

LOHI LAKE

URBAN LAKES FISHERIES STUDY 2014



**Fisheries Assessment by:
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INTRODUCTION

Lohi Lake (46°23'18" N, 81°02'37" W) is a 41.6 ha lake located within the City of Greater Sudbury, in Broder township. It has one main basin with a maximum depth of 19.5 m (Figure 1). A complete summary of physical characteristics can be seen in Table 1.

Lohi Lake is accessed from a small section of public land at a culvert located at the north end of the lake, off South Shore Rd. There are approximately 30 seasonal and permanent residences around the shoreline of the lake and very little public land. Angling for any species is prohibited on Lohi Lake because it has been classified as a year-round fish sanctuary by the Ministry of Natural Resources and Forestry (MNR), as an original intensive monitoring and study lake back in the 70s (Government of Ontario, 2014).

Lohi Lake has been intensely studied and monitored since the early 1970s (Keller *et al.*, 2004; Keller *et al.*, 2007). Attempts were made to neutralize Lohi Lake in 1973, 1974 and 1975 with a total of 27.3 T of Ca(OH)₂ and 15.0 T of CaCO₃ (Scheider *et al.*, 1975; Dillon *et al.*, 1979). However, the treatments provided short term chemical improvements because of continued flushing by acid water from upstream Clearwater Lake. During this research experiment, the Ministry of Natural Resources stocked the lake with 1200 yearling brook trout (*Salvelinus fontinalis*), as well as two forage fish species. Unfortunately the improvement in water quality only lasted for a few years and the pH declined again to levels that would not support fish (Kirk and Drouin, 1990). Regular fisheries netting surveys have been occurring since 2004 (Cooperative Freshwater Ecology Unit, 2014). On June 18, 2008 the lake was stocked with 272 smallmouth bass (*Micropterus dolomieu*) (average size 225 mm) as part of a food web study by A. Luek and G. Morgan.

Table 1 Lohi Lake location and physical description (Kirk and Drouin, 1990).

Township	Broder
Latitude/Longitude	46°23'18" N, 81°02'37" W
MNR District	Sudbury
Watershed Code	2CF
Elevation (m)	265
Shoreline Development Factor	1.97
Number of Cottages/Lodges	30
Forest Type	Birch transition
Shoreline Type	Bedrock/sand
Lake Surface Area (ha)	41.6
Maximum Depth (m)	19.5

Mean Depth (m)	6.2
Volume (x10⁴m³)	250
Secchi (m)	4.43 (July 10, 2014)
Access	Culvert off South Shore Rd.

METHODS

Fisheries Community Assessment

In 2014 the fish community of Lohi 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).

A total of 16 multi-mesh gillnets were set in Lohi Lake from July 8 - 11, 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 Lohi 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 (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 Lohi 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 Lohi 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 Lohi Lake and picked by hand.

Water Quality Assessment

A dissolved oxygen (mg/L) and temperature (°C) profile was measured in the main basin of Lohi Lake on July 10, 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 24, 2014 from the surface of Lohi 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 and inorganic carbon, metals and major ions.

