THE FEEDING ECOLOGY AND BEHAVIOR OF BREEDING ICELAND GULLS *LARUS GLAUCOIDES KUMLIENI* AND COMPARISONS WITH SYMPATRIC LARGE *LARUS* GULLS ON SOUTHWESTERN BAFFIN ISLAND, CANADA

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ABSTRACT

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The feeding ecology and behavior of breeding Iceland Gulls *Larus glaucoides kumlieni* and, to a lesser extent, American Herring Gulls *Larus smithsonianus* and Glaucous Gulls *Larus hyperboreus*, were studied at a large Iceland Gull colony located near Kinngait, Baffin Island, Canada. Iceland Gulls collected food close to the colony, mainly at ebbing and low tides, on or very close to the shoreline, and in adjacent nearshore waters. The most common feeding technique was picking on the water surface while swimming. Additional techniques included plunging to capture food items at greater depths and kleptoparasitism. Known food items included marine invertebrates and small fish. American Herring and Glaucous gulls nested in the study area in substantially lower numbers than Iceland Gulls but used similar feeding habitats and techniques and collected similar food items. The specific feeding techniques used by all three species were typical of many large *Larus* gulls. Sufficient food availability at the time of the study may explain some of the observed similarities in feeding habitat use and behavior. An important component of broad niche separation for Iceland Gulls in areas of sympatry may be sea-cliff nesting and concentrated use of coastal marine habitats for feeding, including shorelines and nearshore areas. In addition, other studies have shown that American Herring and Glaucous gulls use more inland and terrestrial habitats, use more diverse foods, and employ different feeding behaviors, including more predation and scavenging. Additional studies in selected areas are needed to fully address the questions raised in this study.

Key words: Iceland Gull, American Herring Gull, Glaucous Gull, *Larus*, feeding ecology, Arctic

INTRODUCTION

The Iceland Gull *Larus glaucoides* is an Arctic-breeding species of large *Larus* gull. It has been the subject of significant work and discussion with regard to systematics and taxonomy, particularly with respect to relationships between the "Kumlien's Gull" *L. g. kumlieni* and "Thayer's Gull" *L. g. thayeri* (e.g., Macpherson 1961, Smith 1966, Sutton 1968, Gaston & Decker 1985, Snell 1989). Richards & Gaston (2018) estimated that the Iceland Gull breeding population (including *kumlieni* and *thayeri*) in Nunavut, Canada ranged from 50 000 to 100 000 individuals. Brown *et al.* (1975), Gaston *et al.* (1986), Gaston *et al.* (2007), and Gaston *et al.* (2012) presented significant data on the locations and characteristics of breeding colonies of various seabirds, including large *Larus* gulls, on Baffin Island and in other areas of the Canadian Arctic.

However, substantially less information is available on the ecology and behavior of Iceland Gulls (including *kumlieni*, *thayeri*, and nominate *glaucoides*) breeding in the Canadian Arctic and in Greenland. Most of the available information is based on general observations made during the completion of other work in the breeding period or more intensive work completed in the winter. Gaston *et al.* (1985) described food use and feeding behavior of breeding *kumlieni* in the area of Digges Sound, Nunavut. Gaston *et al.* (2007) characterized the feeding behavior of breeding *thayeri* in the Lyon Inlet area of the Melville Peninsula, Nunavut. Salomonsen (1951) described breeding Iceland Gulls in Greenland (nominate *glaucoides*) as primarily feeding on fish caught from the ocean surface (sometimes by plunging) and noted birds scavenging carrion and foraging for berries in the fall. Nicholson (1930) observed plunging and dipping by breeding Iceland Gulls in Greenland, but noted that kleptoparasitism by Iceland Gulls was uncommon, especially compared to the Glaucous Gull *L. hyberboreus*.

Smith (1966) suggested that Iceland and Glaucous gulls breeding on eastern Baffin Island in 1961 fed on marine amphipods, mysids, and euphausiids in waters near the colonies. However, Smith (1966) also reported that in 1960 on Southampton Island, Nunavut, breeding Iceland (*thayeri*), American Herring *L. smithsonianus*, and Glaucous gulls fed exclusively on lemmings *Dicrostonyx* spp., which were abundant at the time.

Macpherson (1961) observed *thayeri* feeding on garbage at a radar station at Kugaaruk, Nunavut, in early June prior to major spring break-up of sea ice, and Parmalee & MacDonald (1960) reported that *thayeri* also fed on garbage on Ellesmere Island. Macpherson (1961) also observed Iceland (*kumlieni*) and American Herring gulls feeding near the floe-edge of the sea ice at Kinngait in mid-May 1955 and described Glaucous Gull presence at Inuit fish weirs near Kugaaruk in 1956. Richards & Gaston (2018) noted that Iceland (*kumlieni* and *thayeri*) and Glaucous gulls fed on polar bear *Ursus maritimus* kills in certain areas.

