Crooked Lake

Emmet County, T35N, R04W, many sections
Cheboygan River watershed, 2019

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Environment

Crooked Lake is a 2,352-acre lake in Emmet County and is part of the Inland Waterway in the Cheboygan River watershed (Figure 1). Tributaries to the lake include Minnehaha Creek and Pickerel Lake Channel (outlet from Pickerel Lake), Mud Creek (outflow from Round Lake), and Oden Creek. The outlet is the Crooked River, which flows downstream into Burt Lake. Crooked Lake has a maximum depth of 68 feet and thermally stratifies in the summer with a thermocline at 28-34 feet in depth (Figure 2, Table 1). There is a hard-surfaced boat ramp access in the northwest corner of the lake off US-31 highway.

History

Fisheries management in Crooked Lake dates back to 1923, when 10,000 Rainbow Trout were stocked in the lake. Rainbow Trout and Lake Trout were stocked periodically through the 1920s, along with Yellow Perch for two years. The 1930s brought an expanded stocking program to Crooked Lake, with Smallmouth Bass, Largemouth Bass, Walleye, Yellow Perch, Bluegill, Northern Pike, and Rock Bass stocked in addition to the Rainbow Trout and Lake Trout during that decade. The same nine species were stocked at various levels and frequency during the 1940s, but Walleye and Yellow Perch were the most consistently stocked species during that time period. The only stocking to take place in Crooked Lake in the 1950s and 1960s was in 1966, when 3,333 adult Coho Salmon were stocked.

Walleye were stocked in Crooked Lake from the 1970s through 2006 with the assistance of the Pickerel-Crooked Lakes Association (PCLA) and a cooperative rearing pond (Table 2). The Pickerel-Crooked rearing pond was built in 1974 on land deeded to the Michigan Department of Natural Resources (MDNR) by the PCLA. The rearing pond was renovated in the 1990s and was thereafter referred to as the Reid Berney pond to honor the MDNR heavy equipment operator who performed the work, and subsequently passed away. Stocking of Walleye in Crooked Lake was discontinued in 2006 due to high catch rates of age-0 fish and good natural reproduction observed in the lake. Continued stocking on top of the naturally produced Walleye would also cause growth rates to be even slower. The Reid Berney walleye pond was used through 2018 with assistance from PCLA to raise walleye for stocking in other area lakes.

In addition to stocking, other fisheries management activities have occurred in Crooked Lake over the years, including habitat improvement and fisheries surveys such as population assessments. In 1953, 210 brush shelters were installed in the lake to provide additional game fish habitat. In 1954, a comprehensive survey of the lake was done by the MDNR Fisheries Division's Institute for Fisheries Research with effort consisting of 54 gill- net lifts as well as seining for smaller-bodied fish. Gamefish species captured in include Largemouth Bass, Smallmouth Bass, Northern Pike, Bluegill, Pumpkinseed Sunfish, Walleye, and Yellow Perch. Nongame fish species were captured in the gillnets and in the seining efforts. These species included White Suckers and Longnose Gar, as well as various shiner species, minnows, darters, Mottled Sculpin, Logperch, and Mudminnows.

In 1951, a sucker removal program was initiated for Crooked Lake. A commercial fisherman from Cheboygan was permitted to net and remove suckers and other "rough" fish during the winter months using trap nets that were tended weekly. Species kept for sale included White Suckers, Burbot, Common Carp, and Bowfin. Game species were returned to the water. The sucker removal program continued each winter (January through early/mid-April) though 1962, except for 1953. Over this time period, a total of 74,115 suckers were removed from Crooked Lake (Table 3). Records of game fish captured during these efforts were typical of the fish community found in the 1954 survey, along with an occasional Brown Trout or Muskellunge.

The Inland Waterway Project, which was completed in 1958, impacted Crooked Lake. The purpose of the project was to have a five-foot deep navigable channel through the Inland Waterway, allowing boats to travel from the Cheboygan River mouth at Lake Huron all the way up to Crooked and Pickerel Lakes. The dredging of this navigation channel resulted in a 1.5-foot drop in the water levels in Crooked and Pickerel Lakes, as well as a decrease in the surface area of Crooked Lake by 288 acres (Fisheries Division Files). The remedy was to install a lock and dam at the outlet of Crooked Lake to restore pre-1958 average water levels to Crooked and Pickerel Lakes. The Crooked River Lock and Dam were built in 1968.

A 1972 survey of Crooked Lake using gill nets found a similar fish community as previous surveys, with most species growing slower than the state average. In addition to the fish species typically encountered during previous surveys, this survey also captured Cisco and Alewife.

A spring netting survey of Crooked Lake in 1989 found that the fish community remained stable, that overall growth rates were below state average, except for Largemouth Bass, Smallmouth Bass, and panfish species, which had above average growth rates. This survey employed large-mesh trap nets, large-mesh fyke nets, and gill nets, and noted good catch rates of Walleye, especially in the west end. Common Carp and Longnose Gar captured during the survey were removed.

