CHANGES IN THE WINTERING DISTRIBUTION OF WRANGEL ISLAND SNOW GEESE *ANSER C. CAERULESCENS*

W. Sean Boyd[1] and Fred Cooke[1,2]

[1]Pacific Wildlife Research Centre, Canadian Wildlife Service, Environment Canada, RR1 5421 Robertson Rd., Delta, B.C., Canada V4K 3N2. Email: sean.boyd@ec.gc.ca

[2]Dept. of Biological Sciences, Simon Fraser University, Burnaby, B.C., Canada V5A 1S6. Email: fcooke@sfu.ca

The long-term changes in the size of the Lesser Snow Goose (Anser c. caerulescens) population that breeds on Wrangel Island, Russia, and its associated wintering populations in North America are described. In contrast to exponential increases in almost all other populations of Snow Geese in North America, the Wrangel population declined in the 1970s and has remained relatively stable since then. The proportion of the entire Wrangel population on the Fraser/Skagit deltas (northern wintering site) increased at a rate of just over 1% per year, almost doubling since 1970. This suggests that the proportion in California must have declined at the same rate. The distribution shift may have been caused by differential emigration, survival, and/or fecundity rates among the two wintering populations. These possibilities are discussed along with what further evidence is needed to test them.

Key Words: Lesser Snow Geese, *Anser c. caerulescens*, Wrangel Island, Fraser Delta, Skagit Delta, California, wintering populations.

It is relatively straightforward to understand the various environmental factors influencing the demographic processes of a resident bird population. However, this is more difficult for a migratory population which has separate breeding and non-breeding areas; features influencing important processes may be difficult to isolate. For example, we may recognize that a migratory population is in decline but not know if the factors responsible are acting on the breeding grounds, on the wintering grounds, or during autumn or spring migration. One way to resolve this dilemma is to choose populations which have a common breeding area but are differently segmented during the non-breeding period. The logic is that if these populations show different patterns of change, this is more likely to reflect events acting on local environments rather than on the breeding grounds which should be common to all birds.

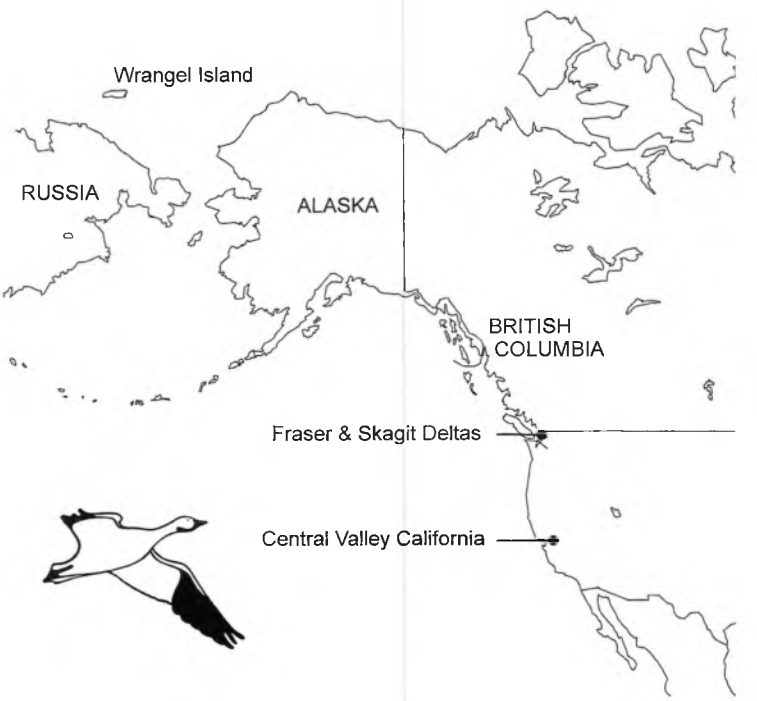

Figure 1. Map showing Wrangel Island in the Russian Arctic and the key wintering areas of Wrangel Snow Geese in North America, the Fraser/Skagit Deltas and Central Valley of California.

