Aerial surveys of Greater White-fronted Geese, Canada Geese, and Tundra Swans on the mainland of the Inuvialuit Settlement Region, Western Canadian Arctic, 1989–1993

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Abstract

From 1989 to 1993, we carried out helicopter transect surveys to determine the numbers, distribution, and productivity of Greater White-fronted Geese *Anser albifrons*, Canada Geese *Branta canadensis*, and Tundra Swans *Cygnus columbianus* on the mainland of the Inuvialuit Settlement Region of the Western Canadian Arctic. The estimated size of the adult populations in the 26 605-km^2 survey area in June was 47 500 for Greater White-fronted Geese, 18 000 for Canada Geese, and 16 900 for Tundra Swans. In addition, we estimated that there were 2900 Greater White-fronted Geese, 4800 Canada Geese, and 1600 Tundra Swans in seven areas (totalling 513 km^2) where moulting adults congregated each year. Low densities of geese and swans are known to occur outside the survey area but still on the mainland of the Inuvialuit Settlement Region. Taking this into account would increase the overall population estimates for the mainland to approximately 55 600 Greater White-fronted Geese, 30 300 Canada Geese, and 28 700 Tundra Swans. In years of average reproductive success, birds from the Inuvialuit Settlement Region would have comprised 11% of the Mid-continent Population of Greater White-fronted Geese, 9% of the Short-grass Prairie Population of Canada Geese, and 35% of the Eastern Population of Tundra Swans. Counts were repeated in a 12 743-km^2 area each year from 1990 to 1993 and were averaged for potential comparisons with future surveys. The overall averages for total population size and number of breeding pairs on this area would allow us to detect an 18% change in the numbers of Greater White-fronted Geese, a 20% change in the numbers of Tundra Swans, and a 35% change in the numbers of Canada Geese. For 1990–1993, a subset of the transects was resurveyed in mid-July to determine an annual index of reproductive success. Productivity was 0.26, 0.29, and 0.21 broods/pair and average brood sizes were 3.0, 3.2, and 2.5 young for Greater White-fronted Geese, Canada Geese, and Tundra Swans, respectively. Productivity was highest in the year of the earliest spring, 1991, and lowest during 1992, when snowmelt was very late. Given the local importance of geese and swans to the Inuvialuit, the continental significance of waterfowl populations from the Inuvialuit Settlement Region, the apparent decline in some populations, and the variety of stressors acting on these populations, we recommend that our surveys be repeated at not more than 10-year intervals to help guarantee the conservation and management of these waterfowl.

1. Introduction

The Inuvialuit Settlement Region of the Western Canadian Arctic is an important breeding and moulting area for Greater White-fronted Geese *Anser albifrons*, Canada Geese *Branta canadensis*, Lesser Snow Geese *Anser caerulescens caerulescens*, Tundra Swans *Cygnus columbianus*, and several other species of waterfowl (Barry 1967; Alexander et al. 1988; Johnson and Herter 1989; Dickson 1997; Kerbes et al. 1999; Hines et al. 2000). The Aboriginal people of the region, the Inuvialuit, rely on waterfowl for subsistence harvest and, by their land claim agreement, are assured of preferential rights to the allowable harvest of the migratory birds in the region (Committee for Original Peoples Entitlement 1984). Information on bird numbers, distribution, habitat requirements, survival, and productivity is needed to determine if current local and international harvest levels are sustainable and to ensure that populations are conserved for the long-term use of the Inuvialuit and other people residing or hunting within the migratory range of these species.

The Greater White-fronted Geese breeding in the Inuvialuit Settlement Region are part of the Mid-continent Population. Geese from this population nest in parts of Alaska, the Yukon, and the Western and Central Canadian Arctic. They stage in the Prairie provinces during migration and winter in Texas, Louisiana, Arkansas, and Mexico. Current information on the status of the population is somewhat uncertain, and there is concern that annual international harvests of Mid-continent Greater White-fronted Geese might exceed sustainable levels. As a result, wildlife conservation agencies have placed a high priority on studies that would help us better manage Greater White-fronted Geese (Anonymous 2002).

From 1989 to 1993, we carried out aerial surveys of waterfowl on the mainland of the Inuvialuit Settlement Region to determine the numbers, distribution, and productivity of Greater White-fronted Geese, Canada Geese, and Tundra Swans in the region. The data so gathered provide an important baseline against which the future status of the populations can be assessed.

2. Study area and methods

The 27 118-km^2 study area lies within the Arctic Coastal Plains Physiographic Region and is characterized by rolling lowland plains and abundant wetlands (especially near the Mackenzie Delta and on the Tuktoyaktuk Peninsula) (Bostock 1970; Wiken 1986). Dominant plant communities include grasses and sedges (*Carex* spp.) in lowland and coastal areas, tall shrubs near some lakes and streams, and widespread tundra composed of shorter shrubs, cottongrass *Eriophorum*, and scattered herbs (Bliss et al. 1973; Corns 1974; Wiken 1986). Open forest–tundra occurs in the southern part of the Inuvialuit Settlement Region, and white spruce *Picea glauca* reaches its northern limit in this area. Daily temperatures average <10°C during spring and summer (Environment Canada 2003). Precipitation is low, averaging 139 mm per year, but snowfall is possible in any season.

Aerial surveys were conducted between 11 and 21 June of 1989–1993, during the period when most species of waterfowl were widely dispersed as breeding pairs. The main survey area was divided into seven main strata (totalling 26 605 km^2) based on geographic, physiographic, and habitat differences (Fig. 1; top). In addition, seven smaller areas (totalling 513 km^2) of known importance to moulting geese and swans (Barry 1967; Alexander et al. 1988) were surveyed more intensively (Fig. 1; bottom). Together, the latter areas were treated as a separate "moulting area" stratum. Due to budgetary and time constraints, not all strata were surveyed annually, although we were able to survey a 12 743-km^2 core area corresponding to the Tuktoyaktuk Peninsula and Mackenzie Delta strata each year from 1990 to 1993. Therefore, annual indices of population size were available for nearly half of the overall study area for a four-year period.

The survey procedure involved flying straight transects in a Bell 206B or 206L helicopter at an elevation of 45 m and ground speed of 80–100 km/h. Most transects were oriented in a north–south direction (approximately perpendicular to the coastline) and were spaced at 10-km intervals, except in a few areas of prime waterfowl habitat, where transects were 5 km apart. Transects in the moulting areas were spaced at 2-km intervals. Regular transects averaged 25 km in length (range: 6–82 km). In the moulting areas, most transects were less than 10 km in length, and the average length was 6 km. All transects were divided into 2-km segments, which served as the basic unit for recording data.

Surveys were conducted with two observers, one seated in the left front seat and the other in the right rear seat (equipped with a bubble window for better viewing). All observations of geese and swans within an estimated 200 m of the flight path were recorded on audio tape and later transcribed.

Population estimates and densities (± standard errors) for the different strata were calculated using the ratio method (Jolly 1969). Population densities for all years were averaged to calculate the average number of geese and swans in the stratum. The standard error (SE) of the mean population estimate for each stratum was determined as follows:

$$SE = \frac{\sqrt{\Sigma S_i^2}}{n}$$

where S_i^2 is the variance of the stratum population estimate in year i and n is the number of years the stratum was surveyed. The sizes of some strata were increased somewhat as the study evolved and we expanded surveys into previously unsurveyed areas. When the size of the stratum varied among years, the largest area surveyed in any year was used in calculating the average population estimate for the stratum. The total population estimate for the Inuvialuit Settlement Region was the sum of the individual stratum population estimates, and the variance for the total population estimate was the sum of all stratum variances.

Female Greater White-fronted and Canada geese are seen infrequently from the air if they are on nests, so each observation of one or two geese was treated as an indicated breeding pair (i.e., as two birds) in calculating numbers of breeding geese (U.S. Department of the Interior and Environment Canada 1987). The total population size was estimated as the number of indicated breeding pairs multiplied by two plus the number of birds in groups of three or more.

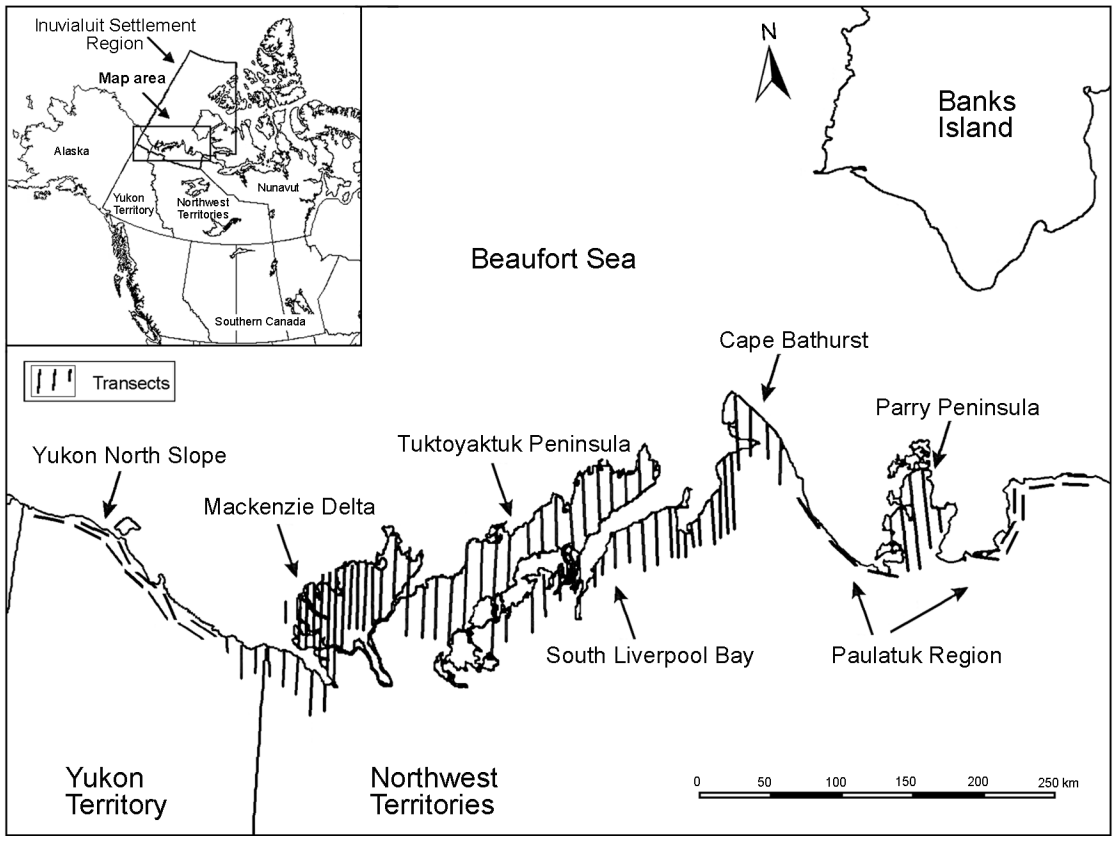
Adjusting observations to account for missed females may still underestimate the actual population size, because there may be groups, pairs, or lone geese that were not sighted from the air. Visibility correction factors to adjust for dark geese missed during helicopter surveys in tundra habitats range between 1.4 and 2.1 (Bromley et al. 1995; Hines et al. 2000; see also Appendix 1). Based on those studies, we believe that using a visibility correction factor of 1.5 provides a conservative estimate of the number of "dark" geese in a given area. We applied this visibility correction factor to both breeding pair and total population estimates (and their standard errors) for all strata except the moulting areas (where geese were typically bunched in large flocks on water and were readily seen from the air).