A survey of Crooked Lake, along with neighboring Pickerel Lake, was done in 2001. The survey focused on Walleye and Northern Pike populations and was intended to estimate abundance for those two species. Effort was substantial for the two lakes, consisting of 63 large-mesh trap-net lifts, 49 large-mesh fyke-net lifts, and 2 electrofishing runs. The survey results estimated that there were 2.1 legal-sized Walleye per acre in Crooked and Pickerel Lakes, which is slightly above the mean of 1.9 per acre for 23 large lakes (Hanchin et al. 2005, Hanchin 2017). Legal-sized Northern Pike abundance could not be estimated due to mostly sub-legal Northern Pike being captured. The size structure of both the Walleye and Northern Pike populations consisted of a high proportion of smaller fish, but overall density of the walleye population was about average compared to other large lake surveys (Hanchin et al. 2005, Hanchin 2017).

A study was initiated in 2011 on the larger Inland Waterway, and was a collaboration between the MDNR, Michigan State University, and Little Traverse Bay Bands of Odawa Indians (LTBB). The study had multiple components, including Walleye population estimates and movement dynamics (Herbst et al. 2016b and Herbst et al. 2017), Walleye foraging ecology (Herbst et al. 2016a), and an examination of limitations on larval Walleye (MacWilliams 2013). Herbst et al. (2017) found that the adult Walleye population estimate at time of spawning in Crooked Lake was 2,360 adult Walleye in

2011, and that approximately 5% of those Walleye moved to each Pickerel Lake and Burt Lake in the summer, with a smaller number moving further down the system to Mullett Lake and Black River. Most of the Walleye (83%) stayed in Crooked Lake for the summer. The Walleye in Crooked Lake also demonstrated very strong spawning-site fidelity, with 96% returning to Crooked Lake to spawn the next year (Herbst et al. 2017).

Walleye diets and prey availability for Walleye have been found to contribute to the current Walleye population and its characteristics. MacWilliams (2013) found that zooplankton availability during Walleye early life history was important in determining Walleye year-class strength, and that zooplankton in Crooked Lake were larger than those in the other Inland Waterway lakes. Herbst et al. (2016a) found that Yellow Perch were the most common species caught in forage gillnets in Crooked Lake, but that Walleyes fed primarily on crayfish. The prevalence of crayfish, which are relatively low in energy, in Walleye diets rather than forage fish likely contributes to the poor growth rates observed for Crooked Lake Walleyes.

The Tip of the Mitt Watershed Council (TOMWC) performed an aquatic plant survey of Crooked Lake in 2015. The report found that muskgrass, variable-leaf watermilfoil, slender naiad, and common bladderwort were the most common species found in Crooked and Pickerel Lakes. The survey found that 52% of the surveyed sites in Crooked Lake had vegetation densities of light, very light, or little/no vegetation. Only 5% of the surveyed sites were classified as having "heavy" densities of vegetation (Cronk et al. 2015). Two aquatic invasive plants were found in Crooked Lake in 2015, curly leaf pondweed and narrow leaf cattails.

The MDNR and LTBB periodically conduct fall walleye evaluations to monitor Walleye year-class strength and index annual recruitment in Crooked Lake. Eleven fall Walleye evaluations were done from 2000-2019. The average catch per unit effort over these surveys is 10.7 age-0 walleye per hour. Year-class strength was variable, with periodic strong cohorts appearing to drive the fishery (Figure 3).

Current Status

A fish community survey was done on Crooked Lake in June 2019 by the MDNR Fisheries Division's Northern Lake Huron Management Unit and Tribal Coordination Unit. A variety of net types and sizes were deployed consistent with the Status and Trends protocol. A Status and Trends survey uses a methodology developed by Fisheries Division in which the gear types are standardized throughout the state and survey effort is based on lake size (Wehrly et al. in press). The various gear types and mesh sizes are intended to sample different sizes of fish, species, and life stages to give a more complete view of the overall fish community and allow for spatial and temporal comparisons. Unless otherwise noted, a lift is equal to a net night. Survey effort consisted of 15 large-mesh trap-net lifts, 12 large-mesh fyke-net lifts, 6 small-mesh fyke-net lifts, 11 experimental gill-net lifts, 6 seine hauls, and 3 boat electrofishing transects at 10 minutes each. Age and growth of sport fish species were determined by collection and examination of fin rays or spines or scale samples from 10 fish per 1-inch group. Weights were estimated using length-weight relationships described by Schneider (2000).

A total of 1,768 fish representing 26 species were collected during this survey. Rock Bass, Bluegill, Longnose Gar, Brown Bullhead, and Pumpkinseed Sunfish (collectively, 69% by number) were the most abundant species, while Black Crappie, Common Carp, and Muskellunge (collectively <1 % by number) were the least abundant (Table 4).

The panfish community of Crooked Lake is comprised of Bluegill, Rock Bass, Pumpkinseed, and Yellow Perch. Panfish species comprised approximately 56% of the catch by number in the survey, and 30% of the catch by weight (Table 4). Bluegill and Pumpkinseed had fairly good size distributions, with fish up to 10 inches present for each species (Figure 4, Table 5). Likewise, Yellow Perch had a good distribution of sizes, with fish up to 12 inches, but overall were in low numbers (Figure 5). Rock Bass was the most abundant species in the survey. Panfish in Crooked Lake are growing well, with growth rates for Bluegill, Pumpkinseed, and Yellow Perch all above statewide average (Table 4).

