Upper Eau Claire Lake Fishery Survey, Bayfield County, Wisconsin, 2017 - 2018

WBIC 2742700

Nathan Klein
Fisheries Technician - LTE
Wisconsin Department of Natural Resources
Northern Region - Brule
July, 2020

Executive Summary

Wisconsin Department of Natural Resources completed a comprehensive fishery survey on Upper Eau Claire Lake from 2017-2018 to obtain a walleye and muskellunge population estimate, assess gamefish and panfish populations and characterize sport and tribal use of the fishery. Sampling followed standardized treaty assessment protocol, including; spring fyke netting, spring and fall electrofishing, and a creel survey. The survey yielded a walleye population estimate of 0.8 adults/acre (sexable fish or ≥ 15 in), which is below the ceded territory average for lakes with a natural recruitment code. Through time, walleye density has decreased, but size structure has shifted towards larger fish. The muskellunge population estimate was 0.15 adults/acre (sexable fish or ≥ 30 in) and showed quality size structure. While the relative abundance of northern pike has decreased, size structure has remained relatively similar. Largemouth bass relative abundance has fluctuated overtime, while size structure has remained similar. Smallmouth bass have remained at low abundance with quality fish present. Bluegill and black crappie relative abundance has decreased, while size structure has improved or remained similar. Total angling pressure during the 2017-2018 fishing season was 16.6 hours/acre, below the ceded territory average of 33.0 hours/acre. Anglers targeted primarily gamefish species, but largemouth bass most frequently, which comprised 21.7% of total directed effort.

Management recommendations include, 1) Re-evaluate current walleye stocking practices after next comprehensive survey but retain current walleye regulations, 2) Continue current muskellunge stocking practices and retain current regulations, 3) Retain current northern pike regulations, 4) Retain current largemouth and smallmouth bass regulations, 5) Retain current panfish regulations, 6) Gather input on angler desires for specific fisheries, 7) Manage

existing Aquatic Invasive Species (AIS), prevent new introductions of AIS, and protect/enhance shoreline habitat and water quality.

Introduction

Upper Eau Claire Lake is a 996-acre drainage lake located in Bayfield County, at the headwaters of a series of interconnected lakes known as the Eau Claire Lakes Chain. It has clear water with a maximum depth of 92 feet and average of 29 feet. Primary nearshore substrates are comprised of sand, gravel and muck. Upper Eau Claire Lake is classified as a complex two-story lake (Rypel et al. 2019) and has three inlets (Smith Lake, Birch Lake and Devils Lake) and one outlet (Eau Claire River). Most of the shoreline is privately owned except for one public boat landing and an island in the northeast portion of the lake. Trophic State Index (TSI; Carlson 1977)) values for secchi, chlorophyll a and total phosphorus indicated the nutrient condition of the lake was near the oligotrophic-mesotrophic divide.

Upper Eau Claire Lake is home to variety of fish species including walleye *Sander vitreus*, muskellunge *Esox masquinongy*, northern pike *E. lucius*, largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, bluegill *Lepomis macrochirus*, pumpkinseed *L. gibbosus*, rock bass *Ambloplites rupestris*, black crappie *Pomoxis nigromaculatus*, yellow perch *Perca flavescens*, white sucker *Catostomus commersoni*, yellow bullhead *Ameiurus natalis*, common shiner *Notropis cornutlus*, spottail shiner *N. hudsonius*, golden shiner *Notemigonus crysoleucas*, bluntnose minnow *Pimephales notatus*, tadpole madtom *Noturus gyrinus*, and cisco *Coregonus artedi*.

Management of Upper Eau Claire Lake by the Wisconsin Department of Natural Resources has included fishery surveys, stocking, regulation changes and habitat improvements.

Surveys targeting walleye following standard treaty assessment protocol occurred in 1993, 2004, 2011 and 2017. Early surveys in 1948 and 1950 reported the presence of walleye, northern pike, largemouth and smallmouth bass, bluegill, black crappie, rock bass, bullheads and suckers. Other surveys in 1961 and 1969 indicated similar results, along with the presence of muskellunge. In 1983, the first comprehensive fish survey was completed reporting the presence of the other species previously listed and included a walleye population estimate and cisco assessment. Since 1983, the Great Lakes Indian Fish & Wildlife Commission (GLIFWC) has conducted two walleye population estimates (1991 and 1999) and walleye recruitment surveys, and the DNR has conducted bass/panfish, walleye recruitment and comprehensive surveys. Currently, Upper Eau Claire Lake is part of a largemouth bass/walleye interaction project investigating the population dynamics following aggressive experimental walleye stocking, more conservative walleye regulations changes and liberal largemouth bass regulation changes.

Stocking efforts in Upper Eau Claire lake have focused on walleye and muskellunge. From the late 1930's to 1950's, a myriad of species were stocked including: largemouth bass, bluegill, black crappie, walleye and muskellunge. Since 1982, only walleye, muskellunge and rainbow trout have been stocked (Table 1), however rainbow trout stocking was discontinued due to poor survival and return to creel (Sand 2007). Walleye and muskellunge stocking efforts have continued and are currently being stocked semi-annually.

Size and bag limits for northern pike, muskellunge and panfish have followed statewide regulations. Walleye size and bag limits also followed the statewide regulations until 2015 when an 18" minimum and a bag of three was established to further protect the adult walleye stock. Largemouth and smallmouth bass size and bag limits followed the statewide regulations until 2016, when a no minimum length and a combined bag of five bass in total was put into place.

Then, in 2019, the smallmouth bass regulation changed to an 18” minimum and a daily bag of one to protect and promote the trophy potential of the population.

Various habitat improvements have also been done on Upper Eau Claire Lake by the WDNR and Eau Claire Lakes Conservation Club. Fish cribs were installed in the late 1980’s and again in 2007, groups of six fish cribs were placed in two locations. Also, in 2007 an artificial rock spawning reef was constructed in Upper Eau Claire Lake. In 2009 and 2010, trees or ‘fish sticks’ were installed into the lake along the state-owned island and multiple private properties to increase the coarse woody habitat.

The objectives of the 2017-2018 survey were to determine the status of the walleye and muskellunge populations, along with sport and tribal use of the fishery. We also were able to determine population parameters of other gamefish and panfish species present in Upper Eau Claire Lake.

Methods

Upper Eau Claire Lake was sampled during 2017-2018 following the Wisconsin Department of Natural Resources comprehensive treaty assessment protocol (Cichosz 2019). These efforts included an early spring fyke netting and electrofishing survey to assess walleye, muskellunge, and northern pike populations, a late-spring electrofishing survey to assess bass populations, a fall electrofishing survey to assess gamefish recruitment, and a creel survey to document recreational pressures on these populations. Sampling in 2018 consisted of late spring fyke netting to complete the adult muskellunge population estimate. Fall walleye recruitment surveys were also conducted in 2018 and 2019.

The adult walleye population estimate was a two-stage, mark-recapture effort conducted in 2017. Walleye were captured for marking in the spring shortly after ice out with fyke nets. Each fish was measured (total length; inches and tenths) and fin-clipped. Walleyes were considered adults if the sex could be determined, or if the individual was 15 inches or longer (received a right ventral clip). Walleyes of unknown sex less than 15 inches in length were classified as juveniles (received a top caudal clip). To estimate adult density, walleyes were recaptured 1-2 days after netting. All walleyes in the recapture event were measured and examined for marks.

The adult muskellunge population estimate was a two-stage, mark-recapture effort conducted in 2017 and 2018. Muskellunge were captured for marking during fyke netting and electrofishing efforts throughout the sampling season in 2017, including late spring fyke netting targeting spawning muskellunge. Each fish was measured (total length; inches and tenths), weighed (lbs.) and fin-clipped. Muskellunge were considered adults if the sex could be determined, or if the individual was 30 inches or longer (received a right ventral clip and tagged with a passive integrated transponder (PIT) tag. Muskellunge of unknown sex less than 30 inches were considered juveniles (received a top caudal clip). To estimate abundance, muskellunge were recaptured in 2018 using fyke nets set during muskellunge spawning. All muskellunge in the recapture were measured, weighed and examined for marks and PIT tags.

Population estimates were calculated with the Chapman modification of the Petersen Estimator using the equation:

$$N = \frac{(M+1)(C+1)}{(R+1)}$$

where N is the population estimate, M is the total number of marked fish in the lake, C is the total number of fish captured in the recapture sample, and R is the total number of marked fish

captured. Abundance and variance were estimated by the total for walleye that were ≥ 15 inches or sexable and for muskellunge that were ≥ 30 inches or sexable.

To assess other populations in the fishery, catch-per-unit-effort (CPUE) was used to index relative abundance, and individuals were measured to characterize size structure during targeted surveys. More specifically, northern pike were targeted during early spring fyke netting, bass and bluegill populations were targeted during late-spring electrofishing, and black crappie were targeted during spring netting surveys. Lake Class Standard CPUE percentiles were calculated by comparing Upper Eau Claire CPUEs for each species to the CPUEs of the other complex cool clear Wisconsin lakes (Rypel et al. 2019).

