

Staging and Wintering Areas of Snow Geese Nesting on Howe Island, Alaska

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ABSTRACT. From July 1980 to July 1990, leg bands were put on 4556 adults, subadults, and goslings from the lesser snow goose (*Chen caerulescens caerulescens*) colony (~1000 nesting birds) on Howe Island, near Prudhoe Bay, Alaska. In addition, 1431 neck bands were put on 1714 of the leg-banded adults and subadults. During the period from September 1980 through May 1991, 3244 discrete, within-year resightings and recoveries were received of neck-banded and leg-banded birds during fall, winter, early spring, and late spring.

During mid to late August each year, the Howe Island geese migrated eastward from the Prudhoe Bay area to staging/feeding areas in the Arctic National Wildlife Refuge, Alaska and in adjacent areas of the Yukon Territory. In mid to late September they moved southward down the Mackenzie Valley. Cluster analyses for the ten-year period 1980-90 revealed six separate distribution loci for the geese during the fall, with the largest proportion (84.7%) in one location in southeastern Alberta and southwestern Saskatchewan. Analyses revealed 11 separate distribution loci for the geese during winter from 1980 to 1991; the largest proportion (79.2%) was in northern California and southern Oregon. There were seven different distribution loci for the geese during early spring from 1981 to 1991; the largest proportion was in northern California and southeastern Oregon (81.4%). There were five distinct aggregations of the Howe Island geese during late spring from 1981 to 1991, with the largest proportion (79.1%) in staging/feeding areas in Montana, Alberta, and Saskatchewan.

Most geese in both flyways were faithful to specific overwintering locations from one year to the next. Of 262 birds for which year-to-year data were available, 98% in the Pacific Flyway returned to the same region in subsequent winters, and 90% in the Central Flyway returned to the same region. Nevertheless, some geese from both flyways moved to the other flyway during subsequent winters, and a few moved from the Pacific to the Central Flyway during the same winter.

In general, the migration routes and overwintering areas of the Howe Island snow geese formed a pattern similar to that documented several decades ago for the much larger Western Arctic population, which nests mainly on Banks Island, Northwest Territories, Canada. The Howe Island geese are likely a satellite colony of the Western Arctic population.

Key words: Western Arctic, Alaska, lesser snow goose, *Chen caerulescens caerulescens*, migration routes, staging areas, wintering areas, flyway fidelity

RÉSUMÉ. De juillet 1980 à juillet 1990, des bagues ont été posées aux pattes de 4556 petites oies des neiges (*Chen caerulescens caerulescens*) adultes, jeunes adultes et oisons faisant partie de la colonie (~1000 oiseaux nicheurs) de l'île Howe, près de Prudhoe Bay en Alaska. En outre, 1431 colliers ont été posés à 1714 des adultes et jeunes adultes déjà bagués. En automne, en hiver, au début et à la fin du printemps, durant la période allant de septembre 1980 à mai 1991, on a enregistré 3244 occurrences distinctes où des oiseaux bagués aux pattes et au cou ont été réaperçus dans l'année ou récupérés.

Chaque année, durant la deuxième quinzaine d'août, les oies de l'île Howe migrent vers l'est depuis la région de Prudhoe Bay en direction des aires de repos / de nutrition du Arctic National Wildlife Refuge situé en Alaska et dans des régions avoisinantes du Territoire du Yukon. Durant la deuxième quinzaine de septembre, elles se déplaçaient vers le sud en suivant la vallée du Mackenzie. Des analyses typologiques portant sur la décennie allant de 1980 à 1990 ont révélé six lieux distincts où se répartissaient les oies au cours de l'automne, la proportion la plus importante (84,7 p. cent) se trouvant dans un site du sud-est de l'Alberta et du sud-ouest de la Saskatchewan. Les analyses montrent qu'il existe 11 lieux distincts où se répartissaient les oies durant l'hiver entre 1980 et 1991; la proportion la plus importante (79,2 p. cent) se trouvait dans le nord de la Californie et le sud de l'Oregon. Au début du printemps, de 1981 à 1991, il y avait sept sites différents où se répartissaient les oies; la plus grande proportion se trouvait dans le nord de la Californie et le sud-est de l'Oregon (81,4 p. cent). À la fin du printemps, de 1981 à 1991, les oies de l'île Howe composaient cinq concentrations distinctes, la plus grande proportion (79,1 p. cent) se trouvant dans les aires de repos / de nutrition du Montana, de l'Alberta et de la Saskatchewan.

La plupart des oies empruntant les deux voies migratoires étaient fidèles à des sites d'hivernage spécifiques d'une année à l'autre. Sur les 262 oiseaux pour lesquels des données d'une année à l'autre étaient disponibles, 98 p. cent de ceux empruntant la voie du Pacifique revenaient dans la même région les hivers suivants, et 90 p. cent de ceux empruntant la voie du Centre revenaient dans la même région. Cependant, certaines oies empruntant l'une ou l'autre des routes changeaient de voie au cours des hivers suivants, et quelques-unes passaient de la voie du Pacifique à la voie du Centre durant le même hiver.

