CLEARWATER LAKE

URBAN LAKES FISHERIES STUDY 2014

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INTRODUCTION

Clearwater Lake (46°22'11" N, 81°03'04" W) is a 75.6 ha lake located within the City of Greater Sudbury, in Broder/Tilton township. It has one main basin with a maximum depth of 21.5 m (Figure 1). A complete summary of physical characteristics can be seen in Table 1.

Clearwater Lake can be accessed publicly at a gravel boat launch located at the north end of the lake, off Tilton Lake Rd. Clearwater Lake has approximately 60 homes and cottages around its shoreline, including a summer camp for teenagers. It is unlikely that the lake receives angling pressure other than that by the occasional lake resident.

Clearwater Lake is one of the intensive monitoring lakes sampled by the Ontario Ministry of the Environment and Climate Change (OMOECC) through the Cooperative Freshwater Ecology Unit. It is recognized within the Official Plan of Sudbury as a principal monitoring lake for the City. It is actually the site of the longest continuous acid rain monitoring program in the world. Clearwater has been recognized as an acidified lake for many decades. In 1956 lake residents attempted to neutralize the lake with crushed limestone. This resulted in an increase in pH for only a few weeks. Further attempts were made using calcium hydroxide ($Ca(OH)_2$) which resulted in an increase in pH to 7.0 until fall turnover. The lake was stocked in 1956 with dace (family Cyprinidae), and again in 1957 with fingerling smallmouth bass (*Micropterus dolomieu*) (Kirk, 1990). Despite these species introductions, fisheries assessments yielded no fish until the late 1990s when the first fathead minnow (*Pimephales promelas*), northern redbelly dace (*Phoxinus eos*) and brook stickleback (*Culaea inconstans*) were observed (Keller *et al*., 2004). Yellow perch (*Perca flavescens*) was observed in September 2001 (J.Gunn pers. comm.) (Figure 2).

In 2014, as part of the Urban Lakes Study, field crews from Laurentian University's Cooperative Freshwater Ecology Unit surveyed Clearwater Lake, along with several other lakes around Greater Sudbury. The lake had previously been netted in 1990, 2003, 2004, 2005, 2006, 2007, 2008, 2009 and 2010.

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

Township	Broder/Tilton
Latitude/Longitude	46°22'11" N, 81°03'04" W
MNRF District	Sudbury
Watershed Code	2CF05
Elevation (m)	267
Shoreline Development Factor	1.61
Number of Cottages/Lodges	60
Forest Type	Birch transition
Shoreline Type	Bedrock/sand
Lake Surface Area (ha)	75.6
Maximum Depth (m)	21.5
Mean Depth (m)	8.4
Volume ($x10^4m^3$)	642.0
Secchi (m)	5.35 (July 18, 2014)
Access	Public launch off Tilton Lake Rd.

METHODS

Fisheries Community Assessment

The fish community of Clearwater Lake was sampled in 2014 according to the Nordic Index Netting protocol (Appelberg, 2000). 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 24 multi-mesh gillnets were set in Clearwater Lake from July 15 to 18, 2014. Nets were set for approximately 12 hours at randomly selected locations on the lake across multiple depth strata (7 nets in <3.0 m; 7 nets in 3.0 - 5.9 m; 5 nets in 6.0 – 11.9 m; 5 nets in 12.0 – 19.9 m). Figure 2 shows the locations of all gillnets set in Clearwater 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 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), and aquatic plants from Clearwater 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 Clearwater 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 Clearwater Lake and picked by hand. Mid-lake hauls using a 30cm diameter zooplankton net (150µm mesh) were used to collect *Chaoborus sp.*

Water Quality Assessment

A dissolved oxygen (mg/L) and temperature (°C) profile was measured in the main basin of Clearwater Lake on June 18, 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 8, 2014 from the surface (~0.5m) of Clearwater 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. The sampling location for water quality can be seen in Figure 2.

