WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Comprehensive Fishery Survey of Big Muskego Lake, Waukesha County, Wisconsin 2021

Waterbody Identification Code 762400

Benjamin Heussner - Fisheries Biologist, Eagle
Steven Gospodarek – Fisheries Technician, Eagle
Joshua Fluur – Fisheries Technician, Eagle
Parker Wyngaard – Fisheries Technician, Eagle
Wisconsin Department of Natural Resources
2022

WISCONSIN
DEPT. OF NATURAL RESOURCES

SPORT FISH RESTORATION

Table of Contents

Executive Summary

In 2019, the Wisconsin Department of Natural Resources (DNR) conducted a comprehensive fishery survey on Big Muskego Lake in Waukesha County, Wisconsin, using a variety of sampling methods throughout the open water period to sample the major components of the fishery. Due to late ice out conditions and subsequent delayed deployment of nets, the peak of northern pike spawning was missed in the 2019 spring fyke netting (SNI) survey. This resulted in suboptimal size structure and abundance estimates from the 2019 northern pike sample and an additional SNI survey was conducted in the spring of 2020 to collect more representative data. The objectives of the surveys were to 1) assess the status of the northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*) and panfish populations, 2) attain population estimates for northern pike, 3) evaluate the protective size and bag limits implemented as part of the 1996 Big Muskego Rehabilitation Project conducted on the lake, and 4) update fisheries management recommendations for Big Muskego Lake. The results of the 2019 and 2020 surveys were compared to lakes with similar characteristics and lake classifications (Latzka, 2016) and the prior comprehensive fisheries surveys conducted by the DNR on Big Muskego Lake in 2008 and 2015.

Five hundred sixty-six northern pike were sampled in the 2019 SNI for a catch rate of 9.9 northern pike/net night (Table 2). This catch rate is well above average (90th percentile) when compared to lakes with similar characteristics (complex-warm-dark). Males comprised 50% of the sample, females 34% and 16% unknown gender. Northern pike ranged from 10.2 to 36 inches. The mean length was 19.3 inches for males, 23.2 inches for females and 20.3 inches for northern pike of unknown sex. Approximately 3% of the northern pike sampled were above the 34-inch memorable proportional size distribution (PSD34).

One thousand fifty-six northern pike were sampled during the 2020 SNI survey for a catch rate of 20.3 northern pike/net night. This catch rate is well above average (95th percentile) when compared to lakes across the state with similar characteristics. Males comprised 47% of the sample and females 53%. Northern pike ranged from 10.3 to 38.7 inches. Mean length was 19.3 inches for males, 25.2 inches for females and 10.6 inches for northern pike of unknown sex. The Schumacher-Eschmeyer multi-census adult population estimate for northern pike in Big Muskego Lake in 2020 was 5,267 (95% CI [3,970-7,893]), equaling a density of 2.4 adults/acre.

A total of 41 largemouth bass were sampled in the 2019 spring electrofishing (SEII), for a catch rate of 8.2 largemouth bass/mile. This catch rate is below average (25th percentile) when compared to lakes with similar characteristics. Largemouth bass ranged from 7.4 to 19.9 inches with a mean length of 13.4 inches. Largemouth bass in Big Muskego Lake show quality size structure with 4.4% (2019) and 10.7% (2020) of the largemouth bass sampled above the current 18-inch minimum length limit.

A total of 18 bluegills (*Lepomis macrochirus*) were sampled in the 2019 SEII for a catch rate of 36 bluegills/mile, which is below average (below the 25th percentile) when compared to lakes across the state with similar characteristics. Bluegills ranged from 3.2 to 8.8 inches, with a mean length of 6.7 inches. Both the 2019 SNI and SEII surveys show that the bluegill population in Big Muskego Lake is represented by a high proportion of quality-size (equal to or greater than 6 inches) and preferred size (equal to or greater than 8 inches) fish.

Management recommendations include:

1. Monitor the fishery for summer and winter fish mortality and implement re-stocking efforts if warranted.
2. Protect the northern pike fishery from overharvest by maintaining the current protected slot limit regulation of no minimum size limit, protected no harvest slot for fish between 25 to 35 inches and a two fish daily bag limit.
3. Monitor the northern pike population to evaluate the effectiveness of the protected slot regulation for maintaining abundance of greater than two adults per acre and implement a more restrictive harvest regulations if the desired density is not maintained.
4. Maintain the current special, restrictive panfish regulation of an 8-inch minimum length limit and 15 fish daily bag limit.
5. Maintain the current, special, restrictive largemouth bass regulation of an 18-inch minimum length limit and one fish daily bag limit.
6. Monitor the Emerald Park tributary for presence and concentrations of common carp and implement partial chemical treatment with rotenone if warranted.
7. Work with local stakeholders and the Big Muskego Lake partnership to discuss the status of emergent and submergent aquatic plants, water quality and water level management. Collectively consider implementation of a seasonal drawdown to re-establish emergent vegetation, reduce wind fetch and internal nutrient loading.
8. Work with local stakeholders and the Big Muskego Lake partnership to begin feasibility planning for a potential full-lake restoration project including water level drawdown and rotenone treatment to eradicate common carp, if warranted.

Introduction

Big Muskego Lake is a 2,260-acre shallow lake with a maximum depth of 23 feet located in Waukesha County, Wisconsin (Figure 1). A major shallow lake rehabilitation project was conducted on Big Muskego Lake in 1996. The project included an extended water level drawdown for two summer growing seasons, installation of habitat structures including islands and chemical treatment with rotenone to remove the common carp-dominated fishery. A suite of protective fishing regulations was implemented following the 1996 project to protect the developing fishery from overharvest. In addition, the DNR restocked Big Muskego Lake and Bass Bay with a combined 1.5 million fingerlings and adult fish and 4 million fry (Table 1). A total of twenty species of fish were stocked in the two lakes and their tributaries. The stocking was very successful in re-establishing thirteen of the twenty species stocked.

Populations of black bullhead (*Ictalurus melas*), brown bullhead (*Ictalurus nebulosus*) and yellow bullhead (*Ictalurus natalis*) have re-established themselves in the lake either by immigration from the watershed or by illegal stocking by the public (Beyler, 2000). Naturally reproducing populations of beneficial predatory fish species including northern pike and largemouth bass, as well as panfish and non-game species, including bowfin (*Amia calva*), have also been established.

Common carp (*Cyprinus carpio*) were able to re-establish in the system during the statewide flood events that occurred during the summer of 2008. Electrofishing for common carp on Big Muskego Lake has shown to be a minimally effective sampling method, as the carp are often observed, but are unable to be sampled due to gear avoidance. A partial chemical treatment of the connected Emerald Park wetland complex was successfully completed in 2012, removing thousands of young of the year and adult common carp.

Methods

In 2019, eleven white nylon fyke nets (0.75-inch bar mesh, 3-foot, single-funnel, 75-foot-lead) were set to specifically target spawning northern pike as part of spring fyke netting (SNI). Open water conditions arrived late in the spring of 2019, and fyke nets were deployed after ice melt on March 28. Seven nets were initially set in Big Muskego Lake, with four more nets added throughout the seven-day survey. Nets were checked daily from March 30 to April 4 for a total of six nights and 70 net nights of effort.

All gamefish netted were measured to the nearest 0.1 inches. Northern pike were also weighed to the nearest 0.1 pounds. Northern pike were given differential fin clips to identify recaptures and facilitate the calculation of a population estimate. Females were marked with a right ventral fin clip, males received a left ventral fin clip and

unknown sex fish received a top caudal fin clip. Additionally, all largemouth bass were marked with a top caudal fin clip to eliminate duplicate counts. All northern pike and largemouth bass netted were observed for fin clips from previous surveys. Additionally, age structures were removed from northern pike according to standard sampling protocols, including removing an anal fin ray. Aging structures were collected until five structures were collected for each species and each sex for every half-inch increment. A subsample of bluegill, black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*) and pumpkinseed (*Lepomis gibbosus)* were measured to the nearest 0.1 inches. Other fish species encountered were identified to species and tallied.

Due to late ice-out conditions and subsequent delayed deployment of SNI nets, the peak of northern pike spawning was missed in 2019. As a result, catch rate, size structure and abundance estimate from 2019 are limited. SNI was repeated in 2020 to obtain additional northern pike data, to better assess population metrics and conduct a continuous mark and recapture population estimate. Open water conditions occurred early in the spring of 2020, with fyke nets set on March 13. Eight white nylon fyke nets (0.75-inch bar, three-foot, single-funnel, 75-foot lead) were set to specifically target spawning northern pike (Figure 12). Nets were checked daily from March 14 to March 19 for a total of six days and 56 net nights of effort. Sampling methods for the 2020 SNI were identical to those used in the 2019 SNI.

Spring electrofishing (SEI) using a DNR standard pulsed direct current (PDC) boom shocker boat was conducted at night on May 2. The SEI sampling included a total of one mile of shoreline effort targeting all fish species (catch all runs). An additional 6 miles of shoreline and three hours of sampling effort were completed, targeting only gamefish species.

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

The objective of SEII was to estimate catch per unit effort (CPUE). During gamefish only sampling, northern pike, walleye and largemouth bass were measured to the nearest 0.1 inch. Largemouth bass were observed for fin clips, and newly sampled fish were given a top caudal fin clip for completing a mark and recapture population estimate. Panfish, to the nearest 0.1 inches and catch rate was calculated to estimate abundance.

Spring electrofishing II (SEII) using a DNR standard PDC boom shocker boat was conducted at night on May 23, targeting largemouth bass and panfish species. The SEII sampling effort included a total of 0.5 miles of shoreline sampling effort

targeting all fish species and 5 miles of shoreline sampling effort targeting only gamefish species. Largemouth bass were observed for fin clips from the SNI and SEI surveys, and newly sampled largemouth bass were given a top caudal fin clip for calculation of a population estimate. Gamefish were observed for fin clips received during previous sampling and lengths were measured to the nearest 0.1 inches. Panfish, including bluegill, black crappie, yellow perch, pumpkinseed and warmouth (*Lepomis gulosus),* were collected and measured to the nearest 0.1 inches. Other fish species sampled were identified and tallied. Fall electrofishing (FE) was not conducted on Big Muskego Lake in 2019.