Large predators in Crooked Lake include Longnose Gar, Largemouth Bass, Northern Pike, Smallmouth Bass, Walleye, Brown Trout, Bowfin, and Muskellunge. The dominant game species in Crooked Lake that are predators, in decreasing order of abundance, were Largemouth Bass, Northern Pike, Smallmouth Bass, and Walleye. These four species made up approximately 14% of the catch numerically and 26% of the catch by weight. Largemouth Bass and Smallmouth Bass had good distribution of sizes, but at fairly low numbers (Figure 6). Smallmouth Bass were less abundant than largemouth, but smallmouth were present up to 21 inches in length and largemouth were present up to 17 inches. Many of the Walleye captured in this survey were in the 14-19 inch range, and growth was very slow (Figure 7, Table 4). Very few Northern Pike were above the minimum size limit of 24 inches (Figure 8).

The prey fish community was diverse, represented by small-bodied species such as Blackchin Shiner, Iowa Darter, Mimic Shiner, Golden Shiner, Brook Stickleback, Emerald Shiner, and Common Shiner. Other non-game fish species encountered include Longnose Gar, Brown Bullhead, Black Bullhead, Yellow Bullhead, White Sucker, Bowfin, Round Goby, and Common Carp.

Temperature and dissolved oxygen profiles (Figure 9, Table 1) show that lake thermally stratifies, with a large section of cooler temperatures.

Analysis and Discussion

The predator fish community of Crooked Lake is comprised of both warmwater species (e.g., Largemouth Bass and Smallmouth Bass) and coolwater species (Northern Pike and Walleye). The limnological characteristics of the lake likely affect the fish populations and put challenges on certain species. The warmwater species, Smallmouth Bass and Largemouth Bass, are growing above statewide average with growth indexes of +1 and +0.9 respectively. There is abundant warmwater habitat for these species. Coolwater predators Northern Pike and Walleye are growing much slower than statewide average with growth indexes of -2.7 and -2.4 respectively. This means that pike and Walleye are more than two inches smaller on average than statewide lengths at age. The lake thermally stratifies, but when temperature is viewed in combination with the dissolved oxygen values it is evident that in the summer dissolved oxygen is lacking in most of the cooler water, which would force Walleye and Northern Pike to spend much of the summer in the warmer upper layer. This essentially forces these fish outside of their optimal thermal preferences and requires them to expend more metabolic energy leading to slower growth. Also contributing to the slow growth is the fact that nutrients are not overabundant (Table 6). Chlorophyll-a and total phosphorus measurements are consistent with an oligotrophic lake classification.

Northern Pike have very slow growth rates and limited growth potential. Hanchin and others (2005) found that growth potential (derived from the $L\infty$ term of the Von Bertalannfy growth equation) for male

Northern Pike was 22.4 inches and 22.8 inches for female Northern Pike. This confirms that most Northern Pike do not reach legal size (24"), and those that do are likely females.

Overall, Crooked Lake has a very stable fish community in its similarity to previous surveys and is characterized by a diverse panfish community that is growing well, as well as a diverse predator community that is slow growing.

Management Direction

1. Consider putting a no minimum size limit (5 fish daily possession limit, 1 fish >24") regulation for Northern Pike on Crooked Lake. This would allow more harvest of smaller Northern Pike, would reduce the abundance of smaller pike thereby increasing growth rates of larger fish through competitive-release, and would be more protective of the generally larger female Northern Pike, which could help shape a better size structure for the fish community.

2. For other species, maintain statewide fishing regulations, which are adequate for the protection of this fishery.

3. Continue to work with the Northern Inland Lakes Citizen Fisheries Advisory Committee on issues related to Crooked Lake and the Inland Waterway.

4. Continue to periodically monitor the contribution of natural production of walleye to the population to determine if the stocking hiatus is appropriate.