The population of Lesser Snow Geese *Anser caerulescens* nesting on Wrangel Island in north east Russia provides an ideal opportunity to examine the effects of environmental differences during the non-breeding period on demographic changes. This population is unusual in that the birds winter in only two distinct locations (see **Figure 1**), in southern British Columbia and northern Washington State (hereafter referred to as the Fraser/Skagit wintering population) and, about 600km to the south, in the Central Valley of California (the California wintering population) (Teplov & Shevarova 1965; Priklonsky & Sapetin 1979; Kerbes *et al.* 1999). These are considered to be separate populations because there is limited exchange between them (Syroechkovsky *et al.* 1995; Boyd 1995). In the early part of the fall, some migrant geese en route to California stop at the Fraser and Skagit deltas but photo counts and telemetry data suggest that the northern wintering population is largely a closed one; once the California birds have passed through, no geese move into or out of the deltas (see Boyd 1995 for details). Also, since pair formation in Snow Geese occurs in winter (Cooke *et al.* 1975; Cooke *et al.* 1995), and parents take their goslings to their traditional wintering grounds, the two groups can be considered from a demographic standpoint to be distinct. This is complicated slightly by the fact that the birds in California mix with a much larger, expanding population of Snow Geese from Banks Island in northern Canada (Syroechkovsky *et al.* 1995).

The aims of this paper are to describe the long-term changes in the relative use

of the two wintering areas by the Wrangel Island population and to explore some of the possible reasons for these changes.

Methods

Population estimates on the Wrangel Island breeding grounds are available beginning in 1970 (Bousfield & Syroechkovsky 1985; unpubl. data from E.V. Syroechkovsky, K.E. Litvin, and V. Baranyuk). Counts were obtained in spring and include all birds (breeding adults and non-breeding birds including yearlings). Reliable estimates are available for the Fraser/Skagit winter population beginning in the late 1940s (Anon. 1992; Boyd 1995, and unpubl. data). These estimates involved early January counts, many of which were photographic counts (see Boyd 1995 for details). Unfortunately, reliable counts are not available for the Wrangel geese in California because they mix with birds from Banks Island.

The proportion of the entire Wrangel population using the Fraser/Skagit deltas was calculated in two ways: (1) the actual mid-winter population as a proportion of the following total spring population on Wrangel Island and (2) the estimated autumn abundance of adults (white birds) as a proportion of the previous total spring population on Wrangel Island. In the latter, the autumn abundance of adults was estimated by adding harvest in autumn-early winter to the mid-winter count (see Boyd 1995 for details). Linear regression analysis was used to determine if the proportions changed over time. These regressions were subjected to an *a posteriori* χ^2 diagnostic for a normal distribution of residuals.

Results

Abundance estimates for the Wrangel Island breeding population since 1970 and for the Fraser/Skagit wintering population since 1948 are presented in **Figure 2**. Both patterns suggest a high level of variability over time which is typical for Arctic nesting geese. This variability is influenced on Wrangel Island mostly by weather conditions which can be severe in some years. Breeding failures occur often and recruitment can range from 0-50% immature birds in the population in any year (mean = ca. 20%). The size of the Wrangel spring population was estimated at ca. 150,000 birds in 1970 but it decreased sharply to ca. 55-60,000 birds by 1975, largely as a result of four consecutive breeding failures (Bousfield & Syroechkovsky 1985). The population increased again to 80-100,000 birds in the late 1970s and remained at that level for most of the 1980s. It declined to 60-70,000 birds in the late 1980s and early 1990s and then increased to 80-90,000 birds in the late 1990s. This pattern is very different from the exponential increases experienced by most populations of Snow Geese in North America during the same period (Abraham & Jefferies 1997).

Between the late 1940s and the present, the Fraser/Skagit wintering population fluctuated between 15-55,000 birds with a mean abundance of ca. 34,000 birds (SE=1,500). A linear model suggests that this wintering population grew at a rate ca. 400 birds per year (n=44 years, $F_{1,42}=21.1$, $P<0.001$) despite the breeding failures in the early 1970s. The latter resulted in a sharp drop in abundance on the Fraser/Skagit deltas, from ca. 50,000 to 15,000 birds between 1970 and 1975.

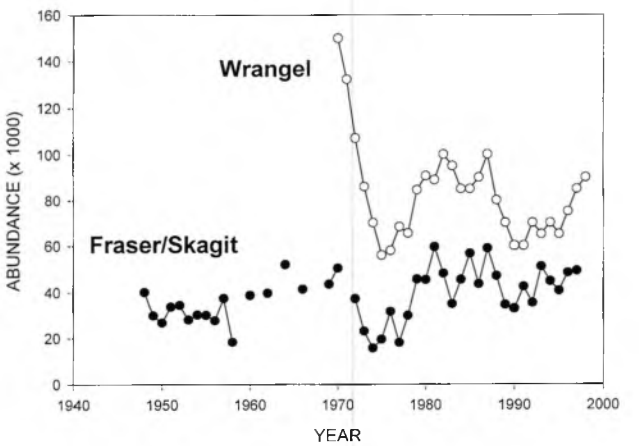

Figure 2. Historical abundance estimates for Snow Geese on Wrangel Island in spring and on the Fraser/Skagit deltas in autumn or early winter. The population estimates for the Fraser/Skagit deltas are predicted values; they have been corrected for bias when aerial visual surveys were involved and they include autumn harvest estimates.

