DAISY LAKE

URBAN LAKES FISHERIES STUDY 2019

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INTRODUCTION

Daisy Lake (46°27’11” N, 80°52’56” W) is a 36.1 ha lake located within the City of Greater Sudbury, in Dill/Neelon township it has two main basins with a maximum depth of 14.5 m (Figure 1). A complete summary of physical characteristics of Daisy Lake can be seen in Table 1. Daisy Lake is situated partially within the Daisy Lake Uplands Provincial Park and can be accessed by Desloges Rd. There are no residents on Daisy Lake and until recently it received very little angling pressure.

Daisy Lake and its surrounding watershed have been regularly studied since 1984 when the lake had a pH of 4.5 (Kirk and Kenzie, 1990). As part of a restoration experiment in 1994, a 38-ha catchment area at the northeast end of the lake (known as Catchment J) was aerially limed with 410 tons of coarse dolomitic limestone, with an additional 54 tons of highly soluble pelletized fine dolomitic limestone added to 15 small wetland sites within the treated area in 1995 (Gunn *et al*., 2001; Gunn *et al*., 2016). The Ministry of Natural Resources attempted to introduce splake (*Salvelinus fontinalis x Salvelinus namaycush*) in Daisy Lake in 2005 (Ontario Ministry of Natural Resources, 2013), however, none have ever been caught (Cooperative Freshwater Ecology Unit, 2014).

Daisy lake was part of the urban lake programming in 1990 and also had a Nordic Survey in 2005 and 2010. In 2014, as part of the Urban Lakes Study, field crews from Laurentian University’s Cooperative Freshwater Ecology Unit surveyed Daisy Lake, along with several other lakes around Greater Sudbury. This research has continued through 2019, however, this time following a Broadscale Monitoring (BsM) protocol.

Table 1 Daisy Lake location and physical description (Kirk and Kenzie, 1990).

Township	Dill/Neelon
Latitude/Longitude	46°27’11” N, 80°52’56” W
MNRF District	Sudbury
Watershed Code	2DB
Elevation (m)	231
Shoreline Development Factor	2.59
Number of Cottages/Lodges	0
Forest Type	Birch transition
Shoreline Type	Bedrock
Lake Surface Area (ha)	36.1
Maximum Depth (m)	14.5
Mean Depth (m)	5.2
Volume ($x10^4m^3$)	187.5
Secchi (m)	5.0 (July 10, 2014)

Access	Desloges Rd. to wetland at west end of Daisy Lake (approx. 10.5 km).

METHODS

Fisheries Community Assessment

In 2014 the fish community of Daisy Lake was sampled following a Nordic Index Netting protocol (Appelberg, 2000; Morgan and Snucins, 2005). The Nordic 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).

In the 2019 survey a total of 20 BsM gillnets were set in Daisy Lake from July 22nd to July 24th. Nets were set for approximately 16-22 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 3 shows the locations of all BsM gillnets set in Daisy Lake during the 2019 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 (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), and aquatic plants from Daisy Lake for food web studies.

Clams and snails were targeted by visually scanning near-shore areas and picking the organism 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 Daisy Lake and picking the organism 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 Daisy Lake and picked by hand.

Water Quality Assessment

A dissolved oxygen (mg/L) and temperature (°C) profile was measured in the main basin of Daisy Lake on July 10, 2014, and July 23rd, 2018, using a YSI Model 52 dissolved oxygen – temperature meter. Readings were taken at 0.5 m intervals through the water column in 2014 and 1.0 m intervals in 2018.

Water samples were collected on July 22, 2014 and from the surface of Daisy Lake. Samples were sent to the Ministry of Environment and Climate Change (MOECC) chemistry lab in Dorset, and analyzed for pH, conductivity, total inflection point alkalinity, dissolved organic carbon, metals and major ions. Sampling location for water quality in 2014 can be seen in Figure 2.

