Crooked Lake
Oakland County, 04N/09E/Sec. 3, 4, 9
Clinton River watershed, Last Surveyed 2023

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Environment

Crooked Lake (previously known as Lower Bushman Lake) is a natural lake located in north-central Oakland County, approximately 2 miles north of Clarkston (Figure 1). The entire lake is within Oakland County's Independence Oaks County Park, providing a largely undeveloped shoreline and riparian zone. The developments around the lake include a boat house, public boat launch, and fishing piers spaced around the lake. A total of 3 docks set up for watercraft use and 8 fishing piers of varying sizes occur around the lake. The lake is restricted to electric motors only, so many people access the lake with kayaks, canoes, or from shore. There is a kayak vending machine for people to rent kayaks if they don't have access to a watercraft. A well-developed trail system surrounds the lake providing multiple opportunities for shore fishing and access to the fishing piers.

Crooked Lake is 68 acres in area with a shoreline perimeter of about 2.3 miles and lake volume of 1,483 acre-feet. The shape of Crooked Lake is elongated with a maximum fetch length of 1.2 miles. Crooked Lake is 68 feet at its deepest with a narrow littoral zone in much of the lake. Seventy percent of the lake area is deeper than 5 feet. The littoral zone of Crooked Lake is mostly natural, less than 1% of the shoreline is armored, and there are 20 submersed trees per mile of shoreline.

Located in the Clinton River headwaters, surficial geology is characterized by end moraines of medium and coarse textured till (89%) along with sand and gravel outwash (11%). This type of geology is well drained and allows good infiltration to the ground water. There is an inlet coming from springs in a wetland west of the lake and an outlet from the southeast end that drains to the Clinton River (Figure 1). The catchment (or lakeshed) of Crooked Lake (Figures 2 and 3) is an area of about 854 acres dominated by forest (62%), with some wetland (18%), agriculture (10%), urban (8%), water (1%), and grassland (1%) (Fry et al. 2011).

Crooked Lake has had water temperature and dissolved oxygen profiles conducted during 5 different years since 1949. The most recent profile was conducted on August 11, 2023 (Figure 4). Lake profiles were collected in the deepest portion of the lake to identify stratification zones. Lake stratification occurs where the water density gradient, caused by warming of the upper waters, is large enough that it prevents wind currents from mixing waters throughout the water column (Wehrly et al. 2015). The epilimnion is the well-mixed, upper layer of warm water with uniform temperatures and dissolved oxygen levels, the metalimnion is the middle layer of cooler water where temperatures change rapidly with depth, and the hypolimnion is the bottom layer of cold water where mixing does not occur, and temperatures decrease slowly with depth. In the lower zones with no mixing, dissolved oxygen is not replenished over time, except where phytoplankton produces oxygen through photosynthesis (Kalff 2002). The most recent profile of Crooked Lake indicated that the epilimnion extends from the surface to a depth of 12 feet. The metalimnion was observed at depths from 12-27 feet and the hypolimnion from 27-66 feet (bottom). The thermocline is the area in the lake with the greatest temperature change and was observed at a depth of 18 feet. Habitats with dissolved oxygen levels of 3.0 mg/L or higher are

suitable for most fish species in Michigan (Schneider 2002). By this definition, dissolved oxygen levels in Crooked Lake were suitable to a depth of 30 feet, about 76% of the lake volume. It is likely that around two-thirds of the lake provides suitable habitat for fish during the period of peak summer stratification, which usually occurs sometime in the months of July and August. This temperature and dissolved oxygen profile is very similar to those conducted in previous years. The amount of suitable habitat for Crooked Lake in the summer months is high for a class 1 lake that typically supports warmwater fish species and is smaller than 440 acres (Wehrly et al. 2012), a very common class for lakes in southeast Michigan.

Fishery Resource

History
The earliest records on file for Crooked Lake are notes taken during lake mapping in the winter of 1943. At that time the lake was in private ownership, and fishing was noted as limited to friends and neighbors of the owner with reports of quality Bluegill and Largemouth Bass. Around 1960, a hunt club was started on 2,500 acres that included Crooked Lake and much of what is currently Independence Oaks Park property. There were 250 members in the club, many of whom were prominent people (e.g. executives from General Motors and Ford Motor Company). Members were required to pay $10,000 to $20,000 annually for membership and used their membership to hunt and fish. Crooked Lake offered fishing opportunities for members, and the hunting lodge overlooked Crooked Lake. The Independence Oaks County Park property was acquired by Oakland County Parks in 1967, with construction of public park facilities beginning in 1974. The park was open to fishing in the late 1960's, but the boat launch was not built until 1975 and the park officially opened in 1976.

A 22-acre marsh on Crooked Lake was operated by the Michigan Department of Natural Resources (MDNR) as a Northern Pike spawning marsh to produce fingerlings to stock in Crooked Lake, as well as other local lakes. Northern Pike were stocked in Crooked Lake from the marsh during 1973 through 1980 (Table 1). Production from the marsh was highly variable with regular issues of contamination by other fish species and its use was discontinued following the 1980 stocking. After the Northern Pike stocking program was discontinued Fisheries Division conducted a Northern Pike removal effort by trapping and transferring 82 adult Northern Pike from Crooked Lake to the nearby Lake Sixteen in 1981. The objective of this effort was to reduce the number of top predators preceding a Rainbow Trout stocking program. Rainbow Trout were stocked in Crooked Lake in 1981 and 1982 (Table 1). This trout stocking program was discontinued after survey results each year failed to show survival of the yearling Rainbow Trout, and a fishery was not created. A Northern Pike stocking program was once again initiated in 2005 (Table 1), but elimination of the statewide Northern Pike rearing program led to this being a single year stocking event.

The fish community has been surveyed 11 times since 1968. A variety of gear was used in the surveys including fyke nets, trap nets, gill nets, seines, and electrofishing, depending on the goal of the particular survey. The total number of species observed over the years was 21 species with Bluegill, Largemouth Bass, Northern Pike, Pumpkinseed, Rock Bass, and Yellow Perch being caught during the majority of the surveys (Table 2). There were some consistent trends among surveys, such as low species diversity and low catch rates. Previous survey reports suggest that the low catch rates were likely a result of gear effectiveness in sampling due to the narrow littoral zone as opposed to low production or over harvest in the lake (Francis 2004). Historically, growth for Bluegill and Largemouth Bass were found to be below state average (Francis 2004), but with fish reaching older ages (e.g. 10 to

12 years old). This provides further evidence that overharvest was not likely a problem. Comments from Oakland County Parks staff suggest that fishing effort is fair with angling effort observed during most days, but not so much that anglers are competing for space. There are no special fishing regulations for Crooked Lake, and therefore the general statewide regulations apply.

