begging calls used immediately after hatching would not also be used in the egg.

Behavioral thermoregulation, potentially achieved when calls from a cold embryo or hatched chick elicit enhanced incubation or brooding by the parent has also been suggested (Evans, in press) as a possible function of embryonic calls in white pelicans. Cooling is a potent stimulus eliciting calling by embryos of this species. When a return to warmer conditions is made contingent upon such calling in a laboratory context, the embryos are able to behaviorally thermoregulate against otherwise continuous cold stress for periods of up to at least 5 hr (Evans, in press). The tendency for parents to push the eggs back while shuffling and then resettle over them, as observed in this study, is consistent with this functional interpretation.

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LITTORAL FORAGING BY RED PHALAROPES DURING SPRING IN THE NORTHERN BERING SEA[1]

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Phalaropes demonstrate considerable plasticity in their choice of foraging habitats. The Red Phalarope (*Phalaropus fulicaria*) alternates use of pelagic environments in winter and migration (Taning 1933, Stanford 1953, Briggs et al. 1984) with wet tundra habitats during the breeding season (Kistchinski 1975, Mayfield 1979, Ridley 1980). Foods available and taken in littoral zones of the Arctic Ocean in fall have been identified (Conners and Risebrough 1978, Johnson and Richardson 1980), but otherwise little attention has been devoted to the transition between the marine and terrestrial periods of the Red Phalarope's life history. We report phalarope use of littoral areas during spring in the northern Bering Sea at Kongkok Bay, St. Lawrence Island, Alaska. In addition, we describe phalarope foraging tactics and foods available in the surf zone, emphasizing this form of littoral foraging as an opportunistic and facultative feeding strategy.

STUDY AREA AND METHODS

This study was conducted at Kongkok Bay (63°24'N; 171°49'W) on the southwestern side of St. Lawrence Island (Fig. 1). The island here contains the southern end of the Poovoot Range, an area of primarily rocky

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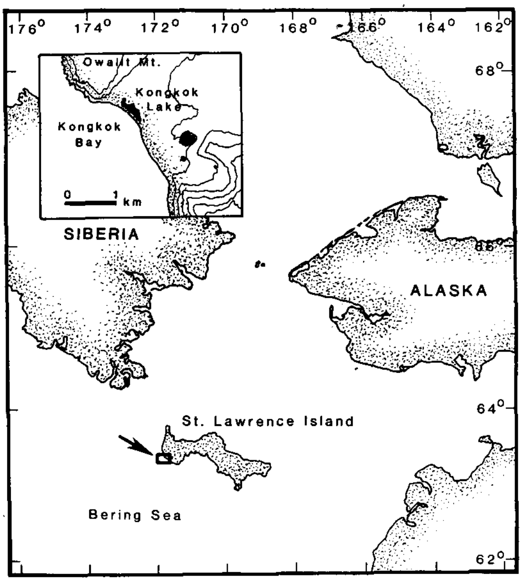

FIGURE 1. Location of Kongkok Bay study area, St. Lawrence Island, in the northern Bering Sea, Alaska.

upland tundra. South and east of Owalit Mountain is a valley with wetter tundra and several lakes fed by snow meltoff streams. Predominant vegetation is composed of lichens, grasses, and several species of forbs (Young 1971). Because Kongkok Bay faces southwest, the direction of prevailing winds during summer and fall, the bay's littoral zone consists of steep rock cobble beach without sand or gravel bars. During the study, temperatures were generally near freezing, but daytime temperatures occasionally rose to 9°C and overnight lows went to −5°C.

Kongkok Bay was searched for arriving seabirds between 25 May and 15 June 1987, and numbers were counted during daily 1-hr sea watches. Phalaropes in the bay were counted at least once daily between 10 and 14 June. On 11 and 12 June, a flock of 149 phalaropes was watched to determine the types, rates, and time allocation of four foraging tactics used in the littoral zone: simple surface picking, spinning prior to picking, head dunking, and vertical bobbing. Surface picking consisted of attempts to seize food when only the bill touched the ocean surface. Spinning consisted of at least one 360° rotation prior to seizing. Complete or partial submergence of the head and neck with the body remaining horizontal relative to the ocean surface was termed dunking. Vertical bobs were recorded if phalaropes completely submerged head and neck while the body upended vertically like a dabbling duck (see also Cramp 1983).

