Long Lake

Ionia County, T08N, R07W, S2-3
Grand River Watershed, last surveyed 2016

Addie Dutton; Fisheries Management Biologist

Environment

Long Lake is a 365-acre natural lake, located in northwestern Ionia County approximately six miles east of the city of Belding. Long Lake has a maximum depth of 57 feet with a control structure that maintains the water level. The bottom substrate is a mixture of marl, peat, muck, sand, and small amounts of gravel. Most of the shoreline of Long Lake is developed with year-round or seasonal residences. The northeastern corner of the lake is within the Flat River State Game Area. Public access is available through the Flat River State Game Area, although it would be a hike through swamp land. Additional public access can be gained from the Michigan Department of Natural Resources (DNR) boating access site on the southern shore. The boating access site includes a gravel-surfaced ramp with one skid pier, an outhouse, and parking for 19 vehicles with trailers.

History

Long Lake has been surveyed many times across history. The earliest survey record on file was from July 1891, which was completed by the Michigan Fish Commission, however it is challenging to interpret. It is unclear what type of gear was used for the survey. Fish species captured included: "speckled bass (Black Crappie), bullheads, Rock Bass, black bass (presumably Largemouth Bass), and Bluegill". There are also notes about Northern Pike and lots of forage including minnows. Long Lake was first mapped in 1953 by the Michigan Department of Conservation, the precursor to the present-day DNR. The initial survey mapped the depth contours and bottom substrate of Long Lake. A variety of fish were reported as present including Northern Pike, Bluegills, bass, Yellow Perch, suckers, Bowfin, Black Crappies, and Ciscoes (Lake Herring). Heavy fishing pressure was noted during both the summer and winter seasons in the 1953 report. In 1953, a total of 90 cottages were counted around the lake indicating that it was already heavily developed.

The first comprehensive fish survey was completed in 1955. Gill nets and bag seines were used to sample the lake. Fish species captured during the 1955 survey included: Black Bullhead, Yellow Bullhead, Grass Pickerel, Northern Pike, Yellow Perch, Largemouth Bass, Warmouth, Bluegill, Pumpkinseed, Rock Bass, Longnose Gar, Bowfin, White Sucker, Bluntnose Minnow, Banded Killifish, Blacknose Shiner, Blackchin Shiner, Johnny Darter, and Golden Shiner. Age and growth structures were removed from Bluegill, Rock Bass, Largemouth Bass, Pumpkinseed, Warmouth, Yellow Perch, Northern Pike, Grass Pickerel, White Sucker, and Golden Shiner. Four age-classes of Largemouth Bass (ages 0-3) and five age-classes of Bluegill (ages 1-5) were present in the 1955 survey. There were only 12 Largemouth Bass aged, which is an insufficient sample size to determine growth rates. However, there were 72 Bluegill aged and 49 of them were age 2. A temperature and dissolved oxygen profile was taken in August 1955. The lake was highly stratified with the thermocline between 15 and 17 feet, with the remaining 40 feet of water being devoid of oxygen.

After the 1955 survey, there were fisheries surveys conducted in 1963, 1971, 1972, 1976, 1978, 1979, 1980, 1982, 1986, 1990, and 2000. General trends across all surveys indicated that Bluegills historically have been slow growing in Long Lake with the majority of fish captured being less than 7 inches in length. The Schneider Index is a metric used to assess the Bluegill fishery in a waterbody by standardizing length-frequency distributions from Bluegill collected by different types of sampling gear (Schneider 1990). The Index is a sliding scale from 1 to 7 with 1 being a very poor Bluegill fishery and 7 being a superior Bluegill fishery. The Schneider Index was calculated for Bluegill captured by electrofishing and large-mesh fyke nets in Long Lake in 1982, 1990, 2000, and 2016. In 1982 and 1990, only fyke nets were used to captured Bluegill. The Schneider Index score for these two sampling events (1982 and 1990) indicated the fishery was between acceptable and satisfactory (Table 5). Similarly, Largemouth Bass were historically slow growing at nearly every sampling event across all age-classes. Few Northern Pike were captured across all the surveys, most likely due to time of the survey and gear used during the surveys. The 1990 survey was the most effective survey at capturing Northern Pike with 22 individuals captured. All 22 Northern Pike were aged, and the mean growth index was calculated at -3.4 indicating that the Northern Pike in Long Lake were growing much slower compared to statewide growth rates.

Given the long history of slow growth and poor size structure of Bluegills, fisheries managers have attempted twice to reduce the population density of Bluegills and increase the growth rates. An antimycin treatment was conducted on Long Lake in May 1977 specifically targeting the Bluegill population. The goal was to remove at least 75% of the Bluegills in Long Lake on the first attempt. The antimycin treatment stirred up a large argument among people in the community and shoreline property owners. The treatment initially was successful with an increase in the growth rates of Bluegills in 1978 and 1979, but the success was short-lived. By 1986, the Bluegill growth rates had fallen again in Long Lake (Table 5). Another approach to reduce the Bluegill density was by stocking Channel Catfish. Channel Catfish were stocked in 1988 and 1989, followed by Channel Catfish that were trapped and transferred from the Maple River to Long Lake in 1990 (Table 1). The 1990 survey did not capture any Channel Catfish from the 1988 or 1989 stocking events. Due to the poor survival of stocked fish and inconsistent production from the hatcheries, the stockings were discontinued in 1991.