References

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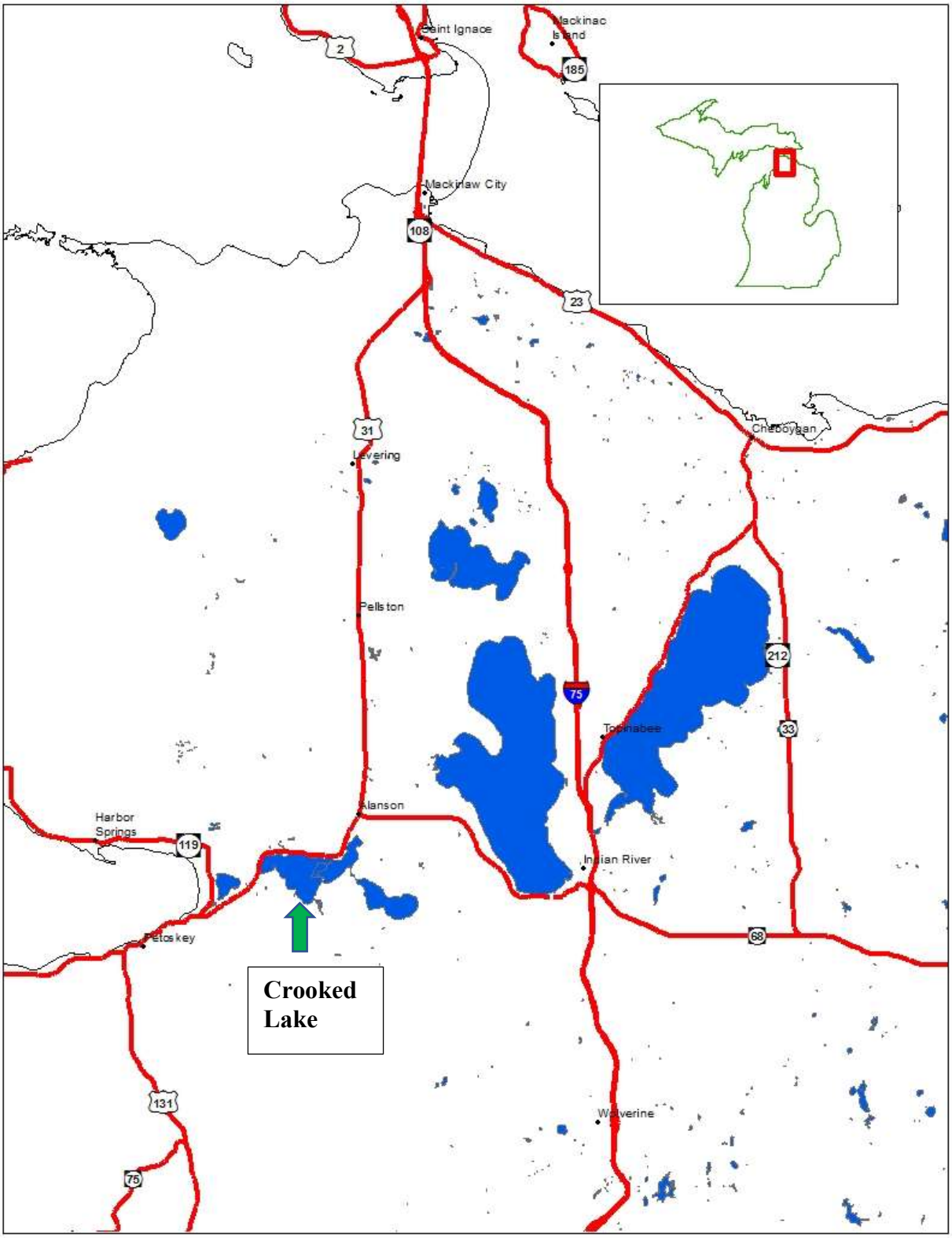

Figure 1. Locator map for Crooked Lake, Emmet County.