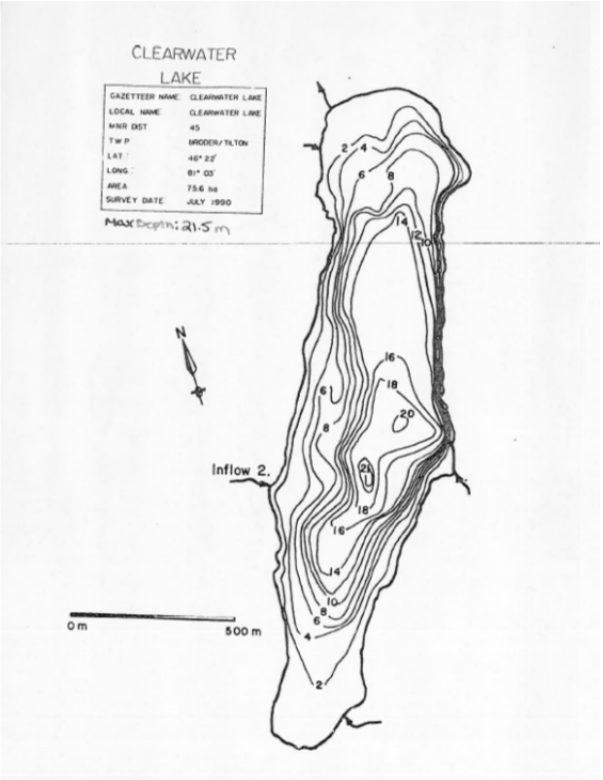

Figure 1 Bathymetric map of Clearwater Lake (Kirk, 1990).

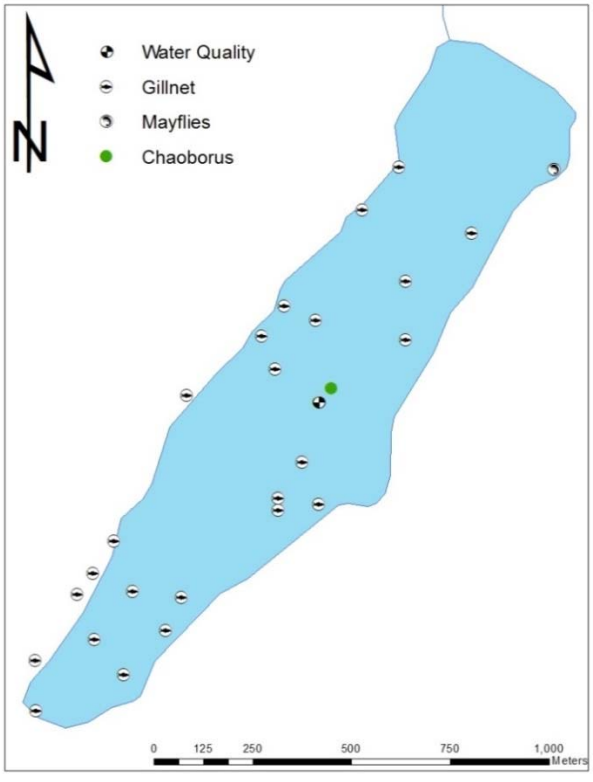

Figure 2 Outline map of Clearwater Lake showing the location of sampling gear or collected organisms.

RESULTS AND DISCUSSION

Fisheries Community Assessment

During the July 15 to 18 netting survey, a total of 24 nets were set, catching a total of three different species: pumpkinseed (*Lepomis gibbosus*), smallmouth bass, and yellow perch. 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 Clearwater Lake July 15 - 18, 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*	5	5	134.4	0.2083	3.9529
Smallmouth Bass	32	30	3465.8	1.3333	144.4083
Yellow Perch*	887	843	14108.4	36.9583	587.85
Grand Total	924	878	17574.2	38.4999	736.2112

Smallmouth bass were the only predator species observed in Clearwater Lake during the survey. A total of 32 smallmouth bass (including many young-of-the-year bass) were captured during the 2014 survey with total lengths ranging from 115 mm to 395 mm. A complete summary of morphological data for smallmouth bass can be seen in Appendix I.