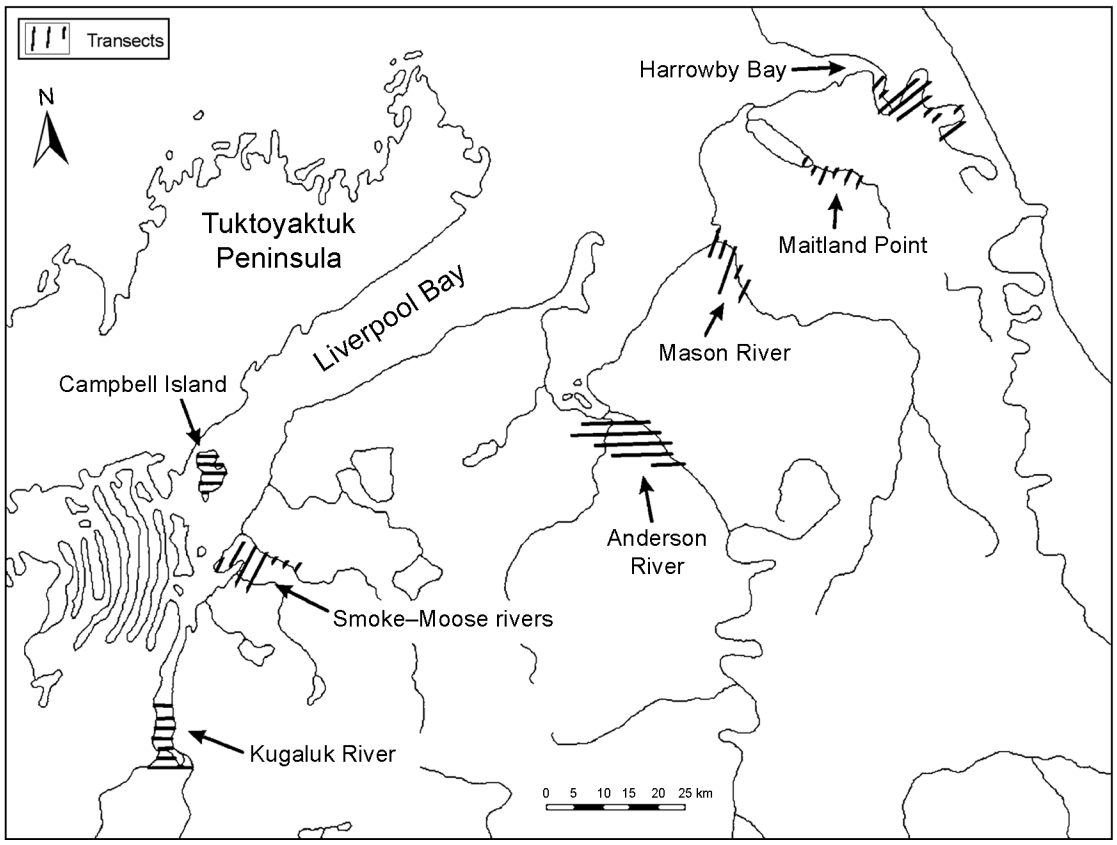
Tundra Swans are highly visible and not likely to be missed during the surveys. Thus, the total population size was calculated using the number of swans actually observed. Indicated breeding pairs were calculated by summing all sightings of one or two swans and then dividing by two (Wilk 1988). Neither the total population estimate nor the breeding pair estimates for Tundra Swans were adjusted by a visibility correction factor.

A 12 743-km^2 "core area" was surveyed each year to determine the year-to-year variability in population sizes of geese and swans, evaluate the relative precision of surveys, and find out what change in population size could be detected by repeating the surveys in the future. As a measure of survey precision, we calculated coefficients of variation for the annual and average population estimates for each species. The percentage change in population size that could be detected in future surveys was then determined following the methods outlined in Krebs (1989: 179). We assumed a significance level of $\alpha = 0.05$ in this evaluation.

Repeat surveys of 22–31% of the study area (6091–8372 km^2) were also carried out in July of 1990–1993 in the Mackenzie Delta, Tuktoyaktuk Peninsula, and South Liverpool Bay strata to calculate an index of the annual productivity of geese and swans. The procedure for these surveys was identical to that for the June breeding surveys, except that particular emphasis was placed on recording sightings of broods and the number of young in each brood.

Figure 1
Transects surveyed for waterfowl in the Inuvialuit Settlement Region, 1989–1993





An index of the number of broods per breeding pair was calculated using information on the number of pairs from the June breeding surveys and on the number of broods from the July surveys for the same transects. The proportion of young in the population was calculated using the number of young seen on the July surveys divided by the total number of birds estimated to be present. In the latter calculation, the estimated number of birds present was the number of young seen (July surveys) plus the number of adults seen on the same transects during the June surveys. Counts from neither the June nor July surveys were adjusted by visibility correction factors when estimating productivity (i.e., we assumed that adult birds were equally visible in both surveys).

3. Results

3.1 Numbers and distribution

3.1.1 Greater White-fronted Geese

The estimated population size of Greater White-fronted Geese was 47 452 ± 2528 geese in the 26 605-km^2 survey area, plus an additional 2870 ± 393 geese in the moulting stratum (Tables 1 and 2; Fig. 2). Among the main survey strata, the highest numbers of geese occurred in the Tuktoyaktuk Peninsula and South Liverpool Bay strata, where densities averaged 2.37 ± 0.18 and 3.43 ± 0.33 geese/km^2, respectively. Fewer geese were present in the other main survey strata, where densities ranged from 0.04 to 1.54 geese/km^2. We estimated that there were 8219 ± 399 pairs in the 26 605-km^2 survey area (Table 3) and an additional 247 ± 33 pairs in the moulting stratum (Table 4).

Estimated numbers of Greater White-fronted Geese in the 12 743-km^2 "core" area surveyed each year from 1990 to 1993 are presented in Figure 3 and Table 5. The overall coefficient of variation for both the mean population estimate and the estimated number of indicated pairs was 7%, indicating that the average estimate of population size for the four-year period was precise and would provide a good baseline for detecting long-term population trends. We determined that if the surveys were repeated in the future and similarly precise estimates were obtained, we would be able to detect an 18% change in population size.

3.1.2 Canada Geese

The estimated population size for Canada Geese was 17 974 ± 3566 in the 26 605-km^2 survey area and an additional 4775 ± 2304 geese in the moulting stratum (Tables 6 and 7; Fig. 4). Aside from the moulting area stratum, which, by the manner in which it was defined, contained very high densities of geese (an average of 9.31 ± 4.49 geese/km^2), the highest numbers of geese occurred on the Parry Peninsula and Cape Bathurst, where densities averaged 3.79 ± 1.18 and 1.23 ± 0.57 geese/km^2, respectively. Fewer geese were present in the other strata, and densities were lower (0.10–0.88 geese/km^2). We estimated that there were 3335 ± 491 pairs in the 26 605-km^2 survey area (Table 8) and only 40 ± 9 pairs in the moulting stratum (Table 9).

Because of the smaller numbers of Canada Geese sighted during the surveys, the precision of both the total population estimates and breeding pair estimates in the core 12 743-km^2 area was much lower than for Greater White-fronted Geese or Tundra Swans (Table 5; Fig. 3). The level of precision of the estimates would allow us to detect a 35% change in overall population or numbers of breeding pairs if similar surveys were carried out in the future.

3.1.3 Tundra Swans

We estimated that there were 16 913 ± 925 Tundra Swans in the 26 605-km^2 survey area and 1634 ± 370 swans in the moulting stratum (Tables 10 and 11; Fig. 5). As expected, the average population density within the moulting area stratum (3.19 ± 0.72 swans/km^2) was higher than within the other strata. The Mackenzie Delta, Tuktoyaktuk Peninsula, and South Liverpool Bay all supported relatively high population densities (0.83 ± 0.10, 0.89 ± 0.07, and 0.75 ± 0.08 swans/km^2, respectively), but fewer swans were present in the other strata, where densities were only 0.08–0.26 swans/km^2. The estimated number of pairs in the 26 605-km^2 survey area was 7190 ± 259 (Table 12), and an additional 189 ± 20 pairs were present in the moulting stratum (Table 13).

Overall population estimates and breeding pair estimates for Tundra Swans were relatively precise (Table 5; Fig. 3). A repeat survey of the 12 743-km^2 core area would allow us to detect a 20% change in overall numbers and an 11% change in the number of breeding pairs present.

3.2 Productivity

Productivity indices were calculated from the subset of transects surveyed during both the nesting and brood-rearing periods. We estimated that Greater White-fronted Geese produced an average of 0.26 broods/pair and had an average brood size of 3.0 young (Table 14). Canada Geese had similar reproductive success (0.29 broods/pair, 3.2 young/brood). Tundra Swans produced an average of 0.21 broods/pair, and the average brood size was 2.5 young. The number of broods per pair and the average brood size varied substantially among years for all species. Reproductive success was especially high after the earliest spring (1991) and very low after the late spring of 1992 (Table 15).