The paper files indicate that Long Lake has had dense vegetation in the lake since the 1950s. The aquatic vegetation community was initially dominated by native species, primarily Chara, but since the early 2000s many invasive plant species have been documented in Long Lake. Due to the presence of the state endangered Pugnose Shiner, there has been a compromise to try to control the invasive plant species in the lake, while also protecting the Pugnose Shiner which requires dense nearshore vegetation. Herbicide treatments, including full lake fluridone (SONAR) treatments, have been used to control aquatic vegetation for over 25 years in Long Lake. Additional vegetation control methods have included mechanical harvesting which continues presently with one harvesting treatment annually.

Data from standardized aquatic vegetation assessment sites (AVAS) surveys completed during 1998-2021 was compiled to assess temporal trends in Long Lake. (All surveys since 2009 were conducted by Progressive AE. The 1998 and 2002 survey data in the MiWaters database did not include surveyor names or affiliation.) The total native plant cumulative cover value, number of submergent species, and number of emergent species remained relatively similar across time. The distribution of Eurasian Watermilfoil (EWM) was 100% in 1998 but has only been over 50% two times since in 2009 and

2019. The cumulative cover value of EWM was the highest in 2009 at a little over 30%, but since 2009 has not been higher than 5%. Starry Stonewort was first found in Long Lake in 2011 and has since expanded in distribution within the lake. The Starry Stonewort cumulative cover value peaked in 2017 and remained below 15% from 2018 through 2021.

Current Status

In June 2016, Long Lake was surveyed as part of the DNR's Status and Trends Program (STP). The STP utilizes a variety of gear including small mesh fyke nets, large mesh fyke nets, experimental gill nets, seining, and nighttime electrofishing to assess fisheries populations in lakes across the state (Table 2). By utilizing standardized sampling protocols, fish data is collected at lakes randomly selected across Michigan to compare spatial and temporal trends in fish populations statewide. All fish captured in Long Lake were measured for total length, and spine or scale samples for age and growth analysis were collected from the first 10 individuals per gamefish species per inch group. Weights for all species were calculated from the length-weight regression coefficients developed by Schneider et al. (2000). Weighted mean length at age and age frequencies were calculated using the procedures developed by Schneider (2000b). On August 11, 2016, water quality, shoreline development, and nearshore habitat were assessed following methods in the STP (Wehrly et al. 2010).

A total of 1,837 fish representing 20 species and one hybrid were captured during the 2016 survey on Long Lake (Table 3). Bluegill was the most abundant species captured with 662 individuals representing 36% of the overall catch by number and 10% by weight. Bluegill varied in length from 1.0 inches to 8.2 inches with an average length of 4.0 inches (Figure 2). Eight age-classes (age 1-8) were captured during the 2016 survey (Table 4). The mean growth index was -1.2 with slow growth exhibited across all age-classes. The Schneider Index score was calculated for the Bluegill fishery both by boom electrofishing and fyke netting. The electrofishing score was 2.7 (poor-acceptable) and the large-mesh fyke netting index score was 3.3 (acceptable-satisfactory; Table 5).

Pumpkinseed was the second most abundant fish species captured in 2016, with 260 individuals representing 14% of the overall catch by number and 9% by weight. Pumpkinseed varied in length from 1.0 to 8.9 inches with an average length of 5.4 inches (Figure 2). Seven age-classes (age 1-7) were captured. The mean growth index was -0.7 which indicates similar to slightly slower growth compared to statewide averages (Table 4).

Other panfish species captured included Black Crappie (n=36), Green Sunfish (n=5), Hybrid Sunfish (n=81), Rock Bass (n=11), and Warmouth (n=45). The diversity of panfish in Long Lake provides anglers with the opportunity to catch numerous species. In addition to the panfish species, 108 Yellow Perch were also captured. Nearly all the Yellow Perch (96%), were less than 7 inches in length making them undesirable for most anglers.

Predators (i.e., Northern Pike, Largemouth Bass, Bowfin, and Longnose Gar) composed 53% of the catch by weight. The two most abundant predator species were Largemouth Bass and Northern Pike. Seventy-four Largemouth Bass were captured and varied in length from 5.1 inches to 16.9 inches with an average length of 10.2 inches (Figure 3). Eight age-classes of Largemouth Bass (ages 1-8) were captured during the survey and on average Largemouth Bass were growing slower when compared to statewide growth rates (Table 4). Only 12% of the Largemouth Bass captured were at least 14 inches in

length making them legal for harvest. Fifty-eight Northern Pike were also captured during the 2016 survey on Long Lake. The Northern Pike varied in length from 11.6 inches to 31.1 inches with an average length of 21.2 inches (Figure 4). Of the 58 fish captured, only 21% were at least 24 inches in length making them legal for harvest. Eight age-classes (ages 1-8) of Northern Pike were captured. The mean growth index was -2.8 indicating that Northern Pike in Long Lake were growing much slower when compared to statewide averages across all age-classes (Table 4).
Numerous forage fish species were also captured including: Blackchin Shiner, Banded Killifish, Bluntnose Minnow, Blacknose Shiner, Blackstripe Topminnow, Iowa Darter, and the state endangered Pugnose Shiner. Ten individual Pugnose Shiner were captured in seine hauls and in small-mesh fyke nets. Pugnose Shiner historically inhabited 18 watersheds across Michigan, but in the past 20 years, Pugnose Shiner have only been found in three locations (Derosier et al. 2015).