En général, les voies de migration et les zones d'hivernage de l'oie des neiges de l'île Howe offrent un schéma similaire à celui

rapporté il y a plusieurs dizaines d'années pour la population beaucoup plus nombreuse de l'Arctique occidental, qui niche surtout dans l'île Banks située dans les Territoires du Nord-Ouest (Canada). L'oise de l'île Howe est probablement une colonie satellite de la population de l'Arctique occidental.

Mots clés: Arctique occidentale, Alaska, petite oie des neiges, *Chen caerulescens caerulescens*, voies de migration, zones de repos, zones d'hivernage, fidélité à une voie de migration

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INTRODUCTION

The lesser snow goose colony on Howe Island, near Prudhoe Bay, Alaska (Fig. 1), is the only consistently used nesting colony of snow geese in Alaska and the United States (Johnson and Troy, 1987; Johnson and Herter, 1989; Johnson et al., 1993), and it is the only location where snow geese nest and rear broods in proximity to an active oil field. The Howe Island population (~1000 nesting geese) is situated between much larger populations on Wrangel Island, Russia (~70,000 birds) and in the Canadian Western Arctic (~350,000 birds) (Bellrose, 1980; R. Kerbes, pers. comm. 1995).

Through an annual capture and banding program in brood-rearing areas, virtually all the birds in the Howe Island population were marked with aluminum leg bands (Johnson, 1994). Many adults and subadults also were marked with plastic neck bands. Through leg band returns and neck band resightings, we determined age- and sex-specific information about staging areas, migration routes, and winter distributions of the Howe Island snow geese.

METHODS

Migration and Winter Distribution

Each year from 1980 to 1990, a field crew of six to eight biologists leg-banded 4556 different adults, subadults, and goslings in brood-rearing areas during annual banding programs in late July. We also put 1714 neck bands on leg-banded adults and subadults; goslings were not neck-banded. Most geese wore several different neck bands over the course of the study (Johnson et al., 1995). Each neck band had a unique four-character alphanumeric code (e.g., KE01). The code was etched on the surface of the neck band by removing the outside blue laminate to reveal the underlying white color. Neck bands were 18 cm long, 5 cm wide, and 1.5 mm thick; they were curled to a diameter of 4.5 cm, with 1.5 cm of overlap. Slightly more neck bands were put on males (749) than on females (682) (Johnson et al., 1995).

During the period from September 1980 to May 1991, we received 3244 discrete within-year (within 10 months of banding) resightings and recoveries of 1564 different snow geese during migration and in staging and overwintering areas. Many birds were resighted several times at different locations over the course of the study. Most of the neck band resightings of adults and subadults from 1988 to 1991 were recorded during resighting efforts coordinated through the

International Snow Goose Banding Project, a cooperative study involving systematic neck banding and resighting of Pacific Flyway and Central Flyway snow geese in Russia, Canada, the United States and Mexico (Kerbes, 1993). A smaller proportion of our data was from leg band recoveries, mainly of goslings killed during hunting seasons (Table 1).

Data were organized and sorted using a relational database and stratified by sex, age, year, and season (Tables 1 and 2). Only discrete records were used in our statistical analyses, i.e., only data from different birds or from the same birds resighted at >30' of latitude or longitude from an earlier record during the same season.

The number of distinct aggregations (exclusive, or partitioned groups) of snow geese during each of the four seasons was determined by using the 'Kmeans' cluster analysis procedure described in Wilkinson (1987:25). T-tests of differences ($p < 0.05$) in the mean center distributions of the different clusters were the statistical basis for pooling data for different years and different age and sex categories (Wilkinson, 1987:25–27).

Fidelity to Overwintering Areas

Analyses of winter movements of geese between the Pacific and Central Flyways (during the same winter and from year to year) were based on 1722 discrete records of Howe Island snow geese. These geese were resighted or recovered during winter in the Pacific and Central Flyways from 1980 to 1991 in this study and from 1987 to 1991 in the International Snow Goose Banding Project (Kerbes, 1993).

Our assessment of inter-year fidelity of geese to Pacific Flyway versus Central Flyway wintering areas was based on resightings or recoveries of the same birds in the same area in two consecutive winters. Assessment of intra-seasonal fidelity of wintering geese was based on sightings of the same birds in both the Pacific and Central Flyways from November to January during the same winter. For both of these analyses, Pacific Flyway geese were those resighted or recovered in northern California and southern Oregon, and Central Flyway geese were those resighted or recovered in southern Colorado, northern Texas, New Mexico, or the Mexican states of Chihuahua and Durango.

