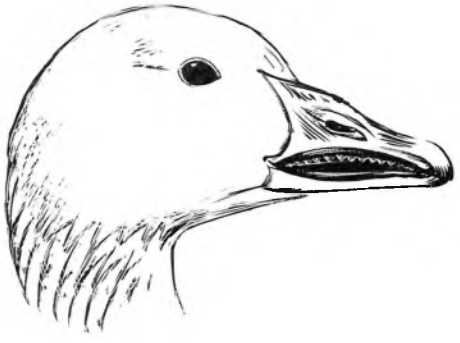
Distribution, abundance and age ratios of Wrangel Island Lesser Snow Geese *Anser caerulescens* during autumn migration on the Yukon-Kuskokwim Delta, Alaska



C.R. ELY, J.Y. TAKEKAWA and M.L. WEGE

We monitored the distribution, abundance, and productivity of Lesser Snow Geese on the Yukon-Kuskokwim (Y-K) Delta, Alaska during September and October 1991, when the geese were en route from their nesting grounds on Wrangel Island, Russia to wintering areas along the Pacific Coast. Adult geese in brood flocks were captured on Wrangel Island and fitted with either satellite platform transmitting terminal (PTT) transmitters (29 birds) or conventional very high frequency (VHF) radio transmitters (68 birds). All geese with active PTTs used the Y-K Delta. Geese marked with PTTs and VHF transmitters were first detected on the Y-K Delta on 19 and 25 September, respectively, and stayed 8-9 days (range 1 to 25 days). Geese with PTTs used the same areas as unmarked geese and geese with VHF radios, except for the south Delta where only satellite data were obtained. Flocks averaged 1122 birds, and did not vary significantly in size during the study. Population estimates from two independent methods ranged from 58,000 to 88,000 geese during October. Productivity of the Wrangel Island population, as determined from the proportion of young in flocks using the Y-K Delta, has varied from 0.5 to 42.1% with a mean of 29%, since 1975. Age-ratio estimates from the Y-K Delta were highly correlated with, and not significantly different from, those from autumn staging and wintering areas further south, which may indicate that immatures in this population of geese suffer little mortality during the second half of their autumn migration.

Lesser Snow Geese *Anser caerulescens caerulescens* on Wrangel Island, Russia (71°N, 180°), in the Chukchi Sea, are the only large population of Lesser Snow Geese nesting in the Palaearctic. They are also one of the few waterfowl populations of Palaearctic origin which is harvested, but does not nest in the Nearctic. Management of the Wrangel Island population of Lesser Snow Geese is additionally complicated, because they winter in two disjunct regions of the Pacific Flyway (Kozlik *et al.* 1959, Rienecker 1965, Syroechkovskiy & Litvin 1986, McKelvey *et al.* 1989). The southern component mixes in California with Lesser Snow and Ross's Geese *Anser rossii* from the Canadian arctic. Harvest regulations in California have largely focused on the larger Canadian segment of the "white goose" population, potentially compromising the Wrangel Island population. The Wrangel Island population has declined since the early 1970s (Bousfield & Syroechkovskiy 1985) so it is especially important that we have an understanding of life history parameters necessary for management decisions.

Attempts to monitor the Wrangel Island population have consisted largely of efforts to determine annual production on the breeding grounds (Bousfield & Syroechkovskiy 1985, V. Baranyuk unpubl. data), and from age-ratio counts during autumn staging on the Yukon-Kuskokwim (Y-K) Delta, Alaska (Clark 1985, Wege 1987-1989 unpubl. reports of U.S. Fish and Wildlife Service, Bethel, Alaska), and on the Fraser River Delta, British Columbia and the Skagit/Stillaguamish River Deltas, Washington (Jeffrey & Kaiser 1979, McKelvey *et al.* 1989). Monitoring efforts on the Y-K Delta have been sporadic, in part because it was not known whether all geese from Wrangel Island staged on the Y-K Delta in autumn and, hence, whether age-ratio counts obtained there were representative of all Lesser Snow Geese from Wrangel Island.

