SPRING MIGRATION OF WATERFOWL IN THE YELLOWKNIFE - THOR LAKE AREA NORTHWEST TERRITORIES:1987

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ABSTRACT

A survey of migrating waterfowl was conducted from 10 - 28 May 1987, in the area of the Thor Lake Mine development. Thirteen staging sites in the intervening area between the mine site and Yellowknife were also surveyed. Objectives of the study were: 1) to document the waterfowl species which occur in the area, 2) to determine the distribution (spatial and temporal) and abundance of waterfowl species in the area and 3) to evaluate the Thor Lake Mine site in a regional context, with regard to migrating waterfowl. A similar survey was completed in 1986.

Nearly 32,500 sightings were recorded and a total of 29 species, including 24 waterfowl species, was observed. Most birds were concentrated at sites with open water. Open-water sites occurred in shallow sheltered bays and along creek and river systems. The greatest concentration and variety of waterfowl were observed along the Beaulieu River. The waterfowl migration in the Yellowknife - Thor Lake area peaked between 14-20 May. A peak of 6,500 birds was recorded on 16 May.

On the Thor Lake study site, about 1,650 sightings were recorded and a total of 18 species, including 16 waterfowl species, was observed. As in 1986, the Thor Lake site ranked ninth among the 14 sites in its importance as migratory bird habitat. This survey did not reveal any significant migratory bird populations near the mine site; thus, the mine development should not result in any significant negative impacts to migratory birds. A final survey is recommended for 1988.

RÉSUMÉ

Des inventaires aériens d'oiseaux aquatiques furent menés entre le 10 et le 28 mai 1987 dans la région du lac Thor, où un projet de développement minier est à l'étude. Ces inventaires nous ont permis de survoler 14 sites d'arrêt migratoire entre Yellowknife et le site de la future mine. Nous avions pour objectifs: 1) d'identifier les oiseaux aquatiques de la région, 2) de déterminer leurs distributions spatiale et temporelle, et 3) d'évaluer l'importance régionale du site de la mine en ce qui regarde la migration de la sauvagine. Une série d'inventaires identiques fut réalisée en 1986.

Environ 32 500 observations et 29 espèces , dont 24 de sauvagine, furent dénombrées. Les oiseaux étaient concentrés dans le fond des baies peu profondes et le long des cours d'eau, là où la glace avait déjà fondu. C'est sur la rivière Beaulieu que la plus grande concentration et diversité d'oiseaux furent observées. La migration a atteint son point culminant entre le 14 et 20 mai. Jusqu'à 6 500 oiseaux furent observés le 16 mai.

Un total de 1 650 observations et 18 espèces , dont 16 de sauvagine, furent dénombrées dans les environs du lac Thor. Tout comme en 1986, ce site s'est classé neuvième en importance parmi les 14 sites inventoriés quant à sa fréquentation par les oiseaux migrateurs. Tout projet minier dans cette région ne devrait pas avoir d'impact significatif sur les populations d'oiseaux migrateurs. Il est toutefois suggéré qu'une dernière série d'inventaires soit réalisée en 1988.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

1.1 Thor Lake Mine Development

The Thor Lake area (62° 06' N, 112° 35' W; Fig. 1) was first staked in 1970 and restaked in 1976 by Highwood Resources of Calgary. Exploratory drilling, conducted from 1977 to 1981, identified deposits in the order of 70 million tonnes. Those deposits contain niobium, tantalum, zirconium, and other rare-earth elements. Subsequent sampling, in 1983 and 1984, confirmed the existence of beryllium deposits in excess of 1.6 million tonnes.

Sampling and metallurgical testing are continuing and a mine feasibility study is in preparation. The company plans to initially mine 900 tonnes per day, yielding approximately 225 tonnes of ore concentrate. The dried ore concentrate will be shipped from the mine site via winter road or boat.

Present site developments associated with the Thor Lake Beryllium Project include accommodation for personnel and a short winter road which terminates at Hearne Channel (Fig. 2). Further developments will be subject to the results of the feasibility study and marketing surveys.

1.2 Potential Environmental Impacts

Mining activities may result in two main types of impact on migratory birds: the degradation of their habitats, and disturbance. After extraction, ore is refined and concentrated. Although the concentrator is usually confined to the mill plant,

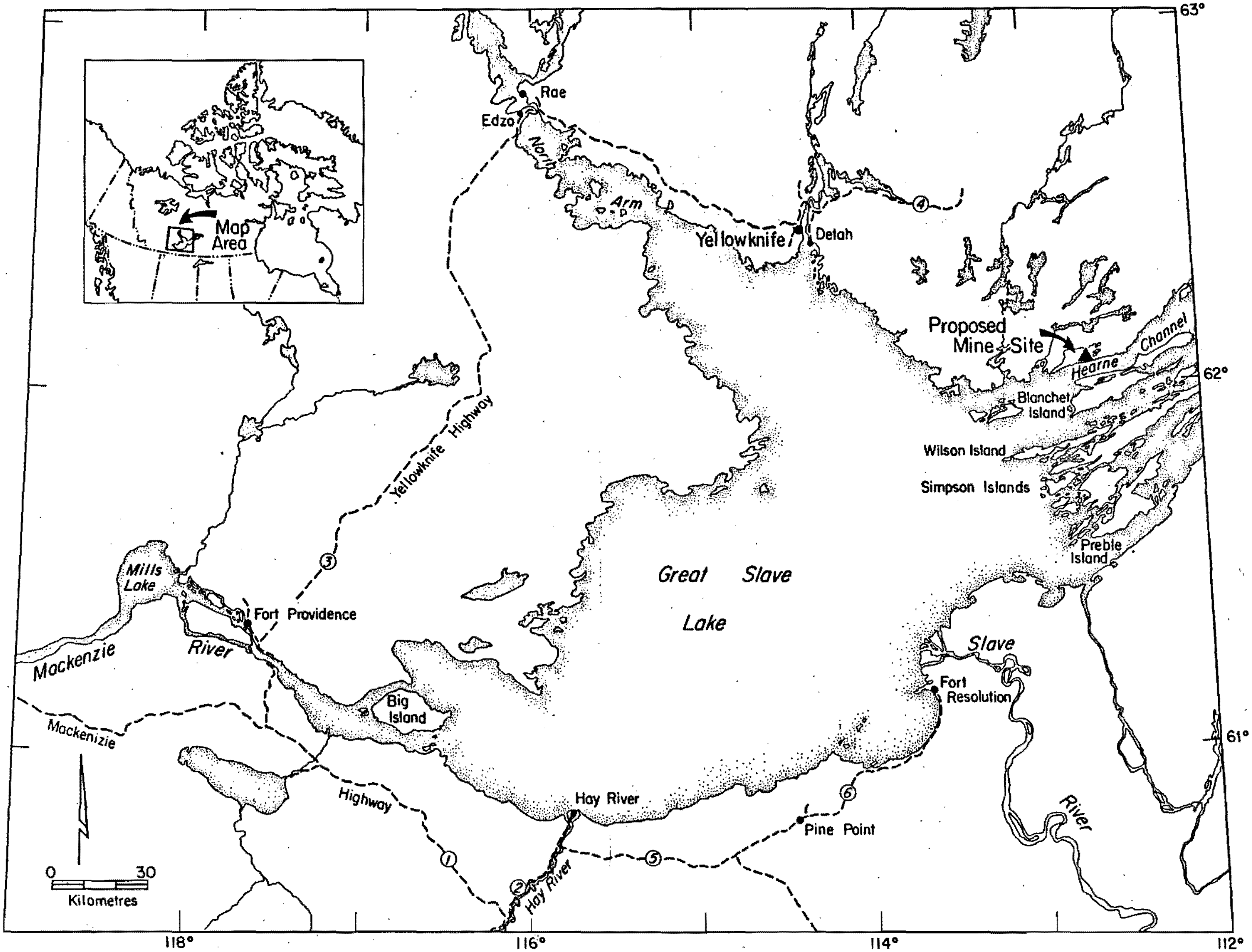

Figure 1. Location of the proposed Thor Lake Mine site within Northwest Territories.