Yellow perch was the most abundant fish species found in Clearwater Lake (Table 2) with total lengths ranging from 33 mm to 232 mm. A length frequency histogram for yellow perch can be seen in Figure 3.

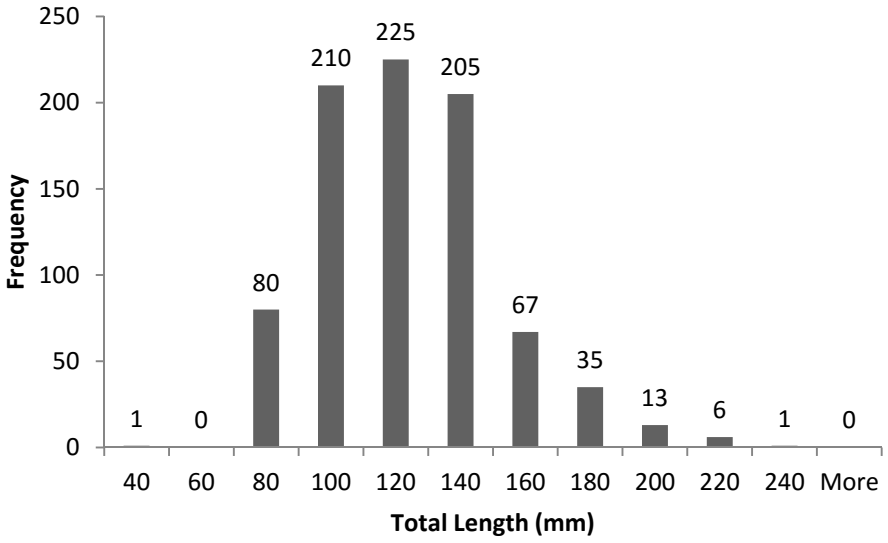

Figure 3 Length frequency histogram for yellow perch (n=843) captured in Clearwater Lake July 15 - 18, 2014.

No fish were caught in Clearwater Lake during the 1991 Urban Lakes Survey and the lake was classified as fishless for nearly the next decade. When the first Nordic survey was conducted in 2003, there were three small-bodied species (yellow perch, pumpkinseed and fathead minnow) and a single smallmouth bass found in the lake with yellow perch accounting for 94% of the total catch. This was also the first observation of smallmouth bass in Clearwater Lake (Keller *et al*., 2004; Cooperative Freshwater Ecology Unit, 2014). Since then, species richness declined to three in 2004 and to two in 2009. The occasional bass was again observed in 2005 and 2007 (Luek *et al*., 2010; Cooperative Freshwater Ecology Unit 2014) however the abundance of this predator species only increased in 2014, now accounting for 3% of the total catch. We do not know where the first bass came from, but they presumably migrated in from Lohi Lake (the downstream lake). Table 3 shows species richness and proportion of total catch for Clearwater Lake.

Table 3 Species richness and proportion of total catch for Clearwater Lake (1. Poulin *et al*., 1991; 2. Cooperative Freshwater Ecology Unit, 2014).Note: not all the results from earlier surveys are shown.

Survey Type	**Multi-Gear Survey**		**Nordic**		**Nordic**		**Nordic**		**Nordic**	
Year	**1990**[1]		**2003**[2]		**2004**[2]		**2009**[2]		**2014**	
Species	***n***	**%**	***n***	***%***	***n***	***%***	***n***	***%***	***n***	**%**
Fathead Minnow	-	-	67	4.31	18	0.95	-	-	-	-
Pumpkinseed	-	-	20	1.29	6	0.32	19	1.35	5	0.54
Smallmouth Bass	-	-	1	0.06	-	-	-	-	32	3.46
Yellow Perch	-	-	1465	94.33	1861	98.7	1390	98.7	887	96.00
Total	-	-	1553	100	1885	100	1409	100	924	100
Species Richness	0		4		3		2		3	

Clearwater lake appears to be following a pattern seen in several other Sudbury lakes where acid-tolerant perch arrive early and establish a large population that crashes when a predator like bass arrives (Lippert *et al*. 2007).

