Population and status of Emperor Geese along the north side of the Alaska Peninsula

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The Emperor Goose *Anser canagicus* is found primarily in maritime areas throughout its annual cycle (Bellrose 1976; Palmer 1976; Eisenhauer & Kirkpatrick 1977). In North America, the breeding population is centred on the coastal fringe of the Yukon-Kuskokwim Delta, Alaska. Birds winter along the Alaska Peninsula, in the Kodiak Archipelago, and throughout the Aleutian Islands. The estuaries along the north side of the Alaska Peninsula are the main staging areas during migration in spring and autumn, during which tens of thousands of birds concentrate for brief periods (US Fish and Wildlife Service [U.S.F.W.S.], unpub.).

Recent publications (Bellrose 1976; Eisenhauer & Kirkpatrick 1977) cite King and Lensink's (1971) estimate of an autumn population of 150,000 Emperor Geese in Alaska. Since 1971 this estimate has not been refined and there has been no serious effort to assess the population status of this goose. There is some concern, however, that the population has declined in recent years (Palmer 1976; R. D. Jones, Jr., and others, pers. com.). Also, little is known about the timing of migration or use of estuaries by geese along the Alaska Peninsula. In conjunction with studies of waterfowl and shorebirds in the eastern Bering Sea region (Gill & Jorgensen 1979; Petersen 1980, 1981), we gathered information on Emperor Geese. Here we: (1) report the number and temporal occurrence of geese observed in Nelson Lagoon; (2) evaluate the relative importance to geese of the major estuaries on the north side of the Alaska Peninsula; (3) assess age ratios and average brood sizes of geese during autumn migration along the Bering Sea coast and Alaska Peninsula; and (4) compare changes in numbers of geese estimated during censuses in spring and autumn from 1963 to 1981.

Study area

The north side of the Alaska Peninsula is a gently sloping coastal terrace, interspersed with numerous estuaries (Figure 1). Combined, these estuaries total some 1,900 km^2. They are characterized by extensive intertidal areas of mud, sand, and sand-gravel, and are partly protected from the open sea by barrier islands or sand spits.

Nelson Lagoon, the principal study area, is part of the Port Moller complex. The lagoon is shallow, with extensive flats (47% of the lagoon) exposed at mean low tide. The study area has been described in detail by Gill & Jorgensen (1979) and Petersen (1980, 1981).

Methods

Populations and age determination

The total number of Emperor Geese along the north side of the Alaska Peninsula was estimated in autumn 1979 and 1980, and in spring 1977 and 1981, from aerial surveys flown at heights of 50–150 m over the lagoons and estuaries. In Nelson Lagoon and adjacent bays we estimated the number of geese from aerial surveys in spring 1977 and 1981 (4 surveys), during summer 1977 (6 surveys), during autumn 1976, 1977, 1979, and 1980 (13 surveys), and during winter 1976–1977 (5 surveys).

Hatching-year birds were identified in autumn by their grey heads and necks, and in spring by their grey–orange legs and bills and the grey feathers remaining on their necks and heads. Two-year olds and older birds were classified as adults by their white head and neck markings (Palmer 1976). Both the number of young per family group and the proportion of young in the population were estimated from a combination of ground and aerial surveys; the aerial surveys were often supplemented with aerial photography. The number of young in family groups in the autumn was sampled at Nelson Lagoon in 1976, 1977, and 1979; at Cape Peirce in 1976; at Angyoyaravak Bay in 1980; and at estuaries between Egegik Bay and Izembek Lagoon in 1979 (Figure 1). Age ratios were estimated by counting the number of adults and young in all flocks seen during autumn migration in 1976, 1977, 1979, and 1980.

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Figure 1. Locations of major estuaries and study sites along the north side of the Alaska Peninsula and Bristol Bay.

Data on brood sizes, age ratios, numbers, and spatial occurrence of geese for the period 1963 to 1980 were also available from unpublished annual reports of the Aleutian Islands and Izembek National Wildlife Refuges, from unpublished field reports of personnel of the U.S.F.W.S., and from unpublished annual reports of survey and inventory activities of the Alaska Department of Fish and Game (A.D.F. & G.).

