

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Comprehensive Fishery Survey of Elkhart Lake, Sheboygan County, Wisconsin 2021

Waterbody Identification Code 59300



Ben Breaker
Fisheries Biologist - Plymouth
Wisconsin Department of Natural Resources
2022



Table of Contents

Executive Summary.....	3
Introduction.....	4
Methods	5
Results.....	8
Northern Pike	8
Walleye.....	8
Muskellunge.....	9
Largemouth Bass.....	10
Smallmouth Bass.....	10
Bluegill.....	11
Pumpkinseed.....	12
Black Crappie.....	12
Yellow Perch.....	12
Rock Bass.....	13
Other Species.....	13
Management Recommendations.....	14
Acknowledgements	15
References	15
Tables and Figures.....	16

Executive Summary

In 2022, the Wisconsin Department of Natural Resources (DNR) conducted a comprehensive fishery survey on Elkhart Lake in Sheboygan County, Wisconsin, using a variety of sampling methods throughout the open water period in an attempt to sample the major components of the fishery. The objectives of the survey were to 1) assess the status of the northern pike (*Esox lucius*), walleye (*Sander vitreus*), muskellunge (*Esox masquinongy*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*) and panfish populations, 2) attain population estimates for northern pike, walleye and muskellunge, and 3) update management recommendations for the fishery of Elkhart Lake. The results of the 2022 survey were compared to lakes with similar characteristics, the prior comprehensive fishery survey conducted in 2011 and a special muskellunge survey conducted on the lake in 2018.

Twenty-three northern pike were sampled during the 2022 spring netting I (SNI) fyke net survey for a catch rate of 0.26 fish/net night. The SNI catch rate for northern pike is below average when compared to lakes across the state with similar characteristics (complex, two-story). An additional eight northern pike were sampled during the 2022 spring netting II (SNII) fyke net survey for a catch rate of 0.14 fish/net night. The mean length of all fish collected was 22.2 inches, with a maximum length of 31.0 inches. Too few northern pike were sampled in 2022 to estimate the population density in Elkhart Lake.

Four hundred twenty-one walleye (including 83 recaptured fish) were sampled during SNI for a catch rate of 4.78 fish/net night. This fyke netting catch rate for walleye is slightly below average when compared to lakes across the state with similar characteristics (complex two-story). The average length of walleye sampled during SNI was 20.7 inches, with a maximum length of 28.5 inches. The Bailey modification of the Petersen Method adult population estimate for walleye in Elkhart Lake was 1,140 (95% CI [778-1,844]), equaling 3.90/acre. This is a substantial increase from the 2011 survey when the adult population estimate for walleye in Elkhart Lake was 348 (95% CI [244-628]), equaling 1.19 fish/acre. The growth rate of walleye in Elkhart Lake is above the statewide and South District average, with female walleye reaching legal harvestable size (18 inches) on average by age-3 and males by age-5.

Five muskellunge (including one recaptured fish) were sampled during SNII for a catch rate of 0.09 fish/net night. Fish ranged in length from a 37.0-inch fish of unknown sex to a 46.0-inch female. Too few muskellunge were sampled in 2022 to warrant a recapture netting event in 2023 to facilitate a population estimate.

Management recommendations include:

1. Continue biennial stocking of large fingerling walleye and continue to evaluate natural reproduction to determine future stocking needs.

2. Continue to evaluate the effectiveness of the county-wide 18-inch minimum length, three fish daily bag limit walleye regulation implemented in 2018 at the time of the next survey.
3. Discontinue biennial stocking of Great Lakes spotted muskellunge due to inadequate returns of adult fish to support broodstock collection.
4. Discontinue Elkhart Lake as a designated muskellunge broodstock lake and change the current muskellunge special regulation of 50-inch minimum length limit to the previous 40-inch minimum length limit regulation.
5. Further assess black crappie and yellow perch populations if new sampling protocols are developed.

Introduction

Elkhart Lake is a 292-acre spring lake with a maximum depth of 119 feet, making it the fourth deepest natural lake in the state. The bottom substrate consists of 42% sand, 43% gravel and 15% muck. The lake is comprised of two major basins, separated by a large central submerged island (Figure 1). The single outlet, located in the northwest corner of the lake, is controlled by a fixed crested weir and flows into the nearby Sheboygan Marsh. The mean summer Trophic State Index (TSI) for Elkhart Lake over the last five years was 43, indicating a mesotrophic status. For a two-story lake, this is considered a “good” rating. Invasive species, including curly-leaf pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*), ornamental water lilies (non-native *Nymphaea* sp.), yellow iris (*Iris pseudacorus*) and zebra mussels (*Dreissena polymorpha*), have been identified in Elkhart Lake.

Much of the shoreline of Elkhart Lake is developed with year-round and summer homes, including one resort. There are a few pockets of undeveloped natural shoreline between homes and in secluded bays, but most of the shoreline has been altered. Public access, provided by Sheboygan County, is available via a boat launch on the northwest side of the lake off County Highway P and offers parking for 20 vehicles and restroom facilities. A public fishing pier is also available at the boat launch. Due to the proximity to the cities of Elkhart Lake, Plymouth and Sheboygan, angling pressure on Elkhart Lake can be high. Recreational watercraft use is also very high on Elkhart Lake, which may contribute to shoreline erosion and the loss of near-shore habitat.

Elkhart Lake supports populations of muskellunge, northern pike, walleye, largemouth bass, smallmouth bass and a variety of panfish species. Cisco (*Coregonus artedii*) are also an important component of the fishery and provide a forage base for predators such as northern pike, muskellunge and walleye. A recent statewide project investigating the status and distribution of cisco in inland Wisconsin lakes observed a catch rate of 137 cisco/night gillnet in Elkhart Lake, the highest of any lake sampled

during this survey (K.M. Renik et al. 2020). However, previous gill netting surveys of Elkhart Lake suggest cisco abundance may be highly variable.

Muskellunge were first introduced to Elkhart Lake in 1987 in a collaborative effort between the Between the Lakes Chapter of Muskies Inc. and DNR (Table 1). At the time, the nearest muskellunge fishery was over 50 miles away, and Elkhart Lake was identified as a good candidate to support muskellunge. These fish were purchased from a private source and referred to as “true musky” to distinguish them from tiger muskellunge (*Esox lucius* × *masquinongy*; northern pike x muskellunge hybrids). These initial stocking efforts were successful and established a muskellunge fishery in Elkhart Lake. Private muskellunge stockings have since been discontinued. Yearling Great Lakes spotted strain muskellunge have been stocked in Elkhart Lake biennially since 2010 in an attempt to establish a broodstock population from which to collect gametes for DNR hatchery production (Table 1). To date, no egg collections have occurred due to the low catch of mature adult fish.

Large fingerling walleye have been stocked in Elkhart Lake biennially since 2014 as part of the Wisconsin Walleye Initiative (WWI; Table 1). Prior to 2014, primarily small fingerling walleye were stocked. Fall electrofishing (FE) surveys to assess the degree of walleye natural reproduction have been conducted in 2010, 2011 and 2018-2022.

Historically, brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were also stocked in Elkhart Lake (Table 1). Records suggest that these efforts were discontinued because these species were not native to Elkhart Lake and would compete with native species, including panfish and cisco, for zooplankton (Nelson 1992). These concerns were especially prudent, given that zebra mussels, a prolific non-native planktivorous mussel, were first identified in Elkhart Lake in 1994 (Surface Water Integrated Monitor System Database).

The first recorded fisheries survey of Elkhart Lake was conducted in 1947. The most recent prior comprehensive fishery survey, including spring netting I (SNI), spring netting II (SNII), spring electrofishing 1 (SEI), spring electrofishing II (SEII) and fall electrofishing (FE), was conducted in 2011. Additionally, a special spring netting survey targeting muskellunge was conducted in 2018. The results of the 2022 survey were compared to each of these previous surveys. High public use of Elkhart Lake by anglers justifies regular fisheries surveys to evaluate management opportunities and maximize the potential of the fishery.

Methods

Eight white nylon 0.75-inch bar mesh fyke nets were set on April 16 to target spawning northern pike, walleye and muskellunge (SNI; Figure 2). Nets were checked daily from April 17 to April 27 for a total effort of 88 net nights. Nets were left open from April 27 to May 9 when SNII sampling began. SNII concluded on May 16 for a total effort of 56

net nights. Water temperature on the first day of SNI was 38 degrees Fahrenheit, and at the conclusion of SNI, the water temperature was 43 degrees Fahrenheit. Water temperature on the first day of SNII was 51 degrees Fahrenheit, and at the conclusion of SNII, the water temperature was 61 degrees Fahrenheit.

All gamefish and panfish netted were measured to the nearest 0.1 inches. Northern pike, muskellunge and walleye were also weighed to the nearest 0.1 pounds. Northern pike, muskellunge and walleye were given differential fin clips to identify recaptures and facilitate the calculation of population estimates. Females were marked with a right ventral fin clip; males received a left ventral fin clip; unknown sex fish received a top caudal fin clip. Additionally, all largemouth bass and smallmouth bass were marked with a top caudal fin clip to eliminate duplicate counts. All northern pike, muskellunge and walleye netted were observed for fin clips from previous surveys. Muskellunge were also scanned for the presence of a Passive Integrated Transponder (PIT) tag. Each PIT tag contains a unique identification number that allows tracking of an individual fish through time. If a muskellunge did not carry a previous PIT tag, a new tag was implanted in the dorsal musculature and recorded. Additionally, age structures were removed from northern pike, muskellunge and walleye according to standard sampling protocols. These protocols include removing an anal fin ray from northern pike and muskellunge, a dorsal spine from walleye greater than 12 inches in length and a scale sample from walleye less than 12 inches in length. Aging structures were collected until five structures were collected for each species and each sex for every half-inch increment. A subsample of bluegill, pumpkinseed, black crappie, rock bass and yellow perch were measured to the nearest 0.1 inches and vouchered for collection of aging structures (otoliths).

Spring electrofishing (SEI) using a DNR standard pulsed direct current (PDC) boom shocker boat was conducted at night on April 28. SEI sampling encompassed the entire shoreline (~3.7 miles) and included 2.05 hours of sampling effort. Sampling began at 2016 hours and concluded at 2231 hours, with a pause from 2140 hours to 2152 hours to process fish. Pulsed direct current was used at 120 volts, 9 amps, at a pulse rate of 80 per second and 25 percent duty cycle. The water temperature was 44 degrees Fahrenheit. SEI sampling utilized two dippers, two probes with a total of 16 droppers and a dip net bar mesh of 0.375 inches.

The objective of SEI was to count and measure adult walleye and northern pike and observe and record marks for adult northern pike and walleye marked with fin clips during SNI to facilitate the calculation of population estimates for both species. All walleye and northern pike sampled were measured to the nearest 0.1 inches and weighed to the nearest 0.1 pounds. Aging structures were collected until five structures were collected for each species and each sex for every half-inch increment.

Spring electrofishing (SEII) using a DNR standard PDC boom shocker boat was conducted at night on May 23, targeting largemouth bass, smallmouth bass and

panfish species. SEII sampling encompassed the entire shoreline (3.5 miles) and included 1.83 hours of total sampling effort. The water temperature was 62 degrees Fahrenheit.

