COOPERATIVE CENTRAL ARCTIC WATERFOWL SURVEYS, 1989-1991

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ABSTRACT

Cooperative aerial surveys for Canada Geese (Branta canadensis hutchinsii), White-fronted Geese (Anser albifrons), and Tundra Swans (Cygnus columbianus) were conducted by Ducks Unlimited Canada and the NWT Department of Renewable Resources in the Kitikmeot Region, Northwest Territories from 1989 through 1991. Reconnaissance surveys were conducted in 1989 and 1990 to determine the general locations of waterfowl concentrations, and as a basis for comparison with past work. Quantitative surveys were conducted by helicopter in 1990 and 1991 to determine waterfowl abundance. The criterion of Alexander et al. (1991), i.e., the presence of 1% of the national population of a species, was used to assess whether or not a new site should be recommended as a Key Migratory Bird Terrestrial Habitat Site. Four new areas are identified and recommended to the Canadian Wildlife Service and the Nunavut Wildlife Management Advisory Board for this designation: the western half of the Kent Peninsula; an area west of Albert Edward Bay on Victoria Island; an area 60 km north of Coppermine; and an area west of Cambridge Bay. Two other areas were identified as warranting further investigation, and two sites already classified as Key Migratory Bird Terrestrial Habitat Sites were confirmed. Populations of geese and swans have increased substantially since the 1960s and 1970s in the Central Arctic.

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INTRODUCTION

To date most effort to delineate and protect important areas for geese in the Northwest Territories (NWT) has been directed towards colonial species such as Lesser Snow Geese (Chen caerulescens caerulescens), Ross' Geese (Chen rossii) and Brant (Branta bernicla), although some areas important incidentally for other species have been identified across the Arctic (e.g., see Alexander et al. 1991). Important areas for White-fronted Geese and Canada Geese in the Central Arctic (Figure 1), that is east of Paulatuk, NWT to the Melville Peninsula, have been poorly documented. Similarly, there has been little other than incidental work to identify important areas for Tundra Swans (Cygnus columbianus) and Sandhill Cranes (Grus canadensis) in the Central Arctic. As a step towards addressing this gap, Ducks Unlimited Canada and the Department of Renewable Resources, Government of the Northwest Territories initiated a cooperative 3 year program (1989-1991) to determine important areas for dark geese (White-fronted Geese [Anser albifrons] and Canada Geese [Branta canadensis hutchinsii]) and for swans. Though not a focus of our surveys, observations of Sandhill Cranes were recorded during quantitative surveys and are reported in Appendix II. This manuscript is the final report on this program.

It is timely to be conducting this work for reasons other than those just mentioned. The Arctic Goose Joint Venture called for in the North American Waterfowl Management Plan is under way and will likely result in increased activity with the populations of concern. White-fronted Geese and Canada Geese are considered the highest priority by the Joint Venture group. Hopefully, the results of the work reported here will increase our capabilities for conservation of arctic geese.

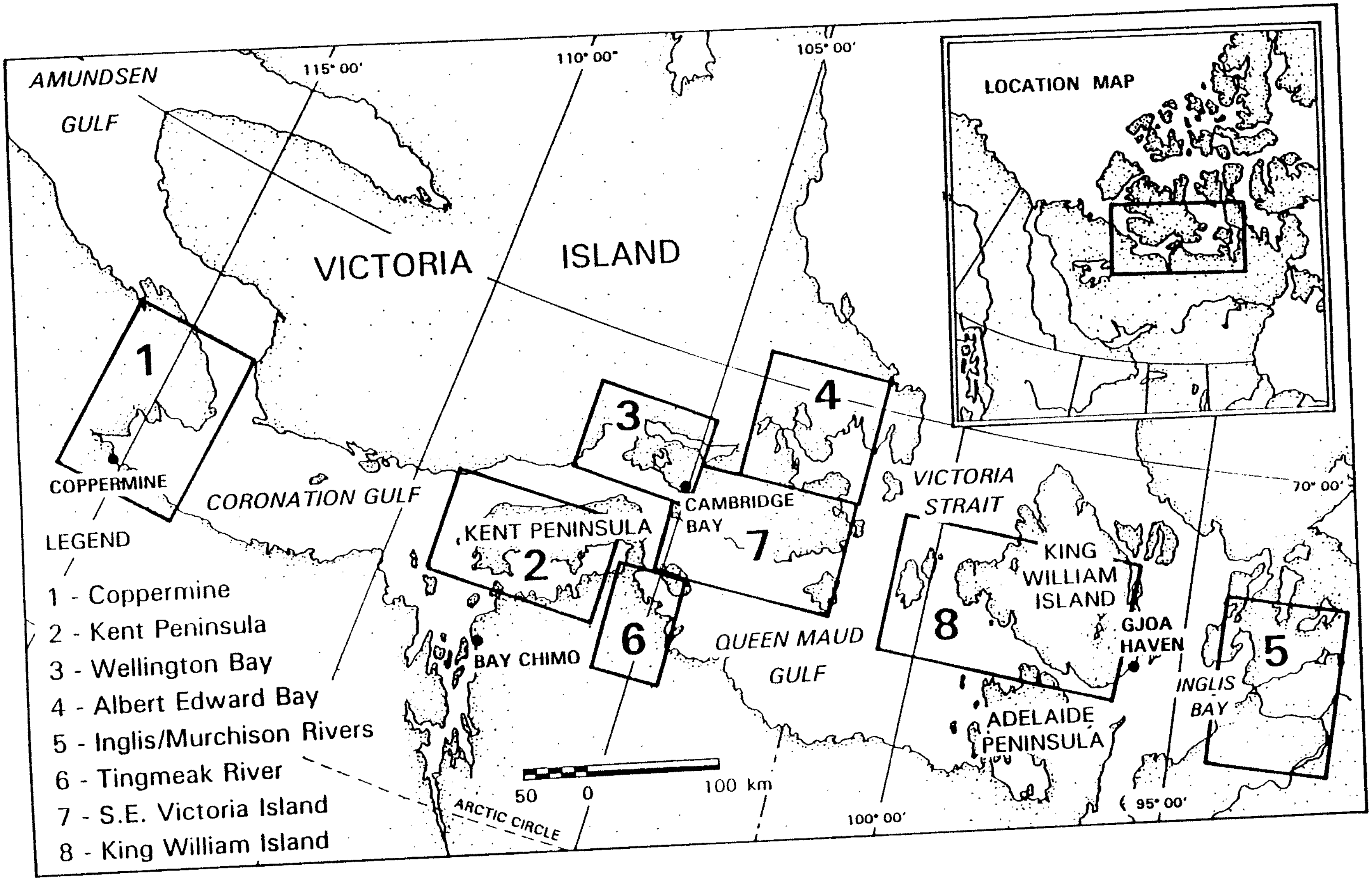

Figure 1. Location of study areas during the Cooperative Central Arctic Goose Survey - 1989-1991.

Target populations which occupy the Central Arctic include Eastern Mid-continent White-fronted Geese and Short Grass Prairie (SGP) Canada Geese. In recent years, possibly due to habitat changes on migratory routes and wintering areas, these populations have changed their patterns of distribution in unknown ways from that previously understood by managers. In addition, SGP Canada Geese are mixing with other Canada Geese during fall and winter harvest periods. As a result, it is becoming increasingly difficult to enumerate these populations and to measure their harvest (Jarvis and Bromley In press). Thus, their status is poorly understood at present (Nieman and Gollop 1993). As a result of increasing knowledge on geographic affinities of White-fronted Geese, there is a tendency to lump Eastern and Western segments of Mid-continent White-fronted Geese into one Mid-continent population.

Tundra Swans in the Central Arctic belong to the Eastern Population, which is gradually increasing (Atlantic Flyway Council 1983 and United States Fish and Wildlife Service 1991). The proportion of this population derived from the Central Arctic is unknown but probably large. Sandhill Cranes belong to the Mid-continent Population, which is stable (Central Migratory Shore and Upland Game Bird Technical Committee 1993).

Although Lesser Snow Geese were not a focus of the surveys, observations were considered of value, because most of our areas of interest were outside the areas that have received adequate attention in the past, and because populations of these birds have been rapidly expanding in recent years (Kerbes et al. 1983, Kerbes 1994).

OBJECTIVES

Objectives were to conduct aerial surveys within the Central Arctic of the Northwest Territories for White-fronted Geese, Canada Geese, Tundra Swans and Sandhill Cranes to:

1. locate and delineate important moulting and brood-rearing areas; and
2. determine the relative importance of areas by documenting numbers.

STUDY AREAS

Surveys were conducted on six specific study areas and opportunistically between areas within 75 km of the arctic coast over 3° of latitude and 24° of longitude, from just west of Coppermine to the Inglis and Murchison rivers delta 100 km east of Gjoa Haven (Figures 1 - 11). All areas lie along the border of the Northern Arctic and Southern Arctic Ecozones of Canada (Wiken 1986). The border of these zones is characterized by rolling lowland plains covered by glacial moraines in interior areas and fine-textured marine sediments in coastal areas. Vegetation is typically shrub-herb-heath arctic tundra to herb-lichen arctic tundra, with sedge and sedge-moss communities in wet lowland habitats (Bostock 1970, Wiken 1986). Climate is cold and dry arctic to very cold and dry arctic (Wiken 1986), with generally colder temperatures and persisting spring snow cover in the eastern survey areas (Maxwell 1980). Reproductive chronology of geese is earlier in the western and southern survey areas than in the eastern and northern, in correlation with climate patterns. For example, western survey areas are south of the 15 June isochrone for mean date of snow cover loss while areas east of latitude 105° W were beyond this isochrone where snow-free dates were typically later (Maxwell 1980). All survey areas are south of the 1 September isochrone for earliest date of snow cover formation (Figure 3.126 in Maxwell 1980: 495). Survey areas are within the Arctic Ecoclimatic Province, and more specifically in the Low Arctic and Moist Low Arctic ecoclimatic regions (Ecoregions Working Group 1989).

Essentially all areas selected for survey resulted from post-glacial rebound as Wisconsin glaciers receded. Land emergence was generally complete by 6000 to 10000 BP (Craig and Fyles 1960, Maxwell 1980). More detailed descriptions of survey areas are provided in Appendix 1.

