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Food Habits of Glaucous Gulls in the Beaufort Sea

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ABSTRACT. During 1973 and 1974, 1877 regurgitated pellets were collected from 15 glaucous gull colonies on inland lakes, river deltas, and coastal reaches of the Beaufort Sea west and east of Tuktoyaktuk, N.W.T. The pellets contained chiefly small rodents, fish, eggs and young of geese and gulls, isopods, berries and grass, and blue mussels. The relative importance of these foods varied among the colonies, both within and between seasons. Predation on young waterfowl was more extensive than predation on eggs. The data show that glaucous gulls are adaptable and opportunistic feeders and that the diversity of foods consumed was high and did not vary within the season.

Key words: glaucous gull, food habits, Beaufort Sea

RÉSUMÉ. Au cours de 1973 et de 1974, on a recueilli 1877 pelotes régurgitées dans 15 colonies de goélands à ailes glauques sur des lacs intérieurs, des deltas de rivières et les limites côtières de la mer de Beaufort à l'ouest et à l'est de Tuktoyaktuk, dans les T.N-O. Les pelotes contenaient surtout de petits rongeurs, des poissons, des oeufs et des oisons et petits de goélands, des isopodes, des baies et de l'herbe ainsi que des moules bleues. L'importance relative de ces aliments variait selon les colonies, à la fois pendant la saison et d'une saison à l'autre. La prédation effectuée sur les petits du gibier d'eau était plus importante que celle effectuée sur les oeufs. Les données montrent que les goélands à ailes glauques sont des mangeurs doués d'adaptabilité et opportunistes, et que la diversité des aliments consommés était importante et restait constante durant la saison.

Mots clés: goéland à ailes glauques, habitudes alimentaires, mer de Beaufort

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INTRODUCTION

In the Western Arctic, glaucous gulls nest in colonies and as solitary pairs on coastal islands, river deltas, and islands in inland lakes. One- and two-year-old non-breeding gulls frequent remote off-shore ice leads in May and June (Barry *et al.*, 1981; Barry and Barry, 1982). Later in the season these age classes accumulate in flocks, numbering upwards of 300 birds, along the coastline of eastern Amundsen Gulf and Dolphin and Union Strait (Barry and Barry, 1982).

From observations made during the past thirty years in the Beaufort Sea region we have the impression that approximately half the breeding glaucous gulls nest in colonies; the remainder nest as solitary pairs or in small groups.

Near their nests and roosts *Larus* gulls regurgitate pellets consisting of the undigested remains of their food. In 1973 we investigated the food habits of glaucous gulls (*Larus hyperboreus*) by collecting and analyzing pellets from the colony in the Anderson River Delta Migratory Bird Sanctuary, near Liverpool Bay, Northwest Territories (N.W.T.). Our purpose was to quantitatively determine the extent that gulls used the local breeding populations of Pacific brant (*Branta bernicla*), snow geese (*Anser caerulescens*), and tundra swans (*Cygnus columbianus*) as a food source. In the summer of 1974 we expanded our investigation to other colonies situated around the Beaufort Sea. This paper considers the food habits of glaucous gulls at the Anderson River delta in both 1973 and 1974 and at 14 other colonies in 1974. Data on glaucous gull distribution and food habits, collected opportunistically during the summers of 1958-87 are incorporated. We made no rigorous attempt to determine the extent and diversity of food availability at Anderson River but instead made many casual observations.

Table 1 gives the names of the colonies sampled, the colony type, dates of visits, and estimates of colony size. Because of poor nesting conditions the number of gulls in the colonies in 1974 was relatively small. In subsequent seasons some colonies, e.g., Escape Reef, had three or four times the number of nests or pairs of gulls that we observed in 1974 (Hawkings, 1987; Alexander and Hawkings, 1988).

TABLE 1. Names, types, visit dates, and population sizes of glaucous gull colonies sampled in 1974

Colony name	Colony type	Dates visited	Estimated number of pairs
Sitidgi Lake	Inland	22 June	25
		24 July	25
Old Man Lake	Inland	2 July	24
		24 July	16
Horton River	River	22 June	20
Mason River	River	22 June	45-50
		28 July	35-40
Anderson River	River	19 June[1]	40
		13 July[2]	40
Kugaluk River	River	22 June	35-40
		24 July[3]	50-60
Kidluit Bay	River	22 June	75
		25 July[3]	65-70
Thumb Island	Coastal	22 June	41
		24 July	
Saunatuk[4]	Coastal	22 June	18
		24 July[3]	5
Moose Channel	Coastal	22 June	16
Hutchison Bay	Coastal	22 June	28
Gary Island	Coastal	23 June	20
		25 July	20
Escape Reef	Coastal	23 June	70
		25 July	55
Phillips Bay	Coastal	22 June	19
Nunaluk Spit	Coastal	22 June	13

[1] Collections of 2, 12, and 19 June are grouped as 19 June.
[2] Collections of 27 June, 1 and 13 July are grouped as 13 July.
[3] Observations made only from the aircraft.
[4] During the summer Saunatuk became increasingly popular for sports fishing and is now the site of a tourist camp.

