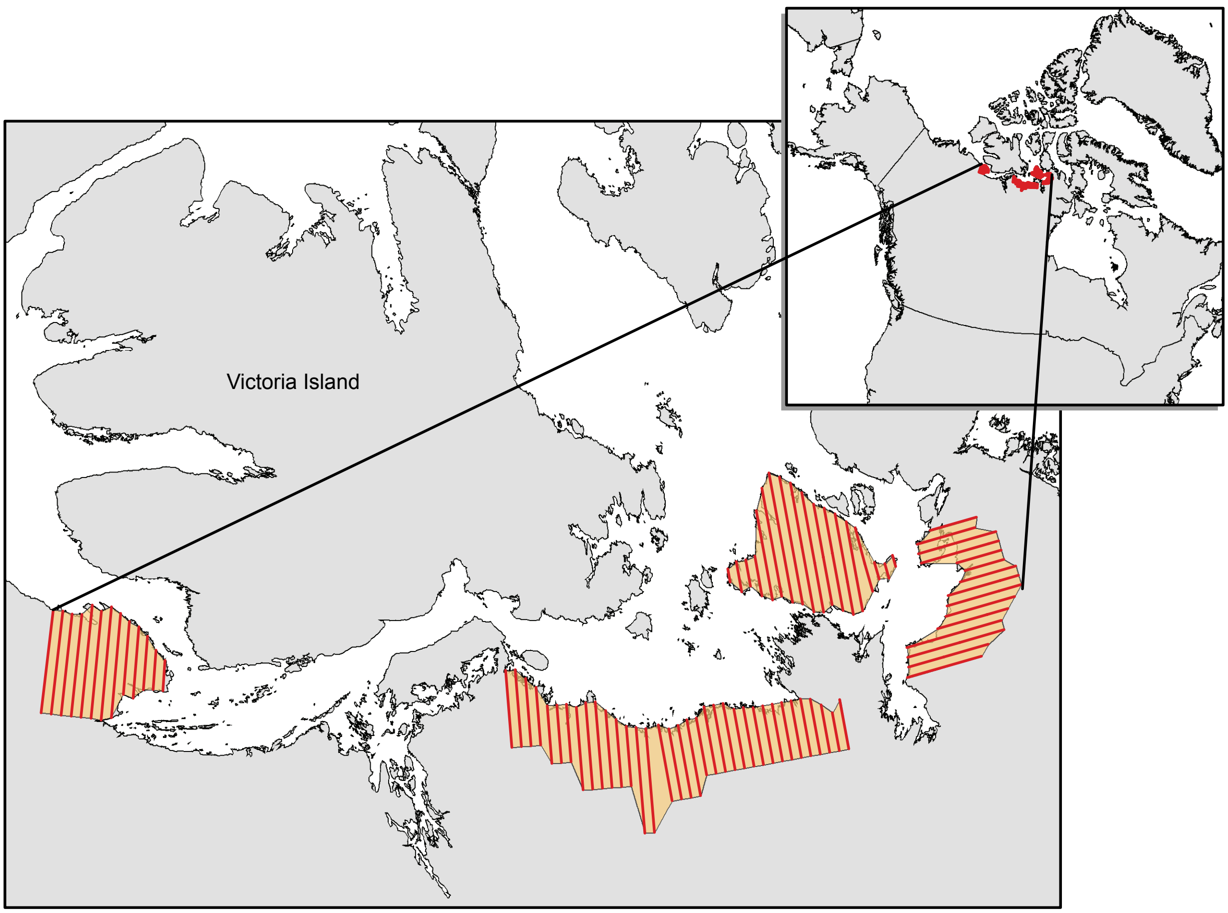
Distribution and Abundance of Wildlife from Fixed-Wing Aircraft Surveys in Nunavut, Canada June 2006