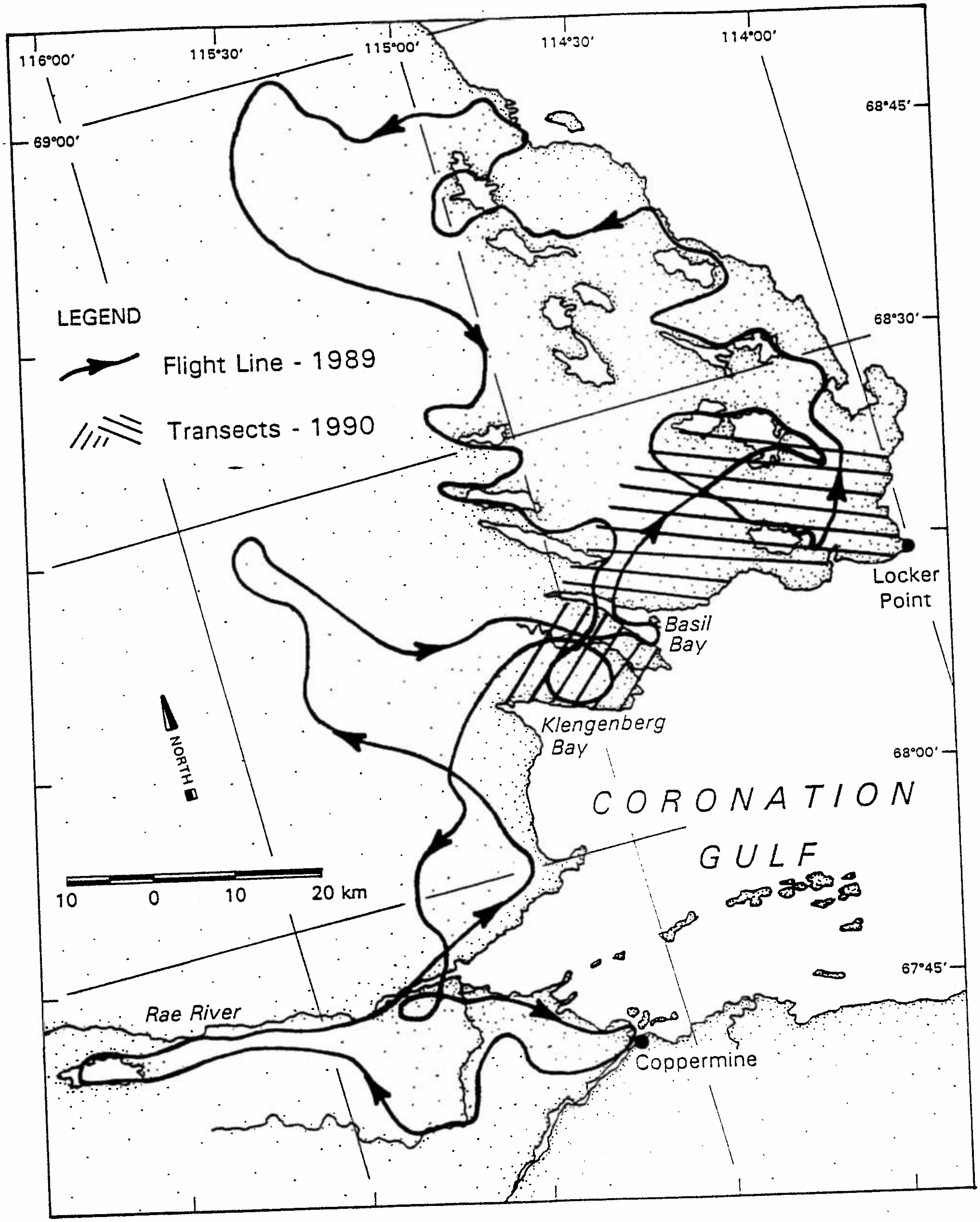

Figure 2. Reconnaissance flight lines and transects in the Coppermine Study Area in 1989 and 1990, respectively.

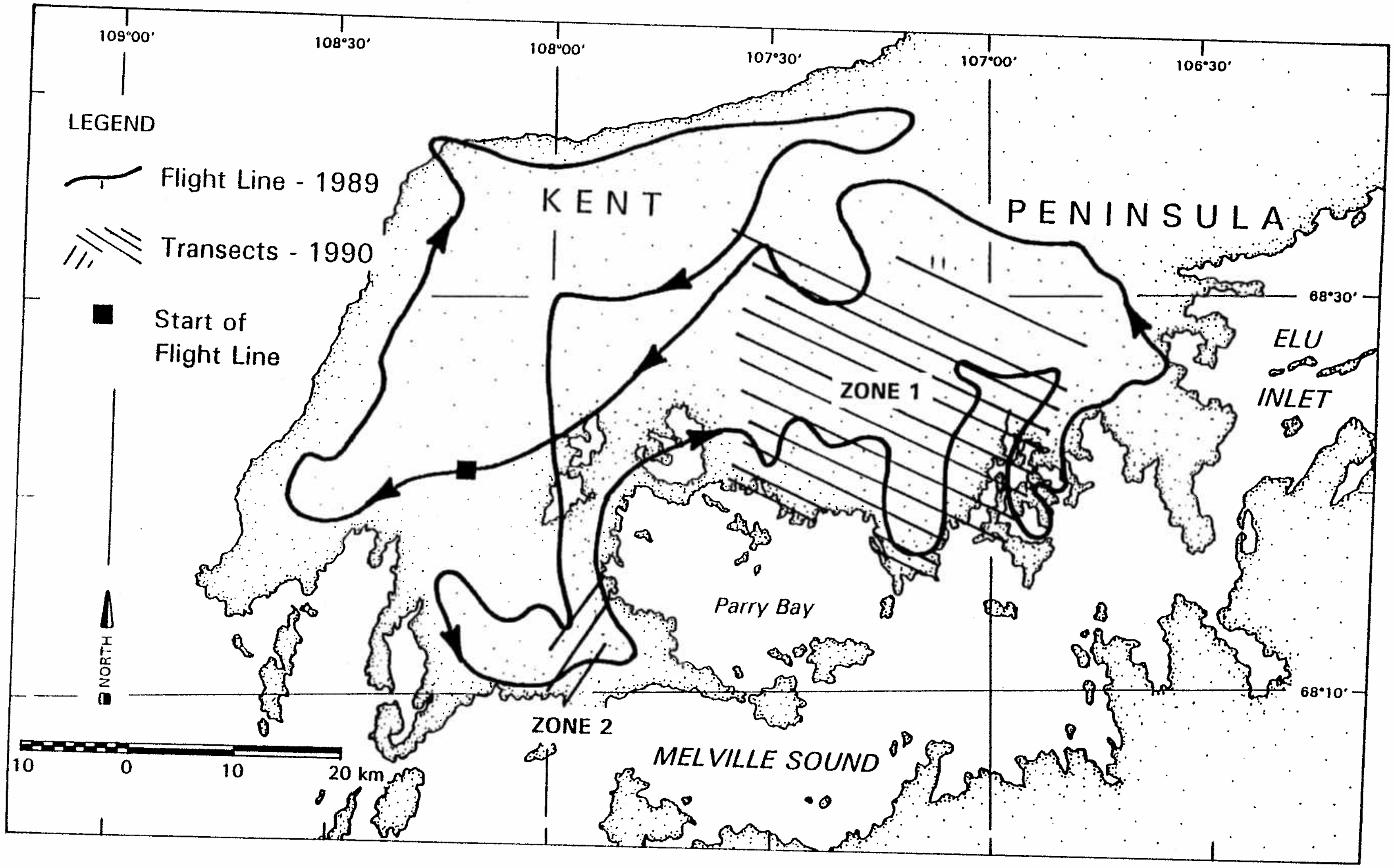

Figure 3. Reconnaissance flight lines and transects in the Kent Peninsula Study Area in 1989 and 1990, respectively.

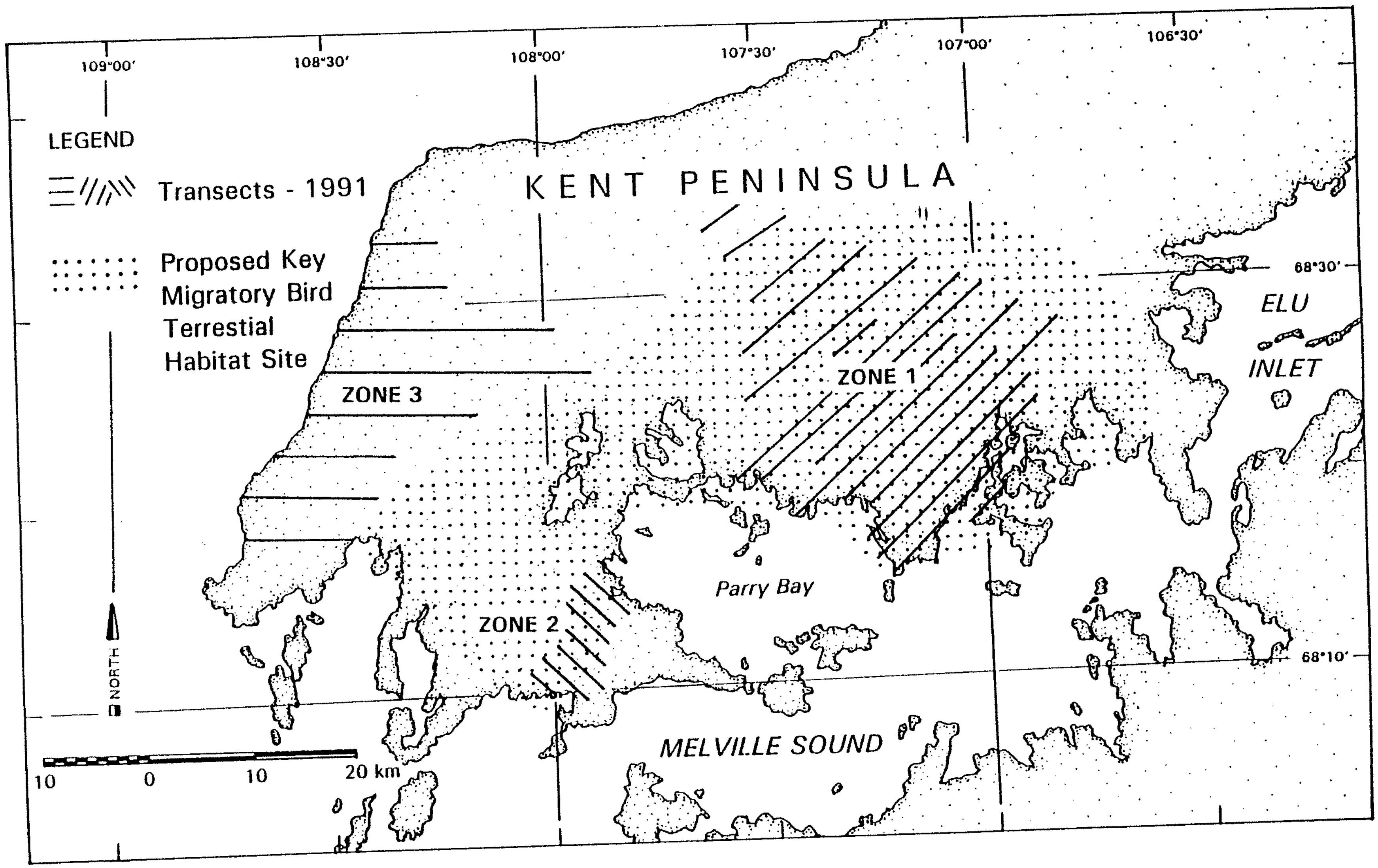

Figure 4. Transects on Kent Peninsula in 1991, and the area of the Kent Peninsula nominated as a Key Migratory Bird Terrestrial Habitat Site.

