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DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF
FALL STAGING LESSER SNOW GEESE ON
COASTAL HABITATS OF NORTHEAST
ALASKA AND NORTHWEST CANADA, 1980 and 1981

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Key Words: snow geese, Anatidae, waterfowl, staging waterfowl,
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Distribution, abundance, and productivity of fall staging Lesser Snow Geese in coastal habitats of northeast Alaska and northwest Canada, 1980 and 1981.

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Abstract: Since 1971 biologists from L.G.L. Ltd., Canadian Wildlife Service, and U.S.F.W.S. have monitored the distribution, abundance, and productivity of lesser snow geese which stage in late August and early September in the arctic coastal regions between Parry Peninsula, Northwest Territories and the Canning River, Alaska. All portions of the staging area were surveyed 1973-76 and 1981; only the Alaska and/or Yukon portions were surveyed 1978-1980.

Lesser snow geese in the region originate from 3 nesting colonies in Canada: Banks Island, Kendall Island and Anderson River delta. Breeding birds were photo-estimated at 152,550 in 1976 and 207,525 in 1981, with an additional 100,000 non-breeding adults also present in the region. These 250-300,000 adults and a variable number of young snow geese produced on the colonies stage between Parry Peninsula in the east and the Canning River in the west. Total numbers were estimated at a minimum of 114,939 in 1974, a maximum of 706,277 in 1975 and 430,000 in 1981. Distribution during fall staging varies annually. In 1975 an estimated 20,972 snow geese used the Alaska and Yukon Territory areas and 685,305 were estimated staging on the Mackenzie delta. For 1978, 325,760 snow geese were estimated staging in the Alaskan portion alone. In 1981 an estimated 20,000 were staging on the Alaska coastal plain while an estimated 80,000 staged in the western half of the Yukon Territory coastal plain. Snow geese departed the area 16-18 September 1981 as the tundra lakes were freezing over. Major departure in previous years has ranged from 7 to 27 September. Age ratio varied between 1% young birds in 1974 and 119% young birds in 1973. In 1981, when the most extensive age ratio sampling to date was obtained, the percent young was greatest south of Liverpool Bay (30-40%), intermediate between the Mackenzie delta and Herschel Island (12%), and lowest between Komakuk Beach and Barter Island (7%). Such spatial variation in age ratio combined with high annual variation in distribution and abundance dictates that future sampling efforts be planned to include all major staging areas in the region, which will necessitate extensive surveys and coordination between Canadian and Alaskan biologists.

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Distribution, abundance, and productivity of fall staging Lesser Snow Geese in coastal habitats of northeast Alaska and northwest Canada, 1980 and 1981.

The arctic coastal plain of eastern Alaska and Yukon Territory, the Mackenzie River delta and surrounding treeline habitats are a major fall staging area for an annually variable number (100,000-700,000) of lesser snow geese (Barry 1967, Gollop and Davis 1974, Patterson 1974, Schweinsburg 1974, Koski and Gollop 1974, Koski 1974, 1975, and 1977). In some years (e.g. 1976), a large proportion of these geese have spent up to three weeks staging on the north slope of the Arctic National Wildlife Refuge (Koski 1977, Spindler 1978). This report summarizes continued efforts at monitoring snow goose activities on ANWR after completion of the Arctic Gas studies in 1977. Specific objectives were to: 1) determine the chronology of migration and staging, 2) estimate the peak numbers of snow geese present during staging, 3) determine distribution and age ratios and 4) identify habitat areas and types used consistently.

Methods

Distribution and abundance were sampled by aerial survey of a grid first sampled in 1973 (Koski 1975). Transect lines were spaced 9.7 km apart, and extended from the Beaufort Sea coastline inland to about the 300 m contour in Alaska, and the 500 m contour in Yukon and Northwest Territories. Transect width was 1.6 km 1973-1975 (Koski 1973-1976) and 2.4 km 1976-1981 (Koski 1977, Spindler 1978a, Spindler 1979). The change to the 2.4 km-wide transect was made by Koski (1977) because it was shown to be better for estimating snow goose numbers than the 1.6 km width. Transects were flown at an altitude of 150 m above ground level, and an airspeed of 200 km/h. While on transect total number in each snow goose flock was visually estimated and also photographed. Flocks on and off transect were recorded on 1:250,000 topographic maps according to location, flock size, and direction of flight. In the studies since 1978 (Spindler 1978a, Spindler 1979, and this study) a deliberate attempt was made to record direction of flight and to keep track of where an airborne flock landed to avoid double-counting from an adjacent transect. Aerial photographs were taken of large flocks on the transect which when accompanied by visual flock size estimates assisted in quantifying estimation error and visibility bias. Usually a survey crew included 3 persons, pilot-observer, observer, and photographer, although some surveys were flown with only 2 persons. Aircraft types used during the surveys varied with availability, but included DHC-2T turbo-Beaver, Helio-courier H-295, Cessna 185, and Cessna 207. Age ratio was sampled along the same transects by visual counts 1973-1977, and by photography 1979-1981. A 35-mm camera with 135 mm telephoto lens was used.

Total goose population staging in the area, arrival and departure dates, and age-ratios among the various years of survey data are affected by the following factors that are not easily quantified or controlled: (1) differing dates of survey and portions of areas covered on particular dates, largely due to inclement weather and logistical difficulties; (2) varying seasonal weather conditions in each year, and: (3) annual, daily, and spatial variation in age ratio, populations, and distribution. Other major factors complicating comparisons, but which can be controlled, are survey methods employed in the various years (techniques are steadily being refined and improved) and

standardization of environmental conditions under which the surveys are conducted.