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Abstract

In June 2006 we conducted a fixed-wing aerial survey for waterfowl in Nunavut, Canada. Areas surveyed were King William Island, Rasmussen Lowlands, and portions of the mainland in the Queen Maud Gulf Migratory Bird Sanctuary and northwest of Kugluktuk. This survey followed a previous design of systematically placed transects in areas of known or suspected high densities of waterfowl and waterbirds (Hines et al. 2003, Alisauskas 2005). Most of the 2006 study area had been surveyed previously by these authors via a helicopter. The results from our survey are presented by four individual areas (Queen Maud Gulf, King William Island, Rasmussen Lowlands, and near Kugluktuk, Nunavut). Concurrent helicopter surveys were also flown by a Canadian Wildlife Service survey crew on King William Island and Rasmussen Lowlands, to compare survey results obtained from the different aerial platforms (results from those surveys are reported elsewhere). We experimented with a double-observer counting technique to determine visibility correction factors from a fixed-wing aircraft. After conducting fixed-wing surveys in Canada's Central Arctic region in 2005 and 2006, we believe that fixed-wing aircraft offer a safe and efficient alternative to the use of helicopters for conducting these surveys. More concurrent fixed-wing/helicopter surveys are recommended to better understand the relationship between the two platforms.

Introduction

Many important nesting areas of North American waterfowl lie outside the range of the existing Waterfowl Breeding Population and Habitat Survey (USFWS 2006) and other cooperative waterfowl survey efforts. For example, portions of the central and western Canadian Arctic are recognized as important nesting areas of waterfowl and other waterbirds but have been surveyed only periodically or not at all. Cooperating agencies of the Arctic Goose Joint Venture and Sea Duck Joint Venture have recently initiated efforts to assess bird abundance and distribution in these areas to improve status information and harvest management for several species of sea ducks, geese, swans, and other waterbirds (Alisauskas 2003 and 2005, Raven and Dickson 2005, Conant et al. 2006).

In early 2005, the Arctic Goose Joint Venture requested that the Waterfowl Management Branch of the U.S. Fish and Wildlife Service (USFWS) in Alaska assist in conducting experimental migratory bird surveys with a fixed-wing aircraft on Victoria Island in Nunavut, Canada. Ray Alisauskas (Canadian Wildlife Service [CWS] – Saskatoon, SK) had conducted a wildlife survey in the same area using a helicopter in June 2004 (Alisauskas 2005). The main purpose of repeating his survey in 2005 was to evaluate the feasibility, safety, and effectiveness of using a fixed-wing aircraft for gathering comparable indices of migratory birds (Conant et al. 2006).

In 2006, we were again requested to fly a survey in southwestern Nunavut using a design used previously by CWS (Alisauskas 2003, Hines et al. 2003, Alisauskas 2006), and to survey an additional area northwest of Kugluktuk. This report summarizes the results from our fixed-wing survey in these areas in 2006.

Study Area

The eastern part of our 2006 study area was identified and described, including flight lines, by Alisauskas (2003, 2006) and Hines et al. (2003). An additional area, northwest of Kugluktuk, was identified through satellite imagery as having similar characteristics as other areas of high waterfowl use (Alisauskas and Nieman 1992). Four survey areas were delineated: Queen Maud Gulf (24,385 km^2), King William Island (13,801 km^2), Rasmussen Lowlands (10,433 km^2), and Kugluktuk (11,112 km^2) (Figure 1). The total area surveyed by fixed-wing aircraft in 2006 was 59,731 km^2 (Table 1).

Survey Design

The survey design developed by Alisauskas and Hines for the three eastern areas (Alisauskas 2003, Hines et al. 2003, Alisauskas 2006) was repeated in 2006, including use of the same transect lines. The transects were spaced systematically across the three areas, 10 km apart and oriented in either a north/south or east/west direction (Table 1, Figure 1). Approximately 4% of the study area was sampled. We used this same basic design and sampling intensity for the one new area we added northwest of Kugluktuk (Table 1, Figure 1).

On King William Island, some of the transects in the design were not surveyed completely by Alisauskas in 2005 due to poor weather (Alisauskas 2006). To facilitate comparison with that survey, we incorporated Alisauskas' 2005 actual transect endpoints (the points where he stopped surveying) into our design and partitioned each transect into two separate ones. Also, in the Rasmussen Lowlands we extended several transects further to the east than were flown by Hines in 1994-1995, thus we partitioned our transects here as well.

