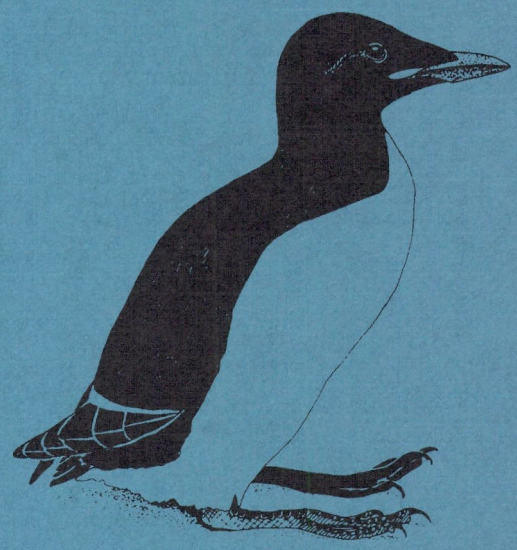
SPRING MIGRATION OF WATERFOWL IN THE YELLOWKNIFE-THOR LAKE AREA NORTHWEST TERRITORIES: 1988

Jacques Sirois
Gordon B. Cameron



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ABSTRACT

For a third consecutive spring, a survey of migrating waterfowl was conducted from 10 May to 2 June 1988, in the area of the Thor Lake Mine development. Thirteen staging sites between the mine site and Yellowknife were also surveyed. Nearly 66,400 sightings and a total of 29 waterbird species were recorded. This represents twice as many sightings as in 1987, and four times the number recorded in 1986. This remarkable increase was likely due to a late spring break-up around Great Slave Lake, and the presence of birds displaced by the severe prairie drought.

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 20-26 May when over 13,200 birds were recorded. As at least 1% of the North American population of Tundra Swans staged in the study area, its designation as a Key Habitat Site for migratory birds is suggested.

Relatively few sightings (550 birds of 18 species) were recorded on the Thor Lake study site, as spring break-up was rather late. The Thor Lake site ranked tenth among the 14 sites in its importance as migratory bird habitat. As this survey did not reveal any significant migratory bird populations near the mine site, the mine development should not result in any significant negative impacts to migratory birds.

RÉSUMÉ

Des inventaires aériens d'oiseaux aquatiques furent menés entre le 10 mai et le 2 juin 1988, dans la région du lac Thor, où un projet de développement minier est à l'étude. Il s'agissait d'une troisième série d'inventaires printaniers depuis 1986. Ces inventaires nous ont permis de survoler 13 sites d'arrêt migratoire entre Yellowknife et le site de la future mine. Environ 66 400 oiseaux, dont 29 espèces, furent observés. Ceci représente deux fois plus d'observations qu'en 1987, et quatre fois plus qu'en 1986. Cette augmentation remarquable fut probablement causée par une débâcle tardive dans la région et par la présence d'oiseaux venus des prairies en raison de la grave sécheresse.

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 20 et 26 mai lorsqu'un maximum de plus de 13 200 oiseaux furent dénombrés. Plus de 1% de la population nord-américaine de Cygnes siffleurs s'est arrêté dans la zone délimitée par ce projet pendant la migration printanière. Par conséquent il est suggéré que cette zone soit désignée site clé pour cette espèce dans les Territoires du Nord-Ouest.

Relativement peu d'oiseaux (550, dont 18 espèces) furent observés dans les environs du lac Thor. La débâcle fut particulièrement tardive à cet endroit. Ce site s'est classé dixième 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.

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TABLE OF CONTENTS

Page

ABSTRACT.....i

RÉSUMÉ.....i

ACKNOWLEDGEMENTS.....ii

LIST OF FIGURES.....iv

LIST OF TABLES.....iv

LIST OF APPENDICES.....v

1.0 INTRODUCTION.....1

1.1 Thor Lake Mine Development.....1

1.2 Potential Environmental Impacts.....4

1.3 Study Objectives.....5

2.0 STUDY AREA.....5

2.1 Climate.....5

2.2 Physiography.....7

2.3 Vegetation.....10

3.0 METHODS.....10

4.0 RESULTS.....11

4.1 Abundance of Migrating Species.....11

4.2 Spatial Distribution of Migrating Species.....12

4.3 Temporal Distribution of Migrating Species.....16

5.0 DISCUSSION.....16

5.1 Methodological Limitations.....16

5.2 Abundance of Migrating Species.....20

5.3 Spatial Distribution of Migrating Species.....24

5.4 Temporal Distribution of Migrating Species.....26

6.0 CONCLUSION 26

7.0 LITERATURE CITED.....29

8.0 APPENDICES.....31

LIST OF FIGURES

Figure Page

1. Location of the proposed Thor Lake Mine site within Northwest Territories.....2

2. Present and proposed developments at the Thor Lake Mine site.....3

3. Location of open-water sites in the Yellowknife - Thor Lake area, Spring 1988.....6

4. Mean daily temperatures during spring break-up at Yellowknife, 1988.....8

5. Relative importance of each open-water site to migrating waterfowl, Spring 1988.....17

6. Temporal distribution of migrating waterfowl in the Yellowknife-Thor Lake area, Spring 1986-1988.....19

LIST OF TABLES

Table Page

1. Ice conditions in the Yellowknife - Thor Lake area, Spring 1988.....9

2. Relative abundance of each species observed at all sites and at the Thor Lake study site during the spring migrations of 1986, 1987 and 1988.....13

3. Peak numbers of each species observed at all sites and at Thor Lake study site during the spring migrations of 1986, 1987 and 1988.....14

4. Percent abundance of the ten most common species at each open-water site.....15

5. Temporal abundance of migrating species in the Yellowknife - Thor Lake area, Spring 1988.....18

6. Prairie bird species observed around or near Great Slave Lake in May and June 1988.....22

LIST OF APPENDICES

Appendix Page

1. Scientific names of birds species observed in the Yellowknife - Thor Lake area, Spring 1988.....31

2. Abundance of migrating species at Wool Bay, Spring 1988.....32

3. Abundance of migrating species at Moose Bay, Spring 1988....32

4. Abundance of migrating species at Jackfish Cove, Spring 1988.....33

5. Abundance of migrating species at Cabin Islands, Spring 1988.....33

6. Abundance of migrating species at Site B, Spring 1988.....34

7. Abundance of migrating species at Drybones Bay, Spring 1988.....34

8. Abundance of migrating species at Matonabbee Bay, Spring 1988.....35

9. Abundance of migrating species at Devil's Channel, Spring 1988.....35

10. Abundance of migrating species at Goulet-Campbell bays, Spring 1988.....36

11. Abundance of migrating species at Site J, Spring 1988.....36

12. Abundance of migrating species at Site K, Spring 1988.....37

13. Abundance of migrating species at Francois Bay, Spring 1988.....37

14. Abundance of migrating species at Thor Lake study site, Spring 1988.....38

15. Abundance of migrating species on the lower Beaulieu River, Spring 1988.....38

16. Relative importance, number of species and amount of open water at each site in 1986, 1987 and 1988.....39

1.0 INTRODUCTION

1.1 Thor Lake Mine Development

The Thor Lake area (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 of yttrium, 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. In 1986, Highwood Resources Ltd. and Hecla Mining Co. of Canada Ltd. formed a joint venture to facilitate the development of a beryllium mine at Thor Lake. In October 1988, a Project Description of the Thor Lake Joint Venture was tabled at the Regional Environmental Review Committee (DIAND), at Yellowknife.

Following the termination of a feasibility study, final decisions regarding the future of the project and the implementation of a ten-year plan are expected in early 1989 (Lockerbie 1988). The company plans to have the minerals milled and processed on site, where no chemical processing is expected to take place. The dried ore concentrate will be shipped from the mine site via winter road or boat. Up to 14,000 tons of ore may be extracted in 1989. The milling operation may require a staff of 15 by 1990 and possibly 40 in the future (RERC 1988).

Present site developments include accommodation for personnel, structures and surface activities related to field tests, and a short road which terminates at Hearne Channel (Fig. 2).