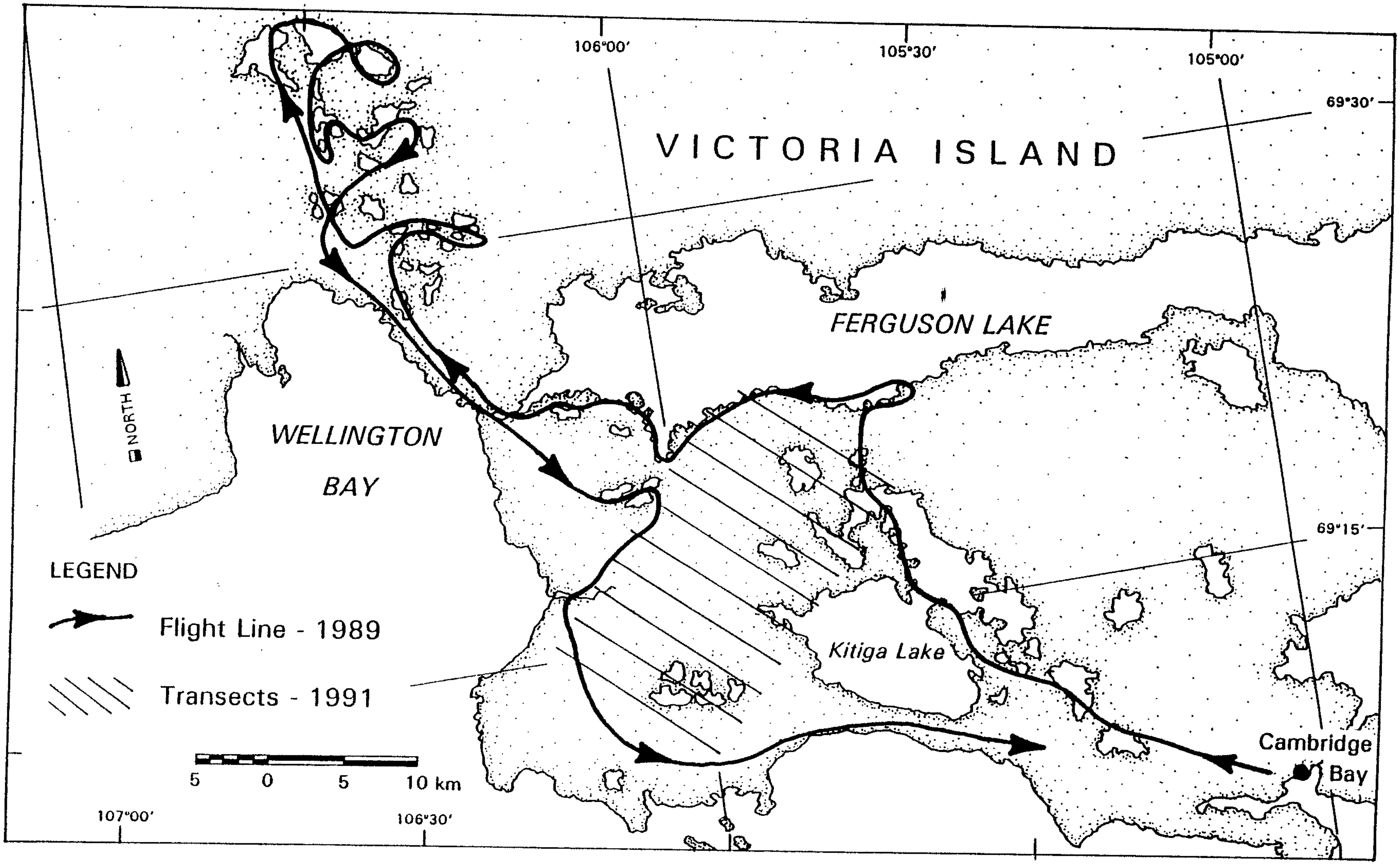

Figure 5. Reconnaissance flight lines and transects in the Wellington Bay Study Area in 1989 and 1991, respectively.

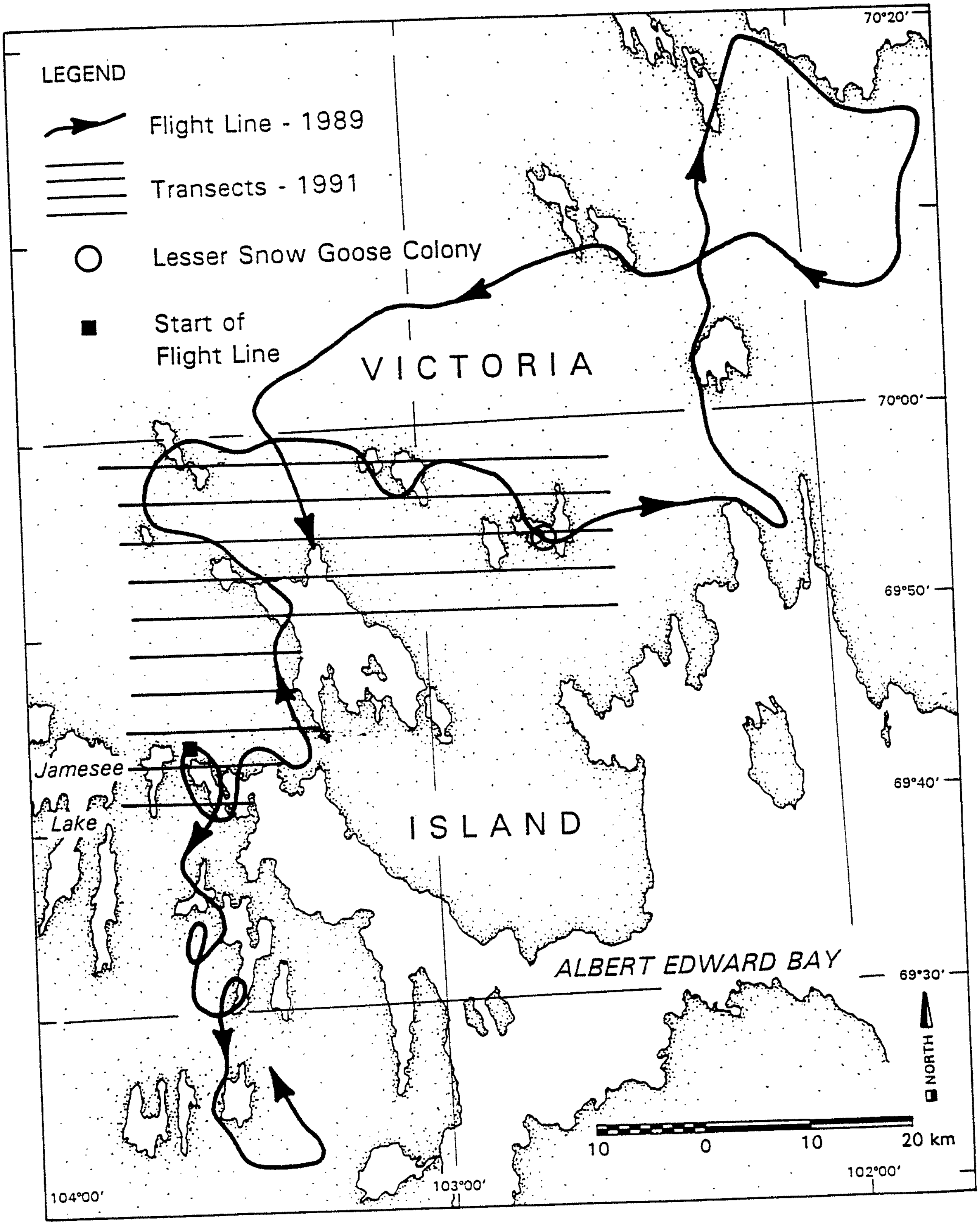

Figure 6. Reconnaissance flight lines and transects in Albert Edward Bay and southeastern Victoria Island in 1989 and 1991, respectively.

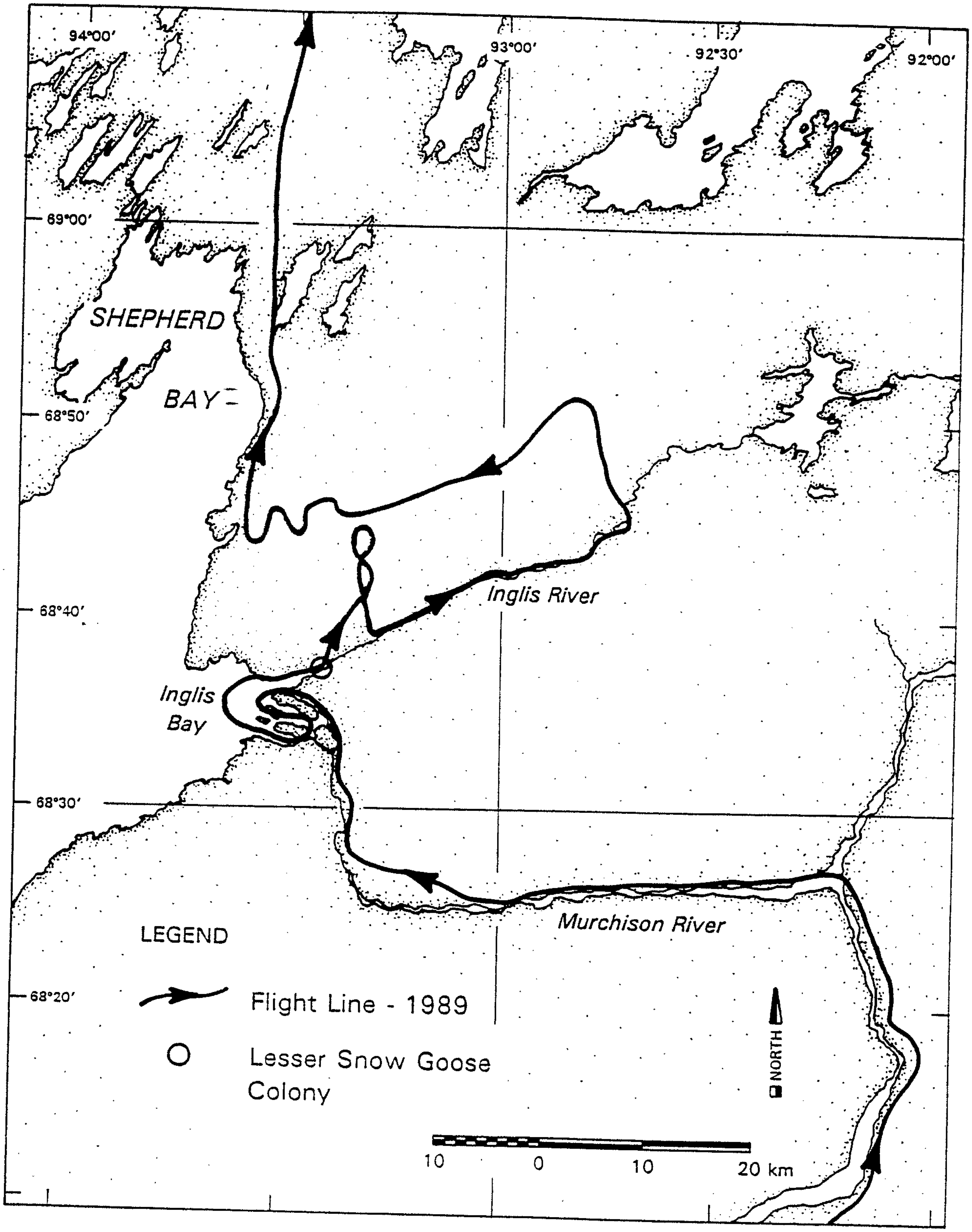

Figure 7. Reconnaissance flight lines in the Lower Inglis/Murchison rivers area in 1989.