Methods

The 2006 survey was initiated on June 17 and completed on June 26. The fixed-wing aircraft used was the specially-modified, one-of-a-kind, turbine-powered de Havilland beaver aircraft that has been used for waterfowl surveys in Alaska since 1977 (Conant and Mallek 2006). Survey procedures followed U.S. Fish and Wildlife Service protocol for waterfowl breeding pair surveys (USFWS and CWS 1987). The centerline of each transect was flown at 30-45 m above ground level and at a speed of 145-170 km/hr, using a Global Positioning System (GPS) in the aircraft panel to navigate along transects to preprogrammed endpoint coordinates. Navigation was also aided by a custom-designed computer program, developed by John Hodges (USFWS, Region 7, Waterfowl Management-Juneau), that provided a seamless, moving, zoomable 1:1,000,000 scale map displayed on a panel-mounted computer screen. Both pilot and front-right-seat observer recorded observations by species (or species group) out to their respective 200-m distance from the flight path. All waterbirds, raptors, ptarmigan, musk oxen, and caribou observed within the transect strip were recorded.

Observations were recorded directly into panel-mounted computers as sound files using John Hodges' computer program. Each computer (one for each observer) was linked to its own respective aircraft GPS unit. The program simultaneously recorded observations and their coordinates into linked sound and ASCII files, respectively. A second computer program, also developed by John Hodges, was used on the ground to replay the linked sound files and to combine the transcribed observation data with the geographic coordinates to produce a final ASCII data file. The transcribed ASCII files were then used for data analysis.

Observations of waterfowl were recorded according to established survey protocol (USFWS and CWS 1987). All observations of lone male ducks (drakes) were recorded as singles. Drakes in flocks of two or more were recorded as flocked drakes. A male duck in close association with a female was recorded as a pair. A hen and two drakes were recorded as a pair and a lone drake, while a drake and two hens were recorded as one pair (the second hen was not recorded). Ducks in mixed-sex groupings of four or more of a given species were separated into singles and pairs if the pair associations were evident; otherwise they were recorded as groups. Observations of lone geese were recorded as singles, two geese in close association were recorded as a pair, and geese in groups of three or more of the same species that could not be separated into singles and pairs were recorded as groups. For "light" geese (snow geese and Ross' geese), only birds that were flying and outside obvious breeding colonies were recorded, because the extremely high densities of birds within the colonies made them difficult to count, and other methods are used to monitor their status. For the remaining species, simply the number of birds present was recorded.

Statistical procedures followed those reported by Smith (1995). Duck and goose population indices were based on indicated total birds: $2 * (S + P) + G$, where S = number of single birds observed, P = number of pairs observed, and G = number of birds in groups. For ducks, flocked drakes <5 were considered as singles, while 5 or more flocked drakes were considered as a group. Scaup were an exception in that neither lone nor flocked drakes were doubled. Population indices of the non-duck and non-goose species were based on total birds observed. Population indices and variances were estimated with the ratio method (Cochran 1977). For comparability with variances reported by Alisauskas (2003, 2006), our transects were fragmented into 2 km segments, and each segment was treated as a sample unit.

Population indices were corrected for visibility bias (birds present within the transect strip but not observed) using two separate methods for comparison. First, we applied the standard visibility correction factors (VCF's) that were developed for duck species in tundra habitats, based on helicopter versus fixed-wing comparison surveys in Alaska from 1989 to1991 (Conant et al. 1991, Smith 1995). These VCF's have been used in Alaska as constant adjustments to annually-obtained breeding population indices (Conant and Mallek 2006). For this portion of our analysis, no VCF's were applied to king eiders, common eiders, or any of the non-duck species.

We also separately corrected the population indices for some species by VCF's that we obtained using the independent double-observer counting technique (Magnusson et al. 1978, Seber 1982, Pollock and Kendall 1987). Double-counting has been used to estimate observer detection bias during surveys of various bird and mammal species (e.g. Graham and Bell 1989, Miller et al. 1998, Bowman and Schempf 1999). Applying it to busy, multispecies aerial surveys of waterbirds is a much greater (perhaps insurmountable) challenge, because the increased density of observations and potential for species misidentification increases the probability of violating critical assumptions. However, the densities and biodiversity of waterbirds in this Nunavut survey area were relatively low, thus we felt that this survey would provide a good opportunity to try the double-counting technique with multiple species.

