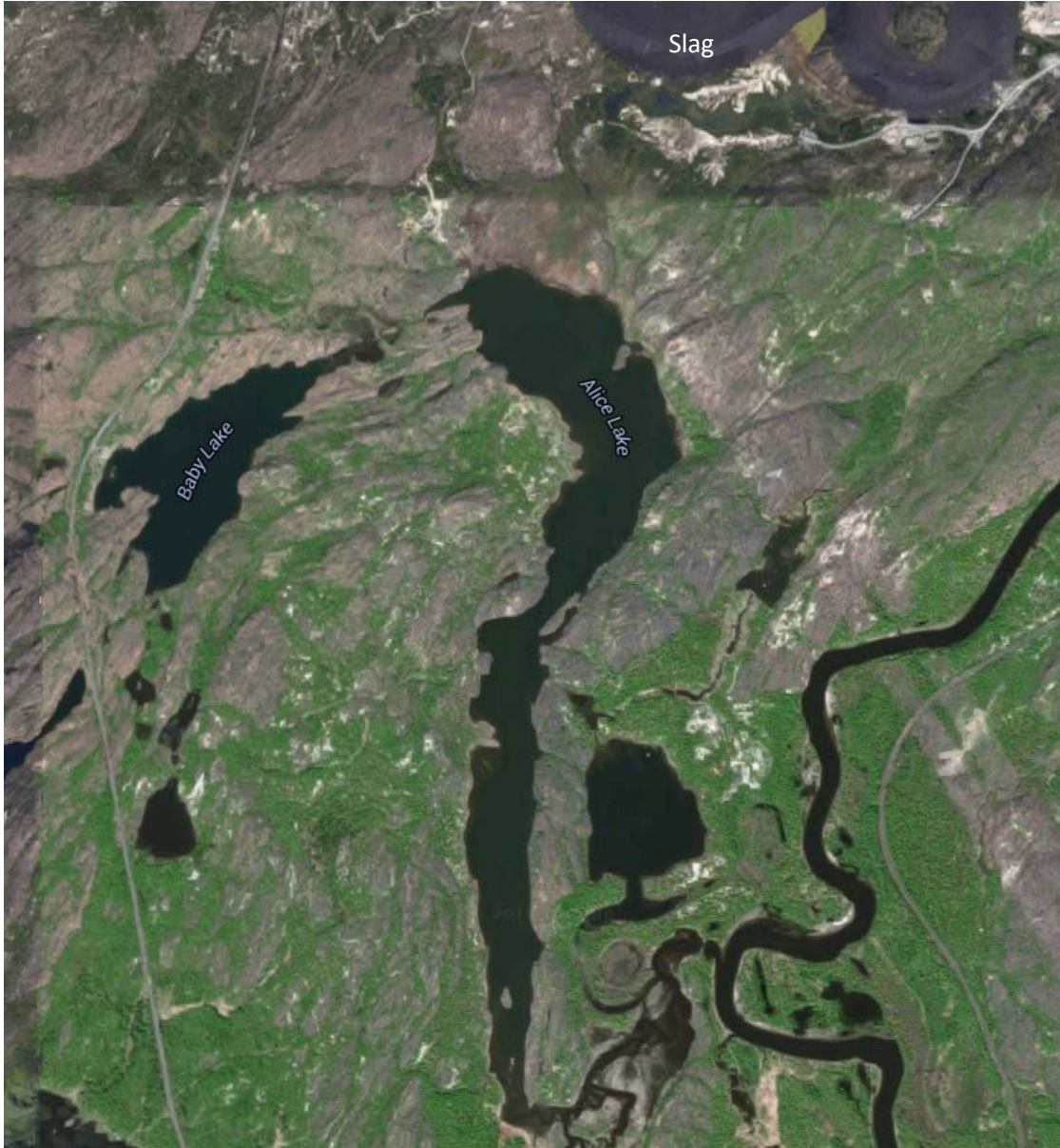


ALICE LAKE
URBAN LAKES FISHERIES STUDY 2014



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INTRODUCTION

Alice Lake (46°27'43" N, 80°51'11" W) is a 27.0 ha lake located just south of the edge of the slag pile near the abandoned Coniston smelter which closed in 1972. Alice Lake is comprised of three main basins and has a maximum depth of 14.0 m (Figure 1). As the cover picture illustrates it drains into the Wahnapiatae River. A complete summary of physical characteristics is provided in Table 1.

