus (Marbled and Kittlitz) murrelets occurred in low numbers in 13 of 15 units; no particularly dense concentrations were noted, however shallower bays appeared to be preferred;

Tufted Puffins were abundant in HALL and SHAW units, in close proximity to the largest breeding colonies in Katmai NP. Several survey units with little suitable nesting habitat yielded no Tufted Puffin observations;

Horned Puffins were distributed across survey units in a manner similar to Tufted Puffins, but were much less abundant. Concentrations of > 100 individuals occurred in HALL and SHAK units.

Colony counts

Seabird breeding colonies were located at 29 sites within Katmai NP. Among those species which nest in large colonies, Glaucous-winged Gulls and Tufted Puffins were the most common species (Table 4). Large numbers of cormorants, Horned Puffins, and Black-legged Kittiwakes were also observed at colonies.

TABLE 4. Estimates of numbers of breeding pairs by species at colonies along the entire Katmai coast. Pigeon Guillemots are not listed because their nest-sites were often dispersed rather than colonial.

Species	# sites	est. # breeding pairs
GWGU	20	2197
TUPU	14	1622
UNCO	9	940
HOPU	15	754
BLKI	3	442
PAAU	2	22

Mixed species colonies at Ninagiak Is. in Hallo Bay and at Shaw Is. north of Cape Douglas contained about a thousand or more breeding pairs (Table 5). Estimates of over 300 pairs were made at 7 other colonies: N. Koshvik, Mt. Pedmar cliffs, Amalik Point Island, Stacks SW of Cape Gull, Nukshak Island, Shakun Islets, and Kiukpalik Is. Glaucous-winged Gulls bred at colonies throughout the coast. Cormorant species were similarly dispersed with relative concentrations at Mt. Pedmar cliffs and at Amalik Point Is. Black-legged Kittiwakes nested at only three sites with 73 % of the breeding pairs concentrated on the Stacks SW of Cape Gull. Concentrations of both species of puffins occurred at

TABLE 5. Estimates of breeding pairs by colony site and species. Pigeon Guillemots which were often dispersed along long sections of shoreline have been reported under nearest colony site. Colony sites are identified by the abbreviation for the coastal survey unit and the initials of the name of the site within that unit as designated in the attached maps.

AREA	Species								TOTAL
	UNCO	OWGU	BLKI	PIGU	PAAU	TURU	HOPU	BLOY	
KATH NF	2	95	0	106	0	0	122	0	325
KATH MP	381	204	0	12	0	27	0	0	624
TAKL JI	0	30	0	0	0	12	7	1	50
TAKL WTI	72	31	0	0	0	0	0	0	103
TAKL API	250	175	0	0	200	0	64	0	629
MISC MBR	0	50	0	0	0	0	0	0	50
KULI GWKC	0	0	0	12	0	0	0	0	12
KULI ISCG	0	42	0	6	0	1	0	1	50
KULI SSCG	0	52	325	0	0	0	15	0	392
KAFI INCG	0	82	0	2	0	13	2	0	99
KUKA KI	0	80	0	0	0	0	0	0	80
KUKA JI	14	36	0	0	0	0	0	0	50
KUKA CWTI	42	0	0	0	0	0	4	0	46
KUKA KPS	0	0	38	0	0	0	0	0	38
KUKA YR	0	14	0	0	0	0	0	1	15
HALL NUIS	0	15	0	126	2	70	210	1	424
HALL ISWN	0	0	0	38	20	0	0	5	63
HALL NIIS	0	434	0	9	0	574	115	7	1139
SHAK ROCK	0	0	79	0	0	0	0	0	79
SHAK ISLT	0	190	0	163	0	155	130	3	641
KIUK IS	0	140	0	106	0	7	48	7	308
FOUR DR	0	0	0	0	0	0	0	25	25
DOUG BNSB	0	32	0	0	0	8	19	0	59
DOUG SPC	19	0	0	4	0	40	32	0	95
DOUG SPR	90	35	0	0	0	0	6	0	131
CP 2 - SHAW IS	0	300	0	29	0	634	33	11	1007
KAMI DRIS	70	40	0	0	0	0	0	0	110
KAMI BayI	0	0	0	1	0	19	1	0	21
TOTAL	940	2077	442	622	22	1620	744	66	6533

From: Martin, Chris. 1989.

Nukshak Is., Ninagiak Is., Shakun Islets, and Shaw Is.: a breeding concentration of exclusively Horned Puffins was observed at N. Kashvik. Small aggregations of breeding Parakeet Auklets occurred on the Island SW of Ninagiak and of Black Oystercatchers on Douglas Reef and on Shaw Is. Aggregations of Pigeon Guillemots were observed at a few sites, but their nest-sites were usually dispersed extensively along the shoreline.