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

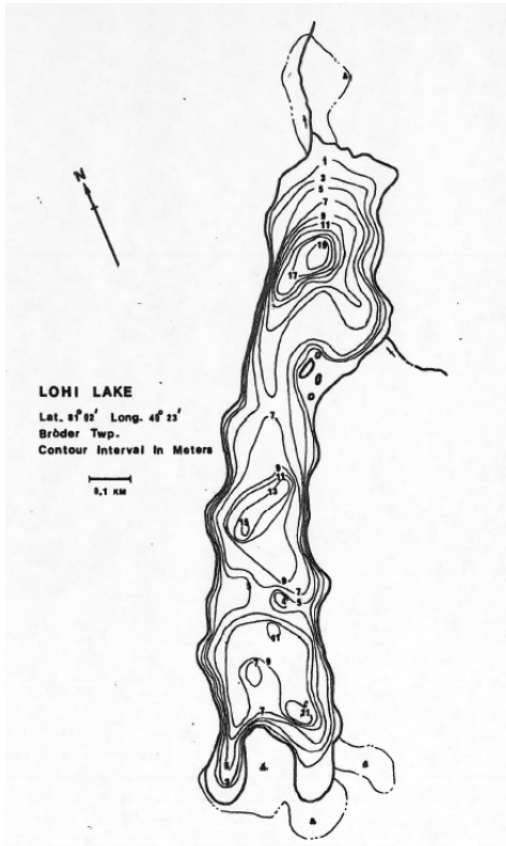


Figure 1 Bathymetric map of Lohi Lake (Kirk and Drouin, 1990).

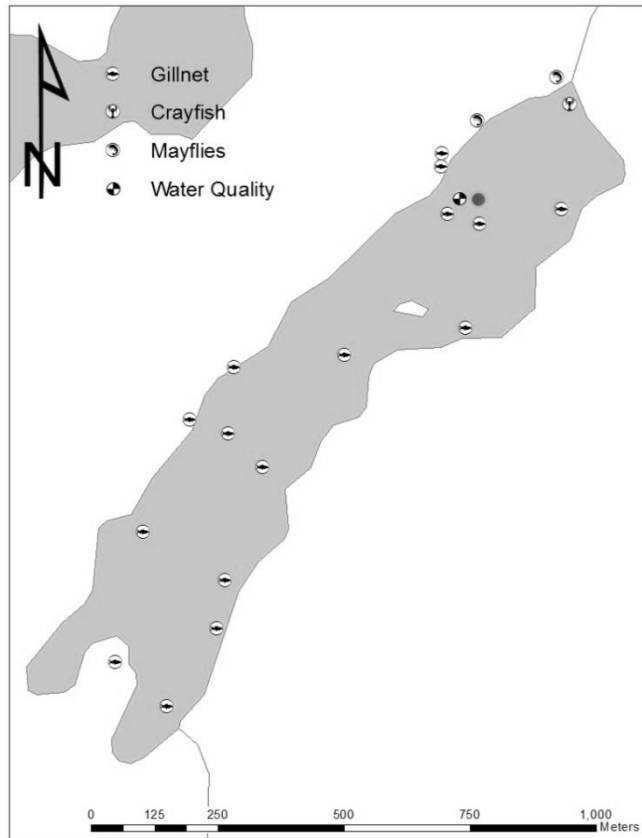


Figure 2 Outline map of Lohi Lake showing the location of sampling gear or collected organisms.

RESULTS AND DISCUSSION

Fisheries Community Assessment

The July 8 to 11 netting survey captured a total of three species: pumpkinseed (*Lepomis gibbosus*), smallmouth bass, and yellow perch (*Perca flavescens*). Other species, observed in previous netting surveys, including golden shiner (*Notemigonus crysoleucas*) and fathead minnow (*Pimephales promelas*) were no longer captured (Cooperative Freshwater Ecology Unit, 2014). Total catch, total weight (g) and catch-per-unit effort (CPUE) from the Nordic survey can be seen in Table 2.

Table 2 Catch summary and CPUE for all species captured in Lohi Lake July 8 - 11, 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)
Pumpkinseed*	17	16	488.2	1.0625	30.5125
Smallmouth Bass	84	81	23787.2	5.25	1486.7
Yellow Perch*	83	80	3202.6	5.1875	200.1625
Total	184	177	27478.0	11.5	1728.875

Smallmouth bass was the most abundant fish species caught in Lohi Lake, with a total catch of 84 individuals and total lengths ranging from 102 mm to 473 mm. A complete summary of morphological information for smallmouth bass can be seen in Appendix I.

Yellow perch have declined to low numbers but the size structure still ranges from 53 mm to 261 mm (Figure 3).