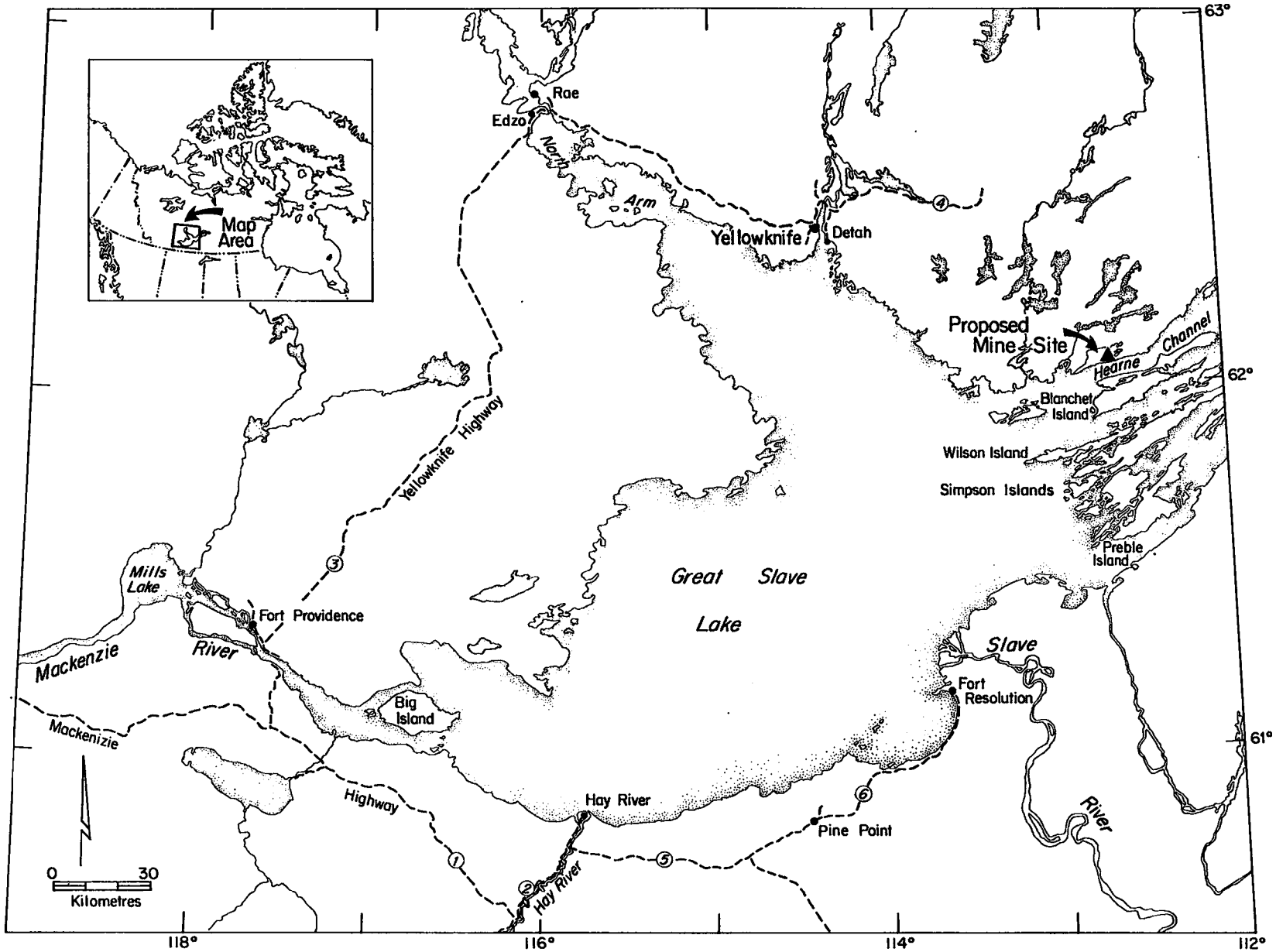

Figure 1. Location of the proposed Thor Lake Mine site within Northwest Territories.

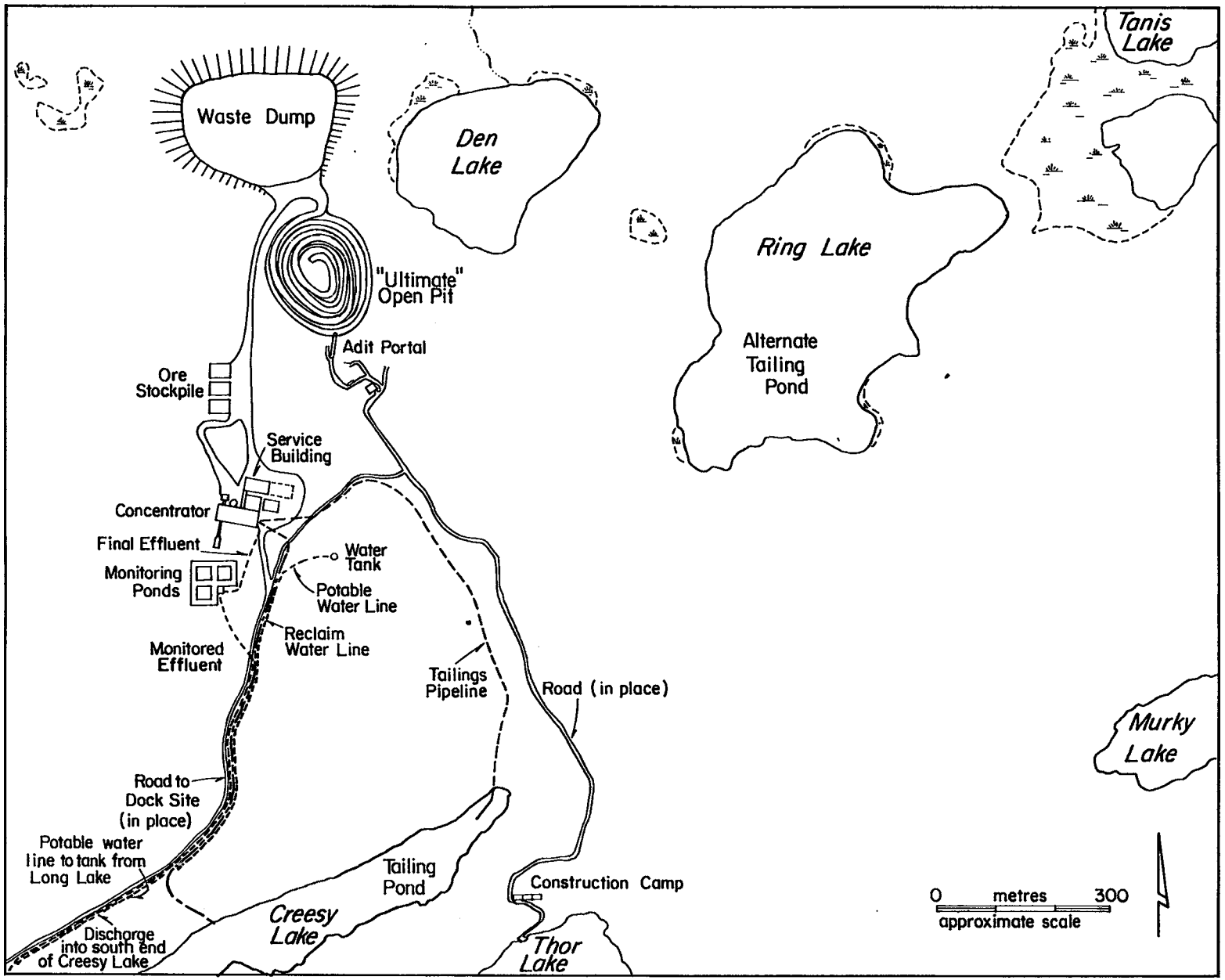

Figure 2. Present and proposed developments at the Thor Lake Mine site.

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, if chemical concentration takes place on site, it may involve 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 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. Conversely, later in the season, nesting, moulting and fall staging habitats are widely available due to the absence of ice.

1.3 Study Objectives

This study was undertaken in light of the above-mentioned potential impacts. Aerial surveys were undertaken to: 1) determine the waterfowl species, and their abundance, at the Thor Lake study site and in a study area described below, 2) determine the temporal and spatial distribution of waterfowl in the study area; and 3) evaluate the importance of the study site to migrating waterfowl in a regional context.

The importance of Thor Lake and environs as a spring staging area for waterbirds was determined in 1986 and 1987 (Sirois and McCormick 1987, Sirois 1987). This report presents the results of the 1988 surveys.

2.0 STUDY AREA

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

2.1 Climate

The 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 in January is -29°C and in July is 16°C (Atmos.

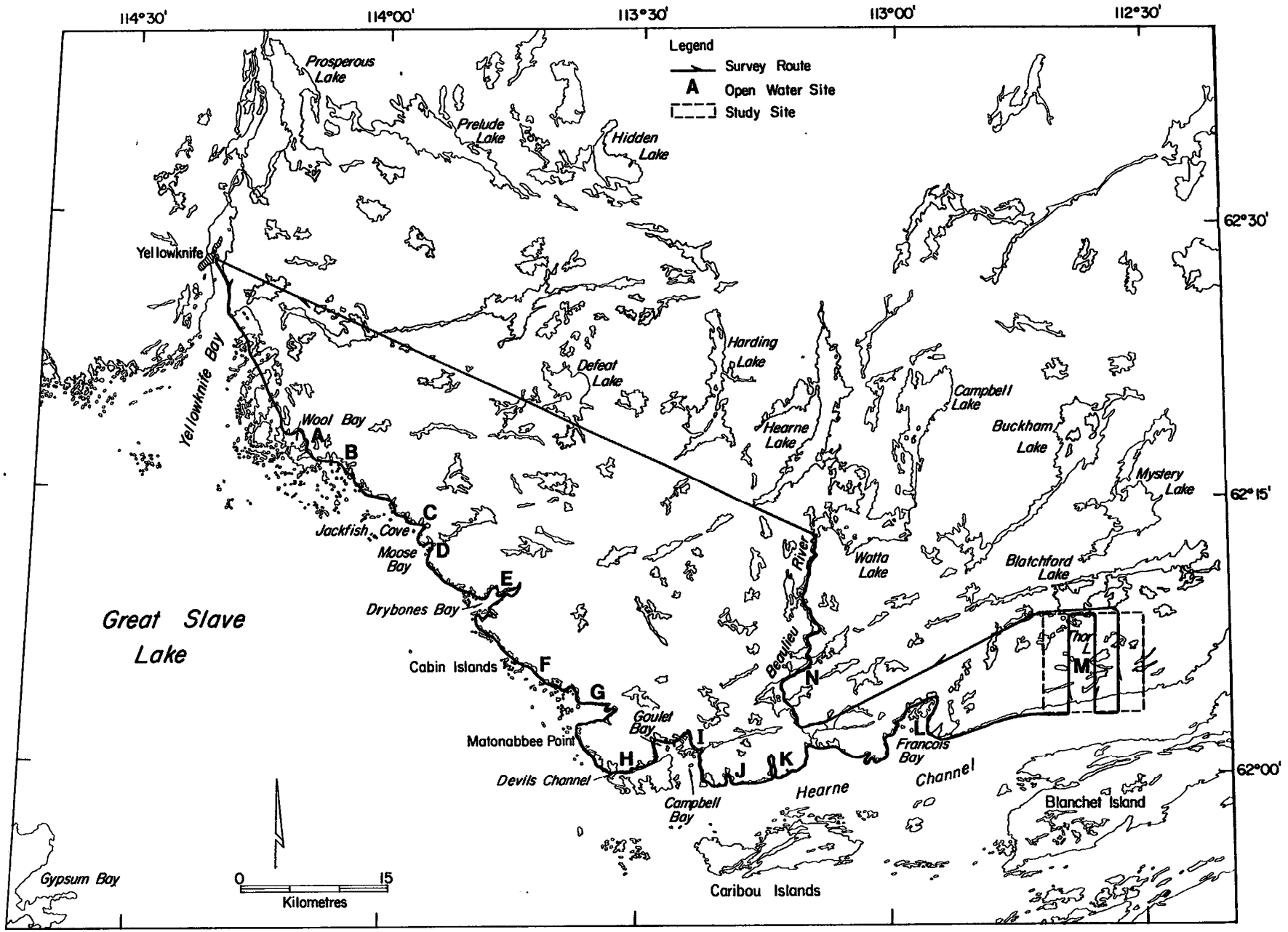

Figure 3. Location of open-water sites in the Yellowknife-Thor Lake area, Spring 1988.