In the first years of survey, 1971-1972, emphasis was on description of timing and size of migration movements, largely from ground observations but accompanied by aerial survey (Schweinsburg 1974, Gollop and Davis 1974). From 1973-1976 the most extensive systematic aerial surveys were conducted (Koski and Gollop 1974, Koski 1975, 1977a, 1977b): population estimates were derived from extrapolation of transect counts and age ratios were obtained from actual aerial and ground composition counts. The ANWR surveys made in 1978-1980 emphasized systematic transect surveys with population estimates made by extrapolation in 1978, and total flock counts combined with photographic counts in 1979 and 1980 (Spindler 1978a, 1979). Age ratios were determined from photographic counts in the latter 2 years. In 1981 the Mackenzie delta, Yukon north slope and Alaska north slope were surveyed using the transect survey grid and photography. Some portions of the Canadian area were surveyed a few days before the Alaska area, but the vast majority of flocks were sampled on both areas on the same day, hence, eliminating some of the temporal variability. This survey required simultaneous efforts on the part of FWS and CWS biologists. Additionally, in 1981, visual estimates of numbers and age ratios made by pilots (experienced at snow goose survey methods) were incorporated because a majority of the geese staged in an area that is rarely used for staging but which was not discovered to have been used in 1981 until after the survey was over (Barry 1982).

Results and Discussion

Chronology

Snow geese which stage in the study area nest in 3 colonies: Banks Island (Egg River 198,125 nesting birds; Anderson River delta, 8,359 birds; and Kendall Island, 1,041 birds (Barry 1982). An additional 100,000 non-nesting birds were estimated to have been present in the region in 1981 (Barry 1982). Adults with young depart the nesting colonies between mid- and late August, arriving first on the Parry Peninsula where they exercise and feed (Barry 1967). Depending on weather and the season, geese then spread westward from the Mackenzie River delta to occasionally as far west as the Canning River, Alaska. First arrival dates in the Mackenzie River delta to Barter Island area have varied between 13 August (1976) and 24 August (1979 and 1981) (Table 1, Fig. 1). Major date of arrival has ranged from 19 August (1980) to 3 September (1975). In some years the period between first arrival and major arrival was only 2 days (1979 and 1980) whereas in most other years it was 5-12 days (Fig.1).

The staging period, during which there is little movement, had a minimum duration of 7 days (1972) but in most years was 15-22 days long; maximum duration was 22 days (1974) (Fig.1). Mean duration of staging was 13.7 days (Table 1). Departure tended to be more compressed than arrival, with last date of observation 4-15 days after major departure had begun. The earliest major departure started 1 September (1980), and the latest major departure began 22 September (1973) (Table 1, Fig. 1). In 3 of the 10 years for which chronology data are available, the last snow goose observation was only 2-3 days after major departure ended. These were years in which freeze-up came suddenly. Koski (1974:13) suggested that weather most likely exerted the major influence upon timing and extent of arrival and departure movements.

