

VARIATION IN SUMMER DIET OF GLAUCOUS-WINGED GULLS IN THE WESTERN ALEUTIAN ISLANDS: AN ECOLOGICAL INTERPRETATION

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The Glaucous-winged Gull (*Larus glaucescens*), like other gulls, is an omnivorous opportunist. Although the literature contains numerous brief references to feeding habits, including discussions of feeding behavior (Moyle 1966) and selective predation (Mossman 1958) at Alaska salmon streams, no detailed analysis of diet has been published. I report here on 2319 regurgitated pellets examined at 4 locations in the western Aleutian Islands, Alaska.

Previous investigations of gull food habits, based wholly or in part on pellet analyses, have been published by Harris (1965), Haycock and Threlfall (1975), Meijering (1954), Otterlind (1948), Threlfall (1968), and Vermeer (1973). Regurgitated pellets probably contain a disproportionate number of certain prey remains. Items such as soft-bodied invertebrates and small fish may not be present in pellets in relation to their occurrence in the diet (Harris 1965). Therefore, the pellets examined in this study do not represent a random sample of food consumed, but merely a sample of prey taken by those gulls eating foods resulting in a pellet.

METHODS

Pellets were examined in the field at the following locations and times: Alaid-Nizki Island—May–July 1976; Agattu Island—August 1974, May–June 1975, June–July 1976; Buldir Island—June and August 1974, June–July and September 1975, July–August 1976; Little Kiska Island—July 1976. No other large gull occurs regularly in the western Aleutian Islands during summer, so pellets were easily recognized as belonging to this species. Most occurred along beaches, in the vicinity of breeding colonies, or in “loafing” areas. All pellet data are lumped by locality in Table 1. A detailed monthly tabulation of the data is available from the author.

Pellet analyses were supplemented by direct observations of feeding gulls. Observational data are discussed in the text whenever they clarify, contradict, or supplement the pellet data.

RESULTS

Glaucous-winged Gulls fed on a large variety of organisms, and species occurrence in pellets varied among islands (Table 1). Pellets examined at Alaid-Nizki and Agattu frequently contained the remains of more than 1 prey species (average of 1.3 and 1.4, respectively). Pellets from the other

TABLE 1
 PERCENT OCCURRENCE OF FOOD ITEMS IN REGURGITATED PELLETS OF THE GLAUCOUS-WINGED
 GULL AT SEVERAL LOCATIONS IN THE WESTERN ALEUTIAN ISLANDS, 1974-76

Food item	Island				
	Alaid-Nitzki (N = 875)	Agattu (N = 738)	Buldir (N = 655)	Little Kiska (N = 51)	Semiso- pochnoi ¹ (N = 137)
Invertebrates (total)	(87.1) ²	(91.0)	(1.9)	(0.0)	(8.0)
Sea urchin (<i>Strongylocentrotus polyacanthus</i>)	80.1	78.9	1.1	—	5.8
Unidentified barnacles (<i>Balanus</i> spp.)	5.8	4.9	—	—	—
Unidentified crabs (Decapoda)	0.6	1.5	—	—	—
Chiton (<i>Katharina tunicata</i>)	8.0	8.8	—	—	—
Limpets (<i>Acmaea</i> spp.)	1.9	3.4	—	—	2.2
Periwinkles (<i>Littorhina</i> spp.)	1.5	1.0	—	—	—
Blue mussel (<i>Mytilus edulis</i>)	2.5	4.9	—	—	—
Unidentified bivalves (Pelecypoda)	0.5	1.2	—	—	—
Unidentified "kelp fly" (Diptera)	—	—	0.8	—	—
Fish (total)	(0.2)	(2.8)	(19.5)	(76.5)	(5.1)
Birds (total)	(0.2)	(2.8)	(79.2)	(25.6)	(86.9)
Leach's Storm-Petrel (<i>Oceanodroma leucorhoa</i>)	0.1	0.4	20.0	—	—
Fork-tailed Storm-Petrel (<i>Oceanodroma furcata</i>)	0.1	—	40.0	2.0	2.2
Unidentified storm-petrels (<i>Oceanodroma</i> spp.)	—	—	0.8	—	—
Red-faced Cormorant (<i>Phalacrocorax urile</i>)	—	0.7	—	—	—
Unidentified cormorants (<i>Phalacrocorax</i> spp.)	—	—	—	2.0	—
Black-legged Kittiwake (<i>Rissa tridactyla</i>)	—	—	0.2	—	—
Ancient Murrelet (<i>Synthliboramphus antiquus</i>)	—	—	10.1	19.6	—
Crested Auklet (<i>Aethia cristatella</i>)	—	—	2.9	—	—
Least Auklet (<i>Aethia pusilla</i>)	—	—	1.4	—	84.7
Cassin's Auklet (<i>Ptychoramphus aleuticus</i>)	—	—	0.2	—	—
Unidentified auklet (<i>Aethia</i> spp.)	—	—	1.4	—	—
Tufted Puffin (<i>Lunda cirrhata</i>)	—	—	0.2	—	—
Unidentified small bird	—	0.7	0.3	—	—
Unidentified bird feathers	0.2	0.6	—	—	—
Unidentified bird eggs	—	1.1	1.7	2.0	—
Vegetation (total)	(1.8)	(3.4)	(2.0)	(0.0)	(0.0)