Current status of the fish community
Methods
The most recent fish community survey for Crooked Lake was completed during spring 2023. The first objective of the survey was to update the MDNR fish community inventory for the lake to provide data that could address fishing complaints from anglers. The second objective was to gather some information on habitat in the littoral zone to help direct future management actions.

A variety of sampling gear was used for the fish community survey, including large and small mesh fyke nets, a 25-foot seine, electrofishing boat, and experimental gill nets. This survey followed the status and trend protocols detailed by Wehrly et al. (In Press). During the week of May 30, 2023, both large and small mesh fyke nets and experimental gill nets were deployed. Large mesh fyke nets were set for three nights, whereas small mesh fyke nets and gill nets were set for two net nights. All gears were lifted and the catch processed after each night of netting. The survey also included two seine hauls and three 10-minute boat electrofishing transects, both of which were conducted on June 6, 2023. The seine hauls were collected during daylight hours, while the electrofishing transects were completed after dark. All fish were measured to the inch group (e.g. 2.0 to 2.9 = 2 inch group), and age structures were collected for Bluegill, and Largemouth Bass.

Results
Collectively, the 2023 fisheries survey captured 1,739 fish representing 15 species. Panfish such as Bluegill, Green Sunfish, Pumpkinseed, and Rock Bass composed 78% of the catch by number (Table 3). Large predators (Largemouth Bass and Northern Pike) composed 4% of the catch by number (Table 3). Minnow, darter, and sucker species (Blackchin Shiner, Blacknose Shiner, Central Mudminnow, Lake Chubsucker, and Iowa Darter), often referred to as forage species, made up 6% of the catch by number (Table 3).

Bluegill were the most abundant species overall, comprising 55% of the catch by number (Table 3). Bluegill ranged from 1 to 9 inches long and averaged 5.1 inches overall. The size distribution for Bluegill was bimodal, with 47% being 1 to 3 inches and 40% being 6 to 8 inches (Table 4). Bluegill ages ranged from 1 to 10 years old, and 59% were 1 to 4 years old (Table 5). The mean growth index (MGI) for Bluegill was -0.9, which suggests the growth rates were substantially lower in Crooked Lake compared to the statewide average (Figure 5). Average catch-per-effort (CPE) of Bluegill in large mesh fyke nets was 46.6 fish/lift, and for small mesh fyke nets and electrofishing it was 35.3 fish/lift and 12.2 fish/minute, respectively.

Bluegill populations can be categorized by the assessment of proportional size distribution (PSD; Zale et al 2012). PSD values refer to the proportion of the population that is longer than a specific length value for a given species where PSDQ = Quality, PSDP = Preferred, PSDM = Memorable, and PSDT = Trophy. The five categories correspond to increasing percentages of the world class lengths for a

species, respectively. The inch group categories for Bluegill are PSDQ >6 inches, PSDP >8 inches, PSDM >10 inches, and PSDT >12 inches (Zale et al. 2012). The PSD values for Bluegill in Crooked Lake are PSDQ = 59, PSDP = 19, PSDM = 0, and PSDT = 0 (Table 6).

Pumpkinseed were the second most abundant species overall, accounting for 17% of the total catch by number (Table 3). Pumpkinseed size ranged from 1 to 8 inches and averaged 5.2 inches (Table 3). Larger Pumpkinseed dominated the size range with 77% being 5 to 7 inches (Table 4). Pumpkinseed CPE was 24.8 fish/lift for large mesh fyke nets, while small mesh fyke nets and electrofishing CPEs were 7.3 fish/lift and 1.1 fish/minute, respectively (Table 6). Pumpkinseed PSD category results were PSDQ = 75 (>6 inches), PSDP = 3 (>8 inches), PSDM = 0 (>10 inches), and PSDT = 0 (>12 inches).

Rock Bass were the third most abundant panfish, accounting for 4% of the total catch by number (Table 3). Rock Bass size ranged from 1 to 9 inches and averaged 5.7 inches (Table 4). Rock Bass CPE was 3.3 for large mesh fyke nets and 0.7 for electrofishing (Table 6). Rock Bass PSD results were PSDQ = 39 (>7 inches), PSDP = 2 (>9 inches), PSDM = 0 (>11 inches), and PSDT = 0 (>13 inches).

Largemouth Bass were the most abundant large predator, making up 4% of the catch by number. Largemouth Bass were caught in broad range of sizes, ranging from 2 to 17 inches and averaging 9.1 inches (Table 3). Largemouth Bass are required to be 14 inches or larger for harvesting in Michigan. This is referred to as a 14-inch minimum size limit (MSL; 2025 Michigan Fishing Guide), and of the 61 Largemouth Bass caught, 12% were larger than the statewide MSL (Table 4). Largemouth Bass PSD category results were PSDQ = 44 (>12 inches), PSDP = 7 (>15 inches), PSDM = 0 (>20 inches), PSDT = 0 (>25 inches). Largemouth Bass ages ranged from 1 to 10 years old with a MGI of -0.7 (Table 5). This suggests Largemouth Bass growth is slightly slower than state average (Figure 6). CPE results for Largemouth Bass were 2.0 fish/lift for large mesh fyke nets and 1.3 fish/minute for electrofishing (Table 6).

Northern Pike were the other large predator species caught during the fisheries survey of Crooked Lake, though only two were caught (Table 3). One Northern Pike was 10 inches, and the other was 32 inches in length (Table 4). Both Northern Pike were caught in inland experimental gill nets to account for a CPE of 0.5 fish/lift (Table 6).

There were four turtle species (Snapping Turtle, Map Turtle, Painted Turtle, and Musk Turtle) caught during the survey of Crooked Lake, totaling 82 turtles. Musk Turtles were the most abundant totaling 26 turtles, ranging in size from 2 to 4 inches. Snapping Turtles were the second most abundant, totaling 23 turtles ranging from 9 to 14 inches. There were 18 Painted Turtles ranging from 3 to 6 inches, and 15 Map Turtles ranging from 4 to 10 inches.

Analysis and Discussion

Crooked Lake supports a moderately diverse fish community with the catch of 15 species from this survey being lower than the median for lakes in LEMU (18 species) and closer to the statewide median (14 species; Wehrly et al. 2015). All the 21 species historically found in Crooked Lake are native

species to Michigan. Even though Rainbow Trout, a non-native species, was introduced in 1981 and 1982, they were never observed through survey efforts, and it is believed that survival was minimal with no natural reproduction. The moderate diversity of prey species (panfish and forage species) and low diversity of large predator species, along with high catch rates for species like Bluegill and Largemouth Bass, suggests the predator-prey balance is sufficient but on the edge of a prey heavy fish community.