The proportion of the Wrangel Island population wintering on the Fraser/Skagit deltas doubled between 1970 and 1998 (**Figures 3a and 3b**). Linear models were significant for both the actual mid-winter population as a proportion of the subsequent total spring population on Wrangel Island (**Figure 3a**; r^2=0.69, $F_{1,26}$=57.8, P<0.001, slope=0.013) and the estimated autumn abundance of adults (white birds) as a proportion of the previous total spring population on Wrangel Island (**Figure 3b**; r^2=0.76, $F_{1,25}$=78.9, P<0.001, slope=0.012). Both regression analyses passed the *a posteriori* χ^2 diagnostic for a normal distribution of residuals (P>0.6). The fact that the regression results are similar suggests that there are no biases associated with the different indices. The regression slopes indicate that the proportion of Wrangel birds wintering on the Fraser/Skagit deltas has increased at a rate of slightly more than 1% per year. Conversely, the proportion wintering outside the Fraser/Skagit deltas must have declined at the same rate.

Discussion

Snow Geese tend to be highly philopatric to specific breeding and wintering areas (Prevett & MacInnes 1980), with adults taking their offspring to their traditional wintering locations. All Wrangel geese breed together in the same colony and moult together in the same area so they are subject to similar weather conditions and predation pressures during the summer. Other things being equal, this should result in a constant proportion of birds in each wintering area. However, available data suggest that the proportions have changed at a rate of about 1% per year to the point where most Wrangel geese are now on the Fraser/Skagit deltas. Three possible, non-exclusive explanations for this distribution shift were proposed. These were: (a) differential emigration, (b)

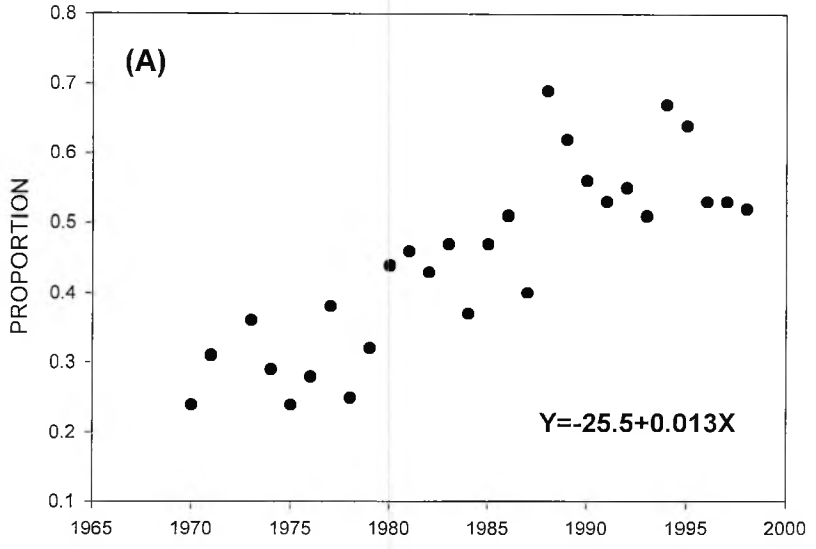

Figure 3a. Actual mid-winter population of Snow Geese on the Fraser/Skagit deltas as a proportion of the subsequent total spring population on Wrangel Island. The actual mid-winter values have been corrected for bias when aerial visual surveys were involved.