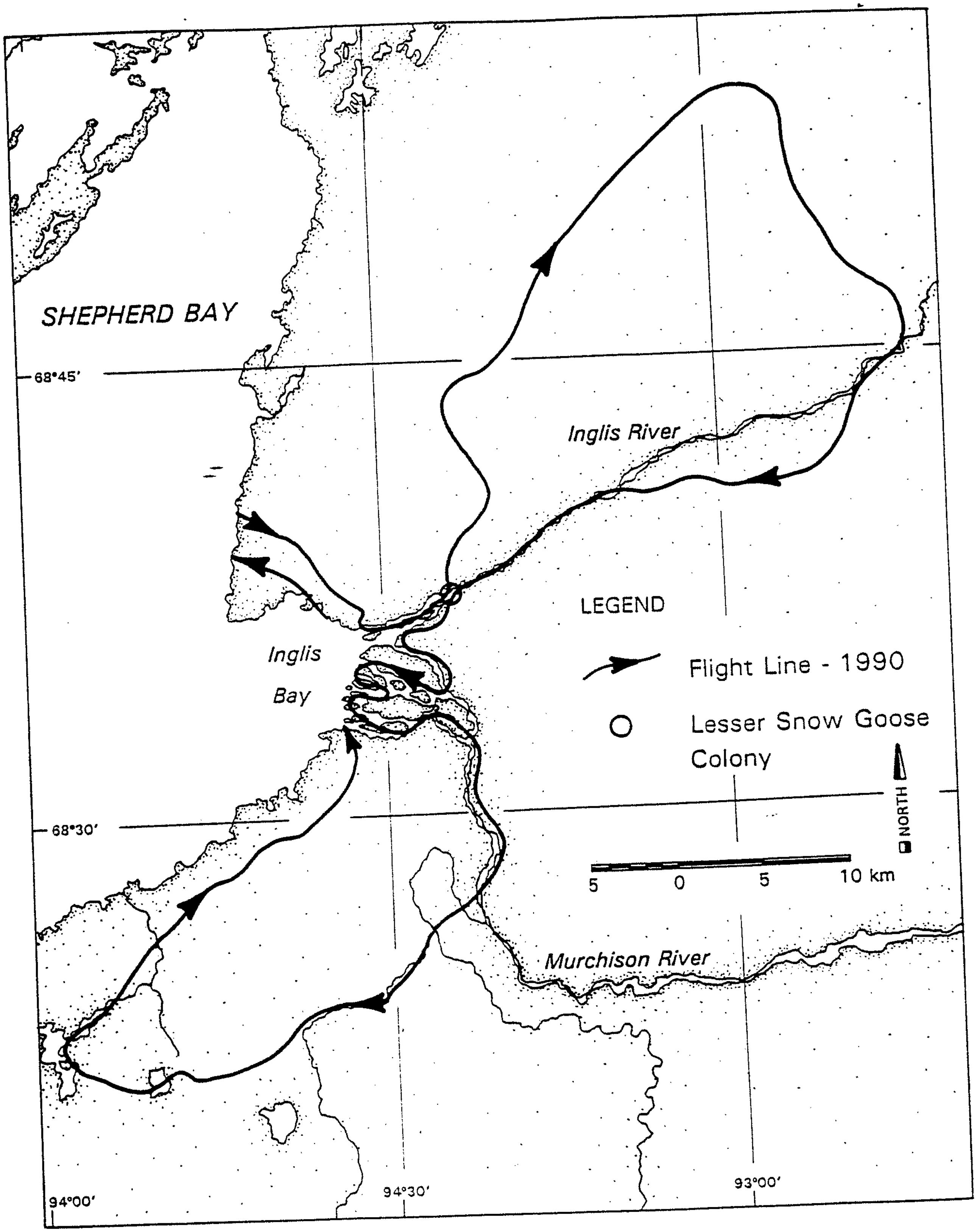

Figure 8. Reconnaissance flight lines in the Lower Inglis/Murchison rivers area in 1990.

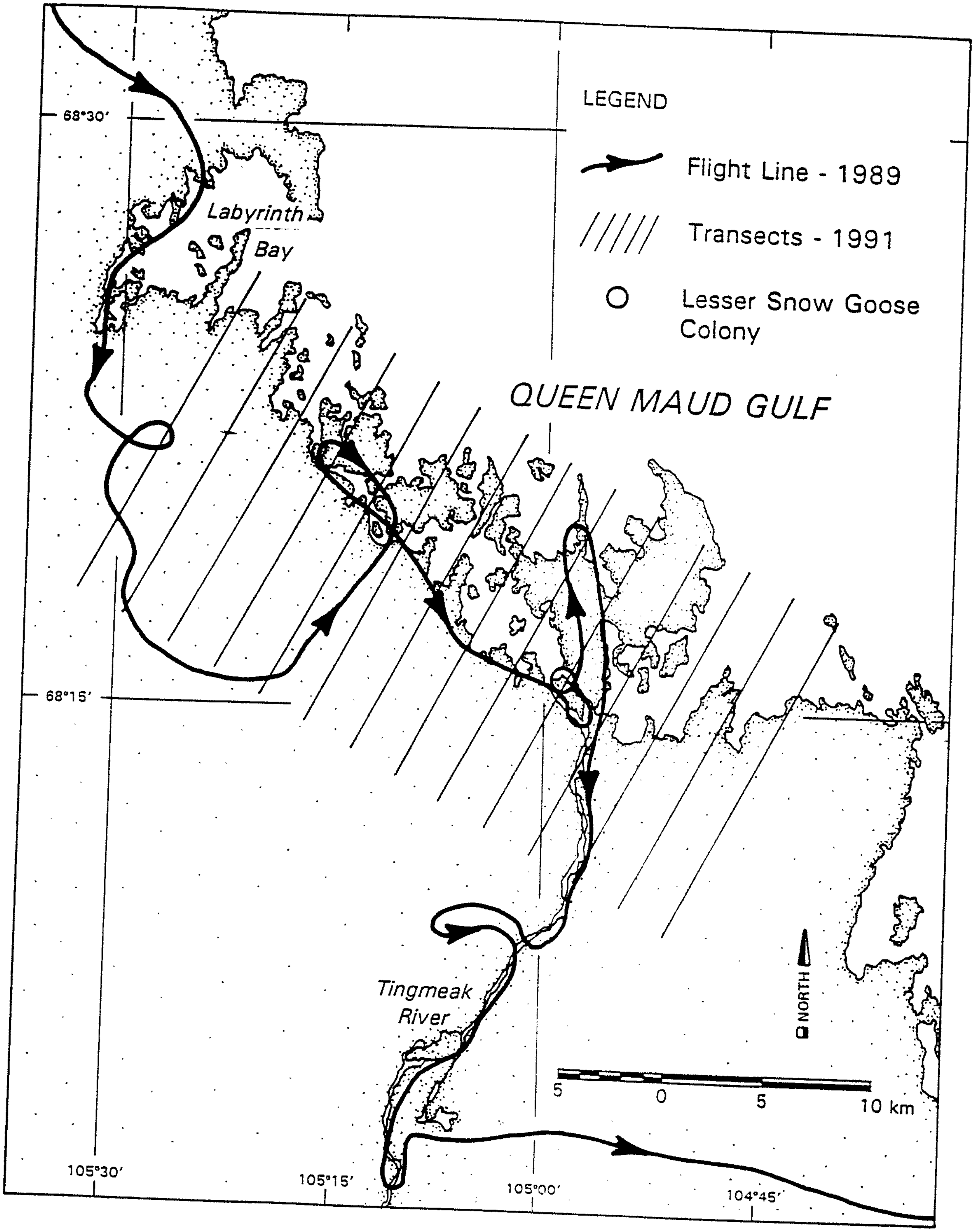

Figure 9. Reconnaissance flight lines and transects in the Tingmeak River Study Area in 1989 and 1991, respectively.

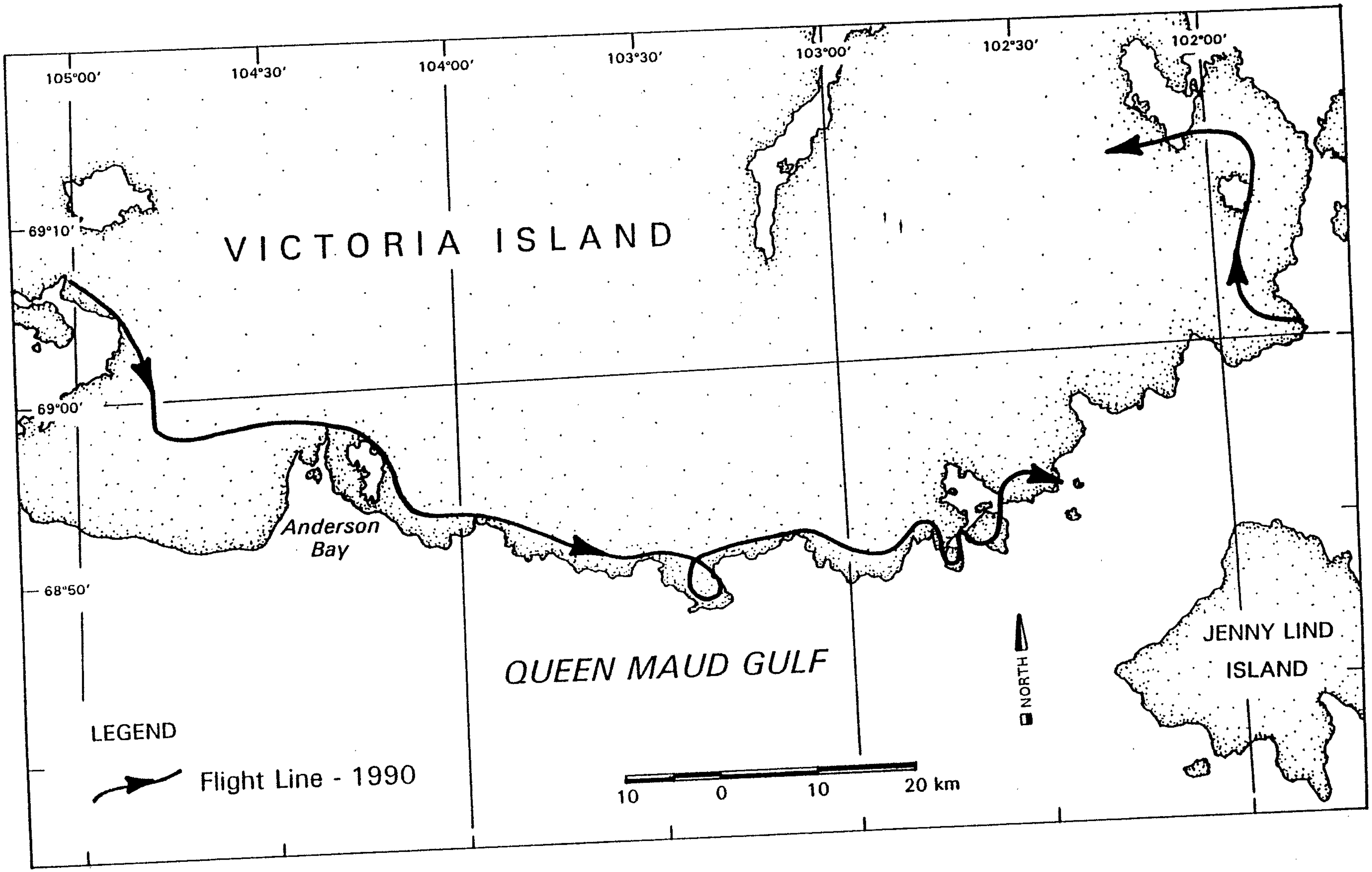

Figure 10. Reconnaissance flight lines on southern Victoria Island in 1990.