We initiated the current investigation as part of a larger project documenting the autumn migration of Wrangel Island Lesser Snow Geese by using satellite and conventional transmitters. Tracking of individual birds has enabled us to estimate the propor-

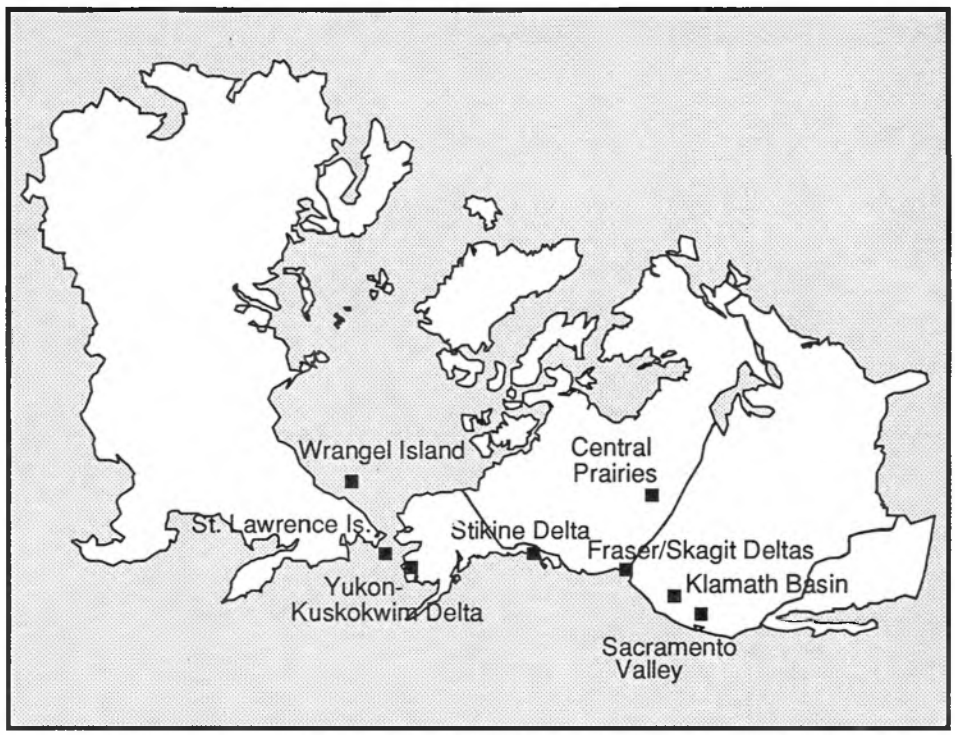


Figure 1. Major staging areas of Wrangel Island Lesser Snow Geese during autumn migration (after Bellrose 1980, and Syroechkovskiy & Litvin 1986).

tion of the Wrangel Island population that uses the Y-K Delta in autumn, and to determine the relevance of adult-immature ratios obtained on the Y-K Delta as an index of productivity. We also present information on annual variation in reproductive success for this population, and provide the first detailed information on the migration chronology and distribution of Lesser Snow Geese on the Y-K Delta in autumn.

Study Area

The study area consisted of the outer portion of the Y-K Delta, one of the most important staging areas for Wrangel Island Lesser Snow Geese during autumn migration (Fig. 1). The outer delta is within the Yukon Delta National Wildlife Refuge, and is dominated by the largest intertidal wetland in North America, characterized by a myriad of small lakes, tidal sloughs, and rivers. The vegetation consists largely of wet and dry tundra comprised predominantly of grasses, sedges, dwarf birch *Betula* spp., willow *Salix* spp., and numerous species of shrubs including *Rubus, Empetrum,* and *Vaccinium* spp.

Methods

Marking

Geese from brood flocks were caught when flightless during late July 1991 on Wrangel Island. Sixty-eight adult geese were fitted with 30-55 g conventional radio transmitters either in a backpack (Dwyer 1972), or neck-collar configuration, and 29 adult geese were similarly fitted with 85 g satellite PTTs (Takekawa *et al.* unpubl. data). All marked geese were also fitted with coded red plastic neck bands and U.S. Fish and Wildlife Service metal leg rings.