4. Discussion

Although the importance of the mainland of the Inuvialuit Settlement Region to waterfowl and other migratory birds has long been known (Barry 1967; Alexander et al. 1988; Johnson and Herter 1989), the helicopter transect surveys conducted from 1989 to 1993 represent the most complete effort to census the population of Greater White-fronted Geese, Canada Geese, and Tundra Swans in the region. Our surveys covered a large part of the mainland of

Table 1
Estimated densities and numbers of Greater White-fronted Geese in survey strata on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Geese observed	Number of transects	Area (km²)	Density ± SE (geese/km²)	Number of geese ± SE
Mackenzie Delta	1989	365	9	3 668	2.35 ± 0.43	8 626 ± 1 581
	1990	247	23	6 091	0.70 ± 0.12	4 236 ± 750
	1991	309	24	6 091	0.81 ± 0.19	4 922 ± 1 143
	1992	261	24	6 091	0.68 ± 0.16	4 157 ± 992
	1993	232	24	6 091	0.61 ± 0.12	3 695 ± 728
			Average (no VCF[a])		1.03 ± 0.11	6 267 ± 641
			Average (adjusted by VCF)		1.54 ± 0.16	9 400 ± 962
Tuktoyaktuk Peninsula	1989	509	17	6 652	1.89 ± 0.29	12 596 ± 1 961
	1990	310	17	6 652	1.15 ± 0.26	7 672 ± 1 728
	1991	528	17	6 652	1.96 ± 0.35	13 066 ± 2 303
	1992	422	17	6 652	1.57 ± 0.24	10 443 ± 1 605
	1993	357	17	6 652	1.33 ± 0.21	8 835 ± 1 380
			Average (no VCF)		1.58 ± 0.12	10 522 ± 815
			Average (adjusted by VCF)		2.37 ± 0.18	15 784 ± 1 223
South Liverpool Bay	1989	765	15	3 280	4.31 ± 0.72	14 128 ± 2 369
	1990	492	15	3 500	2.80 ± 0.69	9 784 ± 2 416
	1991	319	21	4 721	1.49 ± 0.28	7 051 ± 1 300
	1992	337	21	4 721	1.58 ± 0.29	7 448 ± 1 380
	1993	340	21	5 796	1.25 ± 0.21	7 245 ± 1 194
			Average (no VCF)		2.28 ± 0.22	13 243 ± 1 271
			Average (adjusted by VCF)		3.43 ± 0.33	19 864 ± 1 906
Cape Bathurst	1991	53	7	1 737	0.68 ± 0.29	1 186 ± 506
	1992	26	4	1 279	0.50 ± 0.22	640 ± 283
	1993	19	4	1 279	0.37 ± 0.24	467 ± 305
			Average (no VCF)		0.52 ± 0.15	897 ± 253
			Average (adjusted by VCF)		0.77 ± 0.22	1 345 ± 379
Yukon North Slope	1990	11	11	1 821	0.13 ± 0.09	228 ± 156
			(adjusted by VCF)		0.19 ± 0.13	341 ± 233
Parry Peninsula	1991	16	6	2 784	0.16 ± 0.09	435 ± 242
			(adjusted by VCF)		0.23 ± 0.13	653 ± 363
Paulatuk Region	1991	2	10	1 724	0.03 ± 0.02	43 ± 42
			(adjusted by VCF)		0.04 ± 0.04	65 ± 63
All non-moulting strata (adjusted by VCF)				26 605	1.78 ± 0.10	47 452 ± 2 528

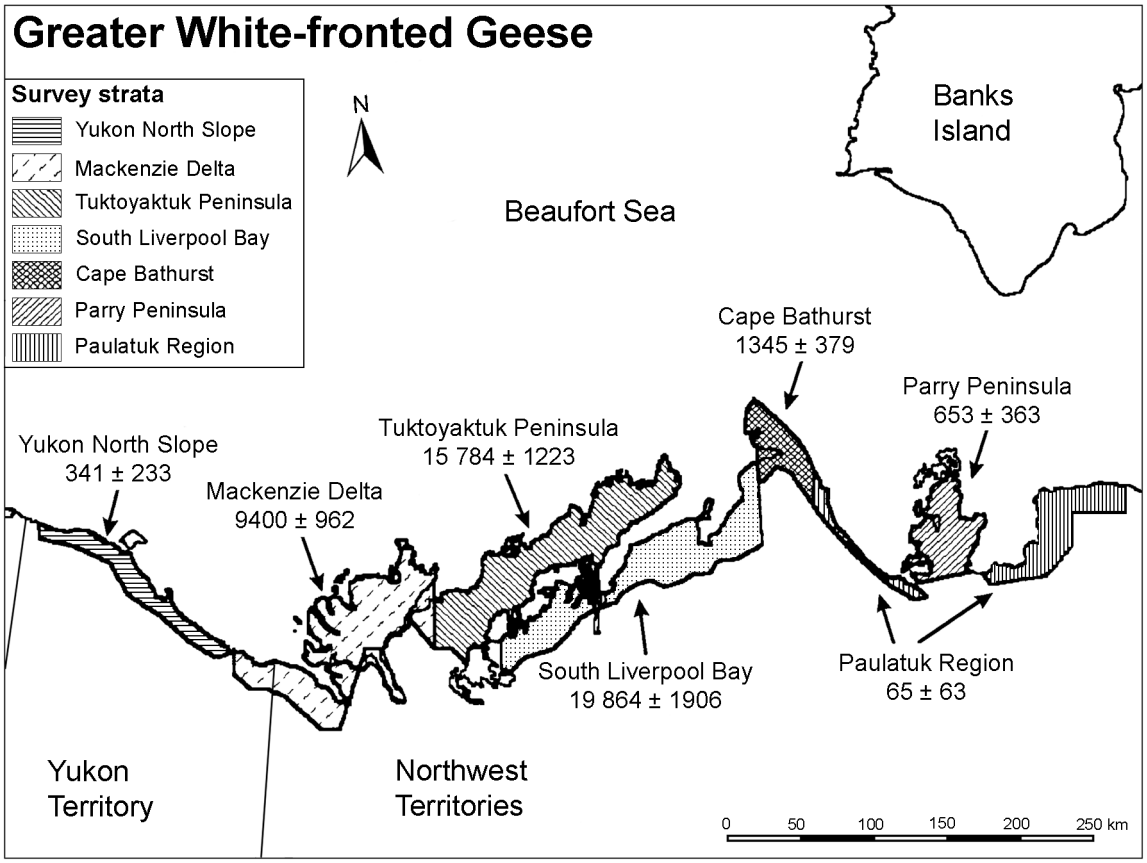
[a] Visibility correction factor.

Table 2
Estimated densities and numbers of Greater White-fronted Geese in moulting areas on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Geese observed	Number of transects	Area (km²)	Density ± SE (geese/km²)	Number of geese ± SE
Kugaluk River	1991	180	7	64	14.06 ± 6.13	903 ± 394
	1992	54	7	64	4.22 ± 1.96	271 ± 126
	1993	148	7	64	11.56 ± 7.94	742 ± 509
			Average (no VCF[a])		9.95 ± 3.41	638 ± 219
Campbell Island	1991	20	5	41	2.50 ± 0.94	102 ± 38
	1992	14	5	41	1.75 ± 0.85	71 ± 35
	1993	10	5	41	1.25 ± 0.77	51 ± 31
			Average (no VCF)		1.83 ± 0.49	74 ± 20
Smoke–Moose rivers	1991	104	7	82	6.19 ± 3.40	510 ± 280
	1992	116	7	82	6.90 ± 2.35	569 ± 194
	1993	44	7	82	2.62 ± 1.04	216 ± 86
			Average (no VCF)		5.24 ± 1.42	432 ± 117
Anderson River	1991	192	4	104	9.23 ± 4.54	962 ± 473
	1992	200	4	104	9.62 ± 3.43	1003 ± 357
	1993	353	4	104	16.97 ± 5.60	1769 ± 583
			Average (no VCF)		11.94 ± 2.66	1245 ± 277
Mason River	1991	116	5	68	8.53 ± 4.97	582 ± 339
	1992	86	5	68	6.32 ± 1.82	431 ± 124
	1993	29	5	68	2.13 ± 1.13	145 ± 77
			Average (no VCF)		5.66 ± 1.80	386 ± 123
Maitland Point	1991	12	6	40	1.50 ± 1.04	61 ± 42
	1992	11	6	40	1.38 ± 0.57	56 ± 23
	1993	15	6	40	1.88 ± 0.72	76 ± 29
			Average (no VCF)		1.58 ± 0.46	64 ± 19
Harrowby Bay	1991	11	7	101	0.55 ± 0.52	56 ± 53
	1992	4	9	113	0.17 ± 0.10	19 ± 11
	1993	2	9	113	0.08 ± 0.08	9 ± 9
			Average (no VCF)		0.27 ± 0.18	30 ± 20
Entire moulting stratum (no VCF)				513	5.60 ± 0.77	2870 ± 393

[a] Visibility correction factor.

Figure 2
Mean annual number (± standard error) of Greater White-fronted Geese present in the different survey strata in the Inuvialuit Settlement Region in June of 1989–1993