The panfish community of Crooked Lake appears to be very abundant, with catch rates exceeding regional (LEMU) medians and being well above or very near the statewide 75th percentile for all gears for Bluegill and Pumpkinseed (Table 6). Rock Bass were near the regional and statewide median for large mesh fyke nets as well as the regional median for electrofishing, but near the statewide 75th percentile for electrofishing (Table 6). Bluegill were the most abundant species in both the 2023 and 2002 surveys, but Pumpkinseed jumped to the second most abundant species in 2023 when Rock Bass was the second most abundant species in 2002 (Francis 2004).

PSD evaluations for panfish show a high ratio of quality (PSDQ) size fish for Bluegill, Pumpkinseed and Rock Bass (Figure 7). Those values quickly diminish at the preferred size (PSDP) and neither species reaches into the memorable (PSDM) or trophy (PSDT) range (Figure 7). PSDQ values can be used to evaluate populations under different management schemes, one of which is balanced Bluegill (prey) and Largemouth Bass (predator) populations. When seeking balanced Bluegill and Largemouth Bass populations a desirable range for Bluegill PSDQ values should be from 20 to 60 (Willis et al. 1993). The PSDQ value of 59 for Bluegill, based on the 2023 Crooked Lake survey suggests that the Bluegill population is within the balanced range, but on the upper edge of the range (Figures 7 and 8). When we compare PSD values from the 2002 and 2023 surveys of Crooked Lake, we see an increase for Bluegill and Pumpkinseed and a decrease for Rock Bass. This is consistent with the catch rate changes we see for the three species as well (Table 6). In 2023, the catch rates of Bluegill and Pumpkinseed were substantially higher for large mesh fyke nets and electrofishing when compared to 2002 (Table 6). The inverse occurred for Rock Bass in both of those gear types (Table 6). This suggests that Bluegill and Pumpkinseed populations substantially increased while the Rock Bass population declined from 2002 to 2023.

Another change that occurred from 2002 to 2023 is the decline in Bluegill growth. In 2002, younger Bluegill ($\leq$ 3 years old) were found to be growing slower than state average while older Bluegill were typically growing similar to or faster than state average (Figure 5). In 2023, Bluegill at every age class were growing slower than state average and at a slower rate than what was observed in 2002 (Figure 5). One potential cause for this decline in growth over time is the change in density of panfish. Interspecies competition for food resources is likely more direct between Bluegill and Pumpkinseed than it would be with Rock Bass. Rock Bass are going to forage for smaller prey fish and crayfish more than either Bluegill or Pumpkinseed. The change in fish community abundance with Pumpkinseed jumping to the second most abundant species has likely increased the interspecies competition for food resources with the most abundant species Bluegill. An increased population size for both species causes further stress on intra- and interspecies competition that has led to the slower Bluegill growth. Despite the slower growth, Bluegill still attain older ages that allow a portion of the population to reach the preferred range (PSDP >8 inches).

Large predators in Crooked Lake continue to be dominated by Largemouth Bass with Northern Pike remaining in low densities. Largemouth Bass also continue to have slow growth that is below but near the state average (Figure 6). Catch rates for Largemouth Bass are similar between the 2002 and 2023 surveys to the point where they are slightly above the regional and statewide medians. There was a slight increase in the proportion of quality size (PSDQ) Largemouth Bass from 2002 to 2023 but a decrease in the proportion of preferred size (PSDP; Figure 7). The change in preferred size Largemouth Bass should be viewed with caution since a couple of individuals could have a big impact on that proportion given the smaller sample size.

As previously mentioned, PSDQ values can be used to evaluate the predator-prey balance and the suggested range for a balanced Largemouth Bass population is from 40 to 70 (Willis et al. 1993). Largemouth Bass PSDQ value from the 2023 survey (44) was at the low end of that range. When we plot the suggested ranges for Bluegill and Largemouth Bass on differing axis, we can show the region (shaded area in Figure 8) that would suggest a balanced predator prey ratio. The intersection of Bluegill and Largemouth Bass PSDQ values (black dot in Figure 8) from the survey lands just into the shaded region (Figure 8). This suggests the predator-prey ratio still fits a balanced fish community but is near out of balance with too many prey and too few predators. This analysis showcases the top predator (Largemouth Bass) and top prey (Bluegill) in the lake but we also have to consider the other species. We see high levels for Pumpkinseed (prey) and very low levels for Northern Pike (predator). This would suggest that the balance is further shifted towards the prey species and that Crooked Lake could benefit from increased large predators to maintain a balance predator-prey fish community.

The nearly all natural shoreline found around Crooked Lake is rare for lakes in southeast Michigan. This natural setting helps maintain a healthy littoral zone that provides diverse habitat for many of the aquatic organisms including fish, turtles and amphibians. This is illustrated by the high number of turtles (82 total) caught during the survey. O'Neal and Soulliere (2006) reported that alterations or development of the shoreline that is higher than 25% can have detrimental effects on a lake's nearshore ecosystem through habitat degradation and loss of woody material. Crooked Lake is surrounded by Independence Oaks County Park and thus provides a scenario where the lake will be protected from additional development, allowing it to remain well below that 25% threshold. The 20 submersed trees/mile found in Crooked Lake is above the regional median of 13.8 submersed trees/mile and provides quality habitat for the lake.

Water temperatures and dissolved oxygen levels in Crooked Lake are suitable for warmwater fish species (e.g. Bluegill and Largemouth Bass) that make up the majority of the fish community. Suitable oxygen levels going as deep as 30 feet also allows for coolwater species, like Northern Pike, to persist with ample coolwater refuge during the summer months. Even though there is ample suitable habitat, Northern Pike relative densities remain low and there is uncertainty as to why.

Management Direction

The bluegill population in Crooked Lake appears to be abundant and has a quality size structure, even though it demonstrates below average growth. Because Bluegill and Pumpkinseed dominated both the

panfish and total catches, it is likely that the panfish fishery is good with high numbers of quality size fish. The Largemouth Bass population in Crooked Lake would be considered moderately dense compared to other Michigan Lakes based on relative catch rates. Stocking an additional predator could improve panfish size structure (Schneider and Lockwood 1997) and provide a better proportion of panfish reaching the preferred category. One way to increase the number of top predators could be to supplement the Northern Pike population through stocking. The Northern Pike marsh that was historically used has transitioned to an emergent wetland and is no longer a feasible option. At this time there are no Northern Pike resources available through the statewide rearing programs that could be used to support a Northern Pike stocking program. If those resources become available, the re-establishment of a Northern Pike Stocking program should be pursued. A low-level stocking on alternate years (5-10 spring fingerlings/acre or 1-4 fall fingerlings/acre) would benefit the Northern Pike Population and enhance the fishery at the same time. Alternatively, a Walleye stocking program could also be used to increase the large predator abundance. There is sufficient suitable habitat to support Walleye survival even though class 1 lakes are recommended to be a low priority in the Management Plan for Walleye in Michigan's Inland Waters (Herbst et al 2021). Development of a Walleye stocking program should target a rate of 10 fall fingerlings/acre or 50 spring fingerlings/acre.

