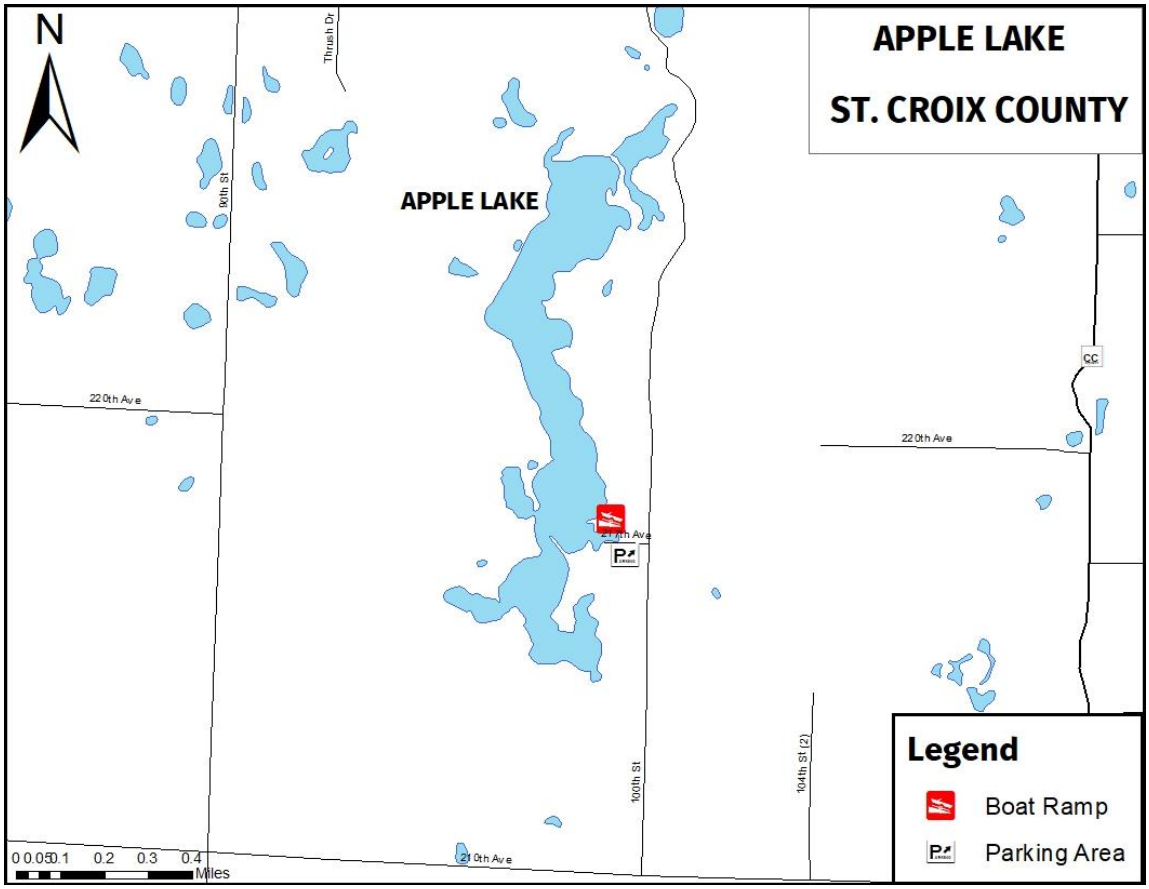
WISCONSIN DEPARTMENT OF NATURAL RESOURCES

2024 Apple Lake Comprehensive Lake Survey Report

Waterbody Code 2499000



Kasey Yallaly
DNR Senior Fisheries Biologist

FEBRUARY 3, 2025

Table Of Contents

Executive Summary

Apple Lake is a small hypereutrophic seepage lake in northern St. Croix County. The lake contains a diverse sport and panfishery and is currently surveyed by WDNR on an 6-year rotation with the last survey in 2018. A comprehensive fisheries survey was conducted in the spring of 2024. Fyke nets and boat electrofishing gear were used to determine the current health and status of the fishery. Largemouth bass *Micropterus salmoides*, bluegill *Lepomis macrochirus* and black crappie *Pomoxis nigromaculatus* were present in high densities. Largemouth bass exhibited excellent size structure. Bluegill and black crappie size structure was limited but growth was moderate. Northern pike have declined in abundance and natural reproduction is likely limited with current low water levels that have resulted in minimal access to spawning habitat. Stocking may be needed to supplement the population while conditions persist. The current fishing regulations are appropriate for Apple Lake and angler harvest is encouraged for walleye, largemouth bass, bluegill and black crappie to reduce or maintain densities, improve or maintain size structure and growth rates. Fisheries habitat improvements are recommended to enhance near shore habitat for multispecies benefits.