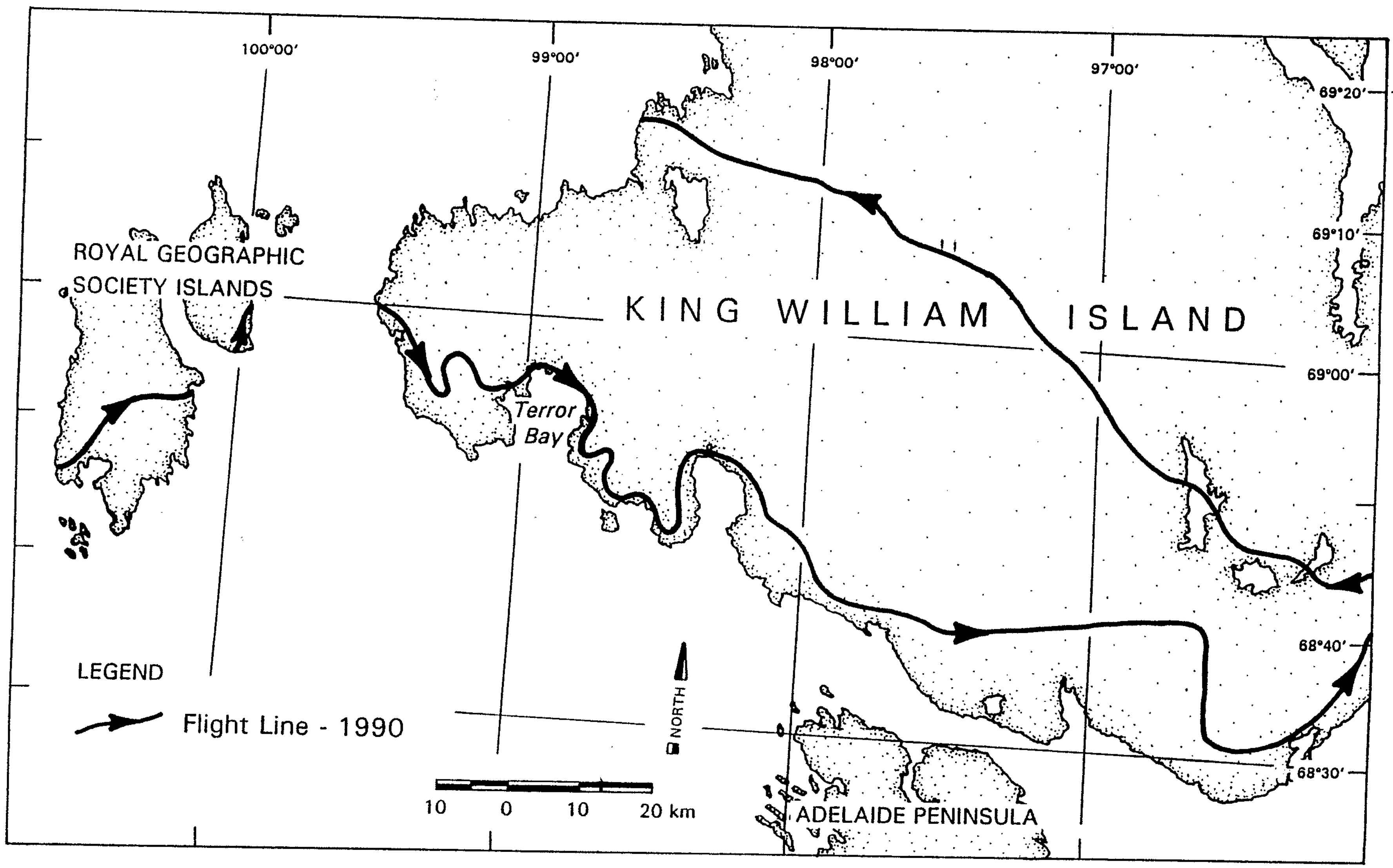

Figure 11. Reconnaissance flight lines on King William Island in 1990.

METHODS

Survey areas were selected on the basis of reports about the presence of geese by local residents, a review of Land Use Information Series maps (Canada Department of the Environment 1978, 1983a, 1983b), and general observations by the senior author during other wildlife work in the region.

Locations, types (reconnaissance or transect) and dates of aerial surveys, and type of aircraft used, varied from year to year (Table 1). During the first year (1989) we used a Helio Courier fixed-wing aircraft capable of extended flight (eight hours or more), slow flying speeds and off-strip landings, and providing good visibility for observers. Two observers were present, one of whom was also responsible for navigation and plotting flight lines. Observations were recorded either directly on 1:250,000 topographic maps or on cassette tape with corresponding observation numbers noted on maps. In 1990 both a Cessna 185 amphibious fixed wing aircraft and a Bell Jet Ranger 206B helicopter were used, the former for reconnaissance surveys and the latter for transect surveys. Only transect surveys were conducted in 1991, with a 206B helicopter. With all aircraft, one observer sat in a front seat and one in the opposite rear seat. Reconnaissance surveys were conducted in areas that appeared to provide suitable breeding habitat, based on the subjective judgement of experienced observers. Flight paths were along pre-determined transects for quantitative surveys.

Results are reported as an index of birds or broods per linear km for reconnaissance surveys. For quantitative surveys, both density (birds or broods per km^2) and a total estimate of birds or broods are reported for a particular census area based on the Jolly method of estimation for one stratum (Krebs 1989). Estimates of numbers were not

Table 1. Location, date, aircraft type and type of surveys conducted in the Central Arctic, NWT, 1989-1991. Aircraft types included Helio Courier (H. Courier), Cessna 185 (C185) and the 206B helicopter (Rotor). Surveys were either reconnaissance (Recon) or transect types.

Location	YEAR SURVEYED		
	1989	1990	1991
Coppermine Zone A	Recon/H. Courier 14 July	Transect/Rotor 24 July	–
Zone B	Recon/H. Courier 14 July	Transect/Rotor 24 July	–
Kent Peninsula Zone 1	Recon/H. Courier 17 July	Transect/Rotor 21 July	Transect/Rotor 21 July
Zone 2	Recon/H. Courier 17 July	Transect/Rotor 21 July	Transect/Rotor 22 July
Zone 3	Recon/H. Courier 17 July	–	Transect/Rotor 22 July
Albert Edward Bay	Recon/H. Courier 19 & 20 July	Recon/C185 12 August	Transect/Rotor 26 July
Wellington Bay	Recon/H. Courier 20 July	–	Transect/Rotor 25 July
Tingmeak River	Recon/H. Courier 21 July	–	Transect/Rotor 24 July
Inglis/Murchison	Recon/H. Courier 21 July	Recon/C185 14 August	–
King William Island	–	Recon/C185 13 August	–
Southeast Victoria Island	–	Recon/C185 14 August	Recon/Rotor 26 July
Royal Geographical Society Islands	–	Recon/C185 13 August	–

calculated if there were $\leq$ 2 observations of the species in the survey area. Broods are additive to numbers of birds, so that, for example, an area with an estimated 300 Canada Geese and 20 broods would actually total 340 adults plus young (i.e., add 2 adults per brood). We were unable to count brood sizes reliably, so numbers of young are not reported. On occasion, geese could not be identified by species, in such cases they were recorded as dark geese. For this report, we retroactively assigned dark geese to either Canada Geese or White-fronted Geese according to the proportion of the total identified geese that each species composed.

To assess the relative importance of areas to waterfowl in a comparative manner, we used the criterion adopted by Alexander et al. (1991). Key Migratory Bird Terrestrial Habitat Sites of the Canadian Wildlife Service are those that are believed to support at least 1% of a national population. We used three-year mean North American population estimates based on 1989 to 1991 surveys (United States Fish and Wildlife Service 1991, Sharp 1992) as the basis from which we made the 1% determination.

RESULTS

Survey Time

In 1989, a total of 53 hours with the Helio Courier was required to conduct the surveys. Of this time, about 26 hours were actual survey hours, while the remainder were required for positioning the aircraft and travel between study areas. In 1990, a total of 43 h of fixed-wing time and 25 h of rotor wing were required, 31 and 18 for actual survey for each type, respectively. Thirty-three h of rotor wing time were required in 1991, of which 27 were dedicated to survey transects. Linear distance of reconnaissance surveys varied between years and survey areas (Table 2).

Weather Conditions

Generally favourable weather conditions prevailed in 1989, with clear to high overcast skies and wind speeds of 0 to 28 kmph. In July 1990, partly cloudy skies and light winds occurred during Kent Peninsula surveys, but moderate to strong winds persisted in the Coppermine area during much of the work. Subsequent surveys in mid-August were conducted under moderate to strong winds in Albert Edward Bay, and light to moderate winds over Southern King William Island, Inglis River and Interior King William Island. In 1991, conditions were favourable with clear skies and light winds (< 10 kmph). Surveys were conducted at all times of the day.

Table 2. Linear distance (km) of reconnaissance (recon) and transect survey effort by location in the Central Arctic, NWT, 1989-1991.

	YEAR/SURVEY TYPE				
	1989	1990		1991	
Location	Recon	Recon	Transect	Recon	Transect
Coppermine	750	–	323	–	–
Kent Peninsula	475	–	376	–	440
Wellington Bay	360	–	–	–	130
Albert Edward Bay	380	–	–	–	307
Southeast Victoria Island	–	155	–	148	–
Tingmeak River	130	–	–	–	238
Southern King William Island	–	241	–	–	–
Interior King William Island	–	181	–	–	–
Inglis/Murchison	175	186	–	–	–

Species Accounts

White-fronted Geese

The White-fronted Goose was one of the most consistently represented species in the survey areas (Tables 3 and 4). Only two small areas, Coppermine zone A and Kent Peninsula zone 3, had insufficient observations to warrant an estimate. Numbers were greater in 1991 than in 1990 for Kent Peninsula zones 1 and 2. The Wellington Bay, Kent Peninsula and Tingmeak River areas were most important for White-fronted Geese, while the Wellington Bay and Coppermine areas were most important for broods. Results of reconnaissance surveys reflected high numbers of white-fronts and white-front broods in the Inglis area.

Table 3. Results of aerial reconnaissance surveys for White-fronted Geese in the Central Arctic, NWT, 1989-91.

Location		PARAMETER			
		Total No.	No. of Broods	Birds/km	Broods/km
Coppermine	'89	1214	26	1.62	0.03
Wellington Bay	'89	573	3	1.59	0.01
Kent Peninsula	'89	859	30	1.81	0.06
Southeast Victoria Island	'90	145	0	0.94	–
Albert Edward Bay	'89	532	107	1.40	0.28
	'90	225	1	1.52	0.01
Tingmeak River	'89	414	13	3.19	0.10
Interior King William Island	'90	20	0	0.11	–
Southern King William Island	'90	164	11	0.68	0.05
Inglis/Murchison	'89	3301	266	18.86	1.52
	'90	1293	10	6.95	0.05

Table 4. Results of quantitative aerial surveys for adult (Ad.) White-fronted Geese and White-fronted Goose broods (Brd.) in the Central Arctic, NWT, 1990-1991.