Limnological studies have occurred on Alice Lake as early as 1968 primarily led by University of Toronto researchers (Hutchinson and Havas, 1986). Due to its close proximity to the Coniston smelter, Alice Lake had severely degraded water quality in the 1950's and 60's (Havas *et al.*, 1995). Ministry of Natural Resources and Forestry (MNRF) records indicate that Alice Lake has never been stocked (Ontario Ministry of Natural Resources, 2013)

In 2014, as part of the Urban Lakes Study, field crews from Laurentian University's Cooperative Freshwater Ecology Unit surveyed Alice Lake, along with several other lakes around Greater Sudbury. The lake had previously been surveyed in 2006 and 1990.

Table 1 Alice Lake location and physical description (Kirk *et al.*, 1990).

Township	Neelon
Latitude/Longitude	46°27'43"N/80°51'11"W
MNRF District	Sudbury
Watershed Code	2DB
Elevation (m)	725
Shoreline Development Factor	2.47
Number of Cottages/Lodges	0
Forest Type	Semi-barren
Shoreline Type	Bedrock/rubble and clay
Lake Surface Area (ha)	27.0
Maximum Depth (m)	14.0
Mean Depth (m)	5.14
Volume (10⁴m³)	138.77
Secchi (m)	4.75 (July 19, 2014)
Access	Private road via Lopes Ltd. property (formerly Coniston smelter) 3.5 km south of Coniston.

METHODS

Fisheries Community Assessment

The fish community of Alice Lake in both 2006 and 2014 was sampled according to the Nordic Index Netting protocol (Appelberg, 2000; Morgan and Snucins, 2005). This netting procedure was developed in Scandinavia and has been used extensively across northeastern Ontario since 1999 (Selinger *et al.*, 2006) to assess the relative abundance and biomass of fish species and provide biological information on the population's status (Morgan and Snucins, 2005).

A total of 16 multi-mesh gillnets were set in Alice Lake from July 17 to 20, 2014. Nets were set for approximately 12 hours at randomly selected locations on the lake across multiple depth strata (5 nets in <3.0 m; 5 nets in 3.0 - 5.9 m; 3 nets in 6.0 – 11.9 m; 3 nets in 12.0 – 19.9 m). Figure 2 shows the locations of all gillnets set in Alice Lake during the survey.

All fish captured were identified to species and tallied by net. Biological information such as fork and total length (mm), weight (g), sex and maturity, and stomach contents were recorded for all large-bodied species. Ageing structures were collected from all of these species, and a muscle tissue sample was collected from up to 20 individuals of each species across a size range for contaminant and stable isotope analysis. All other fish were measured (total length only) and bulk weighed for each net. A bulk sample of up to 20 individuals per species was collected for contaminant and stable isotope analysis.

Baseline Organisms

Attempts were made to collect samples of clams ($n=10$), snails ($n=30$), crayfish ($n=20$), Heptageniid mayflies ($n=50$), *Chaoborus* sp. ($n=300$) and aquatic plants from Alice Lake for food web studies.

Clams and snails were targeted by visually scanning near-shore areas and picking the organisms by hand or with a dip net. Crayfish were targeted by setting three to five wire mesh minnow traps baited with canned cat food overnight in littoral areas. Heptageniid mayflies were targeted by turning over rocks and woody debris along the shore of Alice Lake, and picking the organisms off the surface by hand or with a pair of tweezers. A bulk sample of up to five plants of the same species was targeted by visually scanning the near-shore areas of Alice Lake and picked by hand.

Water Quality Assessment

A dissolved oxygen (mg/L) and temperature (°C) profile was measured in the main basin of Alice Lake on July 19, 2014, using a YSI Model 52 dissolved oxygen – temperature meter. Readings were taken at 0.5 m intervals through the water column.

Water samples were collected on July 17, 2014 from the surface of Alice Lake. Samples were sent to the Ministry of Environment and Climate Change (MOECC) chemistry lab in Dorset, and analyzed for pH, conductivity, total inlection point alkalinity, dissolved organic carbon, metals and major ions.

