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DISTRIBUTION, ABUNDANCE, AND PRODUCTIVITY OF FALL STAGING LESSER SNOW GEESE ON COASTAL HABITATS OF NORTHEAST ALASKA AND NORTHWEST CANADA, ~~1983~~

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Key Words: snow geese, Anatidae, waterfowl, staging waterfowl, population, age ratio, Alaska, North Slope, Arctic National Wildlife Refuge

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Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1983.

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Abstract: The 1983 distribution, abundance, and productivity surveys of lesser snow geese staging in August and September in northeast Alaska and northwest Canada were conducted by the U.S. Fish and Wildlife Service, in cooperation with the Canadian Wildlife Service. The 1983 surveys emphasized changes in temporal and spatial distributions within the staging season through increased survey frequency and examined habitat use, feeding, and behavioral response to aircraft overflights through ground observations. Fall staging was later than the previous 11 years with major arrival occurring within the Canadian sections on 1 September and on ANWR sections on 8 September, a full 13 days later than 1982 and 2 days later than the long-term average. Peak numbers were detected on 12 September. A total of 393,000 snow geese were estimated to have been present: 12,828 on ANWR; 300,651 on the Yukon north slope; 54,523 on the Mackenzie River delta; and 25,000 south of the delta. In 1983, total numbers of geese estimated in ANWR and Mackenzie delta were much lower than the respective long-term averages (99,107 for ANWR and 172,826 for Mackenzie delta), but were much higher than the Yukon long-term average (106,312). Also on this date, age ratio aerial photography was obtained over the entire staging ground. Analysis of 94 usable aerial photographs of flocks representing 8500 geese indicated a weighted age ratio of 26.8% $\pm$ 11.0 (SD) young. Age ratios varied spatially with the highest percent young (45%) observed on the Mackenzie River delta and the lowest (14%) observed on the Yukon north slope. Productivity levels in 1983 were higher than 5 of the 9 previous years, and were higher than any recent year since quantitative photo counts were initiated. Major departures occurred from 21-26 September: by the latter date no geese were seen following 5 days of strong west wind and freezing temperatures. The departure was 5 days later than 1982 and a week later than the 11 year average. Total duration of staging was 4 days less in 1983 than in 1982 and 2 days less than the long-term average. On ANWR, snow goose distribution in 1983 occupied generally the same area between the Hulahula and Egaksrak Rivers as in previous years, except in 1983 the most frequently used "core" concentration area centered more coastally and eastward in the Aichilik, Egaksrak, and Kongakut River deltas. The Okerokovik River area, used more extensively in previous years, was not used as greatly in 1983. Snow cover in 1983 may have been a factor in this slightly-changed distribution. A majority of geese seen in ground behavior scans on the lower Aichilik River on 11 September 1983 were feeding. Observation of feeding geese and areas where geese had recently fed indicated extensive use of sedge rootstocks in wet sedge tundra and grass leaf blades in riparian areas. Snow geese on the ANWR coastal plain were as sensitive to aircraft overflights as geese from other studies in Yukon, with flushing distances averaging 3 km and altitudes up to 3000 m causing flushing in both areas. An evening aircraft overflight on the lower Aichilik River caused all geese within a 4 km radius to take flight, 70% of which left the area; however, total numbers the next morning were comparable to goose numbers the previous morning. Low altitude (less than 30 m) aircraft overflights produced less disturbance than higher altitudes, perhaps due to lessened lateral dispersion of sound.

Distribution, abundance, and productivity of fall staging lesser snow geese in coastal habitats of northeast Alaska and northwest Canada, 1983.

The fall staging of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge (ANWR) and adjacent Yukon and Northwest Territories was monitored for the twelfth year since surveys were initiated in 1971 by L.G.L., Inc. (Schweinsburg 1974). The 1983 surveys represented the sixth year of survey by refuge staff, and the fifth year of photographic age ratio sampling using methods standardized in preceeding years (Spindler 1980, 1983a). Objectives of the study were to : (1) determine the chronology of migration and staging; (2) estimate the distribution and numbers of snow geese present during the peak of staging; (3) estimate the percent young present during staging; (4) identify habitat types and areas used consistently by staging snow geese; and (5) document the normal daily activity regime of staging snow geese and determine if it changes in response to aircraft overflights. The 1983 program emphasized coordination with Canadian biologists to conduct 4 concurrent region-wide surveys during the staging season (late August, early September, mid-September, and late September). This survey design provided data that would describe population changes as well as changes in temporal and spatial distribution. A preliminary test of ground study methods for documenting feeding ecology, habitat use, and behavior, especially following disturbance by aircraft, was conducted in 1983.

Methods and Materials

Sampling procedures employed a predetermined 9.7 km-spaced grid of 2.4 km wide north-south aerial transects (Koski 1977b, Spindler 1983a). Transect surveys were flown with a Helio-courier H-295 aircraft flying approximately 150 m above ground level (AGL) at an airspeed of 200 kph. Flocks of birds encountered were assigned sequential numbers and recorded on a 1:250,000 U.S.G.S. topographic map, along with estimated flock size and direction of movement. Other information such as behavior, circling type of flight vs. migrational, and photograph frame numbers (if any) were coded to the flock number in a separate notebook. Direction of movement information was important in avoiding double counting of flocks moving towards succeeding transects. A crew of 2 persons (1 pilot/observer and 1 observer/photographer/recorder) was used to simultaneously obtain adequate photos and records. Both persons helped find flocks. The observer sitting in the right front seat photographed the total flock at a distance for a flock size estimate. At this time the observer/photographer and pilot made independent estimates of flock size, and came to an agreement as to which estimate would be recorded (usually estimates agreed to within 10%). The pilot then circled closer and age ratio photographs were taken. To avoid excessive disturbances to the geese, care was taken to not circle a flock more than once.

A Mamyia RB-67 60x70 mm large format SLR camera was primarily used for the photography, in combination with a 250 mm telephoto lens and ASA 400 TRI-X PAN film. Secondarily, a 35 mm Pentax SLR with 135 mm telephoto lens and

ASA 50 H&W VTE PAN (Ferguson and Gilmer 1980) was used. Pilot and observer/photographer/recorder used headsets interconnected through an aircraft intercom to facilitate coordination of photography, airplane movements, and record keeping. Photographs were enlarged so that each snow goose flock occupied a 20 x 25 cm sheet of photographic paper. Geese were counted with the aid of a light table. Calculation of the mean age ratio weighted according to flock size was allowable because no correlation was found between percent young and total flock size (R^2 = -0.239). Calculation of weighted mean and its variance weighted by flock size was according to the formulae recommended by S.J. Harbo (pers. comm.):

$$\bar{x}_w = \frac{\sum_{i=1}^{n} (x_i - w_i)}{\sum_{i=1}^{n} w_i},$$

where $\bar{X}_w$=weighted mean
X_i=percent young in flock
W_i=size of flock
n = number of flocks

$$V(\bar{x}_w) = \frac{\sum_{i=1}^{n} (x_i - x_w)^2 \cdot w_i \Big/ \sum_{i=1}^{n} w_i}{n}$$

Age ratio in various groups was compared with F-test and t-test (Steel and Torrie 1960). Estimation of flock size and acutal photo count comparisons were done using paired-t and linear regression (Steel and Torrie 1960).