The first SEII sampling station, targeting all fish species, began at 2143 hours, concluded at 2155 hours (12 minutes of effort) and covered 0.5 miles of shoreline. Pulsed direct current was used at 125 volts and 11.5 amps at a pulse rate of 80 per second on a 25 percent duty cycle. The second sampling station, targeting only gamefish (largemouth bass and smallmouth bass), began at 2204 hours, concluded at 2229 hours (25 minutes of effort) and covered 1 mile of shoreline. The third sampling station, targeting all fish species, began at 2129 hours, concluded at 2152 hours (23 minutes of effort) and covered 0.5 miles of shoreline. The fourth sampling station, targeting gamefish, began at 2206 hours, concluded at 2240 hours (34 minutes of effort) and covered 1.0 mile of shoreline. The fifth sampling station, targeting all fish species, began at 2248 hours, concluded at 2304 hours (16 minutes of effort) and covered 0.5 miles of shoreline. At stations targeting all species, all fish were collected, and gamefish and panfish were measured to the nearest 0.1 inches. Other fish were identified to species and counted. At stations targeting only gamefish, all gamefish were measured to the nearest 0.1 inches. All gamefish were examined for the presence of fin clip marks from previous surveys. All SEII stations employed two dippers, two probes with a total of 16 droppers and a dip net bar mesh of 0.375 inches.

Fall electrofishing (FE) using a DNR standard PDC boom shocker boat was conducted at night on Sept. 28 to assess the abundance and recruitment of young of the year and yearling walleye and muskellunge. The FE survey encompassed the entire shoreline (3.5 miles) and included 1.90 hours of sampling effort. The water temperature was 62 degrees Fahrenheit. Sampling began at 1925 hours and concluded at 2119 hours. Pulsed direct current was used at 150 volts, 16 amps with a pulse rate of 80 per second and 25 percent duty cycle. FE sampling employed two dippers, two probes with a total of 16 droppers and a dip net bar mesh of 0.375 inches. During FE sampling, only walleye and muskellunge were collected and were measured to the nearest 0.1 inches.

Fyke net total catch and catch-per-unit effort (CPUE, number/net night) were calculated to estimate relative abundance; electrofishing total catch and CPUE (number/mile) were also calculated. Length frequency histograms were constructed for northern pike, walleye, muskellunge, largemouth bass, smallmouth bass, bluegill, pumpkinseed, black crappie, yellow perch and rock bass to assess size structure.

Relative weight, the ratio of a fish's weight to the weight of a standard fish of the same length, was used to assess the body condition of walleye and muskellunge using standard length-at-weight equations (Willis 1998). Relative weight values between 75 and 100 indicate normal weight for a given length. A relative weight value

greater than 100 indicates that a fish is in excellent condition. A relative weight value of less than 75 indicates that a fish is in poor condition.

Proportional size distribution (PSD), the ratio of the number of “stock” sized fish to the number of “quality” fish, was calculated for walleye, muskellunge, largemouth bass, smallmouth bass and bluegill. In some cases, PSDs were also calculated for other length categories as the ratio of stock fish to “preferred” (PSD-P), “memorable” (PSD-M) or “trophy” (PSD-T) fish. Stock, quality, preferred, memorable and trophy lengths were based on standardized lengths for each species (Neuman et al. 2012).

Age and growth data were obtained from structures taken from northern pike (anal fin rays), walleye (dorsal spines), muskellunge (anal fin ray) and bluegills (otoliths) collected throughout the comprehensive fishery survey. Structures were mounted in epoxy and sectioned using a Buehler Isomet low-speed sectioning saw. Sectioned wafers were viewed and imaged using an Olympus SZX7 Microscope. Growth data from Elkhart Lake was compared to statewide and regional mean growth rates utilized in the DNR Fisheries Information System (FMIS) database.

Results

NORTHERN PIKE

Twenty-three northern pike were sampled during 2022 SNI for a catch rate of 0.26 fish/net night. This catch rate is below average (1.12 fish/net night) when compared to lakes across the state with similar characteristics (complex, two-story). An additional eight northern pike were sampled during 2022 SNII for a catch rate of 0.14/net night. The mean length of all fish collected was 22.2 inches, with a maximum length of 31.0 inches (Figure 3). Male northern pike ranged in length from 16.2 to 27.0 inches, with a mean length of 20.8 inches. Female northern pike ranged in length from 17.0 to 31.0 inches, with a mean length of 23.8 inches.

One hundred twenty-one northern pike (including 25 recaptured fish) were sampled during the 2011 SNI for a catch rate of 0.72 fish/net night. An additional two northern pike were sampled during the 2011 SNII for a catch rate of 0.06 fish/net night. The mean length of all fish collected was 23.6 inches, with a maximum length of 34.2 inches. Male northern pike ranged in length from 17.1 to 29.0 inches, with a mean length of 22.7 inches. Female northern pike ranged in length from 16.9 to 34.2 inches, with a mean length of 26.8 inches.

Northern pike in Elkhart Lake grow faster than the statewide average, though sample size was low for age-5 (n=2) and age-6 (n=2) fish (Figure 4). Too few northern pike were sampled in 2022 to estimate the population density in Elkhart Lake.

WALLEYE

Four hundred twenty-four walleye (including 83 recaptured fish) were sampled during the 2022 SNI for a catch rate of 4.82 fish/net night. This catch rate is slightly below average (6.59 fish/net night) when compared to lakes across the state with similar characteristics. The average length of walleye sampled during the 2022 SNI was 20.7 inches, with a maximum length of 28.5 inches (Figure 5). Male walleye ranged in length from 13.4 to 26.5 inches, with a mean length of 18.9 inches. Female walleye ranged in length from 17.3 to 28.5 inches, with a mean length of 22.9 inches.

Two hundred seventy-five walleye (including 76 recaptured fish) were sampled during the 2011 SNI for a catch rate of 1.63 fish/net night. The average length of walleye sampled during the 2011 SNI was 24.3 inches, with a maximum length of 29.8 inches. Male walleye ranged in length from 18.9 to 23.6 inches, with a mean length of 20.5 inches. Female walleye ranged in length from 19.5 to 29.8 inches, with a mean length of 25.2 inches.

The Bailey modification of the Petersen Method adult population estimate for walleye in Elkhart Lake was 1,140 (95% CI [778-1,844]), equaling 3.90/acre. This is a substantial increase from the 2011 survey when the adult walleye population estimate was 348 (95% CI [244-628]), equaling 1.19/acre. Gender-specific proportional stock density (PSD) was calculated for walleye sampled during the 2022 SNI and SEI (Table 2). PSD was 98 for males and 100 for females (Table 2). Male PSD-P was 29, compared to 92 for females. During the 2011 SNI and SEI, PSD was 100 for males and 100 for females. Male PSD-P was 63, compared to 99 for females. The majority of walleye sampled in 2022 were of legal harvestable size, with 71% of males and 99% of females above the current 18-inch minimum length limit (Table 2).

Walleye body condition during the 2022 SNI was very good, as suggested by relative weight values ranging from 74 to 169, with a mean of 105 (n=164). Relative weight for females was very good and ranged from 74 to 169, with a mean of 110 (n=95). Male relative weight was good and ranged from 76 to 121, with a mean of 98 (n=69). Relative weight for male walleye was generally lower than females, given the females' spawning condition and presence of eggs at the time of capture.

Walleye in Elkhart Lake grow faster than the statewide and South District averages, with most fish reaching the current 18-inch minimum length limit by age-4 (Figure 6). On average, female walleye reach legal harvestable size (18-inches) by age-3 and males by age-5. High growth rate and body condition values suggest walleye in Elkhart Lake have ample forage.

MUSKELLUNGE

In the 2022 SNI and SNII, five muskellunge (including one recaptured fish) were sampled for a catch rate of 0.03 fish/net night. The average length of muskellunge sampled in 2022 was 40.8 inches, with a maximum length of 46.0 inches (Figure 7). In

2022, none of the muskellunge were identified as Great Lakes spotted strain fish. In the 2018 special muskellunge survey, 17 muskellunge (including one recaptured fish) were sampled for a catch rate of 0.29 fish/net night. Of the 16 individual muskellunge sampled in 2018, only three were confirmed to be Great Lakes spotted strain fish. The netting catch rates of muskellunge in 2022 and 2018 were below average when compared to similar lakes statewide.

Muskellunge body condition was good for fish collected in the 2018 special muskellunge survey and the 2022 SNII, as suggested by relative weight values that ranged from 58 to 130 with a mean of 84 (n=19). Relative weight for females ranged from 73 to 130, with a mean of 93 (n=8). Relative weight for males was slightly lower and ranged from 58 to 96, with a mean of 78 (n=8), indicating sub-optimal body condition of male muskellunge.

LARGEMOUTH BASS

During the 2022 comprehensive fishery survey, 88 largemouth bass were sampled, with the majority (n=35) sampled in SEII for a catch rate of 10.0 fish/mile. This catch rate is above average when compared to lakes with similar characteristics across the state. However, this is a slight decrease from the 2011 SEII, when largemouth bass relative abundance was 16 fish/mile. All largemouth bass sampled in the 2022 SNI and SNII were individually marked with a top caudal fin clip to ensure fish were not counted twice. The average length of largemouth bass sampled during the 2022 SEII was 10.8 inches, with a maximum length of 16.4 inches (Figure 8).

In the 2022 SEII, largemouth bass PSD (greater than or equal to 12 inches) was 53 and PSD-P (greater than or equal to 15 inches) was 11. Similarly, in the 2011 SEII, largemouth bass PSD was 68 and PSD-P was 9. A balanced largemouth bass population typically displays PSD values between 40-60.

The current 14-inch minimum length limit, five fish daily bag limit regulation for largemouth bass in Elkhart Lake has been in place since 1989. Few fish greater than 16 inches were sampled during the 2011 and 2022 SEII surveys, though it's unclear if this is due to slow growth or angler harvest. A largemouth bass population and age and growth estimates were not conducted as part of the 2022 comprehensive fishery survey. However, a population estimate, as well as age and growth estimates, should be conducted during the next comprehensive fishery survey and compared to statewide and regional averages. A catch curve should be conducted to estimate total annual mortality. This information will be valuable to determine if an increased minimum length limit could increase largemouth bass size structure.

SMALLMOUTH BASS

During the 2022 comprehensive fishery survey, 104 smallmouth bass were captured, with the majority (n=74) sampled in SEII for a catch rate of 21.1 fish/mile. This catch

rate is above average when compared to lakes with similar characteristics across the state. The average length of smallmouth bass sampled during SEII was 12.9 inches, with a maximum length of 20.0 inches (Figure 9). Multiple year classes of smallmouth bass appear to be present, with peaks in the 10-inch, 13-inch and 17-inch length bins.

Smallmouth bass PSD calculated from 2022 SEII data for quality-size fish 11 inches and greater was 65 (n=72). The PSD-P value was 41 (n=30) for preferred-size fish greater than or equal to 14 inches. Memorable (equal to or greater than 17 inches) and trophy (equal to or greater than 20 inches) length smallmouth were also collected in SEII for a PSD-M of 12 (n=9) and PSD-T of 1 (n=1), respectively. Smallmouth bass PSD, PSD-P, PSD-M and PSD-T calculated from 2011 SEII data were 73 (n=22), 46 (n=14), 0.03 (n=1) and 0 (n=0), respectively.