The natural aesthetic of Crooked Lake and electric motors only regulation provides a rare opportunity for anglers in southeast Michigan to avoid populated and high traffic lakes. Angler complaints about poor fishing success or inability to catch fish on Crooked Lake are not apparently due to a diminished fish community. Panfish densities are high and Largemouth Bass densities are fair. One potential option to address these complaints could be to install additional woody material near the fishing piers. This could not only benefit the ecosystem but could also cluster portions of the fish community near areas that would be accessible for shore anglers. A "fish sticks" program focused around the fishing piers could be pursued through a partnership with Oakland County Parks. Outreach through signage to promote best management practices to reduce the risk of invasive species introductions could also help work towards maintaining the natural aesthetic of the lake.

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Tables and Figures

Table 1. Stocking history of Crooked Lake, Oakland County (N/A = data not available).

Year	Species	Stage of Development	Number Stocked	Mean Length (in.)	Stocking Density (fish/acre)
1973	Northern Pike	Fry	500	N/A	7.4
1974	Northern Pike	Spring fingerling	2,700	N/A	39.7
1975	Northern Pike	Spring fingerling	25	N/A	0.4
1976	Northern Pike	Spring fingerling	200	N/A	2.9
1977	Northern Pike	Spring fingerling	1,000	N/A	14.7
1978	Northern Pike	Spring fingerling	1,500	N/A	22.1
1979	Northern Pike	Spring fingerling	1,350	3.9	19.9
1980	Northern Pike	Spring fingerling	2,450	3.0	36.0
1981	Rainbow Trout	Yearling	6,000	6.2	88.2
1982	Rainbow Trout	Yearling	5,400	7.2	79.4
2005	Northern Pike	Fall fingerling	63	10.5	0.9

Table 2. Fish species historically observed in Crooked Lake through fisheries surveys. Origin: N = Native and I = Introduced; X indicates the species was caught in the 2023 fisheries survey.

Species common name	Family	Scientific name	Origin	2023
Brook Silverside	Atherinidae	*Labidesthes sicculus*	N	
White Sucker	Catostomidae	*Catostomus commersonii*	N	
Lake Chubsucker	Catostomidae	*Erimyzon sucetta*	N	X
Rock Bass	Centrarchidae	*Ambloplites rupestris*	N	X
Green Sunfish	Centrarchidae	*Lepomis cyanellus*	N	X
Pumpkinseed	Centrarchidae	*Lepomis gibbosus*	N	X
Bluegill	Centrarchidae	*Lepomis macrochirus*	N	X
Northern Sunfish	Centrarchidae	*Lepomis peltastes*	N	
Largemouth Bass	Centrarchidae	*Micropterus salmoides*	N	X
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*	N	
Blacknose Shiner	Cyprinidae	*Notopis heterolepis*	N	X
Blackchin Shiner	Cyprinidae	*Notropis heterodon*	N	X
Grass Pickerel	Esocidae	*Esox americanus*	N	X
Northern Pike	Esocidae	*Esox lucius*	N	X
Brown Bullhead	Ictaluridae	*Ameiurus melas*	N	X
Yellow Bullhead	Ictaluridae	*Ameiurus natalis*	N	X
Iowa Darter	Percidae	*Etheostoma exile*	N	X
Least Darter	Percidae	*Etheostoma microperca*	N	
Yellow Perch	Percidae	*Perca flavescens*	N	X
Central Mudminnow	Umbridae	*Umbra limi*	N	X

Table 3. Catch summary for the Crooked Lake fishery survey, May 30 through June 6, 2023.

Species	Number	Percent by number	Length range (in.)	Mean length (in.)
Bluegill	960	55%	1-9	5.1
Pumpkinseed	295	17%	1-8	5.2
Brown Bullhead	100	6%	6-12	9.6
Largemouth Bass	61	4%	2-17	9.1
Rock Bass	61	4%	1-9	5.7
Yellow Perch	54	3%	2-9	6.1
Yellow Bullhead	52	3%	5-10	8.5
Blackchin Shiner	41	2%	1-2	2.5
Central Mudminnow	25	1%	1-3	2.8
Blacknose Shiner	22	1%	1-2	2.3
Green Sunfish	19	1%	1-6	4.3
Hybrid Sunfish	19	1%	1-7	4.6
Lake Chubsucker	14	1%	2-6	5.1
Grass Pickerel	11	1%	5-10	8.0
Iowa Darter	3	<1%	1	1.5
Northern Pike	2	<1%	10-32	21.5
Total	1,739			

Table 4. Number per inch group of select species collected with all gears combined during the Crooked Lake fishery survey, May 30 through June 6, 2023.

Inch group	Bluegill	Pumpkinseed	Rock Bass	Largemouth Bass	Northern Pike
1	147	18	3		
2	168	23	8	5	
3	138	4	6	1	
4	81	15	4	4	
5	43	45	12		
6	92	118	11	3	
7	170	65	8	5	
8	117	7	8	11	
9	4		1	7	
10				3	1
11				3	
12				8	
13				4	
14				4	
17				3	
32					1
Total	960	295	61	61	2

Table 5. Mean length-at-age of select species collected with all gears combined during the Crooked Lake fishery survey, May 30 through June 6, 2023.

Species	Age class	Number aged	Weighted mean length (in.)	Weighted age frequency
Bluegill	1	10	1.6	15.3%
Bluegill	2	10	2.3	17.5%
Bluegill	3	12	3.4	15.8%
Bluegill	4	14	5.1	10.4%
Bluegill	5	11	5.8	6.4%
Bluegill	6	3	6.9	3.7%
Bluegill	7	15	7.7	19.7%
Bluegill	8	7	7.9	7.1%
Bluegill	9	3	8.7	1.2%
Bluegill	10	4	8.5	2.9%
Largemouth Bass	1	10	3.4	16.4%
Largemouth Bass	2	14	7.5	20.6%
Largemouth Bass	3	14	9.1	20.5%
Largemouth Bass	4	6	10.3	6.4%
Largemouth Bass	5	11	12.4	12.4%
Largemouth Bass	6	13	13.1	14.9%
Largemouth Bass	7	2	14.2	2.6%
Largemouth Bass	8	1	14.6	1.3%
Largemouth Bass	9	2	17.2	3.3%
Largemouth Bass	10	1	17.6	1.6%

Table 6. Comparison of catch-per-effort (CPE) for select species in Crooked Lake (Oakland County) to statewide and Lake Erie Management Unit (LEMU) CPE generated from the Status and Trends Program surveys (Wehrly et al. 2015). CPE for electrofishing is number of fish/minute. CPE for Large-mesh fyke, small-mesh fyke, and experimental gill nets is number of fish/lift.