The limnology and shoreline sampling was conducted during the month of August 2016 when Long Lake was stratified. The epilimnion consisted of the top 12 feet of the water column (Figure 1). The epilimnion was quite warm with water temperatures between 81.6 F to 77.5 F. Dissolved oxygen varied from 9.51 mg/L at the surface to 3.70 mg/L at 12 feet. The thermocline was between 13 feet and 15 feet when the dissolved oxygen fell to less than 1.0 mg/L. From 15 feet to the bottom, Long Lake did not have enough oxygen to support fish or zooplankton. Results from the 2016 temperature and dissolved oxygen profile was much different than the profile taken in September 1974. In 1974, the thermocline was between 27 feet and 33 feet. There has been a substantial loss of available habitat to fish species in the past 42 years. In addition to the temperature and oxygen profile, shoreline sampling was conducted to assess the number of dwellings, docks, submerged trees, and percentage of the shoreline that was armored. These shoreline habitat variables were compared to data compiled for STP surveys completed during 2002-2007 statewide and in the Southern Lake Michigan Management Unit (SLMMU) which includes the southwestern area of Michigan (K. Wehrly, DNR, personal communication). A total of 189 dwellings were counted with 187 docks present. The number of dwellings and docks present on Long Lake was well above the 75th percentile for the number of dwellings and docks found per kilometer on other lakes in SLMMU and across the state. On average, 63.8% of the shoreline of Long Lake was armored, which is much higher than the 75th percentile (46.7%) of the average percent armored for other lakes in SLMMU. Surprisingly, the number of submerged trees in Long Lake (7.24/km) was between the 50th and 75th percentile compared to other lakes in SLMMU and between the 25th and 50th percentile when compared to lakes statewide. Water chemistry sampling was also conducted on Long Lake including total alkalinity, total Nitrogen, total Phosphorus, and Chlorophyll a. Alkalinity was 122 mg/L, total Nitrogen was 0.838 mg/L, total Phosphorus was 0.027 mg/L, and Chlorophyll a was 0.0065 mg/L. These parameters indicate that Long Lake is a hardwater lake with a moderate (mesotrophic) nutrient supply. As the ratio of nitrogen to phosphorus was greater than 15:1, phosphorus appears to be the primary nutrient limiting growth of plants and algae.

Analysis and Discussion

Bluegill and Pumpkinseed catch-per-unit-effort (CPUE) was compared to CPUE from other STP surveys in SLMMU from 2002-2021. The Bluegill CPUE in large mesh fyke nets in Long Lake in 2016 was 25.8 fish/net night, which is slightly above the 25th percentile for SLMMU lakes. Compared to statewide CPUE from 2002-2007, Long Lake was very close to the 75th percentile (26.6 fish/net night) for Bluegill CPUE in large-mesh fyke nets. Pumpkinseed CPUE in large mesh fyke nets in

Long Lake in 2016 was 21.7 fish/net night, which is substantially higher than the 75th percentile for SLMMU lakes (15.6 fish/net night). Compared to statewide averages, this CPUE is also extremely high compared to the 75th percentile (4.67 fish/net night). Compared to area lakes in SLMMU, Long Lake appears to have a lower abundance of adult Bluegill, but similar abundance to lakes across the state. However, Long Lake seems to have a much higher adult population of Pumpkinseed compared to lakes in SLMMU and statewide. The high CPUE of Pumpkinseeds was expected because this species typically inhabits vegetated areas throughout its life cycle.

The Bluegill population in Long Lake has been surveyed many times since 1955. Most of the surveys have taken age structures from Bluegill to determine growth rates. From 1955 through 2016, mean length at age was calculated for Bluegills, Pumpkinseed, Black Crappie, and Largemouth Bass across 11 sampling events (Table 6). In general, Bluegill mean length at age was generally low from 1955 to 1976 with most fish less than six years old. Following the antimycin treatment in 1977, there were two years (1978 and 1979) where Bluegill exhibited higher mean length at age and the population had more older individuals. However, from 1986 through 2016, the general trend of lower mean length at age for Bluegills continued. Due to limited historic data for Pumpkinseed and Black Crappie, it is challenging to assess trends across time for these species. The data that is available seems to suggest a decreasing trend in mean length at age for Black Crappie. Pumpkinseed mean length at age has generally been stable without much difference in recent sampling events that have the most data.

Bluegill growth is also related to the distribution, density, and diversity of aquatic plants in a lake. Growth of rooted aquatic plants is limited by light penetration. Thus, the percentage of lake area covered with aquatic vegetation typically is higher in lakes with broad shoals (such as Long Lake) than in lakes with steep drop-offs. The density of aquatic vegetation in the lake is influenced by the nutrient supply. When human activities increase nutrient inputs to a lake, the biomass of aquatic plants in the lake typically increases. The use of best management practices can reduce external nutrient loading, but the internal cycling of nutrients between the sediments and the water column continues.

Cheruvelil et al. (2005) found a negative relationship between the percentage of a lake covered with aquatic vegetation and growth of Bluegills and Largemouth Bass. Schneider (1981) and Theiling (1990) also observed that Bluegill stunting was most common in shallow weedy lakes. Stunting is caused by a combination of high recruitment of young fish, low natural mortality of young fish, and a scarcity of suitable forage (Theiling 1990; Schneider 1999; Schneider and Lockwood 2002). In southwest Michigan, Largemouth Bass typically are the most important predators of juvenile Bluegills. Dense aquatic vegetation hinders prey detection and movement of Largemouth Bass, resulting in longer search times and lower attack success (Savino and Stein 1982; Engel 1987; Gotceitas and Colgan 1989; Valley and Bremigan 2002). The introduction of EWM into a lake exacerbates Bluegill stunting. EWM forms dense mats that are nearly impossible for Largemouth Bass to penetrate. These mats also can inhibit growth of native plant species, thus reducing the diversity and abundance of macroinvertebrates that are an important food source for Bluegills (Cheruvelil et al. 2001).