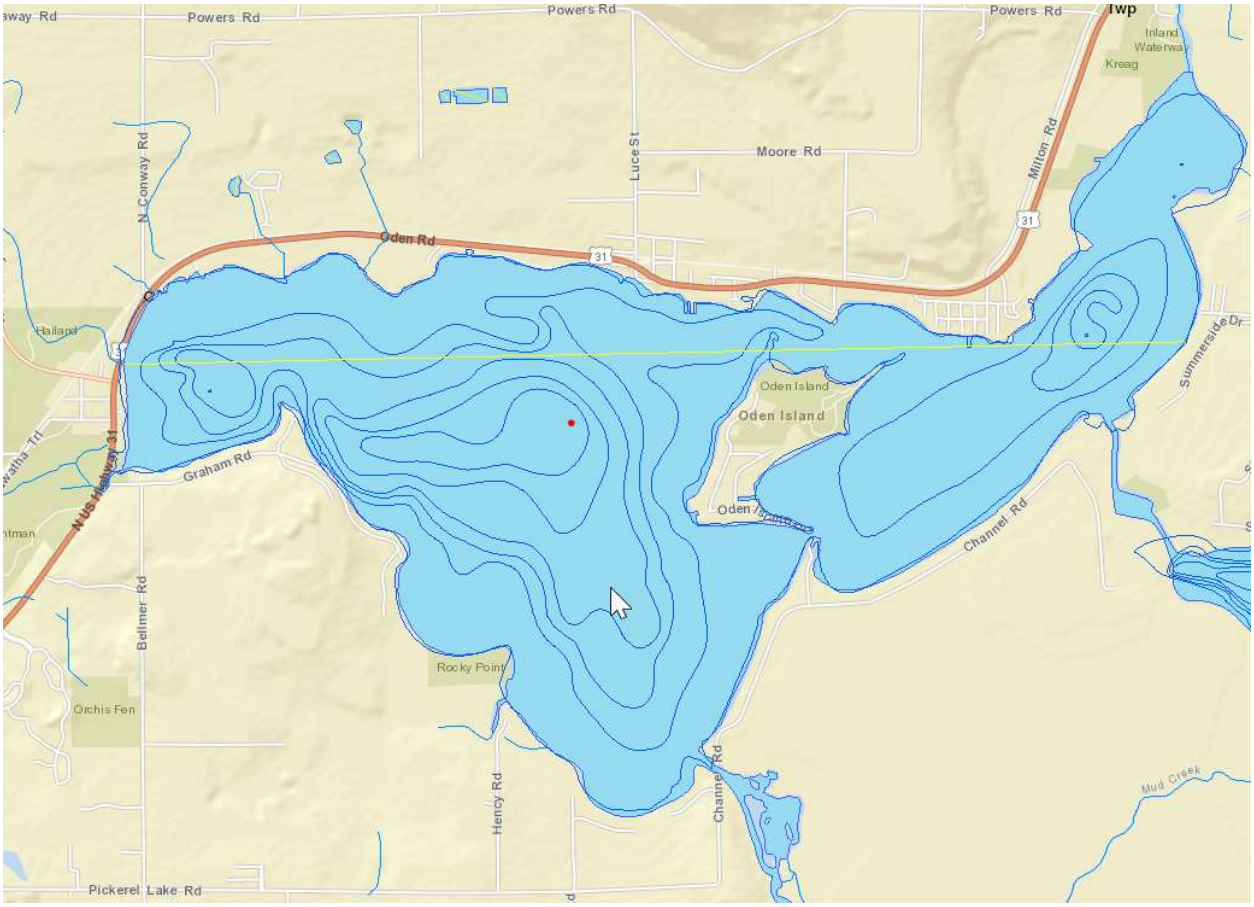

Figure 2. Depth Map of Crooked Lake. Contour lines are at 5', 10', 20', 30', 40' depth contours.

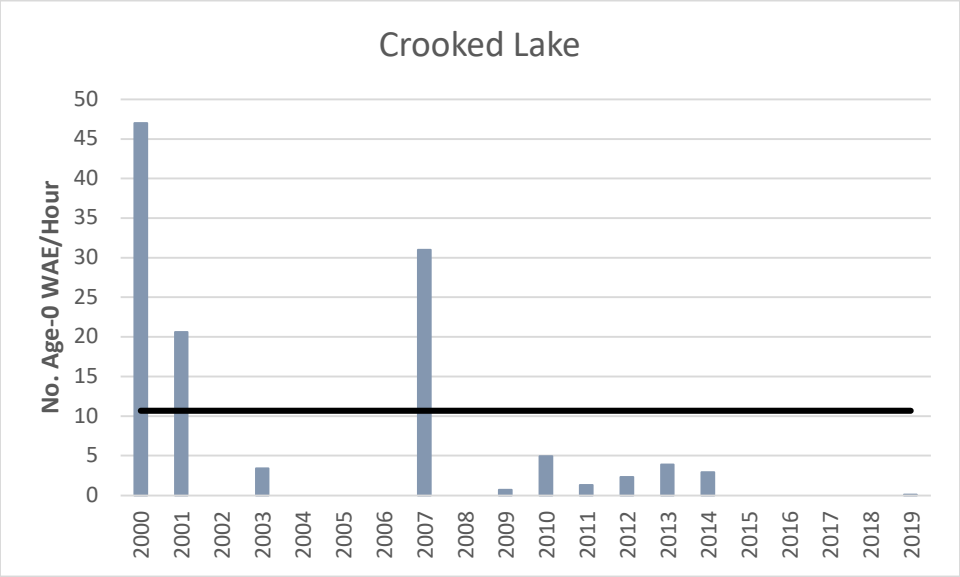

Figure 3. Summary of catch per unit effort for fall walleye evaluations in Crooked Lake, Note that no age-0 walleye were captured in 2019, but a bar appears there to indicate that survey was done.

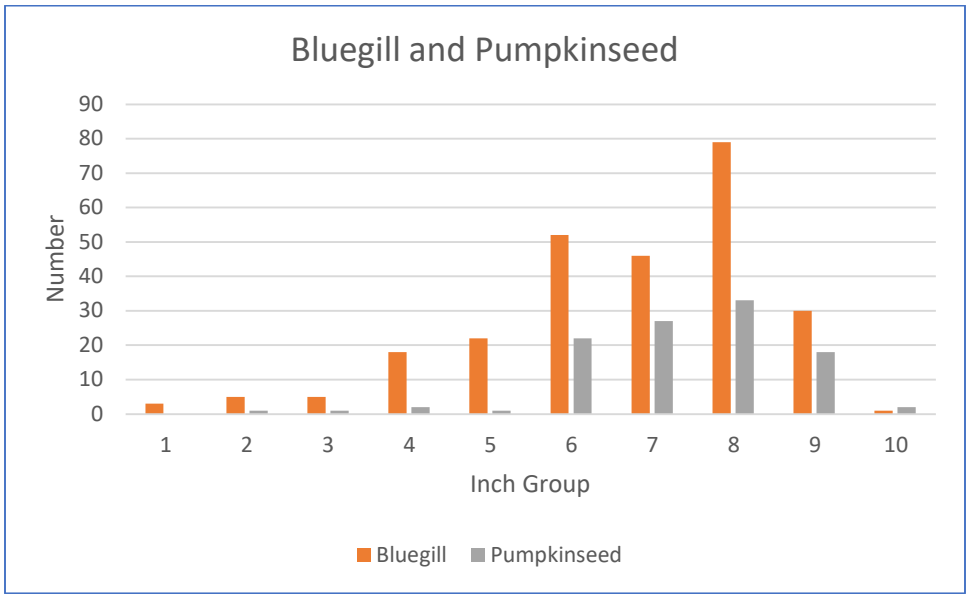

Figure 4. Length-frequency distribution of Bluegill and Pumpkinseed Sunfish captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet County.