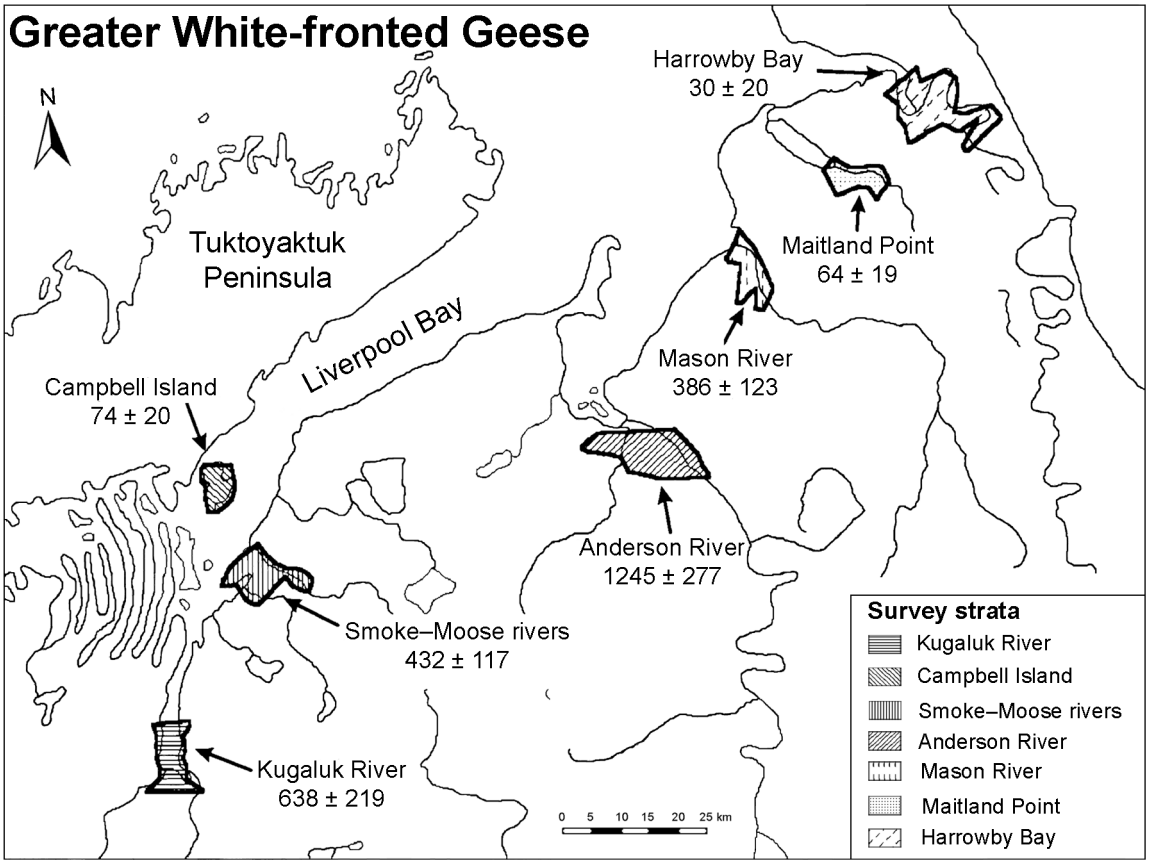


Table 3
Estimated densities and numbers of Greater White-fronted Goose pairs in survey strata on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Pairs observed	Number of transects	Area (km^2)	Density ± SE (pairs/km^2)	Number of pairs ± SE
Mackenzie Delta	1989	53	9	3 668	0.34 ± 0.08	1 253 ± 306
	1990	51	23	6 091	0.14 ± 0.03	875 ± 171
	1991	51	24	6 091	0.13 ± 0.03	812 ± 196
	1992	63	24	6 091	0.17 ± 0.04	1 003 ± 237
	1993	59	24	6 091	0.15 ± 0.03	940 ± 193
				Average (no VCF[a])	0.19 ± 0.02	1 141 ± 129
				Average (adjusted by VCF)	0.28 ± 0.03	1 712 ± 194
Tuktoyaktuk Peninsula	1989	99	17	6 652	0.37 ± 0.06	2 450 ± 371
	1990	64	17	6 652	0.24 ± 0.05	1 584 ± 360
	1991	101	17	6 652	0.38 ± 0.06	2 499 ± 389
	1992	84	17	6 652	0.31 ± 0.05	2 079 ± 350
	1993	94	17	6 652	0.35 ± 0.06	2 326 ± 380
				Average (no VCF)	0.33 ± 0.02	2 189 ± 166
				Average (adjusted by VCF)	0.49 ± 0.04	3 283 ± 249
South Liverpool Bay	1989	102	15	3 280	0.57 ± 0.09	1 884 ± 300
	1990	39	15	3 500	0.22 ± 0.04	795 ± 127
	1991	47	21	4 721	0.22 ± 0.05	1 039 ± 247
	1992	47	21	4 721	0.22 ± 0.04	1 039 ± 204
	1993	98	21	5 796	0.36 ± 0.04	2 088 ± 227
				Average (no VCF)	0.32 ± 0.03	1 851 ± 145
				Average (adjusted by VCF)	0.48 ± 0.04	2 776 ± 217
Cape Bathurst	1991	7	7	1 737	0.09 ± 0.05	157 ± 80
	1992	4	4	1 279	0.08 ± 0.02	98 ± 26
	1993	4	4	1 279	0.08 ± 0.04	98 ± 53
				Average (no VCF)	0.08 ± 0.02	141 ± 38
				Average (adjusted by VCF)	0.12 ± 0.03	212 ± 57
Yukon North Slope	1990	0	11	1 821	0.00 ± 0.00	0 ± 0
				(adjusted by VCF)	0.00 ± 0.00	0 ± 0
Parry Peninsula	1991	5	6	2 784	0.05 ± 0.02	136 ± 59
				(adjusted by VCF)	0.07 ± 0.03	204 ± 89
Paulatuk Region	1991	1	10	1 724	0.01 ± 0.01	22 ± 21
				(adjusted by VCF)	0.02 ± 0.02	32 ± 32
All non-moulting strata (adjusted by VCF)				26 605	0.31 ± 0.01	8 219 ± 399

[a] Visibility correction factor.

Table 4
Estimated densities and numbers of Greater White-fronted Goose pairs in moulting areas on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Pairs observed	Number of transects	Area (km^2)	Density ± SE (pairs/km^2)	Number of pairs ± SE
Kugaluk River	1991	4	7	64	0.31 ± 0.16	20 ± 10
	1992	7	7	64	0.55 ± 0.21	35 ± 13
	1993	0	7	64	0.00 ± 0.00	0 ± 0
				Average (no VCF[a])	0.29 ± 0.09	18 ± 6
Campbell Island	1991	3	5	41	0.38 ± 0.18	15 ± 7
	1992	7	5	41	0.88 ± 0.43	36 ± 17
	1993	3	5	41	0.38 ± 0.21	15 ± 8
				Average (no VCF)	0.54 ± 0.17	22 ± 7
Smoke–Moose rivers	1991	5	7	82	0.30 ± 0.24	25 ± 20
	1992	11	7	82	0.65 ± 0.26	54 ± 22
	1993	7	7	82	0.42 ± 0.15	34 ± 12
				Average (no VCF)	0.46 ± 0.13	38 ± 11
Anderson River	1991	20	4	104	0.96 ± 0.24	100 ± 25
	1992	14	4	104	0.67 ± 0.37	70 ± 39
	1993	41	4	104	1.97 ± 0.72	206 ± 75
				Average (no VCF)	1.20 ± 0.28	125 ± 29
Mason River	1991	3	5	68	0.22 ± 0.16	15 ± 11
	1992	8	5	68	0.59 ± 0.09	40 ± 6
	1993	3	5	68	0.22 ± 0.08	15 ± 5
				Average (no VCF)	0.34 ± 0.07	23 ± 4
Maitland Point	1991	2	6	40	0.25 ± 0.13	10 ± 5
	1992	3	6	40	0.38 ± 0.12	15 ± 5
	1993	3	6	40	0.38 ± 0.12	15 ± 5
				Average (no VCF)	0.33 ± 0.07	13 ± 3
Harrowby Bay	1991	1	7	101	0.05 ± 0.05	5 ± 5
	1992	2	9	113	0.08 ± 0.05	9 ± 6
	1993	1	9	113	0.04 ± 0.04	5 ± 4
				Average (no VCF)	0.06 ± 0.03	7 ± 3
Entire moulting stratum (no VCF)				513	0.48 ± 0.06	247 ± 33

[a] Visibility correction factor.

Figure 3
Estimated numbers (± standard errors) of Greater White-fronted Geese, Canada Geese, and Tundra Swans present in the 12 743-km² "core" area on the mainland of the Inuvialuit Settlement Region surveyed each year, 1990–1993

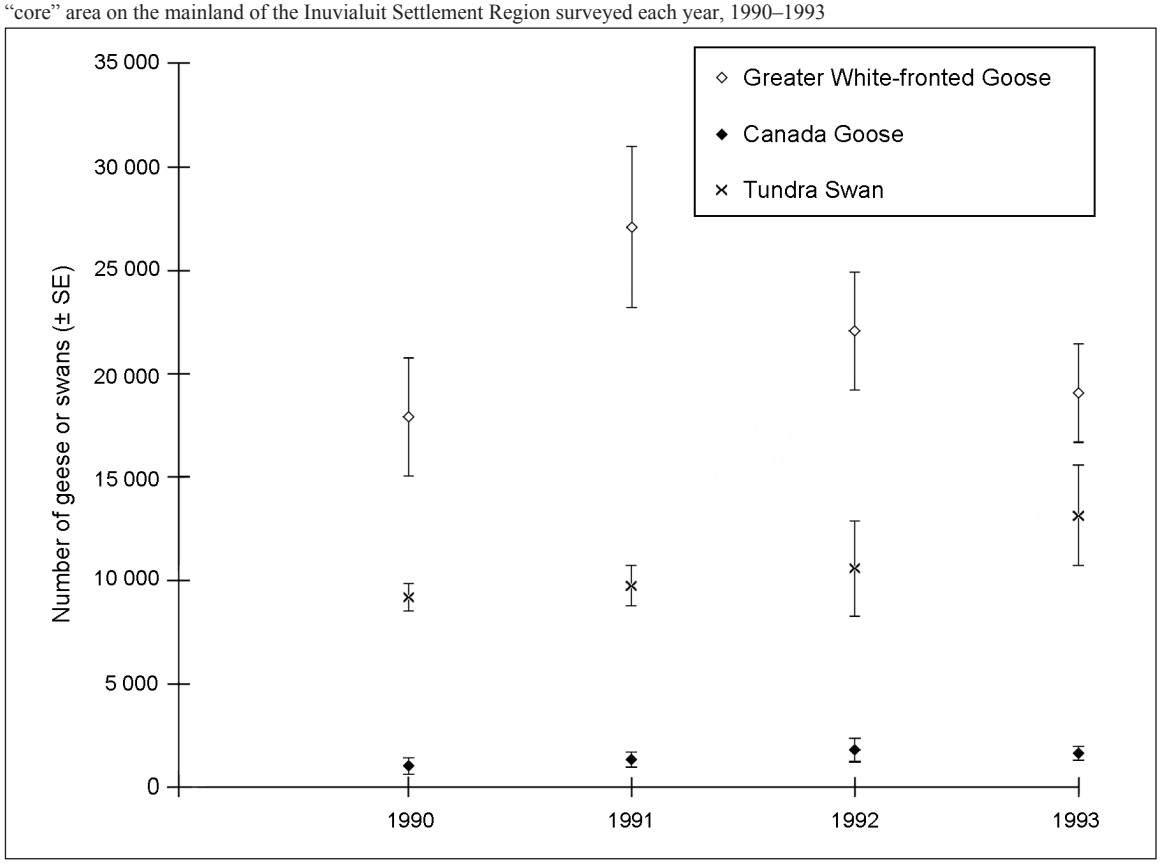


Table 5
The estimated number of Greater White-fronted Geese, Canada Geese, and Tundra Swans present in the 12 743-km² "core" area on the mainland of the Inuvialuit Settlement Region surveyed each year, 1990–1993