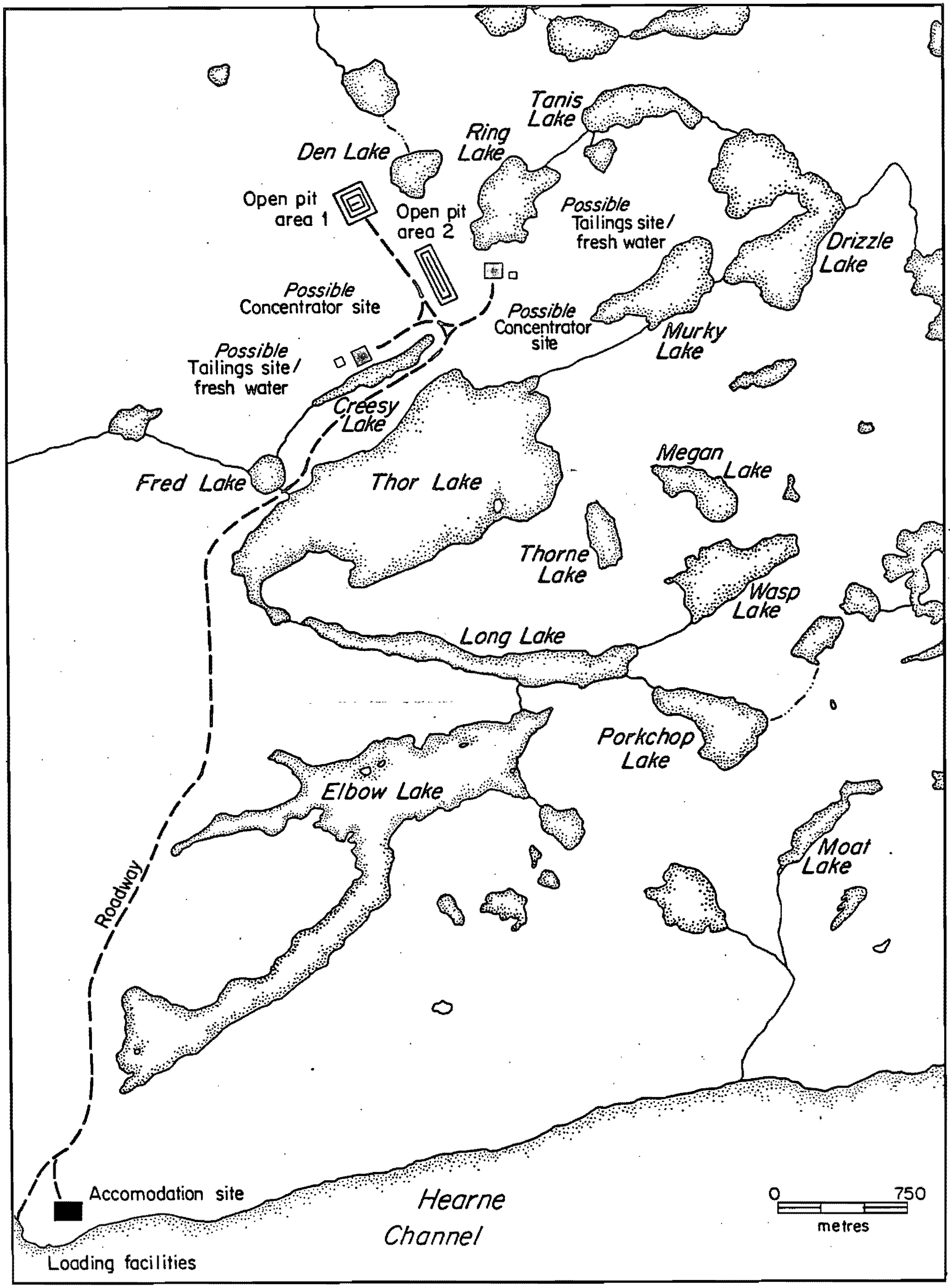

Figure 2. Present and proposed developments at Thor Lake Mine site.

the concentration process often involves leaching with highly concentrated acids or alkalis which are discarded into a tailings pond. The uncontrolled release of toxic tailings into adjacent water systems could result in significant negative impacts to waterbirds and their habitats by disrupting food chains, eliminating protective plant cover, or ultimately killing the birds.

Construction activities, aircraft traffic, and human activity may result in disturbance to wildlife. The impact of disturbance is a function of the species involved, the number of individuals present, the phase of their annual cycle, and the availability of comparable habitat nearby. Species which congregate in a particular area or in specific habitats are most vulnerable to site-specific impacts. Such species include migrating waterfowl, colonial breeding birds, such as gulls, and breeding raptors.

In this region, the protection of waterbird spring staging habitat is of particular concern. Open-water sites are restricted to relatively few locations during spring break-up. On the other hand, nesting, moulting and fall staging habitats are widely available when the ice is absent.

1.3 Study Objectives

This study was undertaken in light of the above-mentioned potential impacts. Ideally, an evaluation of the avifauna on the study site would include both aerial surveys and ground studies for three to five seasons prior to project initiation. Although a previous study at nearby Bullmoose Lake (Arner and Verreault

1985) provides some insight into the breeding birds of the area, additional work on staging species will provide a better perspective on the importance of this site to migratory waterbirds. A third and final series of surveys is planned for Spring 1988.

Aerial surveys were undertaken to:

1) document the waterfowl species which occur in the area:

2) determine the temporal and spatial distribution and abundance of waterfowl species in the area;

3) evaluate the importance of the study site, in a regional context, to migrating waterfowl.

2.0 STUDY AREA

Thor Lake (62°06' N, 112°35' W) is situated approximately 105 km southeast of Yellowknife, and is adjacent to Hearne Channel, Great Slave Lake (Fig. 1). The study area includes most sites of open water between Yellowknife and the Thor Lake site (Fig. 3). The study site includes Thor Lake, Elbow Lake, and all other waterbodies within approximately five km of the proposed mine location (Fig. 2).

2.1 Climate

Although there are no climatic data from the Thor Lake site, certain inferences can be drawn from Yellowknife records. This area experiences a subarctic continental climate with short, warm summers and prolonged periods of daylight. Winters are long and cold, and characterized by short days. The mean daily temperature

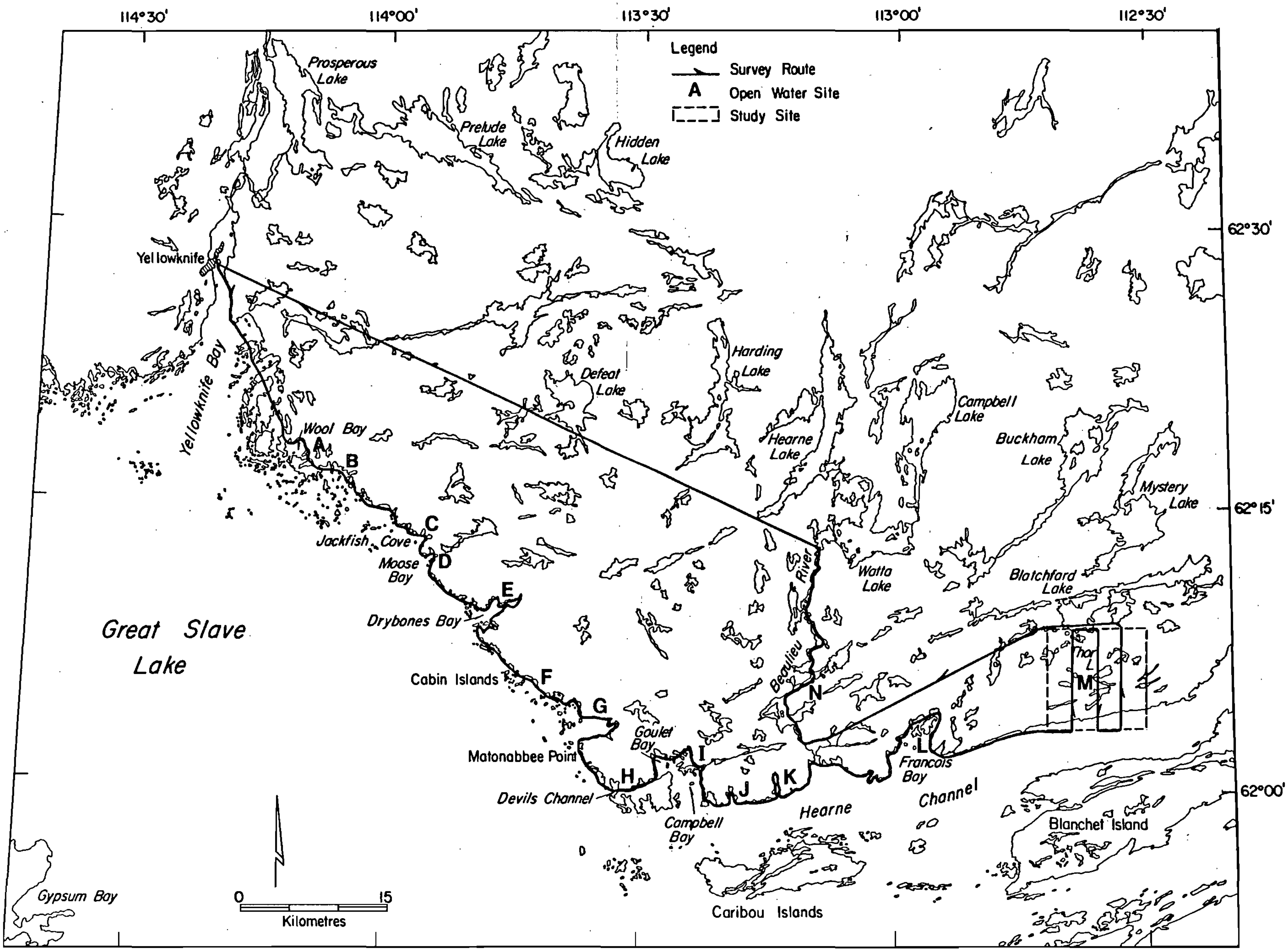

Figure 3. Location of open-water sites in the Yellowknife-Thor Lake area, Spring 1987.