Data analysis

The proportions of various brood sizes and the mean brood sizes were tested for differences among years by using Chi-square analysis and one-way analysis of variance, respectively (Sokal & Rohlf 1969); we then evaluated the similarity of mean brood sizes among years by using Duncan's multiple range test (Steel & Torrie 1960). Since overall percentages of young in the populations were recorded at no more than two locations each year, we tested for differences between locations each year with a test for equality of two percentages (Sokal & Rohlf 1969). Finally, we looked for a relation between the average brood size and the overall percentage of young in the

population at Izembek Lagoon, by using a Spearman rank correlation test (Siegel 1956).

To evaluate the relative importance to geese of each of the major estuaries, we first adjusted the number of geese observed in each to account for differences in area. We then used Chi-square analysis of residuals tests (Everitt 1977) to evaluate the differences between the observed and expected numbers of geese. Geese were rarely found in the open water areas or on the beaches of Herendeen Bay, Bechevin Bay, and Port Moller Bay; consequently those areas were not included in the analysis. In our treatment of specific areas, the Izembek Lagoon complex included Moffet Lagoon, and the Nelson Lagoon complex included Mud Bay and Kudobin Islands. (See US Geological Survey 1:63,360 series topographic maps for exact locations.)

Results

Migration

Migrant geese were present in Nelson Lagoon from March to early June during spring migration, and from late August to November during autumn migration (Figure 2). The number of geese recorded during these periods varied considerably among years; however, the timing of major movements into the area appeared to be fairly consistent. Generally, numbers were greatest from March to April in spring, and from September to October in autumn. In years when surveys were infrequent, peak migration may have been missed; thus timing of surveys may account for some of the variation in numbers of geese recorded during different years. The presence or absence of ice in the lagoon influences the number of geese which remain during winter (P. Gundersen, pers. com.). For example, large numbers of geese were present during early December 1976, an abnormally mild winter.

In spring, some Emperor Geese migrated directly across Bristol Bay from Nelson Lagoon. Other geese passed over or through the lagoon along the coast and moved east to other estuaries before migrating across Bristol Bay. In spring 1977, we recorded a mass movement of geese from Nelson Lagoon beginning on 10 May between 19.00 and 22.00 h. Migration continued through to 20 May, with the number of birds generally increasing in the lagoon by each afternoon and decreasing abruptly as they left early the next morning. A small, delayed movement of yearling geese was noted on 3 June, and by 23 June only a few hundred yearlings remained in Nelson Lagoon.

In autumn, geese arrived at Nelson Lagoon from along the coast rather than from across Bristol Bay (M.R.P. & R.E.G., pers. obs.). Flocks of birds in adult plumage began arriving at Nelson Lagoon in mid-August, and the first young of the year were recorded one to two weeks later (Table 1). Family groups were

Table 1. Chronology of Emperor Goose migration at Nelson Lagoon.

Year[1]	Spring migration	First arrival in autumn	First arrival of family groups
1976		13 August	30 August
1977	10–20 May	7 August	1 September
1979		19 August	23 August

* Observers present from 18 May to 12 October 1976, 18 April to 15 October 1977, and 20 June to 5 October 1979.

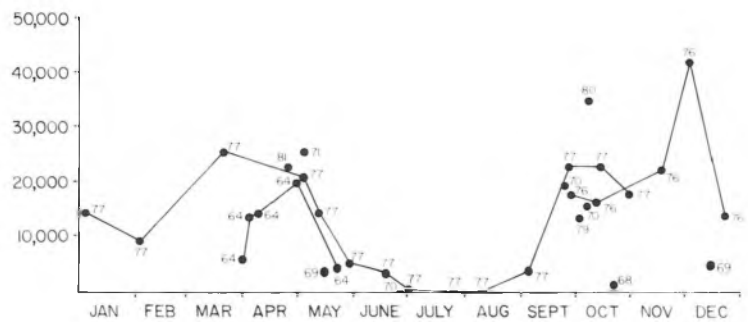

Figure 2. Number of Emperor Geese observed at Nelson Lagoon between 1964 and 1981. Data from Mud Bay and the Kudobin Islands are included in all counts.

common by early September, and apparently remained together throughout the autumn.