We used the independent double-observer technique during two days in which we surveyed King William Island. (Aircraft weight restrictions and personnel logistics precluded us from conducting double-counts during the entire Nunavut survey.) A third observer spent one day each sitting behind the left and right-front observers to obtain detection rates for each front-seat observer. The initial objective was to obtain detection rates by observer for Canada geese, white-fronted geese, tundra swans, king eiders, and long-tailed ducks. Upon starting the survey, we decided that the density of birds was low enough on King William Island that we could include all species. On the suggestion of R. Alisauskas (CWS, personal communication), we also recorded observations of geese and swans by three separate "behavior" categories: 1) flying, 2) on the ground or water, moving ("move"), and 3) on the ground or water, not moving ("still"). The "flying" category included birds that were observed on the ground but were flapping their wings. "Move" was defined as walking, running, or swimming.

The double-observer technique required that observations made by the front and rear-seat observers be independent (Seber 1982). To prevent the rear observer from being visually influenced by movements of the front observer, we attached a long piece of black cloth to the airplane overhead just aft of the front seat. To prevent verbal influences, the front observer positioned his/her headset mouthpiece such that all observations were inaudible to the rear observer. The rear observer refrained from calling out an observation until after it had passed aft of the airplane wing, and the front observer was limited to recording birds observed forward of the wing.

To minimize the potential for erroneously identifying front and rear observations as matched or unmatched, we chose to reconcile observations as they occurred rather than post-survey. When the rear observer made an observation, he remained silent until it was aft of the wing to allow the front observer a chance to detect it. He then communicated via the intercom the species and number of birds he observed, behavior (flying, moving, still), and the observation's position relative to the airplane (near or far). Distance attributes were used only to assist in reconciliation, not for distance sampling. The front observer confirmed or denied observation of the same individuals, either tactily via a connecting cord (right observer) or verbally via the intercom (pilot). The rear observer then recorded his observation into a separate computer with a designation as matched or unmatched. When observers determined that their respective observations were the same birds but they disagreed on species identification or the number of individuals, each observer recorded his/her observation as he/she interpreted it, and the rear observer recorded a comment regarding the discrepancy. For the purpose of data analysis, however, the attributes recorded by the front observer were ultimately assigned to both front and rear observations.

Transcribed front and rear-observer data were displayed in a geographic information system (ArcGIS 9.2, Environmental Systems Research Institute, Redlands, CA) to visually double-check matched observations and to assign matched/unmatched attributes to 30 observations that had been inadvertently overlooked during the flight. The "move" and "still" observations for all species were combined into one "ground" category, because in many instances the bird was motionless when the front observer spotted it but had started moving by time the rear observer detected it. In four cases of matched observations, the bird changed from "still" to "flying" between the time the front and rear observers saw it. All four observations were assigned to the "still" category for both observers, because the bird was motionless when the front observer detected it, and it was the front observer's detection rate that we were interested in estimating.

To estimate the detection rate and VCF for a given species and front observer, we first estimated the total true number of observations of the species in that observer's sampled area (half of the transect strip), using Chapman's modification (1951) of the Lincoln-Petersen estimator for mark-recapture data (Magnusson et al. 1978, Seber 1982, Pollock and Kendall 1987):

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m + 1)} - 1$$

where:
$\hat{N}$ = the estimated true number of observations of the species present in the sampled area;
n_1 = the number of observations of the species recorded by the front-seat observer;
n_2 = the number of observations of the species recorded by the back-seat observer;
m = the number of observations of the species recorded by both front and back-seat observers.

We calculated the standard error of $\hat{N}$ according to Seber (1982:60):

$$SE_{\hat{N}} = \sqrt{\frac{(n_1 + 1)(n_2 + 1)(n_1 - m)(n_2 - m)}{(m + 1)^2 (m + 2)}}$$

The detection rate (p), VCF, and standard error of the VCF were then calculated using the following formulas:

$$p = \frac{n_1}{\hat{N}}$$

$$VCF = \frac{\hat{N}}{n_1}$$

$$SE_{VCF} = \frac{SE_{\hat{N}}}{n_1}$$

To estimate population size and standard error of a given species within each of the four survey areas, the aerial index and standard error for each observer and area were multiplied by the VCF for that species and observer. The visibility-corrected populations and standard errors from the two observers were then averaged.

Rivest et al. (1995) recommended a minimum of 6 matched observations to ensure small bias in the mark-recapture estimator. Therefore, we only calculated corrected population estimates of species for which we obtained 6 or more matched observations from each side of the aircraft.

Results

Population indices adjusted by the standard Alaska VCF's are presented by species/group for each of the four areas in Tables 2 and 3.