Literature documents that minute quantities of crude oil can be toxic to developing embryos. Results of oil contaminant analysis on specimens collected during this study were not yet available at the time of this writing.

Beached bird counts

These data, divided into the coastal survey unit in which each carcass was recovered, appear in Table 6. A summary by species appears in Table 7.

Evidence suggests that most of the birds recovered along Alaska Peninsula beaches were killed around the Barren Islands and southwestern Kenai Peninsula and carried west before being deposited (Piatt et al. 1989). In a corpse drift experiment conducted by the U.S. Fish and Wildlife Service, 100 tagged seabird carcasses were released 10 km northeast of the Barren Islands on May 6. Three of these corpses were subsequently recovered 12, 30, and 55 days later in Puale Bay, some 240 km southwest of the release site.

A vast majority of those carcasses recovered within Katmai National Park were old, waterlogged deposited in greatest numbers where mousse concentrations were the heaviest on beaches, suggesting that birds and mousse had drifted in together. Numbers of live birds were observed in close proximity to heavily impacted areas, but they appeared largely unaffected by the oil.

TABLE 6. Dead seabirds collected along the Katmai coast. (compiled from morgue records maintained by USFWS, Kodiak).

Coastal Unit	Means of collection		Total # collected	birds km.
	Catcher***	Clean-up**		
KATM	192	35	227	5.37
CAKA	11	0	11	0.16
TAKL	10	1	11	0.04
MISS	26	0	26	1.08
KULT	66	5	71	2.47
KAFI	455	17	472	17.14
KUKA	451	14	465	5.28
HALL	1066	25	1091	27.28
SHAK	0	10	10	0.67
SWIK/KIUK	1305	85	1390	34.75
FOUR/DOUG	857	44	901	7.22
SHAW/KAMI	174	0	174	5.13
UNKNOWN***	3240	0	3240	5.29
PARK TOTAL	7853	236	8089	13.21

- * catcher boat data for the period May 2-Sept 15, 1989
 ** clean-up data for the period June 5-September 2, 1989
 *** dead birds collected within Katmai w/o detailed location data.

TABLE 7. Species composition (%) of seabird carcasses recovered.

Bird species	Katmai NP	Alaska Peninsula	Entire spill area .PW (Sound to Alaska Penin.)
UNCO	0.2	0.7	3.4
UNDU	0.6	0.4	2.0
HADU	0.3	0.2	0.9
UNSC	1.2	1.1	3.2
BLOY	0.1	0.1	0.1
GWGU	0.1	0.1	0.4
MEGU	0.2	0.1	0.1
BLKI	0.3	0.1	0.1
UNMU	91.3	89.3	68.1
PIGU	1.8	1.5	2.4
BRMU	0.9	0.6	2.5
ANMU	1.3	1.3	1.1
UNMR	0.9	0.8	1.2
RHAU	0.7	0.6	0.4
UNPU	0.1	0.1	0.2
OTHER	0.0	3.0	13.9
TOTAL	100.0	100.0	100.0

MANAGEMENT RECOMMENDATIONS

Factors which influence the ability of a species to recover following an oil spill include frequency of breeding, duration of post-natal care, number of eggs per clutch, and annual recruitment rate. In order to interpret population data collected in seabird surveys, the following steps are suggested:

- 1) Site specific data on Katmai NP seabird breeding colonies are needed and should be conducted from late May through early September 1990. One time "snapshot" monitoring of colonies is not sufficient: it is critical that activities at several sites be followed throughout the breeding season, if variations in egg-laying, hatching, or fledgling of young are to be detected. Indicator species which can be closely monitored include the Pelagic Cormorant, Glaucous-winged Gull, Black-legged Kittiwake, and Tufted Puffin.
- 2) Harbor counts should be repeated in June and July 1990. This will allow direct comparisons of the "at large" populations of seabirds utilizing various bays of Katmai NP and may indicate whether or not birds are frequenting areas of heavily oiled beaches.
- 3) Katmai NP should attempt to collaborate with and benefit from a number of studies conducted elsewhere in Alaskan coastal waters. There are also a number of individuals in the region with extensive seabird expertise.