The sampling location for water quality can be seen in Figure 2.

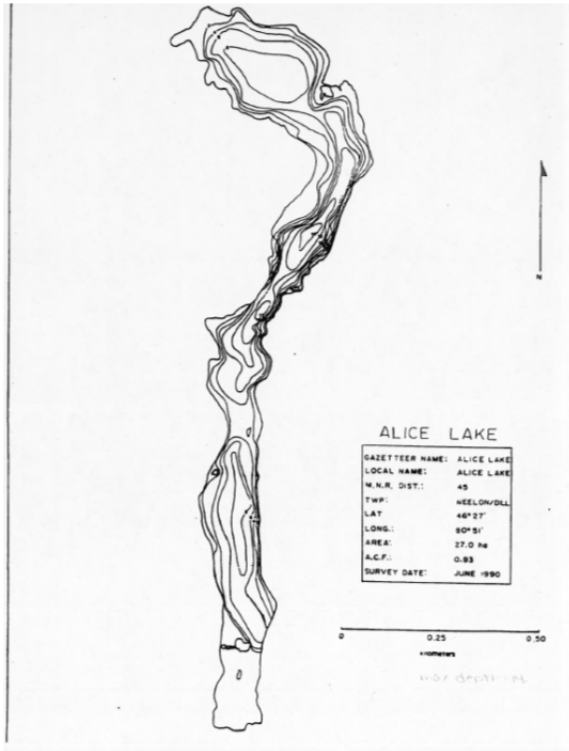


Figure 1 Bathymetric map of Alice Lake (Kirk *et al.*, 1990)

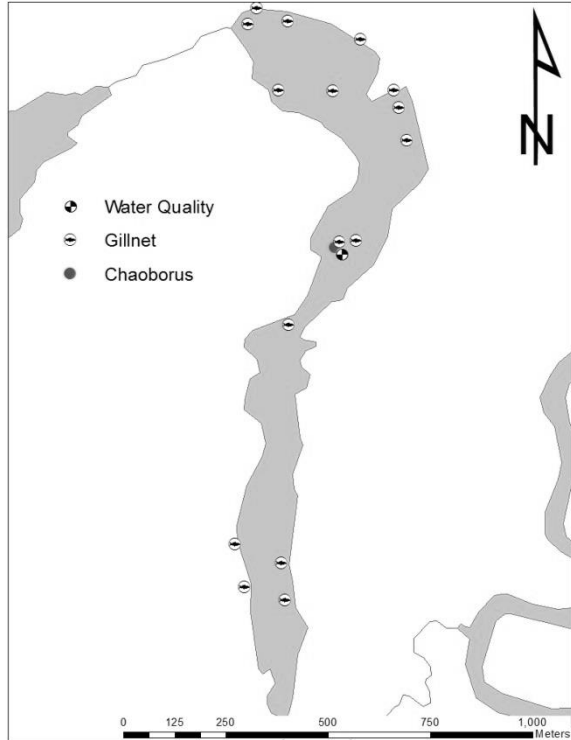


Figure 2 Outline map of Alice Lake showing the location of sampling gear or collected organisms.

RESULTS AND DISCUSSION

Fisheries Community Assessment

During the Nordic survey conducted from July 17 to 20, 2014, a total of 16 nets were set, catching a total of 661 fish from eight different fish species: northern pike (*Esox lucius*), white sucker (*Catostomus commersonii*), golden shiner (*Notemigonus crysoleucas*), common shiner (*Luxinlis cornutus*), rock bass (*Ambloplites rupestris*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*) and yellow perch (*Perca flavescens*). Two of these species, smallmouth bass and rock bass, had not been reported from the lake before. Nine species captured in earlier surveys, including central mudminnow (*Umbra limi*), northern redbelly dace (*Phoxinus eos*) blackchin shiner (*Notropis heterodon*), blacknose shiner (*Notropis heterolepis*), bluntnose minnow (*Pimephales notatus*), fathead minnow (*Pimephales promelas*), brown bullhead (*Ameiurus nebulosis*), brook stickleback (*Culaea inconstans*), iowa darter (*Etheostama exile*) were not captured in 2014 (Cooperative Freshwater Ecology Unit, 2014).