Introduction

Apple Lake is a 129-acre hypereutrophic seepage lake located six miles northwest of the city of New Richmond in northwestern St. Croix County. It has a maximum depth of 32 feet, mean depth of 13 feet and 3.9 miles of shoreline. Water levels are heavily influenced by runoff and are quite variable. Currently, the fishery consists of walleye *Sander vitreus,* northern pike *Esox Lucius,* largemouth bass *Micropterus salmoides,* black crappie *Pomoxis nigromaculatus*, bluegill *Lepomis macrochirus,* pumpkinseed *Lepomis gibbosus*, black bullhead *Ameiurus melas* and white sucker *Catostomus commersonii*. The walleye population in the lake is completely dependent on stocking and walleye are stocked in even years at a rate of 5 per acre. Largemouth bass, bluegill, black crappie and pumpkinseed populations are dependent on natural reproduction. A reduction in the panfish bag limit was implemented in 2008 which reduced the limit from 25 to 10 per day. A special regulation for largemouth bass of 5 fish less than 14 inches and only 1 may be over 18 inches, was also implemented in 2013. There is one public access point on the southeast side of the lake with parking available for several car-trailer units.

Prior to 1988, the lake experienced frequent winterkills which prompted the need for winter aeration. Two aeration units were installed that year which prevented winterkills until 2014 when water levels were extremely low due to droughts that occurred in 2012-2013 which made aeration difficult and dissolved oxygen levels dropped to dangerous levels during the winter of 2014. This winterkill resulted in a significant kill of bluegill and largemouth bass. Northern pike, black crappie and black bullhead to a larger degree, are more tolerant of low dissolved oxygen levels and some individuals survived. Walleye, northern pike, largemouth bass and bluegill

were restocked the following fall and spring. The aeration systems have received upgrades throughout the years as needed and no winterkills have been documented since 2014. Black bullhead were documented in high densities following the winterkill and were again observed in high densities during the 2018 fisheries survey. Due to these high densities and concerns from the lake district, a bullhead removal project was initiated in 2023 using fyke nets and boat electrofishing gear. To date, a total of 3,669 bullhead have been removed from the lake.

Apple Lake is classified as a Complex Warm Dark Lake within Wisconsin's Lakes Classification system. Algal blooms are common during summer and water quality is ongoing issue within the watershed. Most of the lake shore is developed and the Apple Lake Rehabilitation and Management District is active in improving and restoring shorelines using Best Management Practices. Fish habitat within Apple Lake consists of limited aquatic macrophytes and coarse woody debris. A fish habitat improvement project was initiated in 2021 and 16 sets of fish sticks were installed on the shoreline in the winter of 2021-2022 and in 2024-2025.

Table 1. Stocking history of Apple Lake since 1990.

YEAR	SPECIES	AGE CLASS	NUMBER STOCKED
1990	WALLEYE	FINGERLING	1350
1991	WALLEYE	FINGERLING	1290
1992	WALLEYE	FINGERLING	16950
1994	WALLEYE	FINGERLING	6450
1996	WALLEYE	FINGERLING	6400
1997	WALLEYE	LARGE FINGERLING	3225
1999	WALLEYE	SMALL FINGERLING	6450
2001	WALLEYE	SMALL FINGERLING	6450
2005	NORTHERN PIKE	LARGE FINGERLING	250
2008	NORTHERN PIKE	LARGE FINGERLING	249
2013	NORTHERN PIKE	LARGE FINGERLING	258
2014	LARGEMOUTH BASS	LARGE FINGERLING	3225
2014	BLUEGILL	SMALL FINGERLING	7000
2014	WALLEYE	LARGE FINGERLING	550
2015	LARGEMOUTH BASS	LARGE FINGERLING	4124
2016	LARGEMOUTH BASS	LARGE FINGERLING	8247
2016	WALLEYE	LARGE FINGERLING	549
2017	LARGEMOUTH BASS	LARGE FINGERLING	49962
2017	NORTHERN PIKE	LARGE FINGERLING	232
2018	WALLEYE	LARGE FINGERLING	549
2020	WALLEYE	LARGE FINGERLING	549
2022	WALLEYE	LARGE FINGERLING	549
2024	WALLEYE	LARGE FINGERLING	550