Aerial surveys

Aerial surveys were flown in a Cessna 206 aircraft equipped with twin 4-element yagi antennas (Gilmer *et al.* 1981). Survey areas (Fig. 2) were determined based on our findings from

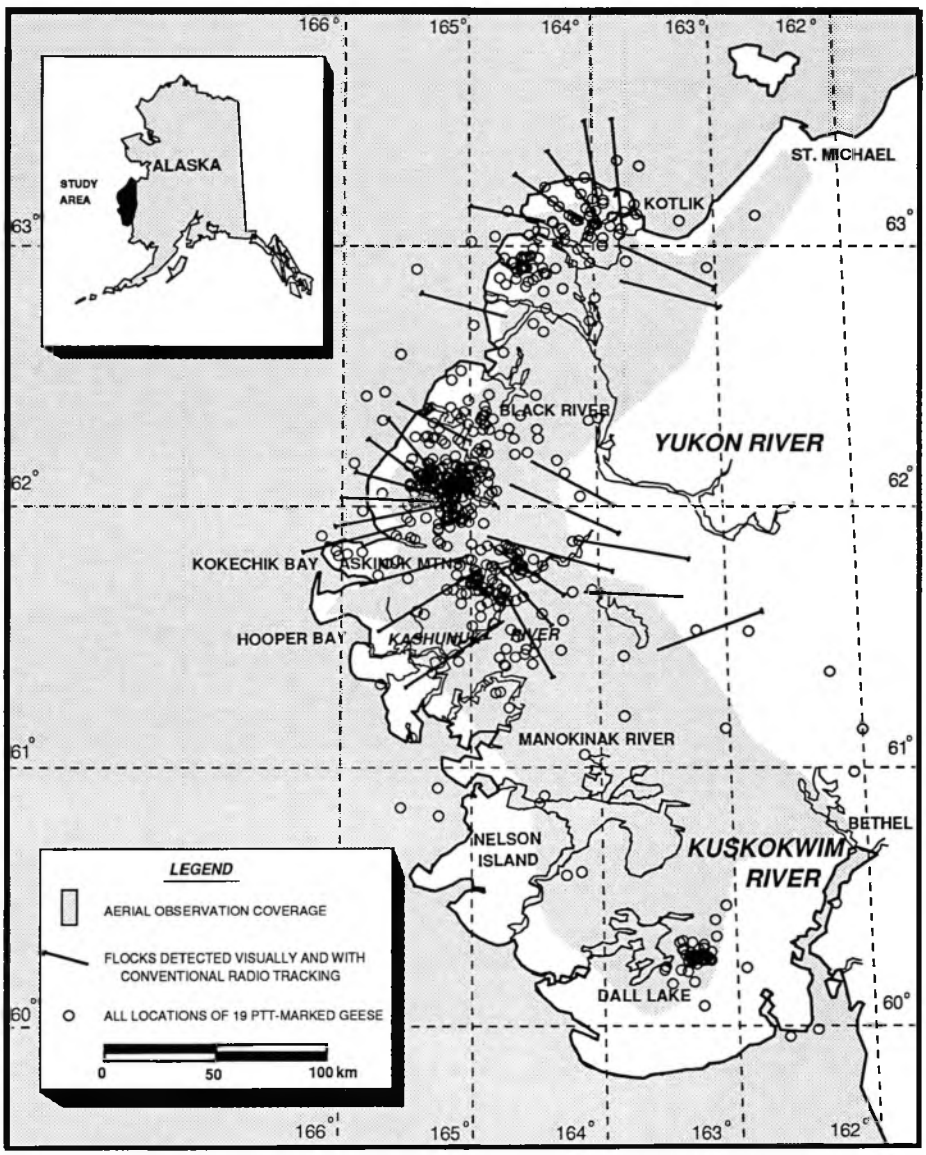


Figure 2. Distribution of Lesser Snow Geese on the Yukon-Kuskokwim Delta, Alaska in autumn 1991.

previous reconnaissance, hunter reports, and location information obtained from satellite radios. All surveys originated from Bethel, Alaska.