Fyke net total catch, and CPUE (number/net night) were calculated for northern pike to estimate relative abundance. Northern pike population size was estimated by continuous mark and recapture using the Schumacher-Eschmeyer formula with 95% confidence intervals. The formula for the Schumacher-Eschmeyer formula is shown here:

$$\hat{N} = \frac{\sum_{t=1}^{s}(C_t M_t^2)}{\sum_{t=1}^{s}(R_t M_t)},$$

where N is the population size, C_t is the number sampled on day t, M_t is the number marked on day t and R_t is the total number of recaptures from the survey (Ricker 1975).

Electrofishing total catch and CPUE (number/mile) were calculated for largemouth bass, bluegill and yellow perch. Mean length calculations and length frequency histograms were constructed for northern pike, largemouth bass, bluegill and yellow perch to assess size structure.

Proportional size distribution (PSD) was calculated for northern pike, largemouth bass and bluegill to assess population size structure. Stock lengths are based on standardized lengths for each species: northern pike (14 inches), largemouth bass (8 inches) and bluegill (3 inches), and quality lengths used were: northern pike (21 inches), largemouth bass (12 inches) and bluegill (6 inches). Proportional size distribution-preferred (PSD-P) was also calculated for northern pike, largemouth bass and bluegill to assess the proportion of fish in the population that are a length preferred by anglers. These are based on standardized lengths for each species: northern pike (28 inches), largemouth bass (15 inches) and bluegill (8 inches). Proportional size distribution-memorable (PSD-M) was also calculated for northern pike to assess the proportion of fish in the population that are a length considered memorable (34 inches) by anglers (Anderson, R.O. 1980).

Age and growth data were obtained from structures taken from northern pike (anal fin rays) collected throughout the comprehensive fishery survey. Anal fin rays were sectioned using a Buehler Isomet low-speed sectioning saw. Sectioned wafers were mounted on a slide with mineral oil, imaged and interpreted by independent readers using an Olympus SZX7 Microscope. Growth data from Big Muskego Lake was compared to statewide and regional mean growth rates utilized in the DNR Fisheries Management Information System (FMIS) database.

Results and Discussion

NORTHERN PIKE

Five hundred sixty-six northern pike were sampled in the 2019 SNI for a catch rate of 9.9 northern pike/net night (Table 2). This catch rate is well above average (90th percentile) compared to lakes with similar characteristics. The sex ratio was 1.5 male northern pike to every female northern pike sampled. Northern pike ranged from 10.2 to 36 inches. The mean length was 19.5 inches for males, 23.5 inches for females and 20.6 inches for northern pike of unknown sex. The length-frequency histogram shows a good size structure (Figure 3).

One thousand fifty-six northern pike were sampled in the 2020 SNI for a catch rate of 20.3 northern pike/net night (Table 2). This catch rate is well above average (99th percentile) when compared to lakes with similar characteristics across the state. Males comprised 47% of the sample and females 53%, nearly a 1:1 ratio (Table 3). Northern pike ranged from 10.3 to 38.7 inches. The mean length was 19.3 inches for males, 25.2 inches for females and 10.6 inches for northern pike of unknown sex (Figure 4). The 2020 catch rate of northern pike has increased from 7.9/net night in 2008 and 16.9/net night in 2015 SNI surveys (Table 4). In 2020 SNI, PSD was 57, PSD-P was 14 and PSD-M was 2. In 2015, PSD was 65, PSD-P was 17 and PSD-M was 1. In 2008, PSD was 44, PSD-P was 5 and PSD-M was 0.4 (Table 5).

Thirty-eight northern pike were sampled in the 2019 SEI for a catch rate of 6.3 northern pike/mile (Table 6). Northern pike ranged from 12.8 to 35.4 inches and the average length was 20.6 inches.

The Schumacher Eschmeyer population estimate for adult northern pike in Big Muskego Lake was 5,267 (95% CI [3,970-7,893]), equaling a density of 2.4 adults/acre. Gender-specific population estimates were calculated; the male northern pike population estimate was 3,043 (95% CI [2215-4859]), and the female population estimate was 2,224 (95% CI [1755-3034]).

Mean length at age data from 2019 indicates that the growth rate of northern pike in Big Muskego Lake is slightly higher than the statewide average (Figure 5). Female northern pike reach the lower end of the current protected slot regulation (25 inches) at age-6 and males by age-8.

LARGEMOUTH BASS

Forty-three largemouth bass were sampled in the 2019 SNI for a catch rate of 0.75 largemouth bass/net night (Table 2). Largemouth bass ranged from 5.7 to 19.2 inches, with a mean length of 13.8 inches (Figure 6). Twenty-eight largemouth bass were sampled in the 2020 SNI for a catch rate of 0.54/net night (Table 2). Largemouth bass ranged from 8.3 to 20.3 inches, with a mean length of 15.2 inches (Figure 7). Seventeen largemouth bass were sampled in the 2015 SNI for a catch rate of 0.33 largemouth bass/net night. Largemouth bass ranged from 13.1 to 17.9 inches, with a mean length of 16.0 inches. One hundred fifty-four largemouth bass were sampled in the 2008 SNI for a catch rate of 1.0 largemouth bass/net night. Largemouth bass ranged from 8.1 to 20.3 inches, with a mean length of 15.2 inches. Largemouth bass sampled in SNI are considered incidental catch, and catch rates are not considered a good estimate of abundance. However, largemouth bass length data is useful in describing size structure with limited data.

Ninety-five largemouth bass were sampled during the 2019 SEI for a catch rate of 15.8 largemouth bass/mile (Table 6). This catch rate is average (50th percentile) compared to lakes with similar characteristics across the state. Largemouth bass ranged from 2.0 to 19.9 inches, with a mean length of 14.0 inches. A total of 41 largemouth bass were sampled during the 2019 SEII for a catch rate of 8.2 largemouth bass/mile (Table 7). This catch rate is below average (25th percentile) compared to lakes with similar characteristics. Largemouth bass ranged from 7.4 inches to 19.9 inches, with a mean length of 13.4 inches (Figure 8). In the 2019 SEI and SEII, 2.4% and 5.3% of the largemouth bass sampled were over the current 18-inch minimum length limit, respectively.

A balanced largemouth bass population typically displays PSD values between 40-60 (Anderson and Neuman, 1996). The PSD of largemouth bass sampled during the 2019 SEI and SEII was 77, indicating good recruitment of juvenile bass into the population and a desirable proportion of quality-size bass (greater than or equal to 12 inches) present. The PSD-P was 46, indicating a large proportion of preferred-size bass (greater than or equal to 15 inches) present in Big Muskego Lake. A population estimate for largemouth bass was not calculated due to insufficient sample size.

BLUEGILL

A total of 65 bluegills were sampled in the 2019 SNI for a catch rate of 1.1 bluegills/net night (Table 2). Bluegill lengths ranged from 5.2 to 8.6 inches, with a mean length of 7.5 inches (Table 10). The 2019 SNI bluegill length frequency distribution shows an excellent size structure with a PSD of 95 and PSD-P of 29 (Figure 9). A subsample of 49 bluegills were measured during the 2020 SNI, ranging from 4.2 to 8.6 inches with a mean length of 6.6 inches. The 2020 SNI length frequency distribution shows a good size structure; however, PSD and PSD-P values were lower at 71 and 10, respectively (Figure 10).

A total of 19 bluegills were sampled during the 2019 SEI for a catch rate of 19 bluegills/mile (Table 6). Bluegill lengths ranged from 3.3 to 7.5 inches, with a mean length of 5.2 inches. A total of 18 bluegills were sampled in the 2019 SEII for a catch rate of 36 bluegills/mile (Table 7). Bluegill lengths ranged from 3.2 to 8.8 inches, with a mean length of 6.7 inches. The catch rates for both the SEI and SEII were below average (10th percentile) compared to lakes with similar characteristics. Bluegill ranged from 3.2 to 8.8 inches, with a mean length of 3.8 inches (Figure 11).

YELLOW PERCH

A total of 30 yellow perch were sampled during the 2019 SNI for a catch rate of 0.53 yellow perch/net night (Table 2). This catch rate is below average (10th percentile) for lakes with similar characteristics. Yellow perch ranged from 3.1 to 8.0 inches, with a mean length of 4.6 inches (Figure 12). Two yellow perch were sampled in the 2020 SNI, demonstrating very low abundance and below-average size structure. The low catch rate of yellow perch is consistent with past SNI surveys of 0.38/net night in 2008 and 0.63/net night in 2015 (Table 5).

A total of eight yellow perch were sampled during the 2019 SEI for a catch rate of 8.0 yellow perch/mile (Table 6). Yellow perch ranged from 2.9 to 7.1 inches, with a mean length of 4.5 inches. A total of five yellow perch were sampled in the 2019 SEII for a catch rate of 10.0 yellow perch/mile (Table 7). Yellow perch ranged from 6.4 to 9.3 inches, with a mean length of 7.9 inches.

BLACK CRAPPIE

A total of 10 black crappies were sampled in the 2019 SNI for a catch rate of 0.18 black crappies/net night (Table 2). Black crappies ranged from 6.2 inches to 16.0 inches with a mean length of 9.3 inches. Seven black crappies were sampled in the 2020 SNI for a catch rate of 0.13 black crappies/net night. Black crappies ranged from 7.0 to 9.0 inches, with a mean length of 7.9 inches. The catch rates in both SNI survey years are below average (1st percentile) for lakes with similar characteristics. Black crappie catch rates were also below average in the 2015 SNI (0.90/net night) and 2008 SNI (0.29/net night). Black crappie catch rates were also low in the 2019 SEI (3/mile) and SEII (2/mile) surveys (Table 6, 7). While the overall abundance of black crappies are low, the species is an important panfish species in Big Muskego Lake as they provide additional angling opportunities and are more tolerant of poor water quality and winterkill conditions.

COMMON CARP

Four common carp were collected throughout the combined 2019 and 2020 sampling efforts on Big Muskego Lake. However, many common carp were observed while electrofishing but evaded capture due to gear avoidance in shallow water. The morphometry of Big Muskego Lake makes effectively sampling common carp very difficult.

OTHER SPECIES

Additional species sampled during the 2019 comprehensive fishery survey included muskellunge (*Esox masquinongy*), walleye (*Sander vitreus*), golden shiner (*Notemigonus crysoleucas*), lake chubsucker (*Erimyzon sucetta*), a special concern (SC) fish species in Wisconsin, pumpkinseed, warmouth, black bullhead, brown bullhead, yellow bullhead and bowfin (Table 6 and 8).