In addition to the systematic procedures used for the 9-12 September survey, several reconnaissance flights were made over the ANWR coastal plain to provide more complete information on the arrival, staging, and emigration of snow geese. Both fixed-wing and rotary aircraft were used in these reconnaissance flights, which followed varying survey routes. Dependent on other survey schedules, weather conditions, and available daylight.

Behavioral and feeding data were gathered on the ground by 3 persons positioned in the center of a large snow goose aggregation area. A Questar 60X and 120X spotting scope was set up in a blind tent pitched on a promontory offering good visibility within a 4 km radius of surrounding terrain. Observations of flocks were made at hourly intervals using the instantaneous-scan method (Altman 1974). Counts were made of the number of birds in each flock engaged in each of 5 main activities (feeding, sleeping, preening, flying, and other), similar to methods employed by Frederick and Klaas (1982). Environmental, habitat, and responses to aircraft disturbance were also noted. A preliminary aircraft disturbance experiment was conducted (after behavioral and feeding data were recorded) using a Helio-courier H-295 aircraft flying at an altitude of 150 m.

Results and Discussion

Population and Estimation Error

In order to accurately estimate peak population using the staging ground, several sources of error must be addressed: (1) completeness and extent of area surveyed, (2) timing of survey segments -- concurrent or nearly so, or otherwise, (3) weather conditions under which surveys were conducted and,

(4) estimation error for flock size. These sources of error are minimized by standardizing the survey protocol: (1) the area of coverage is flown using a systematic survey pattern; (2) the USFWS and CWS portions of the survey are conducted concurrently, and (3) a set of minimum weather and survey conditions must be met (Spindler 1980, 1983a). Estimation error was first addressed in the 1982 survey data when a correction factor of 1.2 was determined and used to correct visual estimates based upon actual photo counts of flocks (Spindler 1983b).

Actual numbers of snow geese counted on 15 photographs of total flocks were compared to instantaneous visual estimates of corresponding flocks made during the aerial surveys of 9 and 12 September 1983 (Appendix Table A-2). Actual photo counts were significantly greater than corresponding visual estimates ($t=2.149$, $n=15$, $p < 0.05$) and a linear relationship existed between the 2 values ($R^2=0.967$, $p < 0.005$). The survey crew consistently underestimated total flock size on ANWR by a factor of 1.15 so that all estimates made on these days were adjusted using this correction factor (Table 1). Adjustments were made on the CWS data by T.W. Barry using similar methods, but also taking into account extent of survey coverage.

Chronology and Numbers

As in previous years, during June 1983 small flocks of snow geese were observed on the coastal plain (a group of 4 and 1 birds flying west on 3 and 4 June, respectively, at VABM Bitty on the Jago River; 26 birds grazing on 13 June and 6 birds flying west on 19 June at Okpilak delta). The first birds observed on ANWR during the staging season were 2 separate flocks each of 30 and a flock of 50 seen at the Egaksrak and Kongakut River deltas on 20 August (Fig. 1, Table 1). Most breeding and molting adults and flightless young in the Banks Island nesting colony (Kerbes 1983) depart and travel overland a distance of about 50 km to the southwest coast of Banks Island in mid-August (Fig. 2). Such overland walks by molting adults and flightless young have also been reported in southern Keewatin as post-nesting dispersal between about 15 and 25 August 1976 (McLaren and McLaren 1982). On 26 August 1983, T.W. Barry (unpubl. data) sighted 6128 geese in the Sachs River area on the southwest coast of the Banks Island, while 5133 were seen on the Canadian mainland, mostly in the Bathurst Peninsula area. By 1 September, however, most of the breeding birds departed the island with their fledged young making their first flight across the Amundsen Gulf. Initial landfalls were made on the Bathurst and Tuktoyaktuk Peninsulas, and the McKinley and Liverpool Bay shorelines (Fig. 2). Also, 3992 birds were seen on the Yukon north slope between the Blow and Malcolm Rivers. The majority of these birds came south from Banks Island on a strong north wind the night of 1 September (T.W. Barry, unpubl. data).

The first major westward movement towards the Yukon and Alaska north slopes was noted on 5 September 1983. Numbers of snow geese on the ANWR coastal plain remained low through 7 September, when only one flock of 7 birds was observed. By 8 September an influx was apparent with over 14,000 snow geese being counted on a reconaissance flight (Table 1). The peak number of geese staging on the ANWR coastal plain is estimated at 19,800 (Table 1). It is likely that the staging populations on ANWR stabilized at about 11,000-12,000 birds for the week of 12-21 September (Table 1). The 12 September survey extended from the Hulahula River on the west to Cape Bathurst on the east, and included all major staging areas on ANWR, the

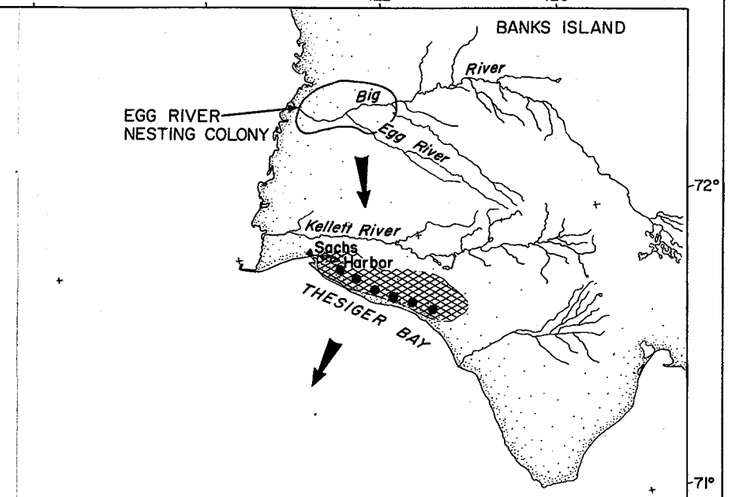
Table 1. Results of aerial snow goose surveys and incidental observations taken during other aerial surveys, coastal plain of the Arctic National Wildlife Refuge, Alaska, Yukon north slope, and Mackenzie River delta, August - September 1983. Numbers given are actual counts or visual estimates; numbers in brackets are total geese estimated to have been present, based on adjustments for estimation error and area covered.