Three different size classes of Canada geese were observed in the study area: small, medium, and large. Because only the pilot differentiated between the small and medium size classes in 2006, those two classes were combined in Table 2. Large Canada geese were observed mostly in the Queen Maud Gulf Migratory Bird Sanctuary (especially the western half), with lesser numbers in the Kugluktuk and Rasmussen Lowlands areas. It should be noted that the pilot, who felt the most confident identifying the different size classes, did not observe any large Canada geese in the Kugluktuk area. Therefore, the right-seat observations and population estimate of large Canada geese in Kugluktuk should perhaps be viewed with caution, at least until future surveys can verify their presence in that area.

Detection rates and VCF's derived from our double-observer experiment are presented for each front-seat observer in Tables 4 and 5. Due to inadequate sample sizes (< 6 matched observations), we were unable to estimate detection rates for several species. For white-fronted geese, tundra swans flying, and Pacific loons, we obtained a sufficient sample for one observer but not for the other. To get an adequate sample for tundra swans, we pooled the observations from the ground and flying categories. We only applied these VCF's to a species' population index if we were able to calculate detection rates for both observers. Corrected population estimates for small/medium Canada geese, king eiders, long-tailed ducks, tundra swans, and glaucous gulls are presented in Table 6.

Discussion

The results obtained this second year with a fixed-wing aircraft as the survey platform are encouraging. The terrain and flying weather we encountered on both this and last year's survey were manageable for flying with a turbine-powered, fixed-wing aircraft.

Based on our very limited experiment with the independent double-observer method for estimating visibility bias, we feel that the technique might have potential as an alternative to using standard Alaska VCF's in portions of the central Canadian Arctic. We believe that it can only work where the densities of observations are relatively low, species/group identification is not confusing, reconciling is accomplished in the air at the time observations are made, and a barrier is used to ensure independence between front and rear-seat observers. We found that the bird density was low enough on King William Island that both front-seat observers could keep up with the dual tasks of recording and reconciling observations. However, some areas, such as portions of Queen Maud Gulf Migratory Bird Sanctuary, have higher bird and mammal densities and may be too busy to allow for on-the-fly reconciling, especially for the pilot.

Applying our VCF's from King William Island to all areas this year might have introduced an unknown bias in our results, if higher densities or other factors changed observer detection rates in other areas. Our results might also have an unknown bias resulting from violation of the assumption that all birds have an equal probability of detection for a given observer (Seber 1982). Perhaps this violation was minimal, because the relatively flat tundra landscape and sparse vegetation reduced the probability that birds were partially hidden. Following the standard protocol to double lone male ducks and single geese theoretically corrected for well-camouflaged females on nests. Our partition of geese into ground and flying behavior categories also helped account for detection heterogeneity for those species. In future years, if a large enough double-observer data set can be collected, then it would also be worthwhile to analyze observations of grouped birds separately from singles and pairs, since flocks tend to be more visible. Birds that are completely hidden from view, i.e. have zero detectability, can not be accounted for with the double-observer count technique; thus even the corrected indices presented in our report should be considered minimal estimates of population size. Indices of species/groups for which we were unable to calculate VCF's via double-observer sampling should also be considered minimum estimates, because their true detection rates are undoubtedly less than 1.0.

Helicopter-based surveys were conducted by Ray Alisauskas in 2006 on the same transect lines on King William Island and the Rasmussen Lowlands within a few days of our surveys. Detection probabilities from double-observer sampling were obtained in the helicopter and should provide data with which to compare population estimates from the two survey platforms.

Recommendations

We recommend that more fixed-wing, aerial waterfowl surveys be conducted in this part of the waterfowl breeding grounds in North America. More concurrent fixed-wing/helicopter surveys are also recommended to better understand the relationship to each other as a platform for gathering wildlife population information. More double-observer work is needed to obtain adequate sample sizes for more species and to better understand the potential effects of different aircraft models, survey crews, bird densities, and variable survey conditions (e.g. wind, glare). Because of fuel availability and safety considerations, we recommend that the fixed-wing aircraft used be turbine powered and have an automated flight following (AFF) system onboard.

We further recommend that future survey designs in this part of the continental breeding grounds take into consideration the full cadre of the major bird species present to maximize the benefits-to-cost ratio.

