BABY LAKE

URBAN LAKES FISHERIES STUDY 2019

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INTRODUCTION

Baby Lake (46°27’42” N, 80°51’55” W) is a 11.9 ha lake located near the abandoned Coniston smelter, but within the City of Greater Sudbury, in Neelon township. It has a single main basin with a maximum depth of 22.5 m (Figure 1). A complete summary of physical characteristics can be seen in Table 1. Baby Lake is situated entirely within the Daisy Lake Uplands Provincial Park and is accessed by private road and rough portage trail since there is no public access to the lake. However, unauthorized access by the public for recreational purposes is a common occurrence.

Limnological studies have been conducted on Baby Lake as early as 1968 (Kirk *et al*., 1990). Due to its close proximity to the Coniston smelter, Baby Lake was heavily impacted by air pollutants prior to 1972 when the smelter permanently ended its operations (Havas *et al*., 1995). Ministry of Northern Development, Mines, Natural Resources and Forestry (NDMNRF) records indicate that Baby Lake has never been stocked (Fish ON-Line, 2022).

In 2014, as part of the Urban Lakes Study, field crews from Laurentian University’s Cooperative Freshwater Ecology Unit surveyed Baby Lake, along with several other lakes around Greater Sudbury. This research has continued through 2019, providing the latest updates on the recovery of these acid-damaged lakes.

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

Township	Neelon
Latitude/Longitude	46°27’42” N, 80°51’55” W
NDMNRF District	Sudbury
Watershed Code	2DB
Elevation (m)	224
Shoreline Development Factor	2.49
Number of Cottages/Lodges	0
Forest Type	Semi-barren
Shoreline Type	Bedrock/boulder and clay
Lake Surface Area (ha)	11.9
Maximum Depth (m)	22.5
Mean Depth (m)	9.59
Volume ($10^4 m^3$)	114.0
Secchi (m)	4.6 (July 19, 2019)
Access	Private road to Baby Lake via Lopes Ltd. property (formerly Coniston smelter) 3.5 km south of Coniston. 500 m portage trail to lake.

Secchi reading was 7.0 m in 2014 – now 4.6 m 5 years later.

METHODS

Fisheries Community Assessment

In 2006 and 2014, the fish community of Baby Lake 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).

In 2004, a new Ecological Framework for Fisheries Management (EFFM) was announced in Ontario (Sandstrom *et al*., 2018). The framework is referred to as the Broadscale Monitoring (BsM) protocol. The goal of the BsM protocol is to improve the way recreational fisheries are managed by considering a broader landscape approach rather than focusing on individual lake management (Sandstrom *et al*., 2018). Active management of lakes under the BsM protocol would therefore occur on a zone basis (Sandstrom *et al*., 2018). The BsM protocol includes a broad-scale fish community monitoring program which uses a combination of two types of gillnets: "Large mesh" gillnet that target fish larger than 20 cm in length and "Small mesh" gillnet that target smaller fish. The Large mesh gillnet (aka North American; NA1; 8 mesh sizes) is the standard net for angler harvested freshwater species in North America (Sandstrom *et al*., 2018). The Small mesh gillnet (aka Ontario Small mesh; ON2; 5 mesh sizes) was developed in Ontario, Canada and is a new standard (Sandstrom *et al*., 2018). In combination the large and small mesh gillnets have a length comparable to Nordic style "gang" net, which the standard in Europe (Sandstrom *et al*., 2018). The BsM protocol is considered the optimum choice due to the compromise between North American and European standards (Sandstrom *et al*., 2018). In addition, the separation of large and small net segments within the same gear offers the advantage of a being able to incorporate a more flexible project design to optimally meet survey needs (Sandstrom *et al*., 2018). During the 2019 lake survey large and small mesh gillnets nets were spatially allocated as equally as possible to all regions of the lakes (Sandstrom *et al*., 2018). This was done by incorporating the total surface area, max depth, and total amount of depth strata to divide the lake into a number of approximately equal-sized areas (sectors) and randomly distribute the net locations to cover as much of these areas as possible (Sandstrom *et al*., 2018). Previously this process was done manually, however in 2016 a data package was developed by the Ministry of Natural Resources and Forestry called the "Broad-scale Monitoring (BsM) Map Creation Package" to automate the entire procedure (Dunkley, 2016). The data package uses a series of python script tools to identify depth contours of the lake, describe physical characteristics, automate the stratified random distribution of net locations, and export all results into a comprehensive map, with accompanied spatial data for field technicians (Dunkley, 2016). The 2019 survey included the use of BsM nets, in addition to supplemental sampling using Nordic nets.