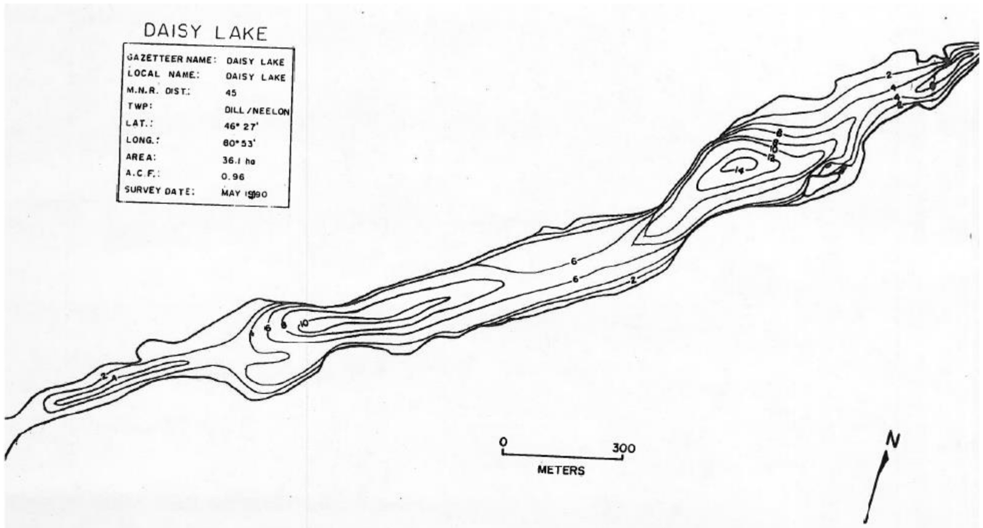


Figure 1 Bathymetric map of Daisy Lake (Kirk and Kenzie, 1990).

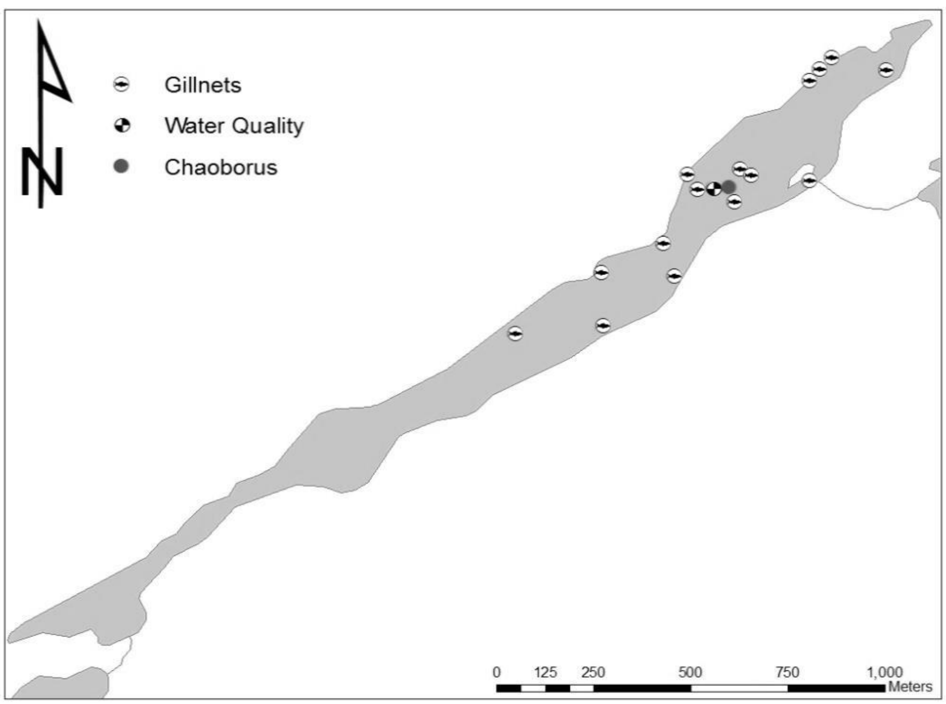


Figure 2 Outline map of Daisy Lake showing the location of sampling gear or collected organisms.