in January is -29^{o} C and in July is 16^{o} C (Atmos. Env. Serv. 1982). Mean daily temperatures during spring break-up are summarized in Figure 4. Precipitation is low (from 175 mm to 200 mm annually) and the region experiences 70-100 frost-free days per year (Wiken 1986).

Freeze-up begins on the smaller ponds by mid-October and continues on the larger lakes and rivers into November. Small waterbodies are usually open by mid-May and larger lakes are open by early June. The progression of ice melt in the Hearne Channel -Thor Lake area during 1987 (Table 1), suggests that temperatures are colder in the vicinity of the mine site than at Yellowknife.

2.2 Physiography

The study area lies within the Bear-Slave Uplands physiographic region of the Precambrian Shield. Numerous lakes, marshes, bogs, and watercourses fill the hollows, and rounded rocky hills of less than 100 metres in height characterize the region (Bostock 1970).

The study site is characteristically flat and rises abruptly (approximately 60 to 65 metres) from the nearby Hearne Channel. It is dominated by numerous lakes and ponds which appear to be stagnant. Although no permanent drainage system is obvious, intermittent streams do connect a number of the waterbodies. Exposed Precambrian outcrops comprise at least 10% of the site.

2.3 Vegetation

The site is dominated by open boreal forest often referred to as

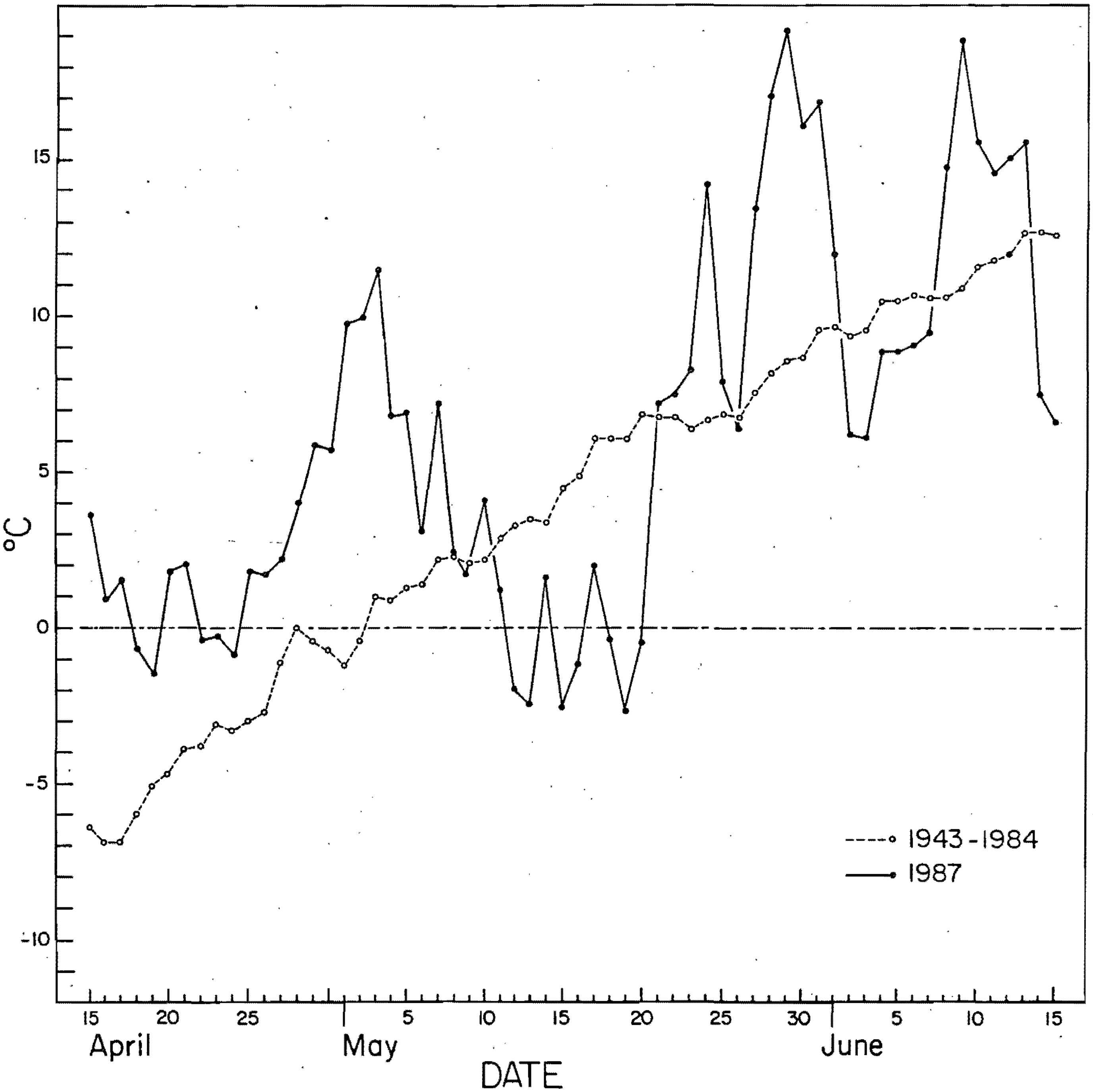

Figure 4. Mean daily temperatures during spring break-up at Yellowknife, 1987.

Table 1. Ice conditions in the Yellowknife - Thor Lake area, Spring 1987.

Date	Yellowknife Bay to Campbell Bay	Hearne Channel - Thor Lake area	Comments
10 May	Shallows around islands are open; landfast ice in many areas; shoreleads 1-5 m wide in most areas; shoreleads up to 50 m in shallow protected bays of GSL*.	Landfast ice in Channel; some water in inner bays and inter-island shallows; all small ponds and lakes open near Thor L.; snow cover melted; rotten ice and 1 to 5-m shoreleads in bigger lakes.	Beaulieu River and Devil's Channel are open but much ice remains in Hearne Channel.
13 May	Ice conditions similar to those on 10 May; thin ice on open water due to cold temperatures.	Same as on 10 May; thin ice on open water in some locations.	Cold temparatures have prevented further melt.
16 May	Shoreleads 5-10 m wide in some areas, less in most cases; much landfast ice left; some inner bays are entirely open, e.g.: Jackfish Cove.	Thor L. shoreleads are 5 m wide; landfast ice in Hearne Channel.	No important change since last survey
19 May	Shoreleads 20-30 m wide in most areas, 50-100 m in others; landfast ice in many locations; many inner bays are entirely open.	Landfast ice in channel; 20 to 50-m shoreleads in bigger lakes.	Mouths of all bays remain obstructed by ice.
22 May	Shoreleads 100-300 m wide in some locations; inter-island waters all open at Cabin Islands; major lead open in the center of GSL.	Some patches of water along Hearne Channel shoreline; 100-m shorelead at Thor Lake and rafts of ice are moving about.	Significant and obvious changes in ice cover in the last three days.
25 May	Shoreleads 500 m wide in some locations; rafts of dislocated ice moving according to wind direction; much open water in the center of GSL.	1-m shorelead and candled ice in Hearne C.; no ice left in Thor Lake area.	Wide areas of open water are now more difficult to survey, birds are dispersed over vast stretches of water.
28 May	Dislocated ice rafts moving about; shoreleads up to 2 km wide in some locations; open water in GSL as far as the eye can see.	Shorelead up to 5 m wide in Hearne C.; up to 2 m of water in some pressure ridges.	Open waters now more abundant than ice.