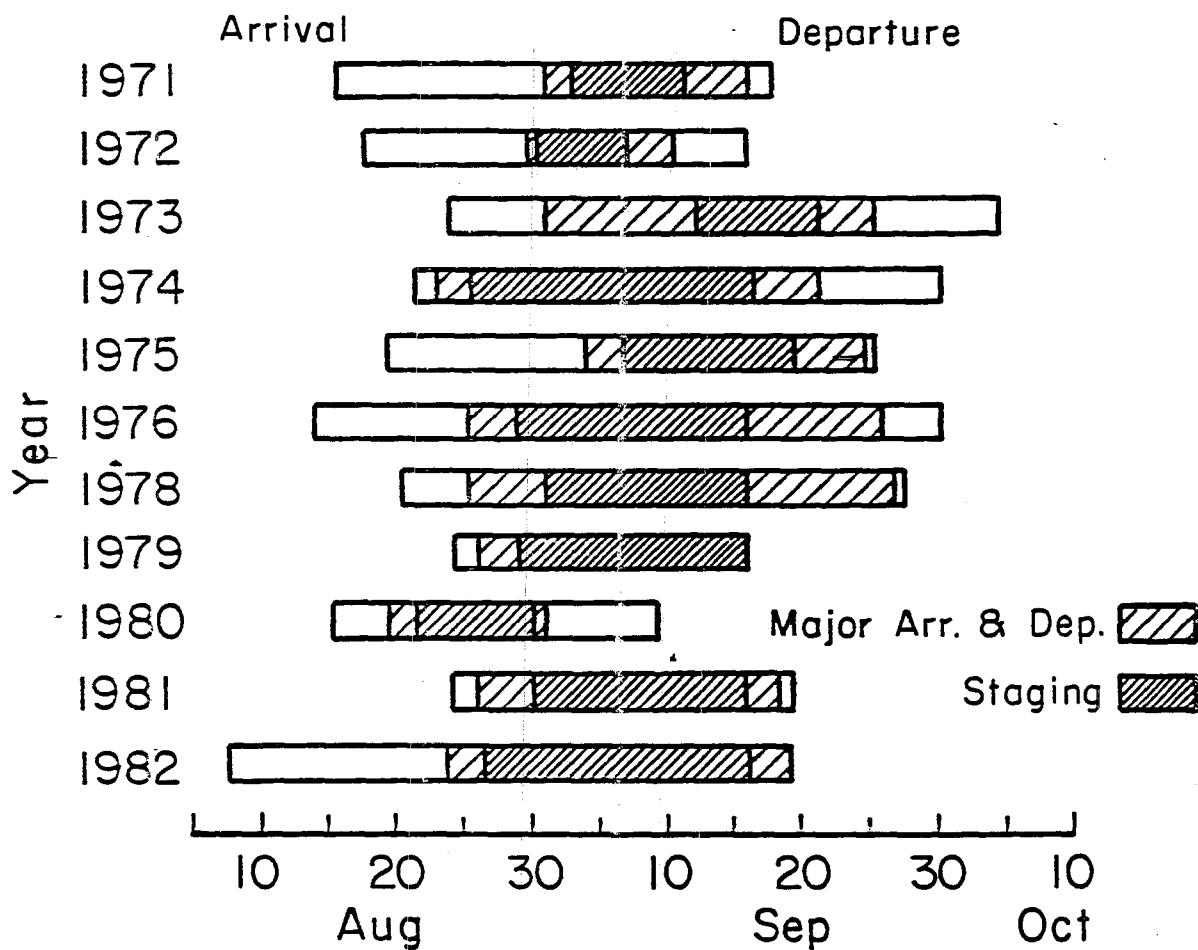


Fig. 1. Chronology of arrival, staging and departure of the western arctic population of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge, Alaska, the Yukon Territory north slope and the Mackenzie River delta, N.W.T.

Table 1. Dates of arrival and departure of snow geese on the Mackenzie River Delta, Yukon north slope, and Eastern Alaskan north slope, August and September 1971-1976 and 1978-1981. The 1978-1981 data are from Arctic National Wildlife Refuge only.

Year	Date first flock sighted	Dates of major arrival	Duration of staging (days)	Major departure	Date last flock sighted	Survey period ^a
1971 ^b	15 Aug.	31 Aug.-2 Sept.	9	12-16 Sept.	17 Sept.	4 June-19 Sept.
1972 ^c	17 Aug.	27-29 Aug.	10	7-10 Sept.	15 Sept.	10 July-17 Sept.
1973 ^d	23 Aug.	1-12 Sept.	9	22-25 Sept.	4 Oct.	25 Aug.-29 Sept.
1974 ^e	21 Aug.	22-25 Aug.	22	17-21 Sept.	30 Sept.	24 Aug.-30 Sept.
1975 ^f	18 Aug.	3-5 or 6 Sept.	12	19-24 Sept.	25 Sept.	20 Aug.-25 Sept.
1976 ^g	13 Aug.	25-28 Aug.	18	16-26 Sept.	30 Sept.	15 Aug.-2 Oct.
1978 ^h	20 Aug.	25 Aug.-1 Sept.	14	16-27 Sept.	27 Sept.	10 June-5 Oct.
1979 ⁱ	24 Aug.	26-28 Aug.	17	15 Sept.	N/D	10 June-12 Sept.
1980 ^j	15 Aug.	19-21 Aug.	10	1-2 Sept.	9 Sept.	5 June-12 Sept.
1981 ^k	24 Aug.	26-30 Aug.	16	16-18 Sept.	18 Sept.	11 July-20 Sept.

33

^a Dates inclusive of aerial and ground observation period. Locations of ground observation and aerial survey coverage varied: 1971-1976 data emphasized Mackenzie and Yukon locations, while 1978-1981 data emphasized Alaskan locations. For details see respective sources:

^b Schweinburg (1974)

^c Gollop and Davis (1974)

^d Koski and Gollop (1974)

^e Koski (1975)

^f Koski (1977a)

^g Koski (1977b)

^h Spindler (1978a)

ⁱ Spindler (1979)

^j Spindler (1980)

^k Unpublished data, ANWR files

Johnson et al. (1975) reported that the main departure from the north slope occurs just ahead of freeze-up.

Distribution

Patterns of spatial distribution on the Yukon north slope and Alaska north slope for 1973-1976 were presented by Koski and Gollop (1974) and Koski (1975, 1977a, 1977b). Analysis of snow goose distribution in the current study included that portion of the north slope staging area within ANWR, 1973-1981.

Generally, spatial distribution within ANWR has been extremely variable (Fig. 2-4). In 1974, 1976, 1978, and 1979, snow geese staged on a widespread portion of ANWR, generally east from the Hulahula River to the Aichilik River and extending inland from the coast to roughly the 305 m contour line. Staging in other years was restricted to certain localities or portions of the coastal plain. In 1973, the use centered along the Aichilik River and extended northwest to the Niguanak River (Fig. 2). In 1975 no large concentrations were observed staging on the ANWR coastal plain (Koski 1977a). Snow goose surveys were not conducted in 1977. In 1980, snow goose distribution, as determined from boat surveys along coastal lagoons in late August, extended from Demarcation Bay west to Beaufort Lagoon, however, it is not known how far inland the area was used (J. Levison, unpubl. data). When the 1980 aerial survey was conducted (9-10 September 1980), the only snow geese observed on the ANWR coastal plain were north of VABM Dar near the Kongakut River and directly on the U.S.-Canada border; much of the population had staged on the Yukon north slope (Spindler 1980). Distribution of snow geese on ANWR in 1981 was again fairly widespread, extending in a 20-25 km wide band north of the 305 m contour line from the Okpilak River east in the Yukon north slope. There was also a small aggregation close to the coast between the Hulahula and the Jago Rivers (Fig. 4).