A total of 20 nets were set in Baby Lake from July 16 to 19, 2019. Nets were set for approximately 20 hours at randomly selected locations on the lake across multiple depth strata (5 nets in 1-3 m; 5 nets in 3-6 m; 5 nets in 6-12 m; 5 nets in 12-20 m). Figure 2 shows the locations of all gillnets set in Baby 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 per species across a size range for contaminant and stable isotope analysis. All other fish were measured for length only.

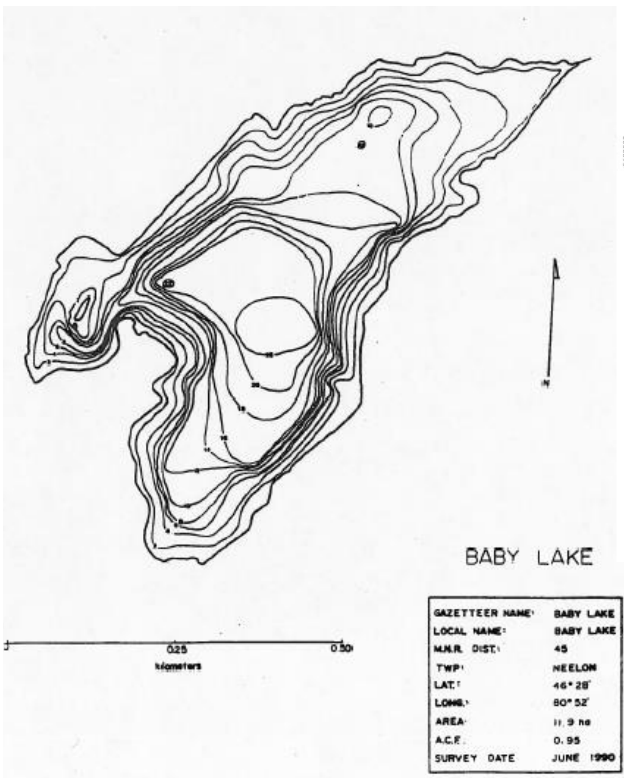
Baseline Organisms

Attempts were made to collect samples of clams (n=10), snails (n=30), Heptageniid mayflies (n=50), and Chaoborus sp. (n=300) from Baby Lake for food web studies using stable isotopes. Clams and snails were targeted by visually scanning near-shore areas and picking the organisms by hand or with a dip net. Heptageniid mayflies were targeted by turning over rocks and woody debris along the shore of Baby Lake and picking the organisms off the surface by hand or with a pair of tweezers. Chaoborus sp. were targeted by conducting vertical zooplankton hauls with a 30cm diameter net (80 μm mesh) from the main basin of the lake.

Water Quality Assessment

A dissolved oxygen (mg/L) and temperature (°C) profile was measured in the main basin of Baby Lake in July of 2018, using a YSI Model 52 dissolved oxygen – temperature meter. Readings were taken at 1.0 m intervals through the water column. Due to technical issues, measurements were not taken in 2019 during the BsM sampling.

Water samples were collected on July 19, 2019, from the surface of Baby Lake. Samples were sent to the Ministry of Environment, Conservation and Parks (MECP) chemistry lab in Dorset, and analyzed for pH, conductivity, total inflection point alkalinity, dissolved organic carbon, metals and major ions.