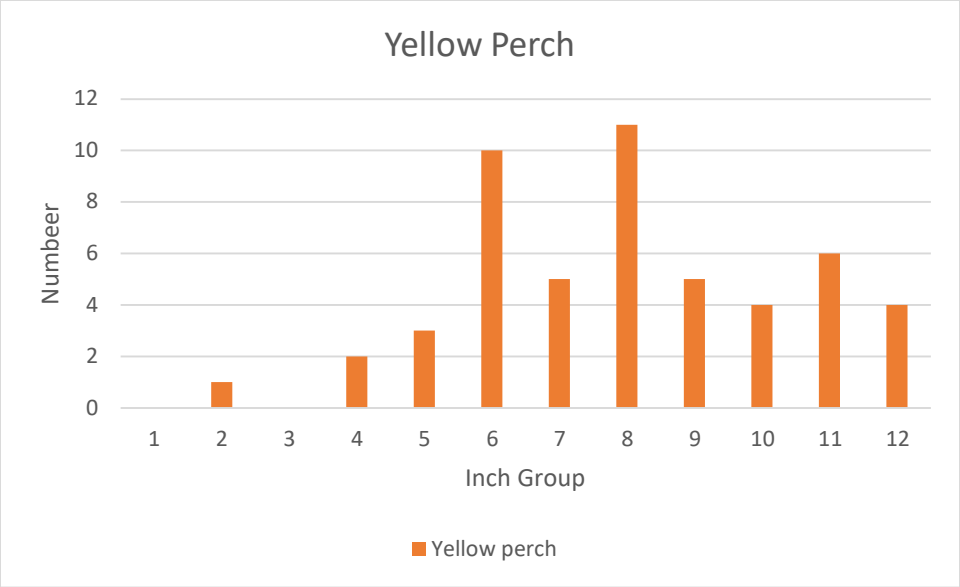

Figure 5. Length-frequency distribution of Yellow Perch captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet County.

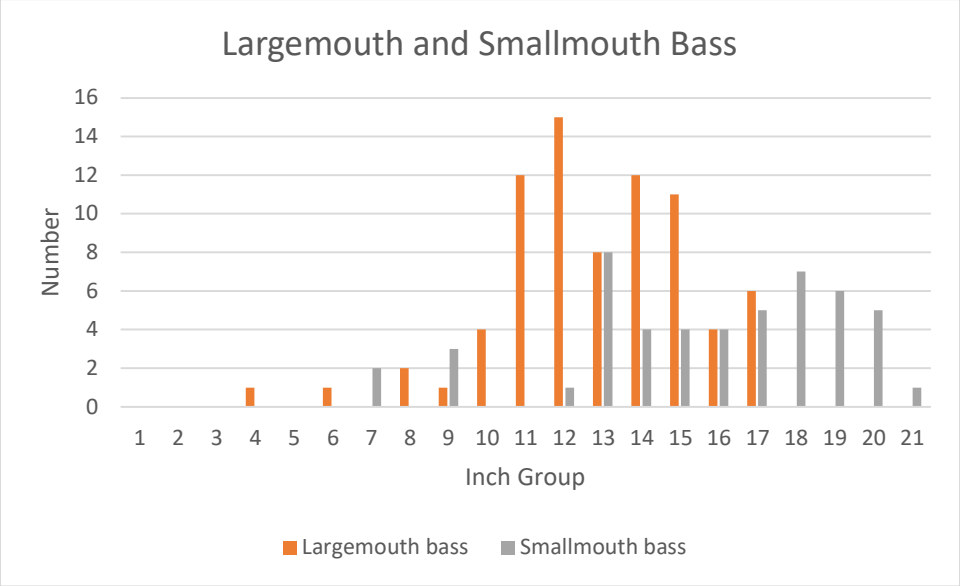

Figure 6. Length-frequency distribution of Largemouth and Smallmouth Bass captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet county.

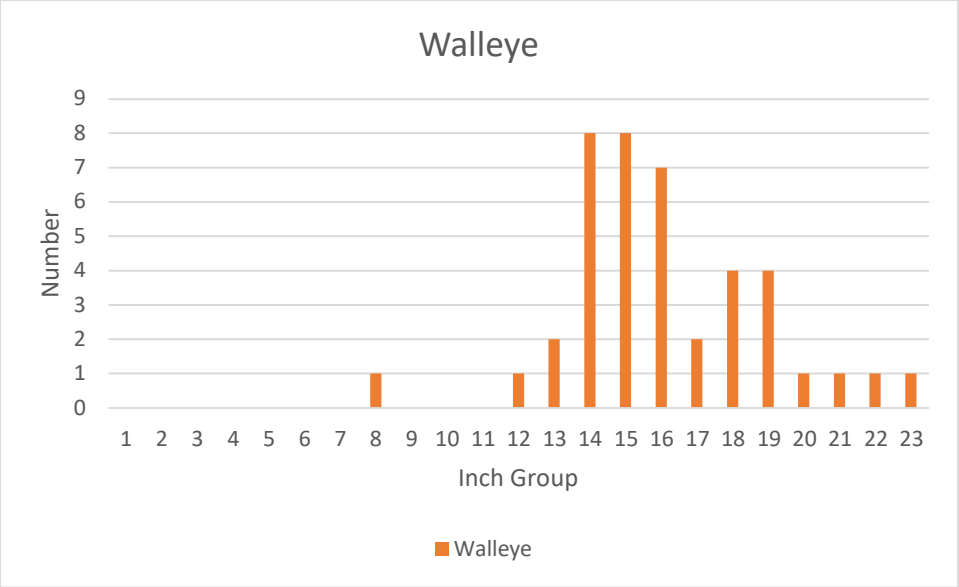

Figure 7. Length-frequency distribution of Walleye captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet County.