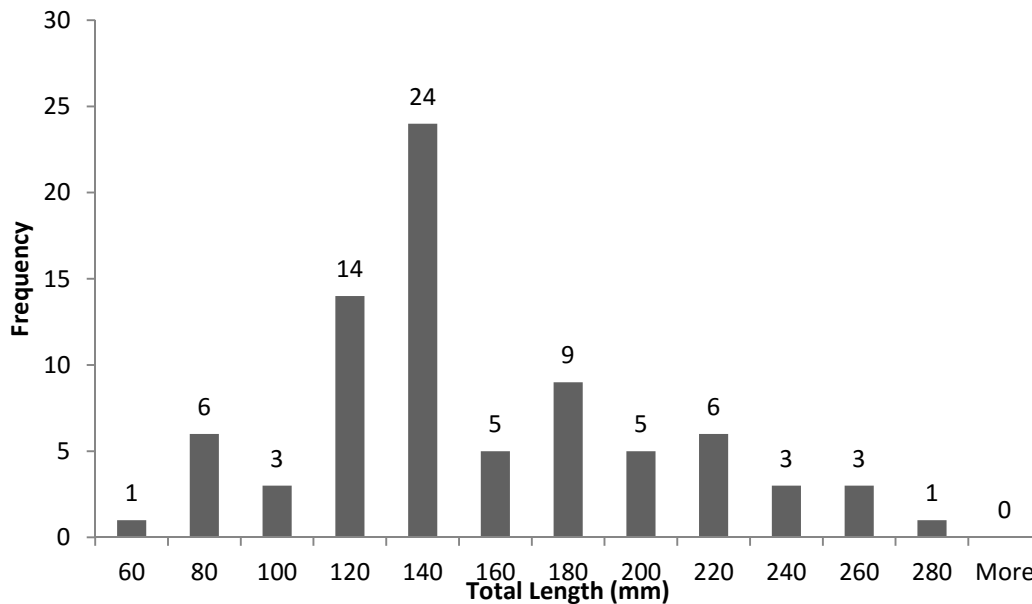


Figure 3 Length frequency histogram for yellow perch (n=80) captured in Lohi Lake July 8 - 11, 2014.

No fish were caught during the 1990 Urban Lakes Survey on Lohi Lake (Poulin *et al.*, 1991) and the lake was classified as fishless at that time with no incidental observation of any fish in the lake. When the first Nordic survey was conducted on the lake in 2004, a total of four species were present with a large population of yellow perch that accounted for 98% of the total catch (Cooperative Freshwater Ecology Unit, 2014). The perch population collapsed rapidly with the introduction of smallmouth bass in 2008 (Luek, unpublished data; Cooperative Freshwater Ecology Unit, 2008).

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

Survey Type	Multi-Gear Survey		Nordic		Nordic		Nordic	
Year	1990 ¹		2004 ²		2009 ²		2014	
Species	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Fathead Minnow	-	-	41	1.88	-	-	-	-
Pumpkinseed	-	-	2	0.09	16	2.63	17	9.24
Smallmouth Bass	-	-	-	-	8	1.31	84	45.7
Yellow Perch	-	-	2134	98	585	96.1	83	45.1
Total	-	-	2177	100	609	100	184	100
Species Richness	0		4		3		3	

In terms of total biomass, as was the case for numerical abundance yellow perch accounted for the majority of the total biomass from 2004 to 2009 (Cooperative Freshwater Ecology Unit, 2014). While total biomass has not changed substantially over the years the switch from perch to bass domination was very dramatic. Smallmouth bass now account for 86% of the total biomass recorded from Lohi Lake (Figure 5).

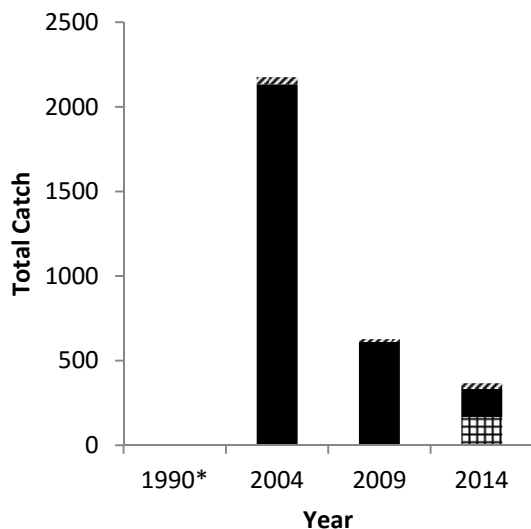


Figure 4 Total catch data from Lohi Lake (*Nordic method was not used during the 1990 Urban Lakes Survey. Poulin *et al.*,1991).