Telemetry flights were at an altitude of 600-700 m to optimize the distance at which radio signals could be detected. All VHF radio frequencies were monitored during each flight using a scanning telemetry receiver. Locations of satellite-marked geese were retrieved daily from the ARGOS system (Fancy *et al.* 1988).

The number of geese in each flock was estimated by the observer at the time of the flight. Flocks were also photographed, as weather allowed, with a 35 mm camera, and the number of geese determined by counting individual birds on slides projected on a screen.

Age ratios

Age ratios were determined from photographs taken during a flight on 6 October. Immatures and adults could be distinguished readily from projected images because the contour feathers of immature Lesser Snow Geese are grey whereas adults have white contour feathers (Bellrose 1980). Photographs were taken from a Piper Super Cub aircraft with a 35 mm camera using 200 ASA colour slide film at an altitude of 100-300 m. For small flocks (< approx. 1000), image size was large enough to determine the age of a large proportion of individuals from a single photo; for larger flocks, a series of non-overlapping photographs was taken to obtain an estimate.

Population estimates

We estimated population size from a modified Lincoln-Petersen estimate based on marked-unmarked ratios of geese with VHF radio transmitters (White & Garrott 1990: 256). We used the mean of the different point estimates as our population estimate.

We derived an additional Y-K Delta population estimate based on counts of the number of adults and young on Wrangel Island and the change in the proportion of young geese between Wrangel Island and the Y-K Delta. This method assumes the adult population remained constant during the time period in question, and the change in proportion of young was due solely to gosling mortality. Hence the number of young on the Y-K Delta was derived from the relationship (x/(adult population + x) = % young on the Y-K Delta).

Results and Discussion

Survey coverage

Seven aerial surveys were flown between 9 September and 15 October, and covered most of the outer Y-K Delta, from Dall Lake north to St. Michael (Fig. 2). Our flight paths were parallel to the coast at intervals of approximately 20 km near the coast, and up to 50 km inland; hence flocks >100 km from the coast were less likely to be encountered. No geese were observed on the first and last flights, although the detection of one bird fitted with a conventional radio on the final flight indicated that some geese were still on the Y-K Delta. Flights on 4 and 5 October were halted due to bad weather, so survey information from these two dates is combined.

Detection of radio-marked geese

Geese with VHF radio transmitters were detected at a range of up to 20 km away when they were on the ground, and up to 80 km or more when they were flying. Seventeen VHF radios were known to have failed, or did not depart Wrangel Island. We encountered 22 (43%) of the remaining 51 geese with transmitters still functioning during September and October (Table 1). Detection rates of birds with conventional radios on the Delta as a whole was probably low because we conducted only seven telemetry flights, we did not survey the entire Y-K Delta on each flight, and geese remained on the Y-K Delta for only a short period (44% of the PTT-marked geese detected were on the Y-K Delta for less than five days).

Table 1. Detection of VHF radio-marked Lesser Snow Geese on the Yukon-Kuskokwim Delta, Alaska during autumn 1991.

	Geese counted[a]	Number of radios new	Population old	Total	estimate[b]
9 September	0	0	0	0	—
25 September	3785	3	-	3	49204
28 September	7530	3	2	5	65269
4 October	12660	11	3	14	43887
9 October	14250	4	4	8	82332
15 October[c]	0	1	—	1	—
Total	38225	22	9	31	60170[d]

[a]Combined visual and photographic counts.
[b]Modified Lincoln-Petersen estimate (White & Garrott 1990).
[c]No visual sightings. Information from this census not included in population estimate.
[d]Standard error is not presented due to the poor precision of the point estimates resulting from the small number of radio-marked geese in the population (E. Rexstad pers. comm.).

After leaving Wrangel Island, all geese with functioning PTTs were located along the mainland of Russia south and east of Wrangel Island, before flying to St. Lawrence Island (Takekawa *et al.* unpubl. data). All (n = 19) of the PTT-marked geese located south of St. Lawrence Island used the Y-K Delta. This is a strong indication that the entire breeding population used the Y-K Delta during autumn.