RESULTS

Most of the fall (94%) and winter (91%) distribution data for gosling snow geese (leg-banded only) were from band

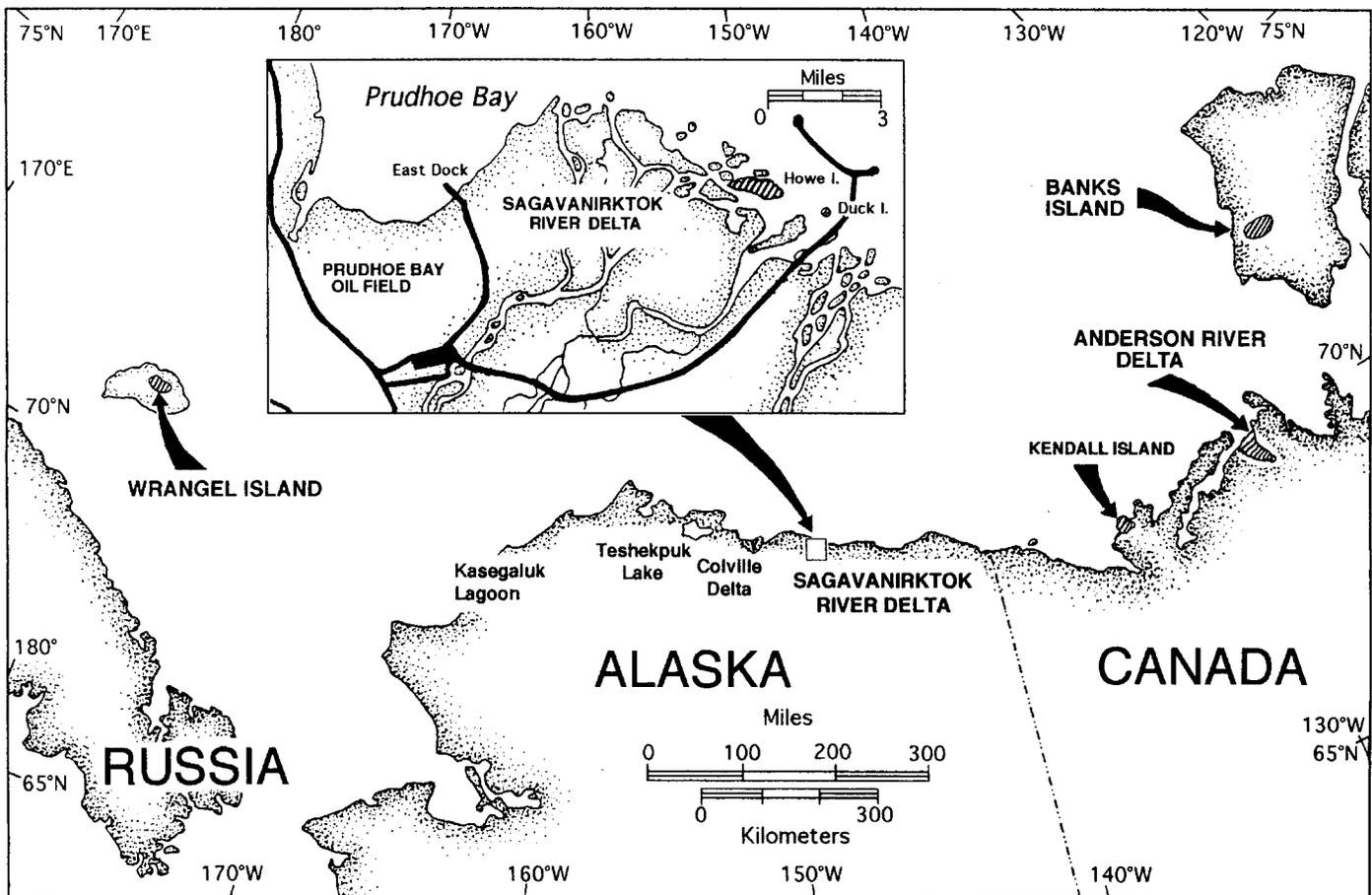


FIG. 1. Locations of lesser snow goose colonies (hatched areas) in the Western Arctic and Russia in relation to the Sagavanirktok River delta study area (box), and Howe Island (inset).

TABLE 1. Status of 3244 discrete records of Howe Island lesser snow geese whose bands were resighted or recovered during migration and winter, from 1980 to 1991.