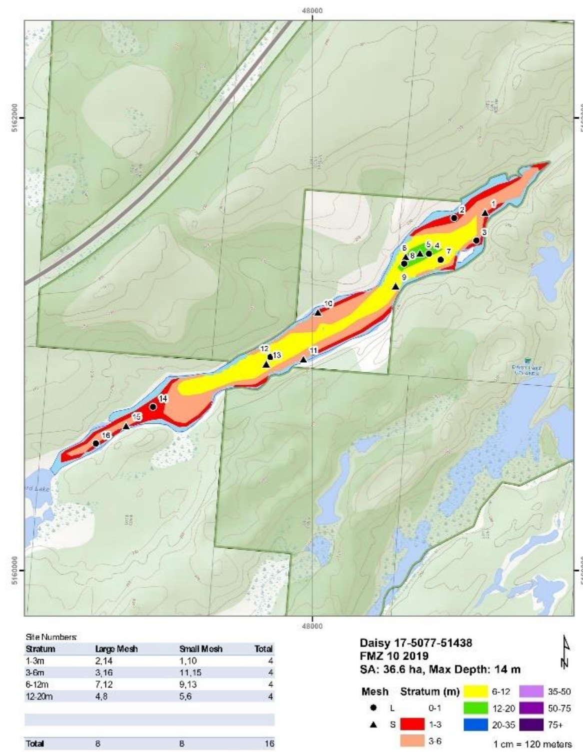


Figure 3 Map of Daisy Lake showing the location of depth stratums and sampling sites in 2019

RESULTS AND DISCUSSION

Fisheries Community Assessment

During the 2019 BsM netting survery conducted from July 22nd to 24th, a total of 20 nets were set, catching seven species: northern pike (*Esox lucius*), white sucker (*Catostomus commersonii*), brown bullhead (*Ameiurus nebulosis*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), and walleye (*Sander vitreus*). Total catch, total weight (g) and catch-per-unit effort (CPUE) from the Nordic survey are listed in Table 2.

Table 2 Catch summary and CPUE for all species captured in Daisy Lake July 22nd – 24th, 2019. *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	9	8	5940	0.45	297
White Sucker	2	2	1350	0.1	67.5
Brown Bullhead	34	-	-	-	-
Pumpkinseed	4	-	-	-	-
Smallmouth Bass	58	40	19880	2.9	994

Yellow Perch*	224	-	-	-	-
Walleye	18	17	4995	0.9	250
Grand Total	349	67	32165	4.35	1608.5

The 8 northern pike sampled during the BsM survey had total lengths ranging from 55mm to 445m, and the 17 walleye caught had total lengths ranging from 249 mm to 460 mm. Smallmouth bass was the most abundant large-bodied sport fish caught during this netting survey (Table 3), with a total catch of 58 individuals, with total lengths ranging from 224 mm to 460 mm. A complete summary of morphological data for northern pike, walleye and smallmouth bass are listed in Appendix I.

Yellow perch was the most numerically abundant fish species found in Daisy Lake (Table 3) and ranged in total lengths from 40 mm to 190 mm. A length frequency histogram for yellow perch can be seen in Figure 4.

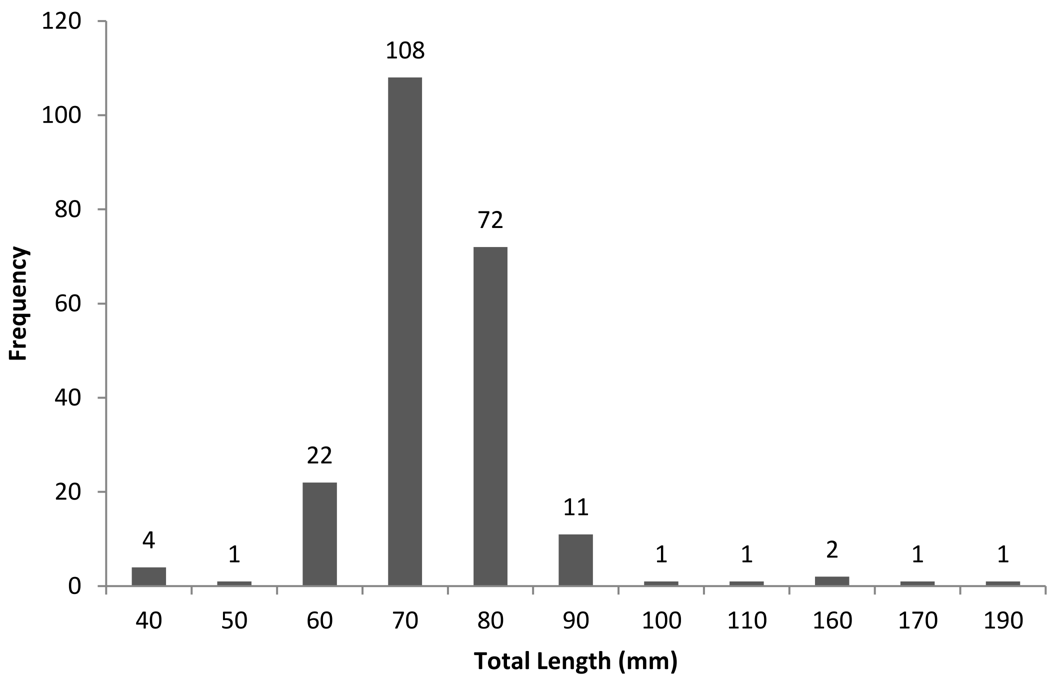


Figure 4. Length frequency histogram for yellow perch (n=224) captured in Daisy Lake July 22nd – 24th , 2019.