BLUEGILL

A total of 270 bluegills were sampled in SNI for a catch rate of 3.06/net night. However, fish were not individually identified with a mark; therefore, individual bluegill may have been netted multiple times. Bluegills ranged in size from 1.5 to 7.5 inches, with a mean length of 4.5 inches (Figure 10). A total of 52 bluegills were sampled in SEII for a catch rate of 20.8 fish/mile. This catch rate is below average (51 fish/mile) compared to lakes across the state with similar characteristics. Bluegills captured in the 2022 SEII ranged in size from 2.5 to 6.7 inches, with a mean length of 4.7 inches (Figure 11).

A total of 91 bluegills were sampled in 2011 SEII for a catch rate of 91 fish/mile. Bluegills captured in 2011 SEII ranged in length from 2.9 to 6.5 inches, with a mean length of 4.9 inches.

The PSD value calculated from 2022 SEII data for quality-size fish 6 inches and greater was 13 (n=7); PSD-P was 0 as no fish collected were greater than the preferred size of 8 inches. These values are very similar to the 2011 SEII when bluegill PSD was 14 and PSD-P was 0. This indicates that both quality-size and preferred-size bluegills are lacking in Elkhart Lake. PSD values between 40-60 generally describe a balanced population. A PSD-P value of 5 is generally considered a minimum benchmark.

The bluegill growth rate in Elkhart Lake was below the statewide mean growth rate for fish age-3 through age-6 (Figure 12). Below average growth may be attributed to the lake's overall productivity (mesotrophic) and interspecific competition with other fish species and invasive zebra mussels. A low bluegill size structure, as indicated by a mean length of 4.7 inches in SEII, provides a mediocre fishing opportunity in Elkhart Lake. Angler exploitation may be structuring the population via harvest of individuals greater than 6 inches in length. However, given below average growth rates, a reduction in panfish bag limits may not be an effective option to increase size structure. Growth rate comparisons cannot be made between survey years, given bluegill aging structures were not collected in the 2011 comprehensive fishery survey.

PUMPKINSEED

One hundred forty-nine pumpkinseeds were sampled in the 2022 SNI for a catch rate of 1.69/net night. Fish were not individually identified with a mark; therefore, individual pumpkinseeds may have been netted multiple times. The mean length was 4.9 inches and ranged from 3.2 to 7.4 inches (Figure 13). A total of 13 pumpkinseeds were sampled in the 2022 SEII for a catch rate of 5.2/mile. This catch rate is slightly above average (4.0 fish/mile) when compared to lakes of similar characteristics. The mean length of pumpkinseeds collected in the 2022 SEII was 5.3 inches and ranged from 3.8 to 7.4 inches (Figure 14).

Nineteen pumpkinseeds were sampled in the 2011 SNI for a catch rate of 0.11 fish/net night. Fish were not individually identified with a mark; therefore, individual pumpkinseeds may have been netted multiple times. The mean length was 5.1 inches and ranged from 3.8 to 7.1 inches. A total of 15 pumpkinseeds were sampled in 2011 SEII for a catch rate of 15 fish/mile. The mean length of pumpkinseeds collected in 2011 SEII was 5.8 inches and ranged from 4.6 to 7.2 inches.

BLACK CRAPPIE

During the 2022 comprehensive fisheries survey, 50 black crappies were captured, with the majority (n=28) sampled in SNI for a catch rate of 0.31 fish/net night. A total of 22 black crappies were sampled in the 2022 SNII for a catch rate of 0.25/net night. Fish were not individually identified with a mark; therefore, individual black crappies may have been netted multiple times. The mean length of black crappies sampled in the 2022 SNI and 2022 SNII was 7.9 inches and ranged from 3.1 to 14.7 inches (Figure 15). Black crappie recruitment in Elkhart Lake appears to be sporadic, with relatively strong year-classes suggested by peaks in the 4-inch and 8-inch length bins.

Sixteen black crappies were sampled in the 2011 SNI for a catch rate of 0.09 fish/net night. One black crappie was sampled during the 2011 SEII for a catch rate of 1.0 fish/mile. The mean length of black crappies sampled in the 2011 SNI was 7.3 inches and ranged from 5.0 to 10.6 inches.

YELLOW PERCH

Sixteen yellow perch were sampled during the 2022 SNI for a catch rate of 0.18 fish/net night. This catch rate is below average (4.8 fish/net night) when compared to lakes with similar characteristics across the state. Fish were not individually identified with a fin clip mark; therefore, individual yellow perch may have been netted multiple times. The mean length was 7.1 inches and ranged from 5.6 inches to 9.9 inches (Figure 16). Fourteen yellow perch were sampled during the 2022 SEII for a catch rate of 9.3 fish/mile. The mean length was 5.7 inches and ranged from 4.1 inches to 8.0 inches (Figure 17).

One-hundred sixteen yellow perch were sampled during the 2011 SNI for a catch rate of 0.69 fish/net night. The mean length was 6.1 inches and ranged from 4.1 to 9.2 inches. Thirty-four yellow perch were sampled during the 2011 SEII for a catch rate of 34.0 fish/mile. The mean length was 5.5 inches and ranged from 3.7 to 9.1 inches.

ROCK BASS

Three hundred thirty-three rock bass were sampled in the 2022 SNII for a catch rate of 5.2 fish/net night. Fish were not individually identified with a fin clip mark; therefore, individual rock bass may have been netted multiple times. The mean length of fish collected in SNII was 6.7 inches and ranged from 4.0 inches to 11.2 inches (Figure 18).

Ninety-two rock bass were sampled in the 2011 SNII for a catch rate of 0.53 fish/net night. The mean length of fish collected in the SNII was 6.6 inches and ranged from 2.6 to 10.3 inches. Although not typically targeted by anglers, rock bass provide an additional panfish species for anglers to harvest.

OTHER SPECIES

In the 2022 comprehensive fishery survey, other species were observed in low abundance that do not warrant analysis but are reported here for consideration. These species included green sunfish (*Lepomis cyanellus*), yellow bullhead (*Ameiurus natalis*) and mudpuppies (*Necturus maculosus*).

Management Recommendations

The northern pike population of Elkhart Lake was not fully assessed in 2022 due to low catch. The low SNI northern pike rate suggests a low-density population is present. Northern pike abundance in Elkhart Lake may currently be limited by poor recruitment due to the lack of suitable spawning habitat.

The walleye population in Elkhart Lake currently provides an excellent fishery, with 82% of adult fish of legal harvestable size (18 inches). Large fingerling stocking appears to be effective at establishing year classes and should be continued. The switch from biennial small fingerling to biennial large fingerling walleye stocking in 2014 may be the reason for the substantial increase in adult walleye abundance since 2011. Although walleye abundance has increased, growth remains above the statewide average, suggesting an ample forage base.

Elkhart Lake is currently managed as a trophy muskellunge fishery with a 50-inch minimum length limit, one fish daily bag limit. This regulation also protects nearly all adult fish from harvest, aiding the potential establishment of the Great Lakes spotted strain broodstock program. However, muskellunge catch rates, including the Great Lake spotted strain, are low. An insufficient number of muskellunge were captured in the 2022 SNI and SNII to warrant a recapture netting event in 2023, which would be necessary to calculate a population estimate. However, since all Great Lakes spotted strain yearling muskellunge receive a PIT tag prior to stocking, PIT tag saturation in the population is assumed to be high. Collaboration with the local chapter of Muskies Inc. by supplying them with PIT tag readers could be one way to collect additional information on the growth and abundance of tagged fish.

Due to the inadequate return of adult fish to support broodstock collection, the biennial stocking of yearling muskellunge and the designation of Elkhart Lake as a broodstock lake should be discontinued. As such, the current muskellunge special regulation of 50-inch minimum length limit should revert to the previous 40-inch minimum length limit regulation.

Elkhart Lake is currently being used as a reference lake in a statewide assessment of experimental panfish regulations. Given the low abundance, size structure and growth of bluegill, the implementation of more restrictive panfish regulations should be reassessed at the conclusion of this statewide study.

Management recommendations include:

1. Continue biennial stocking of large fingerling walleye and continue to evaluate natural reproduction to determine future stocking needs.
2. Continue to evaluate the effectiveness of the county-wide 18-inch minimum length, three fish daily bag limit walleye regulation implemented in 2018 at the time of the next survey.

3. Discontinue the biennial stocking of Great Lakes spotted muskellunge due to inadequate returns of adult fish to support broodstock collection.
4. Discontinue Elkhart Lake as a designated muskellunge broodstock lake and change the current muskellunge special regulation of 50-inch minimum length limit to the previous 40-inch minimum length limit regulation.
5. Further assess black crappie and yellow perch populations if new sampling protocols are developed.

Acknowledgments

The field work, data collection, data entry and structure aging required for this report was conducted by DNR Fisheries Technicians Tanya Meives and Christine Larson. Report reviews and editing was provided by DNR Fisheries Management staff, including Tanya Meives, Laura Stremick and Tim Simonson.

References

K.M. Renik, M.J. Jennings, J.M. Campa, J. Lyons, T.P. Parks, G.G. Sass. 2020. Status and distribution of Cisco (*Coregonus artedii*) and Lake Whitefish (*Coregonus clupeaformis*) in inland lakes of Wisconsin. *Northeastern Naturalist* 27(3):469–484.

J.E. Nelson. 1992. 1991 Fishery Survey of Elkhart Lake Sheboygan County, Wisconsin. Wisconsin Department of Natural Resources. Unpublished Report.

Neumann, R.M., C.S. Guy and D.W. Willis. 2012. Length, weight and associated indices. Pages 637-676 in A.V. Zale, D.L. Parrish and T.M. Surron, editors. *Fisheries techniques*, 3rd edition. American Fisheries Society, Bethesda, MD.

Willis, D.W. 1989. Proposed standard length-weight equation for Northern Pike. *North American Journal of Fisheries Management* 9:203-208.

Tables

Table 1. Fish stocked in Big Elkhart Lake since 1976 including year stocked, species, age class, number of fish stocked and strain.