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 by early June. The progression of ice melt in the Hearne Channel- Thor Lake area during 1988 (Table 1), suggests that temperatures are colder in the vicinity of the mine site than at Yellowknife.

The 1988 spring break-up occurred two weeks later than in 1987 and 1986. Snow was present on the ground until early June and relatively little open water was available until late May. The Beaulieu River, ice-free on 10 May in 1986 and 1987, had its wide sections covered with ice until 26 May. The mean daily temperature in May was 0.9 ^{o}C compared with the normal 5 ^{o}C. The mean daily maximum was 5.9 ^{o}C, compared with the normal 10 ^{o}C, and the mean daily minimum was -4.1 ^{o}C, compared with the normal -0.1 ^{o}C. Two cold temperature records were also established: -9.1 ^{o}C on 15 May and -6.4 ^{o}C on 17 May.

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 m in height characterize the region (Bostock 1970). The study site is characteristically flat and rises

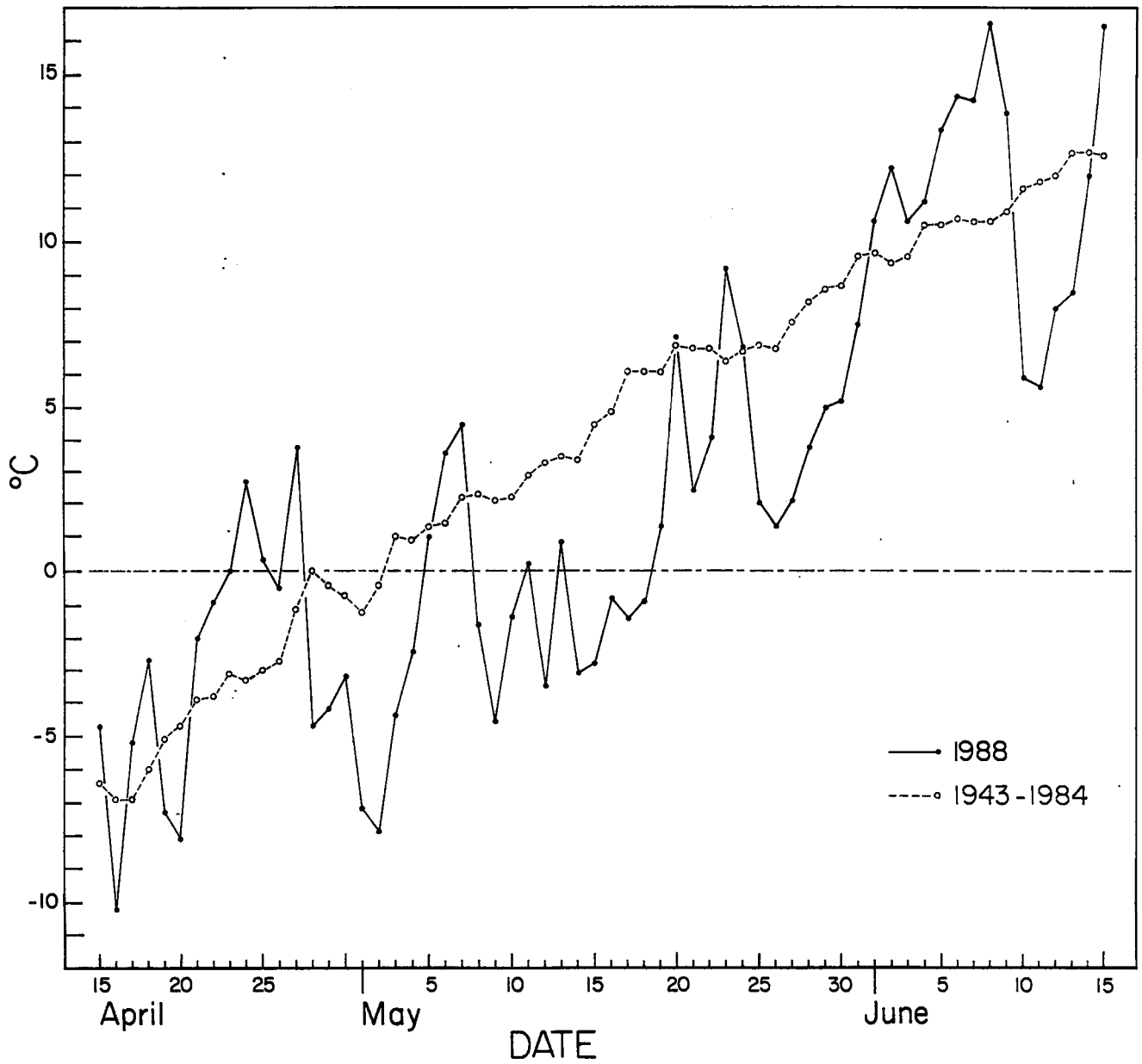

Figure 4. Mean daily temperatures during spring break-up at Yellowknife, 1988.

Table 1. Ice conditions in the Yellowknife - Thor Lake area, Spring 1988.

Date	Yellowknife Bay to Campbell Bay	Hearne Channel - Thor Lake area	Comments
10 May	Open water in few shallow wetlands; wide sections of Beaulieu River completely frozen.	No open water.	Late spring in the region.
13 May	Little change since 10 May; more open water at the bottom of some bays.	Less than 10 shallow wetlands with some open water.	Same comment as above.
17 May	Little change since 10 May, a few more shallows with open water.	Previously open shallows are frozen again.	Same comment as above. Temperatures still below freezing point.
20 May	More shallow waters are ice-free; wide sections of the Beaulieu River are still frozen; vast wetlands open at Cabin Is.	Less than 10 shallow wetlands open; up to 50% of the ground is covered by snow.	In most areas, 10-20% of the ground is covered by snow; temperatures are hovering at the freezing point.
23 May	Shoreleads are 1-3 m wide in many lakes; wide sections of Beaulieu River still covered with ice; shoreleads 10 m wide at Cabin Islands.	Most shallow ponds are open, some larger lakes have shoreleads; up to 10% of the ground is covered by snow.	Temperatures still hovering at the freezing point near the lake surface.
26 May	Shoreleads 10 m wide in some lakes; Beaulieu River mostly open, wide sections covered with candled ice; most shallow wetlands are ice-free; more water than ice at Cabin Is.	Landfast ice in many lakes and in Hearne Channel; candled ice on some lakes; snow cover as on 23 May.	Temperatures below freezing point at night but much warmer during the day.
29 May	Traces of snow left, Beaulieu River is open but ice pans are numerous; some large lakes still have landfast ice.	Snow cover no more than 1%; most large lakes have 2-m wide shoreleads, up to 8 m in some cases; candled ice in most lakes.	Temperatures are warming up. Rains.
02 June	Many locations have too much water for proper surveying. Beaulieu River is ice-free; traces of snow left.	Shoreleads are 2-5 m wide in Hearne Channel. Most lakes are open or have dislocated ice pans.	Dramatic changes caused by rain have occurred in the last three days. Open water now prevails.

abruptly (approximately 60 to 65 m) 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 waterbodies. Exposed Precambrian outcrops comprise at least 10% of the site.

2.3 Vegetation

The site is dominated by open boreal forest and is located within the Taiga Shield terrestrial ecozone (Wiken 1986). The treeline 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

Eight 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 May and 2 June 1988. 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. At

each site, all open waters were surveyed and all observed birds were recorded irrespective of their distance from the flight path. All surveys were flown in a PA-18 Piper Supercub, at approximately 125 km/h and 20 to 30 m above ground level. Flight speed and height were reduced, as necessary, to examine certain staging sites.

All sightings were recorded on a tape recorder and subsequently transferred onto forms. In this study, loons and grebes were considered waterfowl species along with ducks, geese and swans. The flight path was identical to that of 1987 and 1986. The relative importance of the various sites was determined by calculating the percent of the total observations of a particular species recorded at a given site. The percentage values for each of the ten most common species were then summed to yield an "Index of Importance".

As Greater and Lesser Scaup were impossible to distinguish, they were lumped as Scaup spp. and considered as one species. Ring-necked Ducks may also have been identified as scaups if they occurred in the same flocks.

4.0 RESULTS

4.1 Abundance of Migrating Species

Approximately 66,400 birds and 34 species, including 29 waterfowl species, were recorded between Yellowknife and the Thor Lake study site. A peak of over 13,200 birds was recorded on 23 May. About 24% of the total observations were of Scaup spp.,

followed by Canada Geese (20%), Mallards (13%), Tundra Swans (11%), Surf Scoters (7%), American Wigeons (5%), Northern Pintails (4%), Snow Geese (4%), Red-breasted Mergansers and Common Loons (1% each). The silhouettes and behaviour of most unidentified ducks (5% of all records) suggested that they were dabblers such as Mallards, Northern Pintails, and American Wigeons. The relative abundance of each species and their peak numbers in 1986, 1987 and 1988 are presented in Tables 2 and 3 respectively. The abundance of each species observed at each site is summarized in Appendices 2-15.

Approximately 550 records (<1% of all sightings) were collected on the Thor Lake study site. Eighteen species, including 14 waterfowl species, were observed. A maximum of about 280 birds was seen on 29 May. Scaup spp. accounted for about half of the observations (49%), followed by Surf Scoters (18%), Canada Geese (10%), Mallards (4%), Pacific Loons (4%), Common Loons (2%), White-winged Scoters (2%), Buffleheads (2%), Northern Pintails and American Wigeons (1% each). Unidentified ducks accounted for 3% of the total observations. The relative abundance and peak number of each species observed on the Thor Lake site in 1986, 1987 and 1988 are also given in Tables 2 and 3.