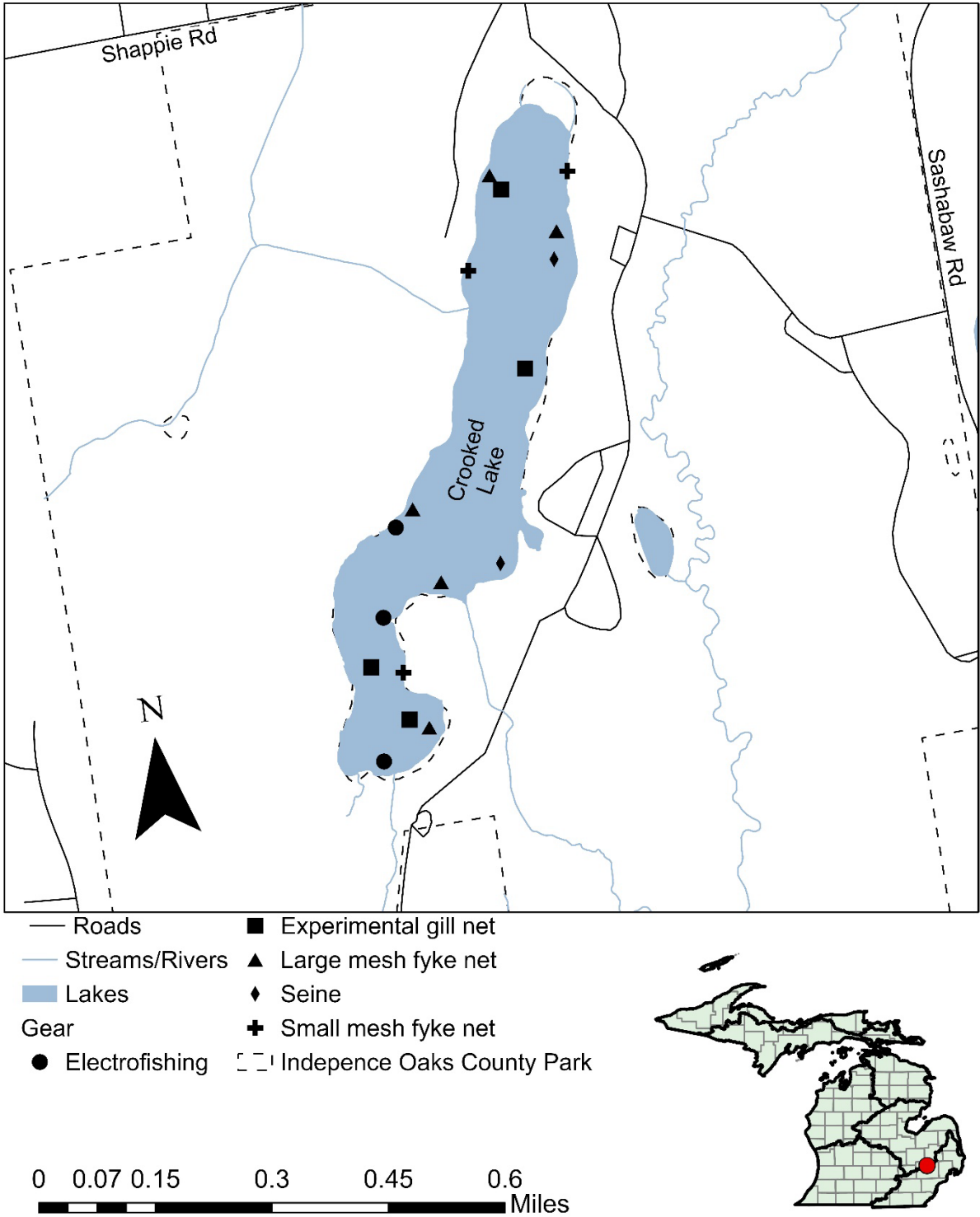| Species	Gear	Statewide 25th Percentile	Statewide Median (50th Percentile)	Statewide 75th Percentile	Crooked Lake 2002	**Crooked Lake 2023**	LEMU Median CPE
Bluegill	Electrofishing	1.2	3.9	7.6	9.1	**12.2**	8.4
Bluegill	Large mesh fyke net	2.5	11.7	31.9	7.4	**46.6**	21.8
Bluegill	Small mesh fyke net	2.3	8.5	36.5	--	**35.3**	25.5
Pumpkinseed	Electrofishing	0.2	0.4	1	0.6	**1.1**	0.2
Pumpkinseed	Large mesh fyke net	0.7	1.9	5.5	0.4	**24.8**	1.7
Pumpkinseed	Small mesh fyke net	0.5	2.3	8	--	**7.3**	1.3
Rock Bass	Electrofishing	0.13	0.3	0.74	2.1	**0.7**	0.6
Rock Bass	Large mesh fyke net	1.3	3.6	8.2	5	**3.3**	2.7
Largemouth Bass	Electrofishing	0.3	0.8	1.6	1.2	**1.3**	0.9
Largemouth Bass	Large mesh fyke net	0.5	1.4	2.7	1.4	**2.0**	1.6
Northern Pike	Inland experimental gill net	0.8	2.0	4.0	0	**0.5**	1.5
Northern Pike	Large mesh fyke net	.3	.7	1.1	0	**0**	0.5