Yellow perch have also accounted for the majority of the total biomass since 2003 (24926g in 2003; 29776g in 2004; 34699g in 2009; 14896g in 2014). No significant trends were observed in total biomass among these years, however an increase in smallmouth bass biomass occurred in 2014, which resulted in a decrease in that of yellow perch. Biomass data can be seen in Figure 5.

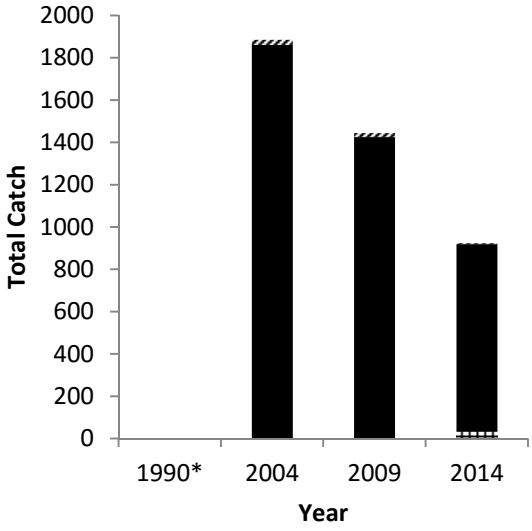

Figure 4 Total catch data for Clearwater Lake (*Nordic method was not used during the 1990 urban lakes survey. Poulin *et al*., 1991).

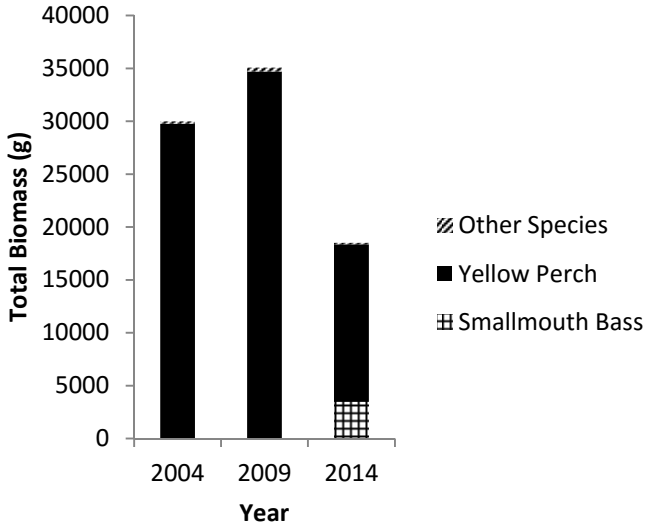

Figure 5 Total biomass data for Clearwater Lake.

Baseline Organisms

No clams or snails were found at Clearwater Lake. A total of seven crayfish were captured in traps set at various locations across the lake. A total of 50 mayflies were captured at the northeast end of the lake. Twenty nighttime zooplankton hauls were conducted at Clearwater Lake on July 22, 2014. Approximately 20 *Chaoborus* sp. were collected. A bulk sample of five Pipewort (*Eriocaulon aquaticum*) was collected from Clearwater Lake.

Water Quality Assessment

At the time of the Nordic Index Netting survey, Clearwater Lake was thermally stratified (Figure 6). Water temperatures ranged from 19.6 °C at the surface to 6.8 °C at 20.5 m. Dissolved oxygen levels ranged from 7.61 mg/L to 4.61 mg/L. Depth at the site of the temperature and dissolved oxygen profiles was 21.0 m and the secchi water clarity was 5.35 m.