History of Change: 1990-2019

Central mudminnow was the only species caught during the 1990 urban lakes survey on Daisy Lake with a total catch of only two individuals (Poulin, *et al*., 1991). A considerably higher total catch of 1190 fish and species richness of five species was recorded in the first Nordic survey conducted on Daisy Lake in 2005. Species richness has continued to improve since 2005 with the arrival of predatory sport fish species such as northern pike, smallmouth bass, largemouth bass and walleye. The total catch of all fish in Daisy Lake appears to have declined since 2005 presumably because of the arrival of top predators. In terms of total catch, yellow perch have been the most abundant species in Daisy Lake since Nordic surveys began, this trend was also observed in the 2019 BsM survey (Cooperative Freshwater Ecology Unit, 2014, 2019). Species richness and proportion of total catch for the 2019 BsM survey are listed in Table 3.

Total catch and species richness have greatly improved since the 1990 urban lakes survey, which used multi-mesh gillnets, small mesh trap nets and minnow traps (Kirk and Kenzie, 1990; Poulin *et al*., 1991). More recent Nordic Index Netting surveys indicate that yellow perch is the most abundant species in Daisy Lake (1140 in 2005; 1005 in 2010; 438 in 2014; 224 in 2019). The total catch data for the 2019 BsM survey can be seen in Figure 4.

Yellow perch accounted for most the total biomass until 2014 when the other species took over. In 2019, yellow perch weights were not recorded, however notable increases in other species biomass include northern pike (increase from 1423.5 grams in 2014 to 5940 grams) and smallmouth bass (increase from 2217.9 grams in 2014 to 19880 grams in 2019). Walleye biomass has decreased since 2014 (8632 g in 2014 to 4995 g in 2019). (Cooperative Freshwater Ecology Unit 2014, 2019). Total biomass data for the 2019 BsM survey can be seen in Figure 5. Species diversity has steadily increased in Daisy Lake since Nordic surveys began.

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

Survey Type	**Multi-Gear Survey**		**Nordic**		**Nordic**		**Nordic**		**BsM**	
Year	**1990**		**2005**		**2010**		**2014**		**2019**	
Species	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Northern Pike	-	-	-	-	1	0.09	3	0.59	9	2.6
Central Mudminnow	2	100	-	-	-	-	-	-	-	-
White Sucker	-	-	4	0.34	-	-	1	0.2	2	0.57
Golden Shiner	-	-	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	40	3.36	38	3.56	19	3.73	34	9.74
Pumpkinseed	-	-	5	0.42	19	1.78	3	0.59	4	1.15
Smallmouth Bass	-	-	-	-	-	-	5	0.98	58	16.62
Largemouth Bass	-	-	-	-	1	0.09	-	-	-	-
Yellow Perch	-	-	1140	95.8	1005	94.2	438	86.1	224	64.2
Walleye	-	-	-	-	3	0.28	40	7.86	18	5.16
Iowa Darter	-	-	1	0.08	-	-	-	-	-	-
Total	2	100	1190	100	1067	100	509	100	349	100
Species Richness	1		5		6		7		7	