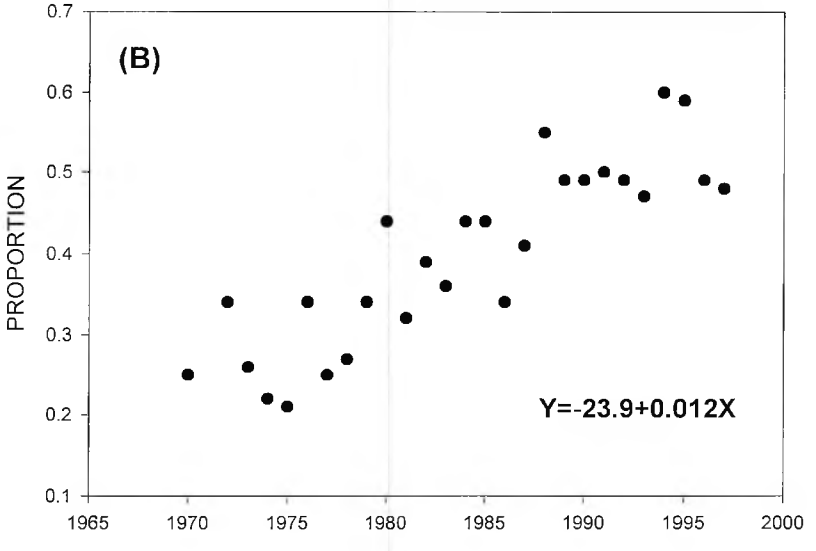

Figure 3b. Estimated autumn abundance of adult Snow Geese on the Fraser/Skagit deltas as a proportion of the previous total spring population on Wrangel Island. The total spring population includes all birds (breeding and non-breeding adults plus yearlings).

differential survival, and/or (c) differential fecundity. Each of these explanations are considered in turn, and suggest further evidence needed to test them.

Differential emigration

Birds may be differentially emigrating to the more northerly wintering location. Permanent emigration between the sites appears to be rare given that fewer than 4% of marked birds (11/278) were seen on the different wintering grounds in different years (Syroechkovsky *et al.* 1995). However, even if only a small number of birds switched each year from the southern to the northern site, this could account for the change in relative proportions. One possible mechanism for this could be that, since at least half of the Californian contingent migrate through the Fraser/Skagit deltas during fall migration (Boyd 1995), some birds may decide to remain if conditions are favourable. This phenomenon is referred to as 'short-stopping' and was widely thought to explain the disappearance of goose populations from the Gulf Coast in the 1970s (Dzubin 1974). Short-stopping may have been facilitated or even encouraged by the establishment of protected areas such as the Reifel Migratory Bird Sanctuary in 1963 and the Alaksen National Wildlife Area in 1972 on the Fraser River delta. The importance of short-stopping is unknown and can only be resolved by examining the occurrence of marked birds in the different wintering areas over successive years. A reasonably good database of neck-collar observations exists for the years 1987 to 1998; these could be scrutinised for evidence of permanent movement between wintering grounds.

Differential survival

If survival rates differ between the two wintering populations this could explain the changing proportions. Survival differences could be due to differential hunting pressure and/or natural mortality. The California-bound birds appear to ride a wave of hunting pressure during autumn migration. Their peak abundance on the Fraser and Skagit deltas in early to mid-October usually coincides with the opening of the local hunting season and peak of hunting pressure. The geese usually arrive at Summer Lake, Oregon, 2-3 weeks before geese from Banks Island and around the opening date for hunting; they are usually heavily hunted at this time (M. St. Louis, pers. comm.). Hines *et al.* (1999) analysed returns from birds neck-collared on Wrangel Island and subsequently observed on the Fraser/Skagit deltas versus locations further south and found no evidence of survival rate differences between the two wintering populations. However, only two years of data were used in their analysis. Several additional years of neck-collar observations are now available; these could be analysed in the same manner to assess differences in survival rates. Also, a large number of Wrangel birds have been marked with leg-rings in recent years, primarily for the purpose of estimating harvest. Analysis of these data might indicate the extent to which differential harvest is responsible for the distribution shift from south to north.

Disease is another factor that may contribute to differential survival rates. Avian cholera has recently been shown to negatively impact the survival of Wrangel geese wintering in California (M. Samuels, pers. comm.). Given that cholera has never been documented in the Fraser/Skagit birds, analysis of Samuels' data might

suggest the extent to which disease is responsible for the distribution shift.

Differential fecundity

The two wintering populations have very different migration routes in spring. The Fraser/Skagit group migrates northward along the coast, stopping at traditional sites including the Stikine River delta, Cook Inlet, and the Yukon River delta in Alaska and specific locations in Russia before reaching Wrangel Island. The California contingent migrates along an interior route through southern Oregon, Montana, Alberta and eventually to the Yukon River delta (Kerbes *et al.* 1999). These two routes differ in distances travelled, disturbance levels, food types, etc. which altogether may result in different rates or timing of nutrient acquisition. Ankney & MacInnes (1978) showed that most lipids and proteins needed for migration, egg production and incubation are acquired just prior to arrival on the breeding grounds. Hence, the reproductive performance of the geese could be influenced by events during spring migration. A comparison of fecundity measures on the breeding grounds of known birds from the two wintering areas would provide some evidence for this. Russian biologists have been collecting these data from marked and face-stained birds; a detailed analysis of these data might reveal fecundity differences.