As Bluegill stunting is most common in lakes with dense vegetation, many researchers have hypothesized that aquatic plant control can produce improvements in Bluegill growth. Three general categories of weed control have been examined: mechanical harvesting, biological control, and herbicides. Trebitz and Nibbelink (1996) and Trebitz et al. (1997) used computer simulations to predict how patterns of vegetation removal would affect bluegill growth. In their simulations, cutting narrow channels that totaled 20-40% of a vegetated area yielded the largest improvements in Bluegill growth rates. Olson et al. (1998) cut narrow channels in four lakes (approximately 20% of vegetation removed) and found that growth of age-3 and age-4 Bluegills improved significantly relative to Bluegills in reference lakes. They predicted that these effects would be short-lived unless cutting was repeated. There is one major caveat to this technique. EWM and Starry Stonewort can reproduce via fragmentation, so mechanical harvesting could increase relative abundance of these invasive species at the expense of native plants that do not reproduce via fragmentation.

Biological control involves the introduction of a predator to consume EWM. In the Great Lakes region, the species that generally has been employed for this purpose is the milfoil weevil. This insect is native to the area and lives almost exclusively on milfoil (both the Eurasian and native varieties). The larvae feed on stem tissue, whereas the adults consume milfoil leaves. Parsons et al. (2011) observed declines in EWM biomass and improvements in the size structure of the Pumpkinseed population in a Washington lake several years after introduction of milfoil weevils. However, the survival of milfoil weevils and their effects on aquatic ecosystems have varied widely from lake to lake. Newman (2004) found that survival of milfoil weevils generally declined with increasing densities of predators such as Bluegills and other sunfish species. Introductions of milfoil weevils to southwest Michigan lakes generally have not yielded substantial declines in EWM abundance (Kieser & Associates 2021).

A variety of herbicides and algaecides have been used on Long Lake. The use of these herbicides is regulated by the Aquatic Nuisance Control Section (ANC) of the Michigan Department of Environment, Great Lakes, and Energy. Fisheries Division collaborates with ANC and ProgressiveAE, who is contracted by the Long Lake Improvement Board for aquatic nuisance control, to ensure that these treatments are conducted in a manner that minimizes effects on Pugnose Shiners and non-target plant species. The focus of these treatments has been suppression of invasive species (EWM, Curlyleaf Pondweed, and Starry Stonewort) and control of filamentous algae to improve recreational opportunities.

As previously noted, Largemouth Bass are often the keystone predator on Bluegills in southwest Michigan lakes. During the 2016 survey on Long Lake, nearly 65% of the Largemouth Bass were captured by nighttime electrofishing with a CPUE of 1.6 fish/minute electrofishing. This is exactly the median electrofishing CPUE for Largemouth Bass in surveys completed on SLMMU lakes during 2002-2021 and slightly above the 75th percentile when compared to the statewide CPUE for electrofishing efforts (1.57 fish/minute electrofishing). Mean length at ages were compared across surveys from 1955 to 2016. Few older Largemouth Bass have been captured in Long Lake and generally mean length at age is low for Largemouth Bass in Long Lake compared to statewide averages (Table 6). As noted above, Largemouth Bass were growing slower compared to statewide growth rates in 2016 (mean growth index -1.1). This slow growth was similar to the 2000 survey when Largemouth Bass had a mean growth index of -0.9.

The timing of the 2016 STP survey was not conducive to targeting Northern Pike. However, the gill nets captured a high number of Northern Pike. The CPUE for the gill netting portion of the survey was 13.25 fish/net night. This CPUE is extremely high compared to SLMMU CPUE from 2002-2021 when the median CPUE for Northern Pike in gill nets during the same general season (early summer) was 2.41 fish/net night and the 75th percentile was 3.21 fish/net night. The high abundance of Northern Pike captured with low growth rates most likely is indicative of a high-density population in Long

Lake. No gill nets were deployed during the 2000 survey, and only four Northern Pike were captured. The 1990 survey did utilize gill nets. Twenty-one Northern Pike were captured in June 1990 resulting in a CPUE of 7 fish/net night which is still much higher than the 75th percentile. The growth rate of Northern Pike in 1990 was also much slower than statewide averages with a mean growth index of -3.4. It appears that Long Lake has had a high density, slow growing Northern Pike population for many years.

Schneider (2000a) observed that predators typically made up 20-50% of the fish biomass in lakes with desirable fisheries. Predators composed 53% of the fish biomass in Long Lake in 2016. Thus, the stocking of additional predators is not recommended.

The Pugnose Shiner population appears to be self-sustaining in Long Lake with 10 individuals captured in 2016. Pugnose Shiners inhabit lakes that have good water quality, are generally clear, and have dense vegetation especially in nearshore areas (Scott and Crossman 1973; Trautman 1981). The health of Long Lake's littoral (shallow water) zone is critical to the survival of Pugnose Shiners. According to Michigan's Wildlife Action Plan, one of the greatest threats to littoral zone ecosystems is shorelines becoming armored by installation of seawalls or rock riprap (Derosier et al. 2015). Currently, Long Lake is heavily armored compared to lakes both locally in SLMMU and across the state. Seawalls fragment upland areas and the littoral zone while also increasing erosion and scour of the shoreline and the littoral zones (Derosier et al. 2015). Depending on wave action at a specific location, bioengineering with native plant species (sometimes in conjunction with limited amounts of rock at the toe of the slope) may be sufficient to protect lakefront property from erosion while maintaining high habitat quality for Pugnose Shiners and other fish species.

Aquatic herbicide and algaecide treatments and mechanical weed harvesting also pose threats to Pugnose Shiners. Copper compounds have a higher potential for direct toxicity to fish than other chemicals used for plant or algae control. Thus, Long Lake ANC permits include special restrictions on the use of copper compounds during Pugnose Shiner spawning season (June-July). It is possible that mechanical weed harvesting results in mortality of Pugnose Shiners through contact with the harvester or by being caught in weed mats removed from the lake. No data are available to quantify mortality of Pugnose Shiners during mechanical harvesting operations.