Migration chronology

Arrival and departure dates of VHF- and PTT-marked geese were variable (Table 1, Figs. 3, 4), and indicated that geese did not migrate to or from the Y-K Delta in unison. The timing of arrival of geese to the Y-K Delta in 1991 was similar to other years, with the first geese being noted by villagers of Kotlik in early September (C. Hunt pers. comm.). The first PTT-marked goose arrived on the Y-K Delta from St. Lawrence Island on 19 September. The final PTT-marked goose arrived on 13 October, and mean arrival was 2 October ± 1.7 days (SE). Data from three of the PTT-marked geese were not used for calculating mean date of departure and length of stay, as either the PTTs did not leave the Delta (n = 2), or were not detected south of the Y-K Delta (n = 1). Mean departure date of PTT-marked geese was 8 October ± 0.9 days, with an average length-of-stay of 9.0 ± 1.8 days (range: 1-25 days, Fig. 3). (The length-of-stay estimate does not equal the difference in days between mean departure and arrival as the 3 PTTs excluded from the length-of-stay estimate arrived on the Delta later than the other 16 PTTs). PTT information should be interpreted with caution however, as transmitters functioned intermittently, and location information was not always precise (Douglas *et al.* 1992).

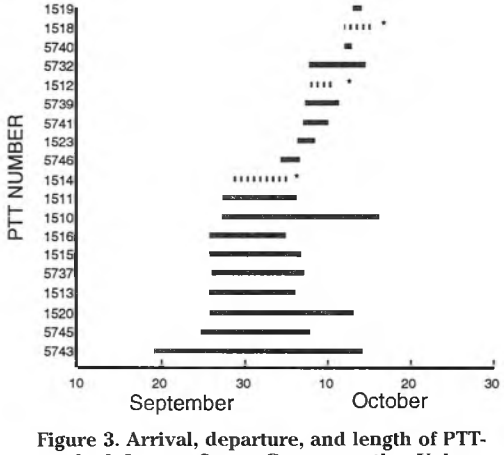


Figure 3. Arrival, departure, and length of PTT-marked Lesser Snow Geese on the Yukon-Kuskokwim Delta, Alaska in autumn 1991. *Denotes PTTs for which only arrival information was obtained.

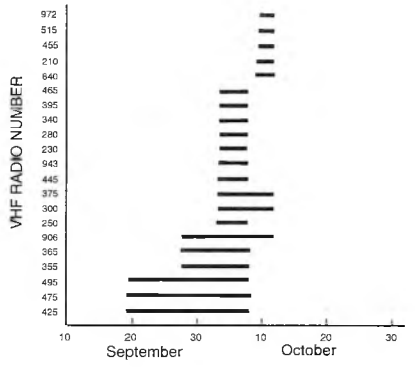


Figure 4. Arrival, departure, and length of stay of VHF-marked Lesser Snow Geese on the Yukon-Kuskokwim Delta, Alaska in autumn 1991. Arrival and departure dates represent midpoints between survey dates (see text).

The first VHF-marked geese were detected on the flight of 25 September when three geese were located on the north and central portions of the Delta (Table 1). The peak population count on the Y-K Delta was on 6 October when 14,455 geese were counted in 18 flocks, only slightly more than the 14,250 estimated three days later. We used the midpoint of the interval between telemetry surveys as an approximation of true arrival and departure dates for VHF-marked geese (Bart & Robson 1982). Arrival and departure dates for the 21 VHF-marked geese were very similar to those for PTT-marked geese (Fig. 4). VHF-marked geese arrived on 30 September ± 1.4 days, left on 8 October ± 0.9 days, and stayed an average of nine days.