* GSL - Great Slave Lake

subarctic open lichen-woodland or northwestern transition zone (Rowe 1972). It is located within the Taiga Shield terrestrial ecozone (Wiken 1986). The tree line lies less than 200 km to the northeast. Soils (Brunisols and Cryosols) are generally very thin or non-existent and discontinuous permafrost underlies the area. The stunted coniferous and deciduous stands are relatively unproductive. Major plant communities include jackpine uplands, birch-aspen slopes, spruce bogs, shrubby stream valleys, shorelines of shrubs and emergents, and submerged aquatics. These communities are respectively characterized by Jack Pine (_Pinus banksiana_), White Birch (_Betula papyrifera_), Black Spruce (_Picea mariana_), Green Alder (_Alnus crispa_), Sweet Gale (_Myrica gale_), River Horsetail (_Equisetum fluviatile_), and Yellow Pond-lily (_Nuphar variegatum_).

3.0 METHODS

Seven aerial surveys of the Thor Lake site and other staging locales in the study area (Fig. 3) were conducted at three-day intervals between 10-28 May 1987. The surveys were terminated when the number of birds had declined significantly and the open-water transects were too wide for satisfactory surveying. No attempt was made to define a transect width, and at each site, all observed birds were recorded irrespective of their distance from the flight path. All surveys were conducted in a PA-18 Piper Supercub. The surveys were flown at approximately 125 km/h and 25 to 30 metres above ground level. Flight speed and height were reduced, as necessary, to examine certain staging sites. I recorded all the sightings on a tape recorder and subsequently transferred them onto appropriate forms.

The flight path was maintained parallel to and within 100 metres of the Great Slave Lake shoreline at all sites except Wool Bay and Thor Lake. At Wool Bay, a short creek perpendicular to the shoreline was also surveyed, and at Thor Lake, a 36-km survey line encompassing the entire study site was flown (Fig. 3). Only usable habitat or open water was surveyed at all sites except Thor Lake, where the flight path covered both land and waterbodies. The length of the surveyed open-water sites varied from three km at Wool Bay to 24 km at Beaulieu River. The width of these areas increased throughout the study period as the ice receded.

The relative importance of the various sites was determined by calculating the percent of the total observations of a particular species recorded at a particular site. The percentage values for each of the ten most common species were then summed to yield an "Index of Importance".

4.0 RESULTS

4.1 Abundance of Migrating Species

The abundance of species observed at each site is summarized in Appendices 2-15. Approximately 32,500 records yielded 29 bird species, including 24 waterfowl species. A maximum of 6,514 birds was seen in one of the seven surveys. As Greater and Lesser Scaup were impossible to distinguish during the survey, they were lumped as "Scaup spp". Ring-necked Ducks may also have been identified as Scaup if they occurred in the same flocks. Overall, 23.3% of the total observations were of Tundra Swans, followed by Scaup spp. (19.4%), American Wigeon (15.3%), Canada Goose (10.3%), Northern Pintail (9.8%), Mallard (3.9%), Red-breasted Merganser (2.0%), Canvasback (1.2%), and Greater White-fronted Goose (1.2%). Bird silhouettes and behaviour suggest that most of the unidentified ducks (8.4% of all records) were dabblers such as Mallard, Northern Pintail, and American Wigeon. The relative abundance of each species and their individual peak number seen during one survey in 1987 and 1986 are presented in Table 2.

Approximately 1,650 records were collected on the Thor Lake study site. Eighteen species, including 16 waterfowl species, were sighted. A maximum of 431 birds was seen during one of the seven surveys. Scaup spp. accounted for most of the observations (75.4%), followed by Bufflehead (3.3%), Surf Scoter (3.1%), American Wigeon (2.6%), Mallard (1.8%), Common Loon (1.5%), Pacific Loon (1.1%), and Red-breasted Merganser (1.0%). Unidentified ducks accounted for 7.3% of the total observations. The relative abundance and peak numbers of each species observed on the Thor Lake site in 1987 and 1986 are also depicted in Table 2.

4.2 Spatial Distribution of Migrating Species

A total of 14 sites, including the Thor Lake study site, were surveyed. The relative importance of each site, in terms of abundance of birds, is depicted in Figure 5. The Thor Lake study site ranked ninth, as determined by an importance index based on

Table 2. Relative abundance and peak numbers* of each species observed at all sites and at the Thor Lake study site during the spring migrations of 1987 and 1986.

Species	Total Records At All Sites 1987	%	1986	%	Peak Numbers 1987	1986	Total Records Thor Lake Area 1987	%	1986	%	Peak Numbers 1987	1986
Red-throated Loon	2	0.006	11	0.06	2	11	0	0	2	0.3	0	2
Pacific Loon	18	0.05	14	0.08	11	10	19	1.1	4	0.7	11	4
Common Loon	43	0.1	42	0.2	14	15	25	1.5	6	1.0	8	3
Horned Grebe	34	0.1	14	0.08	28	8	2	0.1	0	0	2	0
Red-necked Grebe	106	0.3	135	0.8	29	40	8	0.5	7	1.2	2	3
Tundra Swan	7562	23.3	2313	13.8	1382	584	5	0.3	0	0	3	0
G.W.-front. Goose	378	1.7	156	0.9	240	140	0	0	70	11.9	0	70
Lesser Snow Goose	282	0.8	10	0.05	123	10	0	0	10	1.7	0	10
Canada Goose	3362	10.3	802	4.8	1071	657	0	0	0	0	0	0
Unidentified Duck	2749	8.4	5388	32.1	737	3494	121	7.3	64	10.8	44	36
Green-winged Teal	40	0.1	20	0.1	18	15	0	0	0	0	0	0
Mallard	1289	4.0	629	3.7	322	309	31	1.9	2	0.3	11	2
Northern Pintail	3203	9.8	413	2.5	782	346	2	0.1	0	0	2	0
Blue-winged Teal	0	0	29	0.1	0	27	0	0	0	0	0	0
Northern Shoveler	56	0.1	66	0.4	23	34	1	0.06	0	0	1	0
American Wigeon	4982	15.3	664	4.0	1402	258	44	2.7	6	1.0	10	3
Canvasback	382	1.2	71	0.4	98	40	6	0.3	0	0	6	0
Ring-necked Duck	16	0.04	77	0.4	10	70	6	0.3	0	0	6	0
Unidentified Scaup	6320	19.4	4164	24.8	1458	1040	1243	75.4	279	47.4	368	106
Oldsquaw	7	0.02	31	0.1	5	20	5	0.3	31	5.2	3	20
Black Scoter	0	0	10	0.05	0	10	0	0	0	0	0	0
Surf Scoter	355	1.1	647	3.8	122	335	52	3.1	48	8.1	31	20
White-winged Scoter	43	0.1	221	1.3	25	169	4	0.2	40	6.8	4	40
Common Goldeneye	37	0.1	18	0.1	17	16	0	0	0	0	0	0

Table 2. Continued

Species	Total Observations At All Sites 1987	%	1986	%	Peak Numbers 1987	1986	Total Observations Thor Lake Area 1987	%	1986	%	Peak Numbers 1987	1986
Bufflehead	315	0.9	327	1.9	82	159	55	3.3	9	1.5	22	8
Common Merganser	186	0.6	72	0.4	77	38	0	0	0	0	0	0
R.-breast. Merganser	670	2.0	133	0.8	186	38	16	0.9	2	0.3	8	2
Ruddy Duck	5	0.01	0	0	4	0	0	0	0	0	0	0
Osprey	1	0.003	0	0	1	0	0	0	0	0	0	0
Bald Eagle	32	0.09	36	0.2	8	16	2	0.1	1	0.1	1	1
Northern Harrier	7	0.002	2	0.01	2	1	0	0	0	0	0	0
Red-tailed Hawk	0	0	1	0.005	0	1	0	0	0	0	0	0
Rough-legged Hawk	2	0.006	0	0	1	0	1	0.06	0	0	1	0
Golden Eagle	0	0	1	0.005	0	1	0	0	0	0	0	0
Sandhill Crane	1	0.003	8	0.04	1	4	0	0	2	0.3	0	2
Caspian Tern	0	0	1	0.005	0	1	0	0	0	0	0	0
total	32485	100.0	16766	100.0			1648	100.0	589	100.0		

* Peak number of each species seen in one flight; peaks occurred at different dates.