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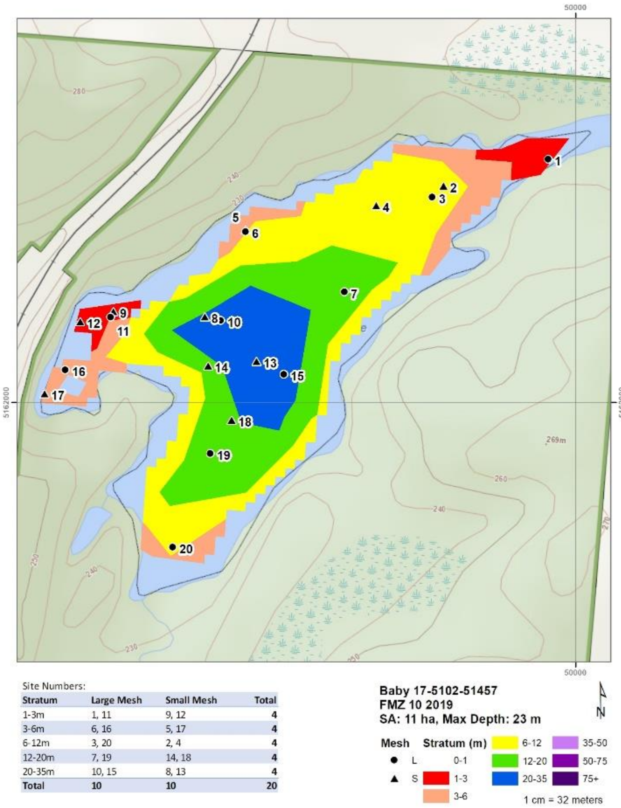

Figure 2. Map of Baby Lake showing the location of depth stratums and sampling gear in 2019.

RESULTS AND DISCUSSION

Fisheries Community Assessment

During the BsM survey conducted in 2019 from July 16 to 19, seven different fish species were captured: northern pike (*Esox lucius*), white sucker (*Catostomus commersonii*), common shiner (*Luxinlis cornutus*), creek chub (*Semotilus atramaculatus*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*) and yellow perch (*Perca flavescens*). Other species observed in previous netting surveys including golden shiner (*Notemigonus crysoleucas*) and brown bullhead (*Ameiurus nebulosis*) were not captured in 2019 (Cooperative Freshwater Ecology Unit, 2019).

Yellow perch was the most numerically abundant fish species found in Baby Lake in 2019 (Table 2). The 551 perch ranged in total lengths from 60 mm to 200 mm. A length frequency histogram for yellow perch is presented in Figure 3.