Figure 1. Map of Crooked Lake, Oakland County with gear effort indicators for the fisheries survey conducted, spring 2023.
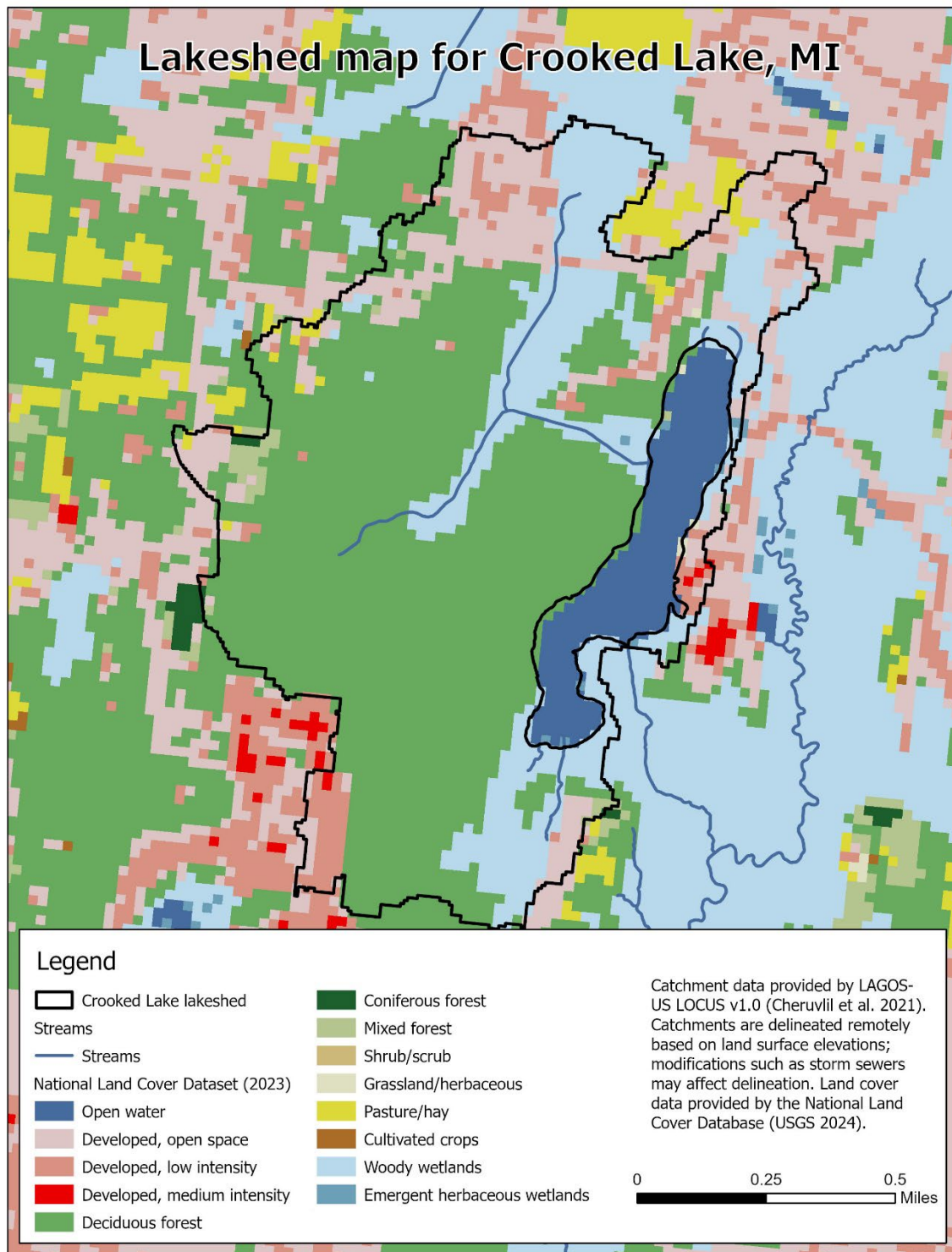
Figure 2. Land cover image from 2023 of the Crooked Lake lakeshed (catchment), Oakland County, Michigan, with land cover imagery.