Methods

SURVEY EFFORT

Apple Lake was sampled according to standard Spring Netting I and Spring Electrofishing II protocols as outlined in DNR Fisheries Monitoring Protocols. The primary objectives for the Spring Netting I survey was to estimate the population sizes and size structure of northern pike and walleye. Boom shockers were then used to electrofish the entire shoreline after water temperatures exceeded 70° F. Gamefish were collected and measured for the entire length of shoreline and panfish were collected and measured within two 0.5-mile stations. A total of 10 fyke nets were set on March 6, 2024 and were ran until March 15th for a total of 88 net nights. Fyke nets were deployed in areas of the lake that contained spawning habitat or were likely travel areas for northern pike and walleye. All gamefish were counted and measured and a subsample of 5 per each 1-inch length group of both sexes (if possible) were weighed and aging structures were removed for age analysis in the lab. Gender was determined for each walleye and northern pike. Dorsal spines were removed from walleye for aging. Otoliths were removed from largemouth bass, bluegill and black crappie. Cleithra were removed from a subsample of Northern Pike in the 18-19-inch range. Northern pike and walleye were given a partial fin clip and all walleye larger than 14 inches were tagged at the base of the dorsal fin with an orange Floy tag. Adult walleye were tagged in order to attempt to estimate angler catch and exploitation and anglers were asked to report any tagged fish to Baldwin Fisheries staff. Walleye were tagged with FD-94 orange Floy tags which were labeled with a phone number to contact for reporting as well as the individual tag number. Estimates of tag loss were adapted from Koenigs et al. 2013 and were estimated at 4.7% for the first 90 days post tagging. A non-reporting rate of 25% was used based on estimates reported in Quist et al. 2010. Exploitation that incorporated tag loss was calculated using the following equation:

$$u = (N_H/T_R) / (N_T[1 - R_{TL}]),$$

where N_H represents the number of tagged fish reported by anglers as harvested, T_R represents the tag reporting rate, N_T represents the total number of fish tagged and R_{TL} represents the probability of tag loss.

The tagging study was conducted in conjunction with an angler kiosk creel survey that was installed at the public boat ramp. Signs were posted and anglers were encouraged to fill out a postcard and submit it in the mailbox provided. Postcards were collected monthly throughout the fishing season. The kiosk was coupled with remote trail cameras in order to estimate angler use of the kiosk and obtain a non-reporting rate. One trail camera was placed at the boat ramp and focused on the kiosk and an additional trail camera was placed on the parking lot. The parking lot trail camera was deployed in order to estimate angler effort and obtain counts of boats each day.

ANALYSIS

Catch per unit effort (CPUE) is an index used to measure fish population relative abundance, which simply refers to the number of fish captured per unit of distance or time. For netting surveys, CPUE is quantified by the number and size of fish per net night. For electrofishing, CPUE is quantified as the number caught per mile of shoreline electrofished. CPUE indexes are compared to statewide data by percentiles and within lake trends. For example, if a CPUE is in the 90th percentile, it is higher than 90% of the other CPUEs in the state.

Proportional Stock Density (PSD) is an index used to describe the size structure of fish populations. It is calculated by dividing the number of quality size fish by the number of stock size fish for a given species. PSD values between 40 - 60 generally describe a balanced fish population.

Length frequency distribution is a graphical representation of the number or percentage of fish captured by half-inch or one-inch size intervals. Smaller fish (or younger age classes) may not always be represented in the length frequency due to different habitat usage or sampling gear limitations.

Mean length at age is an index used to assess fish growth. Calcified structures (e.g., otoliths, spines or scales) are collected from a specified length bin of interest (e.g., 7.0-7.5 inches for bluegill). Mean age is compared to statewide data by percentile with growth characterized by the following benchmarks: slow (<33rd percentile); moderate (33rd to 66th percentile); and fast (>66th percentile). Growth rates of largemouth bass were calculated using the von Bertalanffy growth coefficient and median length at age and were compared to other lakes within the same lakes classification.