Year	Total population size	Standard error	Coefficient of variation	Number of indicated pairs	Standard error	Coefficient of variation
Greater White-fronted Goose						
1990	11 907	1 883	0.158	3 688	597	0.162
1991	17 988	2 571	0.143	4 968	654	0.132
1992	14 601	1 887	0.129	4 623	633	0.137
1993	12 530	1 560	0.124	4 899	639	0.131
Average 1990–1993	14 257	1 005	0.070	4 544	316	0.069
Canada Goose						
1990	934	413	0.443	243	86	0.353
1991	1 205	358	0.297	483	130	0.268
1992	1 632	536	0.329	470	170	0.362
1993	1 401	323	0.231	701	162	0.231
Average 1990–1993	1 293	208	0.161	474	70	0.148
Tundra Swan						
1990	9 116	638	0.070	4 134	337	0.081
1991	9 622	969	0.101	4 301	331	0.077
1992	10 409	2 272	0.218	3 924	426	0.108
1993	12 903	2 386	0.185	5 124	297	0.058
Average 1990–1993	10 512	873	0.083	4 371	176	0.040

Table 6
Estimated densities and numbers of Canada Geese in survey strata on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Geese observed	Number of transects	Area (km^2)	Density ± SE (geese/km^2)	Number of geese ± SE
Mackenzie Delta	1989	18	9	3 668	0.12 ± 0.05	425 ± 186
	1990	19	23	6 091	0.05 ± 0.02	326 ± 107
	1991	38	24	6 091	0.10 ± 0.04	605 ± 220
	1992	59	24	6 091	0.15 ± 0.06	940 ± 350
	1993	40	24	6 091	0.10 ± 0.02	637 ± 141
				Average (no VCF[a])	0.11 ± 0.02	643 ± 109
				Average (adjusted by VCF)	0.16 ± 0.03	964 ± 164
Tuktoyaktuk Peninsula	1989	48	17	6 652	0.18 ± 0.09	1 188 ± 582
	1990	12	17	6 652	0.04 ± 0.04	297 ± 254
	1991	8	17	6 652	0.03 ± 0.01	198 ± 92
	1992	6	17	6 652	0.02 ± 0.01	148 ± 75
	1993	12	17	6 652	0.04 ± 0.02	297 ± 163
				Average (no VCF)	0.06 ± 0.02	426 ± 133
				Average (adjusted by VCF)	0.10 ± 0.03	638 ± 200
South Liverpool Bay	1989	87	15	3 280	0.49 ± 0.37	1 607 ± 1 212
	1990	25	15	3 500	0.14 ± 0.05	497 ± 166
	1991	48	21	4 721	0.22 ± 0.09	1 061 ± 417
	1992	29	21	4 721	0.14 ± 0.06	641 ± 286
	1993	29	21	5 796	0.11 ± 0.03	618 ± 171
				Average (no VCF)	0.22 ± 0.08	1 274 ± 451
				Average (adjusted by VCF)	0.33 ± 0.12	1 911 ± 676
Cape Bathurst	1991	153	7	1 737	1.97 ± 1.13	3 425 ± 1 968
	1992	19	4	1 279	0.37 ± 0.14	467 ± 175
	1993	6	4	1 279	0.12 ± 0.05	148 ± 58
				Average (no VCF)	0.82 ± 0.38	1 420 ± 661
				Average (adjusted by VCF)	1.23 ± 0.57	2 130 ± 992
Yukon North Slope	1990	8	11	1 821	0.09 ± 0.05	166 ± 90
				(adjusted by VCF)	0.14 ± 0.07	248 ± 135
Parry Peninsula	1991	259	6	2 784	2.53 ± 0.78	7 042 ± 2 183
				(adjusted by VCF)	3.79 ± 1.18	10 562 ± 3 275
Paulatuk Region	1991	47	10	1 724	0.59 ± 0.26	1 013 ± 457
				(adjusted by VCF)	0.88 ± 0.40	1 519 ± 685
All non-moulting strata (adjusted by VCF)				26 605	0.68 ± 0.13	17 974 ± 3 566

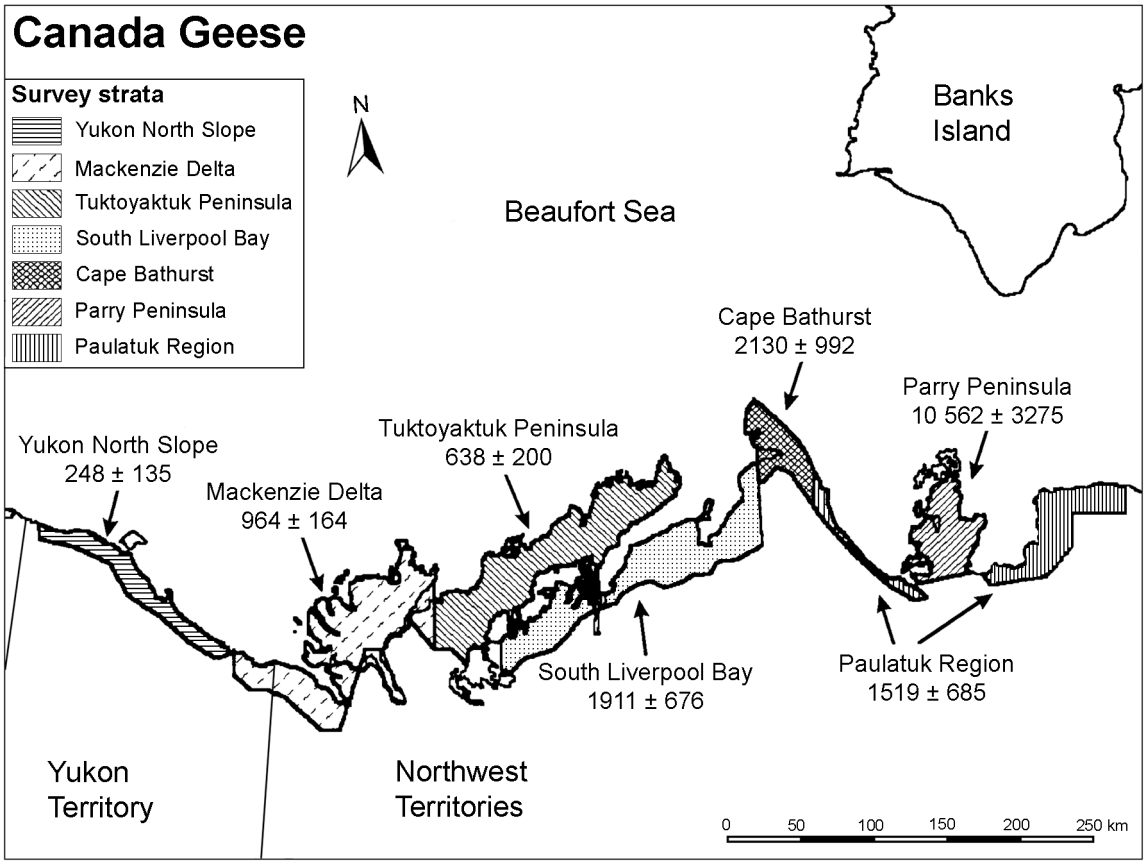
[a] Visibility correction factor.

Table 7
Estimated densities and numbers of Canada Geese in moulting areas on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Geese observed	Number of transects	Area (km^2)	Density ± SE (geese/km^2)	Number of geese ± SE
Kugaluk River	1991	13	7	64	1.02 ± 0.70	65 ± 45
	1992	23	7	64	1.80 ± 1.08	115 ± 69
	1993	2	7	64	0.16 ± 0.14	10 ± 9
				Average (no VCF[a])	0.99 ± 0.43	64 ± 28
Campbell Island	1991	36	5	41	4.50 ± 4.55	183 ± 185
	1992	0	5	41	0.00 ± 0.00	0 ± 0
	1993	0	5	41	0.00 ± 0.00	0 ± 0
				Average (no VCF)	1.50 ± 1.52	61 ± 62
Smoke–Moose rivers	1991	451	7	82	26.85 ± 14.75	2213 ± 1216
	1992	7	7	82	0.42 ± 0.25	34 ± 20
	1993	21	7	82	1.25 ± 0.60	103 ± 50
				Average (no VCF)	9.50 ± 4.92	784 ± 406
Anderson River	1991	11	4	104	0.53 ± 0.33	55 ± 34
	1992	24	4	104	1.15 ± 0.77	120 ± 81
	1993	2	4	104	0.10 ± 0.10	10 ± 10
				Average (no VCF)	0.59 ± 0.28	62 ± 29
Mason River	1991	14	5	68	1.03 ± 1.02	70 ± 70
	1992	0	5	68	0.00 ± 0.00	0 ± 0
	1993	51	5	68	3.75 ± 3.49	256 ± 238
				Average (no VCF)	1.59 ± 1.21	109 ± 83
Maitland Point	1991	161	6	40	20.13 ± 12.59	813 ± 509
	1992	0	6	40	0.00 ± 0.00	0 ± 0
	1993	11	6	40	1.38 ± 1.19	56 ± 48
				Average (no VCF)	7.17 ± 4.22	290 ± 170
Harrowby Bay	1991	1678	7	101	83.90 ± 60.05	8486 ± 6073
	1992	7	9	113	0.29 ± 0.29	33 ± 32
	1993	158	9	113	6.58 ± 3.95	741 ± 445
				Average (no VCF)	30.26 ± 20.06	3407 ± 2258
Entire moulting stratum (no VCF)				513	9.31 ± 4.49	4775 ± 2304

[a] Visibility correction factor.