The available data (1973-1981) indicate that some "core" snow goose staging areas on ANWR can be defined. In years of lower staging population on ANWR (e.g. 1973, 1974, 1980 - possibly, and 1981), staging occurred on limited portions of the ANWR coastal plain, but in all these years (except possibly 1980) 2 "core" areas were used: 1 between the Okerokovik and Jago Rivers north of the 305 m contour line, and the other between the Aichilik and Sikutaktuvik Rivers between the 122 and 305 m contour lines (Fig. 2-4). These core areas were also used in years of high staging population (e.g. 1976, 1978, 1979), but in those years staging also occurred in more widespread areas over the entire coastal plain east of the Hulahula River. Significant staging was documented west of the Hulahula, in 2 years, 1976 and 1979, (Fig. 3 and 4) although small groups of snow geese have also been observed at the Canning delta during the staging period (in 1975, 300 birds on 26 August 1979, 45 and 85 birds on 28 August 1980, 40 and 20 birds on 31 August 1979, and 16 birds on 9 September 1980) (Martin and Moitoret 1981). In 1976, a large staging aggregation was documented in the Carter Creek area and between the Hulahula River and Sadlerochit River (Fig. 3). In 1979 staging occurred along the lower 10 km of the Sadlerochit River (Fig. 2).

FIG. 2 DISTRIBUTION OF ALL STAGING SNOW GEESE

DOCUMENTED AREAS USED BY FLOCKS OF SNOW GEESE
AUGUST AND SEPTEMBER 1973, 1980, 1981

Scale 1:500,000

Miles 6 0 6 12



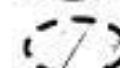
LEGEND

SOURCE



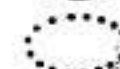
1973

KOSKI AND GOLLO



1980

SPINDLER UNPUBL



1981



FIG. 3 DISTRIBUTION OF FA STAGING SNOW GEESE

DOCUMENTED AREAS USED BY FLOCKS OF SNOW GEESE
AUGUST AND SEPTEMBER 1974, 1976

Scale 1:500,000
Miles 6 0 6 12

LEGEND

SOURCE

- | | | |
|---|------|---------------|
| ○ | 1974 | KOSKI (1975) |
| ○ | 1976 | KOSKI (1977b) |

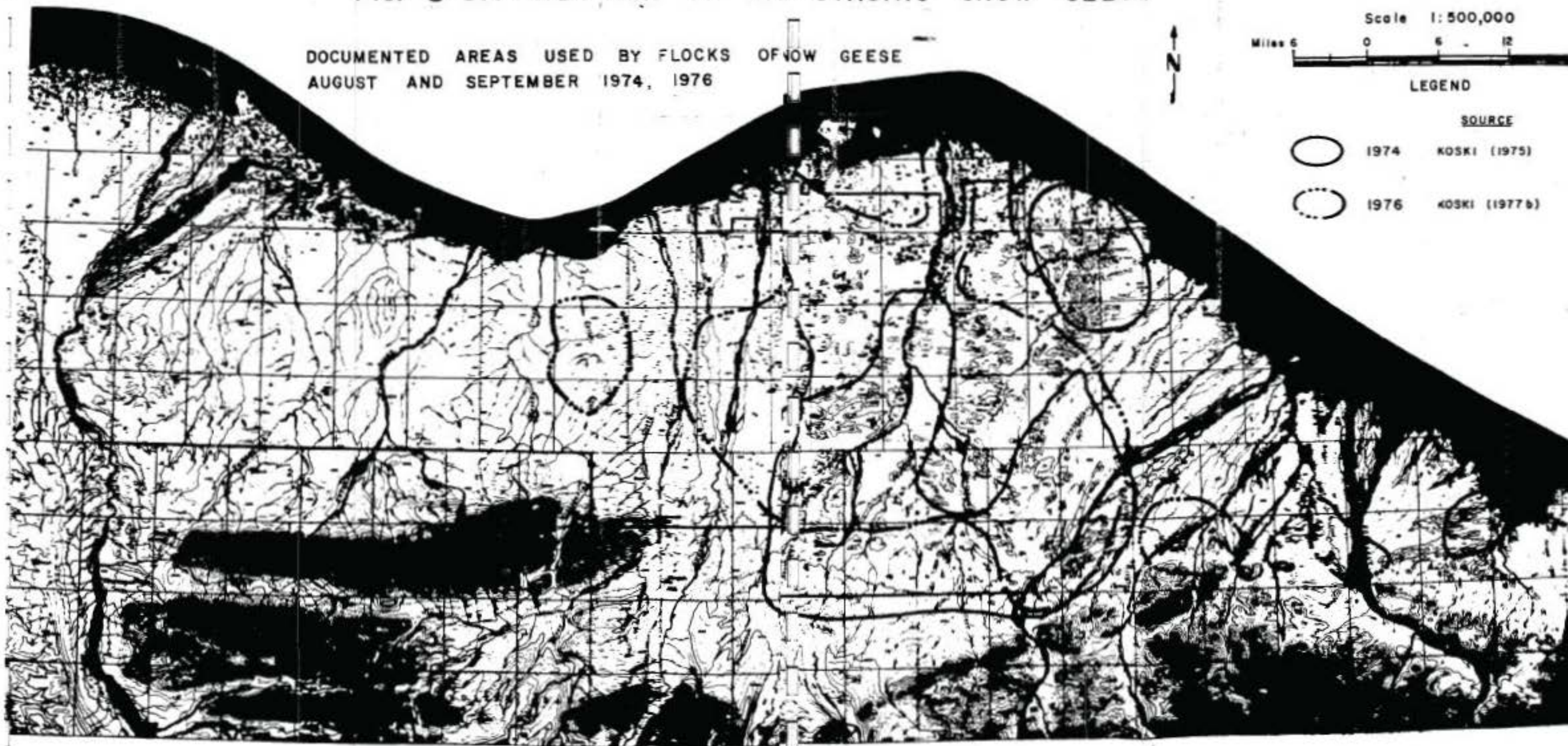


FIG. 4 DISTRIBUTION OF FALL STAGING SNOW GEESE

DOCUMENTED AREAS USED BY FLOCKS OF SNOW GEESE
AUGUST AND SEPTEMBER 1978, 1979

Scale 1:500,000

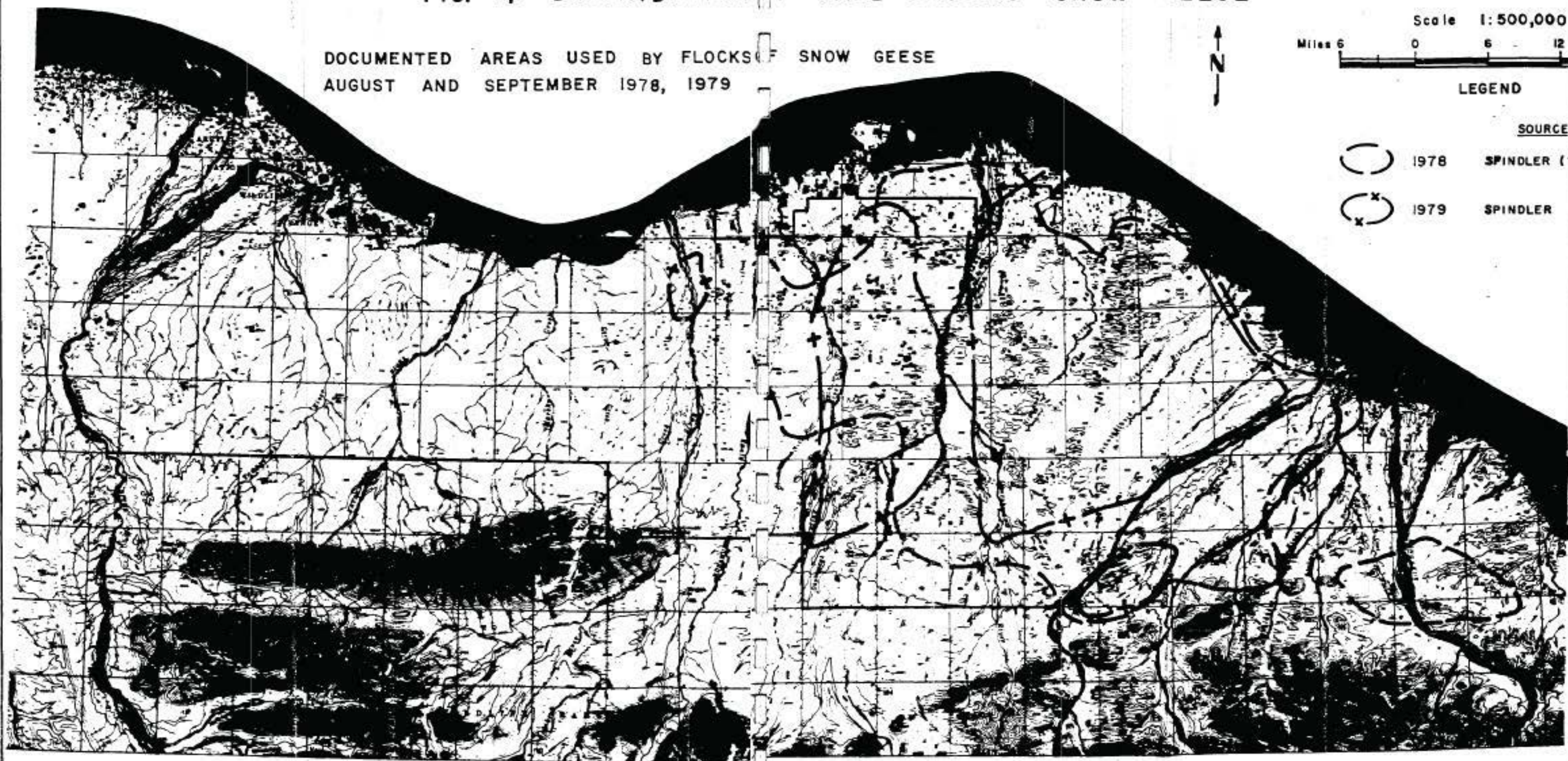
Miles 6 0 6 12

LEGEND

SOURCE

○ 1978 SPINDLER (

○^x 1979 SPINDLER



Habitat Use

Core concentration areas used by snow geese consisted of several tundra types, as determined from examination of snow goose distribution maps (this report) and LANDSAT vegetation maps (by Nodler 1977 [first name]; and USFWS 1982, [numeric abbreviation followed by name]). These habitat types are ranked in general order of their magnitude of use by snow geese.