Walleye age and growth were determined from dorsal spine cross sections viewed microscopically at 100X (Margenau 1982). Walleye growth rates were compared to the average of the 18 counties in the northern district (ND). Size structure quality of species sampled was determined using the indices proportional (PSD) and relative (RSD) stock densities (Anderson and Gutreuter 1983). More specifically, the PSD/RSD value for a species is the number of fish of a specified length and longer divided by the number of fish of stock length or longer, the result multiplied by 100 (Appendix 1). Shifts in walleye density over time were assessed using linear regression.

Creel surveys used a random stratified roving access design (Beard et al. 1997; Rasmussen et al. 1998). The survey was stratified by month and day-type (weekend / holiday or weekday), and the creel clerk conducted interviews at random within these strata. The survey was conducted on all weekends and holidays, and a randomly chosen two or three weekdays. The clerk recorded effort, catch, harvest, and targeted species from anglers completing their

fishing trip. The clerk also measured harvested fish and examined them for fin-clips (given during field surveys).

Results

Total survey effort in 2017 included 75 fyke net lifts targeting spawning walleye and 26 fyke net lifts targeting spawning muskellunge. Three electrofishing surveys of the entire shoreline were conducted totaling 8.4 hours in the spring (walleye recapture and targeted bass/panfish surveys) and 3.6 hours in the fall (walleye recruitment survey). Survey effort in 2018 included 94 fyke net lifts targeting spawning muskellunge. Fall recruitment surveys from 2018 and 2019 are also included.

Walleye. In 2017, the adult walleye population estimate (sexable or ≥ 15 inches) was 765 (0.8 adults/acre) and the male to female ratio was 1:3. Adult walleye ranged in length from 13.9 to 27.5 in. and averaged 21.5 in. (SD = 3.6, N = 104). PSD and RSD-20 values were 95 and 70, respectively. Adult ages ranged from 3 to 14 and individuals matured at age 3 and 4 (males, females, respectively; Figure 3). Overall, the 2017 survey data show that adult walleye abundance has increased slightly since the last survey but overall has decreased significantly since 1983 ($r^2 = 0.68$, $p = .02$; Figure 1). Size structure has shifted toward larger fish (Figure 2), although growth rates have remained similar to northern region averages (Figure 4).

Upper Eau Claire natural walleye recruitment is highly variable, but is nonetheless, documented in every fall recruitment survey conducted. Recent recruitment levels are similar to historical averages for age-0 walleye (7.8/mile, SD = 8.5, N = 31, Figure 5) and age-1 walleye (1.3/mile, SD = 1.3, N = 31, Figure 5).

Muskellunge. In 2017, the adult muskellunge population estimate (sexable or ≥30 in) was 153 (0.15/acre, Figure 6). In 2017, 58 adult muskellunge were marked and in 2018, 38 muskellunge were captured, of which 14 were recaptures from the previous year. In 2017 and 2018 combined, adult muskellunge were captured at a rate of 0.49 fish/net lift placing it in the 50th percentile for complex two-story Wisconsin lakes. Adult muskellunge ranged in length from 26.7 to 50.0 in. and averaged 38.4 in. (SD = 5.9, N = 96). Compared to historic surveys, density (#/acre), relative abundance (CPUE), and size structure is relatively consistent (Table 3, Figure 7).

Northern Pike. During the 2017 spring netting survey, northern pike were sampled at a rate of 0.9 fish/net lift putting it slightly below the 50th percentile for complex two-story Wisconsin Lakes. A total of 64 northern pike ranged in length from 6.6 to 40.2 in. and averaged 18.9 in. (SD = 7.4, N = 64). In comparison to historic surveys, CPUE has decreased slightly while average length has fluctuated (Table 4). Size structure, PSD and RSD-28 has remained similar throughout the surveys (Table 4).

Largemouth and Smallmouth Bass. During the 2017 spring electrofishing survey largemouth bass outnumbered smallmouth bass at a ratio of 4:1. Largemouth bass were sampled at a rate of 6 fish/mile placing it between the 50th and 75th percentile for complex two-story Wisconsin lakes. A total of 66 largemouth bass were measured which ranged in length from 4.2 to 15.7 in. and averaged 12.6 in. (SD = 2.6, N = 66). Compared to historic surveys CPUE has fluctuated (Figure 8), although average length and size structure has remained relatively similar (PSD and RSD-15; Table 5). Smallmouth bass were sampled at a rate of 1.4 fish/mile putting in between the 25th and 50th percentile for complex two-story Wisconsin lakes. A total of 16 smallmouth bass were measured which ranged in length from 6.2 to 19.4 in. and averaged 10.6

in. (SD = 3.7, N = 16). Compared to historic surveys CPUE has remained relatively consistent (Figure 8).

Panfish. During the 2017 spring electrofishing survey, bluegills were sampled at a rate of 22 fish/mile placing it slightly above the 25th percentile for complex two-story Wisconsin lakes. A total of 33 bluegills ranged in length from 4.1 to 8.3 in. and averaged 5.9 in. (SD = 1.1, N = 33). Compared to 2011 spring electrofishing data, CPUE decreased, and average length and size structure increased (Table 6). During the 2017 spring netting survey, black crappies were sampled at a rate of 1.9 fish/net lift placing it between the 50th and 75th percentile for complex two-story Wisconsin lakes. A total of 141 black crappie were measured which ranged in length from 2.7 to 12.8 in. and averaged 6.5 in. (SD = 2.1, N = 141). Compared to 2011 spring netting data, CPUE has decreased, average length has increased, PSD has decreased and RSD and has increased (Table 7). Other panfish species sampled in 2017 include yellow perch, rock bass and pumpkinseed.

Sport and Tribal Fishery. Anglers fished for an estimated 16,538 hours (16.6 hours/acre) during 2017-2018 on Upper Eau Claire Lake, which decreased compared to angling pressure from 1993-1994 (21.4 hours/acre) and 2004-2005 (20.6 hours/acre) fishing seasons. The 2017-2018 projected fishing pressure was lower than the Bayfield County lake average (24.1 hours/acre) and the Ceded Territory lake average (33.0 hours/acre; Creel Survey Report, WDNR).

Walleye were the fourth most targeted gamefish species on Upper Eau Claire Lake in 2017-2018 with 14.0% of directed effort, or 3,315 hours, metrics that have decreased every survey year (Table 8). An estimated 425 walleyes were caught during the 2017-2018 fishing season of which an estimated 131 were harvested (Figure 9), ranging in length from 18.0 to 26.5

in. Tribal harvest accounted for 97 walleyes in 2017, which ranged in length from 12.4 to 25.4 in. Tribal harvest and sport angling represented 12.7% and 17.1% of the adult stock, respectively.

Muskellunge was the third most targeted gamefish on Upper Eau Claire Lake in 2017-2018 with 14.4% of directed effort, a metric that has increased every survey year. Species specific directed effort for muskellunge was 3,408 hours, a metric that has not increased (Table 8). Anglers caught an estimated 74 muskellunge, none of which were harvested. Tribal harvest accounted for three muskellunge in 2017, ranging in length from 42.2 to 47.0 in.

Northern pike was the second most targeted gamefish on Upper Eau Claire Lake in 2017-2018 with 19.3% of directed effort or 4,550 hours, which have remained relatively consistent compared to previous surveys. During 2017-2018, anglers caught an estimated 2,339 northern pike and harvested a projected 294 individuals (Figure 9).

Largemouth bass was the most sought-after gamefish species on Upper Eau Claire Lake during 2017-2018 with a directed effort of 5,126 hours (21.7% of total effort), metrics that have increased every survey year (Table 8). During 2017-2018, an estimated 2,339 largemouth bass were caught and 294 harvested (Figure 9).

Smallmouth bass was the least targeted gamefish species on Upper Eau Claire Lake during 2017-2018 with 7.8% or 1,848 hours of directed effort (Table 8). During 2017-2018, an estimated 690 smallmouth bass were caught and 39 harvested (Figure 9).

Anglers targeting panfish during 2017-2018 fished for an estimated 5,371 hours or 22.7% of the total directed effort. Bluegill were the most sought-after panfish species with 11.7% directed effort, which has decreased slightly when compared to previous surveys (Table 8). During 2017-2018, an estimated 10,090 bluegill were caught and 1,851 harvested (Figure 10).

Black crappie were the second most targeted panfish species on Upper Eau Claire Lake during 2017-2018 with 8.9% directed effort, an increase when compared to previous surveys (Table 8). An estimated 823 black crappies were caught and 442 harvested (Figure 10). Yellow perch, pumpkinseed and rock bass were all minor components of the panfish fishery (Table 8).