Distribution

Flocks of geese were observed at numerous locations throughout the central and northern portions of the Y-K Delta (Fig. 2). Flocks were concentrated in four general areas 1) the mouth of the Yukon River on the north Delta, 2) Black River (northwest of the Askinuk Mountains), 3) the upper Kashunuk River (southeast of the Askinuk Mountains) and 4) Dall Lake on the southern Y-K Delta

(Fig. 2). Geese fitted with satellite transmitters were generally located in the same areas as unmarked geese and geese carrying conventional radio transmitters, with the exception of one PTT-marked goose located repeatedly near Dall Lake. We did not observe geese in the Dall Lake area, nor did we detect birds with VHF radios in the area, although Dall Lake is used regularly by geese in autumn (D. Strom pers. comm.). Nominal laboratory testing indicated that location information obtained from PTTs was accurate within approximately 10 km. Thus the locations of PTTs just off the mainland (Fig. 2) are probably actually on the coast, rather than in the ocean.

All of the 19 PTT-marked geese using the Y-K Delta were located at least once on the mid Delta (61.0° < lat. < 62.5°). Fifteen (78.9%) of the PTT-marked geese were found only on the mid Delta, while the three PTT-marked geese that used the north Delta and one PTT-marked goose that used the south Delta were also found on the mid Delta.

Within the mid Delta there was considerable interchange between the activity areas near the Black River and the upper Kashunuk River (Fig. 2). Of the 16 PTT-marked geese using these specific sites, seven (43.8%) were found on both areas, seven (43.8%) used only the area near Kusilvak Mountain, and two (12.5%) were found only near the upper Kashunuk River.

Flock sizes

A total of 44 flocks was photographed and counted. Average flock size was slightly more than 1100 birds (Table 2), and did not vary significantly ($P>0.05$) over time. Visual estimates of the size of flocks averaged 16% lower than actual photographic counts, but did not deviate significantly from actual counts ($P = 0.271$; $t = 1.12$, df = 43).

Production

Approximately 28% of a sample of 6211 geese counted on the Y-K Delta in 1991 were immatures (Table 3). There was considerable variation among flocks in the proportion of young present (10.0-41.1%), that was unrelated to flock size ($P>0.05$). We encountered no flocks of non-breeders, some of which (<1000) arrived at more southerly areas in early September (S. Boyd pers. comm.). The proportion of young was substantially greater than observed during the previous two years of study (1988 and 1989) but was less than has been reported in some years (Fig. 5). Average production of young since 1975 has been 22.8 ± 3.6%, as determined by age ratios on the Y-K Delta.

Productivity estimates of the Wrangel Island population, as determined from the proportion of immatures in flocks, were highly correlated between the Y-K Delta and both the Stikine River Delta in southeast Alaska ($r_s = 0.80$, $P = 0.20$, $n = 4$ for 1986-91; B. Conant, J.

Table 2. Sizes of Lesser Snow Goose flocks on the Yukon-Kuskokwim Delta, Alaska in 1991.

	n	x ± SE	Range
25 September	2	1692.5 ± 717.5	975-2410
28 September	4	1882.5 ± 1289.5	437-5746
4 October	12	710.9 ± 173.5	103-1881
6 October	18	871.4 ± 199.1	48-3769
9 October	8	1781.8 ± 534.8	284-3894
Total	44	1122.4 ± 182.0	48-5746

Table 3. Proportion of immatures in flocks of Lesser Snow Geese during autumn on the Yukon-Kuskokwim Delta, Alaska in 1991[a].

Parameter	Flock size	n sampled	% Young
Mean	826.2	388.2	28.2
SE	222.0	66.3	2.3
Range	48-3769	48-1041	10.0-41.1
n	16	16	

[a]Determined from photographs taken 6 October 1991 (see Methods).

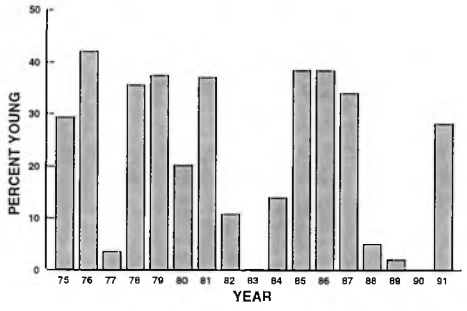


Figure 5. Annual variation in proportion of immatures in flocks of Wrangel Island Lesser Snow Geese on the Yukon-Kuskokwim Delta during autumn.