A diverse fishery assemblage is important in maintaining a balanced fishery. For example, bowfin are a native predator species that is thriving in Big Muskego Lake with excellent natural reproduction, survival and growth. While bowfin are considered a rough fish species that can tolerate poor water quality and habitat, they are an excellent predator of common carp and are therefore considered a beneficial part of this shallow-lake ecosystem.

Management Recommendations

Big Muskego Lake is a high-profile waterbody with above-average fishing pressure. Since the 1996-1997 complete restoration project, anglers and outdoor enthusiasts have benefited from the clear water aquatic plant-dominated state. Current water quality, submergent aquatic plant communities and fisheries remain primarily intact. However, there has been a considerable reduction in emergent vegetation, as shown in Figure 13 (Wyngaard 2020). If emergent vegetation continues to decrease, the need for a lake-wide water level reduction over the summer growing season becomes increasingly important. Natural drought cycles or an induced drawdown can provide the necessary environmental conditions to stimulate emergent aquatic plant growth. The effects of a sustained water level reduction during the growing season can result in high water temperatures that could result in thermally induced mortality for northern pike, a cool water species. Continued monitoring of the lake's emergent and submergent vegetation is critical to making informed management decisions.

Emergent vegetation loss on Big Muskego Lake has likely resulted from a combination of factors, including sustained high-water levels (Figure 14), increased wind fetch resulting from the loss of emergent vegetation (Wyngaard, 2020) and increased presence of common carp. The negative effects of common carp on submergent vegetation are well documented as they uproot native aquatic plants, increase turbidity, contribute to internal nutrient loading and increased algae-dominated state (Sorensen Lab Group, Figure 19).

Maintaining a healthy gamefish population is critical to continued lake health. To provide maximum protection for the northern pike population, a 40-inch minimum length limit and daily bag limit of one fish regulation was implemented from 2010 through 2021. In 2022, the northern pike regulation was changed to a no minimum length limit with a protected slot size of 25 to 35 inches and a two fish daily bag limit. The main objective of the protected slot regulation is to protect larger spawning

females while also providing angler harvest opportunities, focusing harvest on northern pike less than 25 inches in length. The DNR has suspended the stocking of northern pike in Big Muskego Lake as research is needed to identify proper genetic strains for stocking this species in this connected waterbody. In addition, northern pike have shown considerable natural reproductive potential, as indicated by the 2014-2017 northern pike stocking evaluation (Heussner 2019, DNR Draft). Future survey work will determine the effectiveness of the slot size in maintaining pike abundance and population size structure. As a cool water species, northern pike are more tolerant of winterkills, but often succumb to summer mortality as water temperature approaches sustained temperatures above 80 degrees Fahrenheit. The most recent significant summer northern pike mortality was observed in 2012 and was attributed to summer drought conditions and high water temperatures experienced statewide (Figure 17). Winter mortality most commonly affects bluegills on Big Muskego Lake, which is often observed during spring thaw (Figure 18).

The current fishing regulation for largemouth bass on Big Muskego Lake is an 18-inch minimum length limit and a one fish daily bag limit. Natural recruitment remains consistent, supporting good abundance and multiple year classes. Largemouth bass are a warmwater species making them more prone to winterkill than northern pike. Largemouth bass winterkill in Big Muskego Lake has likely been sporadic due to the decrease in the severity of recent winters.

Panfish regulations currently include a reduced combined bag limit of 15 fish with a minimum size limit of 8 inches. This restrictive regulation provides adequate protection from angler over harvest and subsequent reduced size structure. Above average size structure of panfish in Big Muskego Lake potentially contributes to predation on juvenile benthivores, including the eggs, fry and fingerling common carp.

In summary, the Big Muskego Lake fishery continues to thrive and provide quality angling opportunities. Maintaining a relatively high-density gamefish population with a large size structure and a diverse, abundant panfish community is needed to prey on common carp eggs, fry and fingerlings. Maintaining a balanced fishery is also essential to reducing the risk of common carp re-establishing dominance in the lake.

Management recommendations include:

1. Monitor the fishery for summer and winter fish mortality and implement re-stocking efforts if warranted.
2. Protect the northern pike fishery from overharvest by maintaining the current protected slot limit regulation of no minimum size limit, protected no harvest slot for fish between 25 to 35 inches and a two fish daily bag limit.
3. Monitor the northern pike population to evaluate the effectiveness of the protected slot regulation for maintaining abundance of greater than two adults per acre and implement a more restrictive harvest regulations if the

desired density is not maintained.

4. Maintain the current special, restrictive panfish regulation of an 8-inch minimum length limit and 15 fish daily bag limit.
5. Maintain the current, special, restrictive largemouth bass regulation of an 18-inch minimum length limit and one fish daily bag limit.
6. Monitor the Emerald Park tributary for the presence and concentrations of common carp and implement partial chemical treatment with rotenone if warranted.
7. Work with local stakeholders and the Big Muskego Lake partnership to discuss the status of emergent and submergent aquatic plants, water quality and water level management. Collectively consider implementing a seasonal drawdown to re-establish emergent vegetation, reduce wind fetch and internal nutrient loading.
8. Work with local stakeholders and the Big Muskego Lake partnership to begin feasibility planning for a potential full-lake restoration project, including water level drawdown and rotenone treatment to eradicate common carp, if warranted.

Tables

Table 1. Fish stocked in Big Muskego Lake since 1997 including year stocked, species, age class, number of fish stocked and average length.

Year	Species	Age Class	Number of Fish Stocked	Average Length (Inches)
1997	Northern pike	Large fingerling	1,975	18.0
1997	Northern pike	Small fingerling	34,063	3.6
1997	Panfish	Adult (Field transfer)	16,858	3.5
1997	Northern pike	Small fingerling	1,980	3.7
1997	Northern pike	Fry	388,555	0.2
1997	Yellow perch	Adult (Field transfer)	26,094	6.5
1997	Walleye	Fry	1,700,000	0.3
1997	Largemouth bass	Large fingerling	69,517	1.7
1997	Northern pike	Fry	198,000	0.8
1997	Northern pike	Fry	500,000	0.5
1997	Golden shiner	Adult (Broodstock)	23,400	3.5
1998	Largemouth bass	Small fingerling	49,982	2.0
1998	Northern pike	Fry	800,000	0.3
1998	Northern pike	Small fingerling	9,902	3.3
1998	Panfish	Adult (Field transfer)	34,521	3.0
1999	Largemouth bass	Small fingerling	68,160	1.2
1999	Northern pike	Large fingerling	2,500	7.2
2000	Northern pike	Small fingerling	3,710	3.7
2001	Largemouth bass	Large fingerling	39,250	3.4
2001	Northern pike	Small fingerling	28,332	1.9
2006	Northern pike	Large fingerling	2,500	7.7
2008	Northern pike	Large fingerling	1,761	9.3
2009	Northern pike	Large fingerling	2,500	7.6
2010	Northern pike	Large fingerling	9,516	7.7
2011	Northern pike	Large fingerling	11,554	8.0
2012	Northern pike	Large fingerling	4,389	8.2
2013	Northern pike	Large fingerling	10,717	10.0
2014	Northern pike	Large fingerling	2,500	9.1
2015	Northern pike	Large fingerling	4,519	8.8
2016	Northern pike	Large fingerling	4,828	8.9
2017	Northern pike	Large fingerling	3,950	8.8
2018	Northern pike	Large fingerling	4,389	9.3
2019	Northern pike	Large fingerling	4,828	8.4

Table 2. Catch summary of the 2019 and 2020 spring netting surveys (SNI) of Big Muskego Lake, Waukesha County, WI.

Species	2019		2020	
	Number Sampled	Mean Length (Inches)	Number Sampled	Mean Length (Inches)
Black crappie	10	9.3	7	7.9
Bluegill	65	7.5	49	6.6
Lake chubsucker	4			
Largemouth bass	43	13.8	28	15.2
Muskellunge	1	18.2		
Northern pike	566	21.0	1056	22.4
Pumpkinseed	27	7.6	20	7.2
Walleye	6	21.8		
Warmouth			4	5.7
Yellow perch	30	4.6	2	6.2

Table 3. Northern pike catch statistics from the 2019 and 2020 spring netting surveys (SNI) of Big Muskego Lake, Waukesha County, WI.

Sex	2019			2020		
	Number Sampled	Catch/Net Night	Mean Length (Inches)	Number Sampled	Catch/Net Night	Mean Length (Inches)
Female	184	3.2	23.5	557	10.0	25.2
Male	291	5.1	19.5	493	8.8	19.3
Unknown	91	1.6	20.6	6	0.1	10.6
Total	566	9.9	21.2	1056	18.9	18.4

Table 4. Northern pike catch rates from 2008, 2015 and 2020 spring fyke netting surveys (SNI) of Big Muskego Lake, Waukesha County, WI.

	2008	2015	2020
	Catch/Net Night	Catch/Net Night	Catch/Net Night
Female	1.9	6.9	10.0
Male	5.7	8.7	8.8
Unknown	0.3	1.3	
Total	7.9	16.9	18.8

Table 5. Number of individual northern pike of "stock" and "quality" size and resulting proportional size distribution (PSD), proportional size distribution of "preferred" fish (PSD-P) and proportional size distribution of "memorable" fish (PSD-M). Fish were sampled by fyke net (SNI) in spring 2020.

	Stock	Quality	Preferred	Memorable	PSD	PSD-P	PSD-M
Length (inches)	14	21	28	34			
Year							
2008	1095	479	59	4	44	5	0.4
2015	752	491	128	8	65	17	1
2020	957	550	136	17	57	14	2

Table 6. Catch summary for the 2019 spring electrofishing survey (SEI) of Big Muskego Lake, Waukesha County, WI.

Species	Number Sampled	Average Length	Number/Mile
Black crappie	3	7.4	3.0
Bluegill	19	5.2	19.0
Bowfin	3		3.0
Brown bullhead	5		5.0
Common carp	4		4.0
Golden shiner	2		2.0
Lake chubsucker	7		7.0
Largemouth bass	95	13.6	15.8
Northern pike	38	23.7	6.3
Pumpkinseed	4	6.9	4.0
Warmouth	3	7.7	3.0
Yellow perch	8	4.5	8.0

Table 7. Catch summary of the 2019 spring electrofishing survey (SEII) of Big Muskego Lake, Waukesha County, WI.