Discussion

Despite concentrated management efforts, Upper Eau Claire's walleye fishery has declined throughout the survey years. Recent survey results show that adult walleye densities remain at low levels, but size structure trending towards higher quality. The increase in growth and size structure is not surprising, as research has shown density dependent growth in ceded territory walleye (Sass et al. 2004). Anglers have also likely responded to the change in walleye densities as they have reduced their targeted effort toward the species. The Upper Eau Claire walleye population has always been at low densities, but we documented a sharp decline in adult density in 2011 despite substantial natural recruitment in the early 2000's. Since then, more restrictive angling regulations and intensive stocking efforts have not been able to improve adult walleye densities or induced significant natural recruitment. While minimal background natural recruitment exists, research has shown that supplemental walleye stocking can result in minimal returns (Jennings et al. 2005), which could be the case for Upper Eau Claire. Walleye genetics should be collected during the next survey to better understand the proportion of stocked fish. The current walleye regulation (18" minimum length limit and a bag of three fish) seems to be doing an adequate job of protecting the adult population but also allowing a harvest opportunity for anglers. Thus, the current walleye regulation should be retained. The next comprehensive

survey is scheduled for 2023, which should provide ample time to better assess longer-term stocking success, regulation efficacy and angler efforts.

Upper Eau Claire Lake has maintained a low-density muskellunge population over time. The 2017 survey results indicate an increase in muskellunge abundance to 0.15 adults/acre. The increase in abundance has shown no impacts on size structure. Muskellunge in Upper Eau Claire Lake has always exhibited quality size structure, which could be due to the presence of cisco as research has shown the presence of cisco to have positive impacts on muskellunge average length and size structure (VanderBloemen et al. 2020). Upper Eau Claire Lake's current muskellunge population appears to be mainly supported by stocking, consistent with what was previously reported (Sand 2007). Ideal muskellunge spawning habitat could be limiting natural reproduction, research has shown muskellunge reproduction is higher in lakes with more aquatic vegetation, soft organic substrates and woody habitat (Rust et al. 2002), three habitat types that are not abundant in Upper Eau Claire Lake. Muskellunge may also be travelling to adjacent lakes with more ideal spawning habitat to reproduce. Research done on the Manitowish Chain of Lakes in Vilas County, WI, showed that around half of the tagged muskellunge travelled to different lakes during the study (Weeks and Hansen 2009). Survey data also supports this, two muskellunge tagged in Middle Eau Claire Lake were captured in Upper Eau Claire Lake in 2017. The origin and movement of muskellunge in Upper Eau Claire Lake is something that could be investigated further in the future. Origin of muskellunge was evaluated during the 2017 survey, but the results were unclear. Out of the 58 muskellunge collected only 17 had recognizable hatchery clips. This estimate is believed to be underestimating the proportion of stocked fish due to fin regeneration and unrecognizable clips. To reevaluate this in the future, stocked muskellunge could be given PIT tags and/or genetics should be taken on adults. Currently,

muskellunge regulations are doing an adequate job of protecting the species as we continue documenting good numbers and quality size in the population. As the muskies continue to become a more important component of the overall fishery, managers should monitor directed effort carefully. Increases in directed effort could increase hooking/release mortality, and 50% of the population is estimated to be caught each year, already. This is a topic not well researched but should be better understood to further protect the species, especially in cases where muskellunge fisheries are becoming more popular. However, the increase in directed effort (% of total angling effort) for muskellunge on Upper Eau Claire Lake is likely due to decreased directed effort towards other species, as directed effort hours for muskellunge has not increased. Unless angler harvest practices change, the current muskellunge regulations should be kept in place.

Northern pike continues to be a popular gamefish species among anglers on Upper Eau Claire Lake, despite the population being at relatively low abundances. While lower pike densities have been associated with improved size structure (Oele et al. 2016; Pierce et al. 2003), the size structure remains mediocre on Upper Eau Claire. Although the fishery does not provide a great opportunity for average size, it does provide a trophy opportunity. Future work should attempt to profile pike anglers and investigate whether anglers are after quality or trophy opportunities; a regulation change could be explored to tailor to angler motivations while still protecting the species.

Largemouth bass continue to increase in popularity among anglers on Upper Eau Claire Lake. Anglers have likely responded to harvest opportunities provided by recent regulation changes or have discovered this quality largemouth bass fishery, which has resulted in increased directed effort and harvest of the species. While recent survey data show largemouth bass have

decreased in abundance, size structure has increased slightly. Despite the decrease in abundance, largemouth bass CPUE was still between the 50th and 75th percentile when compared to similar Wisconsin lakes. The spike in relative abundance of largemouth in 2016, could have been a result of course woody habitat introduction in 2009 and 2010. Largemouth bass have been found to nest around or near coarse woody habitat in high densities (Lawson et al. 2011), thus the higher quality spawning areas could have led to the increase in abundance. The recent large decrease in relative abundance in 2017 could have been from the regulation change in 2016, which opened harvest opportunities. Creel survey data show that largemouth bass directed effort has been steadily increasing and estimated harvest increased over 300% while catch remained similar when comparing 2004 to 2017. These results show that anglers have taken advantage of the harvest opportunity from the recent regulation change. Following the completion of the bass/walleye study, anglers should be profiled to discover their desires for the bass fishery. The slight increase in size structure could also be associated with course woody habitat, coarse woody habitat has also been shown to increase forage abundance and growth potential of largemouth bass (Ahrenstorff et al. 2009). The current largemouth bass regulations (no minimum length and a bag limit of five fish) should stay in place unless overall fish community management directions shift.

Smallmouth bass have remained at relatively low abundances throughout the survey years, in both fish and creel surveys. Quality fish are still present in the low-density population. Coarse woody habitat could potentially increase smallmouth bass abundance, as it has been shown to benefit smallmouth bass reproduction (Hunt and Annett 2002). The regulation change in 2016 to no minimum length limit, had no detectable impact on catch or harvest of smallmouth bass in 2017, further exemplifying the low abundance of smallmouth bass. The new smallmouth

bass regulation (18" minimum length limit and a bag of one fish) could reduce the already low harvest rate but should definitely protect the existing size structure.

Panfish are a minor component of Upper Eau Claire Lake's fishery. Recent survey data show that bluegill and black crappie have decreased in abundance. Bluegill size structure has improved but remains likely undesirable to most anglers. Research has shown that lower densities of bluegills lead to faster growing and larger fish (Tomcko and Pierce 2005; Wiener and Hanneman 1982), something that could occur if bluegill densities in Upper Eau Claire remain low. Even though black crappies have decreased in relative abundance, they are still above the 50th percentile for similar Wisconsin Lakes. The decrease in black crappie relative abundance has not led to an increase in size structure. Anglers targeting black crappie however, didn't see the decrease in abundance, as they had a higher catch rate in 2017 compared to 2004. With low fishing pressure, the current panfish regulations should be kept in place, unless there are dramatic shifts in the populations.

Summary and Management Recommendations

1. Walleye abundance in Upper Eau Claire Lake has decreased through time, but size structure has improved. Stocking of large fingerling walleye should continue in alternate years but be re-evaluated after the next comprehensive fishery survey is completed and genetic samples are analyzed to better understand the contribution of stocked fingerlings. The current walleye regulation (18" minimum length, and a bag of 3) should be retained.
2. The muskellunge population in Upper Eau Claire Lake has remained stable, but at a relatively low density. Stocking of muskellunge should continue in alternate years, as it appears stocking is the main supporter of this popular sport fishery. Multiple stocked

year classed should be given PIT tags to better understand muskellunge origins (stocked vs natural), evaluate growth, mortality and movement throughout the Eau Claire Lakes Chain. Alternatively, muskellunge genetics could also be evaluated to better understand recruitment dynamics. The current regulation (40" minimum length and a bag of 1) should be retained.

3. Northern pike abundance has remained low with a mediocre size structure, and angling pressure has remained consistent. The current northern pike regulation (no minimum length and a bag of five) should be kept in place but anger interests should be profiled to better understand their desires. However, if northern pike abundance and size structure don't improve, a more restrictive regulation could be considered.
4. Largemouth bass continue to increase in popularity with anglers, while abundance has recently decreased. The current largemouth bass regulation should be kept in place unless desired fish community management efforts shift. Smallmouth bass continue to be present in Upper Eau Claire Lake at low abundances and have low angling pressure. The current smallmouth bass regulations should be kept in place.
5. Panfish are a minor component of Upper Eau Claire Lake's fishery and recent surveys have shown a decrease in abundance. The current panfish regulations should be kept in place unless abundances continue to decrease, and angling pressure increases.
6. Gather input on angler preferences regarding desires for specific fisheries during the next comprehensive fishery survey. (i.e. Trophy, Harvest Opportunity, Action, Combination)
7. Efforts to maintain and improve habitat, water quality and shoreline integrity should be encouraged. Invasive species should be monitored, controlled and prevented it at all possible.

References

Ahrenstorff, T. D., G. G. Sass, and M. R. Helmus. 2009. The influence of littoral zone coarse woody habitat on home range size, spatial distribution, and feeding ecology of largemouth bass (Micropterus salmoides). Hyrdobiologia 623:223–233.

Anderson, R. O., and S. J. Gutreuter. 1983. Length, weight, and associated structural indices. Pages 283-300 in L. Nielson and D. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Beard, T. D., Jr., S. W. Hewett, Q. Yang, R. M. King, and S. J. Gilbert. 1997. Prediction of angler catch rates based on walleye population density. North American Journal of Fisheries Management 17: 621-627.