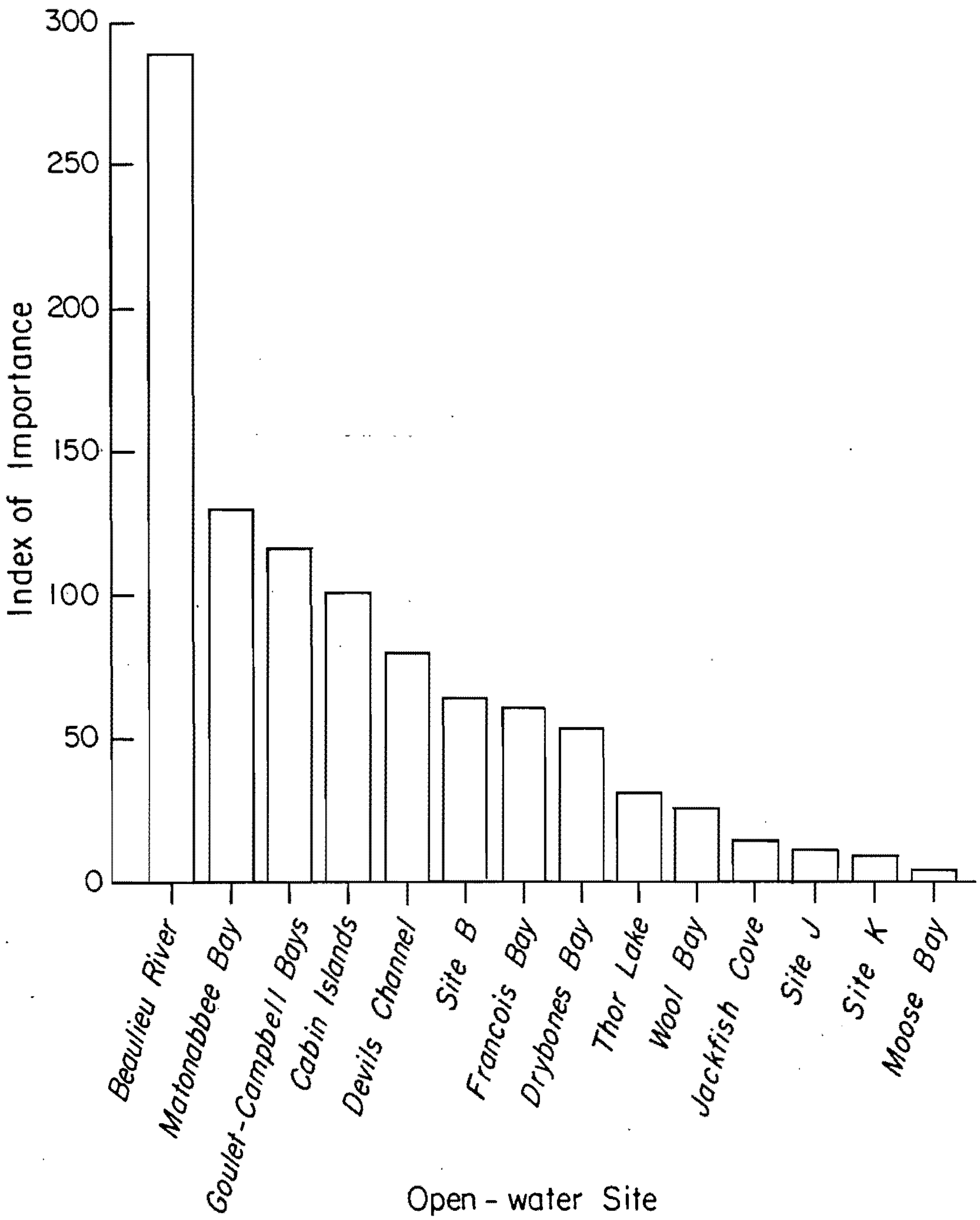

Figure 5. Relative importance of each open-water site to migrating waterfowl, Spring 1987.

the occurrence of the ten most common species (Table 3).

Birds were not necessarily most abundant where open water was most extensive. Although the highest numbers were recorded on the longest stretch of open water (Beaulieu River: 24 km), the second highest numbers were sighted at Matonabbee Bay where only eight km of open water were surveyed. Drybones Bay ranked eighth in importance but had up to 12.5 km of ice-free shoreleads.

The number of observed species varied from eight to twenty-one per site. The diversity of species was not directly correlated to the abundance of birds (Appendix 16). Eighteen species were observed on the Thor Lake study site, ranked ninth in importance, whereas 15 species were observed at Matonabbee Bay which ranked second in importance.

4.3 Temporal Distribution of Migrating Species

The temporal abundance of all species at the 14 sites is depicted in Table 4 and Figure 6. A relatively high number of birds was seen on the first survey (10 May). A peak of migratory activity was recorded on 16 and 19 May. Approximately 13,000 or 40% of all records were made on those two surveys. The number of birds declined sharply after 19 May. The migration peaks for each species (Table 4) indicate that Mallard, Northern Pintail, American Wigeon, Canvasback, and Bufflehead are early migrants in the area. They are soon followed by Tundra Swan, Scaup spp., Canada Goose and Red-breasted Merganser. Late migrants include Pacific Loon, Northern Shoveler, Surf Scoter and Oldsquaw.

Table 3. Percent abundance of the ten most common species at each open water site, Spring 1987.

Site	TS	SC	AW	CG	NP	DU	MA	RM	CA	GG	Imp. Index
Wool Bay	.05	12.16	.84		2.72	3.64	3.56		2.88		25.85
Site B	4.53	6.39	6.70	2.76	4.00	3.60	4.80	25.08		6.61	64.47
Jackfish Cove	1.41	.49	2.87		6.74		2.09	.90			14.50
Moose Bay	.15	1.42	.74		.19		1.70	.60			4.80
Drybones Bay	2.04	5.75	14.73	.08	11.99	2.62	6.90	4.50	5.24		53.85
Cabin Islands	14.16	2.78	11.66	12.81	17.64	5.46	9.07	12.01	3.14	13.23	101.96
Matonabbee Bay	10.22	1.36	13.34	23.52	12.83	4.73	2.32	5.26	1.05	55.56	130.19
Devil's Channel	13.42	6.08	6.82	12.10	2.97	5.60	8.68	3.45	18.85		77.97
Goulet-Campbell bays	18.77	11.49	10.97	17.45	11.99	18.30	6.36	6.61	3.40	13.23	118.57
Site J	2.68	1.46	1.08		.97	.40	3.10	1.65			11.34
Site K	.40	1.87	2.30	1.01	1.06	.07	2.79	.30			9.80
Francois Bay	7.48	12.91	8.43	7.79	2.81	14.08	3.72	3.00			60.27
Thor Lake	.06	19.67	.88		.06	4.40	2.40	2.40	1.57		31.44
Beaulieu River	24.55	16.16	18.58	22.42	24.04	37.14	42.43	34.23	63.87	5.29	288.71
Total number of records	7562	6320	4982	3362	3203	2749	1289	670	382	378	

TS - Tundra Swan; SC - Unidentified Scaup; AW - American Wigeon; CG - Canada Goose; NP - Northern Pintail; DU - Unidentified Duck; MA - Mallard; RM - Red-breasted Merganser; CA - Canvasback; GG - Greater White-fronted Goose.

Table 4. Temporal abundance of migrating species in the Yellowknife-Thor Lake Area. Spring 1987.

	May						
Species	10	13	16	19	22	25	28
Red-throated Loon				2			
Pacific Loon				4		11	4
Common Loon		1	3	10	11	4	14
Horned Grebe		3		28		3	
Red-necked Grebe	2	1	15	15	19	29	25
Tundra Swan	917	1088	1382	1347	1353	1152	323
G.W.-fronted Goose	3	10	240	50	20	55	
Lesser Snow Goose			10	123	117	32	
Canada Goose	335	357	528	1071	831	193	47
Unidentified Duck	737	434	520	514	250	199	95
Green-winged Teal	2	9	6			5	18
Mallard	273	322	213	130	95	105	151
Northern Pintail	256	683	782	514	564	168	236
Northern Shoveler			1	16	7	23	9
American Wigeon	1402	529	1316	908	305	327	195
Canvasback	143	67	98	16	26	17	15
Ring-necked Duck	10	6					
Unidentified Scaup	481	1091	1159	1458	904	746	481
Oldsquaw					2	5	
Surf Scoter			4	54	102	122	73
White-winged Scoter				25		17	1
Common Goldeneye	12	4			2	17	2
Bufflehead	82	66	29	20	44	48	26
Common Merganser	77	53	18	20	5	3	10

Table 4. Continued.