Species	Number Sampled	Average Length	Number/Mile
Black crappie	1	9.2	2.0
Bluegill	18	6.7	36.0
Bowfin	2		4.0
Brown bullhead	6		12.0
Golden shiner	2		4.0
Lake chubsucker	6		12.0
Largemouth bass	41	13.7	8.2
Northern pike	9	22.5	1.8
Pumpkinseed	9	7.6	18.0

Walleye	1	22.6	0.2
Warmouth	1	9.7	2.0
Yellow perch	5	7.9	10

Figures

Figure 1. Bathymetric Map of Big Muskego Lake, Waukesha County, Wisconsin.

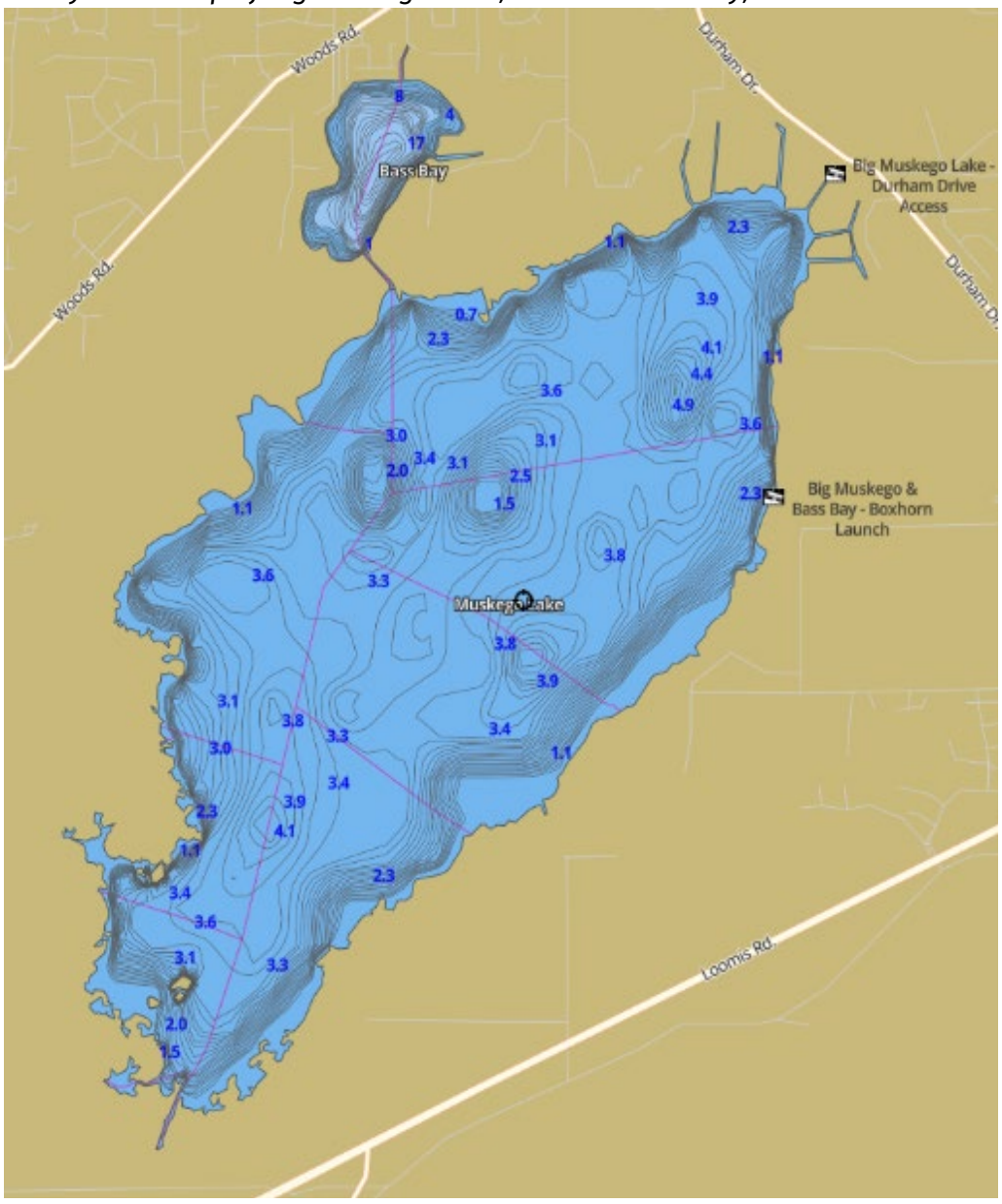


Photo Credit: Nauticalcharts.com

Figure 2. Locations of Fyke nets used in the 2020 spring fyke netting survey (SNI) of Big Muskego Lake, Waukesha County, Wisconsin.

Photo credit: Waukesha County GIS

Figure 3. Length frequency histogram of male and female northern pike sampled during the 2019 spring fyke netting (SNI) survey of Big Muskego Lake, Waukesha County, WI.

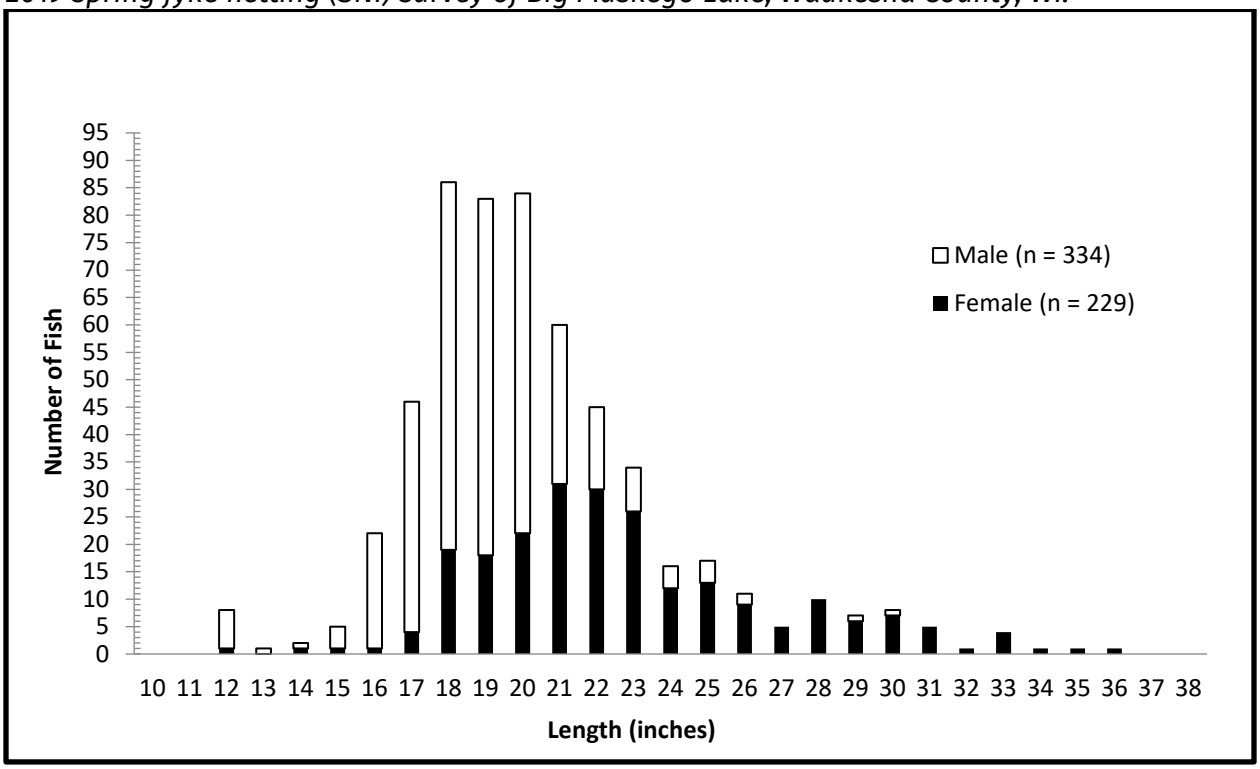


Figure 4. Length frequency histogram of male and female northern pike sampled during the 2020 spring fyke netting (SNI) survey of Big Muskego Lake, Waukesha County, WI.

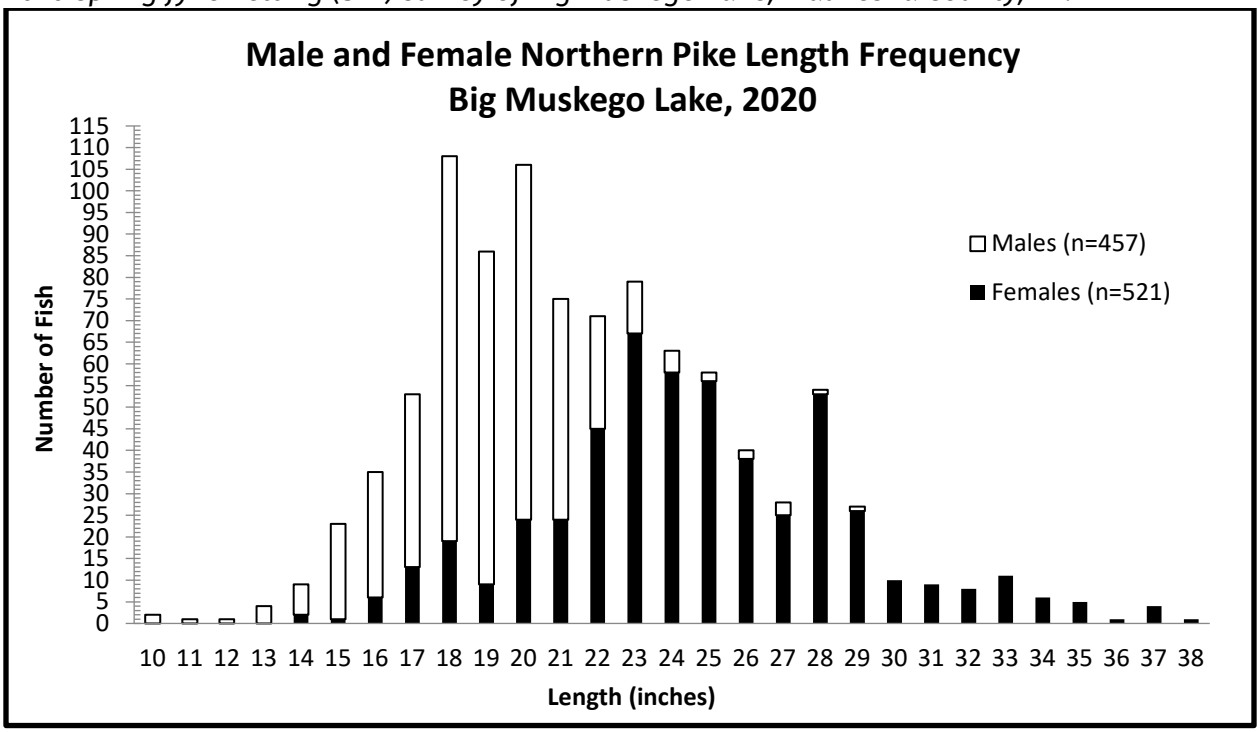


Figure 5. Northern pike length at age determined using anal fin rays collected during the 2019 spring fyke netting survey (SNI) of Big Muskego Lake, Waukesha County, WI.