Carlson, R. 1977. A trophic state index for lakes. Limnology and Oceanography 22: 361 – 369.

Cichosz, T. A. 2019. Wisconsin Department of Natural Resources 2017-2018 Ceded Territory Fishery Assessment Report. Wisconsin Department of Natural Resources. Administrative Report #91, Madison, WI.

Hunt, J., and C. A. Annett. 2002. Effects of habitat manipulation on reproductive success of individual largemouth bass in an Ozark reservoir. North American Journal of Fisheries Management 22:1201–1208.

Jennings, M.J., J.M. Kampa, G.R. Hatzenbeler and E.E. Emmons. 2005. Evaluation of supplemental walleye stocking in northern Wisconsin lakes. North American Journal of Fisheries Management. 25:1171-1178.

Lawson, Z. J., J. W. Gaeta, and S. R. Carpenter. 2011. Coarse woody habitat, lakeshore residential development, and largemouth bass nesting behavior. North American Journal of Fisheries Management 31:666-670.

Margenau, T. L. 1982. Modified procedure for aging walleye by dorsal spine sections. Progressive Fish-Culturist 44:204.

Oele, D. L., A. L. Rypel, J. Lyons, P. Cunningham and T. Simonson 2016. Do Higher Size and Reduced Bag Limits Improve Northern Pike Size Structure in Wisconsin Lakes? North American Journal of Fisheries Management. 36:5, 982-994.

Pierce, R. B, C. M. Tomcko, and T. L. Margenau. 2003. Density Dependence in Growth and Size Structure of Northern Pike Populations. North American Journal of Fisheries Management 23: 331-339.

Rasmussen, P. W., M. D. Staggs, T. D. Beard, Jr., and S. P. Newman. 1998. Bias and confidence interval coverage of creel survey estimators evaluated by simulation. Transactions of the American Fisheries Society 127: 460-480.

Rust, A. J., J. S. Diana, T. L. Margenau, and C. J. Edwards. 2002. Lake Characteristics Influencing Spawning Success of Muskellunge in Northern Wisconsin Lakes. North American Journal of Fisheries Management. 22: 834-841.

Rypel, A. L., T. D. Simonson, D. L. Oele, J. D. T. Griffin, T. P. Parks, D. Seibel, D, C. M. Roberts, S. Toshner, L. S. Tate. and J. Lyons. 2019. Flexible Classification of Wisconsin Lakes for Improved Fisheries Conservation and Management. Fisheries, 44: 225-238.

Sand, C. 2007. Investigational Review of Walleye and Muskellunge Management in Upper Eau Claire Lake, Bayfield County, 1983 – 2006. WBIC Code (2742700). Wisconsin Department of Natural Resources, Brule, WI.

Sass, G. G., Hewett, S.W., Beard Jr., T. D., Fayram, A. H., and Kitchell, J. F. 2004. The Role of Density Dependence in Growth Patterns of Ceded Territory Walleye Populations of Northern Wisconsin: Effects of Changing Management Regimes. North American Journal of Fisheries Management, 24:4, 1262-1278

Tomcko, C. M, and R. B. Pierce. 2005. Bluegill Recruitment, Growth, Population Size Structure, and Associated Factors in Minnesota Lakes, North American Journal of Fisheries Management 25:1, 171-179.

VanderBloemen, S. N., J. A. Gorne, G. G. Sass, and S. L. Shaw. 2020. Influence of cisco (Coregonusartedi, Lesueur) on muskellunge (Esox masquinongy, Mitchill) mean length, population size structure, and maximum size in northern Wisconsin lakes. Journal of Applied Ichthyology, 36: 159– 167.

Weeks, J. G. and M. J. Hansen. 2009. Walleye and Muskellunge Movement in the Manitowish Chain of Lakes, Vilas County, Wisconsin. North American Journal of Fisheries Management. 29. 791–804.

Wiener, J. G., and W. R. Hanneman, 1982. Growth and condition of bluegills in Wisconsin lakes: effects of population density and lake pH. Transactions of the American Fisheries Society 111: 761-767.

Table 1. Stocking records, Upper Eau Claire Lake, Bayfield County, Wisconsin, 1982-2019.

Year	Species	Number Stocked	Size
1982	Walleye	2,000,000	Fry
1984	Muskellunge	1,000	Fingerling
1985	Rainbow Trout	3,034	Yearling
1987	Muskellunge	500	Fingerling
1988	Rainbow Trout	6,432	Yearling
	Walleye	50,318	Small Fingerling
	Muskellunge	1,942	Fingerling
1989	Muskellunge	1,000	Fingerling
1990	Rainbow Trout	1,500	Yearling
1991	Walleye	25,000	Small Fingerling
	Rainbow Trout	1,500	Yearling
1992	Walleye	72,775	Small Fingerling
	Muskellunge	1,000	Fingerling
1993	Walleye	980	Large Fingerling
	Muskellunge	1,000	Fingerling
1994	Walleye	1,858	Medium Fingerling
1995	Walleye	49,900	Small Fingerling
	Walleye	65	Large Fingerling
	Walleye	4,323	Medium Fingerling
1996	Walleye	513	Large Fingerling
	Walleye	4,869	Small Fingerling
	Walleye	1,757	Medium Fingerling
	Muskellunge	1,000	Fingerling
1997	Walleye	49,800	Small Fingerling
	Walleye	3,408	Small Fingerling
	Walleye	386	Large Fingerling
	Muskellunge	500	Fingerling
1998	Muskellunge	900	Fingerling
	Walleye	20,018	Small Fingerling
	Walleye	3,916	Large Fingerling
1999	Walleye	49,800	Small Fingerling
	Walleye	2,040	Large Fingerling
2000	Walleye	13,000	Small Fingerling
	Walleye	2,115	Large Fingerling
	Muskellunge	1,000	Fingerling
2002	Muskellunge	498	Fingerling
2004	Walleye	150,000	Fry
	Muskellunge	498	Fingerling
2006	Muskellunge	274	Fingerling
2008	Muskellunge	496	Fingerling
2010	Muskellunge	374	Fingerling
2012	Muskellunge	496	Fingerling
2013	Walleye	9,898	Large Fingerling
2014	Muskellunge	498	Fingerling
2015	Walleye	10,244	Large Fingerling
	Walleye	1,452	Large Fingerling
2016	Muskellunge	298	Fingerling
2017	Walleye	7,922	Large Fingerling
	Walleye	2,318	Large Fingerling
2018	Muskellunge	548	Fingerling
2019	Walleye	10,244	Large Fingerling

Table 2. Walleye length statistics, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Year	Avg. Length (SD)	N	PSD	RSD-20
1983	18.5 (3.0)	797	89	28
1993	19.6 (3.5)	404	92	42
2004	17.3 (3.6)	655	72	20
2011	17.9 (2.4)	161	96	15
2017	21.5 (3.6)	104	95	70

Table 3. Muskellunge length statistics, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Year	Avg. Length (SD)	N	PSD	RSD-40	RSD-45	CPUE
2004 - 2005	36.4 (5.6)	88	90	26	8	0.65
2011 - 2012	39.6 (4.2)	72	100	43	11	0.40
2017 - 2018	38.4 (5.9)	96	92	42	15	0.49

Table 4. Northern pike length statistics, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Year	Avg. Length (SD)	N	PSD	RSD-28	CPUE
1983	23.2 (6.7)	65	67	17	1.6
1993	19.7 (3.5)	95	36	1	1.6
2004	18.0 (6.6)	84	47	8	2.1
2011	21.4 (6.1)	61	63	13	0.8
2017	18.9 (7.4)	64	58	13	0.9

Table 5. Largemouth bass length statistics, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Year	Avg. Length (SD)	N	PSD	RSD-15
1993	12.2 (2.6)	19	42	11
2002	10.9 (3.2)	55	53	12
2011	13.0 (1.8)	126	84	11
2014	12.0 (1.9)	86	59	4
2016	11.9 (2.3)	210	64	4
2017	12.6 (2.6)	66	79	16

Table 6. Bluegill length statistics, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Year	Avg. Length (SD)	N	PSD	RSD-8	CPUE
2011	5.2 (1.3)	84	30	1	56.7
2017	5.9 (1.1)	33	52	3	22.0

Table 7. Black crappie length statistics, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Year	Avg. Length (SD)	N	PSD	RSD-10	CPUE
2004	9.2 (2.1)	160	81	42	4.0
2011	6.0 (2.2)	221	35	0	3.1
2017	6.5 (2.1)	141	22	11	1.9

Table 8. Angler directed effort % (hours) for creel survey from Upper Eau Claire Lake, Bayfield County, Wisconsin.