Management Direction

1. Continue to protect littoral zone habitats through best management practices to reduce armoring of the shorelines, specifically to benefit the state endangered Pugnose Shiner.

2. Change the Northern Pike regulations on Long Lake. The existing regulations include a minimum size limit of 24 inches and a daily possession limit of 2 fish. The proposed regulations would eliminate the minimum size limit and establish a daily possession limit of 5 fish, only one of which can be over 24 inches. The proposed regulation change would increase harvest opportunities for Northern Pike. It might result in a lower population density and improved growth rates for pike.

3. Continue to collaborate with ANC, Long Lake Improvement Board, and contractors hired for aquatic nuisance control to strike a balance between controlling invasive species, facilitating aquatic recreation, and protecting nearshore habitat for Pugnose Shiners and other fish species.

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Table 1. Fish stocking from 1979-2021 in Long Lake, Ionia County.

Species	Year	Number	Type of Stocking	Average Length (in)
Channel Catfish	1988	20,800	Hatchery Plant	3.23
Channel Catfish	1989	13,000	Hatchery Plant	4.06
Channel Catfish	1990	1,000	Transfer of Wild Fish	7.99

Table 2. Sampling effort during the 2016 STP survey on Long Lake. Each net night is equivalent to one overnight set of one net.

Sampling period	Gear	Effort
June 6-9	Large-mesh fyke net	9 net nights
June 6-8	Small-mesh fyke net	4 net nights
June 6-8	Graded-mesh gill net	4 net nights
June 6 & 7	Seine	7 seine hauls
June 9	Nighttime electrofishing	30 minutes

Table 3. Number, weights, lengths, and mean growth indices for fish species collected during the 2016 STP survey on Long Lake. Fish were captured using fyke nets (small and large mesh), gill nets, seines, and nighttime electrofishing gear.

Species	Number	Percent by Number	Weight (lbs.)	Percent by weight	Length range (in)	Average Length (in)	Percent Legal Size
Black Crappie	36	2	12.9	3	4.0-12.9	8	56
Blackchin Shiner	107	5.8	0.3	0.1	1.0-2.9	1.8	N/A
Banded Killifish	76	4.1	0.3	0.1	1.0-2.9	2	N/A
Bluegill	662	36	44.3	10.3	1.0-8.9	4	14
Bluntnose Minnow	88	4.8	0.4	0.1	1.0-2.9	2.2	N/A
Blacknose Shiner	4	0.2	<0.1	<0.1	2.0-2.9	2.5	N/A
Bowfin	15	0.8	36.3	8.4	12.0-21.9	18.6	N/A
Brown Bullhead	9	0.5	6	1.4	1.0-13.9	10.9	N/A
Blackstripe Topminnow	2	0.1	<0.1	<0.1	2.0-2.9	2.5	N/A
Green Sunfish	5	0.3	0.4	0.1	4.0-6.9	4.9	20
Hybrid Sunfish	81	4.4	16.1	3.7	2.0-8.9	6.2	58
Iowa Darter	3	0.2	<0.1	<0.1	1.0-2.9	1.8	N/A
Largemouth Bass	74	4	51.8	12	2.0-16.9	10.2	12
Longnose Gar	6	0.3	12.1	2.8	20.0-31.9	27.8	N/A

Species	Number	Percent by Number	Weight (lbs.)	Percent by weight	Length range (in)	Average Length (in)	Percent Legal Size
Northern Pike	58	3.2	128.1	29.8	11.0-31.9	21.2	16
Pugnose Shiner	10	0.5	<0.1	<0.1	1.0-2.9	1.7	N/A
Pumpkinseed	260	14.2	39	9.1	1.0-8.9	5.4	35
Rock Bass	11	0.6	2.6	0.6	2.0-8.9	6.4	64
Warmouth	45	2.4	6.3	1.5	2.0-7.9	5.5	31
Yellow Perch	108	5.9	3.5	0.8	2.0-9.9	3.9	4
Yellow Bullhead	177	9.6	70.1	16.3	5.0-12.9	9.3	N/A

[1] Harvestable size is defined as 6 inches for Bluegill, Hybrid Sunfish, Pumpkinseed, and Warmouth and 7 inches for Black Crappie and Yellow Perch.

Table 4. Age and growth analysis for various species captured during the 2016 STP survey on Long Lake. Mean growth indices less than -1 indicate below average growth, indices between -1 and +1 indicate average growth, and indices great than +1 indicate faster growth than state averages.

Species	Age	Number Aged	Length Range (in)	State Average Length (in)	Weighted Mean Length (in)	Mean Growth Index
Black Crappie	2	12	4.9-6.2	6.5	5.47	-1
	3	13	6.3-8.2	7.9	7.02	
	4	2	8.6-9.0	8.9	8.8	
	5	4	10.5-10.9	9.7	10.7	
	6	3	10.2-11.8	10.4	10.93	
	8	1	11.3	11.6	11.3	
	9	3	11.0-12.7	N/A	11.9	
Bluegill	1	15	1.6-2.4	2.4	2.07	-1.2
	2	6	2.2-2.8	4.2	2.52	
	3	11	3.6-4.2	5.3	3.82	
	4	12	3.9-5.1	6.2	4.72	
	5	8	5.3-7.5	6.9	5.78	
	6	15	5.4-8.2	7.4	6.26	
	7	7	6.9-8.0	8	7.13	
	8	2	6.1-8.1	8.4	6.34	
Largemouth Bass	1	3	5.1-5.4	5.4	5.3	-1.1
	2	15	5.6-9.1	8.7	7.25	
	3	18	8.3-11.8	10.6	9.71	