Location/Year		PARAMETER									
		Census Area (km^2)	Sampling Intensity (%)	Estimated Number of		Density ($/km^2$)		Variance		Coefficient of Variation	
				Ad.	Brd.	Ad.	Brd.	Ad.	Brd.	Ad.	Brd.
Coppermine - Zone A	'90	190	15.3	–	–	–	–	–	–	–	–
Zone B	'90	697	14.3	1519	181	2.18	0.26	218336	5837	0.31	0.42
Wellington Bay	'91	274	19.0	2139	74	7.81	0.27	191680	1281	0.20	0.49
Kent Peninsula - Zone 1	'90	839	16.3	2368	–	2.82	–	447405	–	0.28	–
Zone 1	'91	724	15.8	3493	158	4.83	0.22	881013	3502	0.27	0.37
Zone 2	'90	80	16.6	120	–	1.50	–	5569	–	0.62	–
Zone 2	'91	80	19.0	553	–	6.91	–	119938	–	0.63	–
Zone 3	'91	434	10.7	–	–	–	–	–	–	–	–
Albert Edward Bay	'91	1234	10.0	3648	161	2.96	0.13	324010	4565	0.16	0.42
Tingmeak River	'91	565	16.8	2451	–	4.34	–	369121	–	0.25	–

Canada Geese

Canada Geese were well represented in survey areas with only one area (Kent Peninsula zone 2, 1990) having insufficient observations to derive an estimate of numbers (Tables 5 and 6). The Tingmeak River area stood out in both types of surveys as having exceptional numbers of Canada Geese, while transect surveys also identified Coppermine zone A, and Kent Peninsula zones 1 and 2 as having large numbers of this species. Broods were most prominent in the Tingmeak River, Wellington Bay, and Coppermine areas. The Interior King William Island area rated low, as did Kent Peninsula zone 3.

Table 5. Results of aerial reconnaissance surveys for Canada Geese in the Central Arctic, NWT, 1989-91.

		PARAMETER			
Location/Year		**Total No.**	**No. of Broods**	**Birds/km**	**Broods/km**
Coppermine	'89	606	74	0.81	0.10
Wellington Bay	'89	479	58	1.33	0.16
Kent Peninsula	'89	674	52	1.42	0.11
Southeast Victoria Island	'90	220	8	1.42	0.05
Albert Edward Bay	'89	422	23	1.11	0.06
	'91	326	2	2.20	0.01
Tingmeak River	'89	2491	127	19.15	0.98
Interior King William Island	'90	50	2	0.28	0.01
Southern King William Island	'90	319	17	1.32	0.07
Inglis/Murchison	'89	146	15	0.83	0.09
	'90	119	0	0.64	–

Table 6. Results of quantitative aerial surveys for adult (Ad.) Canada Geese and Canada Goose broods (Brd.) in the Central Arctic, NWT, 1990-1991.

Location/Year		Census Area (km^2)	Sampling Intensity %	Estimated Number of		Density ($\#/km^2$)		Variance		Coefficient of Variation	
				Ad.	Brd.	Ad.	Brd.	Ad.	Brd.	Ad.	Brd.
Coppermine- Zone A	'90	190	15.3	1225	–	6.45	–	410563	–	0.52	–
Zone B	'90	697	14.3	941	251	1.35	0.36	93539	12443	0.33	0.44
Wellington Bay	'91	274	19.0	880	142	3.21	0.52	38939	3251	0.22	0.40
Kent Peninsula - Zone 1	'90	839	16.3	3054	196	3.64	0.23	467201	6782	0.22	0.42
Zone 1	'91	724	15.8	4500	89	6.22	0.12	1.61E6	2116	0.28	0.52
Zone 2	'90	–	–	–	–	–	–	–	–	–	–
Zone 2	'91	80	19.0	495	–	6.18	–	226319	–	0.96	–
Zone 3	'91	434	10.7	215	–	0.50	–	20362	–	0.66	–
Albert Edward Bay	'91	1234	10.0	3467	141	2.81	0.11	756392	1305	0.25	0.26
Tingmeak River	'91	565	16.8	9276	208	16.42	0.37	8.71E6	11532	0.32	0.52

Tundra Swans

The Tingmeak River, Inglis River, Kent Peninsula and Southern King William Island revealed the highest indices of Tundra Swans based upon the reconnaissance surveys alone (Table 7). In quantitative surveys, the Kent Peninsula, zone 1 had the highest number of swans (Table 8). Broods were most prevalent in Tingmeak River and Kent Peninsula zone 1. Overall, observations in the broad area represented by the 3 zones in the Kent Peninsula survey reflected extensive use by swans.

Table 7. Results of aerial reconnaissance surveys for Tundra Swans in the Central Arctic, NWT, 1989-1991.

		PARAMETER			
Location/Year		**Total No.**	**No. of Broods**	**Birds/km**	**Broods/km**
Coppermine	'89	121	11	0.16	0.01
Wellington Bay	'89	44	4	0.12	0.01
Kent Peninsula	'89	149	17	0.31	0.04
Southeast Victoria Island	'90	14	3	0.09	0.02
Albert Edward Bay	'89	50	6	0.13	0.02
	'91	0	0	–	–
Tingmeak River	'89	104	13	0.80	0.10
Interior King William Island	'90	21	0	0.08	–
Southern King William Island	'90	103	2	.30	0.01
Inglis/Murchison	'89	89	1	0.51	0.01
	'90	108	0	0.49	–

Table 8. Results of quantitative aerial surveys for adult (Ad.) Tundra Swans and Tundra Swan broods (Brd.) in the Central Arctic, NWT, 1990-1991.

Location/Year		Census Area (km^2)	Sampling Intensity %	Estimated Number of		Density (#/km^2)		Variance		Coefficient of Variation	
				Ad.	Brd.	Ad.	Brd.	Ad.	Brd.	Ad.	Brd.
Coppermine -											
Zone A	'90	–	–	–	–	–	–	–	–	–	–
Zone B	'90	697	14.3	174	35	0.25	0.05	2190	160	0.27	0.36
Wellington Bay	'91	274	19.0	306	–	1.12	–	19200	–	0.45	–
Kent Peninsula -											
Zone 1	'90	839	16.3	532	141	0.63	0.17	13526	1237	0.22	–
Zone 1	'91	724	15.8	1013	114	1.40	0.16	22740	539	0.15	0.25
Zone 2	'90	80	16.6	235	–	2.93	–	206	–	0.06	0.20
Zone 2	'91	80	19.0	337	–	4.21	–	8862	–	0.28	–
Zone 3	'91	434	10.7	122	–	0.28	–	5737	–	0.62	–
Albert Edward Bay	'91	1234	10.0	462	121	0.37	0.10	3406	1568	0.13	0.33
Tingmeak River	'91	565	16.8	635	101	1.12	0.18	45641	591	0.34	0.24

Lesser Snow Geese

Lesser Snow Geese were most abundant in the Southeast Victoria Island, Inglis/Murchison and Tingmeak River areas, and very rare or absent in the Coppermine and Wellington Bay areas (Tables 9 and 10). Small colonies were located in the Kent Peninsula zone 1 and Albert Edward Bay areas, with scattered numbers throughout Southeast Victoria Island. Broods were most abundant in the Tingmeak River and Inglis/Murchison areas (Table 9), with 73 in Kent Peninsula zone 1, 1990 (Table 10).

Table 9. Results of aerial reconnaissance surveys for Lesser Snow Geese in the Central Arctic, NWT, 1989-91.

Location/Year		Total No.	No. of Broods	Birds/km	Broods/km
Coppermine	'89	4	0	0.01	–
Wellington Bay	'89	0	0	–	–
Kent Peninsula	'89	0	0	–	–
Southeast Victoria Island	'90	1927	59	49.59	0.38
Albert Edward Bay	'89	314	37	0.83	0.10
	'91	657	11	4.44	0.07
Tingmeak River	'89	1984	472	15.26	3.63
Interior King William Island	'90	75	33	0.41	0.18
Southern King William Island	'90	874	15	3.63	0.06
Inglis/Murchison	'89	3501	383	20.01	2.19
	'90	1042	8	5.60	0.04

Table 10. Results of quantitative surveys for Lesser Snow Geese in the Central Arctic, NWT, 1990-1991.

Location/Year		Census Area (km^2)	Sampling Intensity %	Estimated Number of Ad.[a]	Density (#/km^2) Ad.	Variance Ad.	Coefficient of Variation Ad.
Coppermine - Zone A	'90	–	–	–	–	–	–
Zone B	'90	–	–	–	–	–	–
Wellington Bay	'91	–	–	–	–	–	–
Kent Peninsula - Zone 1	'90	839	16.3	245	0.29	16428	0.52
Zone 1	'91	724	15.8	810	1.12	186292	0.53
Zone 2	'90	–	–	–	–	–	–
Zone 2	'91	–	–	–	–	–	–
Zone 3	'91	–	–	–	–	–	–
Albert Edward Bay	'91	1234	10.0	241	0.20	28303	0.70
Tingmeak River	'91	565	16.8	2516	4.45	840125	0.36

[a] An estimate of 73 Lesser Snow Goose broods was determined for 1990, Kent Peninsula Zone 1, for a density of 0.09 broods/km^2; CV = 0.50. These broods appeared to originate from one colony.

DISCUSSION

Limitations of the Survey

In consideration of cost/efficiency of aircraft use, aerial surveys such as those reported here are necessarily restricted. Thus one brief view of the distribution and abundance of birds is all that was afforded, and since goose distribution and habitat use will vary according to spring phenology, reproductive chronology and other factors, our information is limited. A survey crossing nearly 25 degrees of longitude in the low to mid-arctic region also crosses waterfowl populations with different regional nesting and moulting chronologies. In particular our mid-August surveys in 1990 were considered to have occurred well beyond the ideal time for such surveys.

Of the various weather conditions we experienced, we felt wind was the more important factor because it appeared to affect the sightability of birds on lakes and ponds. Our impression was that, during windy days when water surfaces were rippled and moving, we were less likely to detect birds than on calm days. We were not able to assess this factor, but it may have contributed to fewer birds being sighted in 1990 when windy conditions were more frequently encountered. Similarly, we were not able to determine the effects of time of day on our survey results, but we suspect that due to 24 hour daylight, diurnal patterns of activity were less likely to influence the sightability of birds than they might in more southern zones with distinct dark and light periods of the day.

Summer surveys of white birds such as Tundra Swans and Lesser Snow Geese are much more reliable than those of dark geese such as White-fronted Geese and Canada Geese, or of Sandhill Cranes. Similarly, it is much easier to spot broods of white birds, yielding a more reliable estimate of number of broods. We noted that Tundra Swans and

Lesser Snow Geese had much higher proportions of breeding birds than did Canada Geese and White-fronted Geese, undoubtedly reflecting the relatively lower visibility rates of the latter two species. Finally, it is more likely that large groups of moulting birds typical of white geese will be observed than single broods or small groups typical of dark geese during the period of the surveys.

Evidence that dark geese are under-detected is accruing, but there are few data on correction factors. Dexter (1990) noted that stationary, clearly visible objects are under counted by aerial survey, even when there is little concealing vegetation and the aircraft flies low and slowly. At low densities ($\leq$ 0.34 pairs/km^2), Malecki et al. (1981) determined a correction factor of 1.4 was required between fixed wing and helicopter counts of Canada Geese, but they apparently assumed that all birds could be detected from the helicopter. Ground to air comparisons of nesting geese in western Alaska indicated that each single or pair counted from a fixed-wing aircraft represented 3.1 to 3.8 Canada Goose nests, or 4.2 White-fronted Goose nests (Butler et al. 1988). In an intensive study area overlapping with our survey areas, Bromley et al. (in prep.) noted that from 1989 through 1992 numbers of White-fronted Geese and Canada Geese they observed in helicopter surveys of nesting geese were low compared to what was known to be present based on ground studies conducted the same years. For singles and pairs during early incubation and over the 4 years, they calculated mean ground to air ratios of 1.92 $\pm$ 0.86 for Canada Geese, and 2.99 $\pm$ 1.47 for White-fronted Geese. Thus, it is probable that our aerial counts of dark geese yielded underestimates of actual numbers present.