	Year		
Species	1993	2004	2017
Walleye	32.1% (6,941)	21.6% (6,309)	14% (3,315)
Muskellunge	8.3% (1,790)	12.7% (3,711)	14.4% (3,408)
Northern Pike	20.1% (4,351)	18.5% (5,411)	19.3% (4,550)
Largemouth Bass	13.3% (2,878)	16.1% (4,692)	21.7% (5,126)
Smallmouth Bass	2.1% (457)	9.1% (2,663)	7.8% (1,848)
Bluegill	15.3% (3,295)	16.4% (4,777)	11.7% (2,758)
Black Crappie	5.9% (1,281)	1.4% (408)	8.9% (2,110)

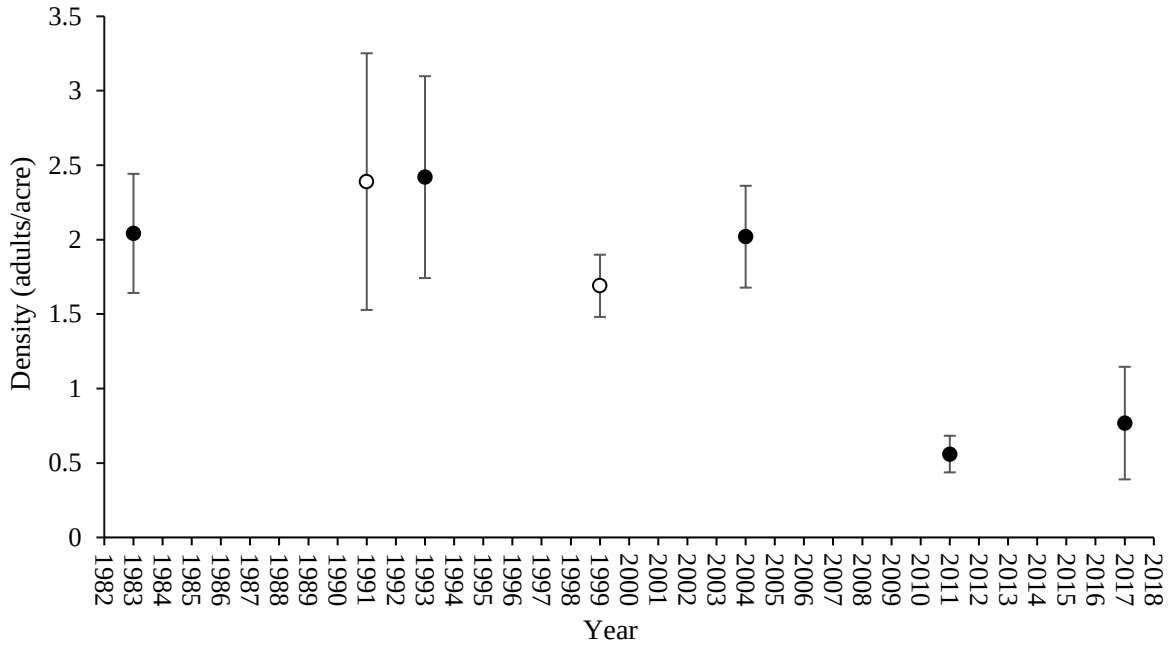

Figure 1. Adult walleye density (sexable or ≥ 15 in; number/acre ± 95% confidence intervals) by year in Upper Eau Claire Lake, Bayfield County, Wisconsin. Estimated density in 1983 was determined by multiple census procedures and calculated using the Schnabel estimate. Estimated density after 1983 was calculated using the Chapman version of the Peterson formula with GLIFWC surveys (open circles) utilizing electrofishing for both the marking and recapture samples and WDNR surveys (solid circles) utilizing fyke-netting and electrofishing for the marking and recapture samples, respectively.

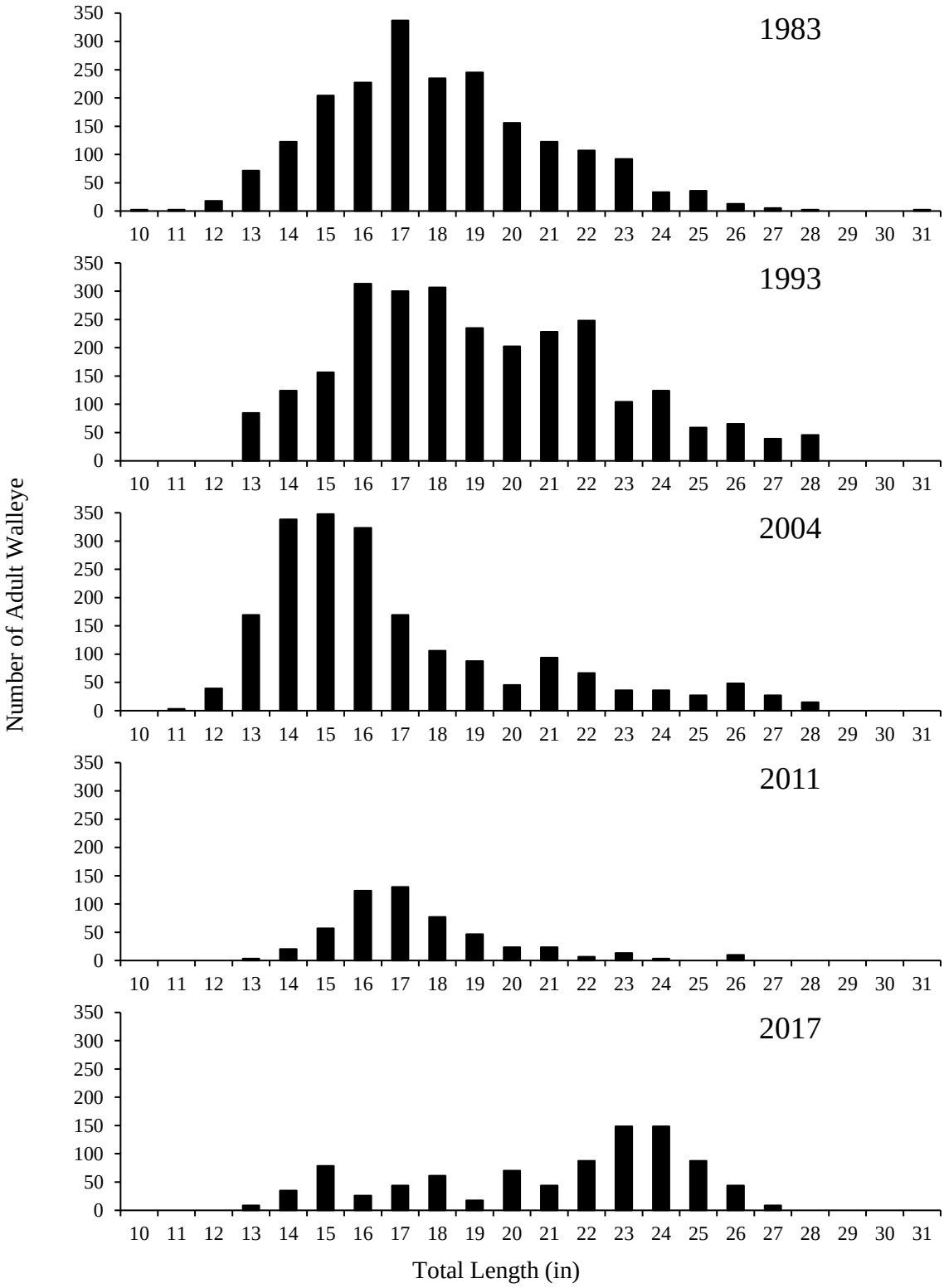

Figure 2. Estimated adult walleye abundance by length interval in Upper Eau Claire Lake, Bayfield County, Wisconsin.