4.2 Spatial Distribution of Migrating Species

The relative importance of the 14 sites surveyed was determined by an Index of Importance based on the occurrence of the ten most common bird species (Table 4). The Thor Lake study site ranked tenth and was among the six least-used sites by birds, as

Table 2. Relative abundance of each species observed at all sites and at the Thor Lake study site during the spring migrations of 1986, 1987 and 1988.

	Total records at all sites						Total records at Thor Lake site					
Species	1988	%	1987	%	1986	%	1988	%	1987	%	1986	%
Red-throated Loon	9	0.01	2	0.006	11	0.06	2	0.4	0	0	2	0.3
Pacific Loon	62	0.09	18	0.05	14	0.08	20	3.6	19	1.1	4	0.7
Common Loon	778	1.2	43	0.1	42	0.2	13	2.4	25	1.5	6	1.0
Yellow-billed Loon	8	0.01	0	0	0	0	0	0	0	0	0	0
Horned Grebe	19	0.03	34	0.1	14	0.08	0	0	2	0.1	0	0
Red-necked Grebe	203	0.3	106	0.3	135	0.8	3	0.5	8	0.5	7	1.2
Tundra Swan	7241	10.9	7562	23.3	2313	13.8	0	0	5	0.3	0	0
G.W.-front. Goose	602	0.9	378	1.7	156	0.9	0	0	0	0	70	11.9
Lesser Snow Goose	2404	3.6	282	0.8	10	0.05	0	0	0	0	10	1.7
Canada Goose	13319	20.1	3362	10.3	802	4.8	57	10.3	0	0	0	0
Unidentified Duck	3015	4.5	2749	8.4	5388	32.1	19	3.4	121	7.3	64	10.8
Green-winged Teal	32	0.05	40	0.1	20	0.1	0	0	0	0	0	0
Mallard	8778	13.2	1289	4.0	629	3.7	22	4.0	31	1.9	2	0.3
Northern Pintail	2760	4.2	3203	9.8	413	2.5	6	1.1	2	0.1	0	0
Blue-winged Teal	0	0	0	0	29	0.1	0	0	0	0	0	0
Cinnamon Teal	1	0.002	0	0	0	0	0	0	0	0	0	0
Northern Shoveler	154	0.2	56	0.1	66	0.4	0	0	1	0.06	0	0
American Wigeon	3036	4.6	4982	15.3	664	4.0	6	1.1	44	2.7	6	1.0
Canvasback	679	1.0	382	1.2	71	0.4	0	0	6	0.3	0	0
Ring-necked Duck	256	0.4	16	0.04	77	0.4	0	0	6	0.3	0	0
Unidentified Scaup	15918	24.0	6320	19.4	4164	24.8	269	48.8	1243	75.4	279	47.4
Harlequin Duck	2	0.003	0	0	0	0	0	0	0	0	0	0
Oldsquaw	476	0.7	7	0.02	31	0.1	2	0.4	5	0.3	31	5.2
Black Scoter	4	0.006	0	0	10	0.05	0	0	0	0	0	0
Surf Scoter	4625	7.0	355	1.1	647	3.8	98	17.8	52	3.1	52	3.1
White-winged Scoter	409	0.6	43	0.1	221	1.3	12	2.2	4	0.2	4	0.2
Common Goldeneye	19	0.03	37	0.1	18	0.1	0	0	0	0	0	0
Bufflehead	486	0.7	315	0.9	327	1.9	12	2.2	55	3.3	9	1.5
Common Merganser	241	0.4	186	0.6	72	0.4	0	0	0	0	0	0
Red-breasted Merganser	776	1.2	670	2.0	133	0.8	4	0.7	16	0.9	2	0.3
Ruddy Duck	6	0.009	5	0.01	0	0	0	0	0	0	0	0
Osprey	3	0.005	1	0.003	0	0	2	0.4	0	0	0	0
Bald Eagle	54	0.08	32	0.09	36	0.2	1	0.2	2	0.1	1	0.1
Northern Harrier	4	0.006	7	0.002	2	0.01	0	0	0	0	0	0
Red-tailed Hawk	0	0	0	0	1	0.005	0	0	0	0	0	0
Rough-legged Hawk	4	0.006	2	0.006	0	0	1	0.2	1	0.06	0	0
Golden Eagle	0	0	0	0	1	0.005	0	0	0	0	0	0
Sandhill Crane	3	0.005	1	0.003	8	0.04	2	0.4	0	0	2	0.3
Caspian Tern	0	0	0	0	1	0.005	0	0	0	0	0	0
Total	66386	100.0	32485	100.0	16766	100.0	551	100.0	1648	100.0	589	100.0

Table 3. Peak numbers* of each species observed at all sites and at the Thor Lake study site during the spring migrations of 1986, 1987 and 1988.

	Peak numbers at all sites			Peak numbers at Thor Lake site		
Species	1988	1987	1986	1988	1987	1986
Red-throated Loon	4	2	11	2	0	2
Pacific Loon	22	11	10	12	11	4
Common Loon	357	14	15	8	8	3
Yellow-billed Loon	6	0	0	0	0	0
Horned Grebe	9	28	8	0	2	0
Red-necked Grebe	55	29	40	3	2	3
Tundra Swan	1653	1382	584	0	3	0
G.W.-front. Goose	248	240	140	0	0	70
Lesser Snow Goose	1085	123	10	0	0	10
Canada Goose	4479	1071	657	55	0	0
Unidentified Duck	601	737	3494	8	44	36
Green-winged Teal	10	18	15	0	0	0
Mallard	2830	322	309	10	11	2
Northern Pintail	868	782	346	2	2	0
Blue-winged Teal	0	0	27	0	0	0
Cinnamon Teal	1	0	0	0	0	0
Northern Shoveler	46	23	34	0	1	0
American Wigeon	752	1402	258	6	10	3
Canvasback	227	98	40	0	6	0
Ring-necked Duck	150	10	70	0	6	0
Unidentified Scaup	4785	1458	1040	165	368	106
Harlequin Duck	2	0	0	0	0	0
Oldsquaw	228	5	20	2	3	20
Black Scoter	2	0	10	0	0	0
Surf Scoter	1470	122	335	77	31	20
White-winged Scoter	208	25	169	10	4	40
Common Goldeneye	8	17	16	0	0	0
Bufflehead	107	82	159	6	22	8
Common Merganser	63	77	38	0	0	0
Red-breasted Merganser	207	186	38	2	8	2
Ruddy Duck	4	4	0	0	0	0
Osprey	1	1	0	1	0	0
Bald Eagle	11	8	16	1	1	1
Northern Harrier	2	2	1	0	0	0
Red-tailed Hawk	0	0	1	0	0	0
Rough-legged Hawk	2	1	0	1	1	0
Golden Eagle	0	0	1	0	0	0
Sandhill Crane	2	1	4	2	0	2
Caspian Tern	0	0	1	0	0	0

* Peak number of each species seen during one flight; peaks occurred on different dates.

Table 4. Percent abundance of the ten most common species at each open water site, Spring 1988.

Site	Species										IMP. INDEX
	SC	CG	MA	TS	SS	AW	DU	NP	SG	CL	
Wool Bay	3.34	.06	.14	.06	2.49	.53	.10	-	-	.39	7.11
Site B	4.17	4.31	2.47	4.27	4.54	5.73	6.47	6.09	4.37	2.06	44.48
Jackfish Cove	2.10	0.47	1.74	.98	.52	4.22	1.33	2.43	-	.64	14.43
Moose Bay	.35	-	.47	.04	.04	1.32	.40	.58	-	.26	3.46
Drybones Bay	6.77	3.17	11.15	3.52	3.68	10.28	4.41	16.34	.42	1.41	61.15
Cabin Islands	7.75	11.07	11.76.	13.34	1.15	10.18	6.90	12.83	19.97	1.16	96.11
Matonabbee Bay	5.09	12.59	7.47	7.54	.50	5.57	8.66	10.83	29.16	.26	87.67
Devil's Channel	3.83	9.25	2.93	13.05	.95	6.39	4.31	7.17	4.16	.77	52.81
Goulet-Campbell Bays	14.66	15.99	15.32	25.40	4.80	14.76	14.03	13.33	14.98	.39	133.66
Site J	.53	.01	.06	1.24	.11	1.25	.66	.07	-	.90	4.83
Site K	1.12	.28	.88	.18	.52	.89	.66	1.52	-	.51	6.56
Francois Bay	6.81	10.56	4.50	6.70	8.45	5.57	4.91	10.40	3.33	5.78	67.01
Thor Lake	1.69	.43	.25	-	2.12	.20	.63	.22	-	1.67	7.21
Beaulieu River	41.78	31.81	40.86	23.68	70.14	33.14	46.53	18.19	23.63	83.80	413.56
Total number of records	15918	13319	8778	7241	4625	3036	3015	2760	2404	778	

SC - Unidentified Scaup; CG - Canada Goose; MA - Mallard; TS - Tundra Swan; SS - Surf Scoter; AW - American Wigeon; DU - Unidentified Duck; NP - Northern Pintail; SG - Snow Goose; CL - Common Loon.

depicted in Figure 5. Seven other sites were used moderately and the Beaulieu River was, by far, the most important open-water site.

The abundance of birds in each site did not appear to be related to the amount of open water available. For example, 15% of all sightings were recorded at Goulet-Campbell bays and 6% at Drybones Bay, but both sites had approximately 12.5 km of open water. However, the highest number of birds (40% of all sightings) was recorded at the longest stretch of open water (lower Beaulieu River: 24 km).

4.3 Temporal Distribution of Migrating Species

A peak of migratory activity was recorded on 23 May, when over 13,200 birds were observed. Over 50% of all sightings were recorded on 20, 23 and 26 May; numbers declined sharply after 29 May (Table 5, Figure 6). The migration peaks for each species indicate that Mallards and Common Mergansers were early migrants. They were followed by Tundra Swans, Northern Pintails, American Wigeons and scaups. Late migrants included Northern Shovelers, White-winged Scoters and Oldsquaws.