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METHODS

From our studies of other species in the region since 1958, locations of most of the gull colonies were already known to us in 1974. We located the rest of the colonies by searching coastlines and lakes while travelling between the known colonies. All of the glaucous gull colonies we investigated were within 20 km of the southeastern Beaufort Sea coast, between 126° and 140° West longitude and above the northern extent of the tree line (Fig. 1). We sampled two colonies from inland lakes, five from river deltas, and eight from coastal areas of the Beaufort Sea. The Anderson River colony, near a Canadian Wildlife Service field camp, was accessible by boat in 1973 and 1974. In 1974, we visited the other colonies in a Hughes 500 helicopter in June and a Cessna 185 fixed-wing aircraft on floats in July.

We visited the Anderson River colony five times during 1973 and six times during 1974. In 1974, we visited other colonies in late June before the sea ice cleared and again in late July. We omitted a second ground visit to some colonies after flooding by a storm surge caused the disappearance of gull chicks and dispersal of the adults, only making an overflight. At colonies inaccessible by float plane in July we only estimated the numbers of gulls present.

During each visit we thoroughly searched the central portion of each colony for fresh pellets, sealing them individually in plastic "whirl-pac" bags for subsequent analysis. The pellets that we collected varied in size from approximately 1 x 1 cm to about 12 x 4 cm. When relatively dry they remained intact for several months.

In the laboratory, we teased apart the pellets and identified the items present by comparison with a Canadian Wildlife Service specimen collection of bird feathers and fish scales. Where necessary we used a dissecting microscope to assist identification. Indigestible materials, such as bones, hair, feathers, and scales, readily combine and form pellets, but the gulls often completely digest such softer foods as downy young geese and other birds, eggs, fruit, ammocete larvae, and insects. Examination of gull pellets, therefore, does not provide a complete measure of the proportion of each kind of food consumed.

The 1877 pellets contained on average 2.6 food items per pellet, and only rarely could we assign each pellet entirely to a food class. In our analysis we report the frequency of occurrence of the various food items independent of the number of pellets (Spaans, 1971; Strang, 1976), rather than the frequency of pellets in each food class (Butler, 1974; Haycock and Threlfall, 1975; Trapp, 1979). Thus each food item in a pellet received equal weight and our sampling unit was not a pellet but rather the food items it contained. We used a Chi-Square procedure (Zar, 1984) to test for significant differences in the distributions of food items between locations as well as sampling periods. Using the method of Brillouin described in Zar (1984), we calculated diversity indices of the six food groups found in pellets for each sample as follows:

$$H = \frac{\{\log (n!) - \log(fi!)\}}{n},$$

$$H_{max} = \frac{\{\log(n!) - (k-d) \times \log(c!) - d \times \log((c+1)!)\}}{n},$$