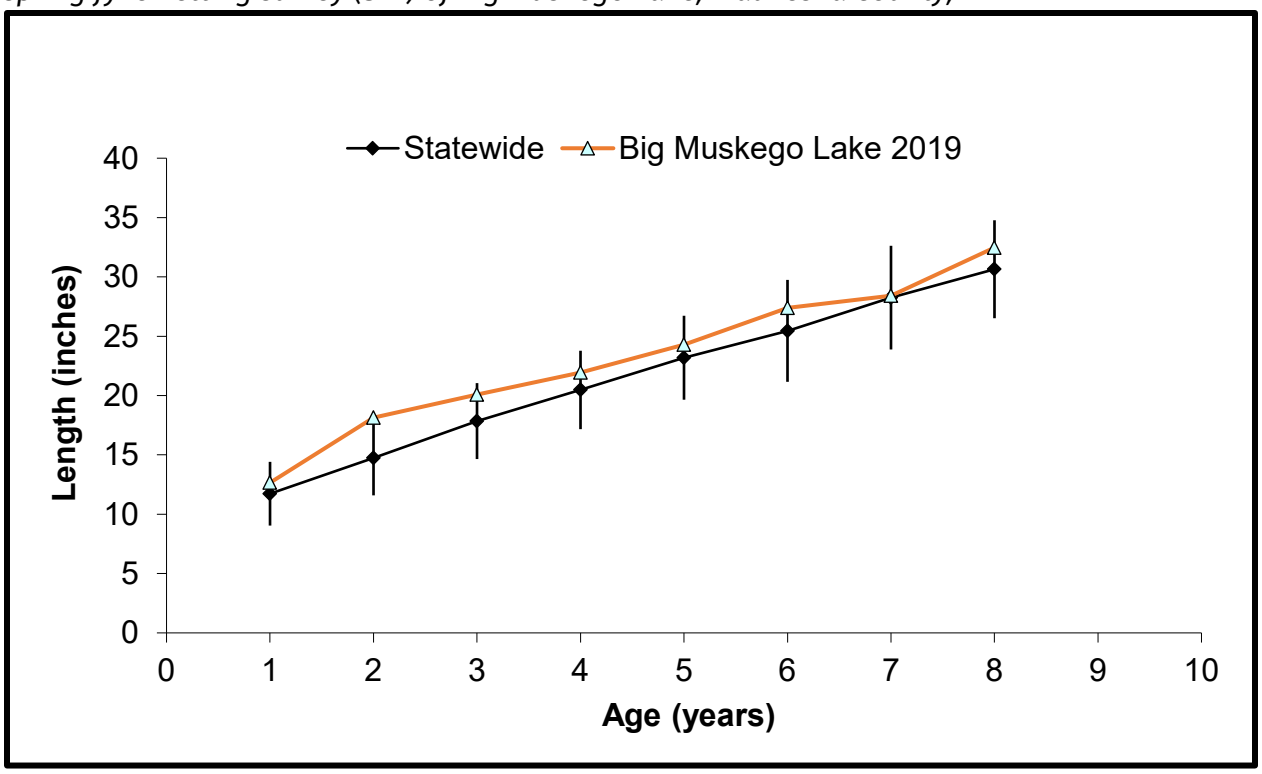


Figure 6. Length-frequency histogram of largemouth bass sampled during the 2019 spring fyke netting survey (SNI) *of Big Muskego Lake, Waukesha County, WI.*

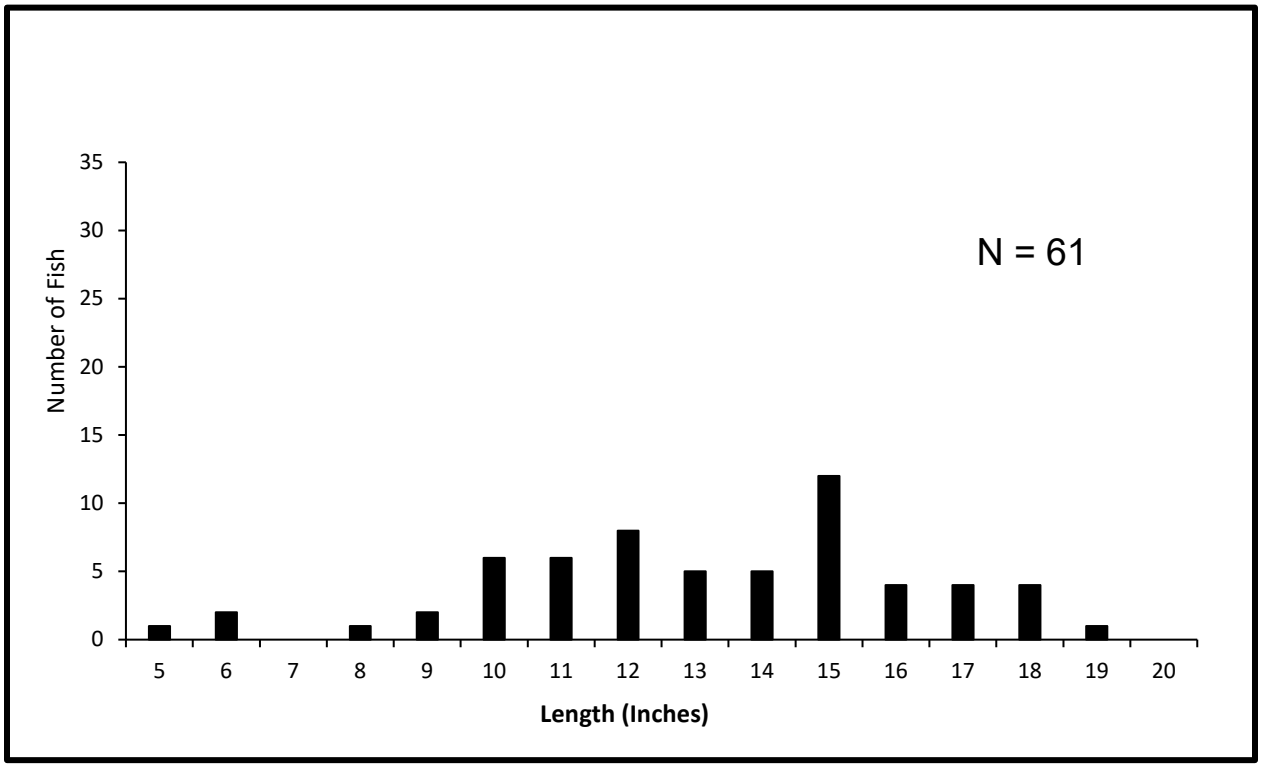


Figure 7: Length-frequency histogram largemouth bass sampled during the 2020 spring fyke netting survey (SNI) of Big Muskego Lake, Waukesha County, WI.

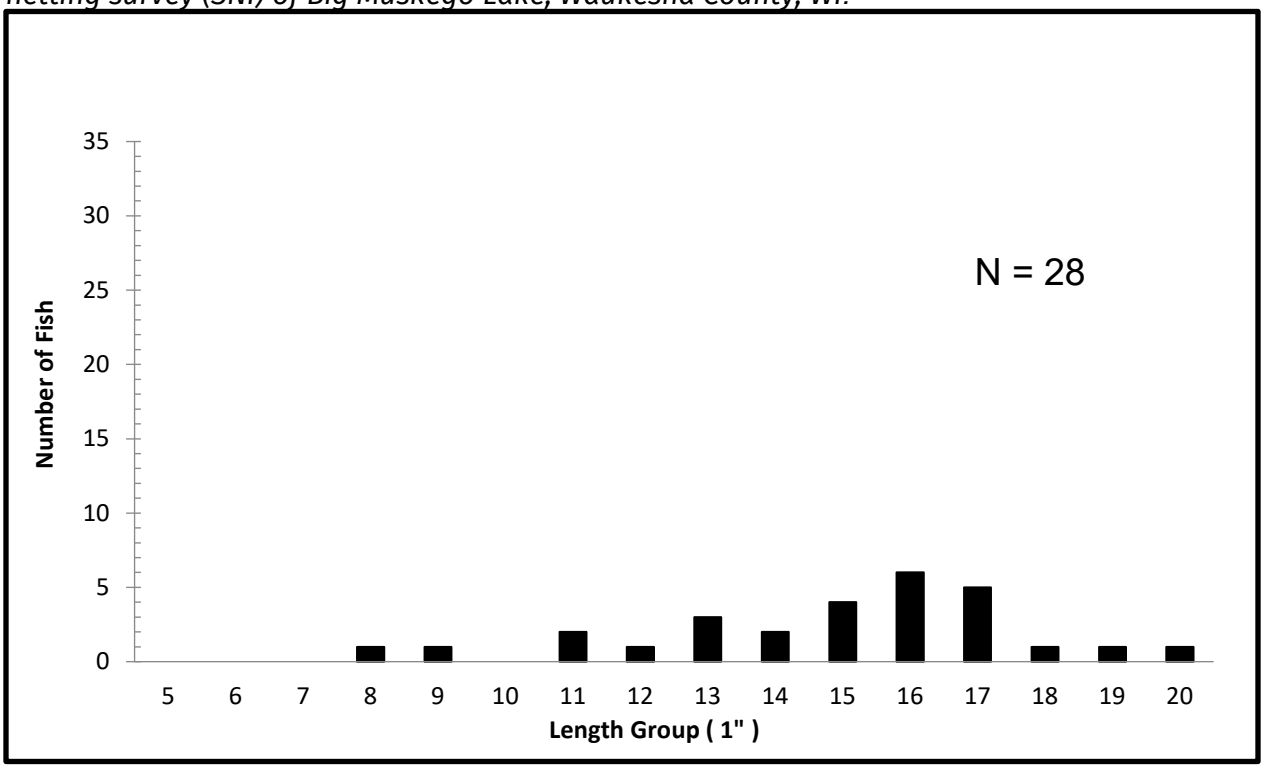


Figure 8: Length-frequency histogram of largemouth bass sampled during the 2019 spring electrofishing survey (SEII) of Big Muskego Lake, Waukesha County, WI.