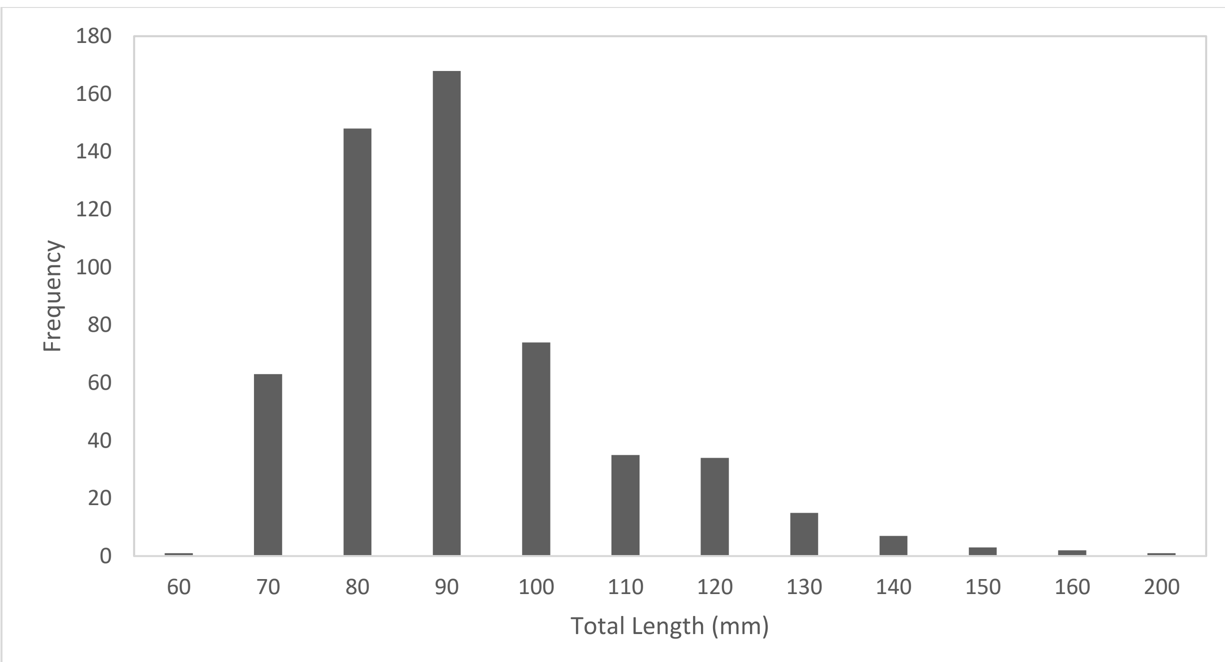

Figure 3. Length frequency histogram for yellow perch (n=551) captured in Baby Lake July 16 – 19, 2019.

Although neither the Nordic Index Netting nor BsM protocols were available at that time, the highest species richness (nine species) was observed back in the 1990 urban lakes survey that used a variety of gears, including trap nets, plexiglass traps, minnow traps and various size gillnets. Perch was still the most abundant species at that time, accounting for 71% of the total catch (Poulin et al., 1991). More recent Nordic and BsM surveys indicate that species richness has decreased from eight species in 2006 to six species in 2014, and then back up to seven species in 2019 (Cooperative Freshwater Ecology Unit, 2019). Species richness and proportion of total catch can be seen in Table 2.

Table 2. Species richness and proportion of total catch for Baby Lake (1. Poulin et al., 1991; 2. Cooperative Freshwater Ecology Unit, 2019).

Survey Type	**Multi-Gear Survey**		**Nordic**		**Nordic**		**BsM**	
Year	**1990[1]**		**2006[2]**		**2014[2]**		**2019[2]**	
Species	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***
Northern Pike	-	-	3	0.84	-	-	1	0.16
White Sucker	-	-	36	10.11	5	0.83	9	1.47
Northern Redbelly Dace	1	1.72	-	-	-	-	-	-
Finescale Dace	1	1.72	-	-	-	-	-	-
Golden Shiner	3	5.17	2	0.56	3	0.5	-	-
Common Shiner	-	-	28	7.87	22	3.66	28	4.58
Mimic Shiner	1	1.72	-	-	-	-	-	-
Fathead Minnow	1	1.72	-	-	-	-	-	-
Creek Chub	-	-	6	1.69	22	3.66	5	0.82
Brook Stickleback	3	5.17	-	-	-	-	-	-
Brown Bullhead	6	10.3	1	0.28	-	-	-	-
Pumpkinseed	1	1.72	2	0.56	17	2.83	10	1.63
Smallmouth Bass	-	-	-	-	-	-	8	1.31
Yellow Perch	41	70.7	278	78.12	532	88.52	551	90.03
Total	**58**	**100**	**356**	**100**	**601**	**100**	**612**	**100**
Species Richness	**9**		**8**		**6**		**7**	

As the total catch of yellow perch has increased in Baby Lake, there have been fluctuations in the catches of other species. From 2006 to 2014, the total catch of white sucker has declined, then increased slightly in 2019. We see the opposite trend with pumpkinseed, with an increase between 2006 to 2014, and a decline in 2019. Although there was a presence of northern pike in 2006, they did not show up in the 2014 survey, however, one was present in the 2019 BsM survey. There has also been a loss of one species since 2014: golden shiner. In addition, 8 smallmouth bass were captured in 2019, a species which has never been previously detected in Baby Lake.