$$\text{Diversity } J = \frac{H}{H_{max}},$$

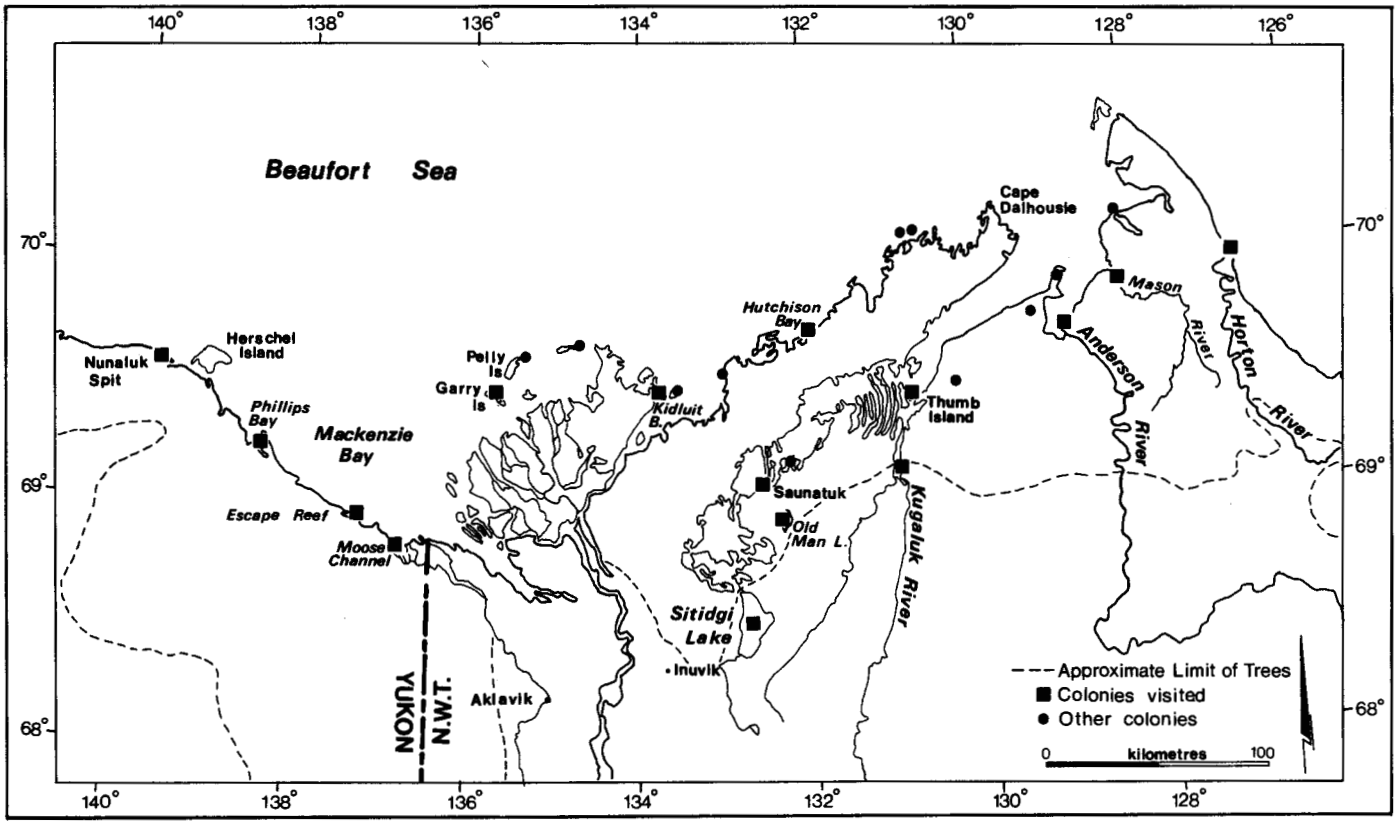

FIG. 1. Glaucous gull colonies along the southeast coast of the Beaufort Sea.

where n = number of food occurrences, f_i = frequency of food type i, k = number of food types available, c = integer portion of n/k, and d = fractional portion of n/k.

In 1973 we collected six glaucous gulls at Anderson River to confirm observed feeding choices. The stomach contents of these birds are not included in the subsequent pellet analysis.

To determine the foraging range of gulls nesting at the Anderson River colony in 1973 and 1974 we marked gulls by placing a foam strip (2.5 x 2.5 x 40 cm) saturated with an orange dye (Picric acid and Rhodamine B) around the edge of each of 12 nest cups. The gulls marked themselves on the breast and wings when they returned to incubate and re-adjusted nest material or attempted to remove the foam. We presume that only female gulls were marked. Color-marked gulls could be easily identified using binoculars from 200-300 m. Originally, we experimented with capturing the gulls on the nest; this resulted in marked gulls but abandoned nests. We observed marked gulls while making periodic travels within the delta and nearby ocean by small boat during June, July, and August.

RESULTS

Pellet Analysis

Analysis of the 1877 pellets collected from the 15 glaucous gull colonies in 1973 and 1974 indicate that the principal foods with indigestible remains are of the following groups: mammals, fish, birds, isopods (*Mesodptea entomon*), vegetation, and other items. The relative importance of these foods is variable by colony, date, and season. As already mentioned, softer but important foods may be underrepresented in our data, although where possible we report direct observations of feeding gulls. These aspects are discussed separately.

Results of the pellet analysis for the inland, river delta, and coastal colonies visited in 1974 are in Table 2, expressed as a percentage of the total food occurrences. Similarly the distribution of food items in pellets collected at Anderson River delta in 1973 and 1974 are in Table 3. The diversity index of the foods found in each sample is also included in these tables.

One factor influencing the results of this study was that the spring thaw was late throughout the Beaufort region in 1974 as compared to 1973. In 1973 the mean daily temperature rose above 0°C consistently on 18-23 May, 7-9 d ahead of the daily minimum temperature (27-30 May). In 1974 these events occurred on 3-7 June and 3-7 July, a difference of 30 d. The river ice broke up at Anderson River on 27 May in 1973 and in 1974 on 10 June. The sea ice and coastal snow cover persisted well into the normal incubation period of glaucous gulls. The late spring severely limited the gulls' access to open water, food, and nesting sites in June, curtailing the nesting effort. At the colonies in the river deltas, however, open water became available following breakup of the river ice, and at Anderson River breeding efforts and regular feeding patterns followed.