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Table 1. Survey design used for fixed-wing aerial surveys in southwestern Nunavut, Canada in June 2006.

	Queen Maud Gulf	King William Island	Rasmussen Lowlands	Kugluktuk	All Areas
Study Area (km^2)	24,385	13,801	10,433	11,112	59,731
No. Transects	35	25	26	13	99
No. Segments	1,215	692	552	581	3,040
Total Transect Length (km)	2429.8	1384.1	1101.7	1158.5	6,074.1
Transect Coverage (km^2)	971.9	553.7	440.7	463.4	2,429.6
% Coverage of Study Area	4.0	4.0	4.2	4.2	4.1

Table 2. Population estimates, by area, of waterfowl from the fixed-wing survey in Nunavut, Canada in June 2006. Single birds (except scaup and tundra swans) were doubled when calculating estimates. Visibility Correction Factors (VCF's) are from 1989-1991 fixed-wing vs. helicopter comparison surveys in Alaska tundra habitats. VCF = 1 indicates that no correction factor was applied.

Species	**VCF**	**Queen Maud Gulf**	**SE**	**King William Island**	**SE**	**Rasmussen Lowlands**	**SE**	**Kugluktuk**	**SE**	**Total**	**SE**
Small/Medium Canada Goose	1	70,421	3,898	31,885	1,794	13,608	1,171	26,131	4,350	142,045	6,221
Large Canada Goose	1	97,115	19,055	50	50	1,606	715	5,666	1,961	104,437	19,169
White-fronted Goose	1	60,913	5,237	5,609	870	23,176	2,053	18,433	4,487	108,131	7,248
Brant	1	0	0	424	283	850	508	0	0	1,274	582
Snow/Ross' Goose[a]	1	288,785	69,166	31,486	15,113	127,431	25,822	0	0	447,702	75,329
Green-winged Teal	8.36	839	593	0	0	0	0	0	0	839	593
Northern Shoveler	3.79	0	0	0	0	358	253	181	181	539	311
Northern Pintail	3.05	94,346	11,186	1,673	586	3,459	1,140	7,073	3,351	106,551	11,747
Unidentified Scaup	1.93	291	153	96	96	0	0	185	113	572	213
Common Eider	1	1,505	818	698	272	0	0	2,726	788	4,929	1,168
King Eider	1	11,641	1,020	7,180	798	3,685	512	622	207	23,128	1,408
Long-tailed Duck	1.87	79,848	4,382	14,685	1,748	9,366	1,268	8,807	1,536	112,706	5,121
Black Scoter	1.17	59	59	0	0	0	0	0	0	59	59
Unidentified Scoter	1.17	59	59	0	0	0	0	0	0	59	59
Red-breasted Merganser	1.27	191	110	0	0	0	0	1,093	482	1,284	495
Tundra Swan	1	8,680	615	5,833	518	5,670	517	2,391	352	22,574	1,018
Swan Nest	1	452	106	1,047	161	921	154	96	58	2,516	253

[a]Only includes flying birds observed outside of breeding colonies.

Table 3. Population estimates, by area, of additional bird and mammal species from the fixed-wing survey in Nunavut, Canada in June 2006. VCF = 1 indicates that no visibility correction factor was applied.

Species	VCF	Queen Maud Gulf	SE	King William Island	SE	Rasmussen Lowlands	SE	Kugluktuk	SE	Total	SE
Sandhill Crane	1	4,817	509	125	66	1,039	171	239	117	6,220	554
Pacific Loon	1	3,588	403	997	211	709	184	1,100	209	6,394	534
Red-throated Loon	1	2,057	289	673	169	638	195	143	89	3,511	397
Yellow-billed Loon	1	376	120	374	124	71	53	96	58	917	190
Common Loon	1	100	71	0	0	0	0	72	53	172	89
Red-necked Grebe	1	25	25	0	0	0	0	0	0	25	25
Glaucous Gull	1	12,694	1,424	3,091	551	2,433	432	1,387	269	19,605	1,609
Herring Gull	1	1,229	205	50	35	331	153	0	0	1,610	258
Sabine's Gull	1	0	0	848	218	47	33	0	0	895	221
Thayer's Gull	1	100	61	0	0	0	0	0	0	100	61
Unidentified Gull	1	0	0	374	374	0	0	0	0	374	374
Arctic Tern	1	4,942	1,235	1,321	253	520	281	48	34	6,831	1,292
Unidentified Jaeger	1	753	153	623	127	307	102	72	41	1,755	228
Unidentified Ptarmigan	1	2,960	326	623	137	402	107	72	53	4,057	373
Common Raven	1	75	43	0	0	189	74	24	24	288	89
Rough-legged Hawk	1	226	75	50	35	94	47	72	41	442	104
Bald Eagle	1	50	35	0	0	0	0	24	24	74	43
Golden Eagle	1	25	25	0	0	0	0	0	0	25	25
Short-eared Owl	1	50	35	0	0	47	33	0	0	97	49
Snowy Owl	1	226	75	424	119	1,110	179	0	0	1,760	227
Musk Ox Adult	1	1,104	746	25	25	260	184	215	193	1,604	793
Musk Ox Calf	1	100	100	0	0	24	24	72	72	196	126
Caribou Adult	1	86,427	14,045	175	90	16,325	2,414	1,267	984	104,194	14,285
Caribou Calf	1	21,525	4,384	0	0	2,150	648	550	480	24,225	4,457