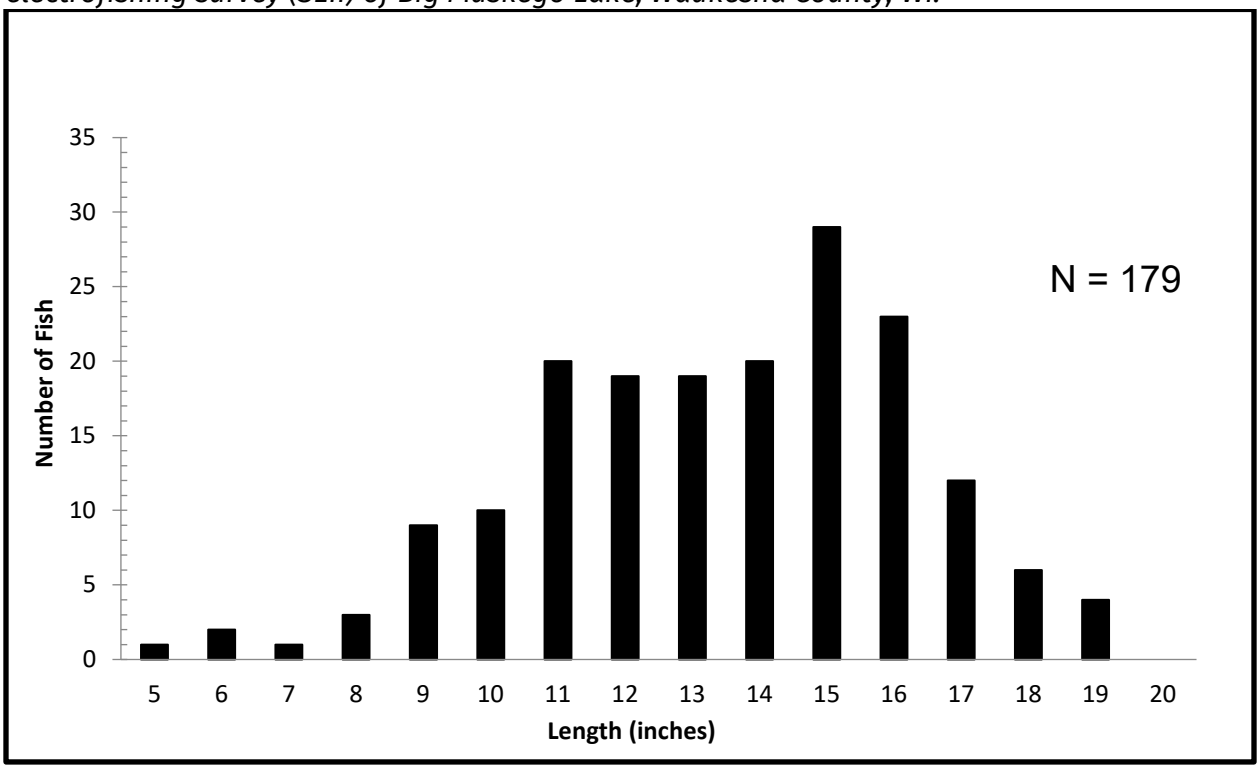


Figure 9. Length-frequency histogram of bluegill sampled during the 2019 spring fyke netting (SNI) survey of Big Muskego Lake, Waukesha County, WI.

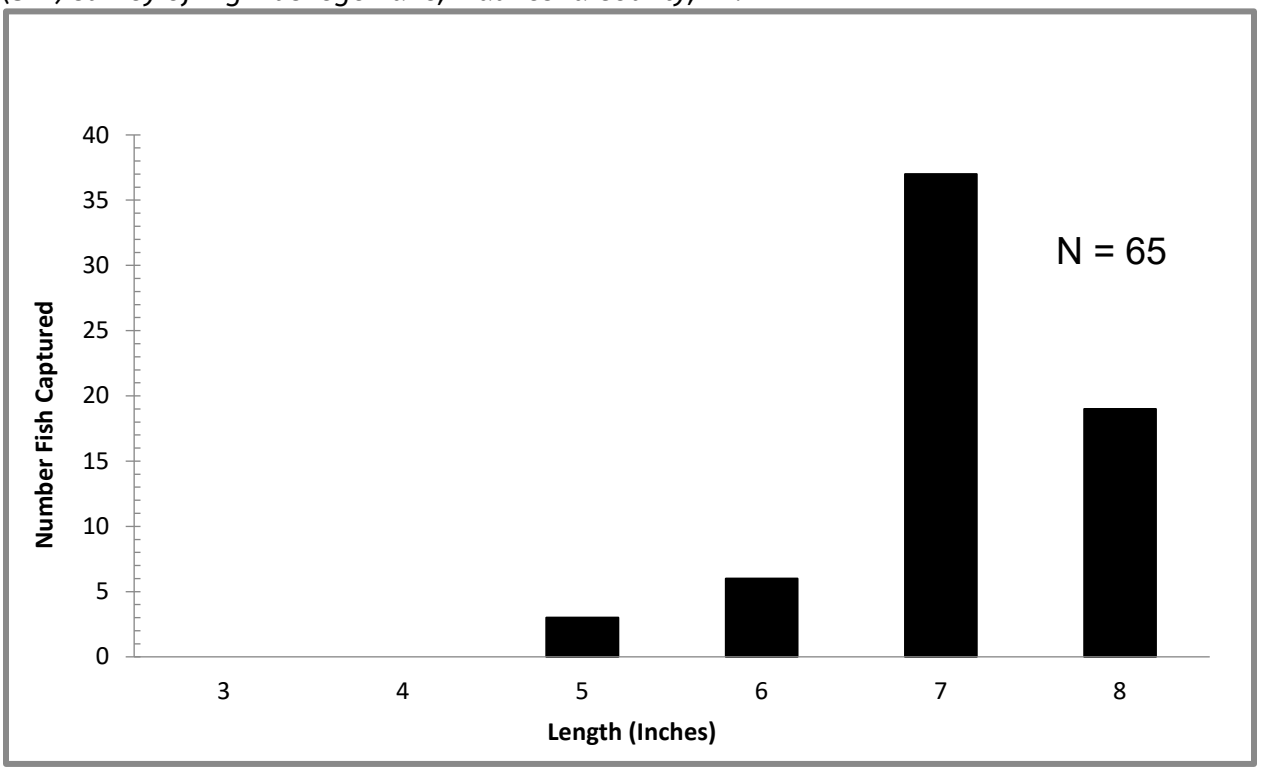


Figure 10. Length-frequency histogram of bluegill sampled during the 2020 spring fyke netting (SNI) survey of Big Muskego Lake, Waukesha County, WI.

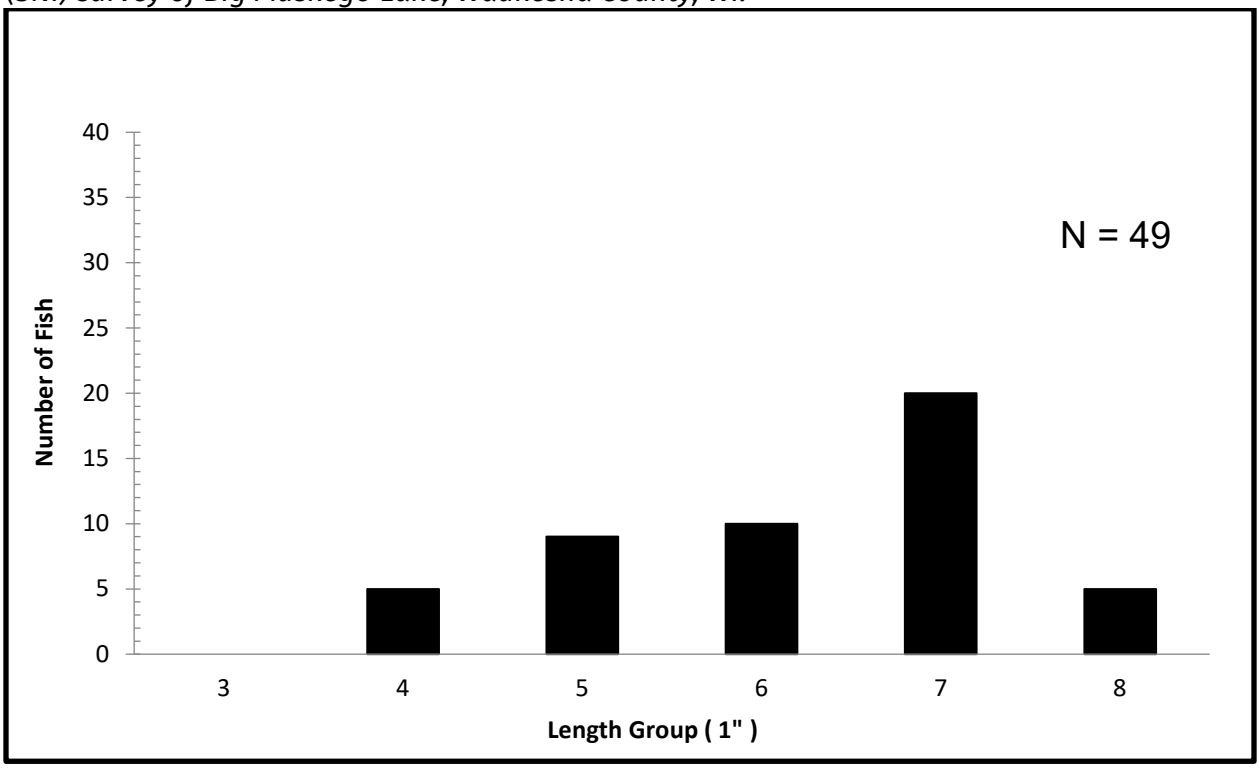


Figure 11. Length-frequency histogram of bluegill sampled during the 2019 spring electrofishing survey (SEII) of Big Muskego Lake, Waukesha County, WI.