Mammals: The frequency of occurrence of mammal species ranged from 2.5 to 39.5% at all colonies visited in 1974. They constituted a major dietary item at most colonies, and gulls consumed them more frequently in the spring. Of mammal remains, *Microtus oeconomus* and *Ondatra zibethicus* made up the majority of non-scavenged items in the pellets from Sitidgi Lake (52%) and Old Man Lake (74%), while at the five

TABLE 2. Frequency of occurrence (% of total occurrences) of major food items at glaucous gull colonies by date in 1974

Colony	Visit date	Mammals[1]	Fish[2]	Birds[3]	Isopods	Vegetation[4]	Others[5]	Total food occurrences	Total pellets	Diversity index J
Sitidgi Lake	22 June	26.8	11.4	5.9	0.0	28.6	27.3	220	68	0.802
	24 July	14.6	22.0	9.8	0.0	29.2	24.4	41	14	0.772
Old Man Lake	2 July	22.9	17.7	11.4	0.0	21.1	26.9	175	63	0.873
	24 July	6.4	26.6	21.3	0.0	22.3	23.4	94	28	0.811
Horton River	22 June	12.1	6.0	18.1	12.1	19.0	31.9	116	44	0.910
Mason River	22 June	11.5	11.1	9.0	17.6	13.6	37.2	323	116	0.896
	28 July	4.3	6.1	18.8	28.5	12.7	29.6	277	98	0.885
Anderson[6] River	19 June	11.7	17.5	19.2	2.9	25.8	22.9	240	107	0.927
	13 July	5.1	18.1	20.4	16.4	20.4	19.6	353	146	0.937
Kugaluk River	22 June	26.5	17.6	7.4	0.0	33.8	14.7	68	30	0.810
Kidluit Bay	22 June	19.8	12.2	10.5	1.7	32.5	23.3	237	94	0.866
Thumb Island	22 June	8.3	7.3	7.6	0.6	26.0	50.2	315	109	0.722
	24 July	2.5	17.4	11.6	2.4	19.0	47.1	121	43	0.771
Saunatuk	22 June	11.6	19.1	16.1	0.4	25.8	27.0	267	101	0.866
Moose Channel	22 June	26.3	14.7	5.3	0.5	30.0	23.2	190	73	0.817
Hutchison Bay	22 June	19.6	11.4	11.4	2.2	18.4	37.0	184	61	0.848
Garry Island	23 June	39.5	3.5	7.6	0.0	16.5	32.9	170	75	0.737
	25 July	25.3	15.2	15.2	0.9	9.1	34.3	99	39	0.828
Escape Reef	23 June	25.9	11.6	10.2	0.0	17.1	35.2	293	109	0.814
	25 July	17.6	15.1	13.5	3.6	21.2	29.0	245	85	0.898
Phillips Bay	22 June	17.8	20.8	7.9	0.0	22.8	30.7	101	37	0.804
Nunaluk Spit	23 June	24.5	11.2	10.2	7.1	11.2	35.8	98	37	0.878

[1] *Sorex* sp., *Lepus americanus, Spermophilus parryii, Tamiasciurus hadsonicus, Castor canadensis, Clethrionomys rutilus, Lemus sibiricus, Dicrostonyx torquatus, Ondatra zibethicus, M. pennsylvanicus, M. oeconomus, Microtus* sp., *Martes americanus, Mustela erminea, Phoca* sp., *Rangifer tarandus, Cervidae*, unidentified.
[2] *Coregonus clupeaformis, Esox licius, Lota lota, Clupea harengus pallasi, Coregonus aurumnalis, Stenodus leucichthys*, unidentified.
[3] Egg-shells and membranes, bird bones and feathers.
[4] *Empetrum nigram, Vaccinium* sp., *Rubus chamaemorus, Arctostaphylos uva ursi* and grasses.
[5] Blue mussels, insects and miscellaneous items.
[6] Collections of 2, 12 and 19 June are grouped as 19 June, and collections of 27 June and 1 and 13 July are grouped as 13 July.