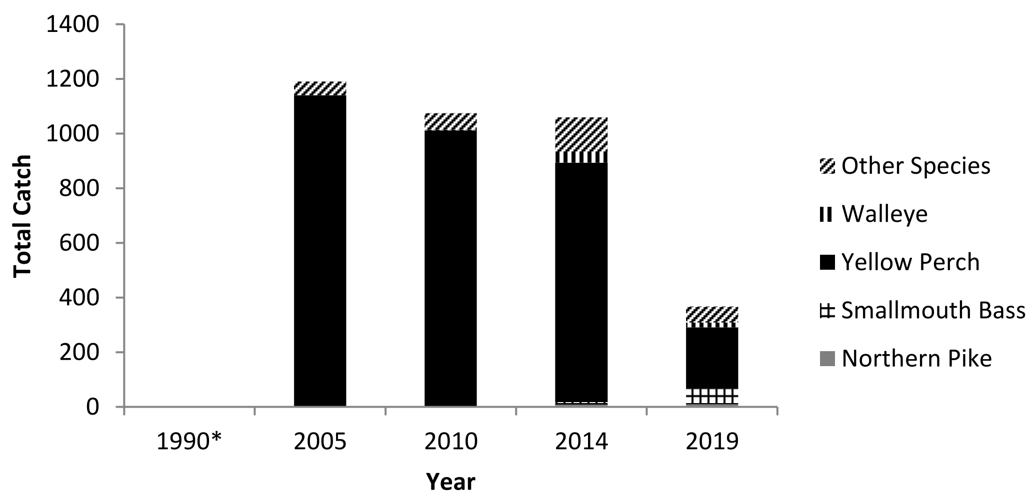
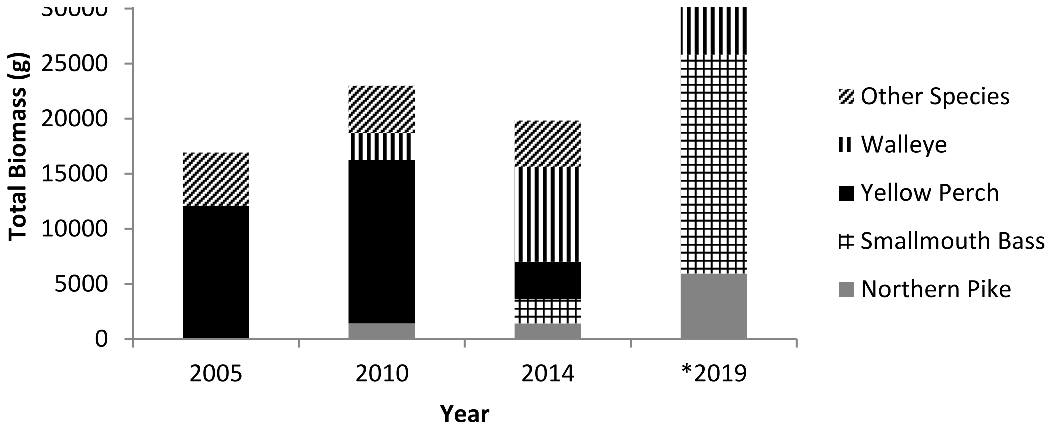


Figure 4 Historic total catch data for Daisy Lake (*Nordic method was not used during the 1990 urban lakes survey. Poulin *et al*., 1991).

Figure 5 Historic total biomass (g) data for Daisy Lake (*Yellow Perch weights were not recorded in 2019)



In 2005, 5 species were recorded in Daisy Lake, resulting in a "low" Shannon H Diversity value of 0.2033. Although species richness increased to 6 in 2010, species diversity remained "low" at a value of 0.2765. Since 2014, species richness has increased to seven, nearly doubling the Shannon H Diversity value (0.5747), this trend continued into 2019 (1.14). Species diversity values can be seen in Figure 6.