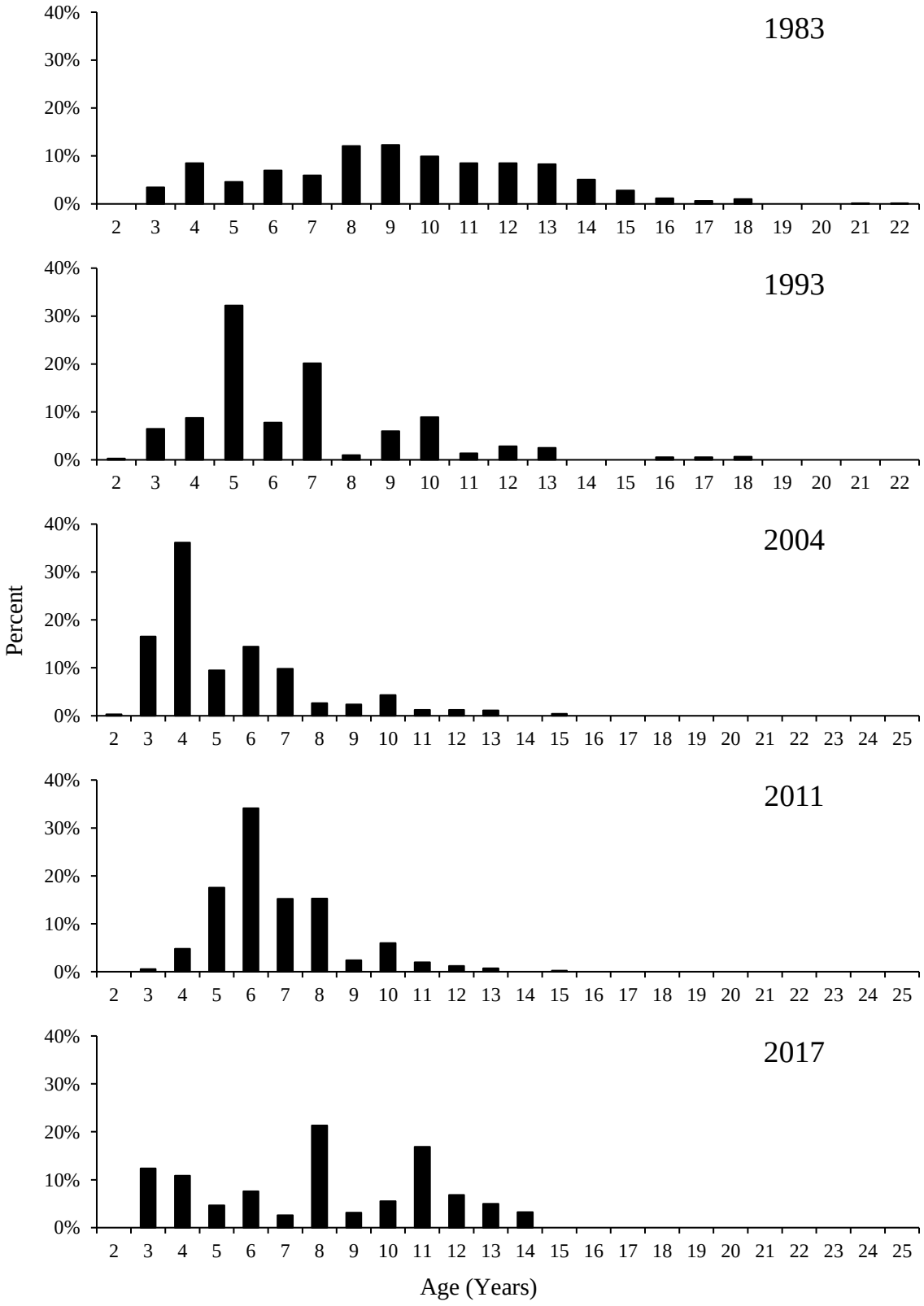

Figure 3. Percentage distribution by age of walleye in Upper Eau Claire Lake, Bayfield County, Wisconsin.

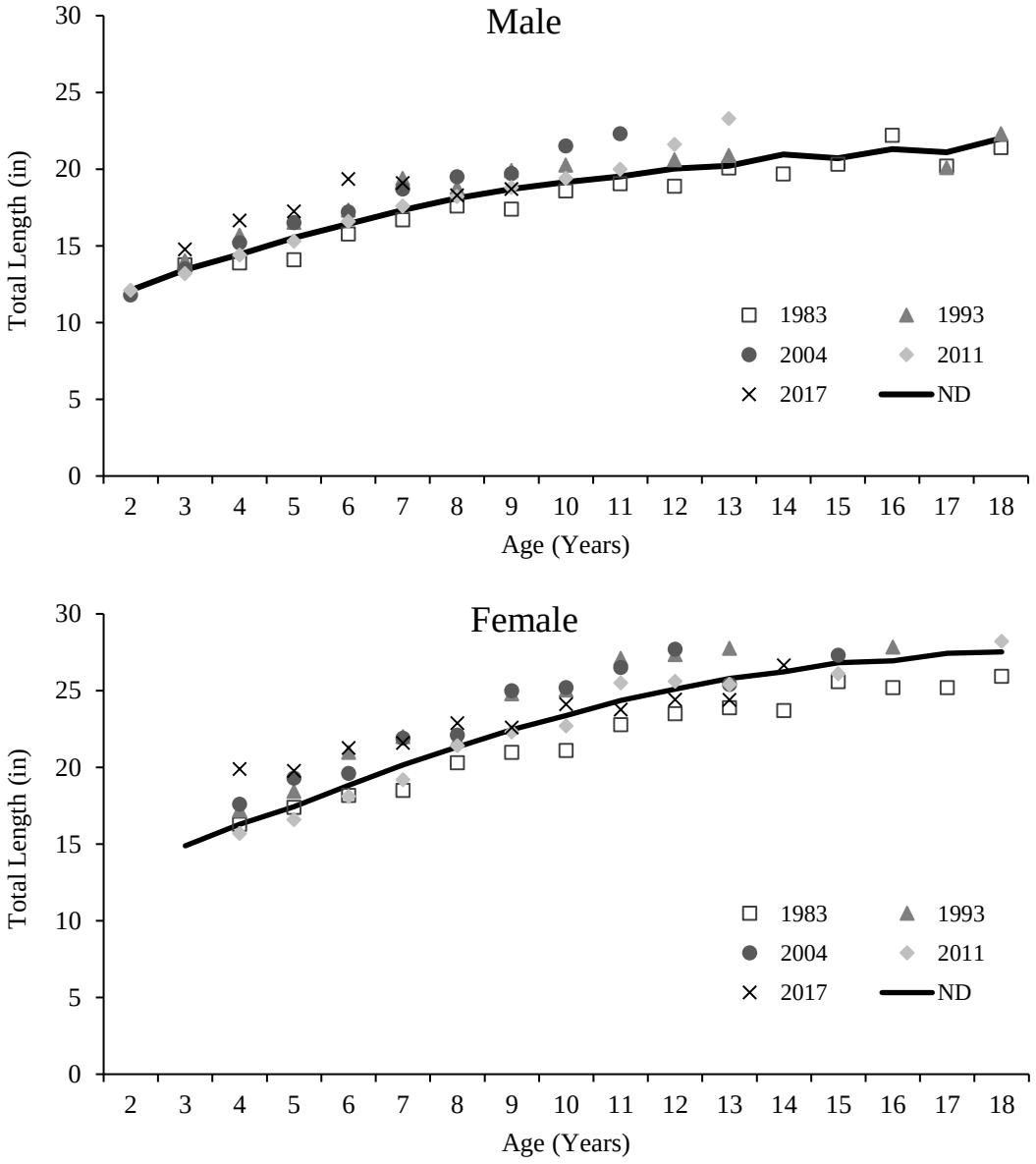

Figure 4. Age at length of male and female walleye in Upper Eau Claire Lake, Bayfield County, Wisconsin.

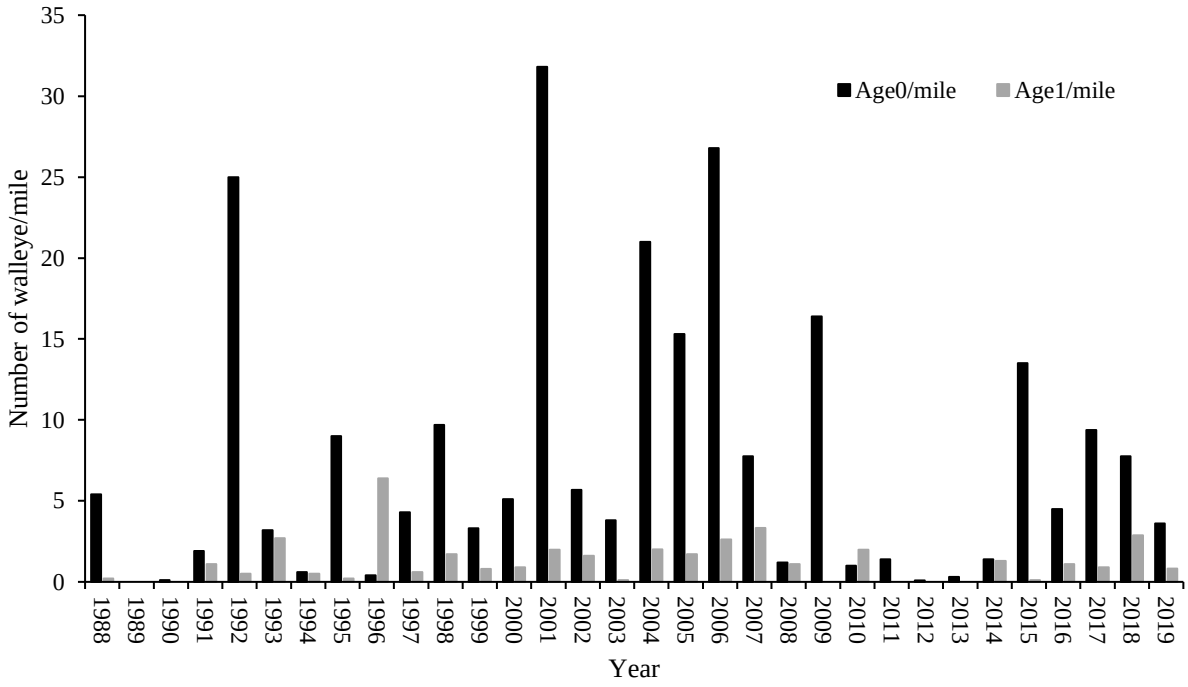

Figure 5. Relative abundance of age-0 (black) and age-1 (gray) walleye determined by fall electrofishing, Upper Eau Claire Lake, Bayfield County, Wisconsin. No survey was conducted in 1989.