Status ²	Fall ¹				Winter				Early Spring				Late Spring				All Seasons			
	Gos.	Subad.	Adult	Total	Gos.	Subad.	Adult	Total	Gos.	Subad.	Adult	Total	Gos.	Subad.	Adult	Total	Gos.	Subad.	Adult	Total
0	0	4	132	136	0	20	373	393	0	17	358	375	0	8	114	122	0	49	977	1026
1	3	0	1	4	3	0	1	4	0	0	0	0	0	0	0	0	6	0	2	8
2	0	4	162	166	7	45	1137	1189	0	13	481	494	0	2	84	86	7	64	1864	1935
3	47	1	24	72	96	3	90	189	0	0	11	11	0	0	3	3	143	4	128	275
Total	50	9	319	378	106	68	1601	1775	0	30	850	880	0	10	201	211	156	117	2971	3244

¹ Fall = September and October, Winter = November to January, Early Spring = February and March, Late Spring = April and May.

² 0 = Unknown, 1 = recaptures of banded geese, 2 = resightings of neck-banded geese, 3 = recoveries of dead geese.

recoveries of hunter-killed birds (Table 1). In contrast, most of the migration and winter distribution data for adults (62%) and subadults (55%) were from neck band resightings (Table 1). Statistical analyses indicated few significant differences in the mean coordinates of clusters of different age and sex categories. The one exception occurred during winter, when goslings overwintering in California were distributed slightly farther north and east compared to adults ($t = 2.45$, $p < 0.05$, $df = 625$). This result may have been a sampling artifact related to the distribution of hunters or observers, rather than to that of the geese: nevertheless, a separate analysis of only

hunter-killed adults versus hunter-killed goslings showed no significant differences in distribution in California during winter ($t = 0.667$, $p > 0.30$, $df = 112$).

Tests for differences in seasonal distribution among years were possible only for years when samples sizes were sufficiently large (Table 2), i.e., only for some clusters in the years from 1987 to 1991, and only when variances among samples were not significantly different. Because of the overall similarity in seasonal distributions and the small sample sizes in most years, data for goslings and adults + subadults of both sexes were pooled within each of the four seasons for the final

statistical determinations of seasonal aggregations (Table 3).

Table 2. Number of discrete records of Howe Island snow geese reported from September to May, 1980–91.

Year ¹	Age and sex classes			
	<1 Yr		>1 Yr	
	Female	Male	Female	Male
1980–1981	2	3	27	29
1981–1982	8	9	28	20
1982–1983	2	1	7	4
1983–1984	5	5	42	18
1984–1985	9	8	25	21
1985–1986	15	9	41	38
1986–1987	7	4	49	69
1987–1988	4	6	209	211
1988–1989	7	10	437	364
1989–1990	3	5	339	287
1990–1991	16	18	712	111
All Years	78	78	1916	1172

¹ Only data for September to May immediately after banding are included.

Fall Distribution (September–October)

Cluster analyses revealed six separate distribution loci for the 378 discrete records of Howe Island snow geese during fall from 1980 to 1990 (Table 3, Fig. 2). A few records were from the Mackenzie Delta (2 of 378, 0.5%) and northern Alberta (1 of 378, 0.2%), but most (320 of 378, 84.7%) were from one area in southeastern Alberta and southwestern Saskatchewan. By the end of October, some geese had already moved as far south as northern California (50 of 378, 13.2%) and southern New Mexico (1.1%), and a few others (0.3%) had been reported in the Fraser River delta in southwestern British Columbia.

Winter Distribution (November–January)

Cluster analyses of the 1775 discrete records of Howe Island snow geese during winter from 1980 to 1991 indicated 11 separate distribution loci (Table 3, Fig. 3). A small proportion of winter records (23 of 1775, 1.3%) were from Alberta, Saskatchewan, and Montana, but the largest proportion (1406 of 1775, 79.2%) were from northern California and southern Oregon. The five records (0.3%) from southern Idaho and northern Utah were probably geese headed to the Imperial Valley in southern California, where a small proportion (7 of 1775, 0.4%) of Howe Island geese were resighted. Although there was only one record of a Howe Island snow goose during the winter months as far east as South Dakota, there were nine records (0.5%) from the coasts of Texas and Louisiana, indicating that some birds had moved south along the eastern side of the Central Flyway and entered the Mississippi Flyway. Most of the geese that moved south through the Central Flyway were reported in four clusters extending from southeastern Colorado and the Texas Panhandle (9 of 1775, 0.5%), through south central Colorado to central and south-