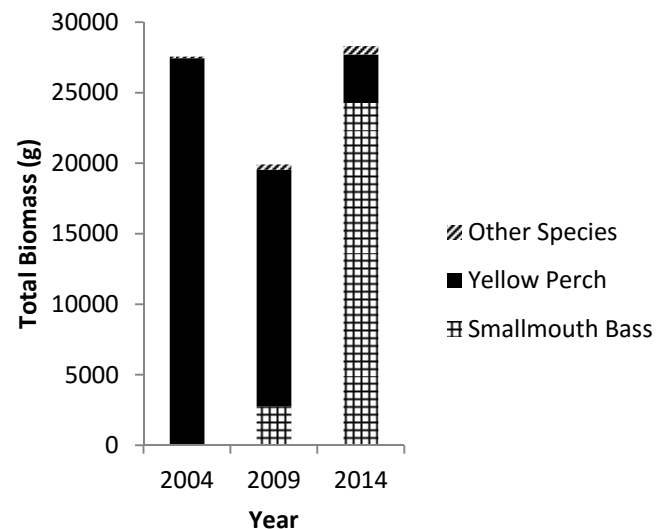


Figure 5 Total biomass data (g) from Lohi Lake.

Baseline Organisms

No clams or snails were collected from Lohi Lake. Approximately 30 mayflies were captured near the outflow at the north end of Lohi Lake. Only one crayfish was captured in a trap set near the outflow at the north end of Lohi Lake. Six additional crayfish were collected from the stomach of a smallmouth bass. Four night time zooplankton hauls were conducted at Lohi Lake

on July 20, 2014. A sufficient stable isotope sample (approx. 50-300) of *Chaoborus* sp. was collected. No aquatic plants were collected from Lohi Lake.

Water Quality Assessment

At the time of the Nordic Index Netting survey, Lohi Lake was thermally stratified (Figure 6). Water temperatures ranged from 22.3 °C at the surface to 5.6 °C at 16 m. Dissolved oxygen levels ranged from 7.64 mg/L to 0.39 mg/L. Depth at the site of the temperature and dissolved oxygen profiles was 16 m and the secchi water clarity was 4.43 m.