Ingolfsson (1967) completed an extensive study of wintering Iceland Gulls (nominate *glaucoides*) in Iceland and reported that this population typically used flying and swimming to locate food, then used surface picking and dipping to collect small food items, including fish, polychaetes (pelagic stage), immature dipterids, and

other invertebrates from the ocean surface in nearshore locations. Shoreline and intertidal habitats were used to a lesser extent. Food selection varied with temporal and geographical changes in food abundance, and nomadic movements based on food availability were also recorded. Ingolfsson (1967) considered this species to be a specialized and agile ocean-surface feeder, with a relatively longer tail and wing and a significantly shorter and narrower bill than the other wintering species in Iceland, including the Great Black-backed *L. marinus*, Glaucous, European Herring *L. argentatus*, and Lesser Black-backed *L. fuscus* gulls. Ingolfsson (1969) reported that wintering Iceland Gulls in Iceland did not take food from wintering Common Eiders *Somateria mollissima* or other diving birds. Gutowsky *et al.* (2020) evaluated broad-scale habitat use by wintering *thayeri* on the Pacific coast of North America.

However, none of these studies specifically focused on the feeding ecology and behavior of Iceland Gulls in the breeding period in the Arctic.

Goals of this study

The primary objective of my study was to describe the feeding ecology and behavior of Iceland Gulls (*kumlieni*) breeding at a large cliff colony located near Kinngait (Cape Dorset) on Baffin Island in Nunavut, Canada. The Iceland Gulls observed were typical adult *kumlieni*, with light gray mantles, variable amounts of gray or slate gray on outer primaries, and variable amounts of dark iris speckling. No adult *thayeri* were observed. Data were also collected for the other large *Larus* gulls that breed in the study area, including the American Herring and Glaucous gulls, which occurred in the study area in substantially lower numbers than the Iceland Gull. A secondary objective of my study was to compare the feeding ecology and behavior of Iceland Gulls with that of American Herring and Glaucous gulls.

METHODS

Study area

Observations were completed mainly from one point ("observation point") located near a basecamp established on the western side of West Inlet, a large tidal inlet extending north from Hudson Strait to a group of bays (Fig. 1). The observation point was located approximately 7.5 km west of Kinngait (64°14′15″N, 076°42′03″W) and approximately 1300 m west-southwest (on the shore directly across) from the Malitjuak cliff-nesting colony of Iceland and Glaucous gulls on Mallik Island (64°14′30″N, 076°40′34″W; Fig. 1). This colony was studied in 1955 by Macpherson (1961) and in 1959 by Smith (1966). The Malitjuak colony is one of the largest colonies located on the southern coast of the Foxe Peninsula (Macpherson 1961), and it consisted of approximately 80 pairs of Iceland Gulls and five pairs of Glaucous Gulls at the time of this study; birds were observed nesting on a large, west-facing cliff above West Inlet. The observation point was at an elevation of approximately 10 m, on a small point of land that offered an unobstructed view of the nesting colony, inlet, and adjacent bays.

Supplementary observations of feeding Iceland, American Herring, and Glaucous gulls were completed in four additional areas, including (1) in the bays adjacent to Kinngait, (2) at a second colony (Sangasuk) in the study area, (3) along the coast between Kinngait and Pudla Inlet, and (4) at a third colony in Pudla Inlet (Fig. 1). The Sangasuk colony was also identified by Macpherson (1961) and Smith (1966), and it is located on a south-facing cliff above a tidal channel, 5.7 km south of the observation point (64°11′28″N, 076°38′60″W). This