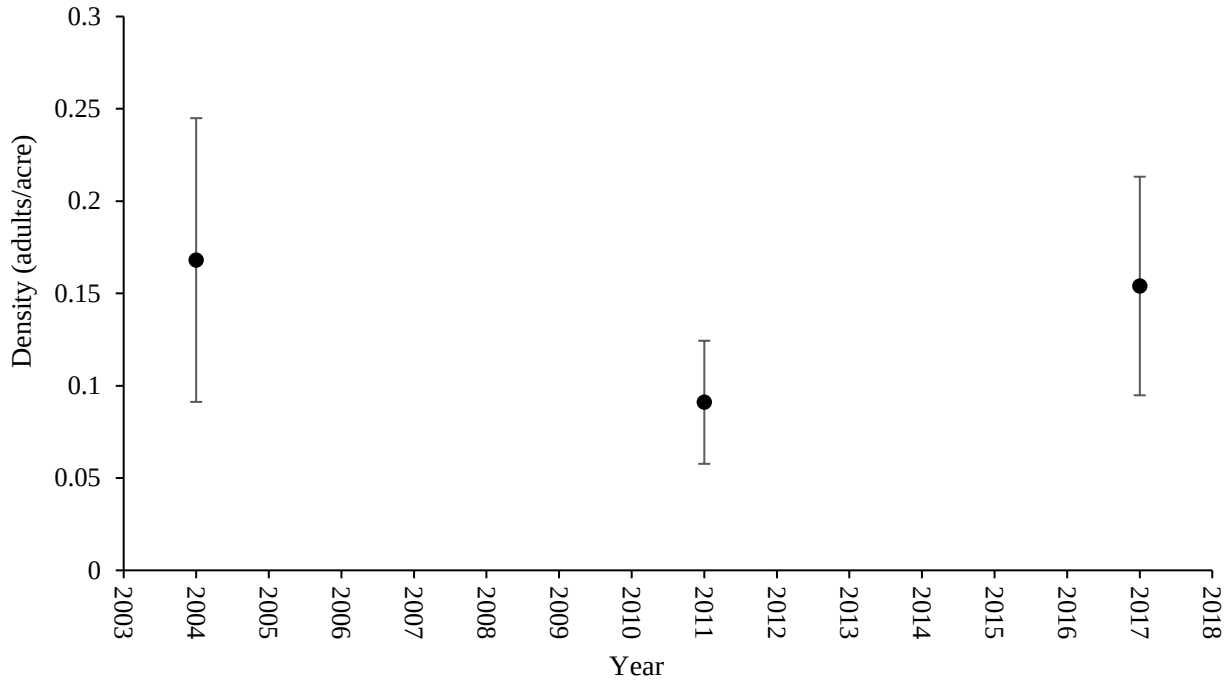

Figure 6. Adult muskellunge density (sexable or ≥ 30 in; number/acre ± 95% confidence intervals) by year in Upper Eau Claire Lake, Bayfield County, Wisconsin.

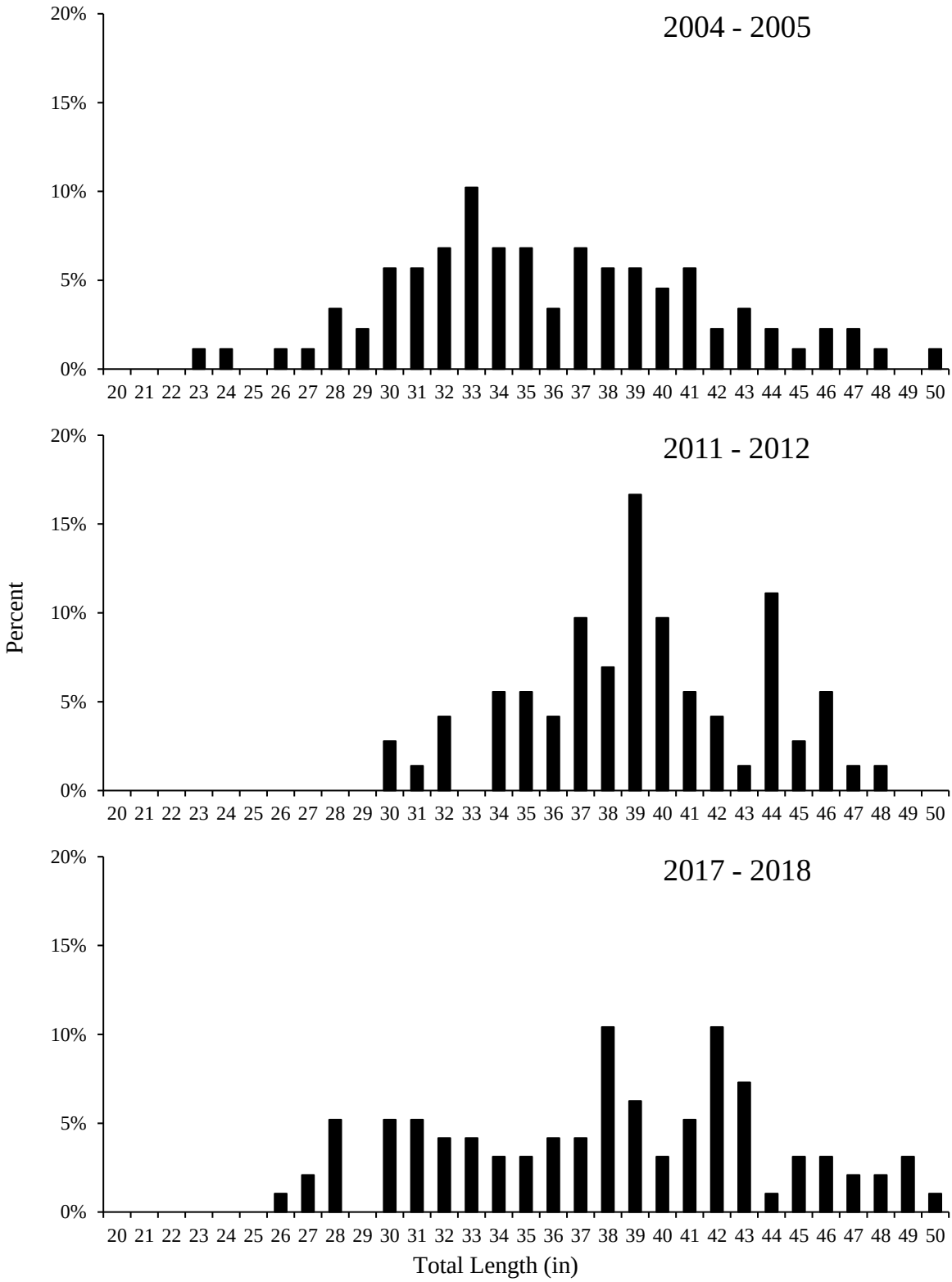

Figure 7. Percent length frequency of muskellunge in Upper Eau Claire Lake, Bayfield County, Wisconsin.

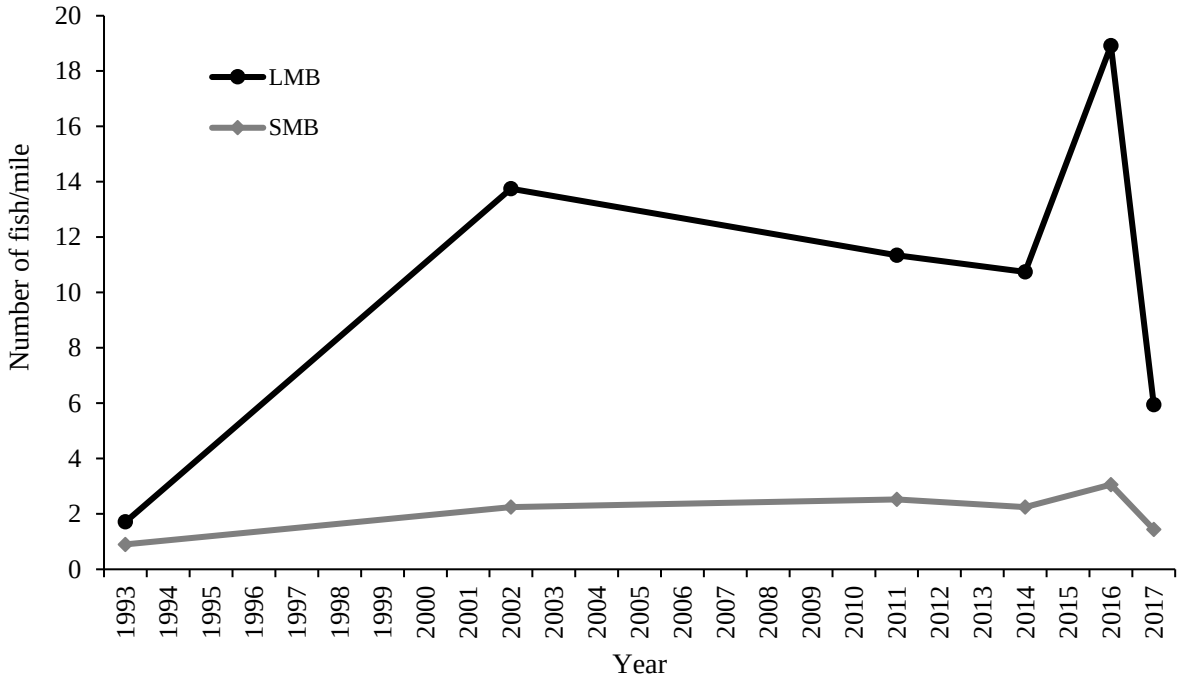

Figure 8. Relative abundance of bass (number/mile) collected during spring electrofishing surveys in Upper Eau Claire Lake, Bayfield County, Wisconsin.