TABLE 3. Frequency of occurrence (% of total occurrences) of glaucous gull foods in pellets collected at Anderson River in 1973 and 1974

	1973					1974					
Food Item	10 June	16 June	24 June	1 July	4 August	2 June	12 June	19 June	27 June	1 July	13 July
Mammals[1]	2.4	0.0	4.3	14.7	1.3	10.7	10.3	12.9	8.1	4.4	4.0
Fish[2]	20.7	23.1	24.1	17.3	34.4	10.7	11.7	24.1	18.6	16.5	18.7
Birds[3]	14.9	19.2	10.3	17.3	14.0	30.4	25.0	10.4	23.3	20.8	18.7
Isopods	44.8	34.7	34.5	25.3	20.4	1.8	0.0	5.2	9.3	15.4	20.5
Vegetation[4]	12.6	19.2	15.6	14.7	17.2	26.8	26.5	25.0	23.3	22.0	18.2
Other[5]	4.6	3.8	11.2	10.7	12.7	19.6	26.5	22.4	17.4	20.9	19.9
Total occurrences	87	26	116	75	269	56	68	116	86	91	176
Total pellets	44	12	52	37	155	27	29	51	42	36	68
Diversity J	0.774	0.776	0.877	0.933	0.841	0.848	0.832	0.911	0.930	0.939	0.937

[1] *Sorex* sp., *Lepus americanus, Spermophilus parryii, Tamiasciurus hadsonicus, Castor canadensis, Clethrionomys rutilus, Lemus sibiricus, Dicrostonyx torquatus, Ondatra zibethicus, M. pennsylvanicus, M. oeconomus, Microtus* sp., *Martes americanus, Mustela erminea, Phoca* sp., *Rangifer tarandus, Cervidae,* unidentified.
[2] *Coregonus clupeaformis, Esox licius, Lota lota, Clupea harengus pallasi, Coregonus aurumnalis, Stenodus leucichthys,* unidentified.
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[4] *Empetrum nigram, Vaccinium* sp., *Rubus chamaemorus, Arctostaphylos uva ursi* and grasses.
[5] Blue mussels, insects and miscellaneous items.
[6] Collections of 2, 12 and 19 June are grouped as 19 June, and collections of 27 June and 1 and 13 July are grouped as 13 July.

river delta colonies *Dicrostonyx torquatus, Ondatra zibethica,* and *Microtus pennsylvanicus* appeared most frequently (28.6-90.9%). At the coastal colonies, of mammal remains the most abundant species were *Dicrostonyx torquatus* and *Microtus pennsylvanicus* (33.3-94.6%).

Fish: Fish species were a major food source for gulls at all colonies; the frequency of occurrence of this food ranged from 3.5 to 26.6%. Scales and bones of whitefish, northern pike, burbot, Pacific herring, arctic cisco, and inconnu occurred in pellets.

Birds: Bird remains in the form of egg shells, feathers, and bones constituted 5.3-21.3% of all food occurrences in pellets. At Old Man Lake, Horton River, Mason River, Anderson River, Saunatuk, and Hutchison Bay, birds were a major food (9.0-21.3%). At Anderson River, the only sampled colony near a large waterfowl breeding area, egg shells and membranes of snow geese, Pacific brant, and glaucous gulls constituted 44-52% of bird remains, and prior to 1 July egg remains occurred in 6.3% of all food occurrences in 1973 and 10.6% in 1974.

Marine Isopods: Our pellet analysis indicates that isopods were an important food for gulls at Horton, Mason, and Anderson River colonies, constituting 12.1-28.5% of all food occurrences in the sampled pellets.

Vegetation: Glaucous gulls in all of the colonies consumed sedges, grasses, and roots at a rate of 9.1-33.8%. They also consumed crowberries, cranberries, cloudberries, and bearberries when these ripened in August and when over-wintered berries were exposed in the spring.

Other: The blue mussel (*Mytilus edulis*) was an important food for gulls only at the Thumb Island colony, where they accounted for up to 21.9% of all food occurrences in June (63.3% of all pellets) and 19.0% in July (53.5% of all pellets). We found that gulls used this food source only sporadically at six of the other colonies (Horton River, Mason River, Kidluit Bay, Saunatuk, Hutchison Bay, and Nunaluk Spit).

Gulls occasionally consumed ground beetles, mosquitoes, and flies (*Diptera*), as well as small quantities of silt, sand, and small stones when eating other foods; these latter items also stuck to the pellets when deposited on the ground, and nearly all pellets contained such materials.

At colonies near radar stations, oil exploration camps, and hunting and fishing sites occupied by the local people, pellets contained items such as an entire hair net, shards of the ubiquitous yellow plastic used to contain explosive charges for marine seismic operations in the late 1960s and early 1970s, and a fish tag from an arctic cisco.

Within each of the three colony types, inland, river delta, and coastal, the distribution of food items in pellets was dependent ($p<0.05$) on the colony — that is, no statistical similarity among the colonies within each group. Although the colonies are different statistically, we will maintain the three designations to preserve ecological contexts, which were not measured but which group important similarities such as geography, food availability and diversity, spring thaw and weather influence, foraging methods, and breeding aspects. We treat the colonies on an individual basis and explore the changes in foods between the two sampling visits and for Anderson River changes between years.