CONCLUSIONS

Seabirds nested throughout the Katmai coast both colonially and as dispersed individuals. Several species were common breeders, including ledge-nesting cormorants and gulls, ground-nesting gulls, and crevice- and burrow-nesting alcids. Breeding cormorants, kittiwakes, and alcids were entirely dependent on available fish and invertebrates in near shore waters to provision both themselves and their chicks. The less specialized large gulls could scavenge and forage along the shoreline. Near shore waters were also used by large numbers of Harlequin Ducks and scoter species which were not observed nesting along the shoreline. The short period over which observations were made at any one site did not allow for estimates of reproductive success. Estimates of numbers of breeding pairs can be compared to those observed in previous surveys (see attached records). Results of oil contaminant analysis on specimens collected during this study were not yet available as of this writing.

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APPENDIX A. Species Life History Accounts.

The following life history accounts for seabird species which occur on the Katmai NP coast are provided as an easily consulted reference source for those not familiar with seabird ecology. Additional information is available by consulting the references cited in each account as Further Reading.

Recent estimates of Alaska breeding population levels are taken from Sowl et al. (1978). Sowl (1979) provides a good overview of the historic status of many of the seabird species present along the Alaska Peninsula. An excellent overall reference concerning the biology and life history of individual species is Ehrlich et al. (1988).

For general discussions of seabird ecology and population dynamics, see Ashmole (1971) and Drury (1979). Ainley and Ganger (1979) and Ganger (1987) both describe the diets and trophic relationships of various seabird species, while Vermeer et al. (1987) provide detailed information specifically about the diet of alcids. King and Ganger (1979) offer an excellent treatment of the relative vulnerability of various seabird species to oil in their environment; oil vulnerability indices listed below are based upon this reference.

Handel et al. (1981) provides a useful annotated bibliography of literature on Alaska water birds.

APPENDIX A (cont.). Species Life History Accounts.

Double-crested Cormorant (Phalacrocorax auritus) - DCCO 6/1 - 8/15

Oil vulnerability index - somewhat vulnerable (52)

Status - Alaska breeding population estimated to number 7,000; population largely restricted to western Gulf of Alaska and Bristol Bay areas. Katmai NP coastal population largely confined to sheltered waters such as Amalik, Kukak, and Kamishak bays.

Diet - Feed at moderate to great depths on schools of small fish and benthic crustaceans. Feed during the day and only for short periods due to rapid loss of buoyancy of wettable plumage.

Nest - Nests in Alaska predominantly found on coastal cliff ledges (rarely in trees). Nests consist of a platform of sticks, seaweed, and other drift material. Nesting occurs asynchronously within colonies: older, more experienced pairs initiate nesting activities earlier than other pairs. Human disturbance at colonies known to result in local population declines.

Young - Clutch size of 3-4 eggs. Incubation period of 25-29 days. Altricial young hatch asynchronously; hatchlings incubated until about 12 days of age, maintain own body temperature by 14-15 days, fledge at 35-42 days.

Incubation
6/1 - 30
Hatch 7/15
fledge 8/15

Further Reading - Dunn, E.H. 1976. Development of endothermy and existence energy expenditure of nestling Double-crested Cormorants. Condor 78:350-356.

McNeil, R. and C. Leger. 1987. Nest-site quality and reproductive success of early- and late-nesting Double-crested Cormorants. Wils. Bull. 99:262-267.

Siegel-Causey, D. and G.L. Hunt, Jr. 1981. Colonial defense behavior in Double-crested and Pelagic cormorants. Auk 98:522-531.

Vermeer, K. and L. Rankin. 1984. Population trends in nesting Double-crested and Pelagic cormorants in Canada. Murrelet 65:1-9.

APPENDIX A (cont.). Species Life History Accounts.

Pelagic Cormorant (Phalacrocorax pelagicus) - PECO

Oil vulnerability index - Highly vulnerable 1/5

Status - Alaska breeding population estimated to number 90,000 in 1985 sites. Widely distributed in Katmai NP, nesting on exposed islands above storm surge zone.

Diet - Dives in pursuit of small, benthic fish and decapod crustaceans. Feed during the day and only for short periods due to rapid loss of buoyancy of wettable plumage.

Nest - Nests located on coastal cliff ledges or islands, often on highest, steepest, least-accessible rocky escarpments facing water. Nests consist of a platform of sticks and/or seaweed ~~and~~ other drift material. Nests used perennially and materials added annually.

Young - Clutch size of 3-5. Incubation period of 26-31 days. Altricial young hatch asynchronously. Young fledge in ? days.

4/1 - 7/5
8/15

Further Reading - Siegel-Causey, D. and G.L. Hunt, Jr. 1981. Colonial defense behavior in Double-crested and Pelagic cormorants. Auk 98:522-531.

Vermeer, K. and L. Rankin. 1984. Population trends in nesting Double-crested and Pelagic cormorants in Canada. Murrelet 65:1-9.