Figure 3. Aerial image showing major land uses within the Crooked Lake lakeshed (outlined in yellow), Oakland County, Michigan.
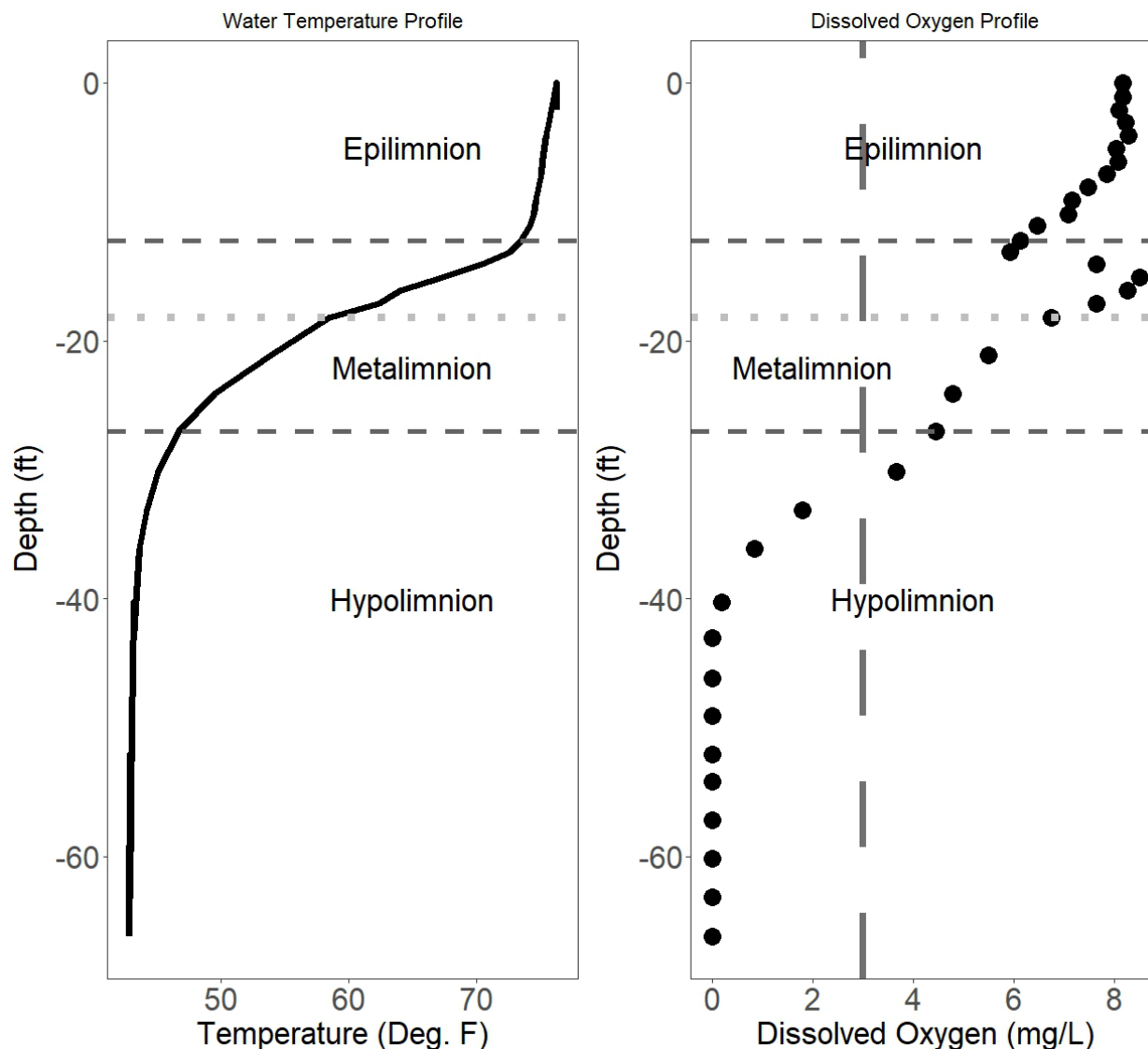
Figure 4. Water temperature (left panel) and dissolved oxygen (right panel) profiles for Crooked Lake collected August 11, 2023. In the left panel, the solid black line indicates water temperature, whereas the horizontal dashed lines indicate the upper and lower bounds of the metalimnion, and the horizontal dotted line indicates the thermocline. In the right panel, the dashed black line indicates dissolved oxygen concentration, whereas the vertical dashed line represents the lower limit of suitable dissolved oxygen (3.0 mg/L); the horizontal dashed lines represent the upper and lower bounds of the metalimnion, whereas the horizontal dotted line indicates the thermocline.
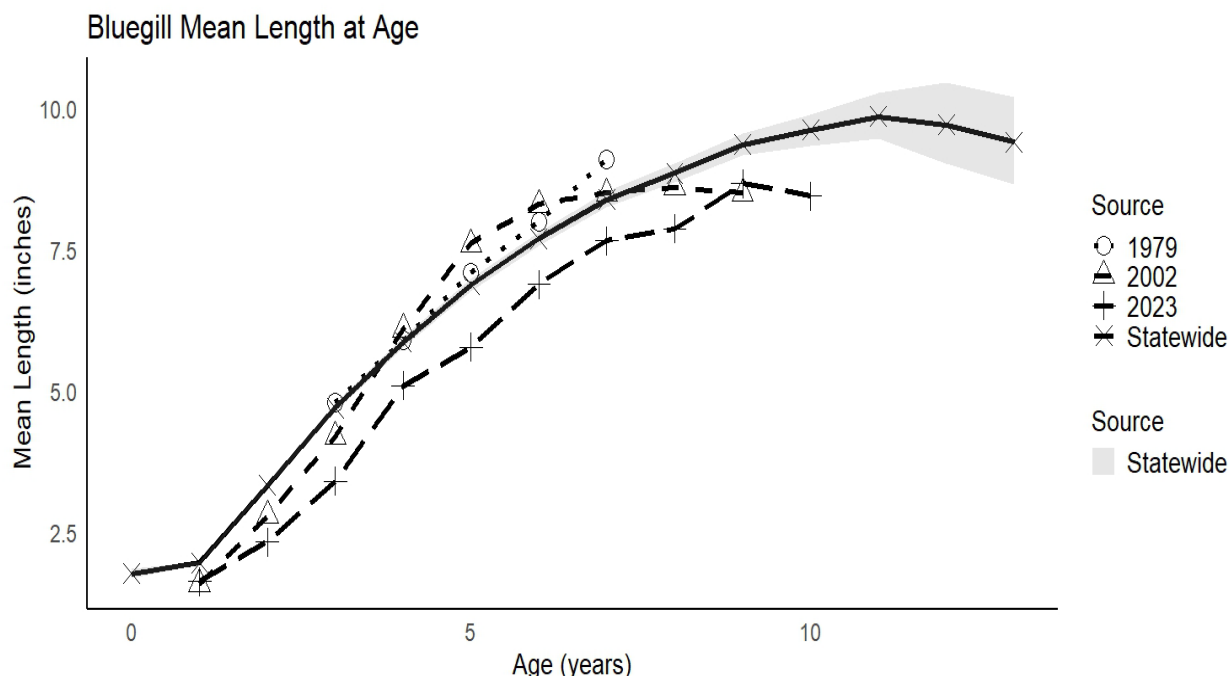
Figure 5. Graph of mean length at age for the Bluegill population from age structures collected during fisheries surveys in 1979 (dotted/circles), 2002 (dashed/triangles), and 2023 (long dash/plus sign) from Crooked Lake, Oakland County. The Bluegill statewide mean length at age (solid/x symbol) along with 95% confidence intervals (grey ribbon) are included.
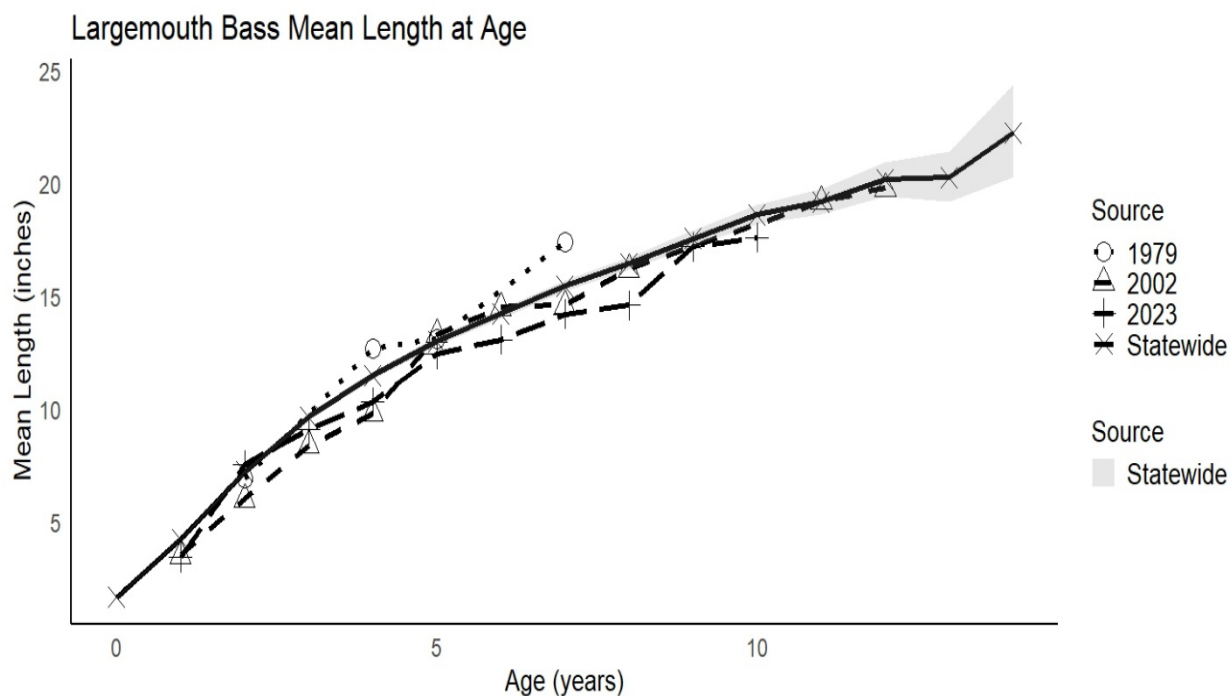