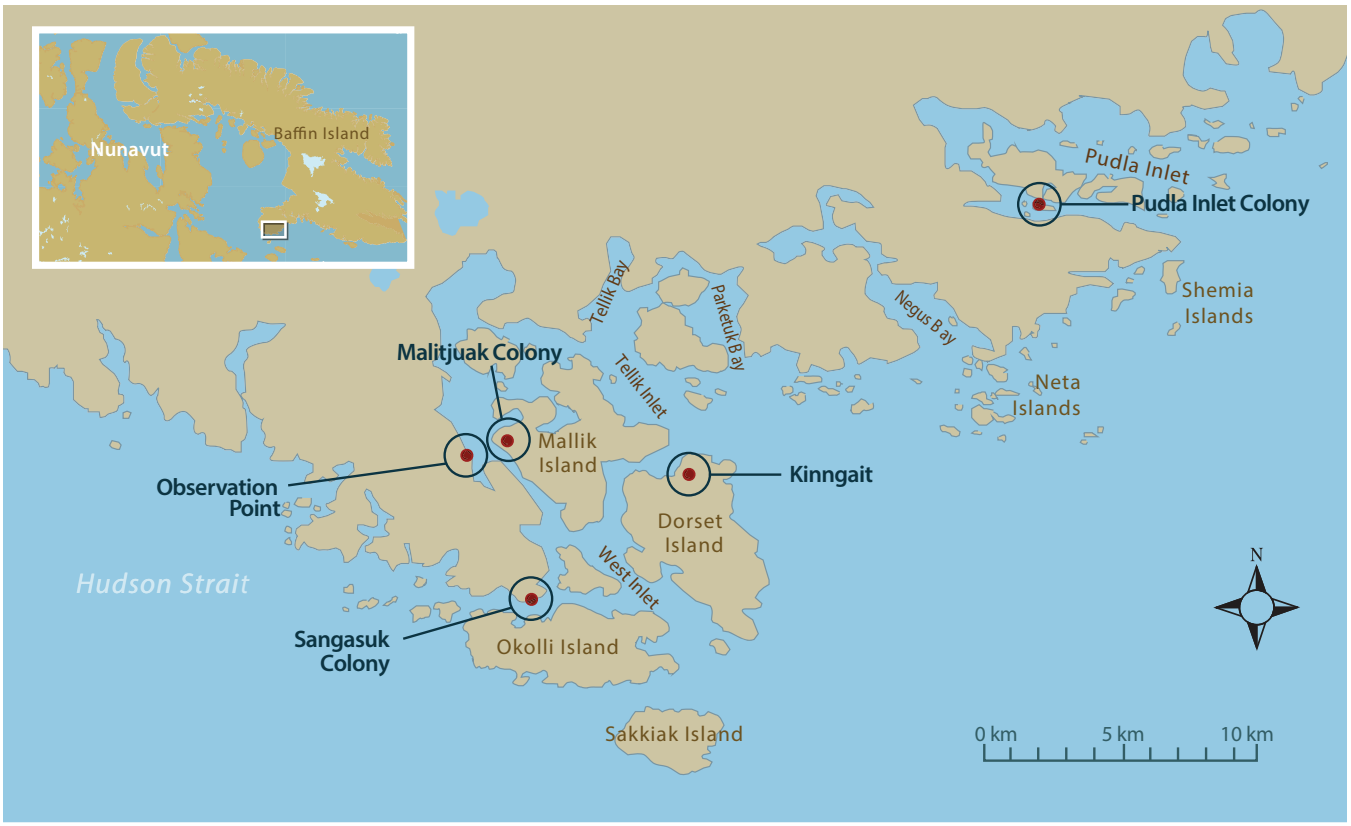

Fig. 1. Map of the study area showing the observation point and the gull colonies at Malitjuak, Sangasuk, and Pudla Inlet.

colony included approximately 90 pairs of Iceland Gulls and 10 pairs of Glaucous Gulls. Sangasuk is also one of the largest Iceland Gull colonies on the southern coast of Foxe Peninsula.

Pudla Inlet includes a group of bays and channels located northeast of Kinngait. The Pudla Inlet colony is 23 km northeast of the observation point (64°19′15″N, 076°16′15″W) and was also identified by Macpherson (1961) and Smith (1966). This colony consisted of approximately 40 pairs of Iceland Gulls and 10 pairs of Glaucous Gulls nesting on a relatively small south-facing cliff on a small island in a narrow portion of a bay. Glaucous Gulls also nested in two small groups of three to five pairs on other coastal cliffs along West Inlet, and five individual pairs of American Herring Gulls nested on small islands and rocks in lakes and ponds near the observation point. The Malitjuak North colony, described by Macpherson (1961) as including eight pairs of Glaucous Gulls and six pairs of Iceland Gulls in 1955 on a small cliff about 3 km north of the Malitjuak colony, was not active at the time of my study.

Observations

Observations of all three species were made between 25 July and 18 August 1984 from the observation point using binoculars and a spotting telescope. Data collection at the observation point covered a total of 88.0 hours over 16 days, including 43.5 hours during low tide (in 14 periods) and 44.5 hours during high tide (in 15 periods; Table 1). All observations were completed between 08h00 and 21h00. On most days, time was evenly split between low and high tides, with an average of approximately three hours per tide period, centered on peak low tide or peak high tide. Each tide period also included both ebbs and floods. Total daily coverage times averaged about six hours. Observations were continuous in each period and included active visual searches for feeding gulls. Gulls were counted only if they were adults and were obviously feeding. Preliminary observations were completed on 22 and 23 July in the Kinngait area. Supplementary observations were completed on three additional days at the Sangasuk and Pudla Inlet colonies and on seven additional days in the combined area of the Malitjuak colony, West Inlet, the bays located at the north end of West Inlet, and Kinngait. These supplementary observations included marine and other habitats (terrestrial areas, lakes, ponds, streams, and developed areas at Kinngait). Travel between locations was mainly conducted by freighter canoe. Areas of land were covered on foot, along with lakes, ponds, and streams from shoreline locations.