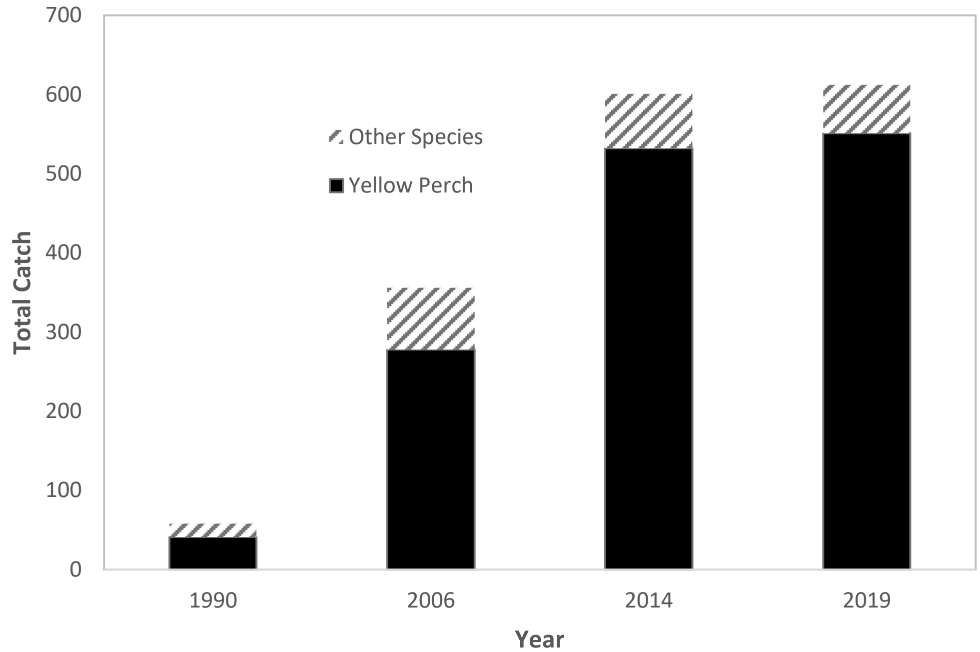

Figure 4. Total catch data from Baby Lake (1990 – Multi-Gear Survey; 2006 & 2014 – NORDIC Survey; 2019 – BsM Survey).

As a result of these changes in species composition, there has been an apparent decline in species diversity. When Baby Lake was first surveyed using the Nordic method, a "below average" Shannon H Diversity value of 0.8086 was calculated. As of 2014, this has declined to a "low" value of 0.5173 (Morgan and Snucins, 2005), dropping again slightly in 2019 with a value of 0.471. Species diversity values can be seen in Figure 5.

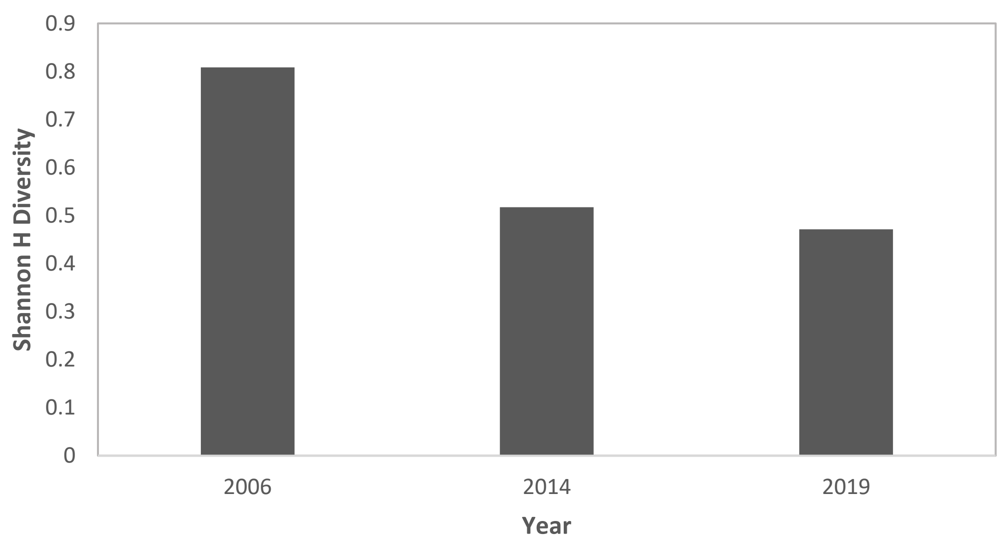

Figure 5. Species diversity (Shannon H Diversity) values from Baby Lake (Morgan and Snucins, 2005).