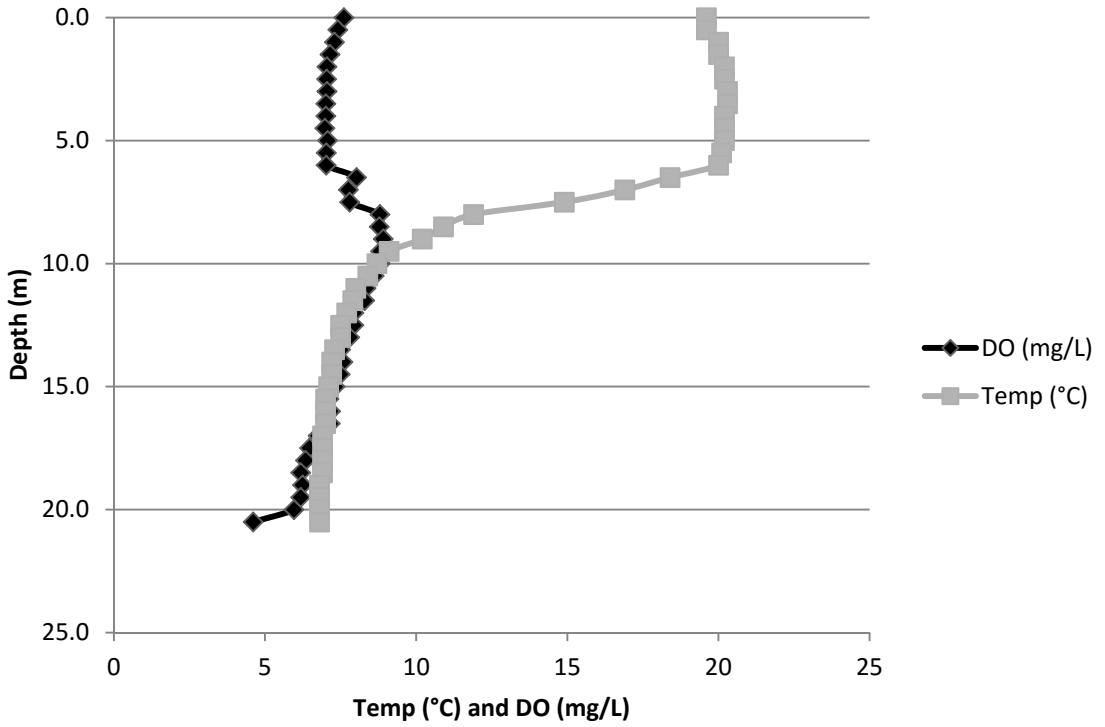

Figure 6 Temperature (°C) and dissolved oxygen (mg/L) profile for Clearwater Lake, measured June 18, 2014

Water quality improvements continue to occur in Clearwater Lake (Table 4). Since 2003, pH has continued to increase to a value of 6.89. TIA alkalinity has improved over this time as well from 1.19 mg/L $CaCO_3$ to 3.52 mg/L $CaCO_3$. Concentrations of metals such as Nickel (Ni), Copper (Cu), Aluminum (Al) and Iron (Fe) continue to decrease which is likely a result of further reductions in emissions from local smelting operations (Keller *et al*., 2007).

As of July 8, 2014, Clearwater Lake has improved to a near-neutral pH level of 6.89 and a positive TIA alkalinity value of 3.52 mg/L $CaCO_3$. Concentrations of Nickel (37.3 µg/L) and Copper (7.1 µg/L) remain above the Ministry of Environment and Climate Change's (MOECC) Provincial Water Quality Objective's (PWQO) criteria for the protection of aquatic life, while Aluminum (11.6 µg/L) and Iron (10 µg/L) concentrations have decreased below these criteria (Ontario Ministry of Environment and Energy, 1994).

Table 4 Water chemistry of Clearwater Lake (T. Traceable amount: interpret with caution; 1. Ontario Ministry of Environment and Energy, 1994; 2. Kirk, 1990; 3. Keller *et al*., 2004).