Date	Time when geese were observed (Alaska Daylight Time)	Flight time (h)	Survey type and area	Estimated numbers	Observer(s)
20 August	1330	8.0	Coastal lagoons/oldsquaw, ANWR	110	ANWR: R. Bartels, T. Doyle
20 August	1400	1.5	Bear telemetry Barter Is. to Firth R.	100	ANWR: L. Martin
22 August	1530-1545	4.1	Snow goose recon. Barter Island to Mackenzie River	172 (122 ad, 50 young)	ANWR: M. Spindler, D. Ross
23 August	1400-1630	2.5	Coastal lagoons/oldsquaw, ANWR	13 (12 ad, 1 young)	ANWR: T. Doyle, T. Wilmers, W. Post
24 August	1700-1930	2.5	Coastal lagoons/oldsquaw, ANWR	310	ANWR: T. Doyle, T. Wilmers, L. Martin
25 August	0600-1500	9.0	Snow goose census Demarcation B. to Tuktoyaktuk	11,111	CWS: T.W. Barry
28 August	0700-1930	11.5	Snow goose census Tuktoyaktuk to Banks Island		CWS: T.W. Barry
1 September	1120-1910	8.5	Snow goose census Tuktoyaktuk to Parry Peninsula	57,587	CWS: T.W. Barry
2 September	1700-1900	2.0	Coastal lagoons/oldsquaw, ANWR	26	ANWR: T. Doyle, R. Bartels, W. Audi
7 September	1200-1430	2.5	Coastal lagoons/oldsquaw, ANWR	7 (4 ad, 3 young)	ANWR: T. Doyle
8 September	1300-1530	2.5	Snow goose reconnaissance	14,230	ANWR: L. Martin, M. Smith
9 September	1405-1908	5.0	Snow goose census Barter Is. to U.S./Canada border	17,357[19,787]	ANWR: M. Spindler, D. Ross
10 September	0630-1500	8.5	Snow goose census Tent Island to Nicholson		CWS: T.W. Barry
12 September	1500-1650 1835-1953	3.4	Snow goose census Barter Is. to U.S./Canada border	11,253[12,828]	ANWR: M. Spindler, D. Ross
12 September	0750-1250 1400-1830	9.5	Snow goose census Demarcation Bay to Cape Bathurst	127,462 [380,174]	CWS: T.W. Barry
21 September	1000-1400	4.0	Snow goose census Barter Is. to U.S./Canada border	11,944	ANWR: T. Doyle, L. Martin, W. Audi
25 September	1130-1900	7.5	Snow goose census Tuktoyaktuk to Komakuk Beach	0	CWS: T.W. Barry
26 September	1100-1700	6.0	Snow goose recon. Barter Island to U.S. Canada border, oldsquaw/bear telemetry	0	ANWR: T. Doyle, L. Martin, T. Wilmers

FIG. 2
PEAK SNOW GOOSE NUMBERS AND GENERALIZED DISTRIBUTION DURING FALL STAGING 1983

LEGEND

- MAIN NESTING COLONY
- 26 AUGUST
- 1 SEPTEMBER
- 6 SEPTEMBER
- 9 SEPTEMBER
- 12 SEPTEMBER
- MAJOR MOVEMENTS
- ● EACH LARGE DOT REPRESENTS 1000 GEESE
- • EACH SMALL DOT REPRESENTS 100 GEESE



BEAUFORT SEA
(ARCTIC OCEAN)

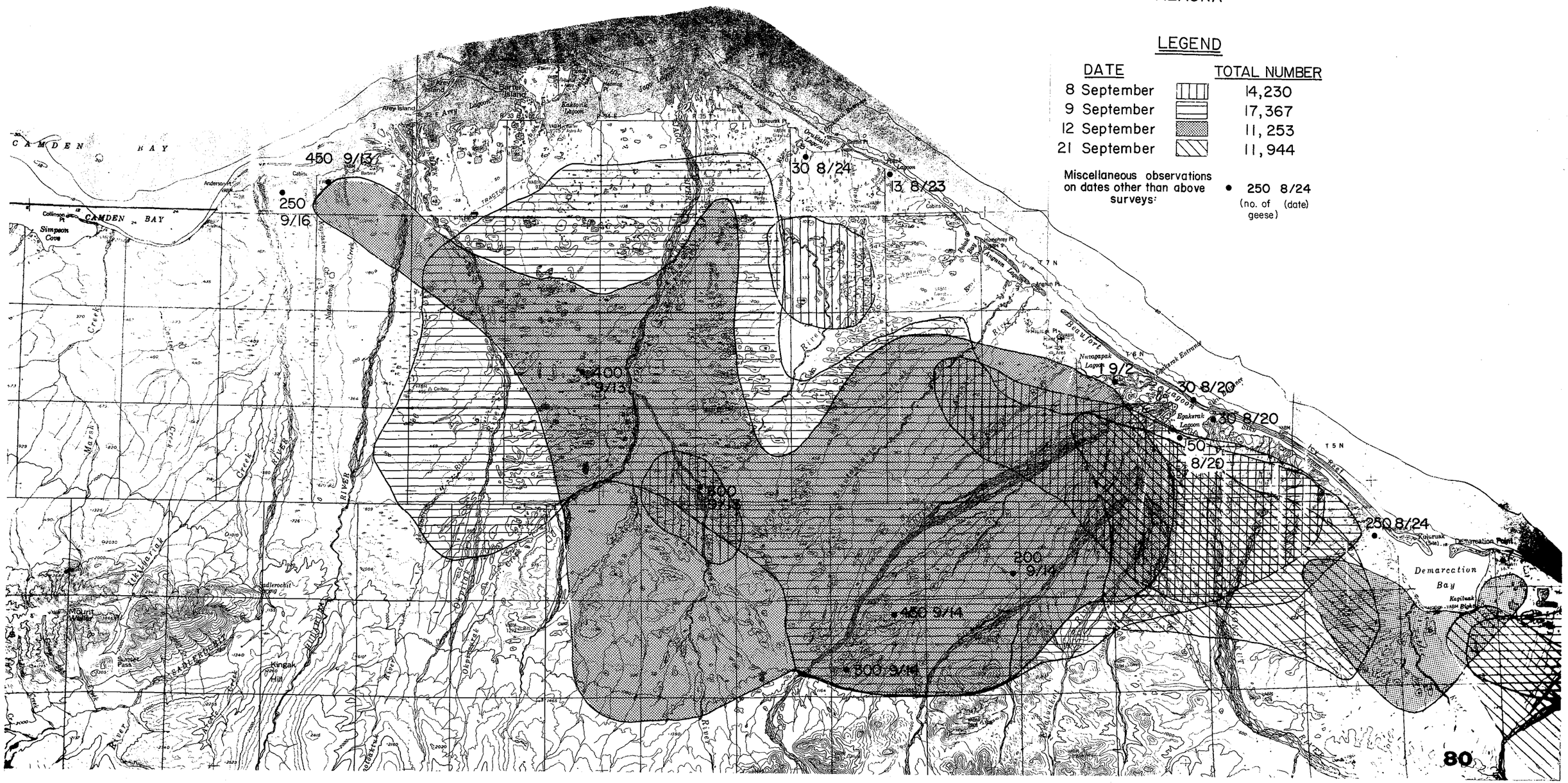
Barter Island
Kaktovik
Okpilak River
Jago River
Hulahula River
Aichilik River
Egaksrak River
Kongakut River
Demarcation Bay
Herschel Island
Herschel
Malcomb River
Stokes Point
Kay Point
MACKENZIE BAY
Tulugaq River
Trail River
Babbage River
Blow River
Firth River
Shingle Point
Tent Island
KENDALL ISLAND NESTING COLONY
Kendall Is.
Richards Is.
Ellice Is.
West Channel
Middle Channel
East Channel
MACKENZIE DELTA
Inuvik
Aklavik
ALASKA
CANADA
Tuktoyaktuk
Eskimo Lakes
LIVERPOOL BAY
ANDERSON RIVER DELTA COLONY
Cape Dalhousie
Wood Bay
Anderson River
Miner River
Kugaluk River
Observation Point
BATHURST PENINSULA
FRANKLIN BAY
PARRY PENINSULA
DARNLEY BAY
Paulatuk
Horton River