- | | | |
|--------------------------|----------------|------------------------------------|
| 1. Upland sedge meadow | 5a | moist sedge-prostrate shrub tundra |
| 2. Tussock meadow | 6a,6b,7a,7b,7c | several moist tundra complexes |
| 3. Wet sedge meadow | 3a | wet sedge tundra |
| 4. Flooded sedge meadow, | 2b,3b,3c | wet sedge tundra- |
| Very wet sedge meadow | | very wet complexes |

Snow geese grazing on the outer coastal plain of ANWR have been observed feeding on sedge rootstocks. At the Okpilak River delta Spindler (1978b) described an area several ha in size in a homogeneous wet sedge-tundra habitat where 34 snow geese had been grazing overnight "... nearly every live Carex plant was uprooted and the tuber and green shoots eaten, leaving only the actual roots and dead or dying leaves in scattered feeding sites several m in diameter." Martin and Moitoret (1981) observed 300 snow geese grazing on wet sedge tundra-very wet complex (3c) and another flock of 45 grazing on wet sedge tundra-non complex on the Canning Delta. J. Levison (unpubl. data) observed snow geese clipping and uprooting Carex Bigelowii in the Beaufort Lagoon area in late August 1978. Schmidt (1970) reported that snow geese left the coastal tundra near Beaufort Lagoon in early September 1970 and migrated inland to feed primarily on berries (probably Empetrum nigrum) located in higher dry tundra. The relative importance of inland berry food sources compared to the coastal rootstock food sources is unknown. Also the extent of use of sedge rootstocks in the interior coastal plain is unknown.

Population

The maximum number of snow geese estimated using the Mackenzie delta and the north slopes of Yukon and Alaska was over 700,000 in 1975, a year when no geese were observed staging on ANWR (Table 2). Barry (1982) estimated 430,000 left the region for wintering grounds in September 1981 (Table 2). The maximum estimated numbers of snow geese occurring on ANWR was over 325,000 in 1978 (Table 2). Between 1973-1981, 3 years had estimated numbers on ANWR greater than 190,000; 3 years had between 20,000 and 50,000; and 2 years had less than 20,000 (Table 2). As mentioned previously, survey conditions and extrapolation methods have changed, and survey coverage was different among years, therefore, these abundance figures represent gross estimates of numbers present and should not be construed as accurate population estimates.

Productivity

The most extensive age-ratio sampling to date was obtained in 1981 (Table 3). The entire survey area (Mackenzie River delta west to Barter Island) had a photo-estimated ratio of $11.3\% \pm 4.1\%$ young birds (weighted mean \pm variance, Table 3). Additionally a "guestimated" composition of 30-40% young birds was made for the area west of Paulatuk, a rarely used staging area that harbored the majority of western arctic snow geese in early September 1981 (Barry 1982). Barry (1982) reported the distribution of snow geese in the Mackenzie delta area was radically different from previous years: "On 5-6 September...250,000 or more snow geese...staged in the vicinity of Paulatuk

Table 2. Total numbers of western arctic snow geese counted during August-September staging surveys, Arctic National Wildlife Refuge coastal plain and areas to the east, 1973-1981.

Year	Alaska	Yukon north slope	Mackenzie River delta	Total	Survey dates
1973 ^a	44,037	126,960	86,520	257,517	Sept. 2,3,5,6,11,12,18,22,23,25
1974 ^a	48,591	37,435	28,913	114,939	Aug. 24,31, Sept. 5,11,16,25
1975 ^a	0	20,972	685,305	706,277	Aug. 25-28, Sept. 8,10,11,13,17-18,20,23
1976 ^a	228,793	224,401	18,363	471,557	Aug. 16-20,29-31, Sept. 4-6,10-13,18-21
1978 ^b	325,760	N/D	N/D	N/D	Sept. 13-14
1979 ^c	195,000	41,000	N/D	N/D	Sept. 6-7
1980	8,996 ^d	7,500 ^e	N/D	N/D	Sept. 9
1981	20,000 ^f	80,000 ^f	330,000 ^f	430,000 ^f	Sept 14,16,20

Sources: ^a Koski 1977b, extrapolation from transects at several points in time, not all areas covered on each date.
^b Spindler 1978a, extrapolation from transects at 1 point in time.
^c Spindler 1979; note Yukon count incomplete, Demarcation Bay to Phillips Bay, estimates of all flocks seen, and photograph counts, at 1 point in time.
^d Ground counts by J. Levinson, estimates of all flocks seen in continuous count during daylight hours.
^e Estimated total; Actual photograph count was less; Demarcation Bay to Phillips Bay.
^f Visual estimates of flock size, Yukon sample includes only area from U.S.-Canada border to Phillips Bay.
^g Barry 1982. Includes 250,000 geese estimated to have staged south and west of Paulatuk, which is east of the Mackenzie delta.

and westwards across the Parry Peninsula and the plains of the middle part of the Horton, Anderson and Smoke Rivers near the tree line." This distribution resulted in separation of subgroups, with groups having higher young ratios using the Paulatuk area and groups of non-breeders or groups with lower young ratios using the Mackenzie River delta, and Yukon and Alaska north slopes. Apparently this separation of cohorts persisted throughout their fall migration in Canada (Barry 1982).

Spatial variation in age ratio is expected when family groups with higher proportions of young do not migrate as far west to stage as do those with lower proportions of young. This pattern is suggested by the data (Table 3) where mean percent young (weighted according to flock size + weighted variance) was $7.4 \pm 9.2\%$ from Barter Island to Komakuk Beach, and $11.8 \pm 8.3\%$ from Herschel Island to Inuvik, both of which were sampled simultaneously on 16 September 1981. Additionally, the 250,000 birds containing 30-40% young reported from Paulatuk, still farther east, suggests a tendency of increasing percent young from west to east.