TABLE 1
Summary of data collection at the observation point

	Hours of observation		
Date (1984)	**Low tide**	**High tide**	**Total**
25 July	5	0	5
26 July	2.5	3.5	6
27 July	4	4	8
28 July	4	4	8
02 August	2	2	4
03 August	0	2	2
04 August	3	3	6
05 August	3	3	6
06 August	3	3	6
07 August	3	3	6
08 August	3	3	6
10 August	3	3	6
13 August	0	1	1
15 August	2	2	4
16 August	3	4	7
18 August	3	4	7
Total hours	43.5	44.5	88
Total observation periods	14	15	29
Total days of observations			16

Each observation of a feeding gull, including single individuals and individuals in small groups, was categorized with respect to habitat use and feeding behavior; known individuals were counted only once. The habitat type used most extensively by each gull was recorded and used in the analysis. Habitat type categories included shoreline (the waterline, and intertidal flats and water within 15 m of the waterline), nearshore (16–300 m from the waterline), inshore (301–600 m from the waterline), and open bay (more than 600 m from the waterline). The "waterline" is defined as the actual waterline at the time of the observations, taking tide conditions into account. Intertidal flats were also covered in the observations, and included areas of mud, sand, gravel, and rock located between the shorelines at high and low tide. Distance estimates were regularly checked against known distances to selected key locations.

I assessed three different overall categories of feeding behavior, along with subcategories or "specific" feeding techniques based on Burger (1988) and Ashmole (1971). The first category was flying, with the subcategories or specific techniques of general flying (with no other behaviors), kleptoparasitism, plunging (head and neck in water), and dipping (a shallow dive with only the bill in water). The second category was swimming, with the subcategories of general swimming (with no other behaviors) and surface picking (only bill in water). The swimming with surface picking technique sometimes included thrusting of the head and neck into the water. The third category was standing, with the subcategories of general standing (with no other behaviors), surface picking, and surface picking with foot stirring. If flying led to swimming or standing, the subsequent behavior was recorded and used in the analysis. If an individual used both swimming and standing, the behavior that was exhibited most extensively was recorded. If a general feeding behavior (e.g., flying) led to using a specific related technique (e.g., plunging), the specific technique was recorded. If more than one specific technique was used by an individual (e.g., general swimming and swimming with surface picking), the technique employed most extensively was recorded.

Primary data on habitat use and feeding behavior were recorded on formal data sheets in the field, along with detailed field notes.

RESULTS

Numbers of feeding gulls recorded as related to tidal conditions

Iceland Gull

A total of 1507 adult Iceland Gulls were recorded feeding during data collection at the West Inlet observation point, including 1233

at low tides (82% of the total, mean per count = 88, range = 22–256) and 274 at high tides (18%, mean per count = 18, range = 5–49; Table 2). The number of gulls recorded per count at low tides was significantly higher than at high tides (Mann-Whitney U-test, two-tailed, $U = 7.5$, z-score = –4.23, $P < 0.00001$, $n = 14$ for low tide counts and 15 for high tide counts). At high tides, many Iceland Gulls were involved in three main activities unrelated to feeding: caring for chicks at the cliff colony, bathing in West Inlet below the colony cliff, and resting and preening at a loafing club on a talus slope at the bottom of the cliff. Most Iceland Gulls recorded feeding at low and high tides were observed individually or in small groups of 2–5 individuals, with a maximum of 30 individuals. Observations indicated that most feeding occurred within approximately 5–7 km of each of the three colonies.

American Herring and Glaucous gulls

Substantially lower numbers of American Herring ($n = 177$) and Glaucous ($n = 117$) gulls were observed, although the percentages recorded in each tide period were similar to those for the Iceland Gull (Table 2). For the American Herring Gull, 67% were observed during low tides and 33% were observed during high tides; for the Glaucous Gull, the numbers were 83% and 17%, respectively.