Year	Species	Age Class	Number of Fish Stocked	Strain
2020	Muskellunge	Yearling	286	Great Lakes Spotted
2020	Walleye	Large Fingerling	1459	Lake Michigan
2019	Muskellunge	Yearling	286	Great Lakes Spotted
2018	Walleye	Large Fingerling	1428	Mississippi Headwaters
2017	Muskellunge	Yearling	449	Great Lakes Spotted
2017	Walleye	Large Fingerling	1533	Lake Michigan
2016	Walleye	Large Fingerling	1902	Upper Mississippi River
2016	Muskellunge	Fall Yearling	300	Great Lakes Spotted
2015	Muskellunge	Fall Yearling	875	Great Lakes Spotted
2014	Walleye	Large Fingerling	1456	Lake Michigan
2013	Muskellunge	Fall Yearling	198	Great Lakes Spotted
2012	Walleye	Small Fingerling	7710	Rock-Fox
2010	Walleye	Small Fingerling	10010	Rock-Fox
2010	Muskellunge	Yearling	53	Great Lakes Spotted
2009	Muskellunge	Yearling	300	Great Lakes Spotted
2008	Walleye	Small Fingerling	10016	Mississippi Headwaters
2006	Walleye	Small Fingerling	10010	Mississippi Headwaters
2004	Walleye	Small Fingerling	28600	Lake Michigan
2003	Muskellunge	Fingerling	300	Unspecified
2002	Walleye	Small Fingerling	25410	Mississippi Headwaters
2000	Walleye	Small Fingerling	28600	Unspecified
1998	Walleye	Small Fingerling	27339	Unspecified
1996	Walleye	Fingerling	16300	Unspecified
1995	Walleye	Fingerling	7000	Unspecified
1994	Walleye	Fingerling	9465	Unspecified
1993	Walleye	Fingerling	6700	Unspecified
1993	Rainbow trout	Yearling	6000	Unspecified
1992	Walleye	Fingerling	14300	Unspecified
1992	Rainbow trout	Yearling	3030	Unspecified
1991	Muskellunge	Fingerling	600	Unspecified
1991	Rainbow trout	Yearling	2000	Unspecified
1991	Walleye	Fingerling	7150	Unspecified
1990	Muskellunge	Fingerling	600	Unspecified
1990	Rainbow trout	Yearling	2000	Unspecified
1989	Brown trout	Yearling	1500	Unspecified
1989	Brook trout	Yearling	1500	Unspecified
1989	Walleye	Fry	50000	Unspecified
1989	Walleye	Fingerling	3320	Unspecified
1988	Muskellunge	Fingerling	800	Unspecified

1988	Brown trout	Yearling	500	Unspecified
1988	Brook trout	Yearling	500	Unspecified
1988	Rainbow trout	Yearling	2000	Unspecified
1987	Muskellunge	Fingerling	600	Unspecified
1987	Rainbow trout	Yearling	10500	Unspecified
1987	Walleye	Fingerling	42450	Unspecified
1986	Brook trout	Yearling	1500	Unspecified
1986	Walleye	Fingerling	14300	Unspecified
1986	Brown trout	Yearling	1500	Unspecified
1985	Brook trout	Yearling	2004	Unspecified
1985	Brown trout	Yearling	2158	Unspecified
1985	Rainbow trout	Adult	74	Unspecified
1985	Walleye	Fingerling	22785	Unspecified
1984	Walleye	Fingerling	15000	Unspecified
1984	Brown trout	Yearling	1580	Unspecified
1984	Brook trout	Yearling	1548	Unspecified
1983	Walleye	Fry	500000	Unspecified
1983	Brook trout	Yearling	1500	Unspecified
1983	Brown trout	Yearling	1500	Unspecified
1982	Brook trout	Yearling	1500	Unspecified
1982	Walleye	Fingerling	13328	Unspecified
1982	Brown trout	Yearling	1500	Unspecified
1981	Brook trout	Yearling	1500	Unspecified
1981	Walleye	Fingerling	26010	Unspecified
1981	Brown trout	Yearling	1500	Unspecified
1980	Rainbow trout	Yearling	1000	Unspecified
1980	Walleye	Fingerling	17520	Unspecified
1980	Brown trout	Yearling	1000	Unspecified
1980	Brook trout	Yearling	1000	Unspecified
1979	Rainbow trout	Yearling	1000	Unspecified
1979	Brown trout	Yearling	1000	Unspecified
1979	Brook trout	Yearling	1000	Unspecified
1979	Walleye	Fingerling	1500	Unspecified
1978	Brown trout	Yearling	1000	Unspecified
1978	Walleye	Fingerling	13621	Unspecified
1978	Brook trout	Yearling	1000	Unspecified
1978	Rainbow trout	Yearling	1000	Unspecified
1977	Brook trout	Yearling	1000	Unspecified
1977	Brown trout	Yearling	1000	Unspecified
1977	Rainbow trout	Yearling	1000	Unspecified
1977	Walleye	Fingerling	1500	Unspecified
1976	Rainbow trout	Yearling	1000	Unspecified
1976	Brown trout	Yearling	1000	Unspecified
1976	Brook trout	Yearling	1000	Unspecified
1976	Walleye	Fingerling	15000	Unspecified

Table 2. Number of individual walleye of “stock” and “quality” size and resulting proportional size distribution (PSD) and proportional size distribution of “preferred” fish (PSD-P). The percentage of sampled fish at or above 18 inches was also calculated. Fish were sampled by fyke net (SNI) and electrofishing (SEI) in spring 2022.

	Stock	Quality	Preferred	Memorable	Trophy	PSD	PSD-P	% Legal
Length (inches)	10	15	20	25	30	98.9	56.3	82.8
All	378	374	213	47	0			
Male	214	210	62	2	0	98.1	28.9	70.6
Female	164	164	151	45	0	100	92.1	98.8

Figures

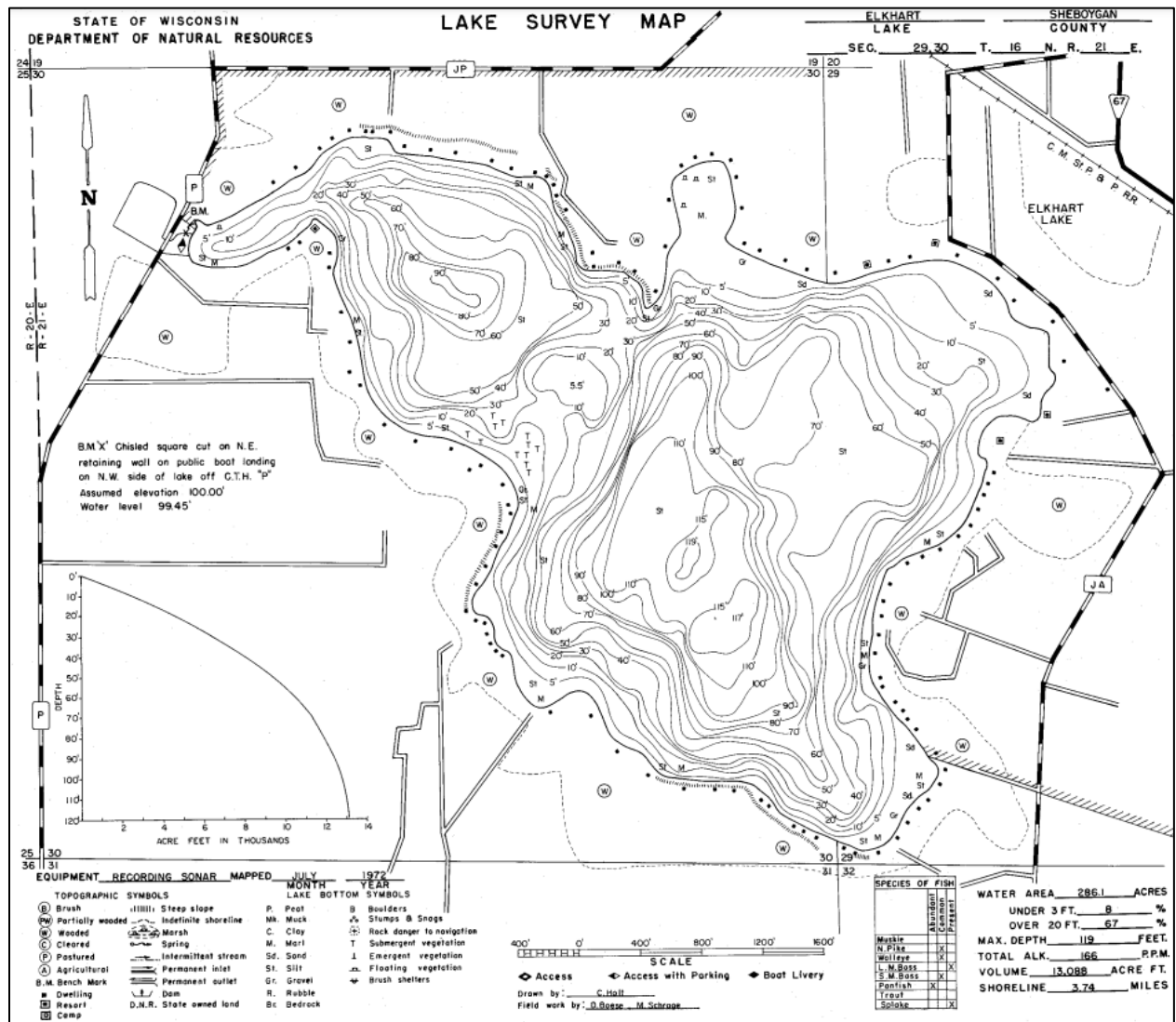


Figure 1. Contour map of Elkhart Lake, Sheboygan County, Wisconsin.



Figure 2. Fyke net locations during the 2022 Comprehensive Fishery Survey of Elkhart Lake, Sheboygan County, Wisconsin.

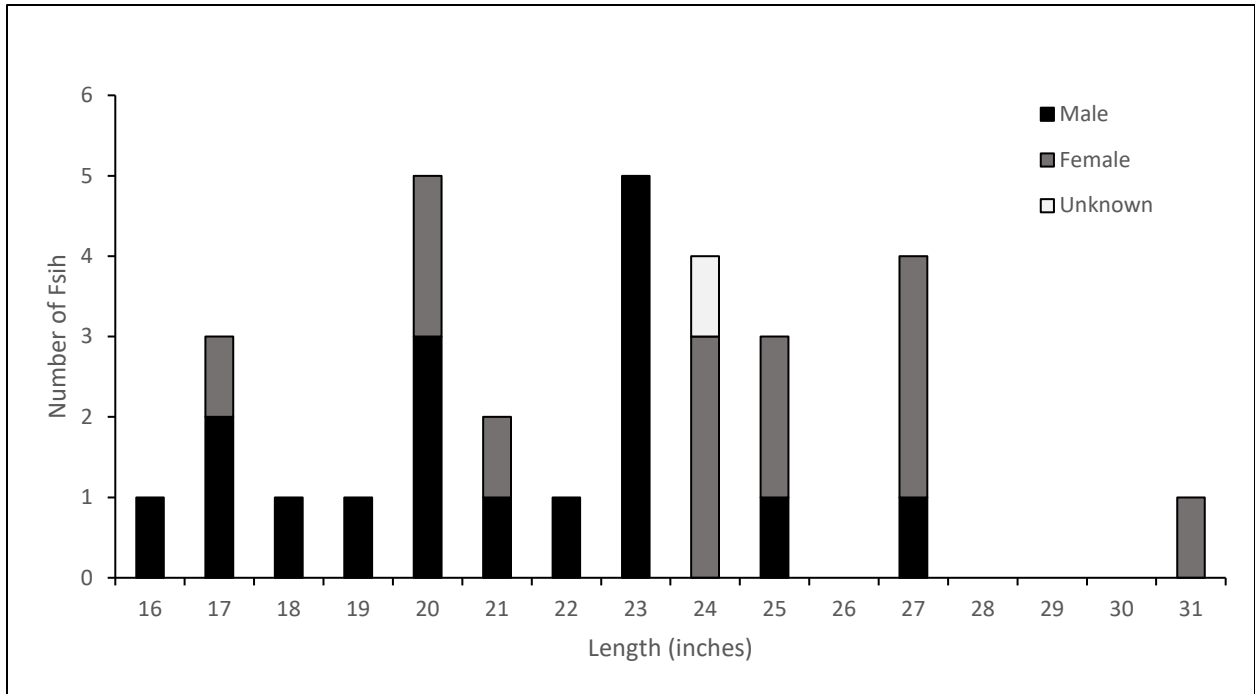


Figure 3. Length-frequency histogram of male, female and unknown sex northern pike sampled during the 2022 spring netting (SNI & SNII) surveys in Elkhart Lake, Sheboygan County, Wisconsin.