APPENDIX A (cont.). Species Life History Accounts.

Red-faced Cormorant (*Phalacrocorax urile*) - RECD

Oil vulnerability index - Highly vulnerable (0.3)

Status - Alaska breeding population estimated to number 130,000.

Center of population abundance is in the Aleutian Islands.

Largest concentration in Katmai NP occurs in Katmai Bay; sizable breeding colony at Mt. Pedmar.

Diet - Dives in pursuit of small, benthic fish and decapod crustaceans. Feed during the day and only, for short periods due to rapid loss of buoyancy of wettable plumage.

Nest - Nests located on ledges of coastal cliffs or islands; securely plastered to wide shelves on low cliffs facing water. Nest are tidily constructed platforms of green grass, sod, seaweed, or other marine vegetation, some lined w/ gull feathers.

Young - Clutch size of 1-4. Incubation period of about 30 days. Altricial young fledge at 60 days.

Further

Reading - Gabrielson, I.N. and F.C. Lincoln. 1959. The birds of Alaska. Wildlife Management Institute, Wash., D.C. 922 pp.

APPENDIX A (cont.). Species Life History Accounts.

Harlequin Duck (Histrionicus histrionicus) - HADU

Oil vulnerability index - Highly vulnerable 180

Status - Alaska breeding population estimate unavailable. Abundant during summer along all rocky coastal areas of Katmai NP.

Diet - Dives to feed on benthic crustaceans, mollusks, aquatic insects, a few fish species.

Nest - Nests on rocky coastal islets, near mountain streams, or occasionally on open tundra. Nest usually located under shrubs, but sometimes in rock crevice, tree cavity, or abandoned puffin burrow. Males desert at onset of incubation by females. Breeding first occurs in second year.

Young - Clutch size of 6-8. Incubation period of 28-30 days. Precocial young become independent at 60-70 days of age.

6/6/30
9/15

Further Reading - Gabrielson, I.N. and F.C. Lincoln. 1959. The birds of Alaska. Wildlife Management Institute, Wash., D.C. 922 pp.

APPENDIX A (cont.). Species Life History Accounts.

Scoters (Melanitta spp.) - UNSC YOUNG

Black Scoter (M. nigra) - BLSC

Surf Scoter (M. perspicillata) - SUSC

White-winged Scoter (M. fusca) - WWSC

Oil vulnerability index - Highly vulnerable (72)

Status - Alaska breeding population estimate unavailable. Large mixed-species rafts occur from Missak Bay northeast to Swikshak Bay.

Diet - Dive to feed on benthic mollusks, crustaceans, aquatic insects, some aquatic vegetation.

Nest - Nest in grass tussocks or shrub clumps on freshwater lakes (Black and Surf) or in open tundra or tundra/taiga with permanent streams or ponds (White-winged). Onset of nesting activities later in season than most other duck species. Adults begin breeding during third year. In all species, males desert shortly after onset of incubation by females. Studies suggest that 80% of successful nests hatch from 7/15-7/31.

Young - Clutch sizes vary from 5-12 eggs. Incubation periods are 30-31 days (Black), 2 days (Surf), and 28 days (White-winged). Occasionally form large (up to 150 individuals) aggregate broods of fledglings attended by several females. Precocial young become independent at 50-75 days of age.

Further Reading - Brown, P.W. and M.A. Brown. 1981. Nesting biology of the White-winged Scoter. J. Wildl. Manage. 45:38-45.

Brown, P.W. and L.H. Frederickson. 1987. Time budget and incubation behavior of breeding White-winged Scoters. Wils. Bull. 19:50-55.

APPENDIX A (cont.). Species Life History Accounts.

Black Oystercatcher (Haematopus bachmani) - BLOY

Oil vulnerability index - Highly vulnerable 163

- Status - Alaska breeding population estimate unavailable. Common and widely distributed on Katmai NP coast: especially frequent on islands, where most nesting occurs.
- Diet - Forages on rocky, intertidal shorelines for various marine invertebrates, including mussels, worms, echinoderms, fish, crustaceans, barnacles, and limpets.
- Nest - Nest located on rocky coasts and islands above high tide line in weedy turf or beach gravel. Nest is placed in basalt crevices or in scrapes made in beach gravel: lined with bits of broken shell. Adults form long-term pair bond.
- Young - Clutch size of 2. Egg-laying occurs from 5/15-7/15. Incubation period of 26 days. Precocial young abandon nest rapidly, but are dependent on parental feeding for an extended period. Young fed primarily during low tide: follow adults into intertidal zone to be fed. Young begin to fly and to capture some of own prey at 35 days of age, but most food still provided by parents. Reproductive success varies widely: less than 50% of clutches survived to hatching in poor seasons; less than 20% of clutches produced flying young. High chick mortality attributed to storms, egg predation by sea otters and corvids, and chick predation by gulls.
- Further Reading - Groves, S. 1984. Chick growth, sibling rivalry, and chick production in American Black Oystercatchers. Auk 101:525-531.