10 0 50 110 Kilometers
10 0 30 70 Miles

142° 140° 138° 136° 134° 132° 130° 128° 126° 124° 122° 120°
72° 71° 70° 69° 68°

81

FIG. 1
1983 SPATIAL AND TEMPORAL DISTRIBUTION OF LESSER SNOW GEESE
DURING FALL STAGING ON THE COASTAL PLAIN OF THE
ARCTIC NATIONAL WILDLIFE REFUGE
ALASKA



Yukon north slope, the Mackenzie River delta, the Tuktoyaktuk Peninsula, and the Anderson River delta (Fig. 2, Tables 1 and 2, Appendix Table A-4). The total estimated population of western arctic snow geese staging in ANWR and northern Canada was approximately 393,000 birds (Table 2, Appendix Table A-4). The majority of geese staging in Canada occurred in the Tent Island-Blow River area, the Blow River-Babbage River area, and the Malcolm River-Komakuk Beach areas (Appendix Table A-4).

The main emigration of geese from the staging areas probably occurred between 21 and 26 September: about half of the geese seen on the 21 September survey of the ANWR coastal plain were migrating east; and on 26 September, after 5 days of west winds with snow and freezing temperatures, no geese were seen on ANWR (Table 1). On 25 September no geese were seen on the Mackenzie River delta and Tuktoyaktuk portions of the Canadian staging grounds and all but 5% of the wetlands were frozen and under complete snow cover (T.W. Barry, unpubl. data).

Staging activities were later in 1983 than in 1982, and later than the average of the previous 11 years. Arrival was 13 days later in 1983 than in 1982, and 2 days later than the average arrival date the previous 11 years (Table 3, Fig. 3). Staging also started later: 7 days later than 1982 and 3 days later than the average initiation of staging the last 11 years (Table 3, Fig. 3). Duration of staging in 1983 was 4 days less than 1982 and 2 days less than the long-term average. Major departure started 5 days later than 1982 and a week later than the average for the last 11 years.

Total numbers of snow geese staging in Alaska were only 12.0% of the previous year and 11% of the average of the last 9 years (Table 2). Numbers of geese counted on the Yukon north slope were 14.0% less than in 1982 but 23.6% more than the 8 year average for that area. The Mackenzie River delta showed 424.2% more birds than in 1982, but 1983 still had only 13.6% of the 6-year average (Table 2). Including adjusted 1983 data, long-term averages of 99,107, 106,312, and 172,826 snow geese staged in the Alaska, Yukon, and Mackenzie areas respectively. The Alaska and Yukon north slopes appeared to be similar in mean numbers while the Mackenzie Delta averaged approximately 1 1/2 times as many birds.

Fewer snow geese staged on ANWR in 1983 than in 1982 possibly because of differing wind regimes during the 15 August - 10 September period when geese would have been migrating west into the refuge. At Barter Island, generally westerly to northwesterly winds (headwinds) predominated during this period in 1983 (67% of the days), whereas northeasterly to easterly winds (tailwinds) predominated in 1982 (70% of the days). Large flocks staging on ANWR in 1982 departed the refuge to the east on 16 and 17 September, 2 days after the first steady and strong west winds of the season at Barter Island (N.O.A.A. Climatological Records for Barter Island, Alaska, 1982 and 1983). In 1983 departure occurred, again with prevailing west winds, on 21-25 September. The direction of these winds was not unique for that season, however, their velocity was, averaging 35 kph from 21-25 September as compared to a mean of 23 kph the previous 2 weeks.

Wind appears to be a major factor in fall departure from ANWR staging grounds, however, other factors not specifically studied may play an important role (e.g. temperature, chronology of freeze-up on wet tundra and wetland habitats). A favorable strong following wind was reported to be the

Table 2. Total numbers of western arctic snow geese counted during August-September staging surveys, Arctic National Wildlife Refuge coastal plain and Canadian areas to the east, 1973-1983.

Year	Alaska	Yukon north slope	Mackenzie River delta and east	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[d]	8,996[e]	7,500[f]	N/D	N/D	Sept. 9
1981[g]	20,000[h]	80,000[h]	330,000[i]	430,000[i]	Sept. 14,16,20
1982[j]	107,072	117,892	6,155	231,000	Aug.24,26,29,31; Sept.1,3,5,9,10,14,15,21,22
1983[k]	11,253	101,350	26,112	144,819	Aug.22,26;Sept.1,8,9,12,21,26
	(12,828)	(300,651)	(54,523)	(393,002)	

Sources:
a Koski (1977b), extrapolation from transects at several points in time, not all areas covered on each date.
b Spindler (1978), extrapolation from transects at 1 point in time.
c Spindler, M., Wildlife Biologist. [Memo to Refuge Manager, Arctic National Wildlife Refuge, U.S. Fish and Wildlife service.] 1979, 1pp.
d Spindler (1980)
e Ground counts by J. Levison, estimates of all flocks seen in continuous count during daylight hours.
f Estimated total; Actual photograph count was less; Demarcation Bay to Phillips Bay.
g Spindler (1983a)
h Visual estimates of flock size, Yukon sample includes only area from U.S.-Canada border to Phillips Bay.
i Barry 1982. Includes 250,000 geese estimated to have staged south and west of Paulatuk, which is east of the Mackenzie delta.
j Spindler (1983b)
k Numbers given are actual count estimates for area surveyed 12 September; numbers in parentheses are total estimated geese present on 12 September based on adjustments for estimation error and area covered. Estimate given for total of all 3 sub-areas includes 25,000 geese estimated migrating south out of the region on 12 September.

Table 3. 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 1978-1983. The 1978-1982 data are from Arctic National Wildlife Refuge only, other years include intensive sampling over entire staging area.

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.
1982[l]	7 Aug.	24-26 Aug.	20	16-18 Sept.	19 Sept.	6 June-25 Oct.
1983	20 Aug.	25 Aug.-2 Sept.	16	21-26 Sept.	21 Sept.	1 June-26 Sept.

[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. The 1982 and 1983 data more equally covered both Canadian and Alaskan locations; survey periods include dates between which extensive aerial surveys were conducted in which snow geese could have been observed. 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 (1978)

[i] Spindler, M., Wildlife Biologist. [Memo to Refuge Manager, Arctic National Wildlife Refuge, U.S. Fish & Wildlife Service.] 1979, 1 pp.