Total catch, total weight (g) and catch-per-unit effort (CPUE) from the 2014 Nordic survey can be seen in Table 2.

Table 2 Catch summary and CPUE for all species captured in Alice Lake, July 17 – 20, 2014. *Fish were not individually weighed. Total weight (g) and CPUE (g/net) measurements are based on total net biomass for that species.

Fish Species	Total Catch	Sample Size	Total Weight (g)	CPUE (fish/net)	CPUE (g/net)
Northern Pike	15	15	20483.5	0.9375	1280.2188
White Sucker	12	9	1569.9	0.75	98.1188
Golden Shiner	1	1	10.6	0.0625	0.6625
Common Shiner	9	2	4.6	0.5625	0.2875
Rock Bass	1	1	107	0.0625	6.6875
Pumpkinseed*	29	24	290.0	1.8125	18.125
Smallmouth Bass	23	22	5693.3	1.4375	355.8313
Yellow Perch*	571	536	6931.0	35.6875	433.1875
Grand Total	661	610	35089.9	41.3125	2193.119

The 15 northern pike sampled during the Nordic survey covered a full range of sizes (and ages). Their total lengths ranged from 320 mm to 661 mm and weights ranged from 193 to 1813g. The 22 smallmouth bass also covered the full range from young-of-the-year to mature adults, their total lengths ranging from 39 mm to 425 mm (0.6-1037g). A complete summary of morphological data for northern pike and smallmouth bass can be seen in Appendix I.

Yellow perch was the most abundant fish species found in Alice Lake in 2014 with 571 perch captured (Table 2). The total lengths of perch ranged from 42 mm to 282 mm. A length frequency histogram for yellow perch can be seen in Figure 3, showing a good distribution of sizes.

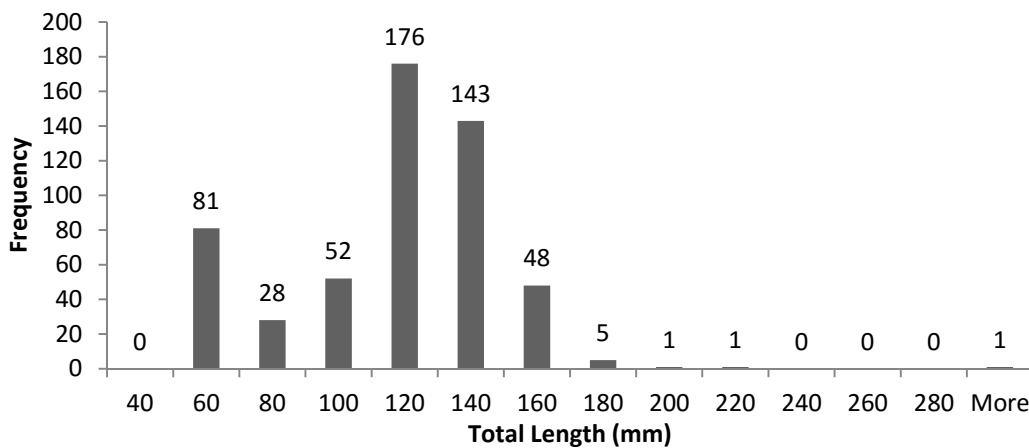


Figure 3 Length frequency histogram for yellow perch (n=536) captured in Alice Lake July 17 – 20, 2014.

The Nordic Index Netting protocol had not been used in the original survey of 1990, but rather a mix of gear (gillnets, trapnets, minnow traps) was used. During the 1990 urban lakes survey on Alice Lake a total of 13 species were captured. In that early survey white sucker was the most abundant species (Poulin *et al.*, 1991). The more recent Nordic surveys in 2006 and 2014 caught more fish in total, however species richness was lower, perhaps because of gear differences or actual changes in composition in the lake. Nine fish species were caught in 2006 with a total catch of 935 fish, with yellow perch being the most abundant species (Cooperative Freshwater Ecology Unit, 2014). Species richness and relative abundance of species in the catch is shown in Table 3.

Table 3 Species richness and proportion of total catch for Alice Lake (1. Poulin *et al.*, 1991; 2. Cooperative Freshwater Ecology Unit, 2014).