Summary

Wrangel Island supports the last remaining population of Lesser Snow Geese in Russia. Following a dramatic decline in abundance in the early 1970s, Snow Geese were added to Russia's list of endangered species. The geese winter primarily at two distinct locations in North America. In the early 1960-70s, the Fraser/Skagit deltas supported only 20-30% of the entire population but currently the deltas support 50-60%. If this rate of proportional shift from California to the Fraser/Skagit deltas continues, the entire Wrangel population could eventually winter in the north. From a population conservation viewpoint, this would be problematic. An acute mortality factor (e.g. an oil spill) could threaten all or a large number of the Wrangel birds. It is therefore important to continue to document the rate of proportional shift and determine why it is happening. We have suggested several explanations but there may be other mechanisms at work. Analysis of existing data sets containing observations of individually marked birds should help resolve this important issue.

Acknowledgements

We thank Russian biologists V.V. Baranyuk, E.V. Syroechkovsky, and K.E. Litvin for providing population abundance data from Wrangel Island. Barry Smith assisted with the statistical analysis. Robert Elner, Barbara Ganter, and an anonymous reviewer provided valuable comments on a previous version of the paper. Funds to conduct the photo counts on the Fraser and Skagit deltas from 1987-1998 were provided by the Canadian Wildlife Service of Environment Canada, Washington State Dept. of Fish and Wildlife, and the Arctic Goose Joint Venture (N.A. Waterfowl Management Plan).

References

Abraham, K.F., & R.L. Jefferies (1997). High goose populations: causes, impacts and implications. In B.D.J. Batt, (ed). *Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group.* Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. Pp. 7-72. 120pp.

Ankney, C.D. & C. D. MacInnes. (1978). Nutrient reserves and reproductive performance of female Lesser Snow Geese. *Auk* **95**:459-471.

Anon. (1992). Management plan for the Wrangel Island population of Lesser Snow Geese. Unpublished report by the Pacific Flyway Council. 25pp.

Bousfield, M.A. & E.V. Syroechkovsky. (1985). A review of Soviet research on the Lesser Snow Goose on Wrangel Island, USSR. *Wildfowl* **36**:13-20.

Boyd, W. S. (1995). Lesser Snow Geese *Anser c. caerulescens* and American Three-square Bulrush *Scirpus americanus* on the Fraser and Skagit River Deltas. Ph.D. Dissertation. Simon Fraser University, British Columbia. 154pp.

Cooke, F., C.D. MacInnes, & J.P. Prevett. (1975). Gene flow between breeding populations of Lesser Snow Geese. *Auk* **93**: 493-510.

Cooke, F., R.F. Rockwell & D.B. Lank. (1995). *The Snow Geese of La Pérouse Bay, Natural Selection in the Wild.* Oxford University Press, Oxford. 297pp.

Dzubin, A. (1974). Snow and Blue Goose distribution in the Mississippi and Central Flyways: A compendium of results of band recovery analyses. A report prepared at the request of the Central and Mississippi Flyway Councils by the Canadian Wildlife Service, Saskatoon.

Hines J.E., M.O. Wiebe, S.J. Barry, V.V. Baranyuk, J.P. Taylor, R. McKelvey, S.R. Johnson & R.H. Kerbes. (1999). Survival rates of Lesser Snow Geese in the Pacific and Western Central Flyways, 1953-1989. In: R.H. Kerbes, M.O. Meeres & J.E. Hines, (eds.) *Distribution, survival, and numbers of Lesser Snow Geese of the Western Canadian Arctic and Wrangel Island, Russia.* Occasional Paper No. 98. Canadian Wildlife Service, Environment Canada, Ottawa. 120pp. Pp. 89-111

Kerbes, R.H., K.M. Meers & J.E. Hines. (1999). *Distribution, survival, and numbers of Lesser Snow Geese of the Western Canadian Arctic and Wrangel Island, Russia.* Occasional Paper No 98. Canadian Wildlife Service, Environment Canada, Ottawa. 120pp.

Prevett, J.P. & C.D. MacInnes. (1980). Family and other social groups in Snow Geese. *Wildlife Monographs* **71**:6-44.

Priklonsky, S.G. & V. Sapetin. (1979). The migrations of the Snow Goose *Chen caerulescens*. In: *Migrations of Birds of East Europe and North Asia.* Moscow, Nauka, pp. 163-178. In Russian.

Syroechkovsky, E.V., F. Cooke & W.J.L. Sladen. (1995). Population structure of the Lesser Snow Geese of Wrangel Island, Russia. *Ecoscience* **1**: 311-316.

Teplov, V.P. & T.P. Shevarova. (1965). About seasonal distribution and hunting of the Snow Geese, Moscow, *Nauka*, pp 25-38. In Russian.