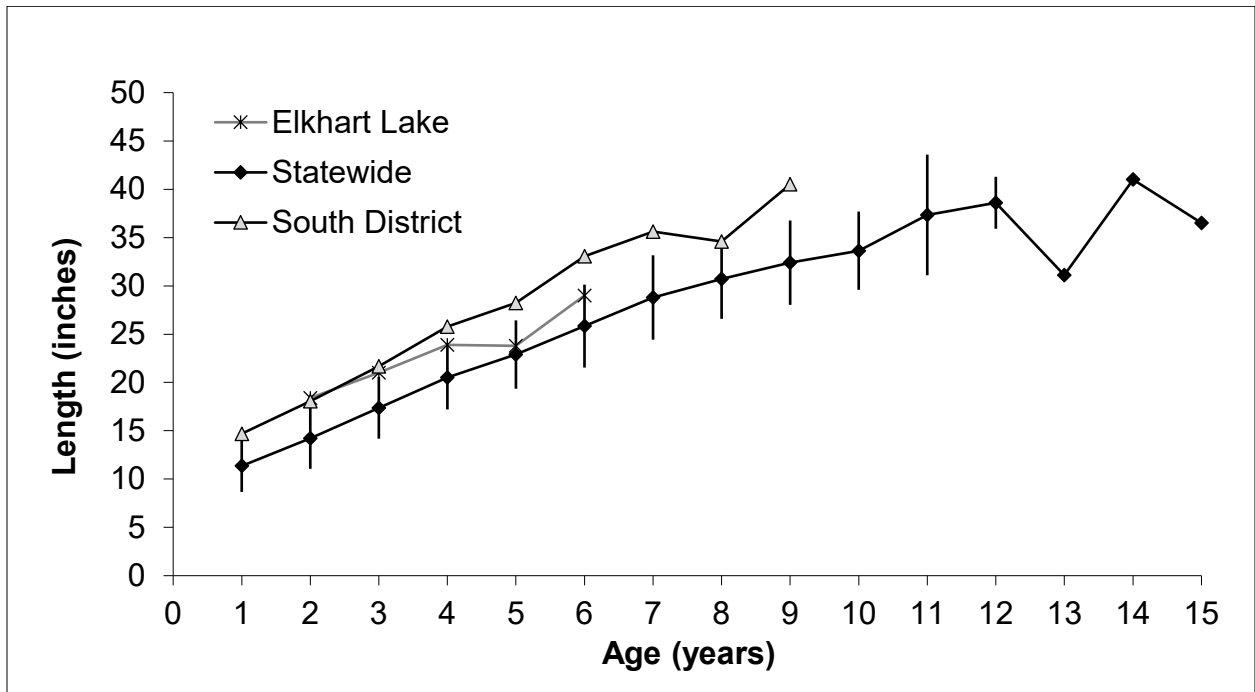


Figure 4. Northern pike mean length at age determined using anal fin rays collected during the 2022 spring netting survey (SNI) of Elkhart Lake, Sheboygan County, Wisconsin compared to the statewide mean length at age from spring (January-May) surveys and the South District average. Error bars represent plus or minus one standard deviation.

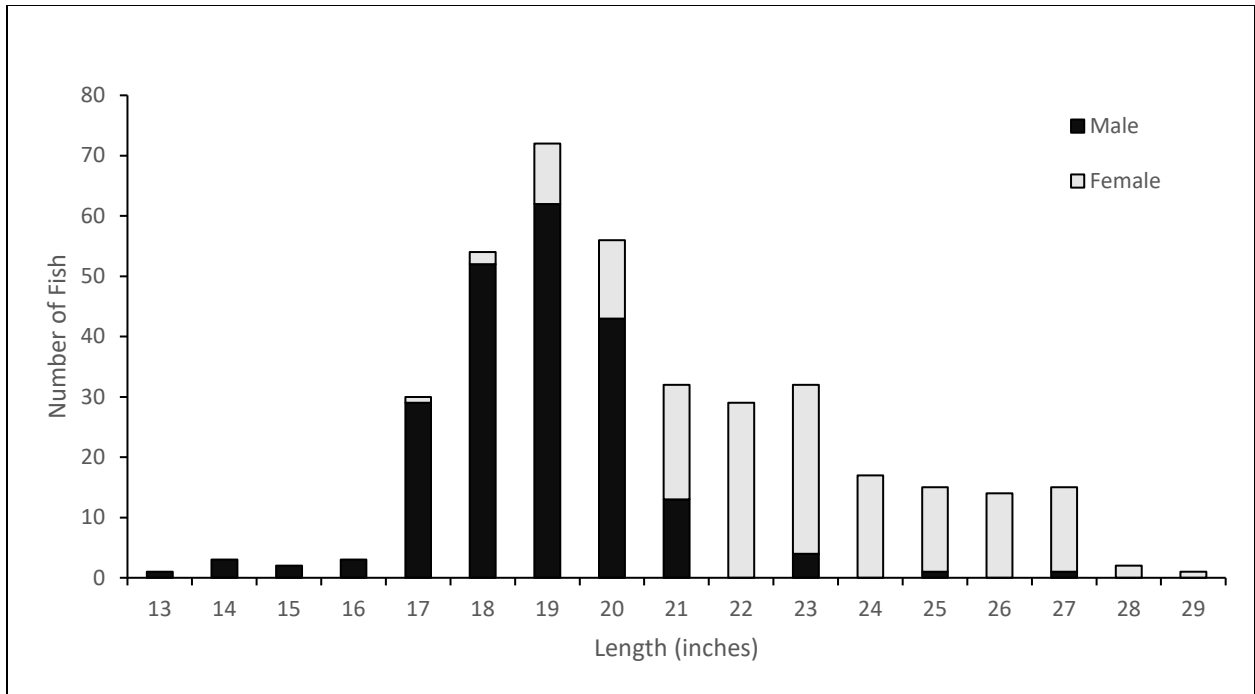


Figure 5. Length-frequency histogram of male and female walleye sampled during the 2022 spring netting (SNI) and spring electrofishing (SEI) surveys of Elkhart Lake, Sheboygan County, Wisconsin.

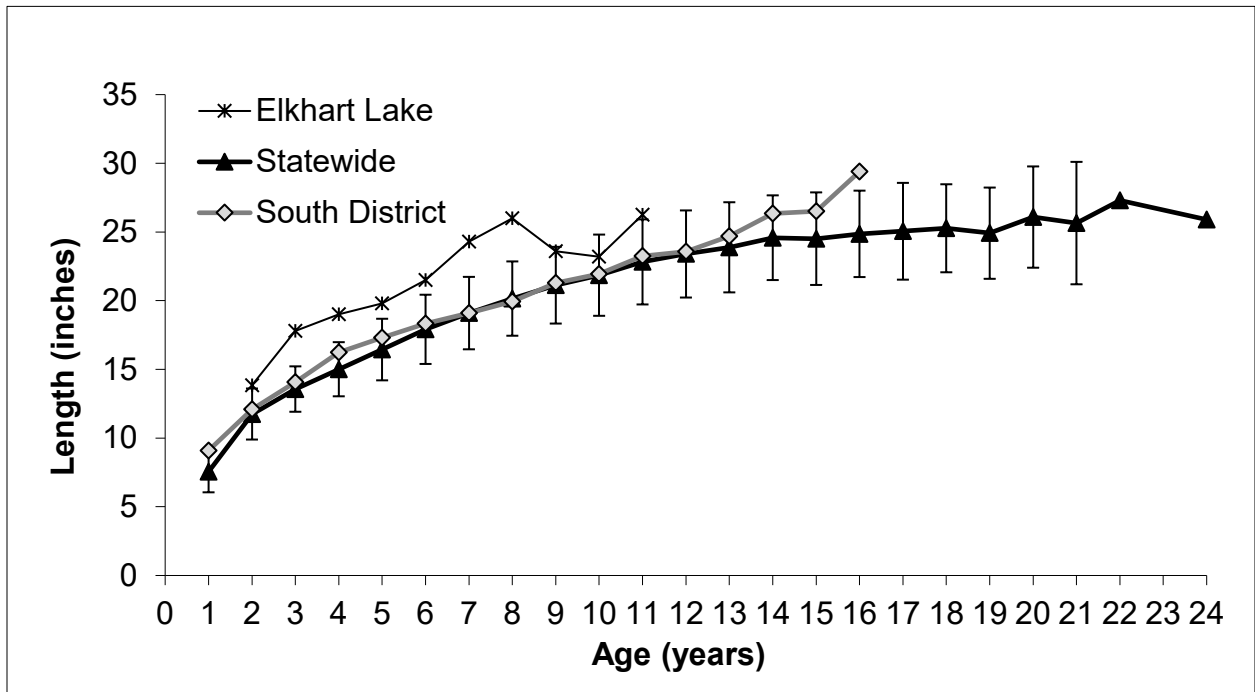


Figure 6. Walleye mean length at age determined using dorsal spines collected during 2022 spring netting (SNI) of Elkhart Lake, Sheboygan County, Wisconsin compared to the statewide mean length at age and the South District average. Error bars represent plus or minus one standard deviation.

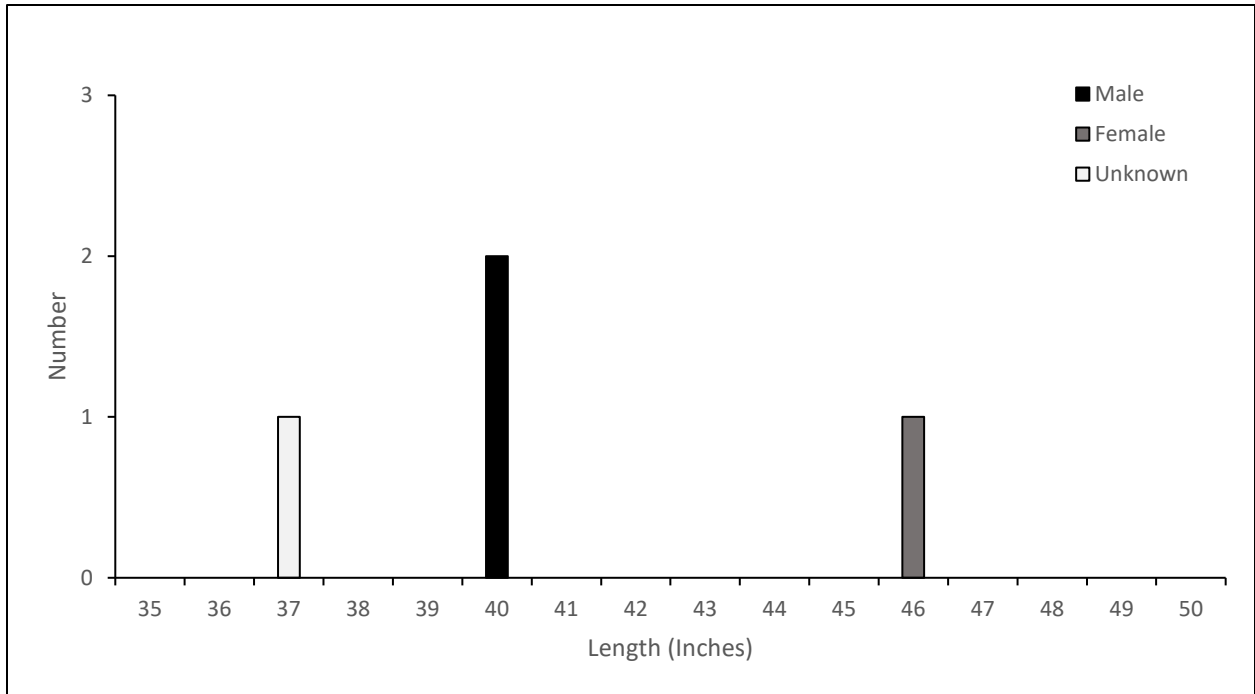


Figure 7. Length-frequency histogram of male, female and unknown sex muskellunge sampled during 2022 spring netting (SNII) of Elkhart Lake, Sheboygan County, Wisconsin.