[j] Spindler (1980)

[k] Spindler (1983a)

[l] Spindler (1983b)

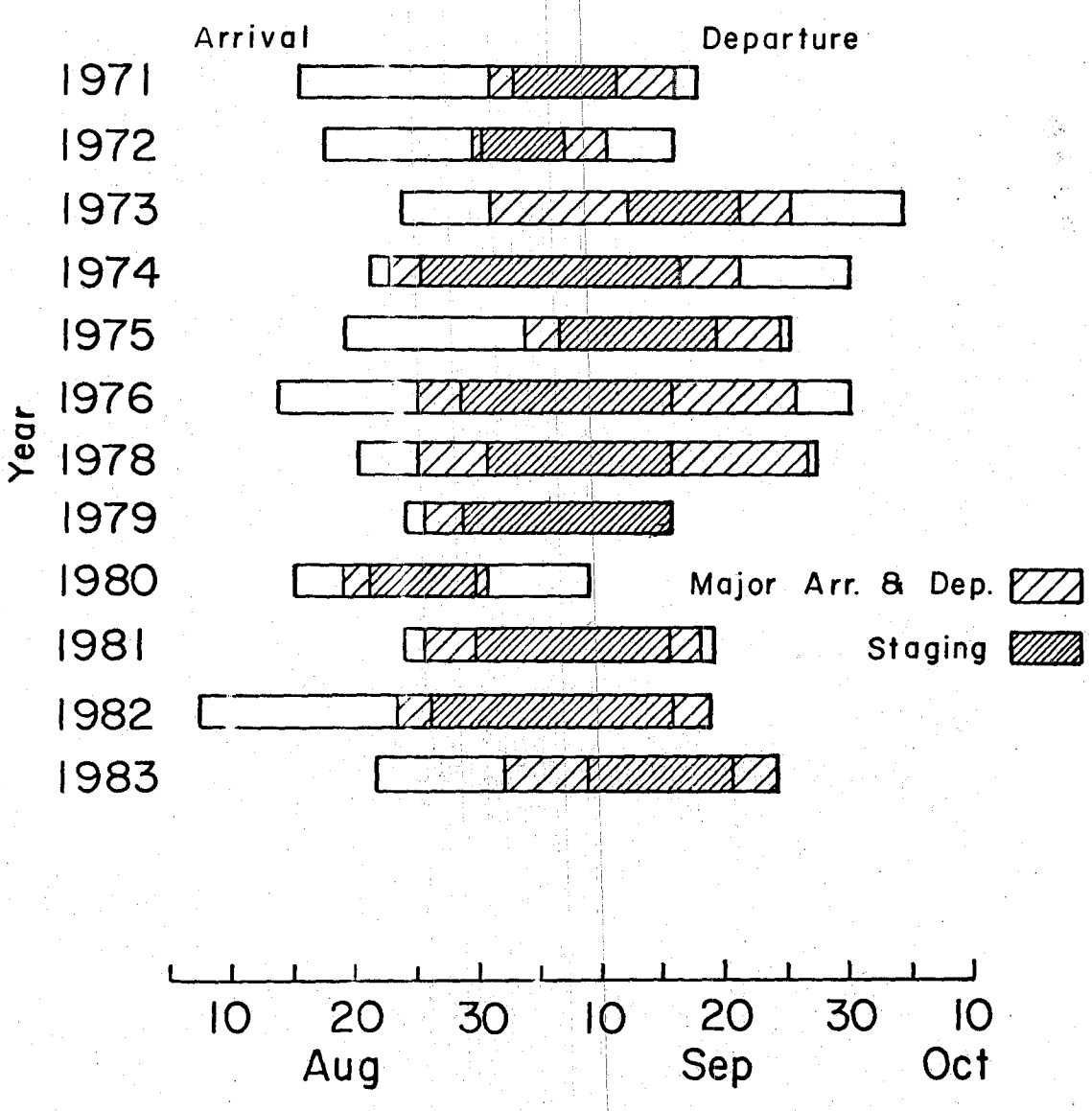


Fig. 3. Chronology of arrival, staging, and departure of the western arctic population of lesser snow geese using the coastal plain of the Arctic National Wildlife Refuge, Alaska, north slope of the Yukon Territory, and the Mackenzie River delta, N.W.T.

most important factor triggering northward migration of waterfowl in the Mississippi Flyway (USDI 1970) and of Canada geese in Minnesota and Manitoba (Wege and Raveling 1983). Other studies, however, have indicated that initiation of northward movements of snow geese were not strongly influenced by surface wind direction (Blokpoel 1974), but that maximum daily air temperature did have a strong influence (Flickinger 1981).

Spatial Distribution

The initial arrival areas in August 1983 were the Kongakut and Egaksrak River deltas (Fig. 1). The major arrival on 7-8 September was to these deltas and the area to 16 km inland between the Sikutaktuvik River and Pingokraluk Point (Fig. 1). On 9 September birds spread across the coastal plain west to the Hulahula River and inland up to 40 km (Fig. 1). By 12 September, distribution had reached its maximum extent, with a further westward expansion to the Sadlerochit River delta, a southward expansion to the area between VABM Bitty and the upper Okerokovik River, and another concentration around the south side of Demarcation Bay. The final area to be occupied by snow geese before major departure was similar to that occupied during major arrival -- Aichilik, Egaksrak, and Kongakut River deltas and inland up to 16 km, as well as south and east of Demarcation Bay to the U.S.-Canada border (Fig. 1).

Distribution in 1983 occupied generally the same area between the Hulahula River and Egaksrak Rivers as in 1982, except in 1983 the most frequently used "core" concentration area centered more coastally and eastward in the Aichilik, Egaksrak, and Kongakut River deltas. In 1982, the "core" area was the upper Niguanak and the Sikutaktuvik Rivers and the central Okerokovik River (Spindler 1983b). The reason for differential use of areas between years is undetermined. However, snow cover may have been a factor. Snow geese initially occupied the generally snow-free areas on the coastal plain on 8 September 1983 (Fig. 1; L.D. Martin, pers. comm.). On 9 September 1983, 15-25% snow cover occurred above the 330 m contour line, but by 12 September all the snow below 660 m had melted (Fig. 1). In most previous years, snow cover was not a factor in the initial distribution of snow geese because the first major snowfall occurred later (in mid-September), which coincided with the departure of the geese and not their arrival (USFWS 1982, Spindler 1983a and 1983b).

The "core" staging areas from 1973 to 1982 included the upper Sikutaktuvik and Niguanak River areas, the middle Okerokovik River and the entire coastal plain portion of the Aichilik River (USFWS 1982, Spindler 1983a). In 1983, the "core" differed only slightly from the previous 8-year pattern in that less of the Okerokovik area was used and more of the Aichilik/Egaksrak/Kongakut River areas were used. Also, the Demarcation Bay area was used more extensively in 1983 than in most previous years (Fig. 1; USFWS 1982; Spindler 1983a, 1983b).

Productivity

Age ratio sampling coverage in 1983 was comparable to coverage in 1982, with the majority of the staging area from the Bathurst Peninsula to Barter Island being surveyed on 12 September 1983 (Tables 1 and 4). On ANWR, a total photo sample of 4619 geese representing estimated flocks including 7438 geese was obtained from 24 usable photographs (Appendix Table A-1).

Table 4. Productivity of western arctic snow geese during staging, Bathurst Peninsula, N.W.T. to Barter Island, Alaska, as determined from coordinated surveys and aerial photography. (All segments were surveyed 12 September 1983, except Bathurst Peninsula which was 1 September).