Survey Type Year	Multi-Gear Survey 1990 ¹		Nordic 2006 ²		Nordic 2014	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Species						
Central Mudminnow	1	0.57	-	-	-	-
Northern Pike	4	2.29	26	2.8	15	2.3
White Sucker	79	45.14	9	1	12	1.8
Northern Redbelly Dace	23	13.14	-	-	-	-
Golden Shiner	3	1.71	16	1.7	1	0.2
Common Shiner	-	-	15	1.6	9	1.4
Blackchin Shiner	-	-	1	0.1	-	-
Blacknose Shiner	1	0.57	9	1	-	-
Bluntnose Minnow	17	9.71	-	-	-	-
Fathead Minnow	18	10.29	-	-	-	-
Brown Bullhead	1	0.57	99	11	-	-
Brook Stickleback	6	3.43	-	-	-	-
Rock Bass	-	-	-	-	1	0.2
Pumpkinseed	2	1.14	38	4.1	29	4.4
Smallmouth Bass	-	-	-	-	23	3.5
Yellow Perch	15	8.57	722	77	571	86
Iowa Darter	5	2.86	-	-	-	-
Total	175	100	935	100	661	100
Species Richness		13		9		8

The overall decline in fish numbers in 2014 is likely due to the arrival of smallmouth bass (0 in 2006; 23 in 2014) as a second predatory species to the lake. Prior to this introduction, northern pike (4 in 1990; 26 in 2006; 15 in 2014) was the dominant predator in Alice Lake (Poulin *et al.*, 1991; Cooperative Freshwater Ecology Unit, 2014). Total catch data can be seen in Figure 4.

Although yellow perch is still the most numerically abundant fish species observed in Alice Lake, northern pike account for the majority of the total biomass (19280.62 g in 2006; 13133.4 g in 2014).

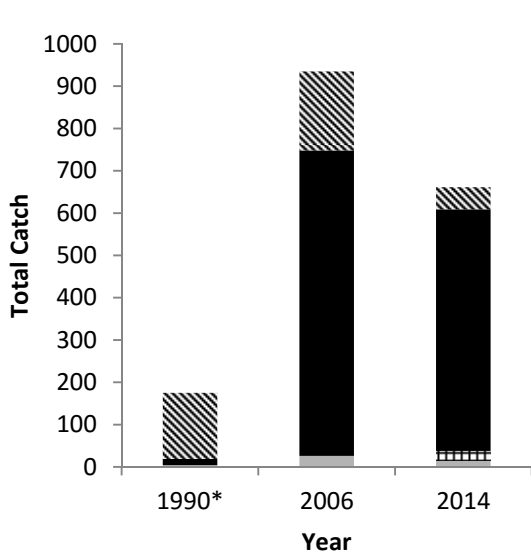


Figure 4 Total catch data from Alice Lake, separated by species (*Nordic method was not used during the 1990 urban lakes survey. Poulin *et al.*, 1991)

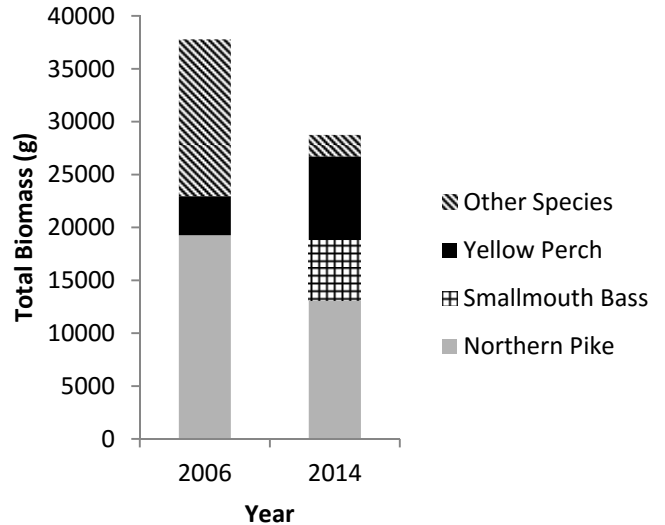


Figure 5 Total biomass (g) data from Alice Lake, separated by species.