Table 4. Numbers of unmatched and matched observations recorded by left-front and left-rear-seat observers on double-count transects, and the estimated detection probability and visibility correction factor of each species for the left-front observer.

Species	No. of Observations: Left-Front Observer Only	Left-Rear Observer Only	Both Observers	Left-Front Detection Probability[a]	Visibility Correction Factor[a]	SE_{VCF}
Canada Goose ground[b]	19	9	10	0.542	1.846	0.290
Canada Goose flying[b]	61	20	71	0.781	1.280	0.048
Greater White-fronted Goose ground	0	0	0	---	---	---
Greater White-fronted Goose flying	10	6	11	0.656	1.524	0.170
Tundra Swan ground	13	8	25	0.760	1.316	0.072
Tundra Swan flying	0	0	5	---	---	---
Tundra Swan ground & flying combined	13	8	30	0.791	1.264	0.056
King Eider	26	6	18	0.756	1.323	0.112
Long-tailed Duck	22	6	8	0.592	1.689	0.290
Pacific Loon	6	0	1	---	---	---
Glaucous Gull	2	2	13	0.868	1.152	0.039

[a]Detection probability and VCF were not estimated for species with an inadequate sample size of matched observations (<6) (Rivest et al. 1995).

[b]Excludes large-sized Canada Geese.

Table 5. Numbers of unmatched and matched observations recorded by right-front and right-rear-seat observers on double-count transects, and the estimated detection probability and visibility correction factor of each species for the right-front observer.

Species	No. of Observations: Right-Front Observer Only	Right-Rear Observer Only	Both Observers	Right-Front Detection Probability[a]	Visibility Correction Factor[a]	SE_{VCF}
Canada Goose ground[b]	8	3	6	0.685	1.459	0.216
Canada Goose flying[b]	26	7	50	0.878	1.139	0.032
Greater White-fronted Goose ground	0	0	0	---	---	---
Greater White-fronted Goose flying	7	3	3	---	---	---
Tundra Swan ground	15	3	20	0.872	1.147	0.057
Tundra Swan flying	2	0	7	1.000	1.000	0.000
Tundra Swan ground & flying combined	17	3	27	0.901	1.110	0.040
King Eider	6	7	12	0.638	1.568	0.144
Long-tailed Duck	6	2	8	0.808	1.238	0.112
Pacific Loon	3	1	7	0.879	1.138	0.072
Glaucous Gull	9	1	9	0.905	1.106	0.073

[a]Detection probability and VCF were not estimated for species with an inadequate sample size of matched observations (<6) (Rivest et al. 1995).

[b]Excludes large-sized Canada Geese.

Table 6. Population estimates, by area, calculated using visibility correction factors obtained from double-observer counts.