Species	Age	Number Aged	Length Range (in)	State Average Length (in)	Weighted Mean Length (in)	Mean Growth Index
Largemouth Bass	4	10	9.9-12.3	12	11.08	
	5	5	10.7-13.6	13.7	12.62	
	6	6	10.7-16.2	15	13.98	
	7	3	13.9-16.9	16.7	15.71	
	8	1	15.4	17.6	15.4	
Northern Pike	1	1	11.6	14.5	11.6	-2.8
	2	11	14.9-19.2	19	17.74	
	3	6	17.0-22.2	21.8	19.54	
	4	11	18.5-23.7	24.2	20.9	
	5	16	19.0-24.9	26.1	22.51	
	6	11	19.6-31.1	27.8	24.07	
	7	1	21	30	21	
	8	1	23.8	N/A	23.8	
Pumpkinseed	1	2	1.8-1.9	2.4	1.85	-0.7
	2	5	2.8-3.6	4.2	3.04	
	3	6	3.2-4.2	5.2	3.9	
	4	12	3.9-5.8	5.8	4.91	
	5	16	5.5-8.2	6.3	6.12	
	6	10	5.6-8.0	6.8	6.72	
	7	5	6.1-8.0	7.2	6.5	
Yellow Perch	1	17	2.7-3.9	4	3.28	-1.2
	2	17	3.5-5.1	5.7	4.08	
	3	9	5.1-6.2	6.8	5.46	
	4	2	6.6-7.3	7.8	6.95	
	5	2	7.4-8.2	8.7	7.8	
	7	1	9.5	10.5	9.5	

Table 5. Schneider Index scores for the Bluegill fishery in Long Lake from 1982 through 2016. The Schneider Index ranks the Bluegill fishery from 1 (poor) to 7 (superior).

Year	Gear	Schneider Index Score	Fishery Rank
1982	Trap Nets	4.0	Satisfactory
1990	Trap Nets	3.3	Acceptable-Satisfactory
2000	Trap Nets	6.0	Excellent
2000	Boom Electrofishing	2.0	Poor
2016	Trap Nets	3.3	Acceptable-Satisfactory
2016	Boom Electrofishing	2.7	Poor-Acceptable

Table 6. Mean length at age for Bluegill, Largemouth Bass, Pumpkinseed, and Black Crappie from fish captured from 1955 through 2016. A minimum of 5 individual fish were aged per species per survey to be included in this table.

Species	Age	Aug-55	May-63	Jun-71	Aug-72	May-76	May-78	May-79	Sep-86	Jun-90	May-00	May-16
Bluegill	1										2.2	2.1
	2	3.9			3.4	2.6					3.0	2.5
	3	5.3	3.9		4.4	3.7			4.3		3.8	3.8
	4		4.9		5.2	4.4	5.4	5.7		4.6	5.0	4.7
	5		5.9	6.1	5.9	5.1	5.9	6.5	5.4	5.3	5.5	5.8
	6		6.1		6.2	6.2	6.8	6.8	6.3	6.3	6.6	6.3
	7						7.2		7.1	7.1	6.9	7.1
	8										7.5	
	9										7.9	
Species	Age	Aug-55	May-63	Jul-71	Aug-72	May-76	May-78	May-79	Sep-86	Jun-90	May-00	May-16
Largemouth Bass	1	5.2			5.4						3.6	
	2		5.8			4.8						7.3
	3		7.8	9.7					10.2	8.2		9.7
	4						12.1			8.9	10.9	11.1
	5						14.2	12.9	16.8		12.1	12.6
	6										13.4	14.0
	7										15.5	
	8										16.4	

Species	Age	Aug-55	May-63	Jun-71	Aug-72	May-76	May-78	May-79	Sep-86	Jun-90	May-00	May-16
Pumpkinseed	1										2.1	
	2	4.0									3.1	3.0
	3	5.0	4.0								3.9	3.9
	4		5.2					5.5	5.6	6.0	5.4	4.9
	5		5.7					7.0		6.3	6.1	6.1
	6		6.0							7.0	6.9	6.7
	7										7.6	6.5
	8										8.4	
Species	Age	Aug-55	May-63	Jun-71	Aug-72	May-76	May-78	May-79	Sep-86	Jun-90	May-00	May-16
Black Crappie	1								4.7			
	2								7.4	5.8	5.6	5.5
	3								9.1			7.0
	4						7.6	6.5	9.1	8.8		
	5						9.1			9.6	9.8	
	6						10.3					