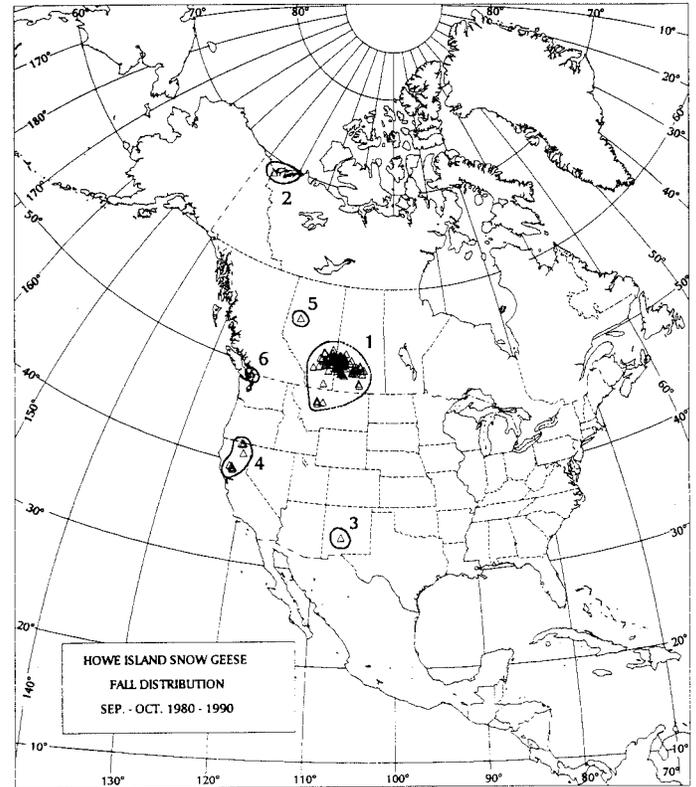


FIG. 2. Fall distribution of Howe Island snow geese (September and October, 1980 to 1990). Numbers represent clusters given in Table 3.

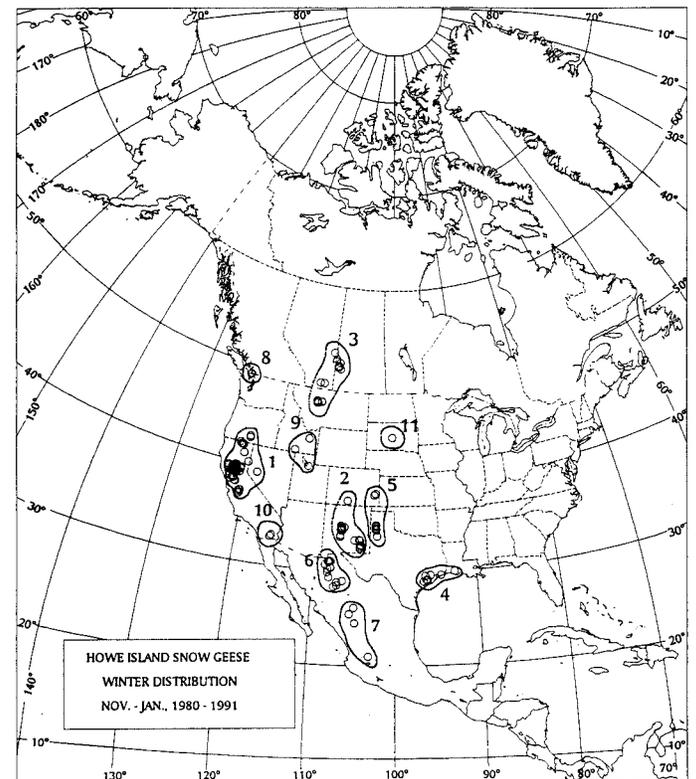


FIG. 3. Winter distribution of Howe Island snow geese (November to January, 1980 to 1991). Numbers represent clusters given in Table 3.

TABLE 3. Mean center coordinates of snow geese clustered in different regions of North America during migration and winter, from 1980 to 1991.

Cluster	Mean center coordinates ²															
	Fall ¹				Winter				Early Spring				Late Spring			
	Lat °N	Long °W	SD	n	Lat °N	Long °W	SD	n	Lat °N	Long °W	SD	n	Lat °N	Long °W	SD	n
1	51.8	109.7	1.85	320	39.5	121.9	0.94	1406	40.6	121.6	1.68	716	50.9	110.6	2.47	167
2	69.0	134.7	1.70	2	34.1	106.5	1.01	269	33.8	106.5	1.99	81	61.3	150.8	0.00	1
3	33.7	106.8	0.00	4	49.9	110.7	2.33	23	26.1	104.8	2.46	8	69.3	124.5	0.00	1
4	40.4	121.8	1.30	50	29.4	95.5	1.24	9	40.8	95.8	0.04	2	42.5	120.3	1.69	41
5	55.8	117.5	0.00	1	35.5	102.4	1.52	9	47.7	112.0	0.09	63	48.0	122.0	0.00	1
6	49.0	123.0	0.00	1	30.3	107.8	1.05	38	38.4	113.2	1.56	3	—	—	—	—
7	—	—	—	—	24.6	104.6	1.91	6	48.1	122.3	0.20	7	—	—	—	—
8	—	—	—	—	49.0	123.1	0.08	2	—	—	—	—	—	—	—	—
9	—	—	—	—	42.8	112.6	1.38	5	—	—	—	—	—	—	—	—
10	—	—	—	—	33.1	115.5	0.08	7	—	—	—	—	—	—	—	—
11	—	—	—	—	44.3	100.3	0.00	1	—	—	—	—	—	—	—	—

¹ Fall = September and October, Winter = November to January, Early Spring = February and March, Late Spring = April and May

² Computations of mean center coordinates and standard deviations of mean center coordinates are described in Wilkinson (1987:25–27).