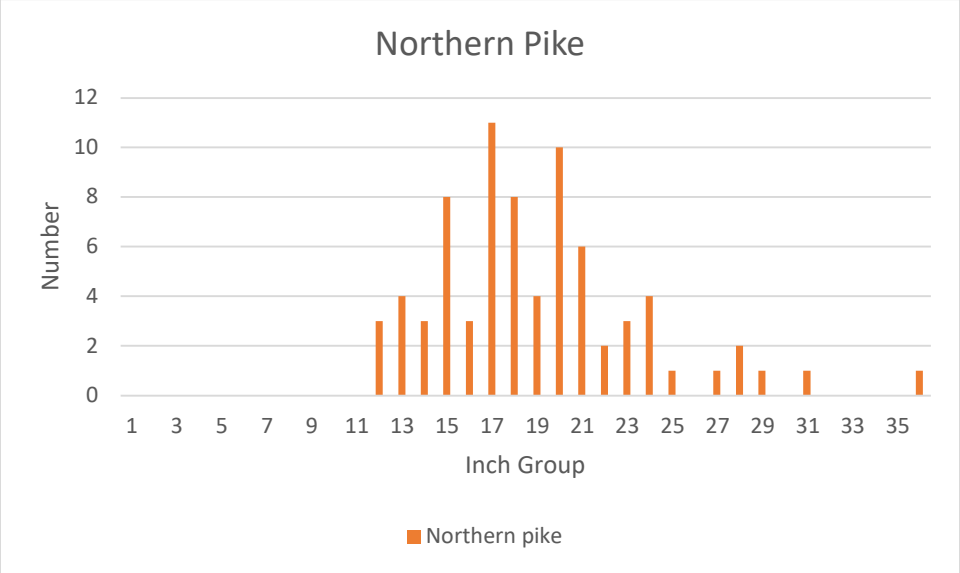

Figure 8. Length-frequency distribution of Northern Pike captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet County.

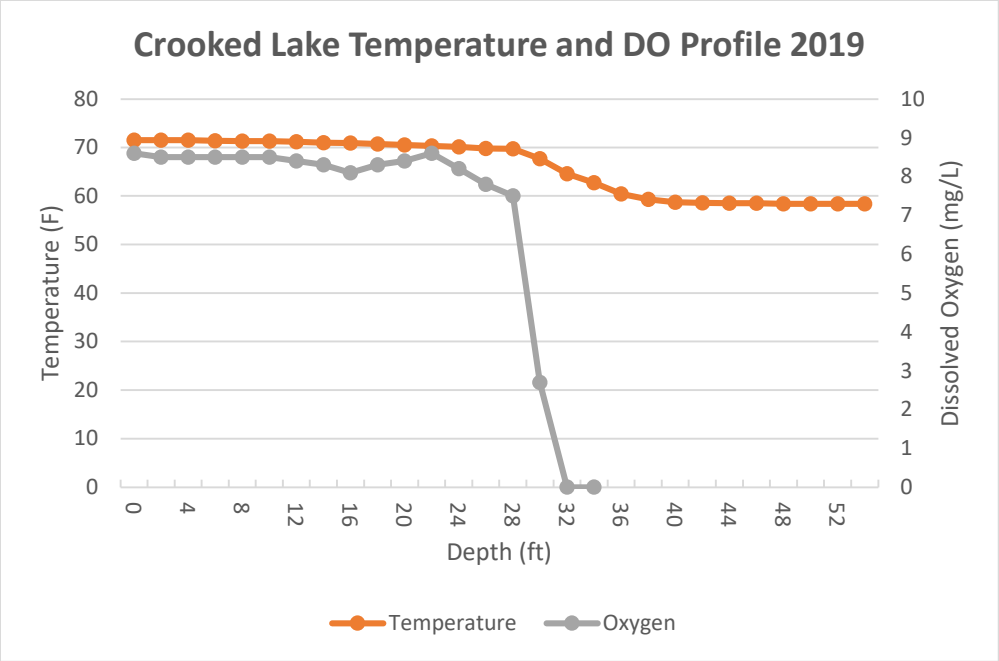

Figure 9. Temperature and dissolved oxygen profiles of Crooked Lake, measured August 26, 2019.

Table 1. Temperature and dissolved oxygen profile of Crooked Lake measured August 26, 2019.

Reading Depth (ft)	Temperature (F)	Oxygen (ppm)
0	71.5	8.60
2	71.5	8.50
4	71.5	8.50
6	71.4	8.50
8	71.3	8.50
10	71.3	8.50
12	71.2	8.40
14	71.0	8.30
16	70.9	8.10
18	70.7	8.30
20	70.5	8.40
22	70.3	8.60
24	70.1	8.20
26	69.8	7.80
28	69.7	7.50
30	67.7	2.70
32	64.6	0.00
34	62.7	0.00
36	60.4	
38	59.3	
40	58.7	
42	58.6	
44	58.5	
46	58.5	
48	58.4	
50	58.4	
52	58.4	
54	58.4	

Table 2. Number of fish stocked in Crooked Lake by species and year, 1979-2006.