Figure 4
Mean annual number (± standard error) of Canada Geese present in the different survey strata in the Inuvialuit Settlement Region, 1989–1993



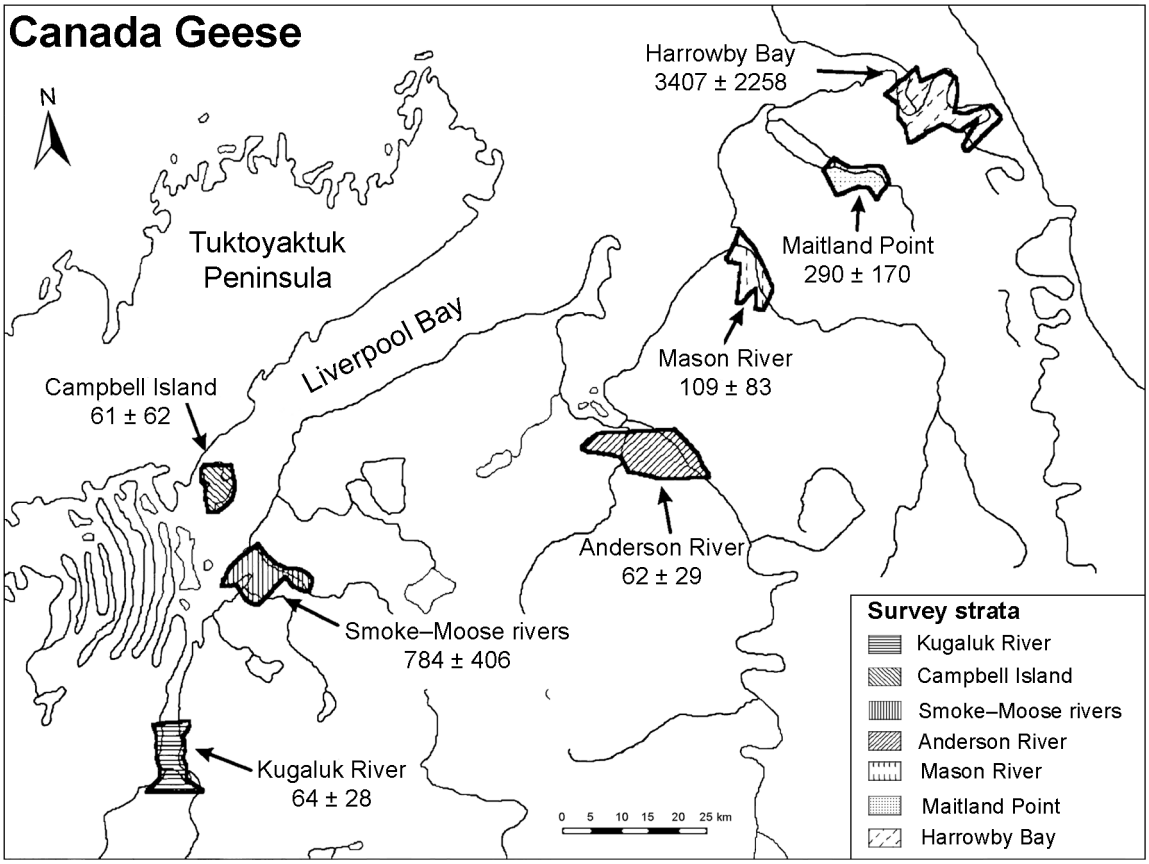


Table 8
Estimated densities and numbers of Canada Goose pairs in survey strata on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Pairs observed	Number of transects	Area (km^2)	Density ± SE (pairs/km^2)	Number of pairs ± SE
Mackenzie Delta	1989	7	9	3 668	0.05 ± 0.03	165 ± 94
	1990	8	23	6 091	0.02 ± 0.01	137 ± 52
	1991	14	24	6 091	0.04 ± 0.01	223 ± 73
	1992	15	24	6 091	0.04 ± 0.02	239 ± 107
	1993	20	24	6 091	0.05 ± 0.01	319 ± 70
				Average (no VCF[a])	0.04 ± 0.01	239 ± 45
				Average (adjusted by VCF)	0.06 ± 0.01	358 ± 68
Tuktoyaktuk Peninsula	1989	8	17	6 652	0.03 ± 0.02	198 ± 100
	1990	1	17	6 652	0.00 ± 0.00	25 ± 24
	1991	4	17	6 652	0.02 ± 0.01	99 ± 46
	1992	3	17	6 652	0.01 ± 0.01	74 ± 37
	1993	6	17	6 652	0.02 ± 0.01	148 ± 82
				Average (no VCF)	0.02 ± 0.00	109 ± 29
				Average (adjusted by VCF)	0.02 ± 0.01	164 ± 43
South Liverpool Bay	1989	12	15	3 280	0.07 ± 0.02	222 ± 73
	1990	8	15	3 500	0.05 ± 0.02	163 ± 62
	1991	18	21	4 721	0.08 ± 0.03	398 ± 126
	1992	10	21	4 721	0.05 ± 0.02	221 ± 75
	1993	13	21	5 796	0.05 ± 0.01	277 ± 83
				Average (no VCF)	0.06 ± 0.01	338 ± 51
				Average (adjusted by VCF)	0.09 ± 0.01	508 ± 77
Cape Bathurst	1991	1	7	1 737	0.01 ± 0.01	22 ± 23
	1992	4	4	1 279	0.08 ± 0.04	98 ± 53
	1993	3	4	1 279	0.06 ± 0.02	74 ± 29
				Average (no VCF)	0.05 ± 0.02	85 ± 28
				Average (adjusted by VCF)	0.07 ± 0.02	128 ± 43
Yukon North Slope	1990	4	11	1 821	0.05 ± 0.03	83 ± 45
				(adjusted by VCF)	0.07 ± 0.04	124 ± 68
Parry Peninsula	1991	44	6	2 784	0.43 ± 0.11	1 196 ± 310
				(adjusted by VCF)	0.65 ± 0.17	1 794 ± 465
Paulatuk Region	1991	8	10	1 724	0.10 ± 0.03	172 ± 52
				(adjusted by VCF)	0.15 ± 0.05	259 ± 79
All non-moulting strata (adjusted by VCF)				26 605	0.13 ± 0.02	3 335 ± 491

[a] Visibility correction factor.

Table 9
Estimated densities and numbers of Canada Goose pairs in moulting areas on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Pairs observed	Number of transects	Area (km^2)	Density ± SE (pairs/km^2)	Number of pairs ± SE
Kugaluk River	1991	0	7	64	0.00 ± 0.00	0 ± 0
	1992	2	7	64	0.16 ± 0.09	10 ± 6
	1993	1	7	64	0.08 ± 0.07	5 ± 5
				Average (no VCF[a])	0.08 ± 0.04	5 ± 2
Campbell Island	1991	1	5	41	0.13 ± 0.13	5 ± 5
	1992	0	5	41	0.00 ± 0.00	0 ± 0
	1993	0	5	41	0.00 ± 0.00	0 ± 0
				Average (no VCF)	0.04 ± 0.04	2 ± 2
Smoke–Moose rivers	1991	4	7	82	0.24 ± 0.19	20 ± 16
	1992	2	7	82	0.12 ± 0.11	10 ± 9
	1993	4	7	82	0.24 ± 0.14	20 ± 11
				Average (no VCF)	0.20 ± 0.09	16 ± 7
Anderson River	1991	1	4	104	0.05 ± 0.05	5 ± 5
	1992	0	4	104	0.00 ± 0.00	0 ± 0
	1993	1	4	104	0.05 ± 0.05	5 ± 5
				Average (no VCF)	0.03 ± 0.02	3 ± 2
Mason River	1991	0	5	68	0.00 ± 0.00	0 ± 0
	1992	0	5	68	0.00 ± 0.00	0 ± 0
	1993	1	5	68	0.07 ± 0.07	5 ± 5
				Average (no VCF)	0.02 ± 0.02	2 ± 2
Maitland Point	1991	2	6	40	0.25 ± 0.15	10 ± 6
	1992	0	6	40	0.00 ± 0.00	0 ± 0
	1993	0	6	40	0.00 ± 0.00	0 ± 0
				Average (no VCF)	0.08 ± 0.05	3 ± 2
Harrowby Bay	1991	2	7	101	0.10 ± 0.06	10 ± 6
	1992	0	9	113	0.00 ± 0.00	0 ± 0
	1993	3	9	113	0.13 ± 0.07	14 ± 7
				Average (no VCF)	0.08 ± 0.03	8 ± 3
Entire moulting stratum (no VCF)				513	0.08 ± 0.02	40 ± 9

[a] Visibility correction factor.

Table 10
Estimated densities and numbers of Tundra Swans in survey strata on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Swans observed	Number of transects	Area (km^2)	Density ± SE (swans/km^2)	Number of swans ± SE
Mackenzie Delta	1989	132	9	3 668	0.85 ± 0.15	3 120 ± 542
	1990	204	23	6 091	0.57 ± 0.06	3 498 ± 350
	1991	298	24	6 091	0.78 ± 0.12	4 747 ± 736
	1992	307	24	6 091	0.80 ± 0.24	4 890 ± 1 445
	1993	431	24	6 091	1.13 ± 0.38	6 865 ± 2 304
			Average (no VCF[a])		0.83 ± 0.10	5 036 ± 595
			Average (adjusted by VCF)		0.83 ± 0.10	5 036 ± 595
Tuktoyaktuk Peninsula	1989	303	17	6 652	1.13 ± 0.19	7 498 ± 1 232
	1990	227	17	6 652	0.84 ± 0.08	5 618 ± 534
	1991	197	17	6 652	0.73 ± 0.10	4 875 ± 631
	1992	223	17	6 652	0.83 ± 0.26	5 519 ± 1 754
	1993	244	17	6 652	0.91 ± 0.09	6 038 ± 620
			Average (no VCF)		0.89 ± 0.07	5 910 ± 476
			Average (adjusted by VCF)		0.89 ± 0.07	5 910 ± 476
South Liverpool Bay	1989	197	15	3 280	1.11 ± 0.21	3 638 ± 671
	1990	122	15	3 500	0.69 ± 0.23	2 486 ± 830
	1991	124	21	4 721	0.58 ± 0.11	2 741 ± 501
	1992	136	21	4 721	0.64 ± 0.11	3 006 ± 522
	1993	198	21	5 796	0.73 ± 0.20	4 219 ± 1 163
			Average (no VCF)		0.75 ± 0.08	4 344 ± 462
			Average (adjusted by VCF)		0.75 ± 0.08	4 344 ± 462
Cape Bathurst	1991	14	7	1 737	0.18 ± 0.09	313 ± 152
	1992	8	4	1 279	0.15 ± 0.04	197 ± 53
	1993	10	4	1 279	0.19 ± 0.05	246 ± 61
			Average (no VCF)		0.18 ± 0.04	305 ± 62
			Average (adjusted by VCF)		0.18 ± 0.04	305 ± 62
Yukon North Slope	1990	22	11	1 821	0.25 ± 0.08	455 ± 153
			(adjusted by VCF)		0.25 ± 0.08	455 ± 153
Parry Peninsula	1991	27	6	2 784	0.26 ± 0.06	734 ± 172
			(adjusted by VCF)		0.26 ± 0.06	734 ± 172
Paulatuk Region	1991	6	10	1 724	0.08 ± 0.04	129 ± 64
			(adjusted by VCF)		0.08 ± 0.04	129 ± 64
All non-moulting strata (adjusted by VCF)				26 605	0.64 ± 0.03	16 913 ± 925