Feeding habitat use

Iceland Gull

At low tides, most Iceland Gulls (85%) fed in shoreline habitats, primarily within 3 m of the waterline (Table 2). The shoreline near the observation point was located at the edge of a large intertidal flat at low tide. It was level and composed of mud, sand, and gravel interspersed with small- to medium-sized rocks and small pools of water. Fewer gulls were recorded in nearshore, inshore, and open bay habitat types; most of these (12%) were in nearshore areas. Broad intertidal flats were not significantly used for feeding. The number of gulls recorded per count at low tides varied significantly among the habitat types (Kruskall-Wallis test, $H = 41.6376$, $P < 0.00001$, $n = 56$). At high tides, most individuals (53%) were observed feeding in shoreline habitats within 3 m of the waterline (Table 2), followed by 32% in nearshore areas, and the remainder in inshore and open bay habitats. The number of gulls recorded per count at high tides also varied significantly among the habitat types (Kruskall-Wallis test, $H = 17.1317$, $P = 0.0007$, $n = 60$).

An additional 102 Iceland Gulls recorded feeding during preliminary observations in the bays adjacent to Kinngait showed similar patterns of habitat use at low and high tides as recorded at the observation point. Only a few adult Iceland Gulls were observed in open-water areas in Hudson Strait between Kinngait and Pudla Inlet; these were noted during boat travel on one day during both low and high tides. In addition, no significant movements of Iceland Gulls between any of the three colonies and potential open-water feeding areas located in Hudson Strait were recorded, although no detailed observations were completed in Hudson Strait. Also, no feeding Iceland Gulls were observed at lakes, ponds, streams, terrestrial habitats, developed areas at Kinngait, or other non-marine habitat types at low or high tides.

American Herring and Glaucous gulls

Similar results were obtained for the American Herring and Glaucous gulls (Table 2). For the American Herring Gull, most individuals observed during low tides were in shoreline habitats (93%), with substantially lower numbers in nearshore areas (7%); none were observed in inshore or open bay habitats. At high tides,

TABLE 2
Feeding habitat use by Iceland *Larus glaucoides*, American Herring *L. smithsonianus*, and Glaucous *L. hyperboreus* gulls at low and high tides

	Iceland Gull		American Herring Gull		Glaucous Gull	
Feeding habitat type[a]	**Number of birds recorded**	**% of total**	**Number of birds recorded**	**% of total**	**Number of birds recorded**	**% of total**
			Low tide ($n = 14$ counts)			
Shoreline	1052	85.3	111	93.3	94	96.9
Nearshore	142	11.6	8	6.7	0	0.0
Inshore	35	2.8	0	0.0	3	3.1
Open bay	4	0.3	0	0.0	0	0.0
Total	1233	100	119	100	97	100
			High tide ($n = 15$ counts)			
Shoreline	144	52.6	24	41.4	6	30.0
Nearshore	87	31.8	32	55.2	12	60.0
Inshore	30	10.9	2	3.4	2	10.0
Open bay	13	4.7	0	0.0	0	0.0
Total	274	100	58	100	20	100
Grand total	**1507**		**177**		**117**	

[a] Shoreline = area within 15 m of the waterline; Nearshore = area within 16–300 m of the waterline; Inshore = area within 301–600 m of the waterline; Open bay = area over 600 m from the waterline

most American Herring Gulls (55%) were recorded in nearshore waters, with lower numbers along the shoreline (41%).

At low tides, nearly all Glaucous Gulls (97%) were observed along the shoreline; at high tides, most were counted in nearshore waters (60%), with fewer along the shoreline (30%). All three species were recorded in lower proportions along the shoreline and in higher proportions in nearshore areas at high tides as compared to low tides, particularly American Herring and Glaucous gulls. Like the Iceland Gull, no American Herring or Glaucous gulls were observed feeding in habitats other than marine areas, and none were observed in open-water areas between Kinngait and Pudla Inlet.

TABLE 3
Feeding behavior of Iceland *Larus glaucoides*, American Herring *L. smithsonianus*, and Glaucous *L. hyperboreus* gulls at low and high tides

	Iceland Gull		American Herring Gull		Glaucous Gull	
Feeding behavior category	**Number of birds recorded**	**% of total**	**Number of birds recorded**	**% of total**	**Number of birds recorded**	**% of total**
			Low tide (*n* = 14 counts)			
Flying						
General flying	763		59		84	
Kleptoparasitism	23		0		0	
Plunging	21		1		2	
Dipping	0		0		0	
Subtotal	807	65.5	60	50.4	86	88.7
Swimming						
Surface picking	329		32		6	
General swimming	4		2		0	
Subtotal	333	27.0	34	28.6	6	6.2
Standing						
Surface picking	87		23		0	
Surface picking with foot stirring	4		0		1	
General standing	2		2		4	
Subtotal	93	7.5	25	21.0	5	5.1
Total	1233	100	119	100	97	100
			High tide (*n* = 15 counts)			
Flying						
General flying	97		25		12	
Kleptoparasitism	8		0		1	
Plunging	2		2		0	
Dipping	1		0		0	
Subtotal	108	39.4	27	46.6	13	65.0
Swimming						
Surface picking	164		30		7	
General swimming	1		0		0	
Subtotal	165	60.2	30	51.7	7	35.0
Standing						
Surface picking	0		1		0	
Surface picking with foot stirring	0		0		0	
General standing	1		0		0	
Subtotal	1	0.4	1	1.7	0	0.0
Total	274	100	58	100	20	100
Grand total	**1507**		**177**		**117**	