Along with the arrival of a second predatory species to Alice Lake, there have been declines or complete losses of some of the prey species. As a result of these trends, there has also been a decline in species diversity. When Alice Lake was first surveyed using the Nordic method, a “below average” Shannon H Diversity value of 0.8998 was calculated. As of 2014, this has declined to a “low” value of 0.6173 (Morgan and Snucins, 2005) (Figure 6).

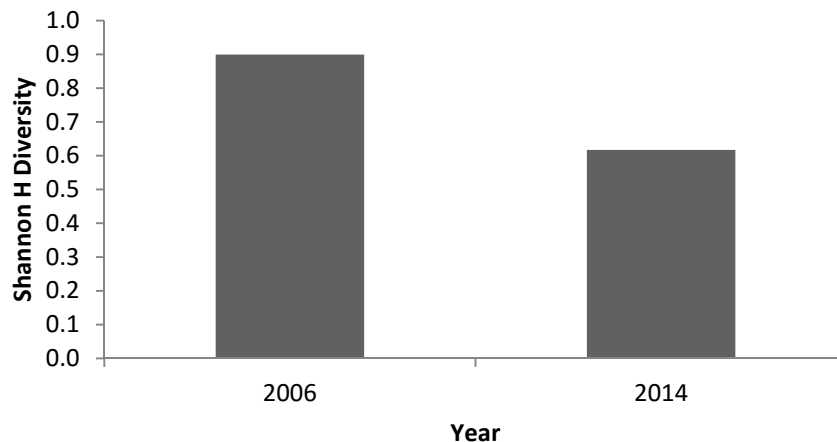


Figure 6 Species diversity (Shannon H Diversity) of Alice Lake (Morgan and Snucins, 2005).

Baseline Organisms

No clams, snails or mayflies were found at Alice Lake suggesting there are lingering water quality problems in the nearshore waters. One incidental crayfish was captured in a gillnet, however none were found in the crayfish traps. A bulk sample of five Pipewort (*Eriocaulon aquaticum*) was collected. Although the exact location was not recorded in the field notes, it is likely this sample was collected from the inflow into the lake at the north end where the most vegetation was observed.

Water Quality Assessment

At the time of the Nordic Index Netting survey, Alice Lake was thermally stratified (Figure 7). Water temperatures ranged from 20.4 °C at the surface to 6.6 °C at 12.5 m. Dissolved oxygen levels ranged from 7.94 mg/L to 0 mg/L. Depth at the site of the temperature and dissolved oxygen profiles was 14 m and the secchi water clarity was 4.75 m.