Figure 6. Graph of mean length at age for the Largemouth Bass population from age structures collected during fisheries surveys in 1979 (dotted/circles), 2002 (dashed/triangles), and 2023 (long dash/plus sign) from Crooked Lake, Oakland County. The Largemouth Bass statewide mean length at age (solid/x symbol) along with 95% confidence intervals (grey ribbon) are included.
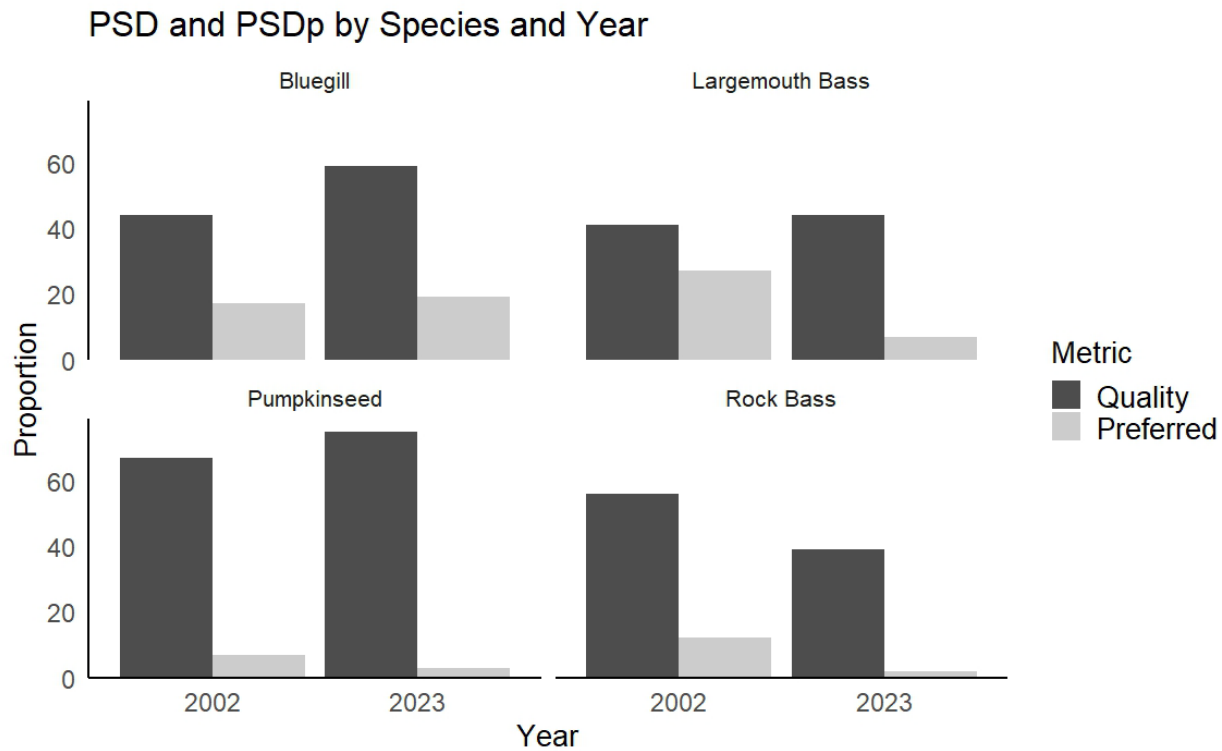
Figure 7. Proportional size distribution values (quality and preferred) for Bluegill (upper left), Largemouth Bass (upper right), Pumpkinseed (lower left), and Rock Bass (lower right) from the 2002 and 2023 surveys of Crooked Lake, Oakland County.
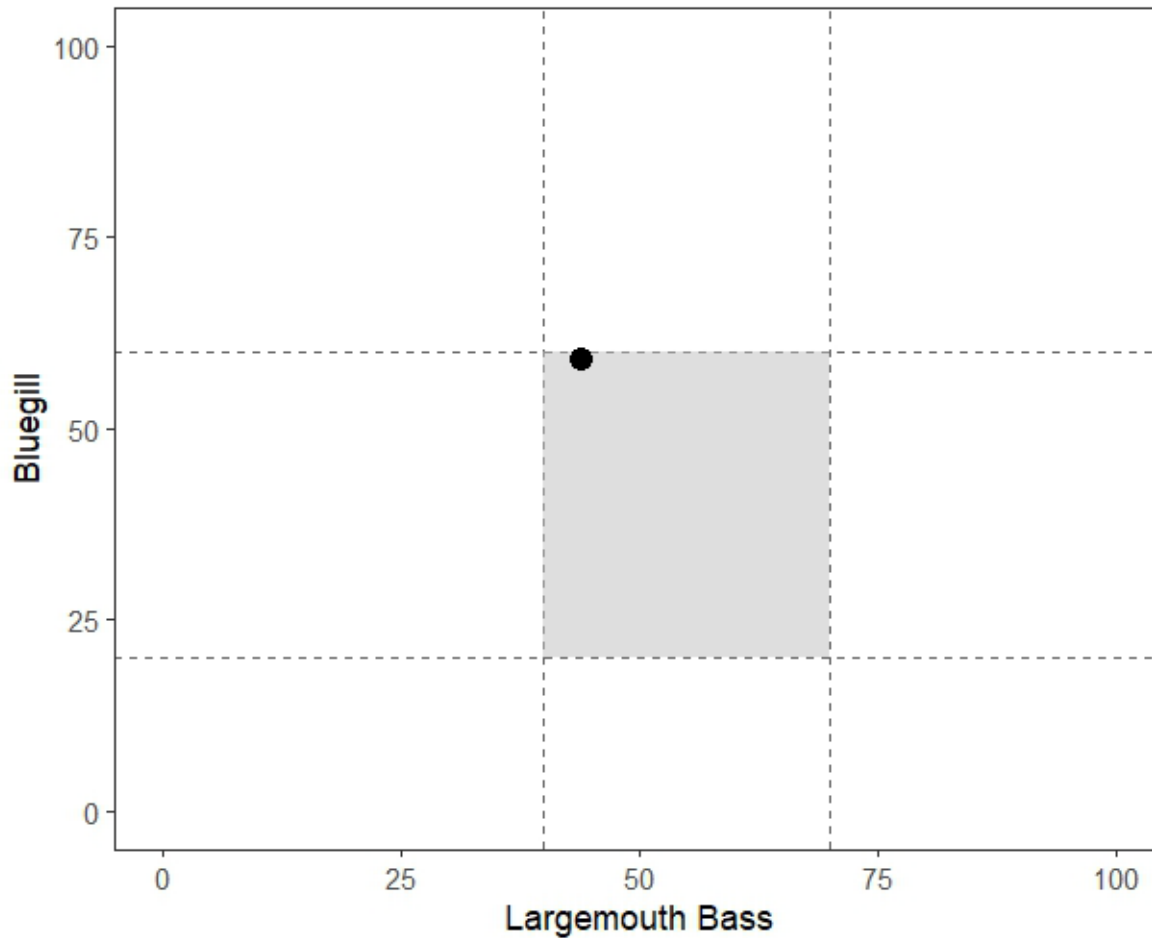
Figure 8. Tic-tac-toe plot of the proportional size density (quality size) for Bluegill (prey) and Largemouth Bass (predator). The grey dotted lines represent the upper and lower bounds of the typical range for each species balanced predator prey management option. The grey shaded area represents the overall range where Bluegill PSD and Largemouth Bass PSD overlap for a balanced predator-prey management option.

Literature Path

Received December 15th, 2025; Approved January 14th, 2026

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Jay Wesley, External Reviewer

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