Age ratio data are available for western arctic snow geese from 1973-1981 (Table 4). Again, direct comparisons are not possible because of differing survey coverage and weather conditions in some years. For years with similar survey coverage and intensity (1973-1976) age ratios varied from a maximum of 119% young in 1973 to a minimum of 1% in 1974. Some variation in annual productivity was occurring, however these data do not provide a basis for accurately assessing this variation for the entire population. Productivity of the western arctic snow goose populations can be affected significantly by bad weather, particularly in June during hatching (Barry 1967).

Conclusions

Available distribution, abundance, and productivity data indicate a high degree of spatial and temporal variation. This variation is largely due to annually varying weather conditions, and within the staging season, variable survey conditions which caused differences in survey coverage and intensity between years and areas.

In order to maximize consistency of data collection wherever possible, the following are recommendations for standardizing survey methods and conditions:

- (1) Continue cooperative USFWS-CWS surveys, by agreeing to areas of sampling responsibility and uniformity in sampling methods.
- (2) Continue systematic sampling of the transects initiated by Koski (1973).
- (3) Use a combination of photography and visual estimates to determine total flock size. Visual estimates are more efficient with extremely large flocks (greater than 10,000 birds) and small flocks (less than 400 birds). Include double sampling procedures to estimate accuracy of visual estimates.
- (4) Use photography for age ratio estimation.

Table 3. Results from 1981 USFWS-CWS cooperative survey of age ratios of staging western arctic lesser snow geese, 11-24 September 1981. Percent young expressed as a mean followed by variance weighted according to flock size.

Location	Date	Adults	Young	Total	No. of flocks	% Young
Inuvik to Bathurst Penn.	24 Sept.	150	0	150	0	0
Tuktoyaktuk Penn., Liverpool Bay, Bathurst Penn.	11 Sept.	1030	43	2073	4	4.0 \pm 4.0
Mackenzie Delta, Shallow Bay, Southern Richards Island	12 Sept.	156	54	210	2	25.7 \pm 321.2
Escape Reef, Blow River, Ellice Island	13 Sept.	40	0	0	1	0
Herschel Island to Inuvik to Outer Mackenzie Delta	16 Sept.	34,940	4713	39,653	46	11.8 \pm 8.3
Barter Island to Komakuk Beach	16 Sept.	3377	272	3649	6	7.4 \pm 9.2
All areas surveyed		39,693	5082	44,775	59	11.3 \pm 4.1

Table 4. Comparison of age ratios for western arctic snow geese staging on the Alaska and Yukon north slope, and Mackenzie River delta 1973-1976 (Koski 1977b) and 1979-1981 (USFWS 1982, Barry 1982, and this study).

Year	Adults	Young	% Young	Area of survey	Technique
1973	4533	5399	119.1	MD, YNS, AK ^b	Comp. count
1974	28,647	29	1.0	MD, YNS, AK	Comp. count
1975	12,223	13,638	111.6	MD, YNS, AK	Comp. count
1976	7375	5541	75.1	MD, YNS, AK	Comp. count
1979	4275	133	3.1	YNS, AK	Photo
1980	1046	37	3.3+1.2 ^a	YNS, AK	Photo
1981	39,693	5082	11.3+4.1 ^a	MD, YNS, AK	Photo
1981	175,000	75,000	30.0	Paulatuk and south-west	Comp. count (estimate) ^c

^a Mean percent young + variance weighted according to flock size of samples.

^b MD- Mackenzie River Delta; YNS-Yukon North Slope; AK-ANWR, Alaska

^c Since Paulatuk is a rarely used staging area, no quantitative survey was conducted. Data are estimates made by experienced biologist.

- (5) Time survey to occur about 20 days after the first arrival date or 7 to 10 days after the major arrival dates each year, irrespective of calendar date. This timing would increase the likelihood that the survey would coincide with maximum staging population, and would minimize temporal variation of age ratio due to varying survey dates.
- (6) Conduct the survey under the following minimum environmental conditions: (1) no snow cover, (2) ceilings greater than 150 m, (3) visibility greater than 16 km, and less than moderate turbulence (as defined by F.A.A.).
- (7) Conduct the survey under good lighting conditions (i.e. allowing shutter speeds of 1/500 or 1/1000 second using ASA 400 film). Avoid heavy overcast days, or early morning/late evening hours. Use large format (6x7 cm) cameras with 250 mm telephoto lens whenever possible.
- (8) The survey crew should be proficient in estimation of flock sizes, having recently practiced with photographs of known flock size or rice grains on a dark table. The crew should also be familiar with the area.

Normal north slope weather conditions, may preclude meeting all of these criteria, however, as much consistency as possible should be achieved. Most important of all is that an adequate extent of area be sampled in as short as possible a time during the peak of staging. Criteria 1, 5, 6, and 7 should be met or the survey is hardly worth conducting.

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Appendix

ANWR Progress Report Number FY83-1

Table A-1. Photographic count results used to determine age ratios of snow geese in 1979, Arctic National Wildlife Refuge, Alaska and western Yukon Territory, north slope, 10 and 13 September 1979. (See Spindler 1979 for analysis of data). Specific area included in sample was between the Hulahula River and Kay Point.