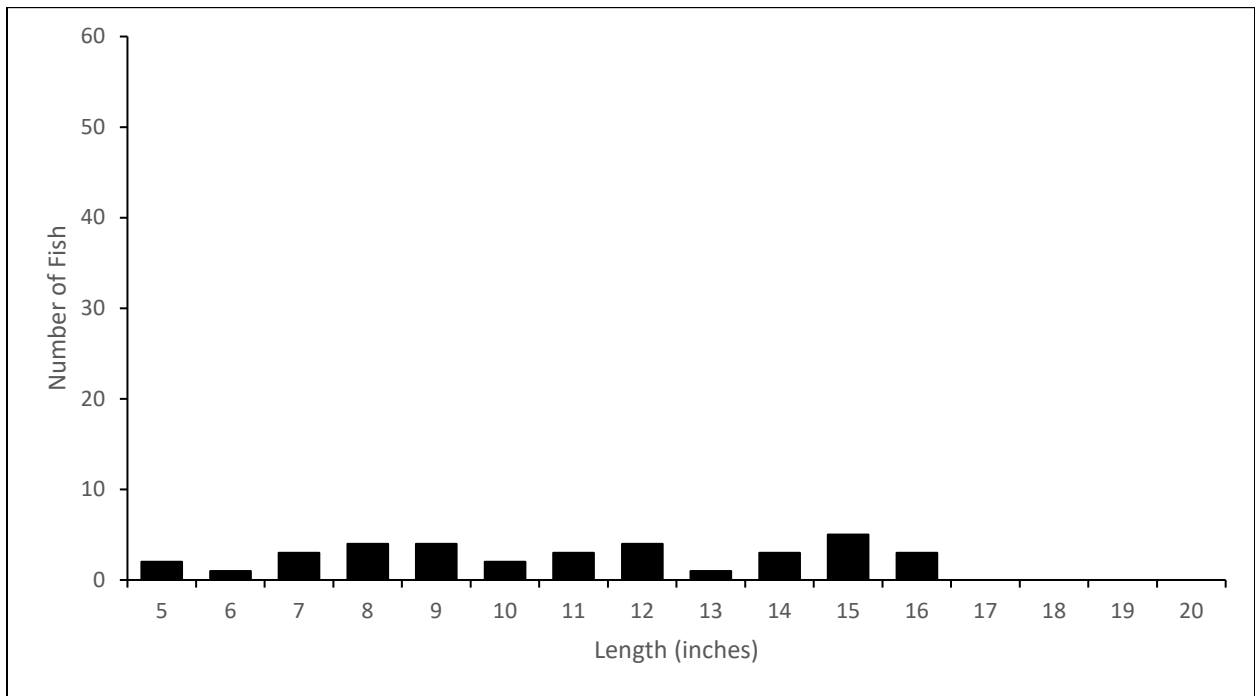


Figure 8. Length-frequency histogram of largemouth bass sampled during 2022 spring electrofishing (SEII) of Elkhart Lake, Sheboygan County, Wisconsin.

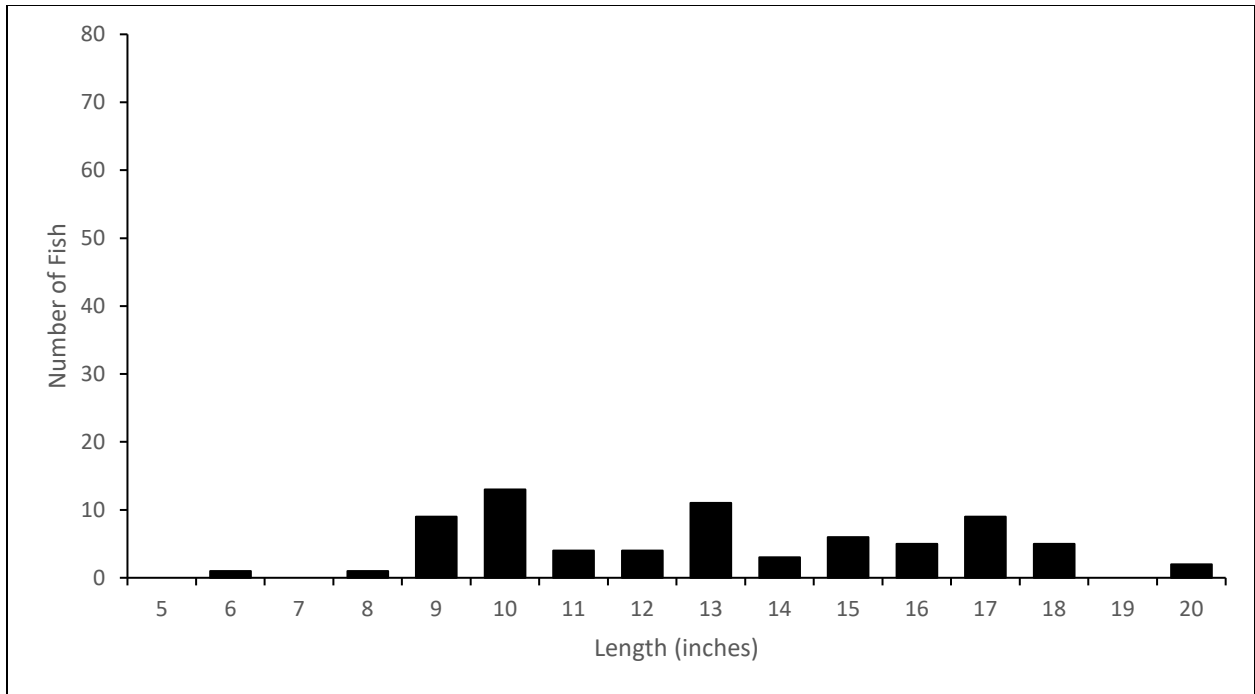


Figure 9. Length-frequency histogram of smallmouth bass sampled during 2022 spring electrofishing (SEI) of Elkhart Lake, Sheboygan County, Wisconsin.

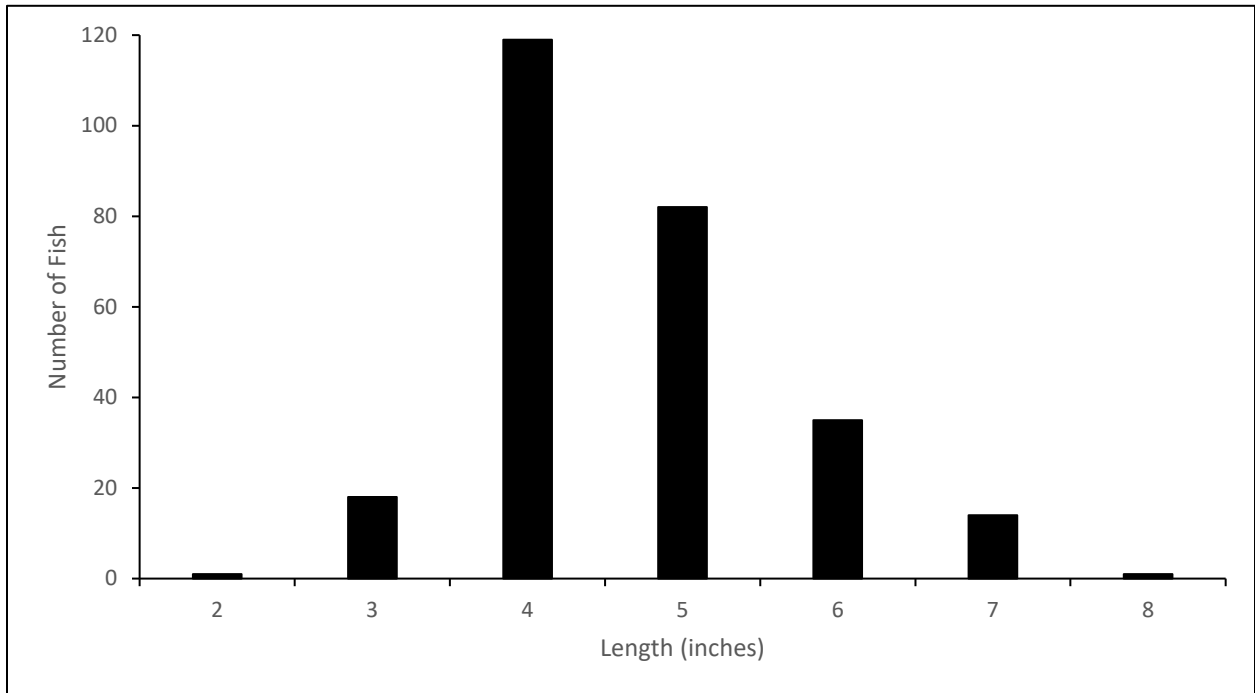


Figure 10. Length-frequency histogram of bluegills sampled during 2022 spring netting (SNI) of Elkhart Lake, Sheboygan County, Wisconsin.