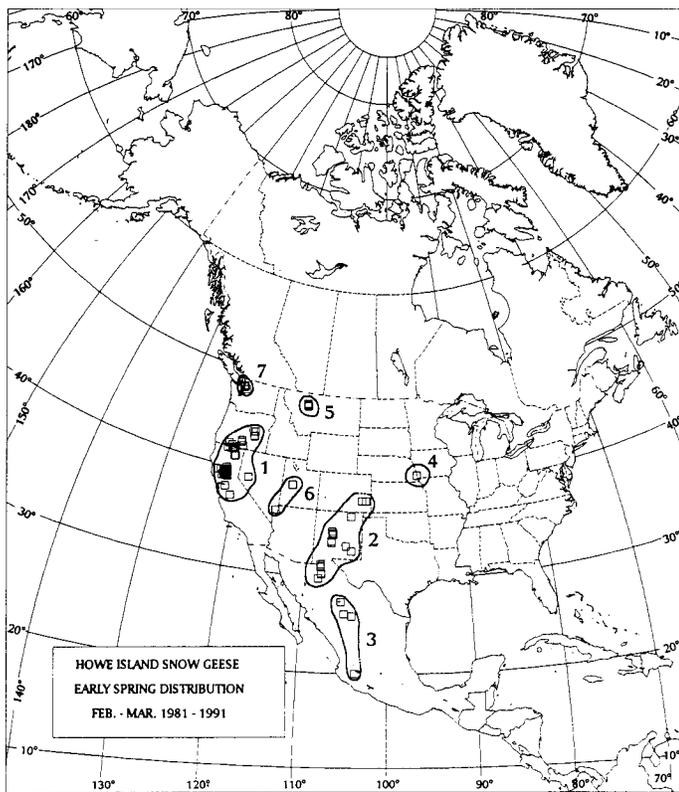


FIG. 4. Early spring distribution of Howe Island snow geese (February and March, 1981 to 1991). Numbers represent clusters given in Table 3.

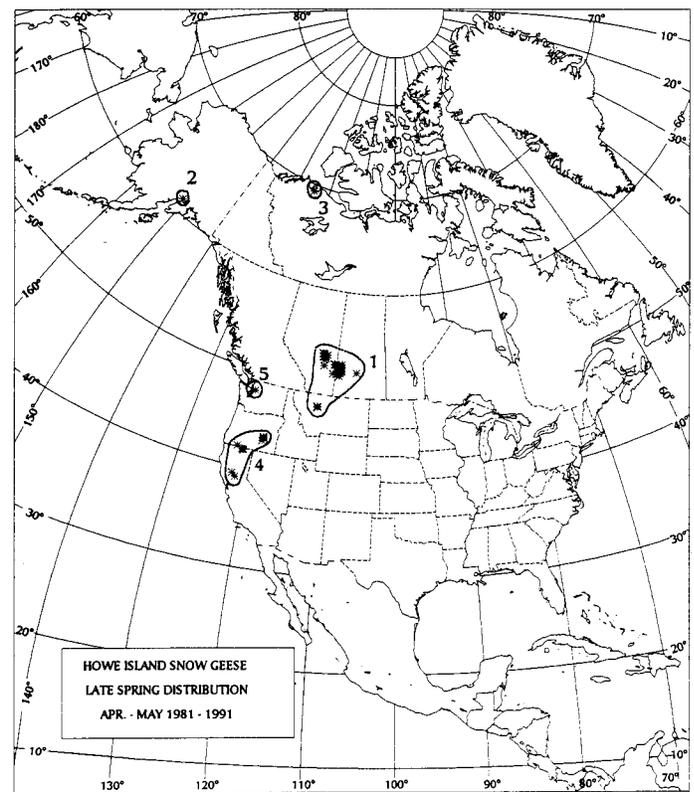


FIG. 5. Late spring distribution of Howe Island snow geese (April and May, 1981 to 1991, excluding records from northern Alaska). Numbers represent clusters given in Table 3.

eastern New Mexico (269 records, 15.2%) and in the playa lakes and agricultural districts of Chihuahua (38 records, 2.1%) and Durango (6 records, 0.3%), Mexico.