APPENDIX A (cont.). Species Life History Accounts.

Glaucous-winged Gull (Larus glaucescens) - GWGU

Oil vulnerability index - somewhat vulnerable 36

- Status - Alaska breeding population estimated to number 500,000 in approximately 547 sites. Center of abundance from Prince William Sound southwest through the Alaska Peninsula. This species is the most abundant seabird breeding on Katmai NP coast; breeds at 220 sites, including 18 on islands.
- Diet - General omnivorous scavengers; feed on fish, mussels, crabs, limpets, other invertebrates; act as catalysts in seabird feeding flocks.
- Nest - Nests located on coastal cliffs, grassy slopes, beach berms, and bare ground; older birds utilize more protected sites. Adults first breed in fourth year. Pair bond and site fidelity strong. Of censused colonies in Alaska, 40% number <100 birds; 40% are 100-1000 in size.
- Young - Clutch size of 2-3 eggs; third egg often smaller. Incubation period of 27-29 days. Fledgling by young variable, usually occurs from 35-54 days of age.
- Further Reading - Irons, D.B., R.G. Anthony, and J.A. Estes. 1986. Foraging strategies of Glaucous-winged Gull in a rocky intertidal community. Ecology 67:1460-1474.
- Murphy, E.C., R.H. Day, K.L. Oakley, and A.A. Hoover. 1984. Dietary changes and poor reproductive performance in Glaucous-winged Gulls. Auk 101:532-541.
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APPENDIX A (cont.). Species Life History Accounts.

Black-legged Kittiwake (Rissa tridactyla) - BLKI

Oil vulnerability index - somewhat vulnerable 4?

- Status - Alaska breeding population estimated to number 1,500,000 in 263 sites. Majority of population breeds from Prince William Sound southwest to tip of Alaska Peninsula. Breeding colonies on Katmai NP coast restricted to three sites, all on sea stacks.
- Diet - Small fish (primarily sand lance and capelin), crustaceans, mollusks, carrion; often acts as a catalyst role in the formation of seabird feeding flocks.
- Nest - Nests located on steep coastal cliffs; ledges occupied by pairs by 3/22. Often breeds in large colonies; nests used perennially. Nest-building well-advanced by 4/5; often continues until 6/1. Nests include algae and other materials from intertidal zone and debris floating on sea.
- Young - Egg-laying dates vary, but usually 5/20-7/10; average laying date about 6/5. Average clutch size of 2; will replace lost clutch, but often only one replacement egg laid. Incubation period of 27 days. Average hatch date around 7/1. Reported mortality rates: 28% of laid eggs fail; 25% of hatched chicks lost by 35 days old; 44% overall mortality rate from laying through fledgling. Subject to heavy nest predation by gulls. First-egg chick hatches first, begs more, grows faster, is more aggressive, often ejects sibling from nest, especially in years with limited food resources. Young fledge at 43 days of age. Young continue to be fed near nest area after first flights. Groups of fledglings later congregate on shores near food resources.

Further

Reading - Braun, B.M. and G.L. Hunt, Jr. 1983. Brood reduction in Black-legged Kittiwakes. Auk 100:469-476.

Galbraith, H. 1983. Diet and feeding ecology of breeding Kittiwakes (Rissa tridactyla). Bird Study 30:109-120.

Maunder, J.E. and W. Threlfall. 1972. The breeding biology of the Black-legged Kittiwake in Newfoundland. Auk 89:789-816.

APPENDIX A (cont.). Species Life History Accounts.

Pigeon Guillemot (Cepphus columba) - PIGU

Oil vulnerability index - Extremely vulnerable (32)

Status - Alaska population estimated to number 200,000 in roughly 300 breeding areas. This widespread species' center of abundance spans an area from the Gulf of Alaska through the Alaska Peninsula. Widely distributed, but not abundant, in nearshore waters throughout Katmai NP coast: especially dense breeding concentrations on Kiukpalik, Shakun, and Hallo Bay islands, and in Kashvik Bay.

Diet - Dive to obtain prey in rocky, coastal waters often to considerable depths. Preferred prey includes various crustaceans and mollusks, but chicks fed mostly fish, especially sand lance and capelin.