Certain foods in the diet of the glaucous gull, e.g., eggs and mammals, became scarce as the season progressed or were replaced in the diet by other food sources that became available, were "preferred," or were easier to procure. With the combined data of those colonies visited twice, the distribution of foods taken varied significantly ($X^2=165.9$, df=5; $p<0.05$) between visits. Decreases in mammal and increases in bird and isopod consumption primarily contributed to this difference. The gulls consumed fish at a relatively constant rate. The diversity index did not change appreciably between visits at most colonies.

More specifically, gulls at Sitidgi Lake exhibited no substantial changes in their diets ($X^2=5.9$, df=4; $p>0.05$) between June and July, while gulls at Old Man Lake consumed fewer mammals and more birds during July ($X^2=16.3$, df=4; $p<0.05$). The Mason River gulls shifted ($X^2=34.5$, df=5; $p<0.05$) from a mammal-dominated diet to one consisting mainly of birds and isopods. At Anderson River, the gulls switched their diet ($X^2=34.5$, df=5; $p<0.05$) from mammals in June to isopods in July. At Thumb Island, while maintaining a relatively constant intake of blue mussels (21.9% in June and 19.0% in July), gulls consumed fewer mammals and more fish ($X^2=19.3$, df=5; $p<0.05$). At Garry Island the opposite occurred, more

mammals and fewer fish (X^2=19.7, df=4; $p<0.05$), while at Escape Reef the gulls took fewer mammals and more isopods in July than in June (X^2=12.2, df=4; $p<0.05$). At Anderson River, for the combined 2-24 June samplings, the yearly distribution of glaucous gull foods differed (X^2=112.8, df=5; $p<0.05$); gulls consumed fewer isopods in 1974 (2.9%) than in 1973 (38.4%). The 27 June to 4 August combined samples also indicated that the distribution of foods differed (X^2=23.4, df=5; $p<0.05$) between years, although in this period gulls consumed fewer fish in 1974 (18.1%) than in 1973 (33.7%).

Soft Foods and Foraging

Food items that are completely digestible do not show up in gull pellets in representative amounts. One of the six gulls that we collected contained 8 ammocete larvae of the arctic lamprey (*Lampetra japonica*) from the muddy shallows of the Anderson River delta. We subsequently counted 55 ammocete larvae in the top 12 cm of a square meter of exposed tidal mudflat excavated in 1974. Ammocete larvae are available and are consumed by glaucous gulls, but their remains were not detected in sampled pellets.

Similarly, the soft-boned downy young of waterfowl did not leave a record in the gull pellets; for example, by the time we recovered a gull we shot shortly after it had swallowed a four-day-old brant, the head of the gosling was almost completely dissolved in the gullet although the down of the rump was still dry.

Prior to ice breakup at Anderson River, glaucous gulls (both marked and unmarked) centered their feeding and foraging on the expanding areas of bare ground to feed on over-wintered berries and scavenging for items that did not survive the winter.

Following the spring breakup flood at Anderson River, the gulls extended their foraging to the newly exposed mudflats and along the edge of the sea ice to the north of the colony. The color-marked gulls regularly foraged 10-16 km away as the ice edge moved north.

In June, concurrent with goose nesting, gulls foraged over the goose grounds and surrounding habitats. Their feeding patterns varied with the weather and the tide. Periods of overcast and rain were accompanied by strong northwest winds, which the gulls would ride while hunting over the willow habitats surrounding the goose colony and along the windward shores of the river. Protracted periods of northwest winds also brought tidal storm surges, up to 2.4 m above normal high tide (Harper *et al.*, 1988), inundating the tidal mudflats and goose nesting areas for days at a time and shifting the gulls' foraging to the flooded habitats. Protracted periods of south to southeast winds pushed the water out of the delta and enlarged the extensive mudflats, attracting many gulls from the colony.

Through the month of July, after the goose hatch, gulls fed on young snow geese and brant scattered in family groups across the delta. During this period gulls also spent much time feeding on shoaling fish in the offshore shallows.

At Anderson River glaucous gulls captured small rodents when flying low over beaches and tracts of scrub willow. On one occasion we observed five gulls feeding on rodents forced to higher ground by a storm surge in late July.

While gulls actively hunted smaller rodents, they scavenged remains from larger animals killed or washed downstream. In 1974, glaucous gulls, in association with common ravens (*Corvus corax*) and golden eagles (*Aquila chrysaetos*), quickly consumed a caribou (*Rangifer tarandus*) carcass washed onto a beach.