TABLE 1 (CONTINUED)

Food item	Island				
	Alaid-Nitzki (N = 875)	Agattu (N = 738)	Buldir (N = 655)	Little Kiska (N = 51)	Semisopchnoi ¹ (N = 137)
Crowberry (<i>Empetrum nigrum</i>)					
berries	1.7	1.8	1.5	—	—
Unidentified marine algae	0.2	2.4	—	—	—
Unidentified vegetation	—	1.0	0.5	—	—
Miscellaneous (total)	(17.6)	(23.2)	(4.3)	(0.0)	(0.0)
Beach pebbles	14.1	22.6	0.8	—	—
Steller's sea lion (<i>Eumetopias jubata</i>) excreta	6.6	0.7	—	—	—
Steller's sea lion hair	—	0.1	3.5	—	—
Calcareous algae	0.8	1.5	—	—	—
Wood chips	—	0.5	—	—	—
Miscellaneous detritus	—	0.2	—	—	—
Arctic fox (<i>Alopex lagopus</i>) hair	—	0.1	—	—	—
Unidentified skin	—	0.1	—	—	—
Paper	0.1	—	—	—	—
Blue glass	0.1	—	—	—	—
Aluminum foil	0.1	—	—	—	—

¹ Data taken from Murie (1959:169).

² All values represent percent occurrence in total sample. Values in parentheses are composite totals for invertebrates, fish, birds, and miscellaneous. Summation of columns exceeds 100% in most cases because of overlap (i.e. occurrence of more than 1 prey species per pellet).

islands rarely contained more than 1 prey species (average of 1.1 at Buldir, and 1.0 at both Little Kiska and Semisopchnoi).

Invertebrates.—The sea urchin (*Strongylocentrotus polyacanthus*) was by far the most common invertebrate in the diet, occurring in more than 78% of the pellets from Agattu and Alaid-Nizki (Table 1). Sea urchins are taken from the sublittoral fringe at low tide. Large individuals are dropped from the air onto a hard surface to crack the shell; smaller individuals are swallowed whole (cf. Barash et al. 1975). Chitons (*Katharina tunicata*), barnacles (*Balanus* spp.), blue mussels (*Mytilus edulis*), and limpets (*Acmaea* spp.) were also used as food to some degree on these 2 islands.

An unidentified "kelp fly" (Diptera) was important in the diet at Buldir for a short time in August (Table 1). These flies were extremely abundant in decomposing kelp scattered along the beach, and among offal of the Steller's sea lion (*Eumetopias jubata*). Adult gulls were observed capturing flies by "flycatching." They sat passively on the beach and snapped at passing flies with their bills. Flies were present throughout the summer, but only in late summer did they become numerous enough for gulls to feed on them.

Fish.—No attempt was made to identify fish remains in pellets. In the Aleutian Islands, Glaucous-winged Gulls are known to feed on Pacific herring (*Clupea harengus*), Pacific sandlance (*Ammodytes hexapterus*), and rock greenling (*Hexagrammos lagocephalus*) (pers. obs.). Fish were particularly frequent at Little Kiska and Buldir, where they occurred in 76% and 20% of the pellets, respectively (Table 1). At Buldir, fish comprised an important part of the diet of young gulls; 33% of the pellets examined in nesting colonies (N = 106) contained fish. Nesting colonies were littered with partially digested fish remains, and when handling young gulls they frequently regurgitated fish. On several occasions adult gulls were observed harassing Horned (*Fratercula corniculata*) and Tufted (*Lunda cirrhata*) puffins in an effort to steal fish.

Birds.—Nine species of birds were found in gull pellets (Table 1). Birds were most frequently taken at Semisopochnoi and Buldir, occurring in 87% and 79% of the pellets, respectively. Pellets collected at Semisopochnoi by Murie (1959) indicated that gulls there fed largely on Least Auklets (*Aethia pusilla*). The Least Auklet colony at Semisopochnoi is one of the largest in the Aleutian Islands (Murie 1959:198). At least 8 species were represented in pellets at Buldir, with 3 species (Leach's Storm-Petrel [*Oceanodroma leucorhoa*]; Fork-tailed Storm-Petrel [*O. furcata*]; Ancient Murrelet [*Synthliboramphus antiquus*]) accounting for 89% of the individuals taken.