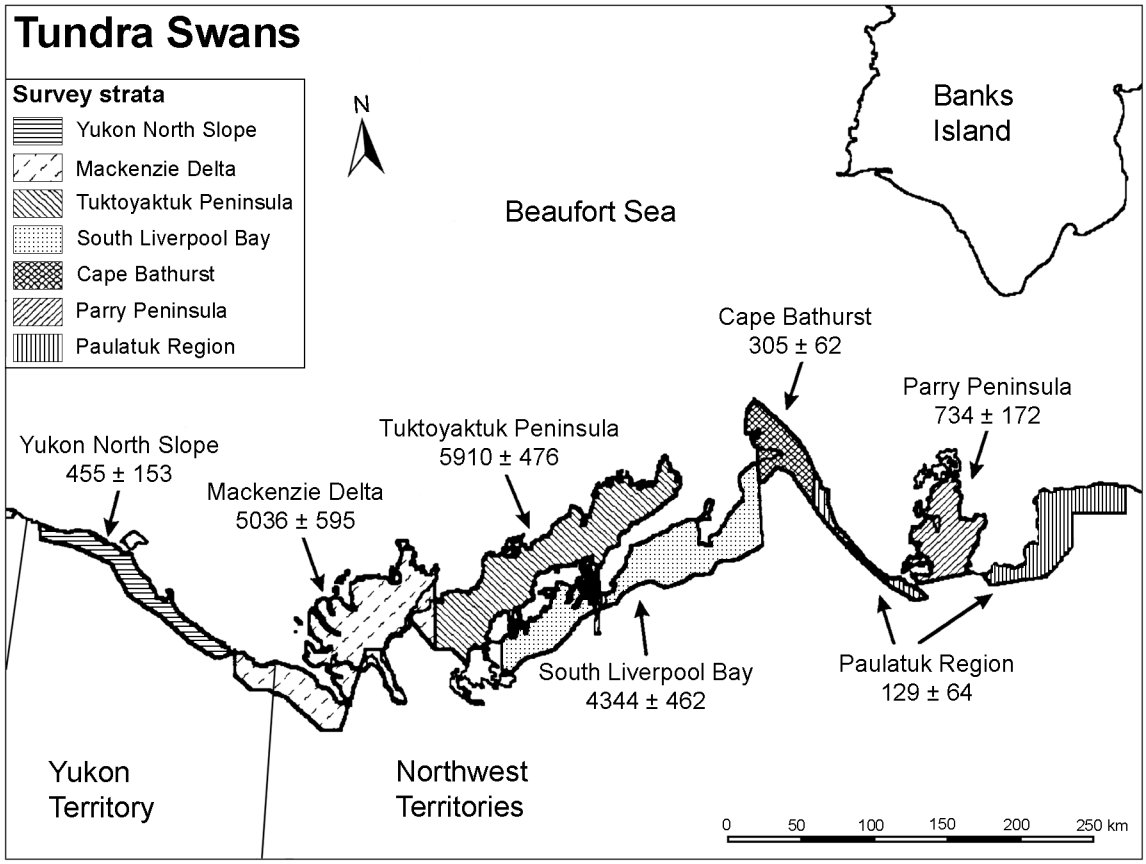
[a] Visibility correction factor.

Table 11
Estimated densities and numbers of Tundra Swans in moulting areas on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Swans observed	Number of transects	Area (km^2)	Density ± SE (swans/km^2)	Number of swans ± SE
Kugaluk River	1991	277	7	64	21.64 ± 9.52	1389 ± 611
	1992	301	7	64	23.52 ± 12.39	1509 ± 795
	1993	207	7	64	16.17 ± 7.10	1038 ± 456
			Average (no VCF[a])		20.44 ± 5.72	1312 ± 367
Campbell Island	1991	1	5	41	0.13 ± 0.10	5 ± 4
	1992	16	5	41	2.00 ± 1.31	81 ± 53
	1993	3	5	41	0.38 ± 0.23	15 ± 9
			Average (no VCF)		0.83 ± 0.44	34 ± 18
Smoke–Moose rivers	1991	32	7	82	1.90 ± 0.88	157 ± 73
	1992	18	7	82	1.07 ± 0.40	88 ± 33
	1993	3	7	82	0.18 ± 0.10	15 ± 8
			Average (no VCF)		1.05 ± 0.32	87 ± 27
Anderson River	1991	9	4	104	0.43 ± 0.16	45 ± 17
	1992	24	4	104	1.15 ± 0.05	120 ± 5
	1993	22	4	104	1.06 ± 0.38	110 ± 40
			Average (no VCF)		0.88 ± 0.14	92 ± 14
Mason River	1991	5	5	68	0.37 ± 0.20	25 ± 13
	1992	9	5	68	0.66 ± 0.53	45 ± 36
	1993	10	5	68	0.74 ± 0.35	50 ± 24
			Average (no VCF)		0.59 ± 0.22	40 ± 15
Maitland Point	1991	0	6	40	0.00 ± 0.00	0 ± 0
	1992	7	6	40	0.88 ± 0.76	35 ± 31
	1993	1	6	40	0.13 ± 0.11	5 ± 4
			Average (no VCF)		0.33 ± 0.26	13 ± 10
Harrowby Bay	1991	5	7	101	0.25 ± 0.13	25 ± 13
	1992	11	9	113	0.46 ± 0.23	52 ± 26
	1993	19	9	113	0.79 ± 0.24	89 ± 27
			Average (no VCF)		0.50 ± 0.12	56 ± 13
Entire moulting stratum (no VCF)				513	3.19 ± 0.72	1634 ± 370

[a] Visibility correction factor.

Figure 5
Mean annual number (± standard error) of Tundra Swans present in the different survey strata in the Inuvialuit Settlement Region, 1989–1993



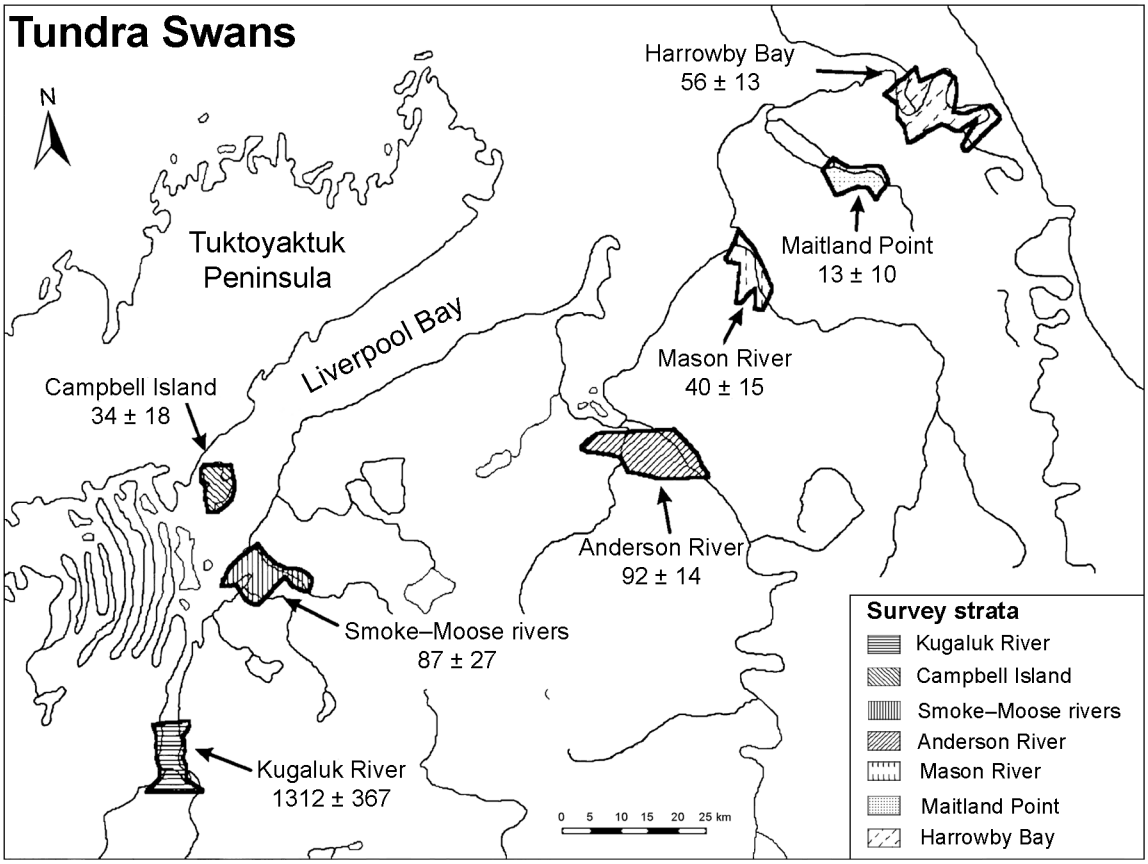


Table 12
Estimated densities and numbers of Tundra Swan pairs in survey strata on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Pairs observed	Number of transects	Area (km^2)	Density ± SE (pairs/km^2)	Number of pairs ± SE
Mackenzie Delta	1989	66	9	3 668	0.43 ± 0.07	1 560 ± 271
	1990	98	23	6 091	0.27 ± 0.03	1 672 ± 162
	1991	131	24	6 091	0.34 ± 0.03	2 087 ± 193
	1992	114	24	6 091	0.30 ± 0.03	1 808 ± 172
	1993	143	24	6 091	0.37 ± 0.03	2 278 ± 171
			Average (no VCF[a])		0.34 ± 0.02	2 087 ± 114
			Average (adjusted by VCF)		0.34 ± 0.02	2 087 ± 114
Tuktoyaktuk Peninsula	1989	141	17	6 652	0.53 ± 0.07	3 489 ± 467
	1990	100	17	6 652	0.37 ± 0.04	2 462 ± 295
	1991	90	17	6 652	0.33 ± 0.04	2 215 ± 270
	1992	86	17	6 652	0.32 ± 0.06	2 116 ± 389
	1993	115	17	6 652	0.43 ± 0.04	2 846 ± 243
			Average (no VCF)		0.39 ± 0.02	2 626 ± 153
			Average (adjusted by VCF)		0.39 ± 0.02	2 626 ± 153
South Liverpool Bay	1989	78	15	3 280	0.44 ± 0.07	1 441 ± 224
	1990	35	15	3 500	0.20 ± 0.04	713 ± 137
	1991	54	21	4 721	0.25 ± 0.04	1 182 ± 207
	1992	62	21	4 721	0.29 ± 0.04	1 359 ± 185
	1993	74	21	5 796	0.27 ± 0.05	1 566 ± 263
			Average (no VCF)		0.29 ± 0.02	1 677 ± 125
			Average (adjusted by VCF)		0.29 ± 0.02	1 677 ± 125
Cape Bathurst	1991	6	7	1 737	0.07 ± 0.03	123 ± 53
	1992	4	4	1 279	0.08 ± 0.02	98 ± 26
	1993	5	4	1 279	0.10 ± 0.02	123 ± 30
			Average (no VCF)		0.08 ± 0.01	141 ± 25
			Average (adjusted by VCF)		0.08 ± 0.01	141 ± 25
Yukon North Slope	1990	11	11	1 821	0.13 ± 0.04	228 ± 76
			(adjusted by VCF)		0.13 ± 0.04	228 ± 76
Parry Peninsula	1991	14	6	2 784	0.13 ± 0.03	367 ± 86
			(adjusted by VCF)		0.13 ± 0.03	367 ± 86
Paulatuk Region	1991	3	10	1 724	0.04 ± 0.02	65 ± 32
			(adjusted by VCF)		0.04 ± 0.02	65 ± 32
All non-moulting strata (adjusted by VCF)				26 605	0.27 ± 0.01	7 190 ± 259