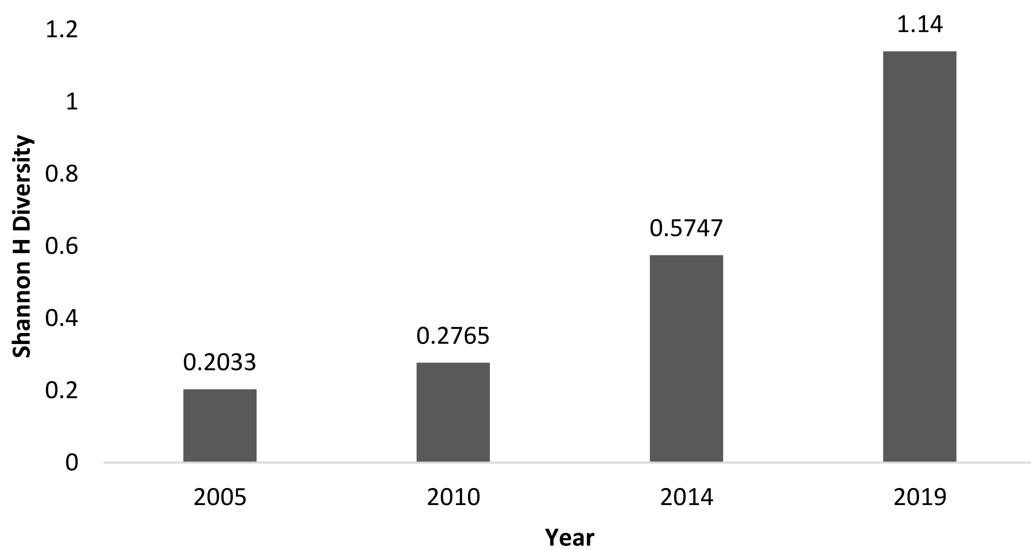


Figure 6 Historic species diversity (Shannon H Diversity) values for Daisy Lake.

Baseline Organisms

No clams, snails or crayfish were collected from Daisy Lake. A total of 50 mayflies and a bulk sample of five Pipewort (*Eriocaulon aquaticum*) were collected from Daisy Lake. Five nighttime zooplankton hauls were conducted at Daisy Lake on July 21, 2014.

Water Quality Assessment

On July 23rd, 2018, Daisy Lake was thermally stratified (Figure 7). Water temperatures ranged from 25.7 °C at the surface to 7.7 °C at 13 m. Dissolved oxygen levels ranged from 8.45 mg/L to 5.05 mg/L. Depth at the site of the temperature and dissolved oxygen profiles was 13 m.

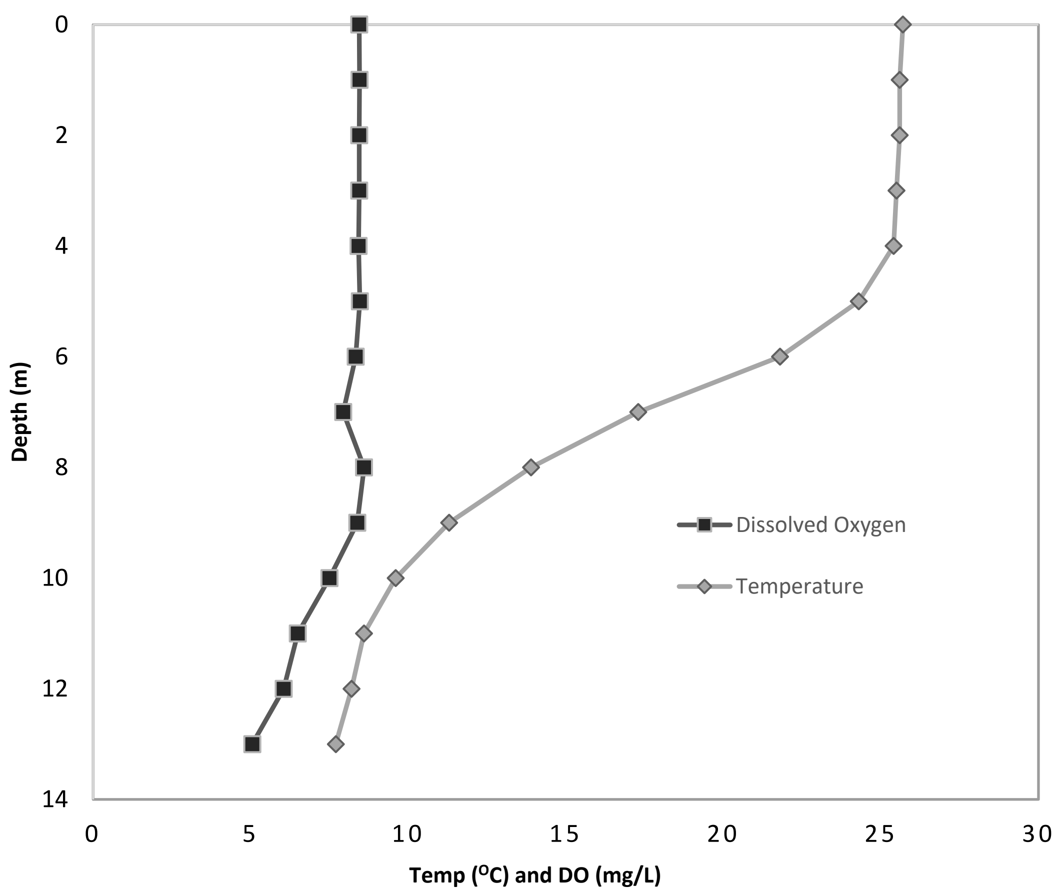


Figure 7 Temperature (°C) and dissolved oxygen (mg/L) profile for Daisy Lake, measured July 23, 2018.