5.0 DISCUSSION

5.1 Methodological Limitations

In general, aerial surveys underestimate animal numbers (Stott and Olson 1972, Caughley 1974, Savard 1982) because they are subject to a number of biases such as observers' identification skills, observer fatigue, angle of prevailing light, ice

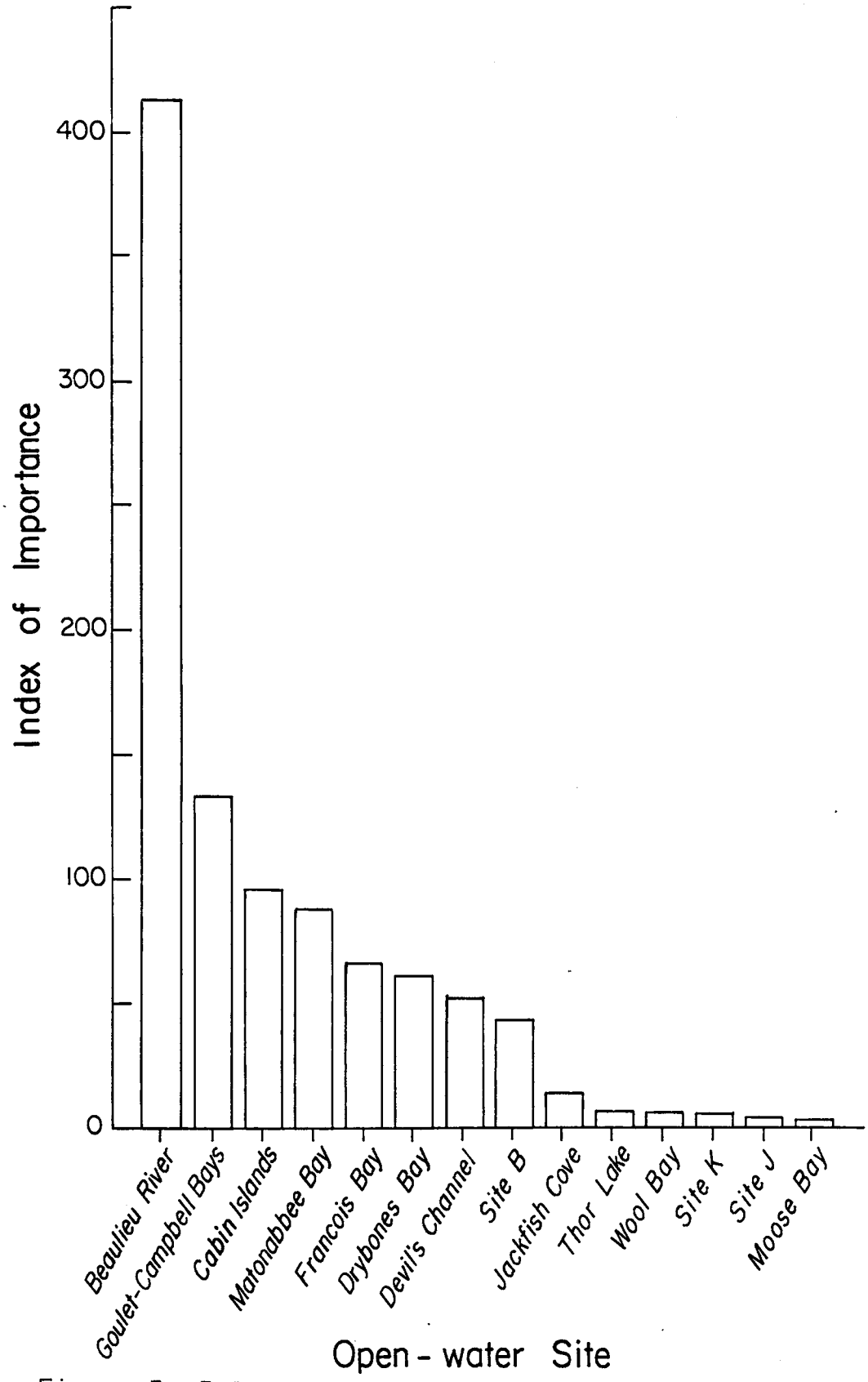

Figure 5. Relative importance of each open-water site to migrating waterfowl, Spring 1988.

Table 5. Temporal abundance of migrating species in the Yellowknife - Thor Lake Area, Spring 1988.

Species	May 10	13	17	20	23	26	29	June 2
Red-throated Loon	-	-	-	-	1	4	-	4
Pacific Loon	-	-	5	22	-	9	8	18
Common Loon	-	3	27	214	357	97	36	44
Yellow-billed Loon	-	-	-	-	-	2	-	6
Horned Grebe	-	-	2	9	2	4	-	2
Red-necked Grebe	4	12	16	55	45	27	15	29
Tundra Swan	259	480	691	1049	1318	1362	1653	429
G.W.-front. Goose	-	2	-	-	196	154	248	2
Lesser Snow Goose	-	-	-	1	582	736	1085	-
Canada Goose	29	25	131	600	3807	4479	4124	124
Unidentified Duck	180	270	468	601	563	473	281	179
Green-winged Teal	-	2	-	10	-	8	9	3
Mallard	2464	2023	2830	588	277	229	180	187
Northern Pintail	-	118	174	547	410	517	868	126
Cinnamon Teal	-	-	-	-	-	-	-	1
Northern Shoveler	-	-	6	16	34	46	18	34
American Wigeon	250	416	464	752	328	471	126	229
Canvasback	2	-	86	96	227	172	38	58
Ring-necked Duck	-	4	-	-	150	35	45	22
Unidentified Scaup	2	484	3922	4785	3032	1799	1329	565
Harlequin Duck	-	-	-	-	-	2	-	-
Oldsquaw	-	-	-	40	103	228	46	59
Black Scoter	-	-	-	-	-	2	2	-
Surf Scoter	-	-	153	652	1470	1184	989	177
White-winged Scoter	-	-	-	-	91	98	12	208
Common Goldeneye	-	1	-	8	-	6	4	-
Bufflehead	32	96	107	100	76	32	22	21
Common Merganser	40	63	23	44	36	25	4	6
Red-breasted Merganser	10	16	66	78	111	207	182	106
Ruddy Duck	-	-	-	4	2	-	-	-
Osprey	-	1	-	-	1	1	-	-
Bald Eagle	2	6	11	7	8	8	1	11
Northern Harrier	1	1	-	2	-	-	-	-
Rough-legged Hawk	1	1	-	-	-	2	-	-
Sandhill Crane	-	-	-	2	-	-	1	-

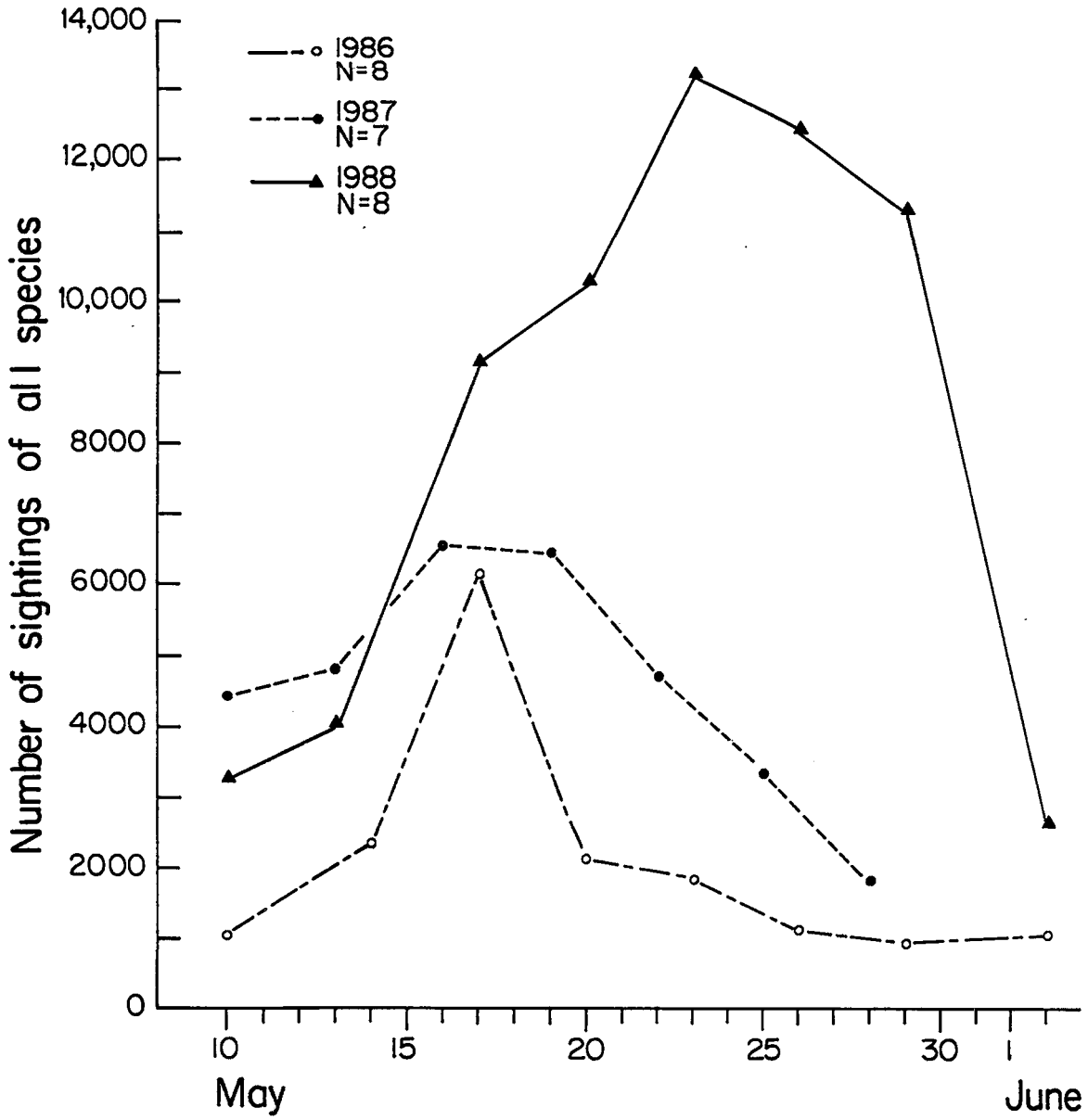

Figure 6. Temporal distribution of migrating waterfowl in the Yellowknife - Thor Lake area, Spring 1986-1988.