Use of estuaries

The relative importance to geese of each of the major estuaries on the north side of the Alaska Peninsula can be assessed from surveys conducted in different years. In all years, geese were found in low numbers in Ugashik and Egegik bays, and used the other estuaries in varying degrees (Table 2). Geese were found in Seal Islands lagoon area and Nelson Lagoon during all surveys in spring and autumn. Port Heiden and Cinder River lagoon contained large numbers of geese most commonly in April and May and sporadically in the autumn. Geese used the Izembek Lagoon complex consistently in spring until late April and May, but much less regularly in the autumn. There were no clear trends or changes in use by geese of individual estuaries between successive springs in 1963 and 1964, and from 1977 to 1981.

Productivity

The average number of young in family groups of Emperor Geese migrating past Angyoyaravak Bay, Cape Peirce, Nelson Lagoon, and Izembek Lagoon, and found during aerial surveys along the Alaska Peninsula, did not differ significantly among locations within a given year. Consequently, all data collected on brood sizes during autumn migration were combined for each year. Average brood sizes varied significantly between 1969 and 1980 ($F_{8, 1,867} = 4{\cdot}11$, $p<0{\cdot}001$), as did the frequencies of different brood sizes ($X^2 = 76{\cdot}42$, df = 54, $p<0{\cdot}025$; Figure 3). However, no obvious trends or constant changes in average brood sizes were apparent over the 12-year period. For example, broods of two young were most common in 1971, 1974, 1976, and 1979, whereas broods of three and four were most common in 1969, 1972, and 1980.

The percentage of young counted within each year during autumn migration did not differ significantly among locations when certain conditions of sampling design were

Table 2. Relative use of major lagoons on the north side of the Alaska Peninsula by Emperor Geese.

	Chi-square value (deviation from expected number)*						
Season and date	Izembek Lagoon complex (344 km²)	Nelson Lagoon complex (141 km²)	Seal Island (50 km²)	Port Heiden (204 km²)	Cinder River (51 km²)	Ugashik Bay (47 km²)	Egegik Bay (74 km²)
Spring							
10–11 Apr.	34·10	4·42	12·27	32·52	11·36	−64·00	−83·95
1963	(+)	(+)	(+)	(+)	(+)	(−)	(−)
30 Apr.–4 May	−55·85	76·65	6·91	7·01	142·80	−54·66	−94·73
1964	(−)	(+)	(+)	(+)	(+)	(−)	(−)
15 May	NS	−10·65	44·92	−20·74	95·23	−37·44	−45·11
1969		(−)	(+)	(−)	(+)	(−)	(−)
4 May	NS	70·02	190·42	−52·72	−20·68	−85·85	−87·73
1971		(+)	(+)	(−)	(−)	(−)	(−)
21–23 March	29·50	247·58	−56.29	−116·76	−53·33	−50·03	−69·45
1977	(+)	(+)	(−)	(−)	(−)	(−)	(−)
23–27 Apr.	−210·69	133·69	174·44	85·25	37·19	−55·96	−64·63
1981	(−)	(+)	(+)	(+)	(+)	(−)	(−)
Autumn							
23 Oct.	NS	−140·15	193·02	−33·55	276·24	−79·12	−105·13
1968		(−)	(+)	(−)	(+)	(−)	(−)
4–5 Oct.	NS	75·55	195·24	−64·22	−18·37	−84·43	−85·62
1971		(+)	(+)	(−)	(−)	(−)	(−)
1–4 Oct.	−138·04	48·34	68·08	164·49	−1·05	−59·83	−77·46
1979	(−)	(+)	(+)	(+)	(0)	(−)	(−)
30 Sept.–8 Oct.	−144·97	309·01	11·48	−46·20	33·13	−57·62	−72·16
1980	(−)	(+)	(+)	(−)	(+)	(−)	(−)

* Values derived from Chi-square test for residuals on adjusted numbers of birds (Everitt 1977). Greater than expected number (+), expected number (0), and less than expected number (−) at 5% standard normal deviate (1·96). NS = not surveyed.