The water quality of Daisy Lake continues to show signs of improvement. Since 2003, pH has increased from 6.20 to 6.89 (July 22, 2014), as has TIA alkalinity, which has increased from 2.02 mg/L $CaCO_3$ to 4.5 mg/L $CaCO_3$. Concentrations of metals such as Nickel (Ni), Copper (Cu), and Aluminum (Al) have continued to decrease during this time (Table 4). These improvements track the reductions in emissions from local smelters (Keller *et al*., 2007). However, Nickel (41.2 µg/L) and Copper (7.6 µg/L) concentrations remain above the criteria set by the Ministry of Environment and Climate Change's (MOECC) Provincial Water Quality Objective (PWQO), while those of Aluminum (10.2 µg/L) have decreased below these levels (Ontario Ministry of Environment and Energy, 1994).

Table 3 Water quality for Daisy Lake (T. Measurable trace amount: interpret with caution; 1. Ontario Ministry of Environment and Energy, 1994; 2. Kirk and Kenzie, 1990; 3. Keller *et al*., 2004)

Parameter	**[1]PWQO**	**Year**			
		[2]1984	**[2]1990**	**[3]2003**	**2014**
pH	6.5-8.5	4.5	4.67	6.20	6.89
TIA Alkalinity (mg/L $CaCO_3$)			60	2.02	4.5
Conductivity (µS/cm)			-0.98	35.4	37.5
True Colour (TCU)			[T]1.0		11.4
DOC (mg/L)			0.8	2	2.4
Ca (mg/L)			4.0	2.58	2.44
Mg (mg/L)			1.42	1.23	1.18
Na (mg/L)			1.42	1.09	1.65
K (mg/L)			0.55	0.42	0.34
SiO_3 (mg/L)			1.6	1.4	1.24
SO_4 (mg/L)			21.05	10.43	6.15
Total Cu (µg/L)	5		87	12	7.6
Total Ni (µg/L)	25		370	80	41.2
Total Zn (µg/L)	30		22	6	1.6
Total Fe (µg/L)	300		[T]25	36	20
Total Mn (µg/L)			200	24	8.1
Total Al (µg/L)	75		330	30	10.2

CONCLUSIONS

Although water quality appears to have greatly improved over three decades, concentrations of Ni and Cu remain above PWQO criteria for the protection of aquatic life (Ontario Ministry of Environment and Energy, 1994). However, as pH has increased to a circumneutral value of 6.89, metal concentrations have declined by 89% for Ni and 91% for Cu since 1984. Clams, snails and crayfish were not observed, however acid-sensitive mayflies appear to be quite common. Daisy Lake supports populations of seven fish species, including three major sport fish: northern pike, smallmouth bass, and walleye. No information on how the walleye entered Daisy Lake exists, however it is believed that they may have migrated in from nearby Richard Lake to the southwest or been introduced by recreational fishing clubs.

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, 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 walleye (*Sander vitreus*) from Daisy Lake, July 22nd – 24th, 2019.

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 0-None 2-Scales 4-Pectoral Ray 7-Dorsal Spine A-Otolith B-Operculum D-Cleithrum	Tissue 0-None 1-Flesh 8-Stomach 9-Gonads A-Whole Fish X-Genetic
Northern Pike	12	497	532	800	1	10	D	1
Northern Pike	13	521	555	950	2	10	D	1
Northern Pike	34	465	490	630	1	10	D	1
Northern Pike	63	512	549	880	2	20	D	1
Northern Pike	64	414	445	590	2	20	D	1
Northern Pike	65	484	512	630	2	10	D	1
Northern Pike	45	520	554	910	2	20	D	1
Northern Pike	47	432	456	550	2	20	D	-
Smallmouth Bass	68	190	-	-	-	-	-	-
Smallmouth Bass	69	200	-	-	-	-	-	-
Smallmouth Bass	1	346	363	750	1	20	B	1
Smallmouth Bass	2	364	375	650	1	20	A	1
Smallmouth Bass	3	300	311	425	1	20	A	1
Smallmouth Bass	4	366	382	800	2	20	A	1
Smallmouth Bass	5	406	431	1200	1	20	AB	1
Smallmouth Bass	6	246	259	140	2	10	A	1
Smallmouth Bass	7	446	460	550	1	10	D	1
Smallmouth Bass	8	285	295	300	1	10	A	-
Smallmouth Bass	9	262	272	280	1	10	A	1