It is likely that annual reproductive success also affected the results of our surveys. Bromley et al. (in prep.) found that population estimates of White-fronted Geese and Canada Geese on the Kent Peninsula based on aerial surveys during early incubation were highly and inversely correlated with nest success. They reported declining levels of nest success for both species from 1989 through 1991, from 75.4% for Canada Geese and 71.2% for White-fronted Geese in 1989 to 31.7 and 38.3% respectively in 1991. Here, we found that in every one of the 7 surveys involving all species reported where annual comparisons were possible in our transect surveys, estimates of numbers were consistently higher in 1991 (when nest success was lowest) than in 1990. Further confirmation of the wide applicability of this relationship is given in the large numbers of broods observed in 1989, compared to subsequent years. Thus we concluded that a similar phenomenon of higher detectability in years of lower reproductive success occurred on a regional basis, and likely affected our survey results. Therefore, we suspect that surveys conducted in 1991, the year of lowest productivity, gave the best estimates of species numbers possible during the 3-year period of work.

Comparison With Prior Work

Coppermine

We are aware of no earlier surveys for waterfowl in the Coppermine area; however, two surveys have been conducted nearby, both on southwestern Victoria Island. In surveys there in 1980, both McLaren and Alliston (1981) and Allen (1982) concluded that the Lady Franklin Point area had the highest densities of Canada Geese (1.9 to 8.1/km^2, and 3.8/km^2, respectively) and Tundra Swans (0.2 - 0.4/km^2, and 0.7/km^2, respectively). They observed few to no White-fronted Geese. During a brief ferrying flight through the Lady Franklin area enroute east in 1989, we noted many Tundra Swans, a few Canada Geese and 75 White-fronted Geese. In the Coppermine area just to the west, we observed total densities of 2.7 White-fronted Geese/km^2, 2.1 - 6.5 Canada Geese/km^2

and 0.4 Tundra Swans/km^2 in 1990. It is probable that both Canada and White-fronted geese have increased in this area since the early 1980s.

Wellington Bay and Albert Edward Bay

Early reconnaissance flights over southeastern Victoria Island occurred during the 1960s and 1970s. Barry (1960 and in Parmelee et al. 1967) subjectively estimated a population of 300 Tundra Swans for southeast Victoria Island. He observed 98 at Albert Edward Bay and 52 in Wellington Bay during surveys from 7-9 August, 1960 compared to our figures of 62 and 52, respectively; however, we estimated a total of 1010 Tundra Swans on our 2 relatively small census zones in 1991. Kuyt et al. (n.d.) counted 302 Tundra Swans in 1350 miles of survey in coastal southeast Victoria Island in 1971, equivalent to 0.14/linear km compared to our estimate of 0.13/km for Albert Edward Bay. Kuyt et al. (n.d.) were not able to survey the Albert Edward Bay itself due to inclement weather. Tundra Swans have certainly increased since the 1960s, but we have no evidence of changes in abundance from the 1970s in this area.

Barry (in Parmelee et al. 1967) observed White-fronted Geese west of Cambridge Bay in the Augustus Hills and Kitiga Lake and at Albert Edward Bay. He estimated there were about 1800 White-fronted Geese on southeast Victoria Island compared to our estimate of 6252 on two relatively small census areas of southeast Victoria Island 25 years later. Parmelee et al. (1967) noted small numbers of White-fronted Geese unevenly distributed throughout the area. Lok and Vink (1986) found that White-fronted Geese had increased since the work in the 1960s. In 1971, Kuyt et al. (n.d.) observed 0.10 birds/km of survey compared to our findings of 1.40 birds/km in Albert Edward Bay and 1.59/km in Wellington Bay. We concluded that White-fronted Geese had increased dramatically in this area from the 1960s and 1970s.

Barry (1960) subjectively estimated that there were 2000 Canada Geese on southeast Victoria Island, with concentrations at Wellington Bay (508) and Albert Edward Bay (52). In 1971 Kuyt et al. (n.d.) saw 1316 Canada Geese or 0.61/km, compared to our figures of 1.11/km for Albert Edward Bay and 1.33/km for Wellington Bay in 1989. Based on comparisons with the work of Parmelee et al. (1967), Lok and Vink (1986) concluded that Canada Geese had increased greatly in the Cambridge Bay area between the 1960s and 1970s. Our estimate of 4913 on two restricted areas surveyed in 1991 confirms this conclusion.

Barry (1960) estimated there were 1500 Lesser Snow Geese on southeast Victoria Island, with the greatest concentration on Albert Edward Bay (313), (Barry in Parmelee et al. 1967). Coincidentally, we observed 314 at Albert Edward Bay in 1989, 29 years later. Barry noted that they breed sparingly near the coast. Kuyt et al. (n.d.) found Lesser Snow Geese concentrated in the extreme southeast of Victoria Island. They observed 684 Lesser Snow Geese or 0.31/km, compared to our record of 0.83/km in Albert Edward Bay in 1989. We observed 388 Lesser Snow Geese in 1989, 2045 in 1990, and 657 in 1991 on southeastern Victoria Island, and estimated 241 in the Albert Edward Bay area. We concluded that Lesser Snow Geese have increased substantially on southeast Victoria Island. No observers have reported Lesser Snow Geese in the Wellington Bay area.

Kent Peninsula

In 1958, Barry (1958) flew over the Kent Peninsula from Walker Bay enroute to Cambridge Bay. He observed 40 Tundra Swans, 50 White-fronted Geese, 20 Canada Geese and 200+ Lesser Snow Geese. Kuyt et al. (n.d.) conducted a survey of 122 km over the Kent Peninsula in 1971 and observed 0.34 Tundra Swans/km, 0.8 White-fronted Geese/km, and 0.83 Canada Geese/km compared to our observations of 0.31, 1.81, and 0.81 respectively in 1989. Subsequently, we estimated there to be 2488 and 4362 White-fronted Geese in 1990 and 1991, respectively; similarly, we estimated 3446 and 5388 Canada Geese, respectively, and 1049 and 1700 Tundra Swans, respectively. We did not observe Lesser Snow Geese in 1989, but estimated 245 in 1990 and 956 in 1991.

These data indicate that White-fronted Geese have increased substantially on the Kent Peninsula since the 1970s.

Tingmeak River

Kuyt et al. (n.d.) mentioned Labyrinth Bay as having abundant waterfowl in 1971, but they do not provide numbers for that area specifically. We included the southeast portion of Labyrinth Bay in our Tingmeak River survey area. Throughout their survey of the Queen Maud Gulf Migratory Bird Sanctuary, Kuyt et al. (n.d.) saw 296 Tundra Swans, 845 White-fronted Geese, 2476 Canada Geese and 3051 Lesser Snow Geese, while in our very restricted survey of Tingmeak River we observed 104 Tundra Swans, 573 White-fronted Geese, 2491 Canada Geese and 1984 Lesser Snow Geese in 1989. Estimates of 2451 White-fronted Geese, 9692 Canada Geese, 837 Tundra Swans and 2516 Lesser Snow Geese were determined for Tingmeak River in 1991. We concluded that, since the 1960s and 1970s, all species surveyed had increased substantially in this extreme western portion of Queen Maud Gulf Migratory Bird Sanctuary.

Inglis/Murchison

Because the Polar Gas Project of the 1970s included a proposal for a pipeline through the Rasmussen Basin Lowlands, considerably more information is available for this survey area than for any other. Barry (1958) surveyed the Inglis/Murchison River Delta and Shepherd Bay in late summer and noted 21 Tundra Swans, 20 Canada Geese, 1 White-fronted Goose and 150 Lesser Snow Geese. Much more intensive surveys were initiated in 1975 (McLaren et al. 1976) and continued through 1977 (Zdan and Brackett 1978, Allen and Hogg 1979).

In a helicopter survey between 18 June and 11 July 1975, McLaren et al. (1976) counted 3140 White-fronted Geese, largely concentrated in the lowlands of the Rasmussen Basin. 92% of the 36 broods observed were on the streams and small rivers, as we observed in 1989. Similarly, almost all birds were on the lower rivers and delta of the Inglis/Murchison system. In early August, they counted 5.08 birds/km in this area, and estimated a population of 5000 to 10000 White-fronted Geese for the entire Rasmussen Basin Lowlands. In mid-July 1976, McLaren et al. (1977) counted 9.32/km on 427 km of survey. They estimated that 10000 White-fronted Geese summer in the area. Allen and Hogg (1979) estimated that 13000 White-fronted Geese were present on the Rasmussen Lowlands in early August 1977. They actually counted over 5600 White-fronted Geese and saw 122 broods. They observed densities of 60/km on the lower Inglis River and 23/km on the lower Murchison River. 27% of the White-fronted Geese were with broods. In comparison, we observed 18.86 White-fronted Geese/km on the lower Inglis and Murchison rivers and delta, and 266 broods in late July 1989. In mid-August 1990, we noted only 6.95 birds/km and 10 broods. White-fronted Geese have at least maintained, and probably increased their numbers since the 1970s.

McLaren et al. (1977), Allen and Hogg (1979) and this study all concluded that Canada Geese were relatively uncommon on the lowlands, particularly as breeding birds. The upper parts of the rivers appear to be used more extensively by moulting Canada Geese. In 427 km of survey, McLaren et al. (1977) saw 0.87/km, similar to our observation of 0.83/km and 0.64/km in 1989 and 1990 respectively. Allen and Hogg (1979) noted 4 broods of Canada Geese compared to the 15 broods we observed in 1989 and none in 1990.

In 1975, McLaren et al. (1976) documented 3 colonies of Lesser Snow Geese in the region; one of these consisted of 56 nests at the mouth of the Inglis River, where 100 moulters and 4 nests were seen in 1976 (McLaren et al. 1977). Allen and Hogg (1979) reported similar numbers of moulters but few nests in 1977, with only 4 broods observed during the early August survey that year. In mid-June 1989, O'Brien and Bromley (1989) observed two to three thousand Lesser Snow Geese nesting on islands at the mouth of the Inglis River. In July 1989, we noted 383 broods and 3501 adults in our survey area. We did not survey the two areas 60 km north and 60 km south where similar numbers of adults were reported during the 1970s. 1042 Lesser Snow Geese and 8 broods were observed in mid-August 1990. Lesser Snow Goose numbers on the Inglis/Murchison rivers delta have increased substantially since the 1970s.

During mid-summer surveys in 1976, McLaren et al. (1977) counted 300 Tundra Swans and estimated the population at 5500 birds throughout the Rasmussen Lowlands. In 142 km of survey on the Inglis and Murchison rivers in early July, they observed 0.48 Tundra Swans/km, compared to our figures of 0.51 and 0.49 in 1989 and 1990. Allen and Hogg (1979) counted 206 Tundra Swans and estimated a population of 2000 Tundra Swans for the area. They noted 27% of the swans had broods, considerably more than in 1989 (9%) and 1990 (0). Tundra Swan numbers appear to be unchanged since the 1970s in this area.