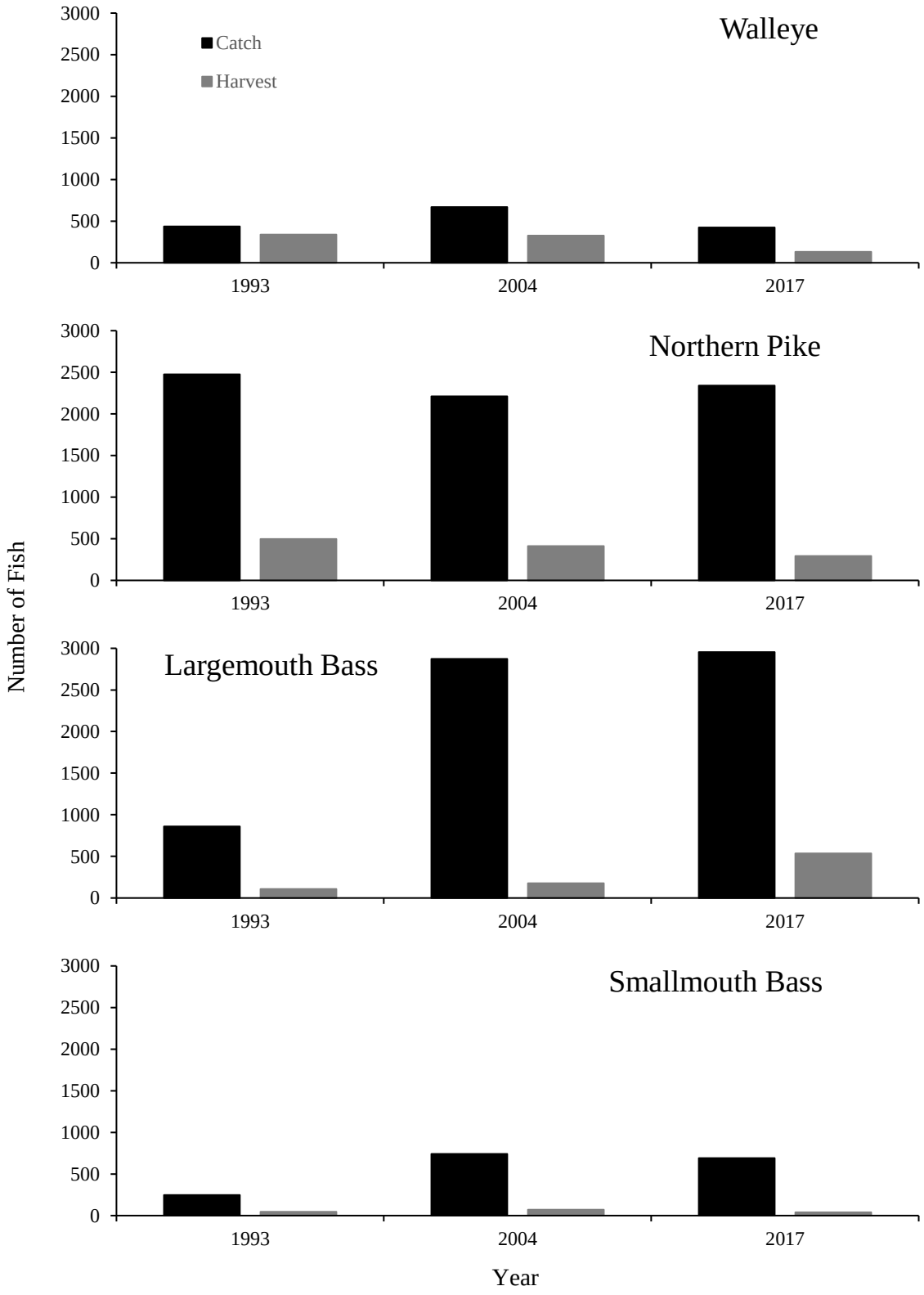

Figure 9. Angler catch and harvest of gamefish, Upper Eau Claire Lake, Bayfield County, Wisconsin.

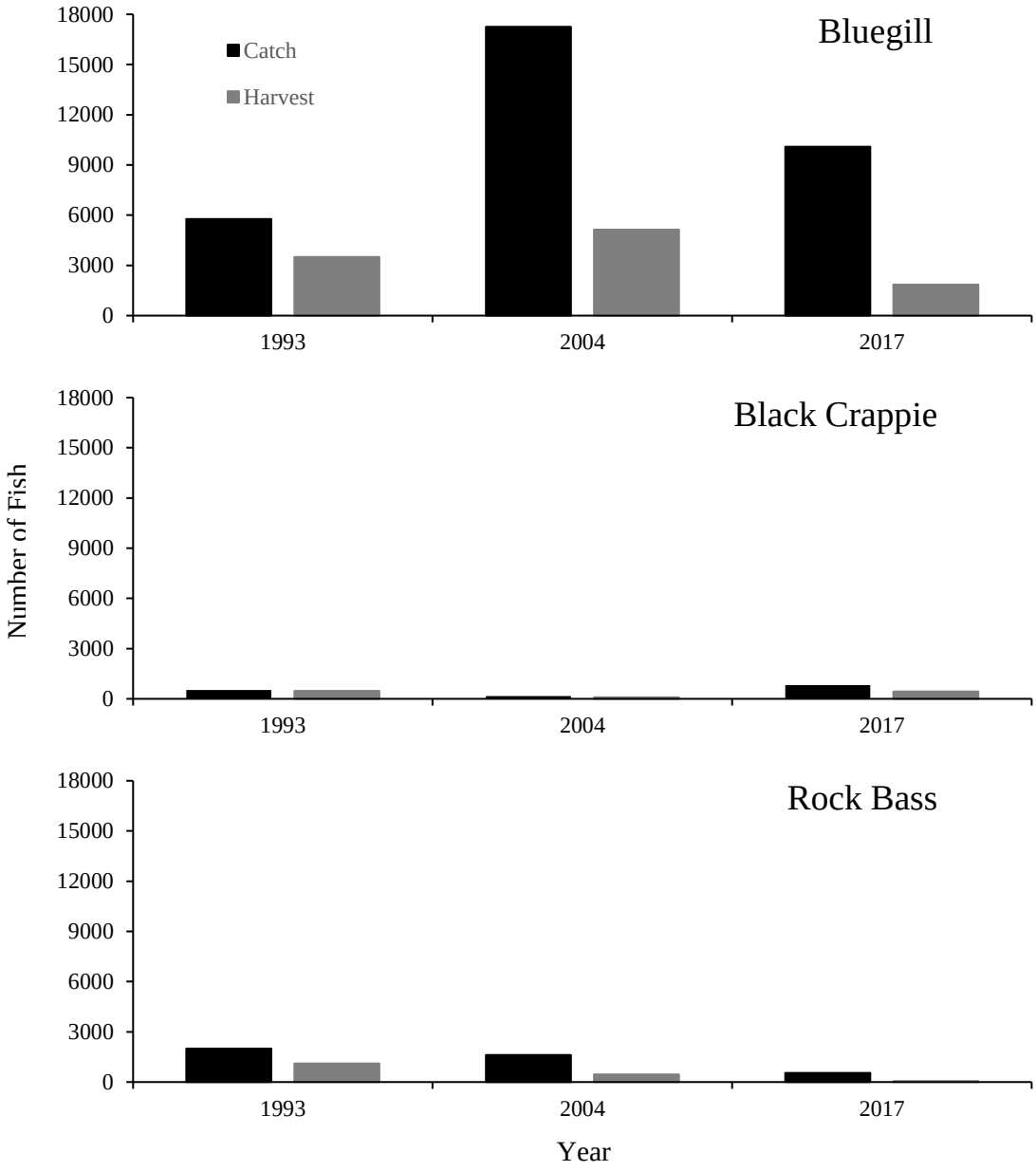

Figure 10. Angler catch and harvest of panfish, Upper Eau Claire Lake, Bayfield County, Wisconsin.

Appendices.

Appendix 1. Proportional and relative stock density values.

Species	Stock Size (in.)	Quality Size (in.)	Preferred Size (in.)
Black Crappie	5	8	10
Bluegill	3	6	8
Largemouth Bass	8	12	15
Muskellunge	20	30	38
Northern Pike	14	21	28
Pumpkinseed	3	6	8
Smallmouth Bass	7	11	14
Walleye	10	15	20
Yellow Perch	5	8	10

Appendix. 2. Lake Map, Upper Eau Claire Lake, Bayfield County, Wisconsin.