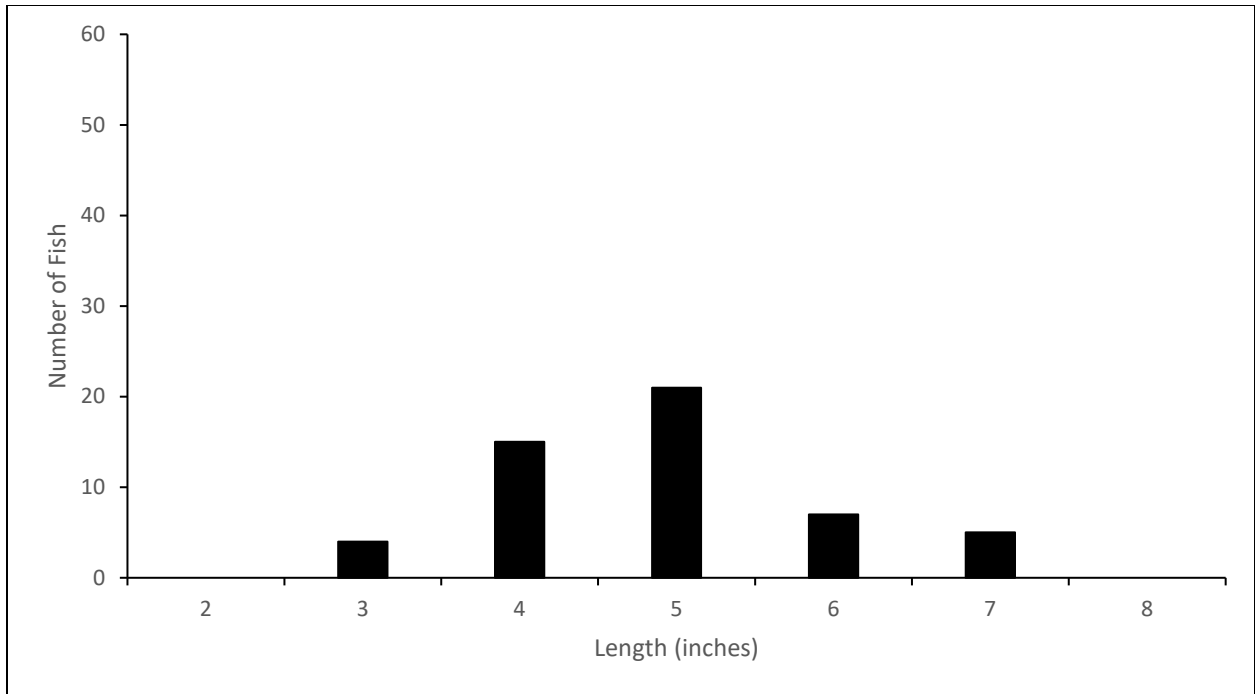


Figure 11. Length frequency histogram of bluegills sampled during 2022 spring electrofishing (SEII) of Elkhart Lake, Sheboygan County, Wisconsin.

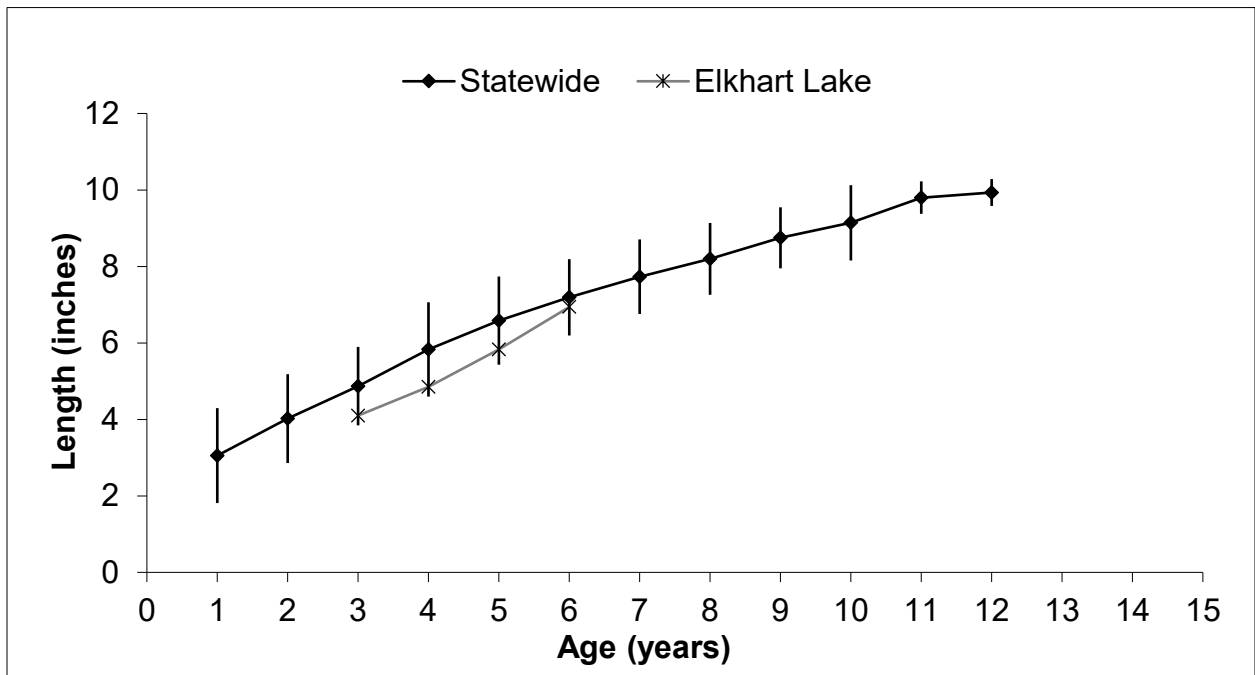


Figure 12. Bluegill mean length at age determined using otoliths collected during 2022 spring netting (SNII) of Elkhart Lake, Sheboygan County, Wisconsin, compared to statewide mean length.

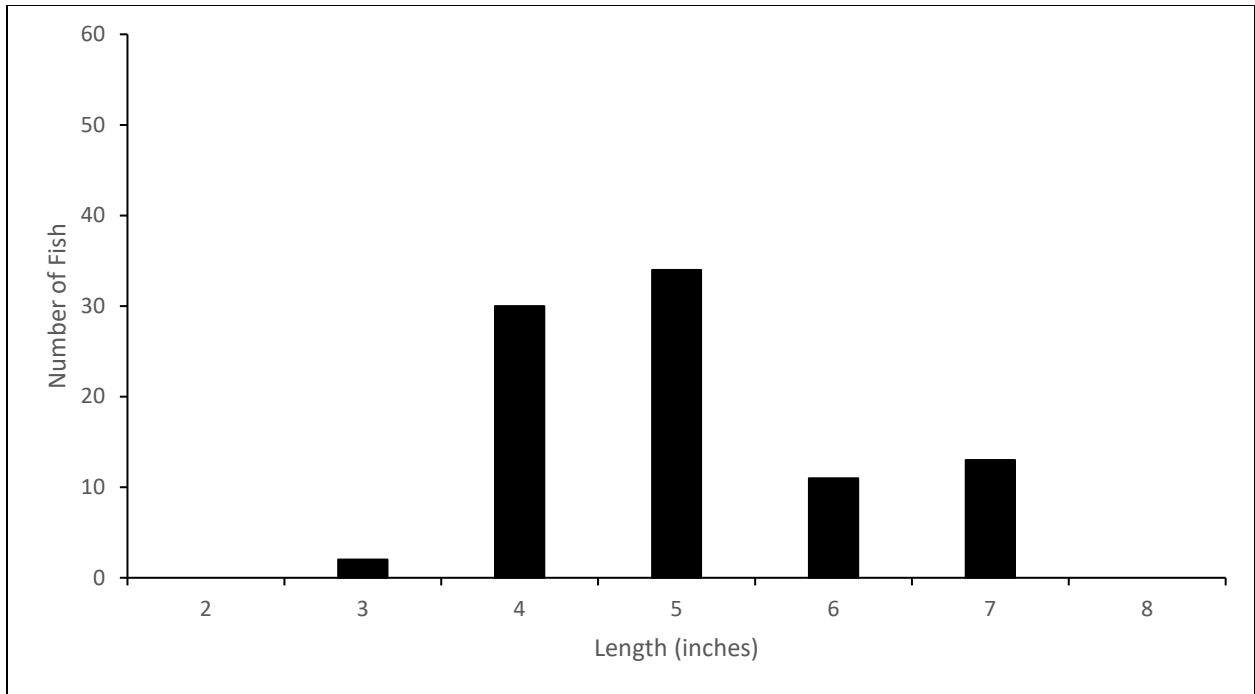


Figure 13. Length-frequency histogram of pumpkinseeds sampled during 2022 spring netting (SNI) of Elkhart Lake, Sheboygan County, Wisconsin.

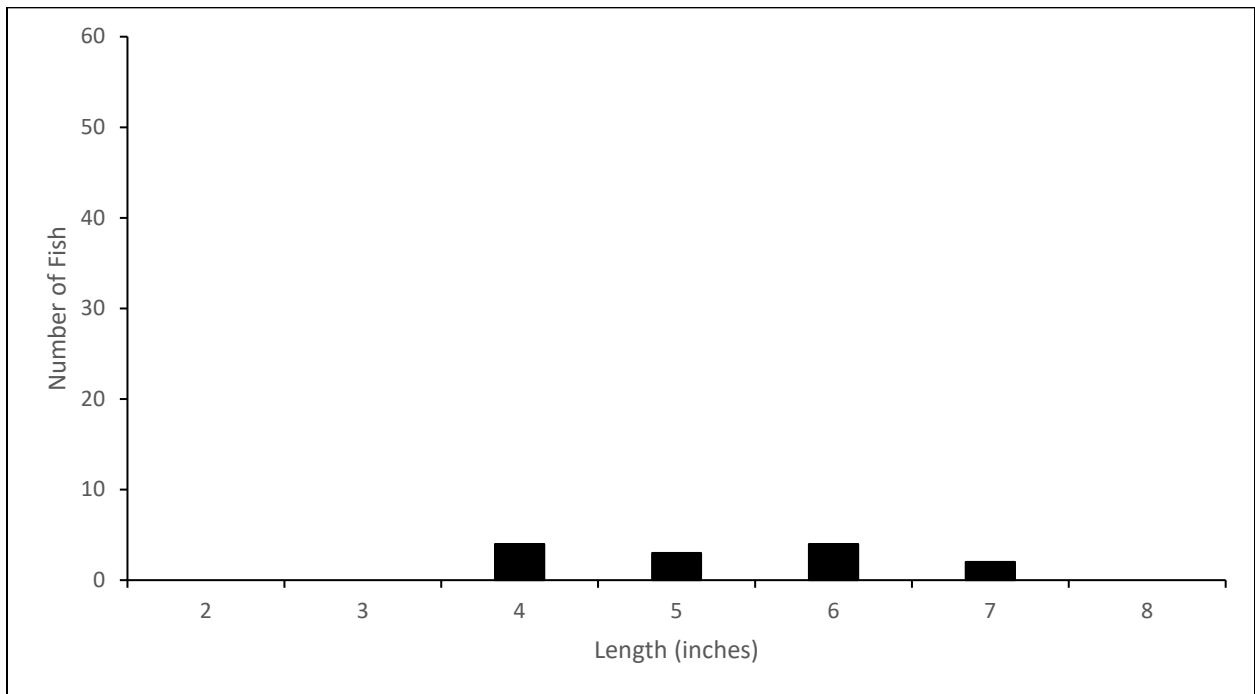


Figure 14. Length-frequency histogram of pumpkinseeds sampled during 2022 spring electrofishing (SEII) of Elkhart Lake, Sheboygan County, Wisconsin.