Storm-petrels were frequent prey at Buldir, where they were found in 61% of the pellets. The method used to capture nocturnal storm-petrels is not known, although they are presumably taken at dusk as they emerge from their burrows. Glaucous-winged Gulls were frequently heard calling, and observed "swarming," shortly after dusk and it was assumed that they were preying on storm-petrels. G. V. Byrd (pers. comm.) has observed Glaucous-winged Gulls methodically inspecting the entrances of storm-petrel burrows for chicks or adults.

Although not reflected in pellet remains, eggs and young of the Red-faced Cormorant (*Phalacrocorax urile*) were preyed on extensively in May and June at Agattu. On many occasions gulls were noted harassing adult cormorants by swooping repeatedly over nests. If an adult was successfully dislodged by these tactics the gull immediately landed on the nest and devoured any eggs or young present. Murie (1959:59) also noted heavy predation on the eggs of this species.

Predation on eggs and young of other cliff-nesting birds, such as Black-legged Kittiwakes (*Rissa tridactyla*) and murrens (*Uria* spp.) was probably also underestimated. Gulls were not observed taking kittiwake eggs at Agattu or Buldir, but on several occasions were noted attacking chicks at Agattu. Predation on murre eggs was not observed, but they are probably taken

whenever given the opportunity. At Bogoslof Island, in the eastern Aleutians, murre eggs and young are one of the main food sources (Murie 1959:183-184; G. V. Byrd, pers. comm.).

Nocturnal, burrow-nesting Ancient Murrelets breed in large numbers at Buldir, and hatching occurs over an approximately 2-week period in mid-July. During the nightly mass migrations to the sea, chicks and adults are extremely vulnerable to gull predation. The opportunistic gulls made heavy use of this temporarily abundant food source; 46% of 102 pellets examined along North Bight Beach (the main terminus of the nightly exodus) in mid-July contained murrelet remains. Overall, murrelets ranked third in frequency of occurrence in pellets at Buldir. At Little Kiska, a locality at which breeding has not yet been confirmed, murrelets were second in frequency of occurrence.

The frequency of small auklets (*Aethia* spp.) in the diet at Buldir is probably underestimated because few pellets were examined in their talus-slope nesting colonies. Auklets were found in less than 6% of all pellets examined (Table 1), but occurred in 42% of the pellets (N = 73) from nesting colonies. Numerous auklet carcasses were observed on all visits to the colonies. Some were no doubt taken by Peregrine Falcons (*Falco peregrinus*) but the majority probably represented gull predation. It may be significant that of the 11 species of alcids nesting at Buldir, the Crested Auklet (*A. cristatella*) was the largest species found regularly in gull pellets. Pigeon Guillemots (*Cephus columbus*), Parakeet Auklets (*Cyclorhynchus psittacula*), Horned Puffins, and Tufted Puffins nested in large numbers but may be too large for gulls to take. On 1 occasion a Glaucous-winged Gull was observed to carry a Tufted Puffin in its bill for about 10 m before dropping it (D. G. Kelleyhouse, pers. comm.).

Vegetation.—Crowberry (*Empetrum nigrum*) berries were taken in late summer at Alaid-Nizki, Agattu and Buldir (Table 1). These berries become ripe in mid-August and were frequently found in pellets examined in the uplands. Marine algae and other unidentified vegetation occasionally found in pellets were probably ingested incidentally.

Miscellaneous.—Small beach pebbles were found in 23% of the pellets from Agattu, 14% of those from Alaid-Nizki, and 1% of those from Buldir (Table 1). These pebbles were probably ingested incidentally by gulls feeding on Steller's sea lion excreta. At Alaid-Nizki large concentrations of sea lions are found on the western half of the island, but none occur on the eastern half; 87% of all Alaid-Nizki pellets with pebbles were found on the western half, compared with 42% of the total sample of pellets. Similarly, nearly all pellets containing pebbles examined on Agattu occurred in the immediate vicinity of sea lion colonies. Occasionally other food items, including sea

TABLE 2
RELATIONSHIP BETWEEN ISLAND PHYSIOGRAPHY, SEA OTTER POPULATIONS, AVAILABLE FOOD RESOURCES, AND THE PRIMARY DIET OF GLAUCOUS-WINGED GULLS

	Island				
	Alaid-Nizki	Agattu	Buldir	Little Kiska	Semisopochnoi
Intertidal zone	Extensive	Extensive	None	Extensive	Moderate
Kelp beds	Moderate	Moderate	Limited	Extensive	Moderate
Sea otter population	Very low	Low	Moderate	High	High
Nesting seabirds	Cormorants	Cormorants	Petrels	Cormorants	Petrels
	Gulls	Gulls	Cormorants	Gulls	Cormorants
	Kittiwakes	Kittiwakes	Gulls	Murrelets	Gulls
		Murres	Kittiwakes		Auklets
			Murres		
		Auklets			
		Puffins			
Primary diet	Invertebrates	Invertebrates	Birds	Fish	Birds

lion excreta, were found mixed with pebbles, but in most cases pebbles were the sole component of the pellet. Gulls were observed feeding on sea lion afterbirths during June and July at Agattu and Buldir. They also scavenged the rotting carcasses of both young and adult sea lions throughout the summer.