In July and August 1974, up to 75% of the gulls from Anderson River (identified by color-marked gulls) fished on shoaling Pacific herring and arctic cisco 5-10 km offshore. Throughout the Beaufort Sea, glaucous gulls regularly fed in flocks of 200-300 individuals swimming close together or hovering low over the water up to 5 km offshore. Often the gulls stole prey from red-throated loons (*Gavia stellata*) and large flocks of molting red-breasted mergansers (*Mergus serrator*). On other occasions, gulls fed over small pods of feeding white whales (*Delphinapterus leucas*), bearded seals (*Erignathus barbatus nauticus*), and ringed seals (*Phoca hispida*).

We noted, as did Barry (1967) and Strang (1976), that glaucous gulls usually consumed goose eggs at the goose nest, but when pressed by the geese, other gulls, or parasitic jaegers (*Stercorarius parasiticus*), they attempted to fly off with the egg, which they frequently dropped. We did not observe gulls preying on goose eggs at the gull colony but regularly saw the gulls stealing down from their nests. We did not see glaucous gulls predating each other's eggs but did find plundered gull nests and broken eggs on the surrounding mudflats, although this could be predation by parasitic jaegers (Martin and Barry, 1978).

In late June and early July, glaucous gulls preyed heavily on newly hatched snow geese and Pacific brant, diving on stragglers and swallowing the smaller goslings whole. Characteristic of their rapid attack, we observed one gull capture and swallow three young snow geese in three successive aerial attacks during a 15 s interval. During 100 hr of observation we recorded 28 occasions where glaucous gulls captured one to four young snow geese from broods. Between hatching and fledging, based on eight years of clutch size and banding data, snow goose production at Anderson River declined from 3.79 eggs/pair to 3.35 young/pair (Barry *et al.*, 1985). We estimate that 10% of this loss is due to gull predation.

Gulls usually attacked older goslings in the water, diving at and pecking the young goose on the head and back, forcing it to dive until the gosling was exhausted. The successful gull then spent much time defending its prey from others.

Glaucous gulls hunted isopods during low tide by wading in shallow brackish waters along tidal mudflats and low sand islands.

Incubating gulls at Anderson River captured, with considerable persistence, flies attracted to regurgitated pellets and heat emanating from the nest. We observed eight glaucous gulls among a flock of 75 long-tailed jaegers (*Stercorarius longicaudus*) feeding on emerging soldier flies (*Stratiomyidae*) on a sphagnum-carex marsh at Anderson River in 1974.

DISCUSSION

We found that the glaucous gull is an opportunistic feeder, maintaining a diverse diet throughout the breeding season. At most colonies their principal foods included small rodents, fish, eggs and young of geese, ducks, and gulls, isopods, berries, grass, and blue mussels. The gulls used these

foods in varying proportions depending on availability or preference, both of which are dependent on the colony, time of year, the season, and large-scale weather patterns. The glaucous gulls at Anderson River obtain their foods through a combination of active hunting, scavenging, and stealing, extending to areas 16 km from the colony. The choice of foraging patterns and methods was often determined by the state of the local weather and tides. In western Alaska, Strang (1976) found a similar menu for gulls nesting in the Yukon-Kuskokwim River delta. These gulls also altered their food sources between the spring and summer periods in response to food availability. Although these studies indicate that the glaucous gulls are generalist feeders, there may be individuals within a colony that are specialists, as Pierotti and Annett (1987) found with herring (*Larus argentatus*) and western (*Larus occidentalis*) gulls.

At many of our sampled colonies mammals were an important food source in the spring and less so by late July, a shift that was coincident with increased use of fish, birds, and isopods and was a pattern also exhibited by the Yukon-Kuskokwim delta gulls. The diversity of foods consumed by the Beaufort Sea gulls did not change between our spring and summer samplings. With data interpolated from Strang's (1976) graphs, the approximate diversity of foods consumed at his colonies was less than that in this study and diversity at his inland colony decreased after the gull hatch, when gulls concentrated on fish and birds.

While glaucous gulls at Anderson River used food sources differently between 1973 and 1974, Strang (1976) found no marked differences at a colony sampled in 1972 and 1973. Undoubtedly the weather extremes that occurred along the Beaufort Sea in 1974 contributed to our statistically significant difference.

In both this study and that of Strang (1976) small rodents of several species were important to the gulls. Johnson and Richardson (1981) reported no mammal remains in the 27 glaucous gull stomachs collected between mid-July and September 1977. Strang (1976) felt that meltwater flooding during the spring thaw was responsible for exposing rodents to gull predation. At Anderson River, this flooding certainly had an effect on rodent habitats. We were surprised to detect *M. pennsylvanicus*, a taiga species, in many pellets at some of the gull colonies outside the normal range of this vole (Banfield, 1974).