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 Teals 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 two. However, we believe that a representative picture of the spring migration emerged and that real differences between sites were satisfactorily established. At no time did we attempt to determine the absolute number or turnover rate of birds staging in the area. Our records constitute an indicator of the importance of the staging sites and provide insight into the relative abundance of each species. No visibility correction factor is available for this region with respect to waterbirds during spring migration.

5.2 Abundance of Migrating Species

Twice as many sightings were recorded in 1988 (66,386) than in 1987 (32,485), and four times more than in 1986 (16,766). Nevertheless, a similar number of species were identified each year: 34, 29, and 31 respectively. Overall peak numbers were comparable in 1986 and 1987 (between 6,000 and 7,000 birds), but the 1988 peak was twice as high (13,200 birds). Some species were present in particularly high numbers during the 1988 spring migration.

The peak numbers of at least seven species were markedly higher in 1988 than in previous years: Common Loon, Oldsquaw, Lesser Snow Goose, Mallard, Surf Scoter, Canada Goose, and Scaup sp. (see Table 3). Two climatological factors may have contributed to such deviations: a late spring break-up in the Great Slave Lake region, and the drought in the North American Prairies (see Anon. 1988a).

In 1988, spring break-up occurred approximately 15 days later than in 1987 and 1986. This is best appreciated by comparing ice conditions between years (Table 1; see Sirois 1987, Sirois and McCormick 1987). As a result, relatively little ice-free waters and wetlands were available in the region until late May and many species were observed in unusual concentrations in relatively few locations. Because all species which displayed sharp increases occur regularly in NWT, we believe that their inflated numbers were primarily due to late break-up. However, Mallards, Northern Shovelers, Canvasbacks and scaups, all of which were markedly or somewhat more abundant in 1988 (see Tables 2 and 3), are also common Prairie species (Bellrose 1976, Godfrey 1986, Anon. 1986). We suspect that their higher numbers in the study area may also have been caused by the displacement of individuals from the Prairies as a result of the severe drought in 1988.

The latter four species were adversely affected by the drought (CWS unpubl. data). The presence of drought-displaced ducks around Great Slave Lake is suggested by unusual observations of species that usually occur in the Prairies (Table 6) and by

Table 6. Prairie bird species observed around or near Great Slave Lake in May and June 1988.

Species/Number	Location	Date	Observer
Wilson's Phalarope/1	Niven Lake/ Yellowknife	26 May	D. Livingston
American Avocet/2	Fort Smith	17 May	E. Kuyt
Yellow-headed Blackbird/1	Willow Flats/ Yellowknife	27 May	M. Fournier
Cinnamon Teal/1	Wool Bay/ Great Slave Lake	2 June	J. Sirois
Cinnamon Teal/1 (unconfirmed)	Back Bay/Yellowknife	2 June	B. Warner
Gadwall/several	Mackenzie Highway near Yellowknife	20 May	D. Kay
Gadwall/9	Stagg River wetlands near Rae-Edzo	29 May	M. Fournier

anecdotal but repeated observations of hundreds of non-breeding ducks, in early summer, in numerous bays of Great Slave Lake (J. Sirois, pers. obs.). So many Prairie species which are unusual in our region, were not observed in 1986 and 1987, nor were such numbers of non-breeding ducks in Great Slave Lake. The displacement of birds toward wetter and/or northern Prairie locales has been observed before in the northern Canadian Prairies (Anon. 1988b), and in Alaska (Derksen and Elridge 1980). Given the magnitude of the drought in the Prairies (Anon. 1988a), we suspect that some of its impacts were recorded around Great Slave Lake. As suggested by Kuyt (1988) and by the observations in Table 6, it appears that not only ducks can be displaced by drought on the Prairies.

Additional, interesting observations include that of Black Scoters, Ruddy Ducks, Harlequin Ducks and Yellow-billed Loons. Black Scoters are rarely observed in this region (Godfrey 1986). They are not mentioned in Bromley and Trauger's (n.d.) regional bird checklist. However, they were also observed in 1986 and may be less rare than previously thought. Ruddy Ducks are also rare about Great Slave Lake but not accidental, as suggested by Bromley and Trauger. They were reported in similar numbers, but in different locations, in 1987 and 1988. Regular but infrequent sightings have also been recorded in the last three years along the Mackenzie Highway, near Yellowknife (D. Kay, M. Fournier, R. Cole, pers. obs.), but breeding has not been recorded. The Harlequin Duck is a rare breeder in the region (Bromley and Trauger n.d.). In 1988, several individuals were reported around

Great Slave Lake, two of which during this survey, on the lower Beaulieu River. Three more individuals were observed between 7-17 May on the lower Yellowknife River, near Yellowknife (J. Sirois, pers. obs.), and another three, on the Mackenzie River at Fort Providence, on 23 May (M. Fournier, pers. obs.). Movements of Harlequin Ducks were perhaps more numerous than usual around Great Slave Lake in 1988, or late break-up, and the relative scarcity of open water, concentrated them in fewer locales where they were easier to detect. Yellow-billed Loons are rare spring and summer transients in the region (Bromley and Trauger n.d.). They were not observed during the 1986 and 1987 surveys. As many as six were observed together at Francois Bay on 2 June. Again, we suspect that late break-up forced them to concentrate in few open-water locales, rendering them easier to detect.

5.3 Spatial Distribution of Migrating Species

The relative importance of the 14 surveyed sites to waterfowl varied considerably. Six sites were poorly used, seven sites were moderately used, and only one site, the lower Beaulieu River, was highly used (Fig. 5). These results were consistent with those of 1987 and 1986. Beaulieu River has remained in first position for the last three years, and the six low-use sites have remained at the bottom of the scale. Only the moderately used sites have shifted positions, but within a comparable range (Appendix 16). Such consistency suggests that the sites have been appropriately ranked.

Sites with equivalent amounts of open water did not necessarily

support the same number of birds. This suggests that some areas were more attractive than others. Although the assessment of the habitat available at each site was beyond the scope of this project, birds were always more abundant where extensive shallows or pools were available early in the spring, along river systems or in wetlands adjacent to Great Slave Lake. We suspect that wetlands along rivers and creeks, or connected to Great Slave Lake, were more productive because of a better supply of nutrients from surrounding aquatic environments.

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 on the north side of Great Slave Lake can support substantial numbers of birds. In fact, the numbers of waterbirds recorded in the study area this year, are comparable to those previously recorded in the Slave River Delta (Thompson et al. 1979).

For the last three years, the Thor Lake site ranked ninth or tenth in importance among the 14 sites. Less than 1% of all sightings were recorded there in 1988, about 5% in 1987, and 4% in 1986. The relatively low use of the area by spring waterbirds was likely caused by late break-up and less productive wetlands. Because of the proximity of Great Slave Lake's East Arm and the treeline, where subarctic to low-arctic conditions prevail, ice conditions at Thor Lake and environs are usually one week late,

compared to those in the North Arm. When the waterbird spring migration peaks, ice-free habitat is much less available near Thor Lake than in the North Arm. Furthermore, the Thor Lake study site does not benefit from any noticeable input of nutrients from a river or adjacent Great Slave Lake.

5.4 Temporal Distribution of Migrating Species

Spring weather and ice conditions had a definite impact on the chronology and pattern of the 1988 waterbird migration. A number of deviations from the long-term daily mean were apparent as cold temperature records were set (see section 2.1). Temperatures were lower than average throughout the study period. Whereas the 1987 waterbird spring migration was slightly later than in 1986, this year's migration was even more delayed as northerly winds and freezing temperatures were recorded until the end of May. Whereas waterbird numbers peaked rapidly and declined before 20 May, in 1986; peaked slowly and remained high for a few days prior to 20 May, in 1987; they peaked on 23 May and remained very high until 29 May, in 1988. This 10-day delay in 1988, compared to 1986, is a good reflection of the 10 to 15-day delay in the ice break-up.

6.0 CONCLUSION

Much higher numbers of staging waterbirds were present in the study area in 1988 than in 1987 and 1986. This sharp increase appeared to have been caused by a late spring break-up which forced birds to concentrate in relatively few areas where open water was available. We suspect that some drought-displaced birds from the Prairies were also present in the region; but because

all species that featured sharp increases occur normally in this region, we conclude that the increases were caused mainly by late break-up.

The restricted amount of ice-free wetlands and waters in May 1988 favoured the concentration of waterbirds in relatively few sites. Accordingly, it likely enabled us to quantify more accurately the spring staging population in the study area. No visibility correction factor is available for spring staging waterbirds in our region. However, if we assume that staging waterbirds congregate and behave in patterns similar to wintering waterbirds wherever they are, and use a correction factor of 2.02, as derived for fix-winged aircraft surveys of wintering waterfowl (Stott and Olson 1972), up to nearly 27,000 birds were present in the study area on 23 May. The vastness and apparent productivity of many wetlands along the shoreline of Great Slave Lake, between Yellowknife and the Thor Lake site, suggest that this estimate is acceptable.

Given the peak number of Tundra Swans recorded in 1988 (1,653) and 1987 (1,382), we suggest that the Yellowknife - Thor Lake area be designated as a Key Habitat Site (McCormick et al. 1984). Indeed, for two consecutive years, at least 1% of the North American Tundra Swan population, or 2% of the eastern population (Anon. 1986), was present in the study area. Unfortunately, peak numbers do not enable us to determine the total number of swans staging in the area. A much bigger portion of their North American population likely stages in the North Arm.

This third series of surveys clearly indicate that the Thor Lake site is of no particular significance to spring staging waterbirds. This is consistent with previous assessments in 1986 and 1987. Given the habitat characteristics of the Thor Lake site and the abundance of similar habitat in the region, we believe that the area resembles nearby Bullmoose Lake (see Arner and Verreault 1985), and consequently is of no particular significance to migratory waterbirds. The mine should have a negligible impact, if any, on the regional population of migratory birds.

7.0 LITERATURE CITED

Anonymous. 1986. North American Waterfowl Management Plan. U.S. Dept. Inter. and Env. Can., Ottawa. 19 pp.