Feeding behavior

Iceland Gull

At low tides, most Iceland Gulls (66%) were observed flying and searching for food (Table 3). The typical pattern was for individuals to fly into the wind for long distances along the shoreline. Flying usually led to swimming or standing when food was located. Flight altitudes were in the 1–25 m range. Behaviors in flight also included kleptoparasitism (23 observations) and plunging to capture food in the water (21 observations). Iceland Gulls were observed attempting to take food, mostly small fish, from Black Guillemots *Cepphus grylle*, Red-throated Loons *Gavia stellata*, and Common Loons *Gavia immer* on the water, but only one of the 23 attempts was successful. Plunging was typically from 1–2 m above the water, often very close to the waterline (within 2 m). Small fish and invertebrates (approximately 3-8 cm long) were captured by plunging. Unsuccessful plunges while flying occasionally led to subsequent jump plunges starting from the water surface.

Individuals were recorded swimming in 27% of observations, and they mainly used the surface picking technique to collect small food items (probably including invertebrates) on or very close to the water surface, mostly within 6 m of the waterline. Thrusting of the head and neck deeper into the water to capture food was also observed. Short flights and swimming were often used to move to new feeding locations on the water. Only 8% of gulls were observed standing during low tides. Nearly all these individuals used the surface picking technique to collect small food items (probably including invertebrates), mostly within 5 m of the waterline. Additional techniques included surface picking with foot stirring on mud and sand substrates (four observations) and collecting small food items (probably including invertebrates) in and under clumps of kelp.

At high tides, most individuals (60%) were observed swimming and using the surface picking technique (Table 3). Thrusting the head and neck below the surface to collect food was also common. Most of these birds were within 6 m of the waterline. Most swimming gulls also made short flights to new feeding locations. Flying was the second most common behavior used during high tides (39%) and included searching for food as described for low tides. Kleptoparasitism of the same three species mentioned above (all attempts unsuccessful), plunging, and dipping were also recorded during high tides. An additional feeding technique observed on two occasions during high winds at high tides involved a group of gulls (10–15) flying very low over the water (< 1 m) into the wind within 25 m of the waterline. These birds repeatedly landed on the water and swam for short periods (5–10 s) with wings raised. The surface picking and subsurface thrusting techniques were used to rapidly collect food, probably including marine invertebrates, while swimming. This behavior lasted from 15-20 minutes in each case, and it appeared to be related to the short-term availability of an abundant food source. Foot pattering on the water's surface while flying was also recorded during these observations, similar to the behavior described by Withers (1979) for the Wilson's Storm Petrel *Oceanites oceanicus*, although food collection by the gulls was done only while swimming.

The Iceland Gulls recorded in preliminary observations in the bays adjacent to Kinngait showed feeding behaviors at low and high tides like those recorded at the observation point.

American Herring and Glaucous gulls

American Herring and Glaucous gulls used feeding techniques like those used by Iceland Gulls (Table 3). At low tides, most American Herring Gulls (50%) were observed flying, with fewer using the surface picking technique while either swimming (29%) or standing (21%). American Herring Gulls and one Glaucous Gull also used foot pattering on the water surface while flying in high winds. This behavior was observed only when they were in groups of Iceland Gulls using the same technique. During high tides, 52% of American Herring Gulls were observed swimming and using the surface picking technique, and slightly fewer (47%) were flying. American Herring Gulls also used plunging. Food items included small fish (approximately 5–10 cm long) and other small food items (probably invertebrates) collected in and under kelp on the shoreline. At low tides, most Glaucous Gulls (89%) were observed flying. During high tides, most were also flying (65%) with fewer swimming and using the surface picking technique (35%). Glaucous Gulls also used plunging, kleptoparasitism of Black Guillemots, and standing using the surface picking with foot stirring technique. Identified food items included small organisms (probably invertebrates) and small fish (approximately 8–10 cm long). In all observed behavioral interactions, both Glaucous and American Herring gulls dominated Iceland Gulls by chasing them from specific feeding locations while swimming or standing.