Survey segment	Adults	Young	Total	% Young	No.of photos
Bathurst Peninsula[a]	2335	2644	4979	53.1	31
Tuktoyaktuk Peninsula	1281	893	2174	41.1	38
Ellice Island to Tent Island	406	504	910	55.4	22
Blow River to Babbage River	288	68	356	19.1	6
Babbage River to Stokes Point	1591	63	1654	3.8	9
Stokes Point to Komakuk Beach	461	259	720	36.0	7
ANWR - Demarcation Bay to Hulahula River	2154	492	2686	18.3	12
Total	8516	4923	13,479	36.5±14.0(SD)	125
Total less Bathurst Peninsula[a]	6181	2279	8500	26.8±11.0(SD)	94
Northwest Territories Segment	1687	1397	3084	45	
Yukon Territory Segment	2340	390	2730	14	
Alaska Segment	2154	492	2686	19	

[a]Bathurst Peninsula survey (1 September) deleted for calculation of regionwide estimate of productivity to avoid movements and double-counting between 1 September and 12 September surveys.

For ANWR, the weighted mean percentage of young birds on 9 September, was 30.0 ± 8.6 (SD) and on 12 September was 19.0 ± 5.5 (SD), a significant difference apparently due to daily changes in flock composition. Because of the significant differences in percent young in only 3 days time between 9 and 12 September 1983 on ANWR, further analyses of ANWR and Canadian age ratios were limited to only those data taken on 12 September.

A total of 10,793 geese were counted on 113 photos of the Canadian staging grounds by T.W. Barry on 1 and 12 September. To avoid the problems of movements and double-counting, only those ANWR and Canadian segments of the survey photographed on 12 September were used to calculate the productivity estimate. This restriction on the photography yielded a sample of 8500 geese from 94 photographs. Therefore, the weighted estimate of western arctic snow goose productivity was 27% ± 11 (SD). These data (Table 4) indicate considerable variation between sample segments, with the greatest concentration of non-breeders occurring in the Babbage River to Stokes Point segment. Conversely, the greatest abundance of family groups was in the Ellice Island to Tent Island segment on 12 September (and the Bathurst Peninsula segment on 1 September). The spatial and temporal differences in age ratios for 1983 (Table 4) were similar in magnitude as observed in previous years (Spindler 1983a, 1983b), underscoring the necessity to conduct the age ratio surveys over the most extensive area within the shortest time frame possible.

The greatest percent young was observed in the Northwest Territories areas, followed by Alaska and Yukon (Table 4). In 1982 a similar pattern existed between Alaska and Yukon, with lowest percent young observed in the Yukon (Spindler 1983b). In 1981 the Northwest Territories areas also had the highest proportion of young in the surveys (Spindler 1983a).

Productivity levels in 1983 were higher than 5 of the 9 previous years and were higher than any recent year since quantitative photo counts were initiated in 1979 (Table 5). Recent age ratio data have not approached the high proportions of young observed in 1973 and 1975 (Table 5). Some of the extreme variation between years is probably attributable to annual variations in sampling coverage and high spatial variation of age ratios within years, particularly 1979, 1980, and 1981 (Spindler 1982a). The 4 earliest years of data (1973-1976) and the 2 most recent years do represent the most extensive real-time coverage attainable given the survey conditions, and these years still exhibit extreme variations in productivity. However, the earlier 4 years (1973-1976) are based upon composition counts, while the 1982 estimates are based on photo estimates (Table 5), and the comparability of productivity estimates derived from these two techniques is not known. Such annual variation may reflect actual changes in productivity, which appears realistic in light of the variation reported from long term colony productivity studies in the eastern Canadian arctic (Davies and Cooke 1983).

Behavior and Feeding

On 10 September a field camp and observation blind were established near the mouth of the Aichilik River, 6 km inland from the coast on a bluff on the east side of the river (69°47'30"N, 142°12'00" W). The blind was located atop the bluff, affording an unobstructed view for a 4 km radius surrounding the site. The camp was located 0.5 km to the west of the blind and was at a lower elevation and out of sight from geese visible from the blind.

Table 5. Age ratios for western arctic snow geese staging on the Alaska and Yukon north slope, and Mackenzie River delta 1973-1976 (Koski 1977b) and 1979-1983 (Barry 1982, USFWS 1982, Spindler 1983a,b,) .

Year	Adults	Young	% Young	Area of survey[a]	Technique
1973	4533	5399	119.1	MD, YNS, AK	Composition count
1974	28,647	29	1.0	MD, YNS, AK	Composition count
1975	12,223	13,638	111.6	MD, YNS, AK	Composition count
1976	7375	5541	75.1	MD, YNS, AK	Composition count
1979	4275	133	3.1	YNS, AK	Photo
1980	1046	37	3.3±1.2SD	YNS, AK	Photo
1981	39,693	5082	11.3±4.1SD	MD, YNS, AK	Photo
1981	175,000	75,000	30.0	Paulatuk and southwest	(estimate)[b]
1982	14,904	889	4.6±0.7SD	MD, YNS, AK	Photo
1983[c]	6181	2279	27.0±11.0SD	MD, YNS, AK	Photo

[a] MD - Mackenzie River delta; YNS - Yukon north slope; AK - ANWR, Alaska.
[b] Paulatuk is a rarely used staging area, no quantitative survey was conducted. Data are estimates made by T.W. Barry.
[c] Estimate based only on those observations made 12 September 1983

Behavior scan data indicated that the majority of geese surrounding the blind area were feeding, and that the most intense time of feeding activity was early morning (Table 6). Staging flocks of snow geese were typically in constant motion as they clipped and uprooted sedges, each time moving a step or two forward to the next clump of sedges. Geese were tallied as walking only if they were not also engaged in feeding. It was not unusual for a flock to move, without flying, 0.5 km during the course of a few hours of feeding if not disturbed.

Table 6. Results of behavior scans of snow goose staging flocks, lower Aichilik River, Arctic National Wildlife Refuge, Alaska, 11 and 12 September 1983 (Figures are average % of all birds seen engaged in each behavior class followed by total numbers of geese observed in behavior classes for all scans in parentheses).

Behavior	Early morning	Afternoon
Sit	0 (0)	1 (10)
Stand	5 (9)	9 (91)
Feed/walk	93 (163)	80 (809)
Walk only	2 (3)	8 (81)
Fly	0 (0)	1 (6)
Bathe	0 (0)	1 (10)

Observations of undisturbed snow geese staging on the north slope of the Yukon Territory by Davis and Wiseley (1973) also reported that the major activity was feeding (57%). However, Fredrick and Klaas (1982) noted that feeding activity (21.6% ± 0.9 SD) in migrating snow geese in Iowa was not the major activity, but was secondary to sleeping (25.3% ± 1.0 SD) and other activities (47.5% ± 1.0 SD).

Plant species eaten by snow geese grazing in wet sedge tundra along the lower Aichilik River area on 11 September included (Carex membranacea, C. aquatilis ssp. stans, C. aquatilis ssp. aquatilis, and Eriophorum angustifolium ssp. subarcticum. Tubers of these species were uprooted and eaten in patches up to 3 m in diameter over several ha. Considerable grazing also occurred in riparian floodplains adjacent to the Aichilik River where clumps Poa alpina and Arctagrostis latifolia were heavily utilized. Leaf tips of these grass species were grazed extensively in some areas, and mud surrounding the grass clumps was heavily trampled.