	May						
Species	10	13	16	19	22	25	28
R.-breasted Merganser	31	84	186	123	72	79	95
Ruddy Duck				1			4
Osprey					1		
Bald Eagle	8	5	3	3	4	1	8
Northern Harrier			1	2	2	2	
Rough-legged Hawk				1		1	
Sandhill Crane		1					

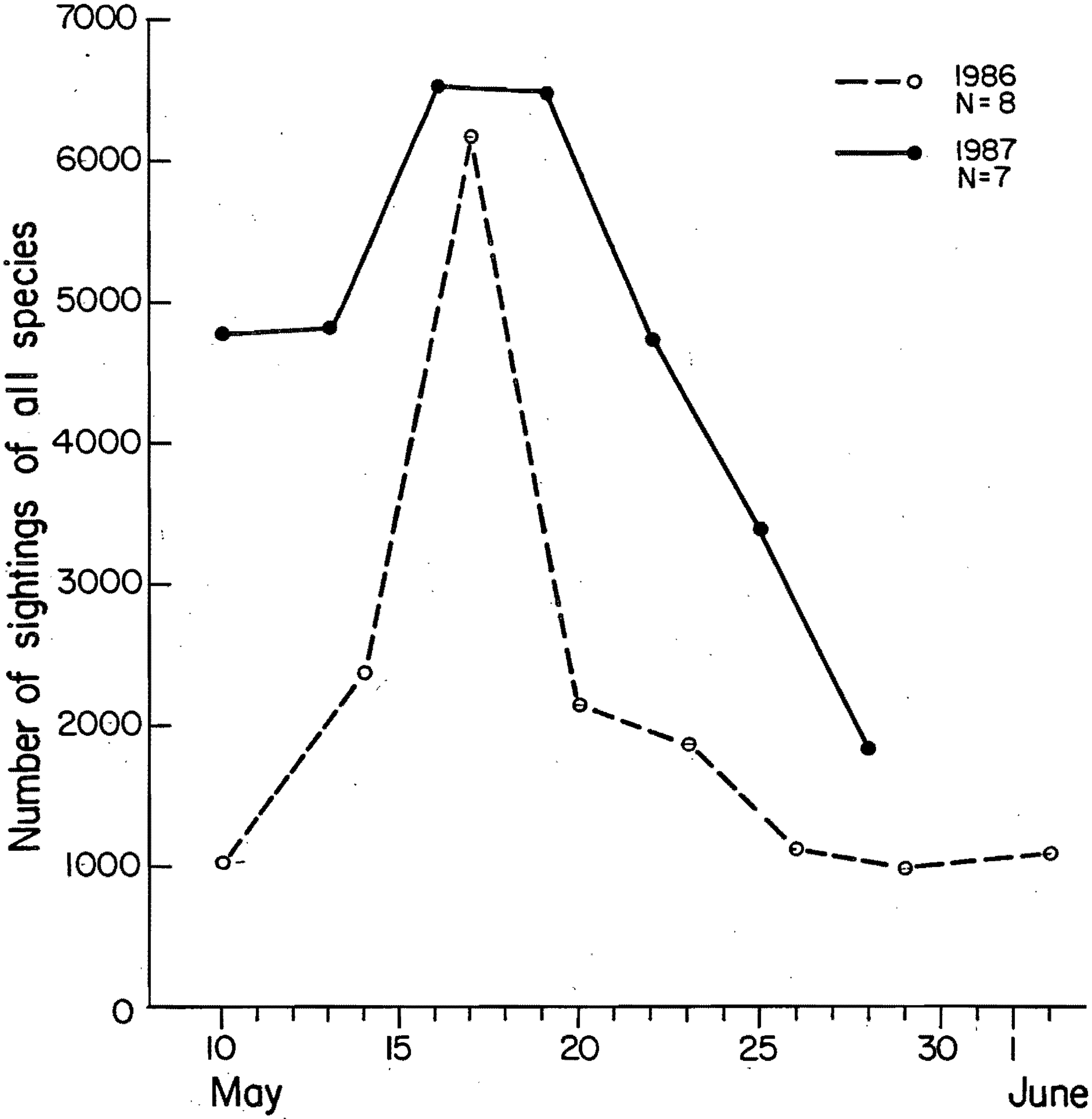

Figure 6. Temporal distribution of migrating waterfowl in the Yellowknife-Thor Lake area, Spring 1986 and 1987. (N=number of surveys)

5.0 DISCUSSION

5.1 Methodological Limitations

Aerial surveys underestimate animal density (Stott and Olson 1972, Caughley 1974, Savard 1982). They are also subject to a number of biases such as observers' identification skills, observer fatigue, angle of prevailing light, ice conditions and albedo, the skill of the pilot, different reactions of bird species to aircraft disturbance, and different patterns of habitat use among species. For instance, casual but repeated ground observations of waterbirds feeding in wetlands adjacent to shoreleads suggest that Green-winged Teal and Mallards often feed deeper into the marsh than Northern Pintails and American Wigeons, which tend to remain on its margin. As a result, the former species would be more difficult to see from an aircraft than the latter. Although every attempt was made to eliminate or minimize those biases, their presence must be considered in the assessment of the results.

The variability of the survey methods must be also considered. Two types of transects were used to survey the 14 sites. Only usable waterbird habitat, namely stretches of open water and shoreline wetlands, was surveyed in 13 of the 14 sites. Although constant in length (Appendix 16), the stretches widened as the ice receded, thus adding variability to the observer's capability to locate the birds. At the Thor lake study site, the 36 km transect line covered 100 square km of usable waterbodies and non-usable (land) waterbird habitat. Despite those variations, I believe that a fairly representative picture of the spring migration emerged and that real differences between sites were satisfactorily established.

5.2 Abundance of Migrating Species

As in 1986, I did not attempt to determine the absolute number or the turnover rate of birds staging in the area. The total number of observations must be considered in terms of "bird-days" rather than the actual number of birds present. It constitutes an indicator of the importance of the staging sites and provides insight in the relative abundance of each species. The peak numbers (highest numbers in one count) of birds, collectively or by species, provide an additional perspective.

Twice as many sightings were recorded between Yellowknife and Thor Lake in 1987 (32,500) than in 1986 (16,800), despite one less survey being flown. However, a similar number of species were identified (29 in 1987, 31 in 1986), and overall peak numbers were comparable (Fig. 6). The most abundant species in 1987 and 1986 were similar although in some cases their relative abundance and individual peak numbers (% increase indicated) have shifted significantly: Tundra Swan (+136%), Greater White-fronted Goose (+71%), Lesser Snow Goose (+1130%), Canada Goose (+63%), Northern Pintail (+126%), American Wigeon (+443%), Canvasback (+145%), and Red-breasted Merganser (+389%). Those increases must be considered in view of the sample size. Although significant locally, the percentages involve fluctuations of only a few hundred birds. The higher numbers of Mallards, Northern Pintails, and American Wigeons are thought to result partly from the smaller fraction of unidentified ducks in 1987 than in 1986 (see below).

On the Thor Lake study site, nearly three times as many sightings were recorded but a similar number of species was observed. The peak number of Scaup spp. tripled (+247%). Other species were noticeably more abundant as indicated by the increase of their individual peak number: Bufflehead (+175%), American Wigeon (+233%), and Mallard (+450%). Again, these figures were obtained from a small number of observations (Table 2).

It appears that the higher total of overall observations was caused primarily by an extended staging period in the area (see temporal distribution below). It also appears that a slightly higher number of birds travelled through the region, as suggested by the highest peak numbers, for all species at all sites, recorded in both years: 6,514 in 1987, 6,169 in 1986 . This small increase (+5%) may be attributed to normal migratory fluctuations. Fluctuations of that magnitude seem very likely and normal in view of the estimated North American waterfowl populations (CWS and USFWS 1986).

A few species were observed less frequently this year. Oldsquaw and White-winged Scoters decreased by over 300% (peak numbers), Surf Scoters by 175%, and Red-necked Grebes by 40%. However, these declines do not appear significant in view of the sample size. Other species (Common Loon, Pacific Loon and Bald Eagle) were observed in numbers similar to 1986. Three new species

(Ruddy Duck, Osprey and Rough-legged Hawk) were observed in 1987 but five others, previously seen in 1986 (Blue-winged Teal, Black Scoter, Golden Eagle, Red-tailed Hawk and Caspian Tern), were not. Again, those fluctuations are not significant in view of the small numbers recorded. All those birds were observed by local birders in the northern Great Slave Lake area during both Spring 1986 and Spring 1987.