Nest - Present at breeding areas by 3/15. May nest solitarily or semi-colonially. Utilize natural cavities within boulder beaches, talus slopes, and rock cliffs. Pair bond apparently long-term and nest site fidelity high: nests sites often used perennially.

Young - Egg-laying initiated about 6/1. Clutch size of 2. Incubation period of 30-32 days, with sexes sharing shifts of as short as 30-60 min. Hatching completed by 7/20. Young fledge at night at 29-39 days of age. Most young fledged by 8/15.

Further Reading - Orent, R.H. 1965. Breeding biology of the Pigeon Guillemot, Cepphus columba. Ardea 53:99-160.

Koelink, A.F. 1972. Bioenergetics of growth in the Pigeon Guillemot (Cepphus columba). M.S. thesis, Univ. Brit. Columbia, Vancouver. 71 pp.

APPENDIX A (cont.). Species Life History Accounts.

Ancient Murrelet (Synthliboramphus antiquus) - ANMU

Oil vulnerability index - Highly vulnerable 741

Status - Alaska population estimated at 400,000 in 40 sites. Primary breeding range includes Aleutian Islands and along the southern coast of the Alaska Peninsula. Infrequent summer resident along coast of Katmai NP; more common as a fall visitor.

Diet - Small fish and macrozooplankton, including fish and squid larvae, crustaceans, gammarids, and mollusks. Feed offshore, seldom in less than 50 m of water and up to 10 km from land. Consumes primarily euphausiid crustaceans during early phases of breeding cycle (4/1-6/1), but relies more heavily upon sand lance after 6/1.

Nest - Often nests in large colonies. Adults (first breed in third year) return to colonies by 4/1; nocturnal on breeding grounds. Burrow excavation or repair initiated by 4/15. Nests located on offshore islands and rocky coasts, usually within 500 m of water; burrows 1 m in length or in cavities under rocks, tree roots, or clumps of sod, or in grass-covered talus slopes.

Young - Egg-laying known to occur from 5/1 through 7/15. Clutch size of 2 eggs; each egg constitutes 22% of female's body weight; not known to re-lay after loss of first clutch. About 7 days elapse between laying of first and second eggs. Incubation period of 33-36 days. Both sexes assume 72-hr incubation shifts, switching at night. Highly precocial, downy young leave nest at night and head for sea an average of 2.2 days after hatching; chicks not fed while at nest; adults and young disperse rapidly from nesting areas starting approx. 6/1 (most had departed for sea by 6/15). Juveniles of all murrelet species forage near shore and frequently are seen together, especially near kelp beds.

Further

Reading - Jones, I.L., J.B. Falls, and A.J. Gaston. 1987. Colony departure of family groups of Ancient Murrelets. Condor 89:940-943.

Sealy, S.G. 1976. Biology of nesting Ancient Murrelets. Condor 78:294-306.

Sealy, S.G. 1984. Interruptions extend incubation by Ancient Murrelets, Crested Auklets, and Least Auklets. Murrelet 65:53-56.

APPENDIX A (cont.). Species Life History Accounts.

Marbled Murrelet (Brachyramphus marmoratus) - MAMU

Oil vulnerability index - Extremely vulnerable 3-

- Status - Precise Alaska breeding population estimates are unavailable. Commonly found in south-coastal Alaska as far west as eastern Alaska Peninsula, but then increasingly rare. Common (although less so than Kittlitz) in shallow bays along entire Katmai NP coast; probably breeds inland, but no nests have been located.
- Diet - Generally feeds within 500 m of shore in depths of less than 30 m; most frequently feeds in duos. Sand lance generally most important prey during terrestrial phase of breeding cycle (5/1-9/1), while capelin, euphausiids, and mysids are important prey in winter.
- Nest - Very few nests ever observed (3 known and 1 probable as of 1983). Return to nesting sites by 5/1. Usually solitary nesters. Adults first breed in third year. Nests typically located in ground depression, although some in conifers or rock crevices; generally located short distance below peak or ridge top. On treeless Alaska Peninsula, nests at 100 m above sea level; most nests on slope with northerly aspect; nests averaged 6 km from coast. Breeding may coincide with cyclic availability of prey.
- Young - Clutch size of 1. Each egg weighs 16% of adult body weight. Incubation period of 27-30 days occurs between 5/15 and 7/15. Incubation by both sexes in 24-hour shifts. Young at nest (6/15-8/15) are fed only at night. Semi-precocial young fledge at 27 days of age; disperse from nests by flight(?) or by following streams downhill(?). Newly-fledged young begin to appear with adults at sea by mid-July. Juveniles of all murrelet species forage near shore and frequently are seen together, especially near kelp beds.