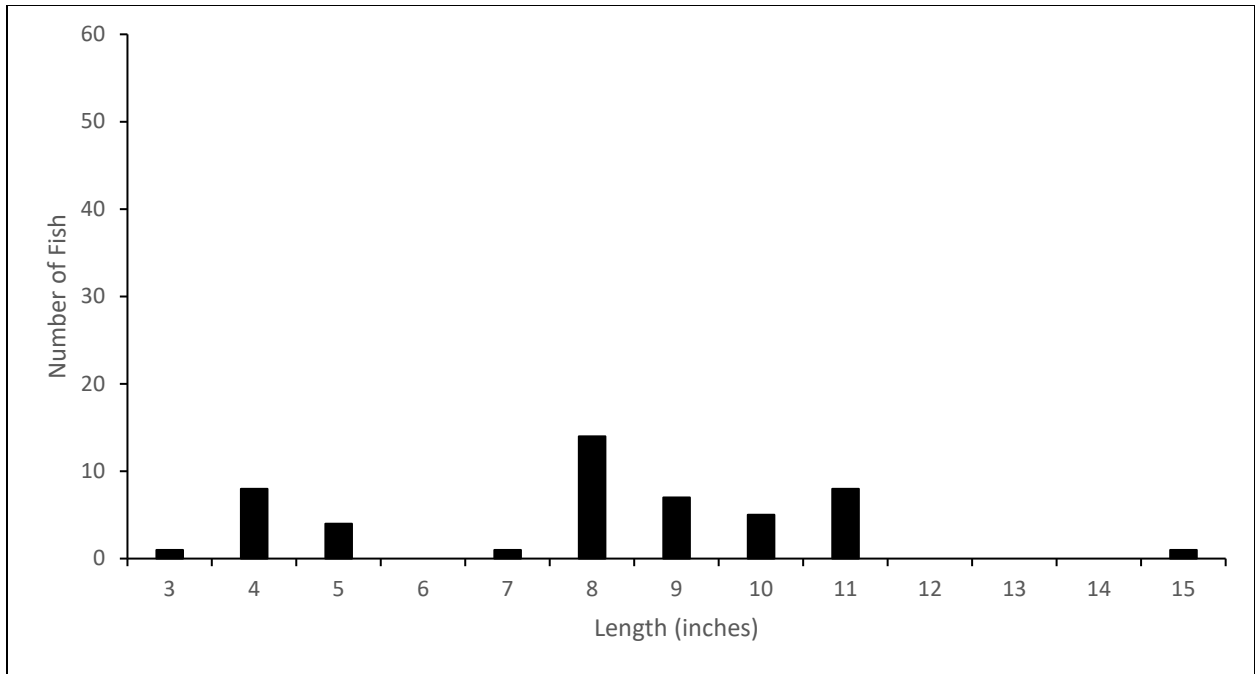


Figure 15. Length-frequency histogram of black crappies sampled during 2022 spring netting (SNI & SNII) of Elkhart Lake, Sheboygan County, Wisconsin.

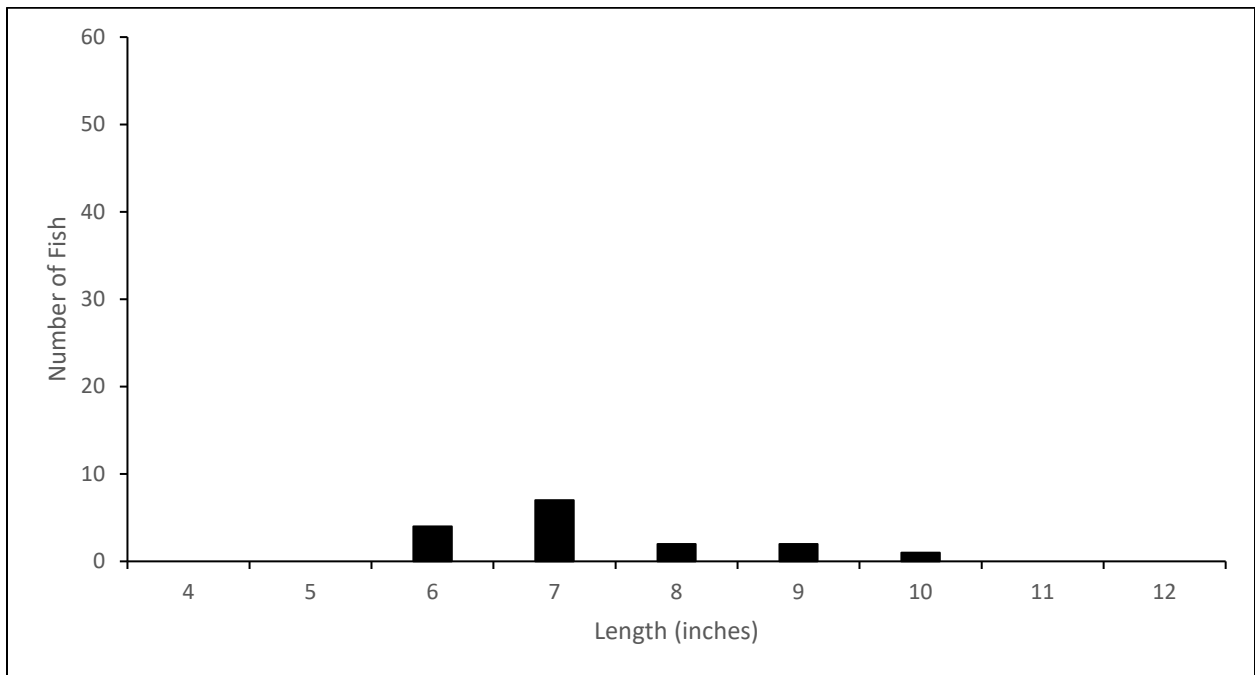


Figure 16. Length-frequency histogram of yellow perch sampled during 2022 spring netting (SNI) of Elkhart Lake, Sheboygan County, Wisconsin.

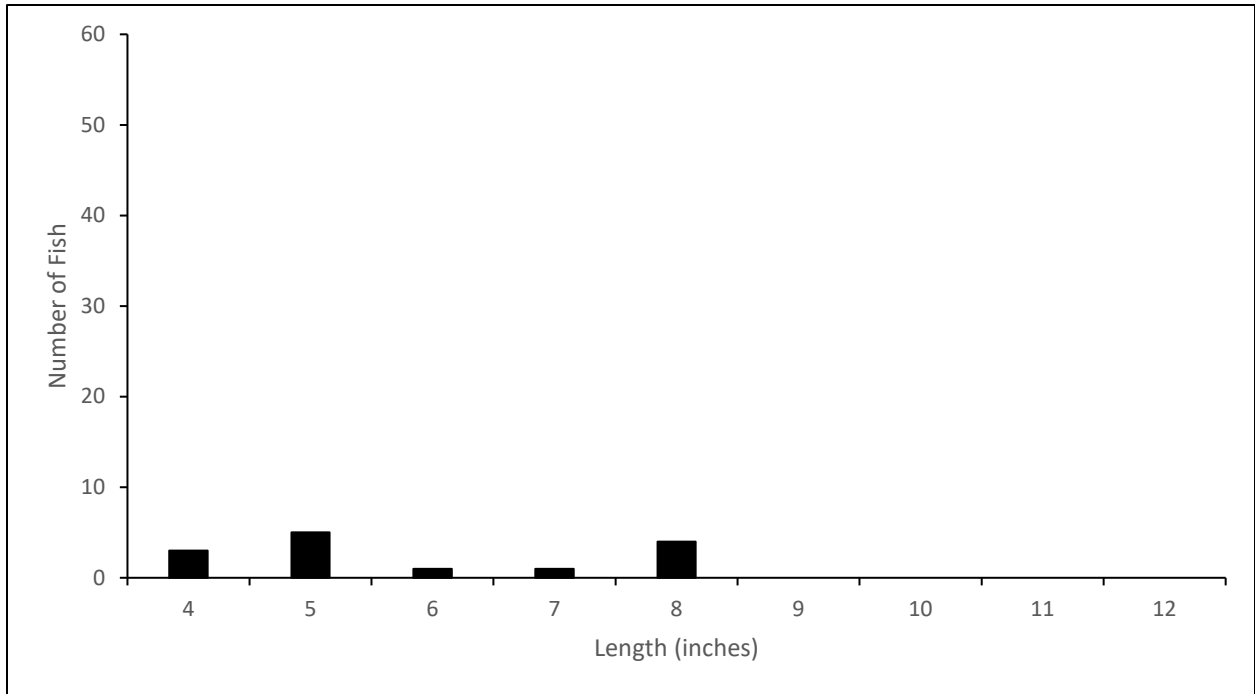


Figure 17. Length-frequency histogram of yellow perch sampled during 2022 spring electrofishing (SEII) of Elkhart Lake, Sheboygan County, Wisconsin.

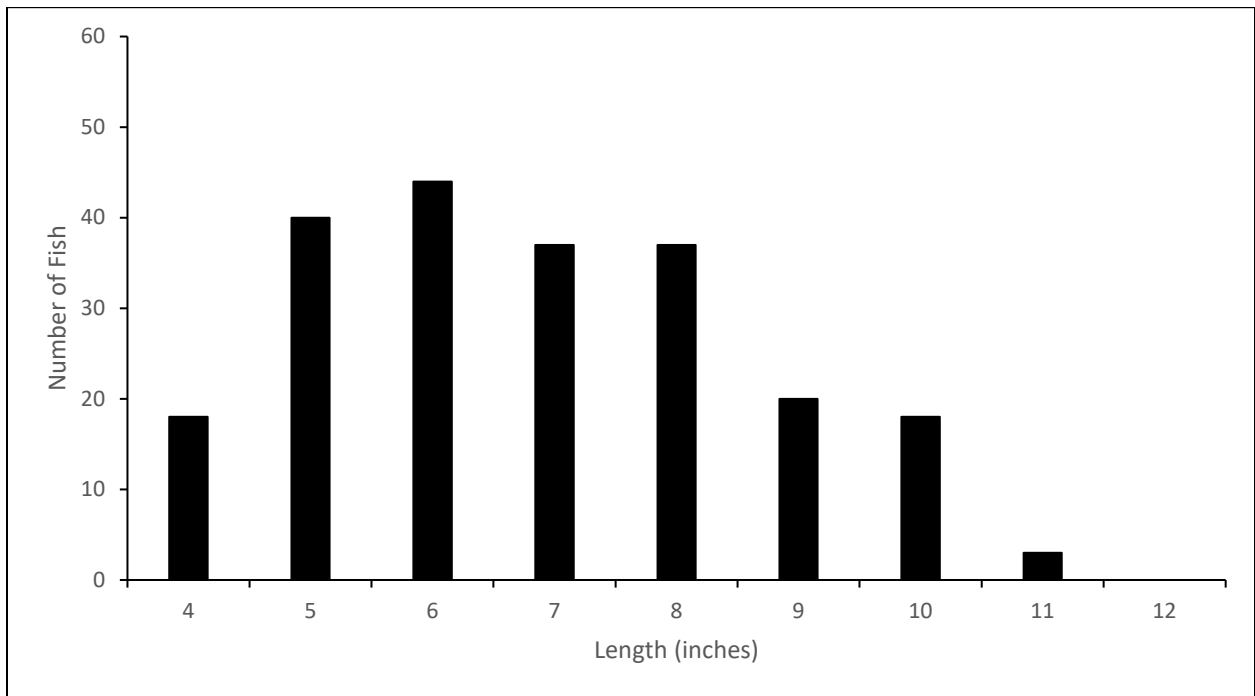


Figure 18. Length-frequency histogram of rock bass sampled during 2022 spring netting (SNII) of Elkhart Lake, Sheboygan County, Wisconsin