DISCUSSION

The specific feeding techniques used by Iceland Gulls observed in this work were very similar to the techniques identified by Burger (1988) for *Larus* and other gulls as a group, including the American Herring, Great Black-backed, Glaucous-winged *L. glaucescens*, Western L. *occidentalis*, Ring-billed *L. delewarensis*, California *L. californicus*, and 10 additional gull species. The most common techniques used by these 16 gull species, in decreasing order of frequency, were picking up (from the ground), surface dipping (from the water surface while swimming), jump plunging, aerial dipping (from the water surface while flying), surface plunging, digging, pirating, and foot paddling (Burger 1988). Iceland Gulls in the current study used seven of these eight techniques. The technique of foot pattering on the water surface while flying in high winds to locate food, as recorded in this study, was not described by Burger (1988), but is similar to behavior described by Camphuysen & Webb (1999) for small gulls in the North Sea such as the Little Gull *Hydrocoloeus minutus* and Black-legged Kittiwake *Rissa tridactyla*. This behavior may be possible for larger species only in high winds.

Many of the observations of *kumlieni* made in this study, including concentrated feeding during ebbing and low tides, flying to locate food, surface picking in shallow water and on the shoreline, plunging, foot stirring, and feeding on invertebrates, are very similar to observations of breeding *thayeri* made by Gaston *et al.* (2007) in Lyon Inlet on the Melville Peninsula. Gaston *et al.* (1985) observed that nesting *kumlieni* on Digges Island collected small organisms from the surface of the open ocean while swimming using the surface picking technique and fed to a lesser extent on the eggs and chicks of Thick-billed Murres *Uria lomvia* and on dropped food items in a very large nesting colony. Iceland Gulls did not feed at the village of Ivujivik, Quebec, although discarded food waste from fish, seals, whales, and walruses *Odobenus rosmarus* was available (Gaston *et al.* 1985). Allard *et al.* (2010) reported that breeding *thayeri* fed almost exclusively at sea, away from a breeding colony on St. Helena Island, Nunavut, and mostly fed fish to their chicks. Open-

ocean feeding was not observed in this study, although no detailed observations were completed in the open-ocean habitat type. The ways in which breeding Iceland Gulls use such areas for feeding may be affected by the specific locations and characteristics of different breeding colonies, food availability, and other factors. The specific feeding techniques and food items identified by Gaston *et al.* (1985) and Allard *et al.* (2010) are, however, similar to observations in this study. The Malitjuak colony was not located near any other major seabird colonies, so this food source was not available.

Observations presented here are consistent with Salomonsen's (1951) and Nicholson's (1930) general observations of breeding Iceland Gulls in Greenland feeding on marine fish. They are also consistent with Smith's (1966) observations of Iceland Gulls feeding on marine invertebrates in waters located near breeding colonies in eastern Baffin Island. In addition, the observation of one adult Iceland Gull in this study feeding on a caribou *Rangifer tarandus groenlandicus* carcass on a beach near Kinngait is similar to observations of carrion feeding by nominate *glaucoides* in Greenland (Salomonsen 1951) and observations by Richards & Gaston (2018) of Iceland (*kumlieni* and *thayeri*) and Glaucous gulls feeding on polar bear kills. Iceland Gulls were not recorded feeding on lemmings in this study and no lemmings were observed, in contrast to Smith's (1966) observations of this behavior by *thayeri*, American Herring Gulls, and Glaucous Gulls on Southampton Island in 1960. No feeding on garbage was recorded in this study, in contrast to the observations of Macpherson (1961) and Parmalee & MacDonald (1960). This behavior may be more common prior to spring break-up of sea ice and in other situations where food availability is limited. In addition, many of my results are similar to Ingolfsson's (1967) observations of wintering Iceland Gulls in Iceland, with respect to habitat use, feeding techniques, and food types. Kleptoparasitism by Iceland Gulls of other birds was common in this study, in contrast to the observations of Ingolfsson (1969) in Iceland in the winter and Nicholson (1930) in Greenland in the breeding period. The extent of kleptoparasitism by Iceland Gulls and other species is probably influenced by a variety of factors. Although Glaucous and American Herring gulls were observed to chase Iceland Gulls from specific feeding locations in my study, they were not observed to kleptoparasitize them. Parmalee and MacDonald (1960) reported that Glaucous Gulls may kleptoparasitize *thayeri* near breeding colonies on Ellesmere Island.