Reaction to Aircraft Overflight

Sensitivity of snow geese to aircraft overflights has been documented on the Yukon north slope adjacent to ANWR (Davis and Wiseley 1974), on the Mackenzie River Delta (Barry and Spencer 1976), and near Prudhoe Bay (Welling et al. 1981). Miscellaneous observations pertaining to the reaction of snow geese to aircraft on ANWR have been made during previous years surveys, but specific studies have not been attempted until 1983.

On 10 September at the lower Aichilik ground observation area a total of 163 snow geese were visible from the blind between 1530 and 1830h, however, visibility was poor, ranging from 13.0 to 0.8 km in light to heavy snow. More geese were heard in the distance beyond the limits of visibility, and after dark, geese were heard flying overhead most of the night. On 11 September, 4 area counts were conducted to determine the numbers of geese visible from the blind and indicated 1444 to 2441 geese present (Table 7). Numbers of geese in the area apparently increased from morning to afternoon except for 1 count taken under conditions of bad heat waves.

Table 7. Numbers of snow geese visible from lower Aichilik River ground observation point, coastal plain, Arctic National Wildlife Refuge, 11-12 September 1983.

Date	Census	Time	No. of snow geese	Conditions (wind/temp/clouds)
11 September	1	0630h	1444	NE 5/25°F/ 150 m overcast
	2	0945h	1761	NE 8/32°F/ high overcast
	3	1300h	1575	NE 8/42°F/ clear, heat waves
	4	1505h	2441	NE 5/35°F/ high overcast
Post Aircraft overflight		1630h	679	NE 5/35°F/ high overcast
12 September	5	0625h	1571	SW 8/40°F/ high overcast

Following completion of the 1505 h count on 11 September, an aircraft overflight was made around the 4 km radius area under observation. The flight was made with a Helio-courier H-295 aircraft at an altitude of 150 m and lasted 10 minutes, takeoff to landing. The count immediately following the disturbance indicated 679 snow geese in the area a 72.2% reduction in numbers (Table 7). Short-term effects of the disturbance were that all flocks within a 4 km radius took flight. Three flocks circled and landed within the observation area, the remainder departed to the south. Flocks took flight from distances as far way as 4 km. One flock of 500 birds 1 km away from and out of sight of the aircraft took flight apparently in response to the sound of the engine run-up since the birds became airborne just as the engine was run-up and before the airplane began to taxi. Numbers of birds in the area under observation started to increase gradually about 1 h after the disturbance as small flocks (numbering 10 to 20) began to move in. The next morning, snow goose numbers were 108.8% of

the numbers observed the preceding morning, however, numbers were 64.4% of those observed prior to disturbance the preceding afternoon (Table 7).

Based upon the above observations and additional observations made during the same period and in previous years, (Appendix Table A-3) snow goose reactions to aircraft overflights appear to have had the following characteristics:

(1) Snow geese reacted to aircraft overflights of up to 3000 m AGL. On the Yukon north slope Davis and Wisely (1974) noted similar reactions.

(2) On ANWR snow geese reacted to aircraft at distances up to 10 km. In the Yukon, snow geese reacted to aircraft up to 22 km distant, but average distance for reactions was 3 km (Davis and Wisely 1974).

(3) Low altitude fixed-wing overflights (30 m AGL) apparently did not disperse the noise laterally from the flight line as far as higher altitudes, therefore low altitude overflights did not cause the widespread disturbance associated with overflights occurring at higher altitudes.

(4) Following aircraft disturbances, snow geese returned to the area gradually, reaching numbers comparable to those present the preceding morning within 14 hours and 2/3 the numbers present prior to disturbance.

Documented reactions of snow geese to aircraft vary considerably -- ranging from taking flight and leaving the area in response to overflights at 3000 m AGL (this study and Davis and Wisely 1974) to nearly complete habituation on the approach and departure routes for the majority of aircraft traffic at Tuktoyaktuk, N.W.T. (T.W. Barry, pers. comm.). Reported variations in sensitivity may be attributed to desirability of food sources, migratory restlessness, and distance from core staging areas. The most intensive disturbance study performed to date on snow geese yielded the following general conclusions (Davis and Wisely 1974):

(1) Flocks of geese reacted significantly more strongly to small fixed-wing (Cessna 185) overflights at 2 h intervals than at 1/2 h intervals, indicating potential habituation.

(2) Flocks flushed at greater distances with 1/2 h intervals than at 2 h intervals of Cessna-185 overflights but flew further in response to the 2 h overflights.

(3) The duration of flock reaction was greater the closer the overflight occurred to the flock.

(4) Flocks took flight at greater distances in reaction to small helicopters than small, medium, and large fixed-wing aircraft.

(5) Snow geese gradually habituated to frequent (1/2 h interval) helicopter flights by flushing closer to the aircraft and flying less distance once flushed, and, conversely, habituated to frequent (1/2 h interval) fixed wing flights by flushing further from the aircraft but not flying as far.

(6) Estimated loss in energy storage caused by reduced feeding time due to disturbance from Cessna-185 overflights at 2 h intervals was 20.0%, and from Bell 206 helicopters was 9.5%.

It was hypothesized that snow geese feeding rates were maximum during staging in order to store sufficient body reserves for migration. Snow geese tend to remain in staging areas as long as possible before freeze up and extensive snow cover, therefore, they can ill-afford to forego feeding opportunities (Davis and Wisely 1974, Patterson 1974)

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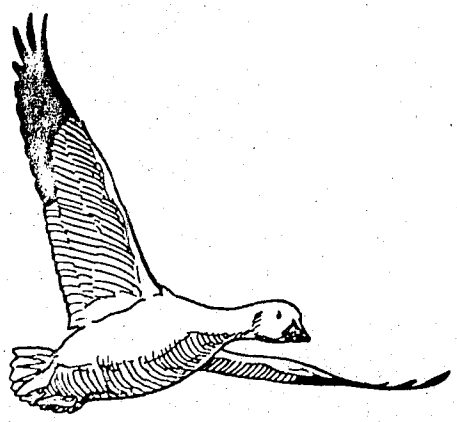

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APPENDIX

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Table A-1. Age ratios of western arctic snow geese as determined from photographic counts on 9 and 12 September 1983, Arctic National Wildlife Refuge, Alaska.

Photo I.D. (roll & frame)	Flock number	Flock size	Sample total	Total adults	Total young	% young
9 September						
VTE 1-5	15	52	52	29	23	44.2
VTE 1-7	16	143	49	24	25	51.0
VTE 1-11	17	147	147	88	59	40.1
VTE 1-14	19	182	182	97	85	46.7
VTE 1-19	21	100	117	62	55	47.0
VTE 1-21	22	262	262	181	81	30.9
VTE 1-25	23	336	336	223	113	33.6
VTE 1-28	25	150	48	40	8	16.7
VTE 1-31	27	200	185	154	31	16.8
VTE 2-9	38	52	52	37	15	28.8
TXP 1-5	41	500	251	217	44	17.5
TXP 1-10	46	350	282	201	81	28.7
TOTAL		2474	1963	1353	620	30.0±8.6SD[a]
12 September						
VTE 2-11	101	157	157	152	5	3.2
VTE 2-17	102	300	101	67	34	33.7
VTE 2-21	110	600	81	59	22	27.2
VTE 2-28	112	500	369	253	116	31.4
VTE 2-35	120A	1000	486	456	30	6.2
TXP 2-3	120B	1000	569	515	44	7.7
TXP 2-6	121	223	223	203	20	9.0
TXP 2-7	124	300	145	89	56	38.6
TXP 2-8	126	172	172	88	84	48.8
TXP 2-16	130A	300	156	117	39	25.0
TXP 2-11	130B	300	85	68	17	20.0
TXP 2-18	131	112	112	87	25	22.3
TOTAL		4964	2656	2154	492	19.0±5.5SD[a]
Overall		7438	4619	3507	1112	22.7±4.6SD[a]

[a] Means and standard deviations are weighted according to flock size.