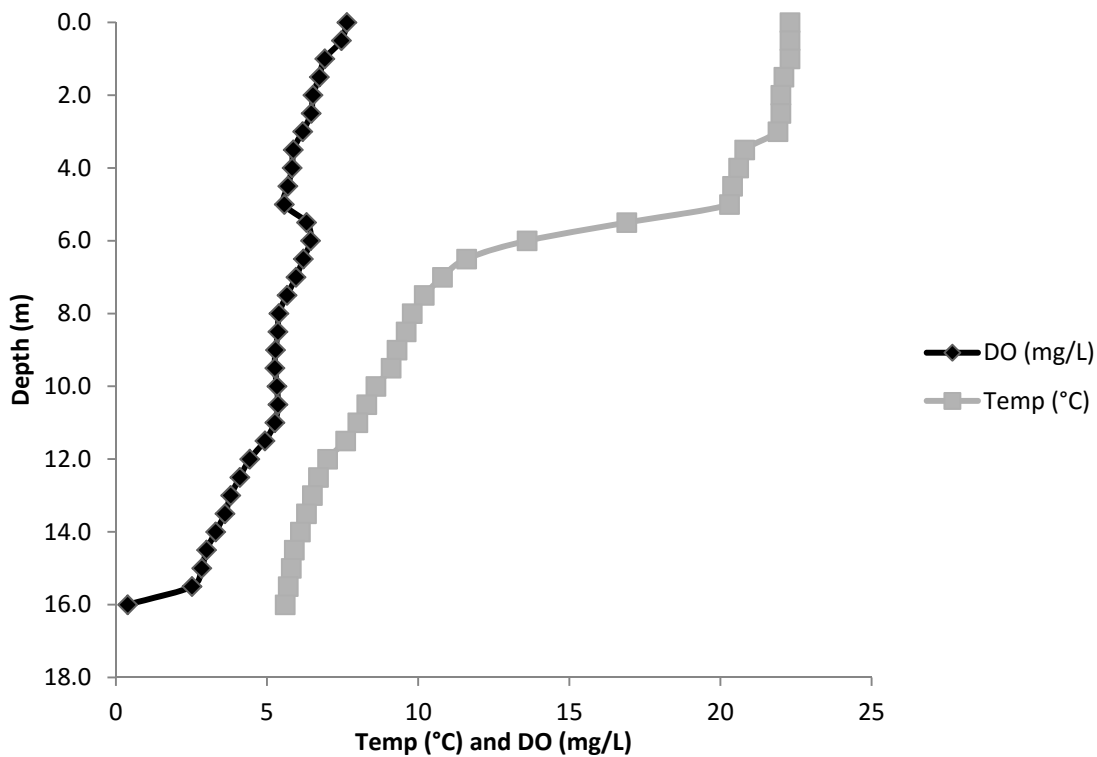


Figure 6 Temperature (°C) and dissolved oxygen (mg/L) profile for Lohi Lake, measured July 10, 2014.

The water quality of Lohi Lake has made a considerable recovery since 1978 (Table 4). During this time, the pH has increased from 4.79 to 6.91, along with an increase in TIA alkalinity from less than zero to 5.13 mg/L CaCO₃. Concentrations of metals such as Nickel (Ni), Copper (Cu) and Aluminum (Al) have declined over the past three decades. The neutralization experiments that occurred during the 1970s improved the water quality for a few years at first (Kirk and Drouin, 1990), however the improvements that have been occurring since 1978 are a result of reductions in emissions from local smelters (Keller *et al.*, 2007).

As of July 24, 2014, Lohi Lake has a neutral pH reading of 6.91 and a TIA alkalinity of 5.13 mg/L CaCO₃. Concentrations of metals have been declining, however Ni (33.1 µg/L) and Cu (8.2 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 (8.8 µg/L) concentrations remain below these levels (Ontario Ministry of Environment and Energy, 1994).

CONCLUSIONS

Lohi Lake is no longer an acid lake and pH has improved from 4.74 in 1979 (Kirk and Drouin, 1990) to 6.91 in 2014. Metal concentrations have also improved with declines of 87% for Ni and 90% for Cu. However, concentrations of Ni and Cu still remain above PWQO criteria for the protection of aquatic life (Ontario Ministry of Environment and Energy, 1994). Clams and snails were not observed in Lohi Lake, however acid-sensitive mayflies appear quite common. Lohi Lake supports populations of three fish species, including smallmouth bass as a predatory sportfish, which is now the most abundant species in the lake. Although no records for this species exist prior to its introduction in 2008 (Luek, unpublished data; Cooperative Freshwater Ecology Unit, 2008), Luek *et al.* (2010) has documented the "occasional smallmouth bass" (1 seen in 2007) prior to the introduction. The source of the fish in Lohi lake, outside of the 2008 intentional stocking of bass is unknown.

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.

Table 4 Water chemistry from Lohi Lake (a. Before lake neutralization; b. after lake neutralization; 1. Ontario Ministry of Environment and Energy, 1994; 2. Kirk and Drouin, 1990; 3. Keller *et al.*, 2004).