Year	Species	Number	Avg. length (in.)
1979	Walleye	20	
1980	Walleye	5	
1981	Walleye	50,000	
1984	Walleye	2,500	1.52
1985	Walleye	5,500	1.52
1986	Walleye	4,000	1.52
1988	Brown Trout	127,410	2.52
1988	Walleye	500	1.72

Table 2. -cont.

Year	Species	Number	Avg. length (in.)
1989	Walleye	750	1.52
1990	Walleye	50	1
1991	Walleye	75,000	2.04
1994	Walleye	160,750	1.16
1996	Walleye	108,500	1.24
1998	Walleye	80,500	1.2
1999	Walleye	2,700	1.52
2000	Walleye	52,500	1.12
2003	Walleye	7,150	1.44
2004	Walleye	27,600	1.36
2006	Walleye	25,000	1.44

Table 3. Number of White Suckers removed from Crooked Lake during winter months by year, 1951-1962.

Year	Number of suckers removed
1951	6,937
1952	6,203
1953	--
1954	5,595
1955	6,870
1956	1,698
1957	7,070
1958	11,455
1959	8,760
1960	9,420
1961	5,364
1962	4,743
Total	**74,115**

Table 4. Number, weight, and length of fish species captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet County. Growth Index is a comparison to statewide lengths at age for that species.

Species	Number	Percent by number	Weight (lb.)	Percent by weight	Length range (in.)	Growth Index
Black crappie	1	0.1	0.7	0	10-10	--
Blackchin shiner	60	3.4	0.2	0	1-2	--
Black bullhead	7	0.4	6.7	0.4	11-14	--
Bluegill	261	14.8	81.9	4.9	1-10	+0.8
Brown trout	10	0.6	22.3	1.3	11-27	--
Bowfin	7	0.4	29.6	1.8	19-23	--
Brown bullhead	116	6.6	112.7	6.7	7-15	--
Brook stickleback	13	0.7	0	0	1-2	--
Common carp	1	0.1	10.4	0.6	28-28	--
Common shiner	7	0.4	7.4	0.4	2-18	--
White sucker	33	1.9	99.8	6	5-23	--
Emerald shiner	13	0.7	0	0	0-3	--
Golden shiner	14	0.8	0.1	0	1-3	--
Iowa darter	26	1.5	0.1	0	1-2	--
Largemouth bass	77	4.4	105.1	6.3	4-17	+0.9
Longnose gar	160	9	403.7	24.1	22-43	--
Mimic shiner	24	1.4	0	0	1-1	--
Muskellunge	1	0.1	28.4	1.7	45-45	--
Northern pike	76	4.3	144.4	8.6	12-36	-2.7
Pumpkinseed	107	6.1	48.3	2.9	2-10	+1.4
Round goby	27	1.5	0	0	1-3	--
Rock bass	576	32.6	359.4	21.5	1-12	--
Smallmouth bass	50	2.8	123.4	7.4	7-21	+1
Walleye	41	2.3	65.6	3.9	8-23	-2.4
Yellow perch	51	2.9	16.6	1	2-12	+0.8
Yellow bullhead	9	0.5	5.9	0.4	8-13	--

Table 5. Length frequency of sport fish species captured during the June 2019 Status and Trends survey of Crooked Lake, Emmet County.

Inch Group	Bluegill	Brown trout	Largemouth bass	Northern pike	Pumpkin-seed	Smallmouth bass	Walleye	Yellow perch
1	3							
2	5				1			1
3	5				1			
4	18		1		2			2
5	22				1			3

Table 5. -cont.

Inch Group	Bluegill	Brown trout	Largemouth bass	Northern pike	Pumpkin-seed	Smallmouth bass	Walleye	Yellow perch
6	52		1		22			10
7	46				27	2		5
8	79		2		33		1	11
9	30		1		18	3		5
10	1		4		2			4
11		1	12					6
12		1	15	3		1	1	4
13		5	8	4		8	2	
14			12	3		4	8	
15			11	8		4	8	
16			4	3		4	7	
17			6	11		5	2	
18		1		8		7	4	
19				4		6	4	
20		1		10		5	1	
21				6		1	1	
22				2			1	
23				3			1	
24				4				
25				1				
26								
27		1		1				
28				2				
29				1				
30								
31				1				
32								
33								
34								
35								
36				1				

Table 6. Water chemistry parameters for Crooked Lake, Emmet County, collected August 26, 2019. MDL refers to Method Detection Limit.

Parameter	Value	Note
Alkalinity, total (mg/L)	148	
Chlorophyll a (ug/L)	0.9	
Nitrogen, ammonia (mg/L)	0.06	
Nitrogen, nitrate + nitrite (mg/L)	0.0	Less than the MDL of 0.0037 mg/L
Nitorgen, total Kjeldahl (mg/L)	0.978	
Phosphorus, total (mg/L)	0.0078	