Baseline Organisms

No clams, snails or mayflies were found at Baby Lake in 2014. In 2019, there were still no sightings of clams or snails, however, mayflies were present and collected. One vertical zooplankton haul was conducted on July 16, 2019.

Water Quality Assessment

In 2018, one year prior to the BsM survey, Baby Lake was thermally stratified (Figure 6). A technical malfunction with the dissolved oxygen meter resulted in no readings in 2019. In July 2018, water temperatures ranged from 23.6 °C at the surface to 4.7 °C at 21 m. Dissolved oxygen levels ranged from 8.57 mg/L near the surface, to 5.92 mg/L near the lake bottom.

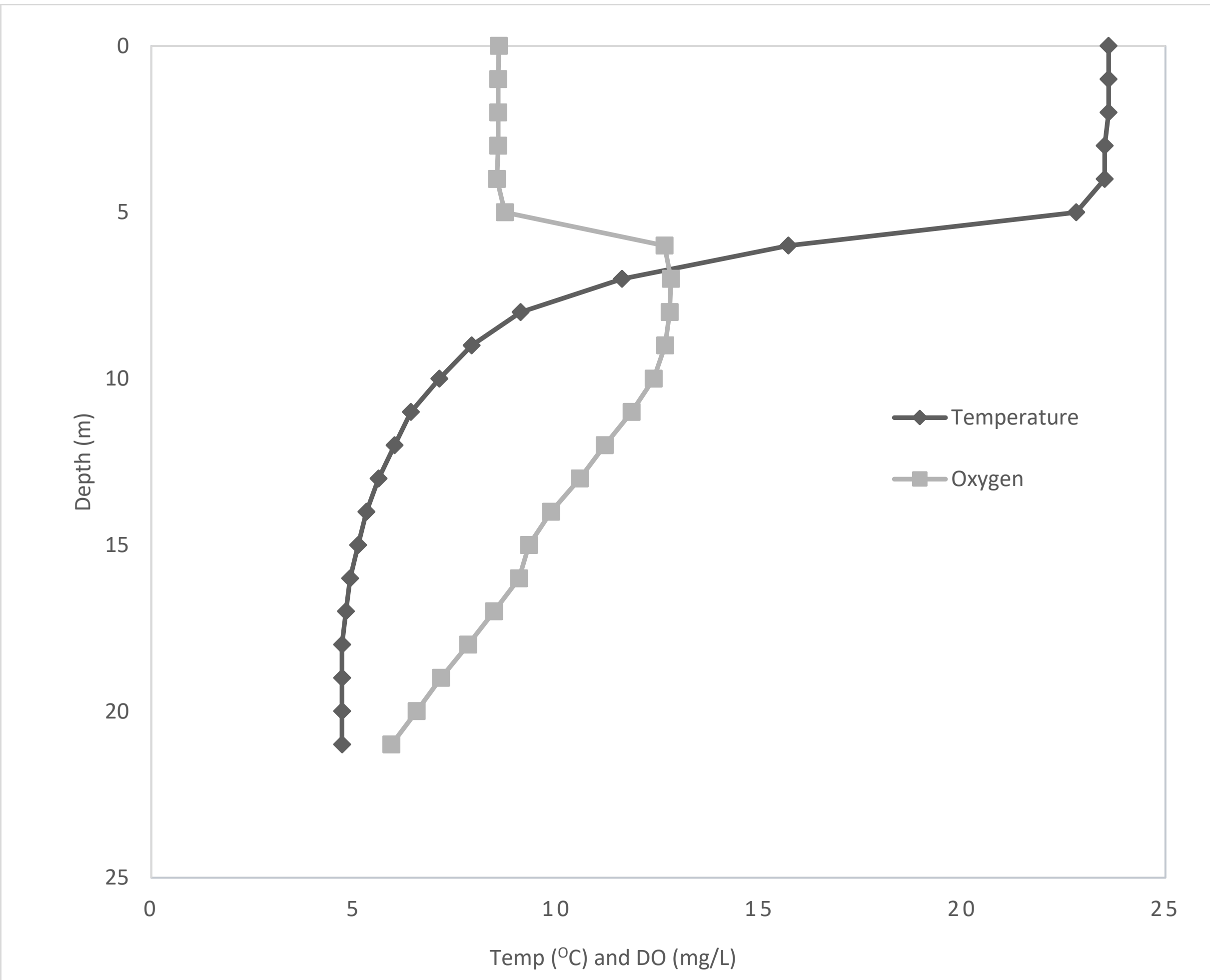

Figure 6. Temperature (°C) and dissolved oxygen (mg/L) profile for Baby Lake, measured in July of 2018.