Early Spring Distribution (February–March)

Cluster analyses revealed seven different distribution loci for the 880 discrete records of Howe Island snow geese during early spring from 1981 to 1991 (Table 3, Fig. 4). The

largest proportion was from northern California and southeastern Oregon (716 of 880 records, 81.4%). The mean center of this aggregation was only slightly farther north than the mean center of winter records for this same area. Other major aggregations were in northwestern Montana (63 records, 7.2%) as geese moved northward toward Alberta and Saskatchewan, and in northern Chihuahua, New Mexico, and southeastern Colorado (81 records, 9.2%). Some Howe Island geese were still present farther south in Mexico during

early spring (8 birds, 0.9%). Three neck bands (0.3%) were reported in Nevada and Utah as geese moved northward, presumably from the Imperial Valley, toward Montana and the Canadian Prairies. Two other birds (0.2%) were reported in the upper Mississippi Valley. Seven Howe Island snow geese (0.8%) were still present in the Fraser River delta, southwestern British Columbia, in February and March.

Late Spring Distribution (April–May)

Cluster analyses indicated five distinct aggregations of 211 discrete records of Howe Island snow geese during April and May from 1981 to 1991 (Table 3, Fig. 5). Most birds (167 of 211 records, 79.1%) had moved north to staging/feeding areas in Montana, Alberta, and Saskatchewan. A few were still present in northern California and southeastern Oregon (41 records, 19.4%) and in the Fraser River delta, British Columbia (1 record, 0.5%). Single records (0.5%) were also reported from the Susitna River delta in south central Alaska, and from Paulatuk, on the mainland south of Banks Island, Northwest Territories.

Fidelity to Overwintering Areas

A very large proportion (1722 of 1775, 97.0%) of winter resightings and recoveries of Howe Island snow geese were from two regions in the Pacific Flyway (Clusters 1 and 10; Table 3, Fig. 3) and from three regions in the Central Flyway (Clusters 2, 5, and 6; Table 3, Fig. 3). Of this large proportion, most (1406 of 1722, 81.6%) overwintered in northern California and adjacent southern Oregon, and the remainder overwintered in New Mexico and northern Mexico. A large proportion of geese in both flyways were faithful to specific overwintering locations from one year to the next. Of 262 birds for which year-to-year data were available, 98% (217 of 221) in the Pacific Flyway returned to the same region (Cluster 1) in subsequent winters, and 90% (37 of 41) in the Central Flyway returned to the same region (Clusters 2, 5 and 6). Nevertheless, a few geese from both flyways, 1 of 221 (0.5%) in the Pacific Flyway and 4 of 41 (10%) in the Central Flyway, moved to the other flyway during subsequent winters, and 3 Pacific Flyway geese (of 221, 1%) moved to the Central Flyway during the same winter.

DISCUSSION

Fall Migration

The fall, winter and spring distributions of Howe Island snow geese suggest several migration routes to overwintering areas in the Pacific and Central Flyways. During fall, a few Howe Island birds may migrate westward from the Sagavanirktok Delta toward the Chukchi Sea coast and then southward with the Wrangel Island snow goose population. However, our data indicate that during fall migration most Howe Island snow geese moved eastward from the

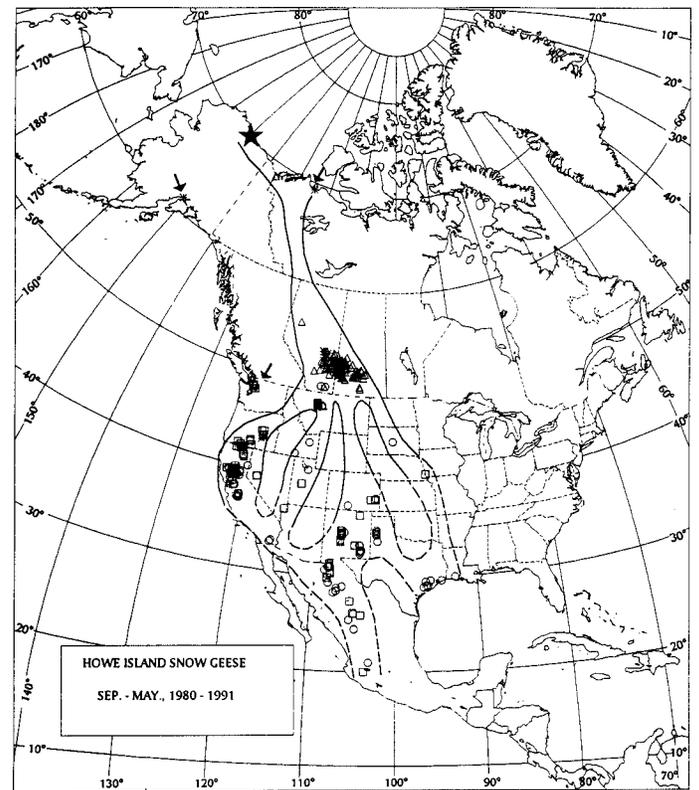


FIG. 6. Inferred migration corridors of Howe Island snow geese, based on all resightings and recoveries during the months of September to May, from 1980 to 1991. Symbols indicate records from different seasons (see Figs. 2–5).