Further

Reading - Carter, H.R. and S.G. Sealy. 1986. Year-round use of coastal lakes by Marbled Murrelets. Condor 88:473-477.

Day, R.H., K.L. Oakley, and D.R. Barnard. 1983. Nest sites and eggs of Kittlitz's and Marbled murrelets. Condor 85:265-273.

Sealy, S.G. 1975. Aspects of the breeding biology of the Marbled Murrelet in British Columbia. Bird-Banding 46:141-154.

APPENDIX A (cont.). Species Life History Accounts.

Kittlitz's Murrelet (*Brachyramphus brevirostris*) - KIMU

Oil vulnerability index = Extremely vulnerable 33

- Status - Precise Alaska breeding population estimates are unavailable. Commonly found along the Alaska Peninsula and further west to the Aleutian Islands. Common (more so than Marbled) in shallow bays along entire Katmai NP coast probably breeds inland, but no nests have been located.
- Diet - Predominantly planktonic crustaceans and larval fish and squid.
- Nest - Very few nests ever observed (14 known and 3 probable as of 1983). Usually solitary nesters. Egg laid on bare ground in depression amid lichen/tundra vegetation. Nests typically located inland, generally located 100-200 m below peak or ridge top. On treeless Alaska Peninsula, nests located 500 m above sea level, 11 km inland; nests on downhill side of rock at least as big as incubating bird; most on slopes with northerly aspect.
- Young - Clutch size of 1. Length of incubation uncertain (27-30 days?). Semi-precocial young fledge at 21(?) days; may follow streams downhill to sea. Juveniles of all murrelet species forage near shore and frequently are seen together, especially amid kelp beds.
- Further Reading - Day, R.H., K.L. Oakley, and D.R. Barnard. 1983. Nest sites and eggs of Kittlitz's and Marbled Murrelets. Condor 85:265-273.

APPENDIX A (cont.). Species Life History Accounts.

Parakeet Auklet (Cyclorhynchus psittacula) - PAAU

Oil vulnerability index - Extremely vulnerable (30)

- Status - Alaska population estimated to number 800,000 in 125 sites. Most breed on islands in the Bering Sea, Aleutian Islands chain, and western Gulf of Alaska. Known to have bred in recent years on Shakun Islets, but apparently now breeding only on small islands southwest of Ninaglak Island and on Nukshak Island.
- Diet - Dive and forage near surface for macrozooplanktonic crustaceans as well as larval fish and squid; prey items include various pelagic amphipods, arrowworms, polychaetes, and larvae of fish and cephalopods.
- Nest - Adults (first breed in third year) arrive on breeding grounds in May, 3-6 wks prior to egg-laying. Nests located deep within cracks, crevices, rock interstices of rubble, talus, or boulders on beach or cliffs. No nest materials gathered. Sometimes nests in small colonies. Adults diurnal with little activity between dusk and dawn; attendance at colonies reaches peak at mid-day. Birds are somewhat secretive through breeding period.
- Young - Egg-laying after 6/15. Clutch size of 1. Incubation period of 35-36 days. Re-laying known to occur. Hatching by about 8/1. Young fed at burrow about 6 times/day; several days of wing-flapping at burrow mouth prior to departure; fledge during night by about 9/1 at 35 days of age. Voles known to prey on young at burrows; studies suggest that approx. 50% of eggs laid eventually result in successfully fledged young.
- Further Reading - Bedard, J. 1969. Feeding of the Least, Crested, and Parakeet auklets around St. Lawrence Island, Alaska. Can. J. Zool. 47:1025-1050.
- Sealy, S.G. and J. Bedard. 1973. Breeding biology of the Parakeet Auklet (Cyclorhynchus psittacula) on St. Lawrence Island, Alaska. Auk 90:659-68.

APPENDIX A (cont.). Species Life History Accounts.