Hodges & C. Iverson pers. comm.), and the Skagit-Fraser River Deltas ($r_s = 0.68$, $P = 0.005$, $n = 15$ for 1975-91; Jeffrey & Kaiser 1979, S. Boyd & R. McKelvey pers. comm.). The proportion of young in flocks was not significantly different between the Y-K Delta and the Skagit River Delta ($P<0.05$, *paired* $t = 0.59$, df = 14), as would be expected if mortality of immatures was significant during the latter half of their migration, if non-breeding geese were included in age-ratio estimates at southerly areas, or if there were significant sampling error during productivity surveys. The apparent high survival of young after departure from the Y-K Delta may indicate that the migration of Wrangel Island Lesser Snow Geese south of the Y-K Delta is less arduous than for those species that undergo prolonged flights over open water (Owen & Black 1991).

Conventional and satellite telemetry data confirm that most, if not all, Lesser Snow Geese nesting on Wrangel Island stop on the Y-K Delta during autumn migration. Age ratios obtained on the Y-K Delta are thus valid indicators of productivity of at least the breeding component of the population (see below). Although the geese still must fly nearly 3000 km to their wintering areas after leaving the Y-K Delta, our data indicate that there may be little additional mortality during this time. However, it may be desirable to obtain age-ratio estimates at more southerly areas if there is differential production between geese wintering in the Fraser-Skagit areas and those wintering in California (M. Bousfield & D. Lank unpubl. data). Age-ratio estimates are annually obtained on the Fraser-Skagit areas for the northern group, and it may be possible to obtain age-ratio estimates of Wrangel Island geese at Summer Lake, Oregon, a major stopover point of California-bound geese.

Staging population

We estimate there were approximately 60,000 geese in the population during our surveys based on Lincoln-Petersen estimates (White & Garrot 1990) of geese with VHF radio transmitters (Table 1). The only other population estimate in 1991 was made when 42,000 adults and 60,000 goslings were counted as they left the nesting area (V. Baranyuk pers. comm.). If we assume the difference in proportion of young in the population between time of hatch (59%) and the arrival of geese to the Y-K Delta (28%) represented gosling mortality during brood rearing and migration, then the breeding segment of the population would have represented approximately 58,300 geese in October (see Methods). This figure is similar to our Lincoln-Petersen estimate. Although the two values compare favourably they should be used with caution, as there were very few radio-marked geese in the population on which to base our marked-unmarked estimate. Also, our estimate assumes that radio-marked geese were evenly distributed in the population, and that the sample of geese we surveyed is representative of the entire population.

Our estimate of population size based on radio-marked geese is likely to be somewhat biased as we did not mark non-breeding or failed nesters on Wrangel Island. Little is known about this segment of the population; it is reported to moult separately from the brood flocks, either on Wrangel Island, or on the mainland (Syroechkovskiy & Litvin 1986). The breeding and non-breeding segments of the population are apparently mixed by the time they arrive at wintering areas (except for approximately 1000 non-breeders that arrive in the Skagit-Fraser area in September - S. Boyd pers. comm.). The strong correlation in age ratios between the Y-K Delta and the Skagit-Fraser area also indicates that non-breeders were on the Y-K Delta during our surveys. There were approximately 60,000 geese on Wrangel Island in 1991 before nesting (V. Baranyuk pers. comm.), which means that approximately 18,000 (60,000-42,000) adult-plumaged geese failed or did not attempt to nest. If there were indeed 60,000 adults in the population in autumn 1991 (assuming no over-summer adult mortality),

then the autumn population estimate based on percent young would be approximately 83,300 geese.