Anonymous. 1988a. 1988 "Dismal for waterfowl". Fish and Wildl. Ref. Serv. Newsletter No. 80. Rockville. 6 pp.

Anonymous. 1988b. 1988 Waterfowl breeding populations and habitat conditions. In North Amer. Waterf. Manag. Plan, West. and North. Reg. Newsletter No. 10. Can. Wildl. Serv. Edmonton. 3 pp.

Arner, B. D. and G. Verreault. 1985. A survey of birds in the area surrounding Bullmoose Lake Gold Mine, Northwest Territories. Tech. Rept. No. 85-5, Can. Wildl. Serv., Yellowknife. 25 pp.

Atmospheric Environment Service. 1982. Canadian climate normals, 1951-1980. Vol. 2 - Temperature. Downsview, Ontario. 306 pp.

Bellrose, F.C. 1976. Ducks, geese and swans of North America. Stackpole Books. Harrisburg. 544 pp.

Bostock, H. S. 1970. Physiographic subdivisions of Canada. Pp. 11-30 In: R. J. W. Douglas (Ed.). Geology and Economic Minerals of Canada. Econ. Geol. Rept. No. 1, Geol. Surv. Can., Ottawa.

Bromley, R.G. and D.L. Trauger. n.d. Birds of Yellowknife. A regional checklist. 12 pp.

Caughley, G. 1974. Bias in aerial survey. J. Wildl. Manage. 38:921-933.

Derksen, D.V., and W.D. Elridge. 1980. Drought-displacement of pintails to the Arctic coast plain, Alaska. J. Wildl. Manage. 44:224-229.

Godfrey, W. E. 1986. Birds of Canada, Rev. Ed. Nat. Mus. Nat. Sci., Ottawa. 650 pp.

Kuyt, E. 1988. A recent record of American Avocet in the Northwest Territories. Alberta Naturalist 19(1): (in press).

Lockerbie, C. 1988. Geologist's heaven - Thor Lake closer to revealing its treasure. Yellowknifer, Dec. 14. Yellowknife.

McCormick, K.J., M.E. Adams, C.J. Stephenson, and A.S. Goodman. 1984. Key migratory bird terrestrial habitat sites in the Northwest Territories. Tech. Rep. 84-6, Can. Wild. Serv. Yellowknife. 175 pp.

Regional Environmental Review Committee. 1988. Minutes of meeting No. 56. Dept. of Ind. Aff. and North. Develop. Yellowknife. 3 pp.

Savard, J. P. L. 1982. Variability of waterfowl aerial surveys: observer and air-ground comparisons - A preliminary report. Prog. Note No. 127, Can. Wildl. Serv., Ottawa. 6 pp.

Sirois, J. and K. McCormick. 1987. Spring migration of waterfowl in the Yellowknife-Thor Lake area, NWT: 1986. Tech. Rept. Ser. No. 24, Can. Wildl. Serv. Yellowknife. 36 pp.

Sirois, J. 1987. Spring migration of waterfowl in the Yellowknife-Thor Lake area, NWT:1987. Tech. Rept. Ser. No. 32, Can. Wildl. Serv. Yellowknife. 38 pp.

Stott, R. S. and D. P. Olson. 1972. An evaluation of waterfowl surveys on the New Hampshire coastline. J. Wildl. Manage. 36:468-477.

Thompson, R.G., R.W. Quinlan, and K. Ambrock. 1979. Assessment of migratory bird resources in the Slave River delta. Final report prepared for the Mackenzie River Basin Task Force. Can. Wildl. Serv. 92 pp.

Wiken, E. 1986. Terrestrial ecozones of Canada. Ecol. Land Classif. Ser. No. 19, Lands Direct., Envir. Can., Ottawa. 26 pp.

Appendix 1. Scientific names of bird species observed in the Yellowknife-Thor Lake area, Spring 1988.

North American English name	Scientific Name	Species code in this report
Red-throated Loon	Gavia stellata	RL
Pacific Loon	Gavia pacifica	PL
Common Loon	Gavia immer	CL
Yellow-billed Loon	Gavia adamsii	Y1
Horned Grebe	Podiceps auritus	HG
Red-necked Grebe	Podiceps grisegana	RG
Tundra Swan	Cygnus 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
Cinnamon Teal	Anas cyanoptera	CT
Northern Shoveler	Anas clypeata	NS
American Wigeon	Anas americana	AW
Canvasback	Aythya valisneria	CA
Ring-necked Duck	Aythya collaris	RD
Unidentified Scaup	Aythya sp.	SC
Harlequin Duck	Histrionicus histrionicus	HD
Oldsquaw	Clangula hyemalis	O1
Black Scoter	Melanitta nigra	BS
Surf Scoter	Melanitta perspicillata	SS
White-winged Scoter	Melanitta fusca	WS
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 1988.

Date	CL	RG	TS	CG	GT	MA	CT	AW	CA	SC	OL	SS	WS	GO	BU	CM	RM	DU
	Species																	
10 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17 May	-	-	-	-	-	4	-	8	-	8	-	-	-	-	-	-	-	-
20 May	-	2	2	8	-	-	-	-	-	80	-	60	-	2	-	-	-	-
23 May	-	-	-	-	-	2	-	-	16	110	20	10	-	-	-	8	-	-
26 May	2	2	-	-	-	-	-	2	10	48	11	-	-	-	-	-	8	-
29 May	1	7	2	-	1	4	-	2	6	208	-	45	-	-	-	-	8	3
2 June	-	7	-	-	-	2	1	4	12	78	-	-	10	-	4	-	-	-

Appendix 3. Abundance of migrating species at Moose Bay, Spring 1988.

Date	CL	TS	GT	MA	NP	AW	SC	SS	CM	RM	DU
	Species										
10 May	-	-	-	1	-	-	-	-	-	-	-
13 May	-	-	-	-	-	-	-	-	-	-	-
17 May	-	-	-	14	-	-	2	-	4	2	8
20 May	-	-	-	4	-	12	40	-	6	-	4
23 May	-	3	-	-	-	10	-	-	3	2	-
26 May	1	-	2	16	-	10	12	-	-	4	-
29 May	-	-	-	6	6	6	-	2	-	2	-
2 June	1	-	-	-	10	2	2	-	-	-	-

Appendix 4. Abundance of migrating species at Jackfish Cove, Spring 1988.

Date	CL	RG	TS	CG	MA	NP	AW	SC	SS	WS	BU	CM	RM	DU
	Species													
10 May	-	-	6	-	30	-	-	-	-	-	-	-	-	-
13 May	-	-	2	1	50	6	30	-	-	-	-	-	-	-
17 May	-	-	22	20	62	40	60	10	-	-	-	-	-	-
20 May	-	2	6	30	-	2	20	210	4	-	20	-	6	-
23 May	5	2	13	-	-	-	12	90	20	10	-	2	-	25
26 May	-	-	10	-	2	5	4	12	-	-	-	-	2	10
29 May	-	-	8	-	7	14	2	-	-	-	-	-	-	-
2 June	-	-	4	12	2	-	-	12	-	-	-	-	2	5

Appendix 5. Abundance of migrating species at Cabin Islands, Spring 1988.

Date	RL	PL	CL	RG	TS	GG	SG	CG	MA	NP	NS	AW	CA	SC	OL	SS	WS	BU	CM	RM	DU	OS	BE
	Species																						
10 May	-	-	-	-	48	-	-	25	503	-	-	60	-	-	-	-	-	-	-	-	-	-	-
13 May	-	-	-	-	56	-	-	-	300	60	-	50	-	50	-	-	-	2	-	-	-	-	1
17 May	-	-	1	-	147	-	-	46	162	34	-	87	-	432	-	-	-	-	-	6	30	-	1
20 May	-	-	-	-	194	-	-	138	40	93	-	52	20	594	-	30	-	2	10	12	70	-	-
23 May	1	-	-	2	125	-	120	600	4	37	6	14	18	48	-	3	-	-	-	15	26	1	2
26 May	-	3	5	2	151	-	300	520	12	46	4	20	16	74	30	-	-	-	2	18	80	-	3
29 May	-	-	2	-	207	22	60	145	-	74	2	10	-	6	-	-	-	-	-	12	-	-	-
2 June	-	-	1	-	38	-	-	-	11	10	4	16	-	30	-	20	30	4	-	10	2	-	-

Appendix 6. Abundance of migrating species at Site B, Spring 1988.

	Species																							
Date	PL	CL	HG	RG	TS	SG	CG	GT	MA	NP	NS	AW	CA	RD	SC	OL	SS	WS	BU	CM	RM	RU	DU	RK
10 May	-	-	-	-	4	-	-	-	27	-	-	-	-	-	-	-	-	-	-	3	-	-	-	1
13 May	-	-	-	-	14	-	2	-	60	-	-	20	-	-	-	-	-	-	-	4	-	-	-	-
17 May	-	-	-	-	26	-	-	-	26	-	-	6	-	-	40	-	-	-	2	4	2	-	-	-
20 May	-	-	-	1	28	-	32	-	32	90	-	74	10	-	180	-	-	-	2	4	2	-	60	-
23 May	-	-	-	-	51	20	150	-	42	4	-	30	2	10	76	16	14	-	2	2	2	2	25	-
26 May	-	7	2	-	93	30	210	2	2	20	12	44	22	-	164	10	111	15	-	-	32	-	50	-
29 May	-	3	-	-	81	55	180	-	-	42	6	-	-	-	190	-	80	-	-	-	10	-	60	-
2 June	2	6	-	1	12	-	-	-	28	12	2	-	2	-	14	-	5	22	2	-	10	-	-	-

Appendix 7. Abundance of migrating species at Drybones Bay, Spring 1988.