[a] Visibility correction factor.

Table 13
Estimated densities and numbers of Tundra Swan pairs in moulting areas on the mainland of the Inuvialuit Settlement Region, June, 1989–1993

Stratum	Year	Pairs observed	Number of transects	Area (km^2)	Density ± SE (pairs/km^2)	Number of pairs ± SE
Kugaluk River	1991	11	7	64	0.82 ± 0.26	53 ± 16
	1992	20	7	64	1.52 ± 0.60	98 ± 39
	1993	17	7	64	1.29 ± 0.41	83 ± 26
			Average (no VCF[a])		1.21 ± 0.26	78 ± 17
Campbell Island	1991	1	5	41	0.06 ± 0.05	3 ± 2
	1992	2	5	41	0.25 ± 0.12	10 ± 5
	1993	2	5	41	0.19 ± 0.12	8 ± 5
			Average (no VCF)		0.17 ± 0.06	7 ± 2
Smoke–Moose rivers	1991	4	7	82	0.21 ± 0.07	17 ± 6
	1992	9	7	82	0.54 ± 0.20	44 ± 16
	1993	2	7	82	0.09 ± 0.05	7 ± 4
			Average (no VCF)		0.28 ± 0.07	23 ± 6
Anderson River	1991	5	4	104	0.22 ± 0.08	23 ± 8
	1992	12	4	104	0.58 ± 0.03	60 ± 3
	1993	11	4	104	0.53 ± 0.19	55 ± 20
			Average (no VCF)		0.44 ± 0.07	46 ± 7
Mason River	1991	3	5	68	0.18 ± 0.10	13 ± 7
	1992	3	5	68	0.18 ± 0.13	13 ± 9
	1993	2	5	68	0.15 ± 0.10	10 ± 7
			Average (no VCF)		0.17 ± 0.06	12 ± 4
Maitland Point	1991	0	6	40	0.00 ± 0.00	0 ± 0
	1992	0	6	40	0.00 ± 0.00	0 ± 0
	1993	1	6	40	0.06 ± 0.05	3 ± 2
			Average (no VCF)		0.02 ± 0.02	1 ± 1
Harrowby Bay	1991	3	7	101	0.13 ± 0.06	13 ± 7
	1992	2	9	113	0.08 ± 0.05	9 ± 5
	1993	10	9	113	0.40 ± 0.12	45 ± 14
			Average (no VCF)		0.20 ± 0.05	23 ± 5
Entire moulting stratum (no VCF)				513	0.37 ± 0.04	189 ± 20

[a] Visibility correction factor.

Table 14
Productivity of geese and swans on the mainland of the Inuvialuit Settlement Region as measured by transect counts of adults in June and broods in July, 1990–1993

Year	Area surveyed (km^2)	Pairs	Broods	Average brood size	Broods per pair	% young in population
Greater White-fronted Goose						
1990	6091	51	14	3.2	0.27	16.9
1991	6091	51	28	4.0	0.55	27.3
1992	8509	159	2	1.0	0.01	0.2
1993	8372	169	36	3.9	0.21	12.5
Average	7266	108	20	3.0	0.26	14.2
Canada Goose						
1990	6091	8	5	2.8	0.63	46.7
1991	6091	14	2	4.5	0.14	20.9
1992	8509	20	2	3.0	0.10	5.0
1993	8372	33	9	2.4	0.27	7.3
Average	7266	19	5	3.2	0.29	20.0
Tundra Swan						
1990	6091	98	25	2.5	0.26	23.3
1991	6091	131	30	2.3	0.23	17.0
1992	8509	195	23	2.6	0.12	6.3
1993	8372	227	54	2.7	0.24	11.8
Average	7266	163	33	2.5	0.21	14.6

Table 15
Mean daily temperatures at Tuktoyaktuk, Northwest Territories, in spring, 1990–1993[a]

Date	Mean daily temperature (°C) 1990	1991	1992	1993	P
1–15 May	−7.62[ac]	1.12[b]	−11.88[c]	−6.49[a]	0.0001
16–31 May	−1.09[a]	1.51[a]	−0.82[a]	0.08[a]	0.144
1–15 June	2.65[ab]	1.34[b]	1.65[b]	5.53[a]	0.007
16–30 June	10.87[a]	8.67[a]	10.87[a]	8.83[a]	0.357

[a] P-values are from ANOVA comparisons among years. Means with the same letter are not significantly different based on Duncan's Multiple Range test.

the Inuvialuit Settlement Region (>27 000 km^2) where geese and swans were most concentrated, but almost 80% of the mainland (101 000 km^2), where each of the three species occurred in low densities, could not be covered. Using data from the widespread but far less intensive waterfowl surveys conducted by the U.S. Fish and Wildlife Service each year in parts of the Northwest Territories, we estimated that the 101 000-km^2 area would have supported an additional 5250 Greater White-fronted Geese, 7253 more Canada Geese, and 10 109 more Tundra Swans.[1] If so, the total spring populations of the three species on the mainland of the Inuvialuit Settlement Region during 1989–1993 would have been about 55 600, 30 300, and 28 700, respectively. In years of average reproductive success, the total fall population size (adults plus young) emanating from the mainland of the Inuvialuit Settlement Region would have numbered about 74 000 Greater White-fronted Geese, 40 000 Canada Geese, and 33 000 Tundra Swans and represented about 11% of the Mid-continent Population of Greater White-fronted Geese, 9% of the Short-grass Prairie Population of Canada Geese, and 35% of the Eastern Population of Tundra Swans.[2] These data underscore the importance of the mainland of the Inuvialuit Settlement Region to continental waterfowl populations.

Estimated numbers of all three species in the 12 743-km^2 area surveyed annually varied from year to year. We believe that some of the variability in goose counts reflected the annual differences in the visibility of the birds, which is less in years when nesting effort is high (Bromley et al. 1995). Given that both our overall population estimates and visibility correction factors were derived over a number of years, annual variations in visibility of geese should not influence these average estimates to any great extent. The 1990–1993 averaged estimates for total numbers and breeding pairs of both Greater White-fronted Geese and Tundra Swans were relatively precise, and repeated surveys should allow us to detect population changes of 20% or less. The estimates for Canada Geese, although less precise, would still allow the detection of a 35% change in population size of that species.

[1] Data are for Stratum 14 of the Aerial Waterfowl Breeding Ground Population and Habitat Survey (Smith 1995). Stratum 14 stretches from the north side of Great Bear Lake to near the southern edge of our study area and encompasses an area of 202 796 km^2. Average densities of Greater White-fronted Geese, Canada Geese, and Tundra Swans in this area were 0.05, 0.07, and 0.10 birds/km^2, respectively, in 1989–1993. Goose population estimates presented by Smith (1995) have been corrected by a visibility correction factor of 2.5 for fixed-wing aircraft.

[2] Fall populations of Arctic geese contain, on average, about 25% young, and the Eastern Population of Tundra Swans contains, on average, about 15% young (see Bellrose 1980; Serie and Bartonek 1991; Ely and Dzubin 1994). Average fall or winter population estimates for geese and swans for 1989–1993 were 676 000 for the Mid-continent Population of Greater White-fronted Geese, 455 000 for the Short-grass Prairie Population of Canada Geese, and 93 000 for the Eastern Population of Tundra Swans (Sharp 1997).

Goose and swan populations from the Inuvialuit Settlement Region face a number of potential conservation problems, as evidenced by increasingly high rates of harvest, reduced rates of survival, and declining fall and winter counts of both Mid-continent Greater White-fronted Geese and Short-grass Prairie Canada Geese (Canadian Wildlife Service Waterfowl Committee 2002). Planned gas and oil development in the heart of the Tundra Swan range in the Mackenzie Delta and environs poses potential future problems for all species of waterfowl as well as swans. Therefore, we recommend that surveys of our core study area be carried out in the near future and repeated for three consecutive years out of every 10 years to monitor the well-being of regional waterfowl populations.

In the study area (6091–8372 km^2) surveyed in both June and July of 1990–1993, the productivity of both geese and swans varied in parallel and in accordance with spring weather. In general, reproductive success of all species was highest in the earliest springs and lowest during the coolest springs. Spring weather and timing of snowmelt have long been known to be critical factors limiting the reproductive success of Arctic waterfowl (e.g., Barry 1962; Newton 1977; Ganter and Boyd 2000). The fact that the reproductive success of the three species varied in parallel is of great interest. Tundra Swans, because of their appearance, size, and behaviour, are perhaps the ideal type of waterfowl to survey from the air and potentially can provide a useful index of the annual productivity for many species of waterfowl sharing the same general areas (King 1973; Lensink 1973). The Mackenzie Delta is one of the most important wetland ecosystems in the Arctic and is internationally recognized as one of the most important waterfowl habitats in North America (U.S. Department of the Interior and Environment Canada 1986). Monitoring of swan numbers and productivity in the Mackenzie Delta should provide a valuable indicator of the impact of industrial development and global climate change on the aquatic birds of this important habitat.

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