DISCUSSION

Inter-island differences in diet.—At Alaid-Nizki and Agattu, Glaucous-winged Gulls fed primarily on intertidal invertebrates (87% and 91%, respectively); at Buldir and Semisopochnoi the principal food was birds (79% and 87%, respectively); while at Little Kiska the primary prey was fish (76%). These dietary differences seem largely related to island physiography and the available food source (Table 2).

Alaid-Nizki and Agattu both have extensive intertidal zones, with numerous reefs and offshore rocks. Sea urchins and other marine invertebrates are abundant while the sea otter (*Enhydra lutris*), a major predator on sea urchins (Kenyon 1969:105–132), is either absent or present in small numbers. Buldir and Semisopochnoi both support immense numbers of colonial nesting seabirds, which are easy prey for gulls (storm-petrels and Crested Auklets at Buldir; Least Auklets at Semisopochnoi). Buldir has no intertidal zone and a moderate sea otter population. Marine invertebrates and fish may be taken at Semisopochnoi more frequently than the data suggest. Little Kiska has a

very large sea otter population and an extensive intertidal zone. Dense kelp beds surrounding the island provide excellent cover and protection for fish.

Inter-species relationships.—Estes and Palmisano (1974) studied the inter-relationship among sea otters, sea urchins, and benthic macrophytes in the Aleutian Islands. They found that littoral and sublittoral community structure varied greatly between islands with and without sea otters. They suggested these differences were principally related to the ecological consequences of sea otter predation. Islands without sea otters had dense invertebrate populations (urchins, mussels, limpets, barnacles) in the littoral and shallow sublittoral zones. These invertebrates were small and sparse on islands with high density sea otter populations, and in their place was a rich assemblage of marine macroalgae.

The results of this study indicate that sea otters may also profoundly affect the diet of Glaucous-winged Gulls. This is most graphically illustrated by comparing the diets among Alaid-Nizki, Agattu, and Little Kiska. All 3 islands have extensive intertidal zones and similar densities of nesting sea birds (Table 2). They differ only in the size of the sea otter population—Little Kiska has a high population (apparently near carrying capacity); Alaid-Nizki and Agattu have low populations. Invertebrates (primarily sea urchins) comprised over 81% of the diet at both Alaid-Nizki and Agattu but were not even represented in the sample from Little Kiska. This suggests that sea otter predation on sea urchins at Little Kiska has made it energetically unfeasible for Glaucous-winged Gulls to exploit this resource.

Fish, an important dietary item at Little Kiska, would benefit from the increased standing crop of macrophytic algae following reduction of the herbivorous sea urchins. Recent work at Attu Island (C. A. Simenstad and J. A. Estes, unpubl.) has confirmed the relationship between the presence of algae (mainly *Alaria fistulosa*, *Laminaria* spp., and *Agarum cribrosum*) and abundance of certain nearshore fishes. However, the relationship is complex and only some species (i.e., rock greenling; sculpin [*Hemilepidotus hemilepidotus*] and others; rock fish [*Sebastes* spp.]) are affected; others (such as offshore or inshore transients) are not. Such species as Pacific herring and Pacific sandlance (both of which are taken by gulls) probably are less affected by kelp abundance than other species.

SUMMARY

More than 2300 regurgitated pellets were examined for prey remains at 4 locations in the western Aleutian Islands. These and direct observation of foraging activities demonstrated that Glaucous-winged Gulls fed on a large variety of organisms, but at any given locality they specialized on those species which were most abundant and vulnerable. Inter-island differences in diet seem related to island physiography, the available food source, and the effects of sea otters on the structure of the nearshore community.

ACKNOWLEDGMENTS

These observations were made while the author was on the staff of the Aleutian Islands National Wildlife Refuge. Logistic support was provided by the U.S. Fish and Wildlife Service Research Vessel "Aleutian Tern" commanded by Captain G. A. Putney. I thank G. V. Byrd for encouragement throughout the study and allowing me to use his data from Buldir. R. H. Day, L. G. Frank, D. G. Kelleyhouse, M. Snigaroff, and M. A. Spindler provided assistance in the field. G. V. Byrd, J. A. Estes, and R. J. Hensel commented on an earlier draft of the manuscript.

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U.S. FISH AND WILDLIFE SERVICE, 1011 EAST TUDOR ROAD, ANCHORAGE, ALASKA 99503. ACCEPTED 2 JUNE 1978.