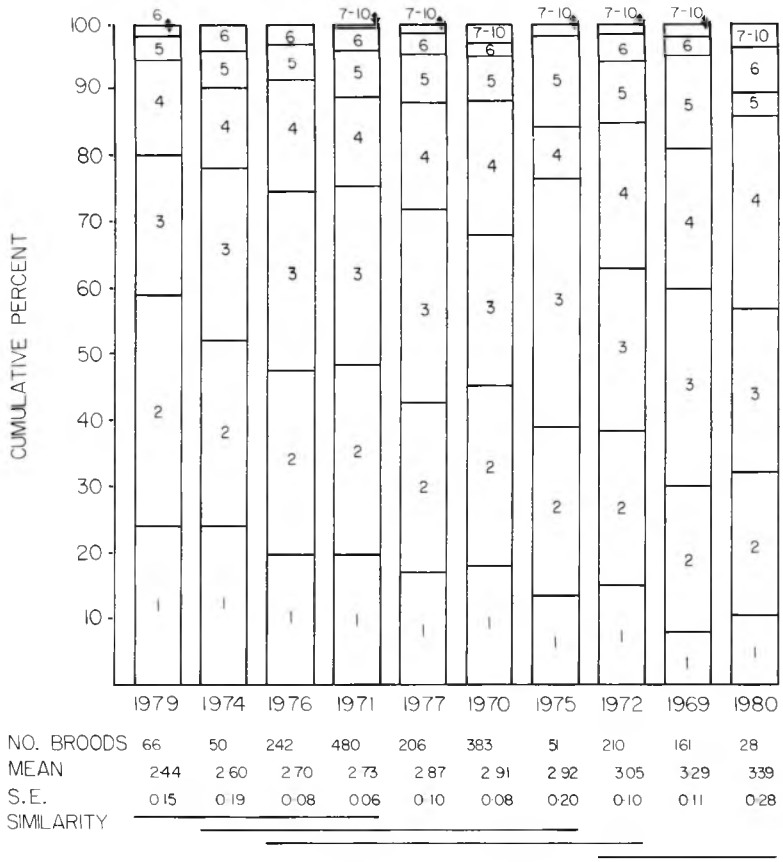

Figure 3. Brood sizes of Emperor Geese during autumn migration. Data from 1969 to 1975—Izembek Lagoon; 1976—Cape Peirce, Nelson Lagoon, and Izembek Lagoon; 1977—Nelson Lagoon and Izembek Lagoon; 1979—aerial surveys between Angyoyaravak Bay and Izembek Lagoon; and 1980—Angyoyaravak Bay. Years not connected by a solid line are significantly different ($p<0.05$).

consistent: (1) observers at each location had to begin counts with the first arrival of geese and continue them throughout migration; or (2) counts obtained during aerial surveys had to include family groups, non-breeders, and unsuccessful breeders. Data from areas where we could not determine migration dates and survey dates were excluded. The percentage of young in the population during autumn (Table 4) varied significantly ($X^2 = 30.94$, df = 3, $p<0.05$) among years. Age ratios were similar in 1977, 1979, and 1980, when there was less than 14% young. The highest proportion of young (20·9%) was recorded in 1976; however, the sample size was relatively small.

The percentage of young in the population each year was not positively correlated with the average number of young per family group ($N = 4$ years, $r_s = 0.375$, $p>0.05$). In 1980, when we recorded a high average brood size of 3·39 young per pair, there was 12·3% young in the population. In 1976, when the proportion of young in the population was higher (20·9%), the average number of young per family group was low (2·70 young per pair). The percentage of young was similar in 1977 and 1979, when the average brood size was moderate and low, respectively. Similar data from Izembek Lagoon (Table 4) indicated that the proportion of young in the population was correlated with the average size of broods. We suspect these data may be biased, however, since counts in most years were initiated after migration of Emperor Geese had begun (R. D. Jones, Jr., pers. com.).