Parameter	¹ PWQO	Year											
		² 1962	² 1973 _a	² 1973 _b	² 1974	² 1975	² 1976	² 1977	² 1978	² 1979	³ 1990	³ 2003	2014
pH	6.5-8.5	5.2	4.39	6.12	6.04	6.09	6.09	5.27	4.79	4.74	4.92	6.28	6.91
TIA Alkalinity (mg/L CaCO ₃)	-	22	<0	3.8	2.3	5.1	2.2	1.1	<0		-0.69	2.57	5.13
Conductivity (µS/cm)	-	114	87.5	76.3	75.2	78.9	76.8	76.7	77.6	78.3	90.8	71.6	60
True Colour (TCU)	-	-	-	-	-	-	-	-	-	-	-	-	16
DOC (mg/L)	-	-	-	-	-	-	-	-	-	-	1.1	3.4	3.6
Ca (mg/L)	-	-	6.2	9.0	7.9	8.6	8.0	7.2	6.7	6.6	6.18	4.34	3.66
Mg (mg/L)	-	-	2.5	1.3	1.3	1.1	1.2	1.6	1.6	1.5	1.75	1.31	1.12
Na (mg/L)	-	-	1.9	1.7	1.5	1.7	1.6	1.6	1.6	1.8	3.89	5.71	4.44
K (mg/L)	-	-	1.3	1.1	1.0	0.85	0.75	0.76	0.70	0.75	0.850	0.720	0.68
SiO ₃ (mg/L)	-	-	1.3	1.2	1.6	2.2	2.2	2.2	2.2	0.77	0.56	1.12	1.36
SO ₄ (mg/L)	-	-	26.7	27.3	25.9	24.0	25.0	24.8	23.7	21.4	19.57	10.39	6.9
Total Cu (µg/L)	5	-	83.6	19.0	43.7	43.1	37.3	43.9	70.5	64.3	50	12	8.2
Total Ni (µg/L)	25	-	254	140	195	166	176	221	237	210	200	59	33.1
Total Zn (µg/L)	30	-	41.6	21.3	32.3	28.1	38.0	33.1	32.4	29.1	29	10	8.2
Total Fe (µg/L)	300	-	90	36.0	51.2	114	92.6	72.0	58.2	43.3	130	106	30
Total Mn (µg/L)	-	-	284	223	243	174	140	168	279	290	230	41	4.9
Total Al (µg/L)	75	-	-	-	143	106	123	97.4	157	140	130	22	8.8

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APPENDIX I

Morphological data for smallmouth bass (*Micropterus dolomieu*) from Lohi Lake, July 8 – 11, 2014.