	Species																							
Date	RT	PL	CL	RG	TS	SG	CG	GT	MA	NP	NS	AW	CA	RD	SC	OL	SS	WS	BU	CM	RM	DU	BE	NH
10 May	-	-	-	-	13	-	-	-	424	-	-	20	-	-	-	-	-	-	-	-	-	-	1	-
13 May	-	-	-	-	14	-	10	-	310	42	-	95	-	-	60	-	-	-	-	2	-	50	-	1
17 May	-	-	-	-	25	-	-	-	128	30	-	80	-	-	140	-	10	-	38	-	-	-	2	-
20 May	-	-	-	-	16	-	2	10	34	90	-	46	10	-	184	-	10	-	-	4	-	-	1	-
23 May	-	-	-	-	54	-	80	-	12	41	24	26	130	30	174	-	50	-	-	8	10	-	4	-
26 May	1	-	7	2	63	10	140	2	15	74	-	22	2	-	296	-	50	63	4	-	5	50	-	-
29 May	-	-	1	-	38	-	180	-	40	158	2	12	-	-	100	-	50	-	-	-	-	3	-	-
2 June	1	1	3	2	32	-	10	-	16	16	10	11	25	-	124	7	-	62	-	-	2	30	1	-

Appendix 8. Abundance of migrating species at Matonabbee Bay, Spring 1988.

Date	CL	RG	TS	SG	CG	GT	MA	NP	NS	AW	CA	RD	SC	OL	SS	WS	BU	RM	RU	DU	BE	CR
	Species																					
10 May	-	-	42	-	2	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13 May	-	2	12	-	-	-	100	10	-	25	-	-	50	-	-	-	20	-	-	60	-	-
17 May	-	3	34	-	17	-	290	10	-	32	46	-	115	-	3	-	-	10	-	60	3	-
20 May	-	-	75	1	113	-	15	70	6	64	6	-	420	-	-	-	-	-	4	-	-	-
23 May	-	6	137	300	440	-	2	52	-	14	37	30	160	-	20	-	-	20	-	-	-	-
26 May	-	2	108	150	720	-	19	36	4	22	10	-	52	3	-	-	-	20	-	66	-	-
29 May	-	-	99	250	375	-	15	101	-	2	10	-	4	-	-	-	-	4	-	35	-	1
2 June	2	1	39	-	10	2	15	20	4	10	-	-	10	20	-	52	-	5	-	40	1	-

Appendix 9. Abundance of migrating species at Devil's Channel, Spring 1988.

Date	PL	CL	RG	TS	GG	SG	CG	MA	NP	NS	AW	CA	SC	SS	GO	BU	RM	DU	BE	NH	RK
	Species																				
10 May	-	-	-	1	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	1	-
13 May	-	-	-	8	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	1
17 May	-	1	-	56	-	-	-	70	-	-	10	-	110	-	-	2	-	-	-	-	-
20 May	-	-	-	131	-	-	60	2	112	-	40	-	150	-	6	6	8	60	-	-	-
23 May	-	-	6	170	-	-	18	17	32	-	34	-	90	6	-	-	4	-	1	-	-
26 May	-	1	2	224	50	50	520	8	32	10	46	-	115	28	-	4	22	-	1	-	-
29 May	-	-	-	231	-	50	600	10	22	-	-	8	10	-	-	-	4	40	-	-	-
2 June	2	4	-	124	2	-	34	10	-	-	64	-	135	10	-	-	6	30	-	-	-

Appendix 10. Abundance of migrating species at Goulet-Campbell Bays, Spring 1988.

	Species																							
Date	PL	CL	RG	TS	GG	SG	CG	GT	MA	NP	NS	AW	CA	RD	SC	OL	SS	WS	BU	CM	RM	DU	BE	NH
10 May	-	-	-	45	-	-	-	-	420	-	-	50	-	-	-	-	-	-	-	-	-	100	-	-
13 May	-	-	-	139	2	-	-	-	240	-	-	50	-	-	60	-	-	-	-	-	-	-	2	-
17 May	-	-	-	210	-	-	26	-	490	20	-	12	-	-	860	-	-	-	4	-	3	160	-	-
20 May	-	-	4	325	-	-	66	-	108	24	-	190	26	-	834	-	24	-	6	-	6	50	1	1
23 May	-	-	-	353	66	120	1000	-	28	80	-	54	-	-	168	-	56	-	4	4	10	20	-	-
26 May	-	2	4	304	-	90	600	2	18	72	14	44	50	25	152	70	50	14	2	-	26	70	2	-
29 May	-	-	2	403	26	150	435	-	-	136	2	16	14	-	234	-	92	-	2	-	12	11	-	-
2 June	1	1	4	60	-	-	3	1	41	36	14	32	-	-	26	32	-	-	2	-	14	12	5	-

Appendix 11. Abundance of migrating species at Site J, Spring 1988.

	Species											
Date	CL	TS	CG	MA	NP	AW	SC	SS	BU	RM	DU	NH
10 May	-	-	-	-	-	-	-	-	-	-	-	-
13 May	-	-	-	-	-	-	-	-	-	-	-	-
17 May	-	-	-	-	-	-	-	-	-	-	-	-
20 May	2	4	-	-	-	20	20	-	-	-	10	1
23 May	-	10	-	-	-	-	20	2	2	-	-	-
26 May	-	17	2	3	-	14	20	-	2	2	-	-
29 May	-	42	-	-	2	-	4	-	-	-	10	-
2 June	5	17	-	2	-	4	20	3	-	3	-	-

Appendix 12. Abundance of migrating species at Site K, Spring 1988.

Date	Species															
	CL	RG	TS	CG	MA	NP	AW	CA	SC	OL	SS	WS	BU	RM	DU	BE
10 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17 May	-	-	-	-	40	-	10	-	10	-	-	-	-	-	-	1
20 May	-	-	2	-	20	-	-	-	80	-	-	-	-	-	-	-
23 May	-	-	5	25	2	-	-	-	34	-	2	-	8	-	20	-
26 May	-	-	4	12	6	20	2	10	46	8	-	4	2	2	-	-
29 May	-	4	2	-	4	22	6	-	2	-	10	-	-	3	-	-
2 June	4	-	-	-	5	-	9	-	6	-	12	-	-	-	-	1

Appendix 13. Abundance of migrating species at Francois Bay, Spring 1988.

Date	Species																							
	RL	CL	YL	HG	RG	TS	GG	SG	CG	MA	NP	NS	AW	CA	SC	OL	SS	WS	BU	CM	RM	DU	BE	RK
10 May	-	-	-	-	-	2	-	-	-	120	-	-	-	-	-	-	-	-	-	-	4	-	-	-
13 May	-	-	-	-	-	4	-	-	-	60	-	-	-	-	-	-	-	-	6	-	4	-	-	-
17 May	-	-	-	-	-	12	-	-	-	112	-	-	-	-	100	-	-	-	2	-	-	-	-	-
20 May	-	-	-	-	-	5	-	-	12	39	30	-	24	-	192	-	30	-	6	-	6	-	3	-
23 May	-	28	-	2	-	106	30	-	200	40	2	4	68	2	304	45	45	-	6	3	2	65	1	-
26 May	-	7	2	-	1	92	-	60	264	9	124	2	31	2	302	28	90	2	4	-	14	30	-	1
29 May	-	9	-	-	-	203	100	20	930	5	119	6	16	-	170	26	140	-	-	-	-	23	-	-
2 June	3	1	6	-	-	61	-	-	-	10	12	-	30	-	16	-	86	30	4	-	5	30	-	-

Appendix 14. Abundance of migrating species at Thor Lake, Spring 1988.

	Species																		
Date	RL	PL	CL	RG	CG	MA	NP	AW	SC	OL	SS	WS	BU	RM	DU	OS	BE	RK	CR
10 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13 May	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	1	1	-	-
17 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20 May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
23 May	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
26 May	2	-	2	-	2	7	2	6	36	2	4	-	2	-	7	1	-	1	-
29 May	-	8	3	-	-	2	2	-	165	-	77	10	6	2	2	-	-	-	-
2 June	-	12	8	3	55	3	2	-	68	-	17	2	2	2	8	-	-	-	-

Appendix 15. Abundance of migrating species on the lower Beaulieu River, Spring 1988.

	Species																											
Date	RL	PL	CL	HG	RG	TS	GG	SG	CG	GT	MA	NP	NS	AW	CA	RD	SC	HD	OL	BS	SS	WS	GO	BU	CM	RM	DU	BE
10 May	-	-	-	-	4	98	-	-	2	-	679	-	-	120	2	-	2	-	-	-	-	-	-	32	37	6	80	1
13 May	-	-	3	-	10	231	-	-	12	2	813	-	-	146	-	4	264	-	-	-	-	-	1	68	57	12	160	2
17 May	-	5	25	2	13	159	-	-	22	-	1432	40	6	159	40	-	2095	-	-	-	140	-	-	59	15	43	210	4
20 May	-	22	212	9	46	261	-	-	139	-	294	36	10	210	24	-	1801	-	40	-	494	-	-	58	20	38	345	2
23 May	-	-	324	-	29	291	100	22	1294	-	128	162	-	66	22	80	1758	-	22	-	1242	81	-	52	6	46	382	-
26 May	1	6	63	2	12	296	104	46	1489	-	112	86	-	204	50	10	470	2	66	2	851	-	6	12	23	52	110	2
29 May	-	-	17	-	2	337	100	500	1279	8	87	170	-	54	-	45	236	-	20	2	493	2	4	14	4	125	94	1
2 June	-	-	8	2	11	42	-	-	-	-	42	8	-	47	19	22	24	-	-	-	24	-	-	3	6	47	22	3

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

Site	Relative importance* 1988	1987	1986	Number of species 1988	1987	1986	Amount of open water (km) **
Beaulieu River	1	1	1	28	23	22	24.0
Goulet-Campbell bays	2	3	4	24	20	18	12.5
Cabin Islands	3	4	3	23	22	17	7.7
Matonabbee Bay	4	2	7	22	16	13	8.0
Francois Bay	5	7	5	24	15	18	9.5
Drybones Bay	6	8	8	24	15	17	12.5
Devil's Channel	7	5	2	24	16	16	6.0
Site B	8	6	6	24	16	17	4.5
Jackfish Cove	9	11	11	14	9	12	3.5
Thor Lake Study Site	10	9	9	19	19	17	36.0***
Wool Bay	11	10	10	18	19	11	3.0
Site K	12	13	14	16	14	11	4.5
Site J	13	12	12	12	10	9	4.5
Moose Bay	14	14	13	11	9	10	3.5

* Relative importance determined by "Index of Importance", see 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.