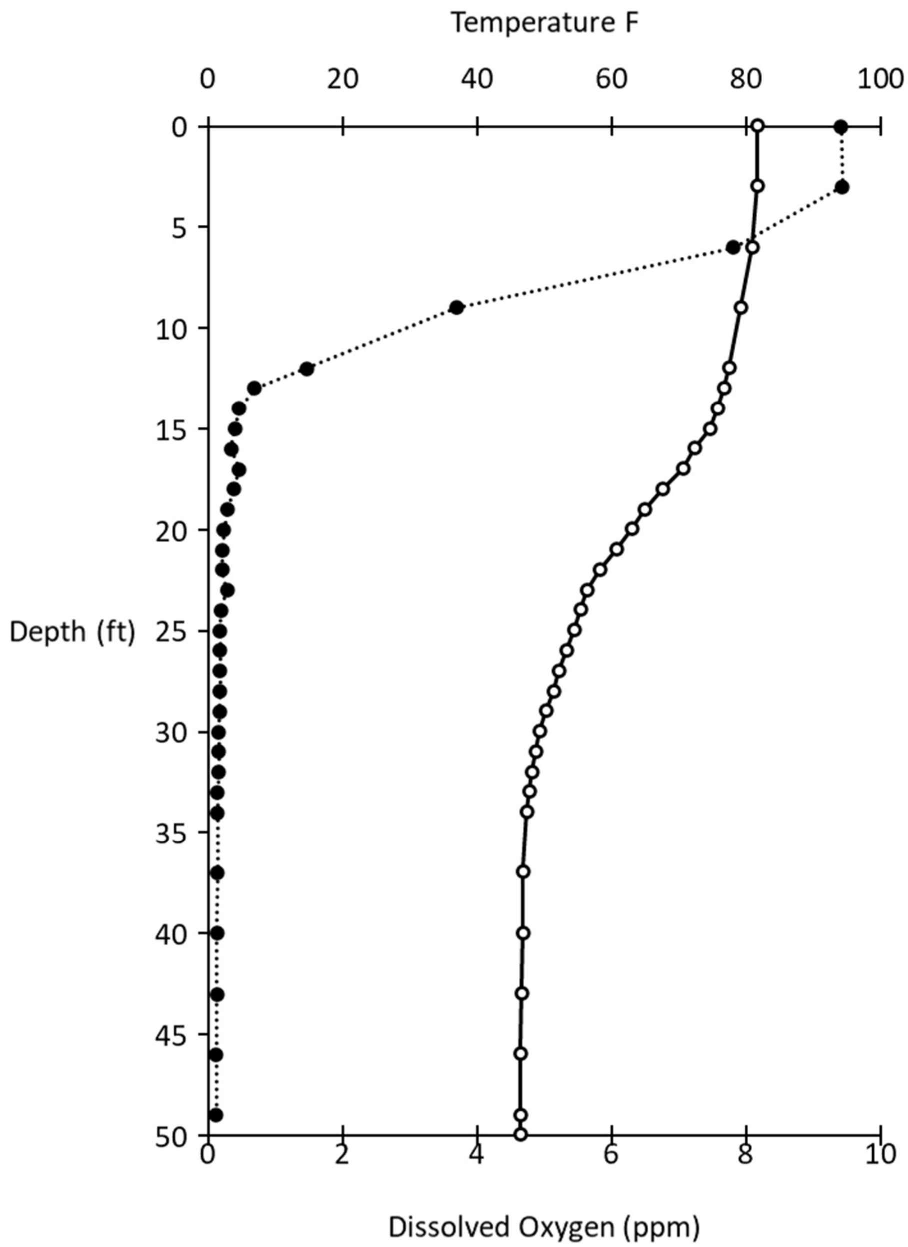

Figure 1. Temperature and dissolved oxygen profile of Long Lake recorded August 11, 2016. The solid line with open circles represents temperature. The dotted line with black circles represents dissolved oxygen.

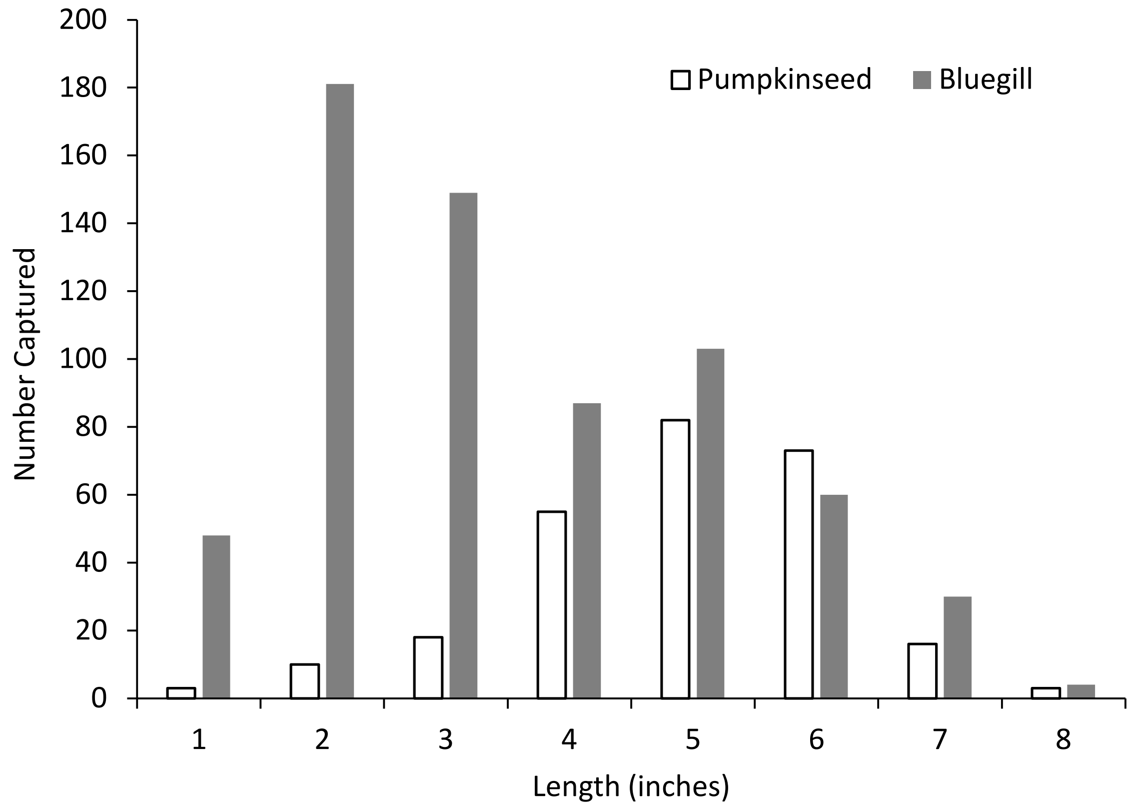

Figure 2. Length frequency histogram of Bluegill (gray bars) and Pumpkinseed (white bars) captured during the 2016 STP survey on Long Lake.