The water quality of Baby Lake appears to have improved considerably since 1990 (Table 3). Since then, pH has undergone an increase from 6.73 (Kirk et al., 1990) to 7.25 in 2014, and slightly down to 6.97 in 2019. Conductivity has continued to decrease from 71 µS/cm to 37 µS/cm over the past three decades, as have concentrations of metals such as Copper (Cu), Nickel (Ni), Aluminum (Al), Iron (Fe) and Zinc (Zn).

These improvements are likely a result of the closure of the Coniston smelter (Havas et al., 1995) as well as further reductions in emissions from smelters in Sudbury (Keller et al., 2007).

However, Cu (8 µg/L) and Ni (60 µg/L) concentrations 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 (6.6 µg/L), Iron (30 µg/L) and Zinc (3.7 µg/L) concentrations are below these criteria (Ontario Ministry of Environment and Energy, 1994).

*Copper PWQO has recently undergone an interim change based on new research suggesting that TIA Alkalinity $CaCO_3$ (mg/L) will affect the quantity of Total Cu that should be present (Canadian Council of Ministers of the Environment, 1998). In previous reports, 5 µg/L was the standard total Cu value for protection of aquatic life and now an interim change to the PWQO states that at a low TIA Alkalinity value of 0-20 mg/L of $CaCO_3$ should not have Total Cu readings greater than 1 µg/L. Anything greater than 20 mg/L of $CaCO_3$ continues to have the 5 µg/L standard.

Table 3: Water chemistry from Baby Lake (1. Ontario Ministry of Environment and Energy, 1994; 2. Kirk et al., 1990, 3. Baby Lake Urban Fisheries Study 2019)

Parameter	**[1]PWQO**			**Year**		
		[2]1972	**[2]1985**	**[2]1990**	**[3]2014**	**[3]2019**
pH	6.5-8.5	4.05	5.8	6.73	7.25	6.97
TIA Alkalinity (mg/L $CaCO_3$)	-	-	-	3.6	8.24	7.88
Conductivity (µS/cm)	-	153	140	71	41.9	37
DOC (mg/L)	-	-	-	-	1.9	1.5
SO_4 (mg/L)	-	-	-	21.07	7.85	6.8
Total Cu (µg/L)	*1, 5	780	60	21	7	8
Total Ni (µg/L)	25	3200	410	240	63	60.1
Total Zn (µg/L)	30	180	60	18	2.7	3.7
Total Fe (µg/L)	300	-	-	45	40	30
Total Mn (µg/L)	-	-	-	38	5.9	16.8
Total Al (µg/L)	75	-	-	17	6.9	6.6
Total Ca (µg/L)	-	-	-	-	5.87	6.25

CONCLUSIONS

Although considerable water quality improvements have taken place over the past two decades in Baby Lake, concentrations of Cu and Ni remain above the threshold for the protection of aquatic life (Ontario Ministry of Environment and Energy, 1994). Metal concentrations have, however, declined by 98% for Ni and 99% for Cu since 1972. Sensitive invertebrates such as clams, snails were not observed, however, mayflies appear to be recolonizing. Baby Lake does support populations of seven fish species, however only 2 large-bodied sport fish (northern pike and smallmouth bass) were observed during the 2019 BsM survey. The arrival of bass and the various baitfish species over the years, suggest that anglers and local residence are intentionally or unintentionally introducing species into the lake. Very high water levels of downstream Alice Lake may also allow some species to invade from that source which is connected to the Wanapitei River. Competition and predation among these species appear to account for some of the observed variations over time, including the loss of some introduced species.

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