Table 3. Age ratios of Emperor Geese observed during autumn migration.

Year	Total birds aged	Percent adults	Percent young
1976*	483	79·1	20·9
1977†	4,163	87·8	12·2
1979‡	3,293	86·9	13·3
1980§	2,343	87·7	12·3

* Data collected at Cape Peirce from 19 August to 4 September by ground observations with a spotting scope.
† Data collected at Nelson Lagoon from 25 August to 11 October by ground observations with a spotting scope.
‡ Data collected between Egegik Bay and Izembek Lagoon from 1 to 4 October from aerial surveys and photographs, and at Nelson Lagoon from 11 August to 30 September by ground observations with a spotting scope.
§ Data collected between Egegik Bay and Izembek Lagoon from 30 September to 8 October from aerial photographs, and at Angyoyaravak Bay from 23 August to 17 September by ground observations with a spotting scope.

Table 4. Average brood sizes and percent of young in the population of Emperor Geese at Izembek Lagoon during autumn and winter 1966 to 1980.

	Brood sizes		Percent young	
Year	Mean	Rank	Percent	Rank
1966	2·5	2	27·5	6
1967	3·3	13	28·4	7
1968	2·8	6·5	32·9	10
1969	3·3	13	41·8	14
1970	2·9	8·5	33·7	11
1971	2·7	4·5	29·8	8
1972	3·1	11	32·7	9
1974	2·6	3	15·5	3
1975	2·9	8·5	35·2	12
1976	2·7	4·5	14·4	2
1977	2·8	6·5	40·2	13
1978	3·0	10	26·2	5
1979	3·3	13	11·8	1
1980	2·3	1	24·8	4

$r_s = 0{\cdot}156$, $t = 1{\cdot}918$, $df = 12$, $p < 0{\cdot}05$

Populations

The number of geese recorded on surveys of the north side of the Alaska Peninsula and Bristol Bay in spring and autumn was very variable; estimates ranged from 18,000 in 1972 to 139,000 in 1969. Only during autumn 1979 and 1980 and spring 1963, 1964, and 1981 was an effort made to estimate the total number of geese in all areas where geese are known to concentrate. Data from one or more estuaries were not available in some years, and several tens of thousands of birds may not have been counted. The highest estimates were obtained during surveys on 5–8 April 1964, a year when spring was late, and on 6 October 1969 (139,000 and 139,830, respectively). The October count did not include geese in Izembek Lagoon. Estimates from the survey conducted in spring 1981 (a normal or slightly early spring) suggested that the total population of Emperor Geese was approximately 91,000 birds. This estimate, however, was much higher than that obtained in autumn 1980 (63,000 birds), suggesting that it is difficult to accurately census these geese in autumn.

Discussion

Emperor Geese use estuaries along the north side of the Alaska Peninsula during spring and autumn migration. Our data and impressions from field observations of behaviour suggest that most geese pass through Nelson Lagoon, and that many geese remain within the lagoon for six to eight weeks before continuing their migration across Bristol Bay (spring) or along the coast (autumn). We are uncertain, however, if the pattern of use observed in 1977 and 1979 at Nelson Lagoon is similar to that in other areas. Although some estuaries are obviously preferred by geese (Nelson Lagoon and Seal Islands lagoon in spring and autumn), others may be more important than our analysis suggests. Emperor Geese may prefer certain habitats within each estuary and a more detailed analysis of habitat use and the distribution of favoured habitats may more accurately define the relative importance of each major estuary. Also, to more fully understand the importance of estuaries to staging and migrating Emperor Geese, we need to determine more precisely how long an individual remains in each estuary.