The proportion of unidentified ducks was reduced from 32% in 1986 to 17% in 1987. The overcast conditions during many of this year's surveys significantly reduced the visibility problems associated with bright and sunny conditions and high ice albedo. Colours and plumages were easily identifiable this year where only black silhouettes were observed last year. Also, fewer birds were loafing on the ice in dense concentrations.

5.3 Spatial Distribution of Migrating Species

Migrating waterbirds depend on open water for staging and feeding. Accordingly, concentrations of waterfowl were associated with open water sites. The relative importance of various sites for waterfowl varied considerably (Fig. 5). The sites with most open water did not necessarily support the most birds (Appendix 16), suggesting that some areas, regardless of the extent of open water, were more productive and attractive to birds than others. An attempt to rank the sites in terms of bird density (number of birds per km of open water) proved unsuccessful. I believe that under that approach, sites of truly minor importance were rated too high. The "Index of Importance", as defined earlier, appears to rank the 14 sites in a more realistic manner.

Little is known about the importance of Great Slave Lake as a migratory staging area. With the exception of the Slave River Delta, and Beaver and Mills lakes (two enlargements of the Mackenzie River), no major concentration of migratory birds is known to occur in the region (McCormick et al. 1984). However, this study has revealed that some areas, where open water occurs early in the spring, can support substantial numbers of birds. As in 1986, Beaulieu River was the most heavily utilized site. Strong currents in the river result in open water which appears early and expands rapidly. This site maintained significant numbers of waterfowl throughout the study period. Tundra Swans, Scaup spp., and American Wigeons were particularly abundant.

As in 1986, the Thor Lake site ranked ninth in importance among the 14 sites (Fig. 5). Despite substantial increases over last year, a relatively low number of birds was seen at the Thor Lake site. The area does not benefit from any noticeable input of nutrients from a river or adjacent Great Slave Lake. Consequently, it provides less productive and attractive habitat than nearby sites. However, a relatively high number of species (18) was observed in the vicinity of Thor Lake. By comparison, Beaulieu River supported a total of 21 species, but nearly five times as many birds were observed. The relative importance of each site in 1986 and 1987 is remarkably similar (Appendix 16) despite the marked increase in bird sightings in 1987, and variations in species composition. Such consistency suggests that the sites have been appropriately rated.

The Yellowknife-Thor Lake area belongs to what has been defined as the Precambrian Edge: a narrow strip extending along the western edge of the Precambrian Shield from Great Bear Lake to Lake Athabasca. It provides a better-than-average type of northern habitat and has a substantially greater breeding duck density than either the Precambrian open forest to the northeast or the closed forest of the Mackenzie lowlands (Interior Plains) to the southwest. The area has a greater density of ponds than the adjacent portion of the Mackenzie lowlands, and is apparently more fertile than the remainder of the Precambrian open forest due to sedimentation and enrichment during post-glacial stages of Great Slave Lake (Murdy 1964).

Although the breeding potential of the Precambrian Edge has been identified in previous studies, its potential as a spring staging area, apart from the Peace-Athabasca-Slave river system and the head of the Mackenzie River, is poorly known. This study suggests that Great Slave Lake provides significant areas of spring staging habitat.

5.4 Temporal Distribution of Migrating Species

The migration phenology documented by this project is best understood in light of the weather information (Fig. 4) and the ice conditions (Table 1). A number of deviations from the long-term daily mean are apparent for 1987. Those deviations are not unusual (G. Burke. AES, pers. comm.). However, the timing of fluctuations may vary from year to year. During the study period (10-28 May) temperatures were lower than average at the beginning, but higher than average towards the end. This pattern is very similar to that of 1986. The main difference between the two years lies in the length of the mid-May cold spell. It lasted twice as long in 1987. This year as well, temperatures were significantly higher before and after the study period. As expected, ice break-up and melt patterns are directly related to prevailing temperatures. This year, the ice cover had already melted significantly throughout the region before the first survey was completed. Thereafter, melting virtually stopped for ten days, then resumed and proceeded steadily until mid-June. In 1986, the break-up began just before our first survey and progressed more regularly until the end.

As a result, the temporal distribution of birds was somewhat different between the two years. In 1986, bird numbers built up slowly in the first part of May, peaked rapidly on 17 May, and declined sharply thereafter. In 1987, bird numbers had already built up by 10 May, then peaked for a longer period between 16-19 May, and declined sharply thereafter. As in 1986, this year's peak coincided with a mid-May cold spell. North winds, which are not conducive to the northward spring migration, prevailed for a longer period in 1987 and probably resulted in a reverse migration or an extended staging period in the area. This may have significantly inflated the number of sightings of birds migrating through the area without an influx of new birds. A thorough assessment of the impact of weather on the migration is beyond the scope of this study.

Migration peaks varied among species. As a rule, early and late migrants were the same in both years. Early migrants are typified by Mallards and Common Mergansers and late migrants by Northern Shovelers and Surf Scoters. Those records are in accordance with the Yellowknife regional checklist (Bromley and Trauger, n.d.). Some migration peaks have little meaning in light of the few individuals observed.

6.0 CONCLUSION AND RECOMMENDATIONS

The Precambrian Edge , a better-than-average breeding area for northern waterfowl, also provides attractive spring staging habitat for many migratory bird species. Although concentrations of birds such as those observed in the Slave River Delta or at the head of the Mackenzie River were not recorded in the Yellowknife-Thor Lake area, a significant diversity and number of waterbirds were found to use the open water areas along the shore of Great Slave Lake.

Despite the number of scaup and the diversity of bird species observed in the vicinity of the Thor Lake Mine site, it would appear that the area is not significant to migrating waterfowl in a regional context. However, as the spring migration of waterbirds in the Yellowknife-Thor Lake area has never been thoroughly documented, I recommend that spring aerial surveys be conducted for one more year.

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Appendix 1. Scientific names of bird species observed during the Yellowknife - Thor Lake survey, Spring 1987.

Common Name	Scientific Name	Species Code
Red-throated Loon	Gavia stellata	RL
Pacific Loon	Gavia pacifica	PL
Common Loon	Gavia immer	CL
Horned Grebe	Podiceps auritus	HG
Red-necked Grebe	Podiceps grisegena	RG
Tundra Swan	Olor columbianus	TS
Greater White-fronted Goose	Anser albifrons	GG
Lesser Snow Goose	Chen caerulescens	SG
Canada Goose	Branta canadensis	CG
Unidentified duck		DU
Green-winged Teal	Anas crecca	GT
Mallard	Anas platyrhynchos	MA
Northern Pintail	Anas acuta	NP
Northern Shoveler	Anas clypeata	NS
American Wigeon	Anas americana	AW
Canvasback	Aythya valisneria	CA
Ring-necked Duck	Aythya collaris	RD
Unidentified Scaup	Athya sp.	SC
Oldsquaw	Clangula hyemalis	OL
Surf Scoter	Melanitta perspicillata	SS
White-winged Scoter	Melanitta fusca	WS
Common Goldeneye	Bucephala clangula	GO
Bufflehead	Bucephala albeola	BU
Common Merganser	Mergus merganser	CM
Red-breasted Merganser	Mergus serrator	RM
Ruddy Duck	Oxyra jamaicensis	RU
Osprey	Pandion haliaetus	OS
Bald Eagle	Haliaeetus leucocephalus	BE
Northern Harrier	Circus cyaneus	NH
Rough-legged Hawk	Buteo lagopus	RK
Sandhill Crane	Grus canadensis	CR

Appendix 2. Abundance of migrating species at Wool Bay, Spring 1987

	Species																			
Date	HG	RG	TS	GT	MA	NP	NS	AW	CA	SC	OL	SS	WS	BU	CM	RM	RU	DU	BE	NH
10 May					30	60		20		80								100		
13 May	2			3	4	2			8	83				2	1	2				
16 May		2			2	16				100				2					1	
19 May	7	4			6		2	2	1	252		4	15				1			1
22 May		4	2		1	7	1	4		94		10		1						
25 May		1	2		1	2		8	2	84	2		1	2		2				
28 May		4			2			8		76		4					4			

Appendix 3. Abundance of migrating species at Site B, Spring 1987

	Species																
Date	CL	HG	RG	TS	GG	CG	GT	MA	NP	NS	AW	SC	SS	BU	CM	RM	DU
10 May				40		5			6		30			20	10		27
13 May				36	10	1	6	16	30		80	20		6	10	22	30
16 May				61	15			12	25		86	55			12	25	7
19 May	1		2	53				3	20	2	55	91	10		10	26	30
22 May			3	95		67		14	25		51	131	22			15	
25 May		1		47		20		11	12	2	31	34	2	2	2	20	5
28 May				11				6	10	2	1	73		2		59	

Appendix 4. Abundance of Migrating Species at Jackfish Cove, Spring 1987

	Species								
Date	TS	MA	NP	NS	AW	SC	BU	RM	BE
10 May	18	15	5		65				1
13 May	27	2	60		12		2		1
16 May	31		40		10				
19 May	4		48	2	33			6	
22 May	10	1	37		12				
25 May	15	5	4	1	9	4	2		
28 May	2	4	22		2	27			

Appendix 5. Abundance of Migrating Species at Moose Bay, Spring 1987.