In summary, it is apparent that all species surveyed have increased in numbers from the 1960s to the early 1980s. While the increases are reflected in most areas examined, there are some areas where numbers of some species are unchanged, while other areas reflect remarkable increases.

Key Waterfowl Habitat Sites

Van Horne (1983) demonstrated that habitat quality does not always correlate well with animal densities, and thus he urged caution in the interpretation of survey results, particularly in the absence of multi-annual demographic studies of single species over the range of habitats being measured. Although we concur that habitat quality might best be reflected through the density, survival rates and reproductive potential of individuals in one habitat relative to another (Van Horne 1983:896), these parameters were beyond the scope of this work. Use of the 1% criterion employed by the Canadian Wildlife Service risks making errors in identification of key habitat, but in vast areas such as the NWT it is considered a valid starting point. Thus, while we have ordered survey areas according to the abundance of waterfowl as an indication of the importance of an area to specific species, we caution managers about the potential for error and the need to continue our assessment of areas identified as key habitats.

Two sites we surveyed are already included within key habitats identified in Alexander et al. (1991). Our surveys have confirmed that both the Inglis River and Tingmeak River areas host significant populations of White-fronted Geese, Canada Geese and Tundra Swans.

We reviewed all key habitat sites identified for geese and swans in Alexander et al. (1991) to determine the average size of sites within which the 1% of populations resided. Sites averaged 4555 km^2 (n = 32 of 80), well above the average area of sites we surveyed and report below (mean = 808 km^2, n=4).

Coppermine

The Coppermine area meets the 1% criterion for White-fronted Geese (Table 11), and thus is nominated as a Key Migratory Bird Terrestrial Habitat Site. The area also has significant numbers of Canada Geese. With reasonable expansion of the survey area, we believe that the criterion would also be met for Canada Geese. Fair numbers of Tundra Swans were also observed. The area overlaps to a minor degree with two wildlife areas of special interest to the NWT Department of Renewable Resources for musk-ox and raptors (Ferguson 1987).

Wellington Bay

The Wellington Bay area meets the criterion for White-fronted Geese (Table 11), and thus is nominated as a Key Migratory Bird Terrestrial Habitat Site. Despite its small size, the area hosted high densities of White-fronted Geese, Canada Geese and Tundra Swans. We suspect that Tundra Swan densities would extend into peripheral areas if surveys were expanded, but due to apparent changes in habitat, densities of geese would decline to the north and west of the survey area.

Table 11. Minimum population estimates for survey areas in the Central Arctic, NWT, 1989-1991, compared to 1% of National Populations.

	SPECIES			
Location/Year	White-Fronted Goose	Canada Goose	Tundra Swan	Sandhill Crane
Coppermine (Zones A&B)	1881	2668	244	--
Wellington Bay	2287	1164	306	21
Kent Peninsula	3809[a]	4678[a]	1241[a]	621[b]
Albert Edward Bay	3789	3749	704	--
1% of National Population	1373	3905	928	3915

[a] Estimates are for Zone 1 only.

[b] Estimate is for Zones 1-3 combined.

Kent Peninsula

Zone 1 of the Kent Peninsula area greatly surpassed the criterion for White-fronted Geese, Canada Geese and Tundra Swans (Table 11). Based on this information, high densities of birds found in Zone 2, and the survey data of Bromley et al. (in prep.) for an affiliated zone with very high densities, we nominate an area of the western Kent Peninsula (Figure 4) as a Key Migratory Bird Terrestrial Habitat Site.

Albert Edward Bay

The Albert Edward Bay area greatly surpassed the criterion for White-fronted Geese (Table 11), and we believe the criterion would be met for Canada Geese and Tundra Swans when visibility rates or a slight expansion of the area are considered. On this basis, we nominate the Albert Edward Bay area as a Key Migratory Bird Terrestrial Habitat Site.

Other Sites

Based on our reconnaissance surveys in 1989, and subsequent opportunistic surveys during ferrying among study areas, we recommend that southeast Victoria Island be investigated further and in a more quantitative manner, for its importance to Canada Geese, White-fronted Geese and Lesser Snow Geese. Similarly, southern King William Island is worthy of further work to determine its importance for Tundra Swans and Canada Geese populations. The strong association between the presence of geese and areas of post-glacial rebound indicate that this habitat characteristic is a fruitful one to employ in the early stages of work to identify key habitat sites of arctic waterfowl.

CONCLUSIONS

I. This project has identified the following new Key Migratory Bird Terrestrial Habitat Sites, in order of importance:

1) Kent Peninsula - the western half (Figure 4);
2) Albert Edward Bay - the area off the western extremity of the bay (Figure 6);
3) Coppermine area - 60 km to the north of the community (Figure 2); and
4) Wellington Bay - the area west of Cambridge Bay and south of Ferguson Lake (Figure 5).

II. These four locations are recommended to the Canadian Wildlife Service and to the Nunavut Wildlife Management Advisory Board for formal inclusion in the list of Key Migratory Bird Terrestrial Habitat Sites in Canada. Any development activities planned in or near these areas should consider the exceptional waterfowl resource inhabiting the sites.

III. The Central Arctic populations of White-fronted, Canada and Lesser Snow Geese, and Tundra Swans have increased substantially from the 1960s to the early 1980s.

IV. Extensive waterfowl surveys in areas suggested by local residents and researchers to be commonly used by birds can yield important new information on waterfowl distribution in the Central Arctic.

V. This report provides a basis for quantitative comparisons of future changes in waterfowl abundance within the Central Arctic.

VI. Survey work of this nature almost certainly underestimates numbers of dark geese. Further documentation of visibility correction factors with ground to air comparisons are needed to address this problem. The numbers reported herein are minimum numbers.

VII. Further surveys in the region should be conducted to investigate:

1) the importance of southeastern Victoria Island to waterfowl,
2) the importance of southern King William Island to waterfowl, and
3) other areas that have not yet been identified.

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APPENDIX I
Habitat Descriptions of Survey Areas

The following survey area descriptions have been summarized from the Northern Land Use Information Series topographic maps of 1978 and 1983 (Canada Department of the Environment 1978, 1983a, 1983b).

Coppermine

The Coppermine survey area (Figure 3) is a till-covered drumlin plain with vegetation ranging from generally closed shrubland in the south to desert-like to open shrubland in the northern portion. Close to the town of Coppermine is a large sheltered basin covered in lacustrine and marine sediments hosting lush vegetation atypical of the surrounding environs. Along the coast extensive sedge meadows and salt marshes are established. Lakes are numerous and shallow, silty towards the coast and clear inland. Numerous small rivers drain the survey area, with the Rae and Richardson rivers dominating the southern part. In the northern and northeastern parts, lakes are narrow, long and parallel, orientated in a northeast-southwest direction, and interspersed with dry, cracked sparsely vegetated tundra.

Kent Peninsula

The central part of the Kent Peninsula survey area (Figures 3 and 4) consists of a low lying plain with thick marine deposits and areas of almost barren active fluvial deposits. Plant cover is patchy to continuous sedge. Willow-lichen-sedge associations exist on low-lying wet sites, with sparse to continuous cover of lichens and mosses on upland sites. Lakes and ponds are much less numerous in the western part than in the central portion of the Peninsula. The land rises from the south coast inland, so that spring break-up is relatively delayed in the higher inland areas. Zone 1 encompasses this rise, offering a wide variety of habitats. This zone has numerous waterbodies, which range in size from quite small ponds (< 2 ha) to large lakes (> 100 ha). Zone 2 is very low-lying on the south coastal fringe, with a low density of ponds and large tracts of moderately vegetated tundra. On the northwest coast of the peninsula lies Zone 3, which is also low-lying but has few ponds and is very sparsely vegetated. Exposure to the prevailing northwest winds crossing Coronation Gulf causes the area to have retarded phenology and low productivity relative to other survey zones.

Wellington Bay

The Wellington Bay survey area (Figure 5) consists of low-lying coastal plains with marine deposits on the surface. Continuous to discontinuous cover of willow-sedge and mosses with mixed herbs exist throughout. The very large Ferguson and Kitiga lakes dominate the wetlands in the northern part of the area, but many small and shallow lakes, occurring in a patchy distribution, are present throughout.

Albert Edward Bay and Southeast Victoria Island

The Albert Edward Bay and Southeast Victoria Island survey areas (Figures 6 and 10) lie within the McClintock Plains Ecoregion. The rolling topography and calcareous moraine deposits are covered with sparse to continuous vegetation, usually lichen-heath but with rich sedge meadows in the wet lowland especially near the coast. Poorly drained lowlands with numerous wetlands are typical, and concentrated along small to tiny creeks and rivulets. Upland ponds and lakes are well defined with often abrupt shorelines, while those in the lowlands have poorly defined boundaries grading into wet sedge meadows draining slowly towards the sea.

Lower Inglis/Murchison Rivers

The Inglis River survey area (Figures 7 and 8) lies within the Murchison Lowlands Ecoregion. This is a large coastal plain of deep silty marine deposits with extensive and active fluvial deposits. The area is characterized by low relief, with a shallow seaward slope. Continuous cover of tussocky cotton grass and mosses occurs, with sedges and mosses on wet sites and sedges and trailing willow on drier sites. Ponds and lakes are shallow and numerous, well defined in the more upland areas away from the rivers, but typically less so close to the rivers. A complex riverine system is a dominant feature, providing an intricate travel network for waterfowl broods and moulting flocks to use when dispersing from breeding sites.

Tingmeak River

The Tingmeak River survey area (Figure 9) is within the western extremity of the Queen Maud Gulf Migratory Bird Sanctuary, and is a low-lying plain covered by marine silts. The coastline and numerous islands are rocky, except for the many channels in the delta of the Tingmeak River, where the murky water reflects the silty composition of the channel banks and river bottom. The open shrubland vegetation is considered lush. The Tingmeak River is the dominant feature progressing inland from the coast, and is accompanied by low, rolling, sparsely vegetated hills.

Southern King William Island and Interior King William Island

Royal Geographical Society Islands and the southwest portion of King William Island (Figure 11) are in the McClintock Plains Ecoregion which provides important waterfowl nesting and moulting habitat. Interior King William Island is in the Adelaide Plains Ecoregion, which includes prime nesting and moulting habitat for waterfowl. Wetlands are well defined basins which occur in moderate density and interspersed with rolling tundra, typically vegetated with lichen-heath. Very occasionally, low-lying ponds have a rich sedge-meadow perimeter.

APPENDIX II

Results of quantitative surveys for adult Lesser Sandhill Cranes in the Central Arctic, NWT, 1990-1991.

Location/Year		Census Area (km^2)	Sampling Intensity %	Estimated Number	Density ($\#/km^2$)	Variance	Coefficient of Variation
Coppermine - Zone A	'90	--	--	--	--	--	--
Zone B	'90	--	--	--	--	--	--
Wellington Bay	'91	274	19.0	21	0.08	151	0.58
Kent Peninsula - Zone 1	'90	839	16.3	282	0.34	4162	0.23
Zone 1	'91	724	15.8	310	0.43	4142	0.21
Zone 2	'90	--	--	--	--	--	--
Zone 2	'91	80	19.0	58	0.72	1403	0.65
Zone 3	'91	434	10.7	253	0.58	7982	0.35
Albert Edward Bay	'91	--	10.0	--	--	--	--
Tingmeak River	'91	565	16.8	208	0.37	2074	0.22