Species	Fish #	Fork Length (mm)	Total Length (mm)	Weight (g)	Sex			Ageing Structure				Tissue											
					1-Male	2-Female	9-Unknown	1-Immature	2-Mature	9-Unknown	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	10	341	360	645.1	1			2				A											1
Smallmouth Bass	11	186	192	97.3	9			1				A											1
Smallmouth Bass	12	196	205	108.2	2			1				A											1
Smallmouth Bass	13	165	174	62.9	2			1				A											0
Smallmouth Bass	14	106	110	15.9	2			1				A											1
Smallmouth Bass	34	451	473	1460.8	1			2				A											1
Smallmouth Bass	35	335	354	565	1			2				A											1
Smallmouth Bass	36	324	340	501.3	2			2				A											1
Smallmouth Bass	37	195	206	106.2	2			1				A											0
Smallmouth Bass	38	196	208	108.1	2			1				A											0
Smallmouth Bass	39	200	211	107.1	9			1				A											0
Smallmouth Bass	40	181	192	79	2			1				A											0
Smallmouth Bass	41	180	190	85.1	9			1				A											0
Smallmouth Bass	45	232	245	199.7	2			2				A											1
Smallmouth Bass	46	285	304	343.2	2			2				A											1
Smallmouth Bass	47	427	453	1162.1	1			2				A											1
Smallmouth Bass	48	339	358	635.6	1			2				A											0
Smallmouth Bass	49	182	190	82.1	9			1				A											0
Smallmouth Bass	50	197	208	105.4	9			1				A											0
Smallmouth Bass	51	187	195	92.6	2			1				A											0
Smallmouth Bass	52	174	182	65.2	1			1				A											0
Smallmouth Bass	53	107	111	16.8	9			1				A											0
Smallmouth Bass	63	341	363	714.8	1			2				A											0
Smallmouth Bass	64	342	355	613.4	2			2				A											0
Smallmouth Bass	65	326	344	548.8	1			2				A											0
Smallmouth Bass	66	309	326	466	1			2				A											0
Smallmouth Bass	67	228	233	169.7	1			9				A											0
Smallmouth Bass	68	217	228	160.9	1			9				A											0
Smallmouth Bass	69	198	209	125.5	1			1				A											0
Smallmouth Bass	70	189	199	84.8	9			1				A											0
Smallmouth Bass	71	180	189	88.3	2			1				A											0
Smallmouth Bass	87	347	371	646.3	1			2				A											1
Smallmouth Bass	88	329	345	523.9	1			2				A											1
Smallmouth Bass	89	192	204	97	9			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	90	297	314	392	2	2	A	1
Smallmouth Bass	91	224	230	154.9	2	1	A	1
Smallmouth Bass	92	340	358	597.5	2	2	A	0
Smallmouth Bass	93	285	305	352.4	2	2	A	0
Smallmouth Bass	94	234	245	205.1	1	9	A	0
Smallmouth Bass	95	195	207	113.6	2	2	A	0
Smallmouth Bass	96	184	194	89	9	1	A	0
Smallmouth Bass	97	303	321	380.8	2	2	A	1
Smallmouth Bass	98	313	329	439.5	1	2	A	1
Smallmouth Bass	99	326	346	550.4	1	2	A	1
Smallmouth Bass	100	216	234	139.2	2	2	A	0
Smallmouth Bass	101	321	340	452.8	1	2	A	0
Smallmouth Bass	102	230	241	174.4	2	1	A	0
Smallmouth Bass	103	226	235	159	1	1	A	0
Smallmouth Bass	104	218	226	162.8	1	9	A	0
Smallmouth Bass	105	215	225	153.8	2	1	A	0
Smallmouth Bass	119	183	192	94.2	2	1	A	1
Smallmouth Bass	120	400	420	932.7	2	2	A	1
Smallmouth Bass	121	325	345	543.9	1	2	A	1
Smallmouth Bass	122	340	359	593.8	2	2	A	0
Smallmouth Bass	123	325	345	560.5	2	2	A	0
Smallmouth Bass	124	329	347	481.4	1	2	A	0
Smallmouth Bass	125	302	321	425.5	2	2	A	0
Smallmouth Bass	126	190	200	98.5	9	1	A	0
Smallmouth Bass	127	196	207	104.9	9	1	A	0
Smallmouth Bass	128	198	209	112.1	2	1	A	0
Smallmouth Bass	138	322	340	498.1	1	2	A	0
Smallmouth Bass	139	179	190	86.4	2	1	A	0
Smallmouth Bass	140	104	110	15.7	2	1	A	0
Smallmouth Bass	141	97	102	11.4	2	1	A	1
Smallmouth Bass	155	177	187	78.6	1	1	A	0
Smallmouth Bass	156	184	194	87.5	1	1	A	0
Smallmouth Bass	157	201	210	123.5	1	9	A	0
Smallmouth Bass	158	200	209	106	2	1	A	0
Smallmouth Bass	159	240	252	192.4	1	9	A	0
Smallmouth Bass	160	111	123	35.4	1	9	A	1
Smallmouth Bass	161	205	214	120.3	1	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	167	329	348	518.2	2	2	A	0
Smallmouth Bass	168	318	335	462.1	1	2	A	0
Smallmouth Bass	169	306	324	384.4	1	2	A	0
Smallmouth Bass	170	314	335	456	2	2	A	0
Smallmouth Bass	171	310	325	411.7	2	2	A	0
Smallmouth Bass	172	236	248	199.5	1	9	A	0
Smallmouth Bass	173	275	292	305.5	2	2	A	0
Smallmouth Bass	174	202	211	121.4	1	1	A	0
Smallmouth Bass	175	197	207	111.2	2	1	A	0
Smallmouth Bass	176	200	210	113.1	1	1	A	0