Parameter	[1]PWQO	Year						
		[2]1979	[2]1981	[2]1982	[2]1989	[2]1990	[3]2003	2014
pH	6.5-8.5	4.41	4.52	4.48	4.8	4.71	6.33	6.89
TIA Alkalinity (mg/L $CaCO_3$)			-1.86	-1.90		-0.83	1.19	3.52
Conductivity (µS/cm)		85.0	76.0	78.00		84.0	61.0	56.7
True Colour (TCU)						[T]1.0		11.8
DOC (mg/L)			0.4			0.5	2.9	3.1
DIC (mg/L)			0.4					0.94
Ca (mg/L)		6.3	6.00	6.00		6.5	4.30	3.48
Mg (mg/L)		1.4	2.70	1.38		1.440	1.09	1.02
Na (mg/L)		1.7	2.00			3.22	4.00	4.13
K (mg/L)		0.70	0.55			0.630	0.575	0.6
SiO_3 (mg/L)		1.3	1.35			0.70	1.10	1.0
SO_4 (mg/L)		22.0	20.0	19.4		17.56	10.70	7.45
Total P (µg/L)	20	2.4	8.0				5	3.3
Total Cu (µg/L)	5	59.8	46.0	58.0	51	47.0	10	7.1
Total Ni (µg/L)	25	220	190.0	230.0	180	180.0	70	37.3
Total Zn (µg/L)	30	31.4	28.0	35.0		25.0	11	4.5
Total Fe (µg/L)	300	55.0	40.0	30.0		[T]46.0	15	10
Total Mn (µg/L)		282	286.0	279.0	280	290.0	26	3.9
Total Al (µg/L)	75	272	200.0	250.0	170	140.0	16.0	11.6

CONCLUSIONS

The water quality of Clearwater Lake has shown considerable improvements over the past 35 years, including an increase in pH to a near-neutral 6.89. Concentrations of Ni and Cu remain above the PWQO criteria for the protection of aquatic life. These concentrations have, however, declined by 83% for Ni and 88% for Cu since 1979. Clams and snails were not observed in the lake, however crayfish and acid-sensitive mayflies are present and appear quite common. Clearwater Lake supports populations of three species of fish, including a recent arrival of smallmouth bass, a predatory sport fish. It is assumed that this species migrated in from nearby Lohi Lake as this lake was stocked with smallmouth bass in 2008 (Luek, unpublished data; Cooperative Freshwater Ecology Unit, 2008).

ACKNOWLEDGEMENTS

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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 smallmouth bass (*Micropterus dolomieu*) from Clearwater Lake, July 15 – 18, 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 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
Smallmouth Bass	1	230	241	186	2	2	A	1
Smallmouth Bass	2	122	128	27.3	9	1	A	1
Smallmouth Bass	3	111	115	19	2	1	A	1
Smallmouth Bass	4	111	115	16.8	2	1	A	1
Smallmouth Bass	101	131	137	34.5	9	1	A	1
Smallmouth Bass	182	119	124	24.4	9	1	A	1
Smallmouth Bass	183	118	124	25.1	2	1	A	1
Smallmouth Bass	184	117	124	26.1	9	1	A	1
Smallmouth Bass	185	129	135	31.7	9	1	A	1
Smallmouth Bass	186	118	123	24.2	9	1	A	0
Smallmouth Bass	187	120	126	25.7	2	1	A	0
Smallmouth Bass	326	128	135	28.4	2	1	A	1
Smallmouth Bass	327	118	124	24.5	2	1	A	1
Smallmouth Bass	328	379	395	1012.5	2	2	A	1
Smallmouth Bass	329	117	122	22.8	9	1	A	1
Smallmouth Bass	378	248	258	246	2	2	A	1
Smallmouth Bass	379	259	270	327.3	2	2	A	1
Smallmouth Bass	514	264	277	309.5	2	2	A	1
Smallmouth Bass	515	243	254	230	2	2	A	1
Smallmouth Bass	516	148	154	46	2	9	A	1
Smallmouth Bass	604	140	147	45	2	9	A	1
Smallmouth Bass	664	255	265	260.6	2	2	A	1
Smallmouth Bass	665	251	263	272.6	1	2	A	1
Smallmouth Bass	666	127	132	29.8	2	1	A	1
Smallmouth Bass	667	121	126	26.7	9	1	A	1
Smallmouth Bass	698	122	128	25.8	9	1	A	1
Smallmouth Bass	850	118	123	24.5	9	1	A	1
Smallmouth Bass	878	132	139	33.5	1	1	A	1
Smallmouth Bass	879	128	134	31.5	2	1	A	1
Smallmouth Bass	880	123	129	28	1	1	A	1