Sagavanirktok Delta (Fig. 6) and mixed with the Canadian Western Arctic population. They probably stopped to feed (stage) on the coastal plain of the Arctic National Wildlife Refuge, Alaska, and adjacent Yukon Territory, Canada (Bellrose, 1980; Salter et al., 1980; Johnson and Herter, 1989). From the North Slope and Mackenzie Delta, the geese moved south along the Mackenzie Valley to reach northern Alberta, as documented for the Western Arctic population (Bellrose, 1980). Although a few birds remained along the Beaufort Sea coast during September and others reached wintering grounds by late October, most of the Howe Island population aggregated in the grain fields of southeastern Alberta and southwestern Saskatchewan during September and October. They remained in these areas and fattened on waste grain before moving farther south to overwintering areas in the Pacific and Central Flyways.

Winter

From Alberta and Saskatchewan, the largest proportion of the Howe Island population moved south and west through Montana and Idaho to reach Pacific Flyway staging and overwintering areas in southern Oregon, northern California and north central California (Fig. 6). Some of these birds moved still farther south through southern California to overwintering areas in northern and central Mexico.

Another segment of the Howe Island snow goose population migrated south from the Canadian Prairies along the

Central Flyway, through Montana, Colorado, and the Texas Panhandle, to reach wintering areas in New Mexico and Mexico (Chihuahua and Durango) (Fig. 6). Smaller proportions moved directly southward through the Great Basin (Idaho, Utah and Nevada) to reach wintering areas in southern California, and a few others appear to have moved southeastward from Saskatchewan, through the upper Mississippi River valley (Francis and Cooke, 1992), to wintering areas along the Gulf of Mexico coasts of Texas and Louisiana (Fig. 6).

The Howe Island geese reported from southwestern British Columbia in fall and winter may have reached that location by flying westward from southern Alberta and Saskatchewan, or they may have migrated along the Pacific Flyway from western Alaska with the Wrangel Island population.

Spring Migration

The early spring distribution of Howe Island snow geese is similar to their winter distribution, but some birds that wintered in the Pacific Flyway had moved north to southern and east central Oregon and northwestern Montana during this period. By the end of March, geese that had wintered in southern Mexico had moved north into New Mexico and Colorado, and those that had wintered in southern California had moved north into the Great Basin and northwestern Montana (Fig. 6). The few Howe Island snow geese that had wintered along the Texas and Louisiana coasts had moved north along the eastern edge of the Central Flyway and probably were incorporated (immigrated) into populations that used the Mississippi Flyway (see Francis and Cooke, 1992).

By late spring, most Howe Island snow geese had retraced their fall migration routes to reach southeastern Alberta and southwestern Saskatchewan. They remained in this area, as they had done in the fall, to feed on waste grain and fatten before continuing to northern Alberta, the Mackenzie River valley (Bellrose, 1980), and westward across the North Slope to Alaska. They arrived in the Sagavanirktok River valley in mid to late May and, in most years, began nesting in late May or early June (Johnson and Herter, 1989; Johnson, 1995). Late spring records in coastal south central Alaska and coastal west central Northwest Territories, suggested that a few Howe Island snow geese had immigrated to adjacent nesting populations on Wrangel Island, Russia, and Banks Island, Canada (Johnson, 1995).

Flyway Fidelity

Over 80% of winter resightings and recoveries of Howe Island snow geese were from California and Oregon in the Pacific Flyway. Most (about 99%) of these Pacific Flyway birds returned to the same California and Oregon overwintering locations from one year to the next. About 20% of winter resightings and recoveries of Howe Island snow geese were from the Central Flyway, mainly New Mexico and northern

Chihuahua, Mexico. A similar proportion (90%) of these Central Flyway birds returned to the same overwintering locations in subsequent years. Nevertheless, small proportions of geese from both flyways switched to the other flyway in subsequent years. The fact that three Pacific Flyway geese were documented moving to the Central Flyway during the same winter suggests that some Howe Island snow geese may migrate to overwintering locations in Mexico using a Pacific Flyway route through California and New Mexico, rather than entirely via a Central Flyway route.

In general, the migration routes and overwintering areas of the Howe Island snow geese are similar in pattern to those documented several decades ago for the much larger Canadian Western Arctic population (Bellrose, 1980). This fact, and the additional evidence (Johnson, 1995) of regular immigration to Howe Island of females from Banks Island and the Anderson River delta, Canada, suggest that the Howe Island population is a satellite colony of the Western Arctic population.

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recovered the birds up and down the Pacific, Central, and Mississippi flyways. Richard Kerbes and two anonymous reviewers made useful comments that improved this paper.

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