Smallmouth Bass	10	291	300	320	2	10	A	1
Smallmouth Bass	82	120	-	-	-	-	-	-
Smallmouth Bass	83	140	-	-	-	-	-	-
Smallmouth Bass	92	200	-	-	-	-	-	-
Smallmouth Bass	93	200	-	-	-	-	-	-
Smallmouth Bass	14	362	381	780	9	99	A	1
Smallmouth Bass	97	130	-	-	-	-	-	-
Smallmouth Bass	98	150	-	-	-	-	-	-
Smallmouth Bass	11	248	261	240	2	20	A	
Smallmouth Bass	23	212	224	150	2	10	A	1
Smallmouth Bass	24	285	297	400	1	10	A	1
Smallmouth Bass	25	233	240	195	1	10	A	
Smallmouth Bass	26	385	402	900	2	10	A	1
Smallmouth Bass	27	285	295	360	1	10	A	1
Smallmouth Bass	28	265	276	310	1	10	A	1
Smallmouth Bass	29	280	291	340	1	10	A	1
Smallmouth Bass	30	287	296	330	2	20	A	1
Smallmouth Bass	36	276	287	320	2	20	A	1
Smallmouth Bass	37	250	263	265	2	20	A	1
Smallmouth Bass	38	370	385	235	1	20	A	1
Smallmouth Bass	17	380	398	850	2	20	AB	1
Smallmouth Bass	303	120	-	-	-	-	-	-
Smallmouth Bass	304	130	-	-	-	-	-	-
Smallmouth Bass	317	140	-	-	-	-	-	-
Smallmouth Bass	61	245	259	220	1	10	A	1

Smallmouth Bass	62	386	400	790	1	20	A	1
Smallmouth Bass	60	393	411	980	1	20	A	1
Smallmouth Bass	39	381	404	900	2	20	A	1
Smallmouth Bass	40	356	373	650	1	20	A	1
Smallmouth Bass	41	291	305	470	2	20	A	1
Smallmouth Bass	42	385	406	870	1	20	A	1
Smallmouth Bass	43	355	369	660	2	20	A	1
Smallmouth Bass	44	387	402	920	2	20	A	1
Smallmouth Bass	340	150	-	-	-	-	-	-
Smallmouth Bass	341	160	-	-	-	-	-	-
Smallmouth Bass	48	250	268	240	2	20	A	1
Smallmouth Bass	49	236	250	230	2	20	A	1
Smallmouth Bass	50	283	296	340	2	20	A	1
Smallmouth Bass	51	321	336	510	2	20	A	1
Smallmouth Bass	52	308	320	390	1	20	A	1
Smallmouth Bass	53	281	294	380	1	20	A	1
Smallmouth Bass	54	256	267	240	2	20	A	1
Smallmouth Bass	342	110	-	-	-	-	-	-
Smallmouth Bass	343	130	-	-	-	-	-	-
Smallmouth Bass	344	130	-	-	-	-	-	-
Smallmouth Bass	345	140	-	-	-	-	-	-
Smallmouth Bass	346	150	-	-	-	-	-	-
Smallmouth Bass	347	150	-	-	-	-	-	-
Smallmouth Bass	348	160	-	-	-	-	-	-
Walleye	15	258	273	170	1	10	A	1

Walleye	16	332	354	350	1	10	A	1
Walleye	18	262	270	145	2	10	A	1
Walleye	19	260	272	165	2	20	A	1
Walleye	20	254	265	155	1	10	A	1
Walleye	21	331	350	350	1	10	A	1
Walleye	22	397	410	600	1	10	A	1
Walleye	35	252	265	145	1	10	A	1
Walleye	31	254	263	165	1	10	A	1
Walleye	32	237	249	140	1	10	A	1
Walleye	33	252	266	150	1	10	A	1
Walleye	67	342	366	420	2	20	A	1
Walleye	55	241	255	130	1	10	A	1
Walleye	56	257	279	190	2	10	A	1
Walleye	57	294	303	220	1	20	A	1
Walleye	58	418	438	750	1	20	A	1
Walleye	59	433	460	750	1	10	A	1