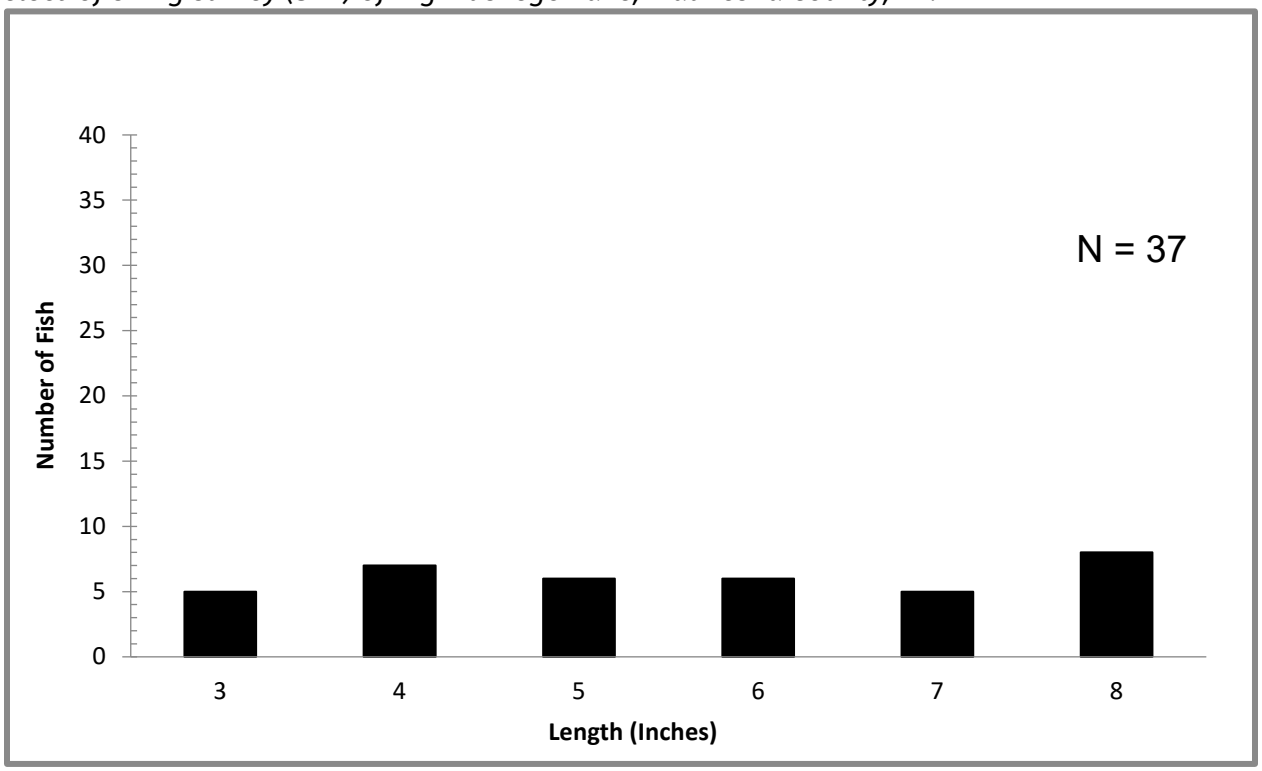


Figure 12. Length-frequency histogram of yellow perch sampled during the 2019 spring fyke netting (SNI) survey of Big Muskego Lake, Waukesha County, WI.

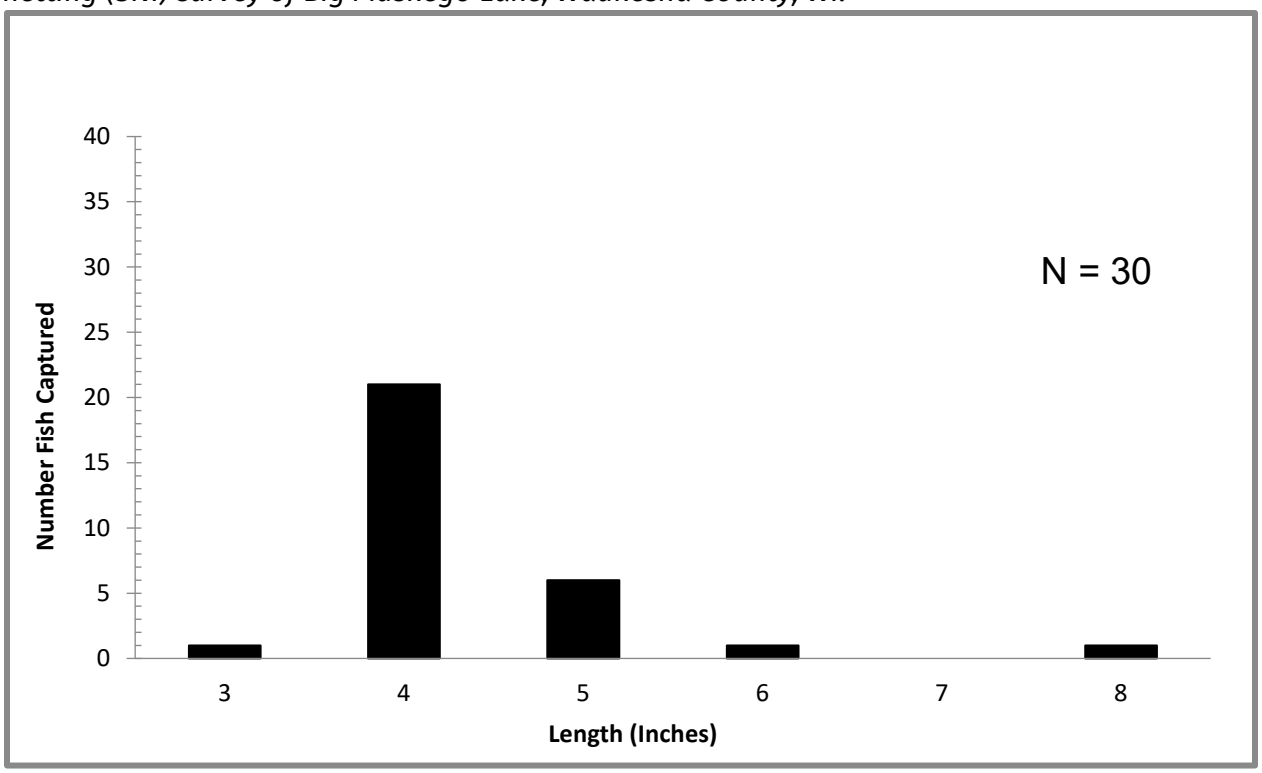


Figure 13. Air photos showing emergent vegetation coverage of Big Muskego Lake during 1990, 2008 and 2022. (Historical air photos provided by WC Land Information Office, WLIP, SEWRPC, Ayres Associates).

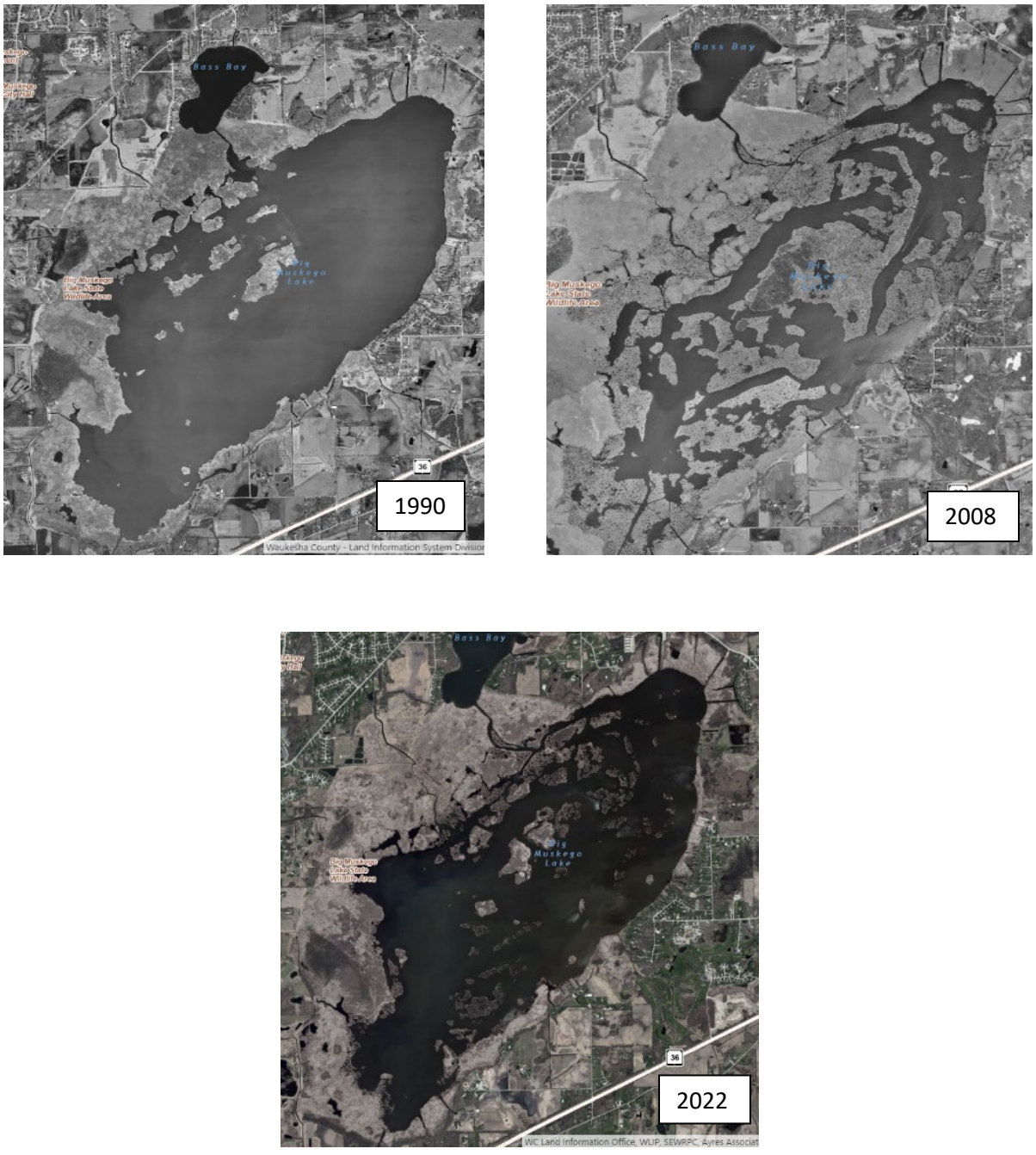


Figure 14. 2020 Hydrograph of Big Muskego Lake, Waukesha County, WI.