The results of this work indicated many similarities in the feeding ecology and behavior of Iceland, American Herring, and Glaucous gulls in the breeding period in an area where they are sympatric. Some of these similarities may have been based on food availability, as indicated by several observations: first, reproductive success at the time of the study appeared to be good, with many broods of two Iceland Gull chicks observed at all three cliff colonies. Gaston *et al.* (1985) reported an average of 1.6 Iceland Gull chicks per brood in the Digges Sound area. The first fledged and flying juvenal Iceland Gull at the Malitjuak colony was observed on 18 August, which is similar to the mid-August fledging dates described by Macpherson (1961) and Richards & Gaston (2018). Second, individuals of all three species were often observed successfully obtaining food, and feeding activity often rapidly declined and ceased before the end of the low tide observation periods. Third, all observations were made when food was needed by both adults and chicks of all three species. These observations, combined with additional information indicating that most required food could be collected at low tide and close to the three colonies, may be evidence that food availability in marine shoreline and nearshore habitats was not limiting, and that it was sufficient to support concentrated use by all three species during this study. It is not known whether this situation is typical of other geographic areas and breeding seasons. Other studies have shown that large *Larus* gulls are opportunistic feeders that show both short-term and long-term changes in feeding behavior, including habitat use and feeding technique, in response to changes in food availability (Hunt & Hunt 1973, Washburn *et al.* 2013). Iceland (*thayeri*), American Herring, and Glaucous gulls feeding exclusively on abundant lemmings on Southampton Island in 1960 (Smith 1966) is probably an example of this type of response. Changes in feeding habitat use by large *Larus* gulls have also been observed at various stages of the breeding period, in response to changes in food abundance and availability, the nutritional needs of adults and chicks, and other factors (Schmutz & Hobson 1998, Washburn *et al.* 2013).

If feeding ecology and behavior are generally similar among these large gulls, how do they maintain sympatry? In areas where all three species co-occur (and where only Iceland and Glaucous gulls co-occur more widely in the Canadian Arctic and Greenland), an important component of broad niche separation in the breeding period may be sea-cliff nesting and concentrated feeding in coastal marine habitats by the Iceland Gull. Predation by Arctic foxes *Vulpes lagopus*, red foxes *V. vulpes*, and polar bears on nesting seabirds, including the eggs and chicks of large *Larus* gulls, in the Arctic is significant (Smith 1966, Gaston *et al.* 2007); this is minimized or avoided by using certain inaccessible cliffs for nesting. Glaucous Gulls are also cliff nesters in the Canadian Arctic and Greenland, but their larger size may preclude the use of the smaller cliff ledges used by Iceland Gulls. In addition, other work suggests that niche separation is probably increased through use of a wider range of inland and terrestrial habitats for nesting and feeding, a wider range of foods, and different feeding behaviors by American Herring and Glaucous gulls (Richards & Gaston 2018). Specific differences in feeding behavior include more predation and scavenging by Glaucous Gulls (Gaston *et al.* 1985, Barry & Barry 1990, Gilchrist & Gaston 1997, Samelius & Alisauskas 1999, Richards & Gaston 2018) and American Herring Gulls (Allard *et al.* 2006, Richards & Gaston 2018).

In coastal marine habitats used by all three species for feeding, as observed in this study, Iceland Gulls may also feed on smaller food items, including smaller invertebrates and fish, than American Herring and Glaucous gulls, based on their relatively small bills (especially nominate *glaucoides* and *kumlieni*). Smith (1966) presented detailed information on bill sizes of Iceland (*kumlieni* and *thayeri*), American Herring, and Glaucous gulls on Baffin Island, on Southampton Island, and in adjacent areas. Ingolfsson (1967) presented detailed information on bill sizes and other morphological characteristics of wintering Iceland Gulls (nominate *glaucoides*) and other large *Larus* gulls in Iceland and suggested this relationship between bill size and prey size. Niche separation among Iceland Gulls and related large *Larus* gull species could also be significant in the winter, as described for Iceland by Ingolfsson (1967).

The Iceland Gull is not listed as a Species at Risk with respect to conservation status by the Committee on Status of Endangered Wildlife in Canada (COSEWIC 2019). Richards & Gaston (2018) described the Nunavut population as stable, but also noted the significant need for more detailed information. Current and expected future warming in the Canadian Arctic (Bush & Lemmen 2019), along with resource extraction, tourism, pollution, commercial fishing bycatch, and other factors (Richards & Gaston 2018), could

adversely affect breeding seabird populations, including large *Larus* gulls. Additional information on the ecology and behavior of these gulls will be helpful in addressing potential impacts and developing appropriate management programs.

Additional studies of the Iceland Gull (all subspecies) and other large Arctic-breeding *Larus* gulls that address feeding ecology and behavior and that cover other geographic areas, habitat types (with a specific focus on use of open-ocean habitats), food availability, specific food use, environmental conditions, seasonality, morphological characteristics, sympatry, and other factors are needed to more fully address the questions raised in this study.

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