Our contention that all geese breeding on Wrangel Island used the Y-K Delta in autumn 1991 is supported by the subsequent distribution of geese fitted with VHF radios that were detected on the Y-K Delta. Radio-marked geese using the Y-K Delta in autumn were found on all major staging areas (Fig. 1), and both major wintering areas. Ten of the 22 VHF radios we detected on the Y-K Delta were also found on the Fraser and/or Skagit River Deltas (S. Boyd pers. comm.) during migration, while of the 19 VHF radios functioning through November (date by which winter site affinities were evident), five (26%) were on the Skagit/Fraser River Deltas, and 14 (74%) were located in the Sacramento Valley of California (S.Boyd pers. comm., J. Takekawa *et al.* unpubl. data). In addition, PTT-marked geese migrated through Alberta and Saskatchewan (the Central Prairies) after they were on the Y-K Delta (J. Takekawa *et al.* unpubl. data); an indication that geese using the purported "interior" route during autumn (Syroechkovskiy & Litvin 1986) also use the Y-K Delta.

It is apparent from our results that wetlands on the Yukon Delta National Wildlife Refuge are of critical importance to Lesser Snow Geese from Wrangel Island during autumn. Autumn is a time of unpredictable weather at northern staging areas, and migrating geese must maximise feeding time when opportunities are available. Lesser Snow Geese must find adequate nourishment to fuel their flight from the Y-K Delta to southern staging areas, the longest leg of their journey from the breeding grounds. The Y-K Delta is also a very important spring staging area for geese breeding on Wrangel Island; it is imperative that the wetlands used by these geese remain protected.

The contributions of the many people involved in gathering the data contained in this paper have been invaluable. We would like to especially acknowledge the early photographic work by C.P. Dau (Yukon Delta National Wildlife Refuge - YDNWR) and J. Clark (YDNWR). E. Burns (Alaska Fish and Wildlife Research Centre - AFWRC) counted the number of immature and adult geese on the aerial photographs. B. Conant (U.S. Fish and Wildlife Service - USFWS), J. Hodges (USFWS), C. Iverson (U.S. Forest Service), and S. Boyd (Canadian Wildlife Service - CWS) kindly allowed us to cite their unpublished data on age ratios from the Stikine Delta, and Fraser-Skagit Deltas, respectively. Marking geese with transmitters on Wrangel Island would not have been possible without the cooperation of the Wrangel Island Reserve (WIR - A. Sukhov, director), and V. Baranyuk (WIR), K. Litvin (Russian Academy of Sciences - RAS), S. Kuznetsov (RAS), R. Kerbes (CWS), and S. Boyd (CWS). Nippon Telephone and Telegraph kindly contributed the PTTs and satellite access time. D. Douglas (AFWRC) and C. Robbins (AFWRC) compiled the satellite data. J. Morgart (YDNWR), G. Walters (YDNWR), C. Lind (AFWRC), P. Paniyak (YDNWR), and R. Baccus (YDNWR) assisted with telemetry work. D. Derksen (AFWRC), A. Palmisano (AFWRC), S. Haseltine (Northern Prairie Wildlife Research Centre - NPWRC), and D. Gilmer (NPWRC) arranged funding and supported the work on very short notice. D. Derksen (AFWRC), J. Hupp (AFWRC), E. Rexstsad (University of Alaska, Fairbanks), and M. Bousfield kindly reviewed an earlier version of the manuscript.

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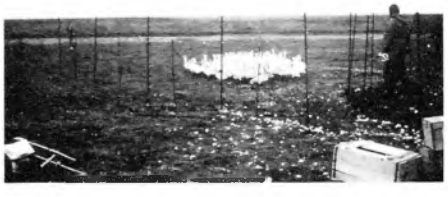
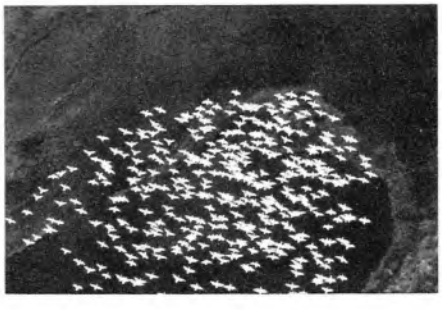


Capturing flightless Lesser Snow Geese on Wrangel Island, Russia.
(see "Marking" p.25)



Flock of Lesser Snow Geese during autumn on the Yukon-Kuskokwim Delta, Alaska.
(see "Age ratios" p.27)