Tufted Puffin (Fratercula cirrhata) - TUPU

Oil vulnerability index - Highly vulnerable (72)

- Status - Alaska population estimated to number 4,000,000 in 502 sites. Most breed from north central Gulf of Alaska westward throughout the Aleutian Islands chain. More abundant than Horned Puffin in Katmai NP waters; breeding colonies of 500 pairs located on Ninagiak and Shaw islands.
- Diet - Forage both in inshore and offshore waters during the breeding season. Dive to feed on small fish that school at midwater depths. Predominant prey include sand lance and capelin; also consume gadids, cephalopods, sculpin, and greenling in lesser quantities. Subject to kleptoparasitism by gulls while carrying bill-loads of fish to burrows; colony locations may shift in response to frequent predation.
- Nest - Present at breeding colonies by 5/1. Nests located on steepest slopes and narrow strips of soil just above cliff faces or rarely in rock crevices. Burrows are 0.5-3 m deep with one or more entrances, located predominantly in hairgrass. Prefer tree- and shrub-free sites where takeoffs/landings not hindered. Intolerant of human disturbance in incubation phase; will desert nests. Vulnerable to brown bear and fox predation at burrows.
- Young - Egg-laying begins 6/5. Clutch size of 1. Incubation period of 41 days. Re-laying occurs if first egg lost early during incubation. Hatching completed by 8/1. Semi-precocial young fledge after 9/1 at 45 days of age. Adults drop food on burrow floor near young during first week, near burrow entrance thereafter; amount of time spent underground by adults delivering food decreases from several minutes (first 0-3 days) to <10 seconds (in later weeks). Adults deliver 2-4 bill-loads daily; most food deliveries occur in the morning.
- Further Reading - Vermeer, K. 1979. Nesting requirements, food, and breeding distribution of Rhinoceros Auklets (Cerorhinca monocerata) and Tufted Puffins (Lunda cirrhata). Ardea 67:101-110.
- Wehle, D.H.S. 1983. The food, feeding, and development of young Tufted and Horned puffins in Alaska. Condor 85:427-442.

APPENDIX A (cont.). Species Life History Accounts.

Horned Puffin (Fratercula corniculata) - HOPU

Oil vulnerability index - Highly vulnerable (71)

Status - Alaska population estimated at 1,500,000 in 433 sites. Center of abundance encompasses islands off southern coast of the Alaska Peninsula. Less abundant than Tufted Puffin in Katmai NP waters; breeding colonies of 100 pairs located on Nukshak, Ninagiak, and Shakun islands and along Kashvik Bay.

Diet - Forage primarily in inshore waters during the breeding season. Dive to feed on small fish that school at midwater depths. Predominant prey include sand lance and capelin; also consume greenling, gadids, squid, and sandfish. Subject to kleptoparasitism by gulls while carrying bill-loads of fish to burrows.

Nest - Nests located under boulders, in talus, in fractures or crevices of cliffs. Re-laying occurs if first egg lost early in incubation period

Young - Egg-laying begins 6/5. Clutch size of 1. Incubation period of 40-42 days. Hatching begins about 7/15. Semi-precocial young fledge after 9/1 at 45 days of age. Adults drop food on burrow floor near young during first week, near burrow entrance thereafter; amount of time spent underground by adults delivering food decreases from several minutes (first 5-7 days) to <10 seconds (in later weeks). Adults deliver 2-4 loads daily; most food deliveries occur in the morning

Further

Reading - Corkhill, P. 1973. Food and feeding ecology of puffins. Bird Study 20:207-220.

Sealy, S.G. 1973. Breeding biology of the Horned Puffin on St. Lawrence Island, Bering Sea, with zoogeographical notes on the North Pacific puffins. Pac. Sci. 27:99-119.

Wehle, D.H.S. 1983. The food, feeding, and development of young Tufted and Horned puffins in Alaska. Condor 85:427-442.

APPENDIX B. Taxonomic Alphabetic Code list for selected seabirds,
based on U.S. Fish and Wildlife Service coding system.

Alpha Code	Common Name
UNCC	Unidentified Cormorant (Dbl-crested, Pelagic, Red-faced)
CCCO	Double-crested Cormorant
PECC	Pelagic Cormorant
RFCO	Red-faced Cormorant
UNDU	Unidentified Duck (puddle ducks, diving ducks)
HADU	Harlequin Duck
UNSC	Unidentified Scoter (White-winged, Surf, Black)
WWSC	White-winged Scoter
3USC	Surf Scoter
BLSC	Black Scoter
UNME	Unidentified Merganser (Common, Red-breasted)
BLOY	Black Oystercatcher
GWGU	Glaucous-winged Gull
BLKI	Black-legged Kittiwake
PIGU	Pigeon Guillemot
ANMU	Ancient Murrelet
BRMU	<u>Brachyramphus</u> Murrelet
MANU	Marbled Murrelet
KIMU	Kittlitz Murrelet
TJPU	Tufted Puffin
HOPU	Horned Puffin
MISC	miscellaneous (uncommon alcids, shorebirds, ducks, etc.)

APPENDIX C: LITERATURE

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APPENDIX D: COLONY DATA FROM 1973-1989
 SEE N3637-30 for this data