Twenty-five phalaropes out of 149 were randomly selected with replacement, i.e., each phalarope had an equal chance of being chosen at any draw (Snedecor and Cochran 1980). Phalaropes were evenly distributed within and swam throughout an area approximately 100 m long by 5 m wide. Every 6 min, the first phalarope to swim directly perpendicular to the observer's arbitrary but consistent location along the beach was followed for 5 min, and the number of feeding attempts within each of the above-mentioned categories was recorded. Although some phalaropes may have been monitored more than once, a cross-section of individuals was assured. Phalaropes of both sexes were selected. Because phalaropes could be classified into five groups based on the extent of achieving complete alternate plumage (e.g., <25%: $n = 8$; 25–50%: $n = 11$; 50–75%: $n = 54$; >75%: $n = 56$; 100%: $n = 20$), different individuals within sexes were monitored as well.

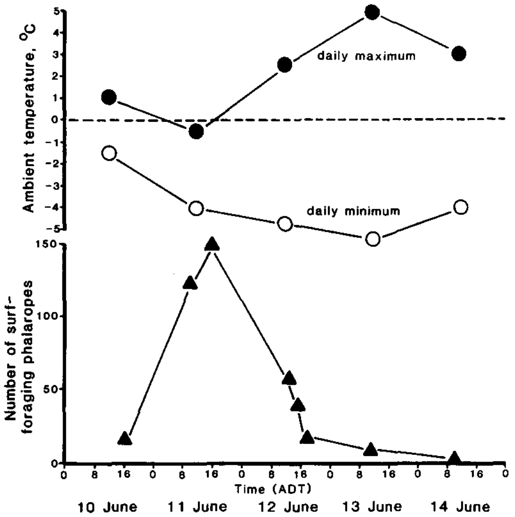

FIGURE 2. Numbers of Red Phalaropes feeding in the littoral zone of Kongkok Bay and their relation to ambient air temperature during June 1987.

The probability that consistent directional spinning by phalaropes was as likely as bidirectional spinning was calculated with the binomial distribution, n trials and success probability P, when n = total number of phalaropes observed spinning more than once and $P = 0.5$. A spin consisted of one or more rotations followed or preceded by one of the other foraging tactics. The conditions for Bernoulli trials (random draws with replacement) were satisfied for the test for all spinning phalaropes.

Foods available to phalaropes in the littoral zone of Kongkok Bay were collected with a 3-gal (11.4-l) bucket pulled for 1.5 m across the surf line at the water surface perpendicular to the beach. A total of 47.3 l of water was sampled. Phalaropes fed exclusively where fragments of benthic algae were suspended near the surface, a situation which precluded the use of conventional plankton nets. If present, fast-swimming, potential prey items such as euphausiids may have been missed by this sampling technique. Large invertebrates were separated from algal fragments with forceps. Small invertebrates suspended in the water were removed with a pipette for later identification.

RESULTS AND DISCUSSION

Phalaropes first arrived in numbers at Kongkok Bay on 10 June although single birds were seen as early as 5 June. These dates were slightly earlier than dates

TABLE 1. Foraging tactics of Red Phalaropes feeding in the littoral zone of Kongkok Bay, St. Lawrence Island, Alaska.

	Surface picking	Spinning	Head dunk	Vertical bob
Number (%) of birds using method	25 (100)	17 (68)	25 (100)	18 (72)
Percentage of total foraging attempts				
$\bar{x}$	84	4	9	3
SD	8	5	5	3
Range	67–96	0–18	3–20	0–10
Foraging rate (min^{-1})				
$\bar{x}$	13.4	0.5	1.6	0.4
SD	8.7	0.5	2.2	0.5
Range	4.2–45.4	0–1.4	0.4–11.6	0–1.8

given for Arctic Canada where nesting phalaropes arrived at a mean date of 16 June, with a range of 5 to 28 June (Mayfield 1979). Most phalaropes fed in freshwater streams and lakes near the bay on 10 June, but then moved to littoral areas during a temporary cold spell that iced over all open water (Fig. 2). Phalaropes returned to freshwater habitats as daytime temperatures again went above freezing, and their numbers in the bay declined to almost zero by 14 June.