Our Beaufort Sea glaucous gulls consumed a variety of fish species, depending on the time of year and ice conditions; generally fish consumption increased later in the season, as the sea ice cleared and the fish were running. In western Alaska, Strang (1976) found that the gulls used primarily one species of fish (*Eleginus gracilis*; "tomcod") and that fish consumption also increased during the summer. The gulls captured many fish at Anderson River and in Alaska (Strang, 1976) by feeding on shoaling and running fish offshore. At Anderson River gulls also stole prey from other species of fish- eating birds and mammals feeding offshore and in river estuaries. Trapp (1979) describes this behavior for glaucous-winged gulls (*Larus glaucescens*), which mobbed horned puffins (*Fratercula corniculata*) and tufted puffins (*Lunda cirrhata*) in the Aleutian Islands.

Gulls took birds in the form of eggs and young at all colonies that we sampled but more so at colonies where larger numbers of waterfowl nested. Although glaucous gulls took many eggs in the Anderson River delta goose colony, parasitic jaegers, which regularly hunted the goose grounds and the gull colony, or the occasional forays by grizzly bears (*Ursus horribilis*) made more substantial impacts. In 1986, grizzly bears destroyed some 2500 nests (10 000 eggs) of snow geese and brant, as well as other waterfowl and glaucous gulls during a ten-day period. While glaucous gulls are not the major predator on waterfowl eggs, they are a significant predator of young geese and ducks up to about four weeks of age; we estimate that gull predation at Anderson River accounts for approximately 10% of the decline in brood size from hatching to fledging. Environmental conditions that resulted in young geese straying from the flock or family group and being exposed to predation were wind and storm surges. The intrusion of large mammals, eagles, aircraft, boats, and humans contributed to disturbance and substantially increased predation (Barry, 1967; Martin and Barry, 1978).

Most of the glaucous gulls nesting in the Beaufort Sea region are not associated with waterfowl concentrations and therefore relied on other food sources.

Strang's (1976) study area was situated, as the Anderson River colony was, in or near goose and waterfowl breeding grounds. At his coastal colony, prior to the gull hatch, egg shell remains appeared in the pellets and stomachs at about three times the rate of feathers and at an inland colony at two-thirds the rate.

Although we rarely saw glaucous gulls eating each other's young, their disappearance coincided with a whitish down appearing in pellets. Ferguson-Lees (1963) reports that glaucous gulls regularly ate chicks of their own kind. Cannibalism also occurs with ivory gulls (*Pagophila eburnea*), which readily destroy their young under even slight disturbances (S.D. Macdonald, pers. comm. 1975). Human presence also caused chick cannibalism with glaucous-winged gulls (Gillett *et al.*, 1975; Murphy *et al.*, 1984) and with ring-billed gulls (*Larus delawarensis*) (Fetterolf, 1983). Haycock and Threlfall (1975) report that predation by great black-backed gulls (*Larus marinus*) and herring gulls occurs on the eggs of their conspecifics within the colony.

Isopods and other marine invertebrates occurred in glaucous gull pellets and stomachs collected in the Yukon-Kuskokwim delta, but they were not considered a dominant food (Strang, 1976). At Simpson Lagoon in 1977 isopods constituted 33% of the volume of 27 stomachs, and as a group marine invertebrates occupied 66% (Johnson and Richardson, 1981). Johnson and Richardson (1981) found that bivalves formed 0.5% of the volume of their stomach samples from Simpson Lagoon, while Strang (1976) found no evidence of bivalves in his samples from the Yukon-Kuskokwim delta. With glaucous-winged gulls near Seward, Alaska, blue mussels were the predominant food in the absence of fishes and other preferred items (Murphy *et al.*, 1984). We were unable to locate the source of mussels at Thumb Island, but presumably they were exposed by tide or ice push.

Although grasses and sedges may have food value for gulls, they also serve to bind indigestible materials into pellets. These materials may be inadvertently consumed with other food items (Strang, 1976; Martin and Barry, 1978; Trapp, 1979).

Trapp (1979) also noted "fly-catching" activities by glaucous-winged gulls on *Diptera* that were attracted to decomposing kelp and sea lion offal scattered on Aleutian island beaches. We found that incubating gulls at Anderson River actively pursued insects attracted by heat and regurgitated pellets around the nests.

In Strang's (1976) study on the Yukon-Kuskokwim delta, vegetation was present in 10-46% of the food items taken by glaucous gulls throughout the year; this included a marine brown algae (*Fucus* sp.) and various berries. Johnson and Richardson (1981) reported no vegetation in the 27 glaucous gull stomachs that they sampled at Simpson Lagoon in 1977.

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