	Species								
Date	TS	GT	MA	NP	AW	SC	WS	RM	NH
10 May				2	2				
13 May			10		14			2	
16 May	4		2	4	6	2			
19 May	4		1		6	53		2	
22 May			2		2	25			
25 May	2	2	3		7	2			1
28 May	2		4			8	1		

Appendix 6. Abundance of Migrating Species at Drybones Bay, Spring 1987

Date	CL	HG	RG	TS	SG	CG	MA	NP	NS	AW	CA	SC	SS	RM	DU	BE
								Species								
10 May				4			20	20		159	5	20		1	20	
13 May				6				25		67		75		6		
16 May				24			21	180		286		64		9	40	
19 May	1	15		52		2	4	50		157		72	2	9	10	1
22 May				27			8	51		32		64	2	2		1
25 May			2	33	1	1	18	10	4	14	5	67			2	
28 May	1		1	9			18	48		19	10	2		3		1

Appendix 7. Abundance of Migrating Species at Cabin Islands, Spring 1987

Date	RL	HG	TS	GG	SG	CG	GT	MA	NP	NS	AW	CA	SC	SS	WS	BU	CM	RM	DU	OS	BE	NH	CR
											Species												
10 May			157					12	55		209						20	2					
13 May			144			32		16	126		108		40						60				1
16 May			186			155		48	150		120		5					36	60			1	
19 May	2		199	30	20	150		4	86	6	87	12	25	10				19	30		1	1	
22 May			198	20	30	94		10	80		14		61					8		1			
25 May		2	144					12	18	4	31		33		12			3					
28 May			43				2	15	50	2	12		12	20		4		12			1		

Appendix 8. Abundance of Migrating Species at Matonabbee Bay, Spring 1987

Date	RG	TS	GG	SG	CG	MA	NP	NS	AW	CA	SC	SS	BU	RM	DU	BE	NH
									Species								
10 May		139			160	2			172	2						1	
13 May		153			150		100		2		2		4	2		1	
16 May		130	205	8			85		279		10			8			
19 May	1	161		50	311	8	80		157	2	10	2		8	100		
22 May	2	98		80	150	9	117		27		30		2	11	20		1
25 May		73	5		10	4	18	8	6		7		3	6			
28 May		19			10	7	11	2	22		27		2		10	1	

Appendix 9. Abundance of Migrating Species at Devil's Channel, Spring 1987.

Date	RG	TS	CG	MA	NP	NS	AW	CA	RD	SC	SS	BU	GO	RM	DU	BE	RK
									Species								
10 May		102	30	16	20		206		6	80							
13 May	1	150	55	22			54			112		11	2	2	30	1	
16 May		236	161	46	50	1	16	72		36		2		4			
19 May	1	178	66	19	12	2	36			82				7	50		
22 May	2	203	50	6	5		18			25	2	2		3	51		
25 May		115	45	1			2			32	1	8		7	23	1	1
28 May	4	31		2	8		8			17		4					

Appendix 10. Abundance of Migrating Species at Goulet-Campbell Bays, Spring 1987

	Species																		
Date	CL	RG	TS	GG	SG	CG	GT	MA	NP	AW	CA	SC	SS	BU	GO	RM	DU	BE	NH
10 May		2	196			60			30	47	8	115				15	60		
13 May			213			60		21	80	141		60		2	2		50		
16 May		2	284		2	152		18	81	115	5	131	2	4		1	146		
19 May		1	251		45	180		12	86	106		270				14	196		
22 May			181			80		2	2	8		45		2		2	10	1	1
25 May	1	6	211	50	22	43	1	8	60	85		41	16	4		7	10		
28 May		2	84			12		21	45	45		64	3			5	31		

Appendix 11. Abundance of Migrating Species at Site J, Spring 1987

	Species										
Date	TS	MA	NP	NS	AW	SC	BU	CM	RM	DU	BE
10 May	8				6			10			
13 May		7	10		6	30					
16 May	24	2	1		10						
19 May	42	7	8		6	12					
22 May	64	2			7	24	2		10		
25 May	62	7			14	14	3				
28 May	3	15	12	2	5	12			1	10	1

Appendix 12. Abundance of Migrating Species at Site K, Spring 1987

Date	CL	TG	TS	CG	MA	NP	NS	AW	SC	SS	BU	RM	DU	BE	NH
								Species							
10 May				25				40						2	
13 May			4	9		5		11						1	
16 May			12			5		22							
19 May	1		8		19	10	2	18	10						
22 May			5		3	2	3	6	50	1					
25 May		1	2		1	10	2	12	26	2	4				1
28 May	1				13	2		6	32			2	2	1	

Appendix 13. Abundance of Migrating Species at Francois Bay, Spring 1987

Date	RG	TS	GG	SG	CG	MA	NP	NS	AW	SC	SS	WS	BU	RM	DU	BE
									Species							
10 May		44			10	20	30		181	44					40	2
13 May		71							32	96			3	3	50	
16 May		90			50	20	3		117	127				2	60	
19 May		59	20		60	4	6		37	102	4	6		2	16	
22 May		86		1	120		44		39	145	31		2	7	84	
25 May	4	216			22	4	7	2	14	302	63	2	4	6	137	
28 May																

Appendix 14. Abundance of Migrating Species at Thor Lake, Spring 1987

	Species																			
Date	CL	PL	HG	RG	TS	MA	NP	NS	AW	CA	RD	SC	OL	SS	WS	BU	RM	DU	BE	RK
10 May						3	2		10			54						15		
13 May	1					11			2	6	6	346				22		34		
16 May	2					2			6			368				8		44	1	
19 May	7	4	2	2		2			4			274		4	4	12	3	3		1
22 May	4			2	2	1			10			98	2	4		10		2	1	
25 May	3	11		2		6			10			59	3	31		3	8	2		
28 May	8	4		2	3	6		1	2			44		13			5	21		

Appendix 15. Abundance of Migrating Species on Beaulieu River, Spring 1987

	Species																						
Date	CL	HG	RG	TS	GG	SG	CG	GT	MA	NP	NS	AW	CA	RD	SC	SS	WS	BU	GO	CM	RM	DU	BE
10 May				209	3		45	2	155	26		255	128	4	88			62	12	37	13	475	2
13 May		1		284			50		213	245			53		227			14		7	45	180	1
16 May	1		11	300	20		10	6	40	142		243	20		261	2		13		41	101	163	1
19 May		4	4	336		8	302		41	108		204	2		205	18		8		10	27	79	1
22 May	7		6	382		6	270		36	194	3	75	26		112	30		23	2	5	14	73	1
25 May			13	230		9	52	2	24	27		84	10		41	7	2	13	17	1	20	30	
28 May	4		12	116			25	16	38	28		65	5		87	33		14	2	10	8	21	3

Appendix 16. Relative importance, number of species and amount of open water at each site.

Site	Relative importance* 1987	Relative importance* 1986	Number of species 1987	Number of species 1986	Amount of open water(km)**
Beaulieu River	1	1	23	22	24.0
Matonabbee Bay	2	7	16	13	8.0
Goulet-Campbell bays	3	4	20	18	12.5
Cabin Islands	4	3	22	17	7.7
Devil's Channel	5	2	16	16	6.0
Site B	6	6	16	17	4.5
Francois Bay	7	5	15	18	9.5
Drybones Bay	8	8	15	17	12.5
Thor Lake Study Site	9	9	19	17	36.0***
Wool Bay	10	10	19	11	3.0
Jackfish Cove	11	11	9	12	3.5
Site J	12	12	10	9	4.5
Site K	13	14	14	11	4.5
Moose Bay	14	13	9	10	3.5

* Relative importance determined by "Index of Importance", see Figure 5 and Methods.

** Amount of open water was constant from survey to survey but width increased as ice receded; see Table 1.

*** 36-km survey line above the study site includes open water, ice, and land.