Photo I.D. roll & frame	Flock number	Adults	Total geese Young	in sample	% young
10 September					
1-10A	Flock X	590	18	608	3.0
3-15	Flock 10	465	3	468	0.6
3-13	Flock 9	121	1	122	0.8
3-12	Flock 9	201	0	201	0.0
3-1	Flock 6	26	2	28	7.1
4-26	Flock 20	178	0	178	0.0
4-27	Flock 20	177	12	189	6.3
4-28	Flock 21	51	2	53	3.8
4-29	Flock 21	63	3	66	4.8
4-31	Flock 22	90	3	93	3.2
4-32	Flock 22	208	13	221	5.9
4-33	Flock 22	74	0	74	0.0
4-6	Flock 15	168	7	175	4.0
4-3	Flock 14	20	0	20	0.0
4-12	Flock 17	94	4	98	4.1
4-10	Flock 16	99	5	104	4.8
4-5	Flock 15	38	0	38	0.0
4-16	Flock 18	119	1	120	0.8
4-18	Flock 18	195	2	197	1.0
4-11	Flock 17	134	4	138	2.9
13 September					
5-4	Flock 1	300	5	305	1.7
5-6	Flock 2	53	11	64	17.2
5-7	Flock 3	51	29	80	36.3
5-11	Flock 6	184	0	184	0.0
5-14	Flock 7	93	1	94	1.1
5-15	Flock 7	79	0	79	0.0
5-16	Flock 8	404	7	411	1.7

Table A-2. Photographic count results used to assess accuracy of snow goose flock size visual estimates made in 1979, Arctic National Wildlife Refuge, Alaska and western Yukon Territory north slope, 10 and 13 September, 1979. (See Spindler 1979 for analysis of data).

Photo I.D. frame number	Snow geese as counted on photo after survey	Snow geese as estimated visually during survey
6A	533	1200
4A	2175	4000
10A	608	750
12A	748	1100
15A	4675	18,000
17A	2254	4000
19A	451	700
21A	179	150
22A	443	200
23A	2742	4500
25A	1020	600
27A	1690	600
29A	578	450
31A	1139	2500
32A	414	350

Table A-3. Photographic count results used to determine age ratio in 1980. Arctic National Wildlife Refuge, Alaska and western Yukon Territory north slope, 9 September 1980. (See Spindler 1980 for analysis of data). Specific area included in sample was between Demarcation Bay and Herschel Island.

Flock number	Flock size	Photo subsample				Total flock			
		Ad.	Young	Tot.	% Young	Ad.	Young	Tot.	% Young
1	13	10	3	13	23.1				
2	1115	410	4	414	2.8				
3	542	60	0	60	0				
4 A	458	76	2	78	2.6	63	7	70	10.0
4 B	150	50	5	55	9.1				
5	25	22	3	25	12.0				
6	188 ^a	71	0	71	0	150	2	152	1.3
7 A	No data ^b	51	8	59	13.6				
7 B	No data	46	3	49	6.1				

A Subsample total exceeds total flock size, indicating photographs of flocks (subsamples) overlapped.

B Photographic quality unsuitable for counting.

Table A-4. Count results used to determine age ratios of snow geese in 1981, Arctic National Wildlife Refuge, Alaska, Yukon Territory north slope, and Mackenzie River delta area, N.W.T. 11-24 September, 1981. Specific areas included in samples are given below, all counts (visual) by T. Barry, Canadian Wildlife Service, except for 16 September (Photographic) by Arctic NWR.

Date	Adults	Young	Total geese in sample	% Young
11 September.	Tuktoyaktuk Peninsula, Bathurst Peninsula, South shore of Liverpool Bay. Fog Patches. (Visual).			
	500	0	500	0
	100	0	100	0
	330	18	348	5.2
	100	25	125	20.0
12 September.	Mackenzie Delta--Shallow Bay, Southern Richards Island. Fog on outer delta and coastal region to east and west. (Visual).			
	150	44	194	22.7
	6	10	16	62.5
13 September.	Escape Reef, Blow River, parts of Ellice Island. Snow squalls and fog. (Visual).			
	40	0	40	0
16 September.	Barter Island to Komakuk Beach: windy, tubulent, patchy fog. (Photographic).			
<u>Photo I.D.</u>				
1-18	556	19	575	3.3
2-6	548	26	574	4.5
2-11	170	7	177	4.0
2-21	316	24	340	7.1
2-32	995	59	1054	5.6
3-2	792	137	929	14.7
16 September.	Inuvik to Herschel Island to outer Mackenzie Delta. Blowing snow, fog, winds west-northwest 80 km/h. High turbulence. Migration had begun. (Visual).			
(in 30 flocks)	22,872	0	22,872	0
	500	300	800	37.5
	4	8	12	66.7
	6,500	2,275	8,775	25.9
	1,450	400	1,850	21.6
	4	6	10	60.0
	1,000	300	1,300	23.1

Table A-- (Continued).

Date	Adults	Young	Total geese in sample	% Young
	115	60	175	34.3
	70	60	130	46.2
	600	550	1,150	47.8
	50	60	110	54.5
	340	60	400	15.0
	53	22	75	29.3
	12	12	24	50.0
	560	240	800	30.0
	40	30	70	42.9
	770	330	1,100	30.0
24 September.	Inuvik to Bathurst Peninsula. Freeze-up of higher lakes. (Visual).			
	150	0	150	0

Table A-5. Summary of photographic count efforts for snow goose age ratio and flock size determination, Arctic National Wildlife Refuge, Alaska, and Yukon Territory north slope.

Year	Frames exposed for total count	Frames usable for total count	Frames exposed for age ratio	Frames usable for age ratio
1979	39	15	118	27
1980	29	7	61	11
1981	47	Not performed (too poor light conditions)	77	6



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