Table A-2. Photographic count results used to assess accuracy of visual flock size estimates for snow geese, 9 and 12 September, 1983, Arctic National Wildlife Refuge, Alaska.

Photo I.D. (roll & frame)	Flock number	Total geese estimated visually (X)	Actual photo count (Y)
VTE 1-5	15	49	52
VTE 1-9	16	120	143
VTE 1-11	17	100	147
VTE 1-14	19	100	182
VTE 1-19	21	100	117
VTE 1-21	22	150	262
VTE 1-25	23	250	336
VTE 1-31	27	200	185
VTE 2-9	38	50	52
VTE 2-11	101	150	157
TXP 2-19	119	100	144
VTE 2-31	120	1000	919
TXP 2-6	121	200	223
TXP 2-8	126	150	172
TXP 2-18	131	100	112
Mean		187.9	213.5
Standard deviation		231.4	208.4
Ratio	For each estimated goose there were 1.146 counted on photos.		
Linear regression		$R^2 = 0.967$	
Equation		$y = 0.886x + 47.1$	
ANOR		$F = 375.5$, $p < 0.005$	
Paired-t	All observations $n = 15$	$t = 2.149$, $p < 0.05$	

Table A-3. Reactions of snow geese to aircraft and human disturbance, Arctic National Wildlife Refuge, Alaska, and adjacent areas, 1978 - 1983

Date	Time	Reaction
13 Sept.1978	-	Turbine Beaver overflight at 150 m AGL caused geese 4-8 km away to take flight; most groups circled (Clear & sunny).
7 Sept.1979	-	Turbine Beaver overflights up to of 3000 m AGL caused geese to take flight; the higher altitudes caused geese to take flight from farther distances away from aircraft flight path. (High overcast.)
15 Sept.1982	-	Cessna 185 overflights at 300 to 600 m AGL caused snow geese 4-10 km away to take flight. (Clear and sunny).
9 Sept.1983	-	Helio H-295 overflights at 150 m AGL caused geese to take flight from distances of 4-6 km. (High overcast).
10 Sept.1983	1530h	Helio H-295 take-off with intentional departure away from geese and maintaining 30 m AGL until 15 km away caused variable reaction depending on distance from airstrip. One flock of 15 birds 1 km away from airstrip took flight and landed 2 km distant (Birds could not see aircraft from its take-off point). Flocks of 30, 50 and 20 birds 3 km away from airstrip did not take flight.
10 Sept.1983	1715h	Helio H-295 landing with low approach caused 100 geese nearest air-strip (0.2 km away) to take flight and land 0.5 km away.
11 Sept.1983	1120h	Photographer on ground intentionally stalked to within 150 m lateral distance of flock of 45 birds, causing it to take flight and land 2 km away.
11 Sept.1983	1600h	Helio H-295 airplane intentionally flown over snow goose aggregations at 150 m AGL for 10 minutes, lower Aichilik River, caused reduction in snow goose numbers from 2441 to 679 in immediate 4 km radius of study site. The first flock to be disturbed numbered about 500 birds and departed to the southwest upon hearing the aircraft engine run-up, then landed 0.5 km away. As the aircraft took off this flock and 6 others, numbering 150, 200, 400, 200, 300, and 300 birds, took flight and departed to the south; all except 1 flock disappeared beyond the horizon. The 1 remaining flock, numbering 400, landed 5 km to the south of the observation blind. One flock 12 km to the south (visible only through 120x Questar scope) did not take flight during the disturbance, therefore in this instance, reaction distance appeared to be between 4 and 10 km. Weather conditions were high (2000 m AGL) broken clouds, clear 45 km to the east, temperature 40°F, winds northeast at 7 km/h. The Helio did not sound as loud as a Cessna 207 which passed later in the day in level cruise flight at similar altitude.
11 Sept.1983	1700h	Helio H-295 aircraft took off, departing to northwest at 30 m AGL, caused 1 flock of 371 birds 5 km to the east

Table A-3. Continued.

Date	Time	Reaction
		to take flight, circle for 1 minute and land. Another flock 6 km to the north did not take flight but became alert, with heads erect (High overcast).
11 Sept.1983	1855h	Landing Helio H-295 approached from north, flew 30 m AGL over Aichilik River to minimize disturbance and caused 2 flocks (numbering 180 and 370 birds) to take flight for 30 seconds and land 0-5 km from where they were disturbed. Reaction distance was about 3 km (High overcast).
12 Sept.1983	0850h	Helio H-295 taxiing to turn around on a gravel bar caused flocks of 300 and 400 (out of sight of airplane) to take flight. As aircraft takes off 500 other snow geese take flight. 700 geese fly 4 km in about 5 minutes, disappearing beyond the horizon. Flocks of 200 and 300 land 3 km from airstrip (High overcast).
12 Sept.1983	1020	Landing Helio H-295 approached from north, flew 30 m AGL over Aichilik River causing flock of 400 geese 0.6 km to east to take off and fly 3 km to north in 2 minutes, and land. Also a flock of 50 geese 3 km east took off and flew south 0.5 km in 30 seconds and landed (High overcast).
25 Aug. - 12 Sept.1983	-	With Cessna 185 airplane and Bell 206B helicopter, T.W. Barry noted flushing distances of 1-5 km from survey altitudes of 150-500 m Bathurst Peninsula to Demarcation Bay. Also noted was habituation of snow geese to 20-50 helicopter flights/day near Tuktoyaktuk.

Table A-4. Population estimates of staging snow geese using various survey segments, Bathurst Peninsula, Northwest Territories to Hulahula River, Alaska, 12 September 1983.

Segment	Estimated number
Nicholson - Wood Bay	540
McKinley Bay	7,860
Tuktoyaktuk - Toker Pt.	28,275
Richards Is., Langley Is.	320
Ellice Is., Tent Is.	17,528
Tent Is., - Blow R.	93,000
Migrated south of Mackenzie	25,000
Blow R. - Babbage R.	120,953
Babbage R. - Stokes Pt.	11,310
Stokes Pt. - Roland Bay	5,248
Roland B. - Firth R.	15,240
Firth R. - Malcolm R.	12,000
Malcolm R. - Komakuk	35,490
Komakuk - Clarence Lagoon	6,210
Clarence Lagoon - Demarcation B.	1,200
Demarcation B. - Hulahula R.	12,828
Total	393,002