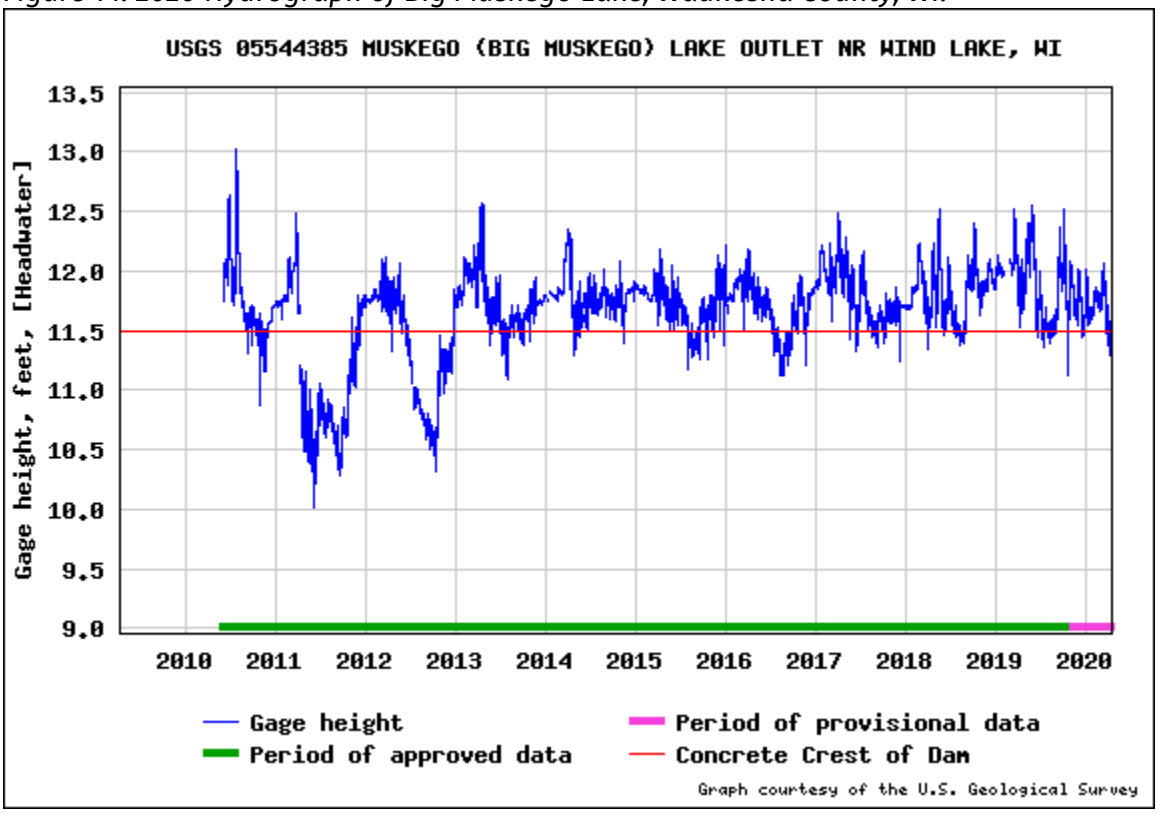


Figure 15. Illuminated and magnified northern pike anal fin cross section used for age estimation.

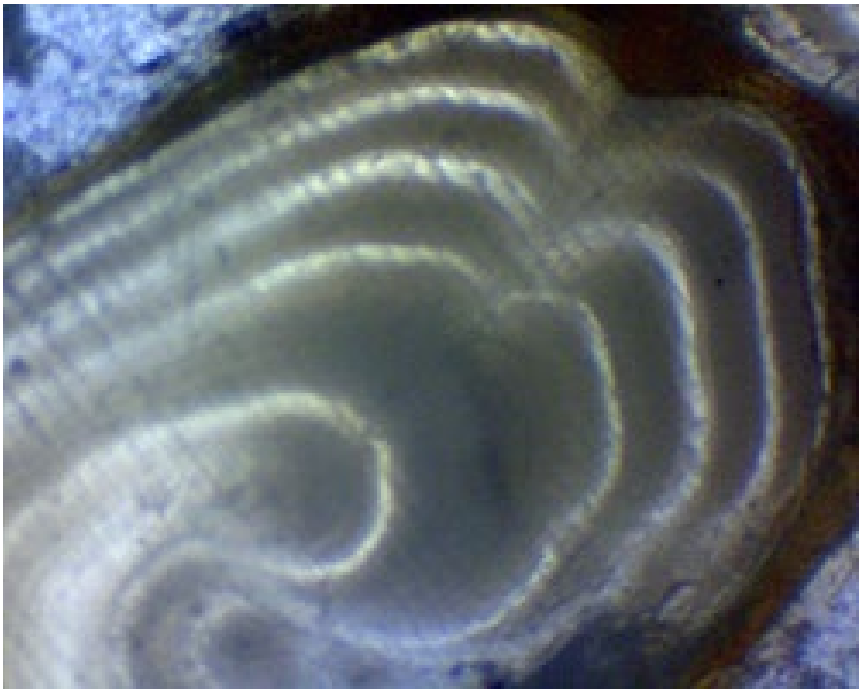


Photo Credit: Wisconsin DNR

Figure 16. Northern pike summer mortality, 2012.

Photo Credit: Wisconsin DNR

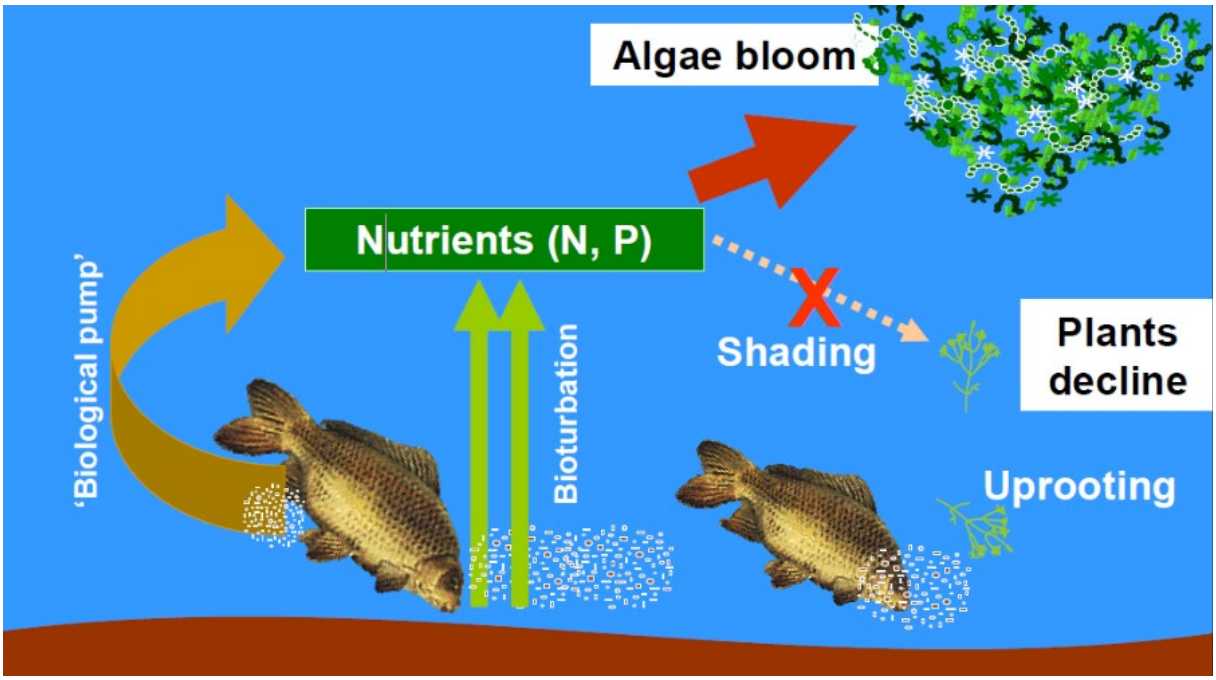
Figure 17. Panfish winterkill, evident during 2014 spring thaw, Big Muskego Lake, Waukesha County, WI.

Photo Credit: Wisconsin DNR

Figure 18. Algae bloom in the summer of 2020, Big Muskego Lake, Waukesha County, WI.

Photo Credit: Greg Burmeister

Figure 19. Negative impacts of common carp on water clarity, aquatic plants, resuspension of solids and internal nutrient loading.



Graphic Courtesy of University of Minnesota – Sorensen Lab Group

Acknowledgments

The field work, data collection, data entry and structure aging required for this report was conducted by DNR Advanced Fisheries Technicians Steven Gospodarek and Tanya Meives and DNR Limited Term Employee Fisheries Technicians Joshua Fluur and Parker Wyngaard. Report reviews and editing was provided by DNR Fisheries Management staff, including Laura Stremick and Tim Simonson.

References

Anderson, R. O. 1980. Proportional stock density (PSD) and relative weight (W_r): interpretive indices for fish populations and communities. Pages 27-33 in S. Gloss and B. Shupp, editors. Practical fisheries management: more with less in the 1980's. Proceedings of the 1st Annual Workshop of the New York Chapter American Fisheries Society

Anderson, R. O. and A. S. Weithman. 1978. The concept of balance for coolwater fish populations. American Fisheries Society Special Publication 11:371-381.

Big Muskego/Bass Bay Protection and Rehabilitation District, City of Muskego, Southeastern Wisconsin Regional Planning Commission, DNR. 2004. Big Muskego Lake and Bass Bay Management Plan

Latzka, A., DNR Fisheries Management Information System (CPUE by Lake Classifications).

Heussner, B.M. 2008. DNR Big Muskego Fisheries Survey Report