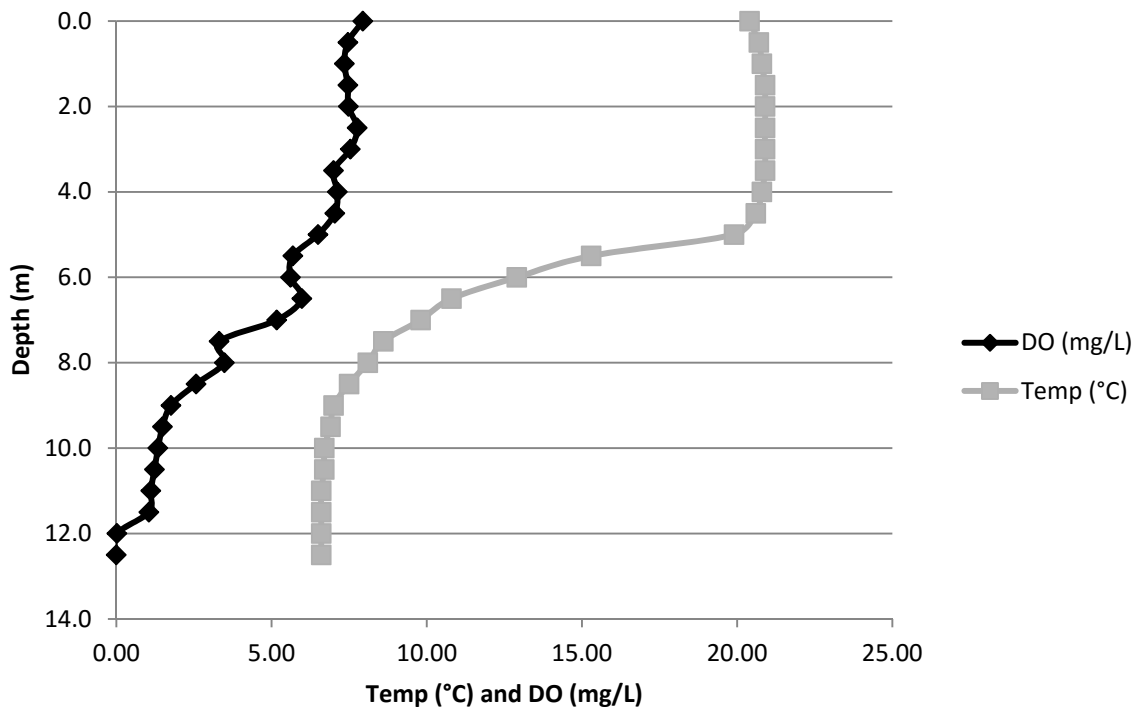


Figure 7 Temperature (°C) and dissolved oxygen (mg/L) profile for Alice Lake, measured July 19, 2014.

While pH has remained neutral since 1990, there appear to have been other improvements in the water quality of Alice Lake (Table 4). With the exception of Iron (Fe), metal concentrations have continued to decrease since 1990 which is likely a result of the closure of the Coniston smelters (Havas *et al.*, 1995) as well as further reductions in emissions from smelters in Sudbury (Keller *et al.*, 2007).

The water quality of Alice Lake is heavily impacted by the proximity of the old smelter site and the waste slag piles as well as the buffering effect of clay deposits on the north shore. We have no evidence of extremely low pH in the past, the lowest pH was recorded as 5.87 in 1969 (Hutchinson and Havas, 1986). Metals were however very high in the past (1972: Cu 250 µg/L; Ni 6900 µg/L) according to Hutchinson and Havas (1986).

As of July 17, 2014, Alice Lake remains slightly above neutral with a pH value of 7.6. Copper (6.8 µg/L) and Nickel (128 µg/L) concentrations are much reduced but remain above criteria set by the Ministry of Environment and Climate Change's (MOECC) Provincial Water Quality Objective (PWQO) for the protection of aquatic life. Aluminum (4.6 µg/L), Iron (70 µg/L) and Zinc (1.1 µg/L) concentrations are below these criteria (Ontario Ministry of Environment and Energy, 1994).

Table 4
Water chemistry from Alice Lake (1. Ontario Ministry of Environment and Energy, 1994; 2. Kirk *et al.*, 1990.)

Parameter	¹ PWQO	Year			
		² 1972	² 1985	² 1990	2014
pH	6.5-8.5	6.10	6.30	7.34	7.64
TIA Alkalinity (mg/L CaCO ₃)				18.83	25.8
Conductivity (µS/cm)		490	250	280	166
DOC (mg/L)					3.2
SO ₄ (mg/L)		266	92	98.41	33.9
Total Cu (µg/L)	5	250	90	15.0	6.8
Total Ni (µg/L)	25	6900	1400	1100	128
Total Zn (µg/L)	30			7.4	1.1
Total Fe (µg/L)	300			37	70
Total Mn (µg/L)		960	130	140.0	13
Total Al (µg/L)	75		76	28	4.6

CONCLUSIONS

Although water quality has improved greatly over the past two decades, concentrations of Cu and Ni remain above the PWQO threshold for the protection of aquatic life (Ontario Ministry of Environment and Energy, 1994). Metal concentrations have however declined by 98% for Ni and 97% for Cu since 1972. Sensitive invertebrates such as clams, snails and mayflies were not observed, and crayfish appear to be a rare occurrence. However, Alice Lake does support populations of eight fish species, two of which are major sport fish: northern pike and smallmouth bass. There is no information on how the smallmouth bass or the other species entered Alice Lake, however it is assumed that they probably migrated in from the nearby Wahnapiatae River to the southeast.