Species	Queen Maud Gulf	SE	King William Island	SE	Rasmussen Lowlands	SE	Kugluktuk	SE	Total	SE
Small/Medium Canada Goose	92,727	4,677	40,621	1,944	17,076	1,324	34,978	5,909	185,402	7,894
King Eider	16,594	1,411	10,514	1,139	5,339	742	951	320	33,398	1,985
Long-tailed Duck	62,128	3,164	11,093	1,249	7,372	997	6,726	1,152	87,319	3,728
Tundra Swan	10,298	724	6,823	594	6,729	594	2,819	412	26,669	1,183
Glaucous Gull	14,371	1,621	3,470	616	2,745	478	1,558	298	22,144	1,824

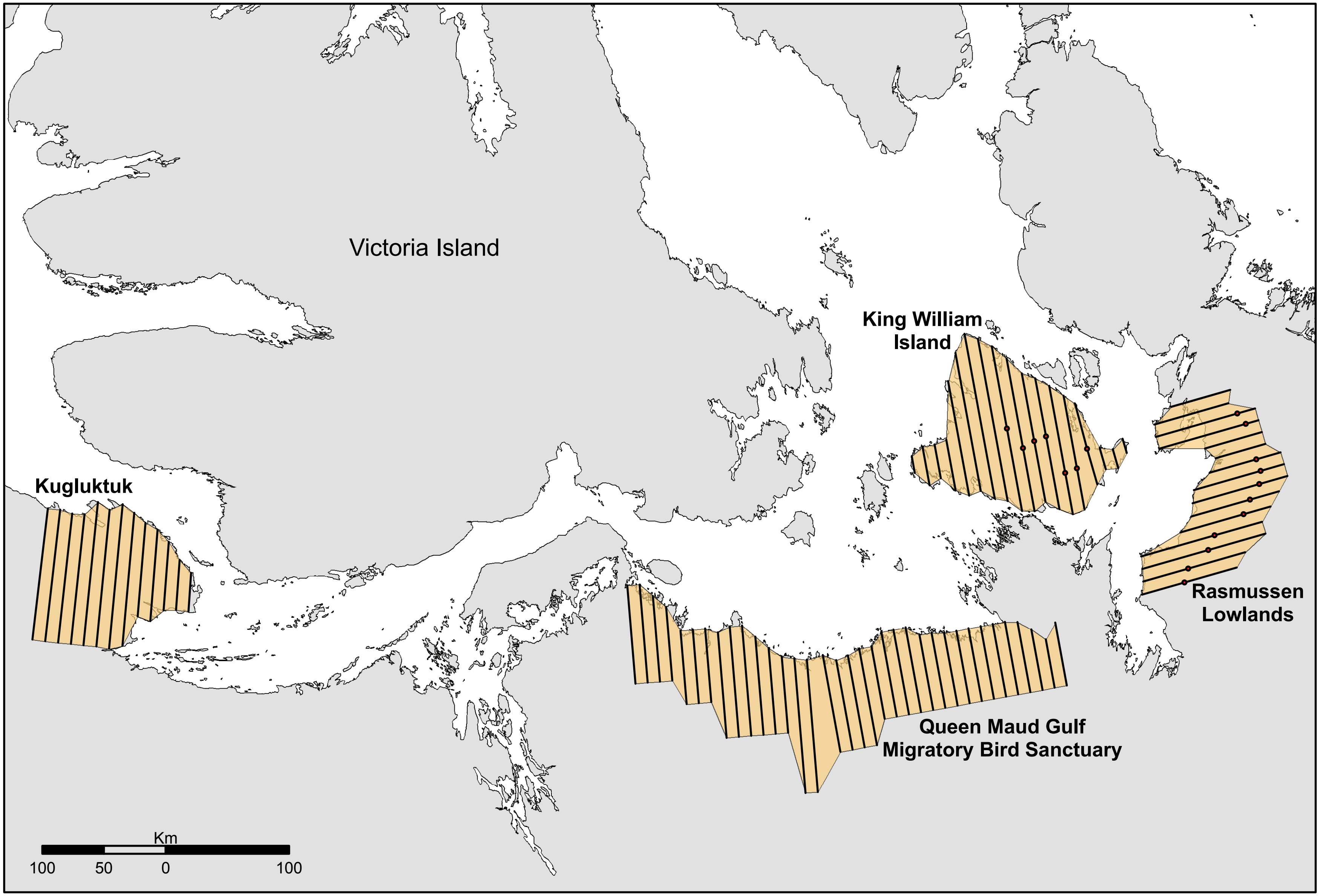

Figure 1. Transect lines within four areas surveyed for wildlife by fixed-wing aircraft in Nunavut, Canada, 16-26 June 2006. Red dots mark locations where transects were partitioned to facilitate comparability with previous surveys.