Concurrent with these atmospheric conditions, strong swells and surf from the south-southeast prevailed in the bay on 11 June. Fragments of benthic algae were concentrated within a linear extent of 100 m at the northern part of the bay west of Kongkok Lake. Phalaropes foraged only in association with these algal fragments. Wind direction shifted from southerly to westerly between 11 and 13 June, and swell heights dropped from 1 to 2 m to 0.5 to 0.75 m during this period. Algal fragments and phalaropes were then dispersed along approximately 300 m of shoreline. Turnover of individuals within flocks was high, and birds spent less time in the surf and more time inland on lakes and streams by 13 June.

Most feeding occurred 1 to 3 m behind breaking wave crests, but some phalaropes fed up to 5 m seaward of the surf zone. Individual phalaropes generally swam actively within the entire area containing algal fragments, occasionally flying to adjacent areas within this foraging zone. A few Red-necked Phalaropes (*Phalaropus lobatus*) and Black-legged Kittiwakes (*Rissa tridactyla*) also fed with Red Phalaropes, but no interspecific encounters were witnessed.

Phalaropes often picked up algal fragments when foraging and manipulated invertebrates up to 20 to 25 mm in length for several minutes before swallowing. Foods available included *Anisogammarus* amphipods (preserved wet weights ranging from 0.001 to 0.452 g), *Ampithoe* amphipods (tube builders on benthic algae), and both adults and eggs of the isopod *Idotea fewkesi*. All of these invertebrates are obligate or facultative associates of benthic macroalgae. No pelagic copepods, a frequent item in the diets of phalaropes in littoral zones of the Arctic Ocean (Johnson and Richardson 1980), were caught in the samples.

Average rate for all foraging tactics used by phalaropes was 15.8 attempts per minute (SD = 10.3, range = 6.0–57.0). Simple surface picking was by far the most common tactic used (Table 1), but we were not able to ascertain whether this method was the most efficient for prey capture. Seventeen phalaropes were seen spinning, of which 14 spun more than once in a 5-min period. Thirteen (93%) spun consistently in one direction. The probability that 13 of 14 phalaropes would be recorded spinning unidirectionally was unlikely to be due to chance ($P = 0.001$, binomial distribution). Probabilities that individual phalaropes would be recorded spinning in only one direction in successive spins during a 5-min period ranged from 0.25 to 0.008 (binomial distribution; $n = 2$ to 7 spins/bird). The hypothesis that left-and right-handed spinning were equally likely could not be rejected (31% vs. 69%, respectively, $n = 13$; $\chi^2 = 1.92$, $0.2 < P < 0.4$, df = 1).

In the Bering Sea, phalaropes may feed at the boundary between the Bering Shelf and Anadyr Water (Haney, unpubl. data), with pinniped mammals (Ryder 1957), and at prey-rich mud plumes produced by gray whales (Obst and Hunt 1986). In the Arctic Ocean, phalaropes feed on copepods or amphipods, in coastal lagoons as well as in seaward-facing littoral zones (Conners and Risebrough 1978). The presence of ice, wind direction and speed, and other environmental factors appear to act together to determine where and upon what phalaropes feed (Johnson and Richardson 1980).

Littoral feeding by phalaropes at Kongkok Bay appeared to be both opportunistic and facultative. Phalaropes are known to frequently associate with marine macroalgae, apparently because these patches contain localized concentrations of invertebrate food (c.f. Bent 1927, Scott 1959, Rowlett 1980, Haney 1986). But the algae and its invertebrate associates at Kongkok Bay were available to the surface-foraging phalaropes only because storm swells had displaced the material from the benthos. Phalaropes in Kongkok Bay appeared to be handling large amphipods with difficulty. Laboratory studies have shown that phalaropes usually prefer smaller prey, approximately 2 to 5 mm in length (Dodson and Egger 1980).

In Alaska, littoral foraging by Red Phalaropes has been described primarily for juveniles during fall in the Beaufort and Chukchi seas (Conners and Risebrough 1980, Johnson and Richardson 1980). Elsewhere, adult phalaropes are known to wait in littoral areas for 2 to 3 weeks prior to nesting if their terrestrial breeding habitats remain frozen (Cramp 1983, Hayman et al. 1986). Phalaropes feed offshore in open water in late May around St. Lawrence Island (Fay and Cade 1959), but littoral zones are generally much closer to their breeding areas. Littoral foraging by phalaropes during spring in the northern Bering Sea may enable birds to minimize distances traveled and energy expended when these unpredictable (but frequent) cold spells preclude feeding nearer to their nesting grounds.

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