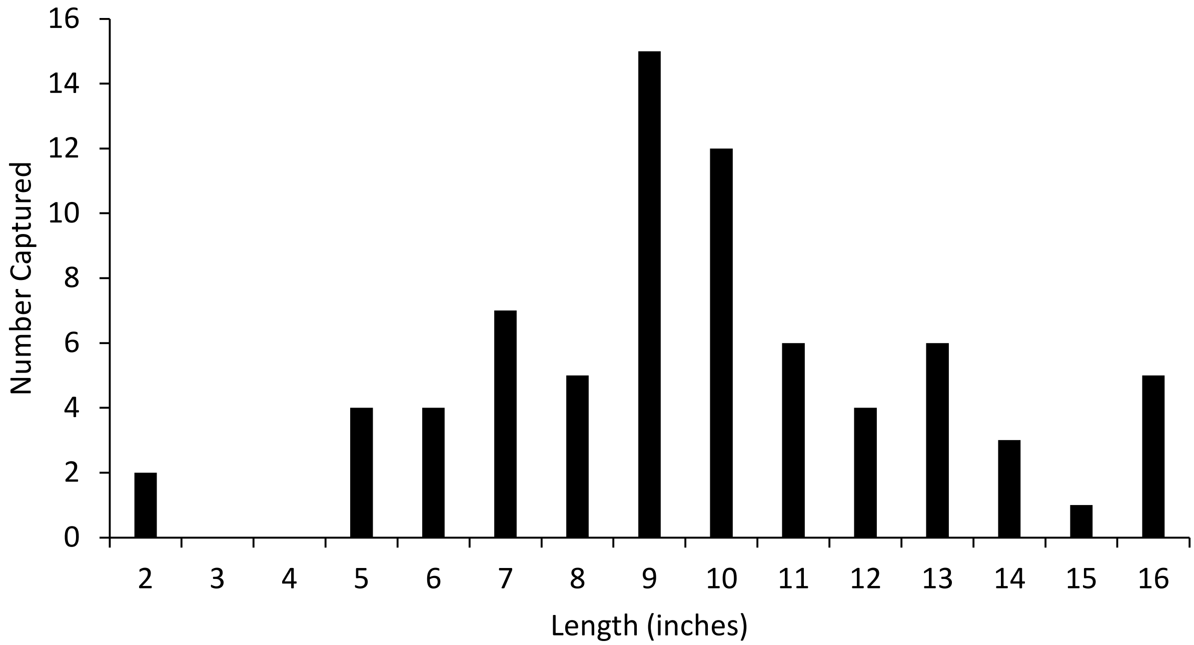

Figure 3. Length frequency histogram of Largemouth Bass captured during the 2016 STP survey on Long Lake.

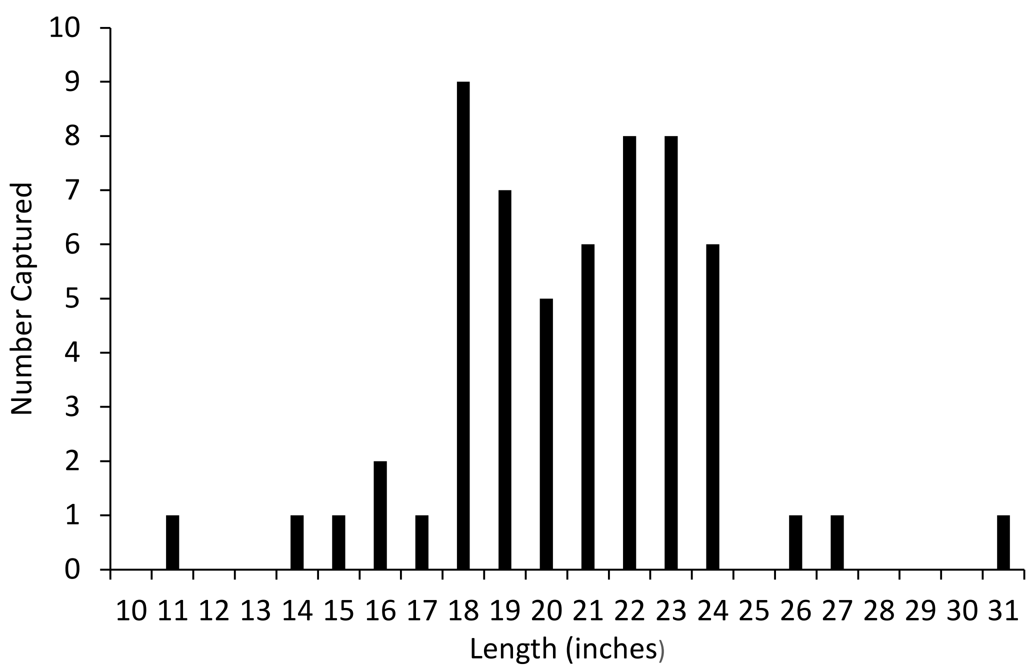

Figure 4. Length frequency histogram of Northern Pike captured during the 2016 STP survey on Long Lake.

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Brian Gunderman, Unit Review and Approval

Scott Heintzelman, External Reviewer

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Randall M. Claramunt, Desktop Publisher and Approval