Based on descriptions of the surveys conducted in April 1964 and October 1969, it is possible that the number of geese estimated during those surveys closely reflected the actual number of Emperor Geese in Alaska during that period. A similar survey in April 1981 produced an estimate of 91,267 geese, which was 34% fewer geese than recorded in the 1960's. However, between 1960 and 1980 there were too few surveys designed to estimate the total number of geese for us to substantiate a significant decline in population. It is difficult to accurately estimate

the number of Emperor Geese in autumn because of their prolonged migration (late August through October) and the variability in timing of migration. Thus, a survey in early autumn would not include family groups that might still be north of Bristol Bay, and a late survey would not include failed- and non-breeders that migrate to wintering areas before family groups arrive. Problems in attempting to estimate the numbers of geese in spring also centre around the timing and duration of movement of birds. During years when habitat on the breeding grounds is available earlier in spring than normal, birds move along the Alaska Peninsula over a protracted period and do not concentrate in numbers. However, during years of normal and late spring break-up (such as 1964 and 1981), ice and snow cover precludes early use of the nesting grounds and birds tend to congregate in Bristol Bay and along the north Alaska Peninsula, allowing a more accurate estimate of the population.

People living near Izembek Lagoon, Nelson Lagoon, Seal Islands Lagoon, and Ugashik Bay have expressed the concern that the number of geese using those estuaries in autumn has declined in recent years. Our analysis of the number of geese using each estuary suggests that the proportion in each estuary relative to the total estimated number of geese has not changed between 1963 and 1981. Thus, we believe that the apparent decline in the population cannot be attributed to local changes in habitat or hunting pressure in any single lagoon or estuary on the Alaska Peninsula. However, these conclusions are based on only six surveys in spring and four surveys in the autumn.

Production, expressed as the average number of goslings per family group during autumn migration, suggested that those Emperor Geese that raise young have relatively large families (average of 2·4 to 3·4 young per year) as compared with Snow Geese *A. caerulescens* (1·0 to 2·6 young) and White-fronted Geese *A. albifrons* (1·8 to 2·5 young) that wintered on the Pacific Coast between 1961 and 1980 (U.S.F.W.S., unpub.). There has been no obvious decline in average brood size of Emperor Geese between 1966 and 1980. Thus, we believe that any recent decline in the number of Emperor Geese cannot be attributed to factors that would have reduced the average number of young per brood surviving through autumn migration.

Production, expressed as the proportion of young Emperor Geese in the population, was low in three of four years between 1976 and 1980, with the average for the four years being only 14·7% young during years of normal and late spring break-up (such as 1964). This percentage is lower than would normally be expected for stable populations of other geese—e.g., 26–50% young for White-fronted Geese between 1961 and 1980 on the Pacific Coast (U.S.F.W.S., unpub.). With such low production, Emperor Geese might be unable to maintain their present population level, particularly if hunting or natural mortality were to increase. However, rates of mortality have yet to be estimated; therefore, precise predictions of population trends are not possible.

We believe that further studies of Emperor Geese are necessary before we can precisely monitor the status of this species. In particular it is necessary to: (1) determine the number of Emperor Geese in the population; (2) determine the natural mortality rates and annual hunting mortality of young, subadults, and adult geese; (3) collect and evaluate unbiased data on age ratios of geese during spring and autumn migrations each year; (4) identify habitats primarily used by geese on the breeding areas, staging areas, and wintering areas; and (5) determine more precisely the importance of each estuary to staging and migrating geese.

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Summary

We gathered information on the timing of spring and autumn migration of Emperor Geese *Anser canagicus* from Nelson Lagoon, the age ratios of geese during autumn migration, and the numbers of geese in estuaries along the north side of the Alaska Peninsula and Bristol Bay during

spring and autumn migration. Birds staged in most of the lagoons and bays along the north side of the Alaska Peninsula, but Nelson Lagoon and Seal Islands Lagoon were the most heavily used. Geese concentrated in Nelson Lagoon for about six to eight weeks in both spring and autumn. We suspect that the population of Emperor Geese in Alaska may have declined by as much as 34% between the 1960's and 1981. Although the average number of young per successful breeding pair has remained high during this period, the overall proportion of young in the population has been extremely low, at least during the past five years. More studies are necessary to determine factors influencing the status of this species.

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