ACKNOWLEDGEMENTS

The urban lakes fisheries monitoring program in Sudbury is conducted by staff and students of the Cooperative Freshwater Ecology Unit with support from OMNRF, OMOECC, the City of Greater Sudbury, Vale and Glencore. Over the past 25 years the program has been led by Rod Sein, Rob Kirk, George Morgan, Ed Snucins, Michelle Gillespie and John Gunn, with technical support by Jason Houle, Lee Haslam, Andrew Corston and dozens of students (includes graduate students: Andreas Luek, Kelly Lippert, Elizabeth Wright, Scott Kaufman) and summer assistants. Data from water quality monitoring was provided by OMOECC through the assistance of Jocelyne Heneberry, Bill Keller and John Bailey. We thank all who contributed, including the many land owners who provided access to these study lakes.

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APPENDIX I

Morphological data for northern pike (*Esox lucius*) and smallmouth bass (*Micropterus dolomieu*) from Alice Lake, July 17 – 20, 2014.

Species	Fish #	Fork Length (mm)	Total Length (mm)	Weight (g)	Sex 1-Male 2-Female 9-Unknown	Maturity 1-Immature 2-Mature 9-Unknown	Ageing Structure	Tissue
							0-None 2-Scales 4-Pectoral Ray 7-Dorsal Spine A-Otolith B-Operculum D-Cleithrum	0-None 1-Flesh 8-Stomach 9-Gonads A-Whole Fish X-Genetic
Northern Pike	1	604	645	1545.4	2	2	AD	1
Northern Pike	2	585	641	1621.3	2	2	AD	1
Northern Pike	23	490	525	880.8	1	2	AD	1
Northern Pike	68	620	661	1813.1	2	2	AD	1
Northern Pike	69	462	496	832.1	2	9	AD	1
Northern Pike	120	389	424	498.7	1	1	AD	1
Northern Pike	121	362	390	365.6	2	1	AD	1
Northern Pike	244	424	451	572.2	2	2	AD	1
Northern Pike	368	589	622	1636.4	2	2	AD	1
Northern Pike	373	466	495	719.9	1	1	AD	1
Northern Pike	374	413	440	570.4	2	1	AD	1
Northern Pike	450	550	582	1141.6	1	2	AD	1
Northern Pike	451	302	320	193	1	1	AD	1
Northern Pike	470	381	405	406.4	2	1	AD	1
Northern Pike	471	356	383	336.5	2	1	AD	1
Smallmouth Bass	70	399	425	1037.3	1	2	A	1
Smallmouth Bass	122	197	209	123.7	2	1	A	1
Smallmouth Bass	288	399	420	1024.7	1	2	A	1
Smallmouth Bass	289	399	418	1006.7	1	2	A	1
Smallmouth Bass	290	398	411	1139.1	2	2	A	1
Smallmouth Bass	291	194	204	103.1	1	1	A	1
Smallmouth Bass	292	186	197	92	2	1	A	1
Smallmouth Bass	293	203	214	118.5	2	1	A	1
Smallmouth Bass	294	87	92	95.5	1	1	A	1
Smallmouth Bass	295	120	127	23.3	9	1	A	1
Smallmouth Bass	369	330	347	574	2	2	A	1
Smallmouth Bass	370	105	112	14.7	1	1	A	1
Smallmouth Bass	375	102	109	13.4	9	1	A	1
Smallmouth Bass	376	174	184	73.3	9	0	A	1
Smallmouth Bass	377	184	194	97.2	1	1	A	1
Smallmouth Bass	384	94	98	12	9	9	0	0
Smallmouth Bass	466	42	48	1.2	9	9	0	0
Smallmouth Bass	467	102	108	14.6	9	1	A	1
Smallmouth Bass	468	116	122	21.8	2	1	A	1

Species	Fish #	Fork Length (mm)	Total Length (mm)	Weight (g)	Sex 1-Male 2-Female 9-Unknown	Maturity 1-Immature 2-Mature 9-Unknown	Ageing Structure	Tissue
							0-None 2-Scales 4-Pectoral Ray 7-Dorsal Spine A-Otolith B-Operculum D-Cleithrum	0-None 1-Flesh 8-Stomach 9-Gonads A-Whole Fish X-Genetic
Smallmouth Bass	469	179	190	87.1	2	1	A	1
Smallmouth Bass	518		39	0.6	9	9	0	0
Smallmouth Bass	519	114	122	19.5	9	1	A	1