Relative weight is an index used to assess the plumpness (i.e., condition) of fish. It is calculated by comparing the observed weight of a fish to the standard weight (i.e., predicted average weight) of that fish, given its length. A relative weight of 93 means it has average plumpness/weight compared to other fish of the same length. Relative weights above 93 mean it is plumper than average.

Recruitment was evaluated through residual analysis where the sign and magnitude of residuals from a catch-curve regression indicate relative year-class strength. Larger, positive residuals indicate years of higher recruitment and zero or negative residuals indicate years of poorer recruitment. Fisheries Analysis and Modeling Simulator (FAMS) version 1.64.2 was used to calculate catch curves and estimate total annual mortality.

Results

WALLEYE

A total of 153 walleye were sampled during the spring surveys for catch rates of 0.4 fish per net night (25th percentile) during the fyke netting survey and 9.3 fish per mile during the electrofishing survey. The walleye population was estimated at 1.8 adults per acre (95% C.L. 1.3 to 2.9/acre; CV=19.2%) or 233 individual adults. The walleye population has expanded since 2018 in which the population was estimated at 1.4

adults per acre. Walleye ranged in length from 10.9 to 27 inches with a mean length of 15.7 inches, (75th percentile; Figure 1) which is lower than mean length from the previous survey of 18.8 inches. PSD of walleye was 61 while RSD-P was 9. A total of 61% of fish were larger than 15 inches. Walleye were in excellent condition with a mean relative weight of 99.

Walleye recruitment is heavily reliant on stocking with stocked years contributing strong year classes in 2022 and 2020 with the 2018- and 2016-year classes contributing to a lesser extent (Figure 2). Limited natural reproduction was evidenced by walleye ages that originated from 2021 (Figure 2). Growth rates of walleye were slightly above average during the early years (ages 2 and 4) and were well above average for older aged fish (ages 6 and 8) which were composed of female walleye (Figure 3). The small age-3-year class which resulted from natural reproduction, exhibited growth rates slightly below average.

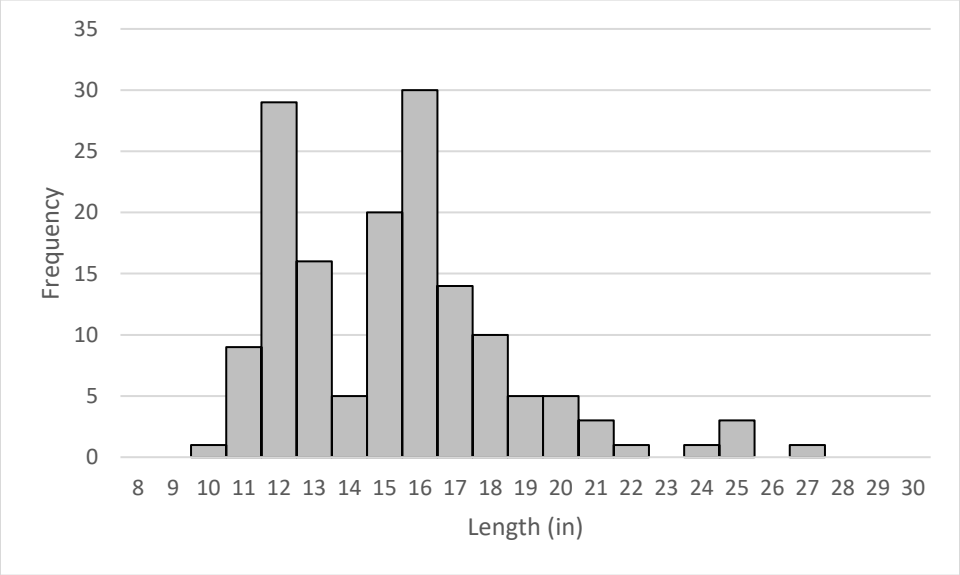


Figure 1. Length frequency distribution of walleye collected from Apple Lake in St. Croix County in 2024.

A total of 131 adult walleye were tagged during the spring 2024 surveys ranging in length from 14.1 to 27 inches. Angler exploitation of walleye was low during 2024 with only five tagged walleye reported caught and only three of those fish reported as harvested. This resulted in an exploitation rate of 3.2%.

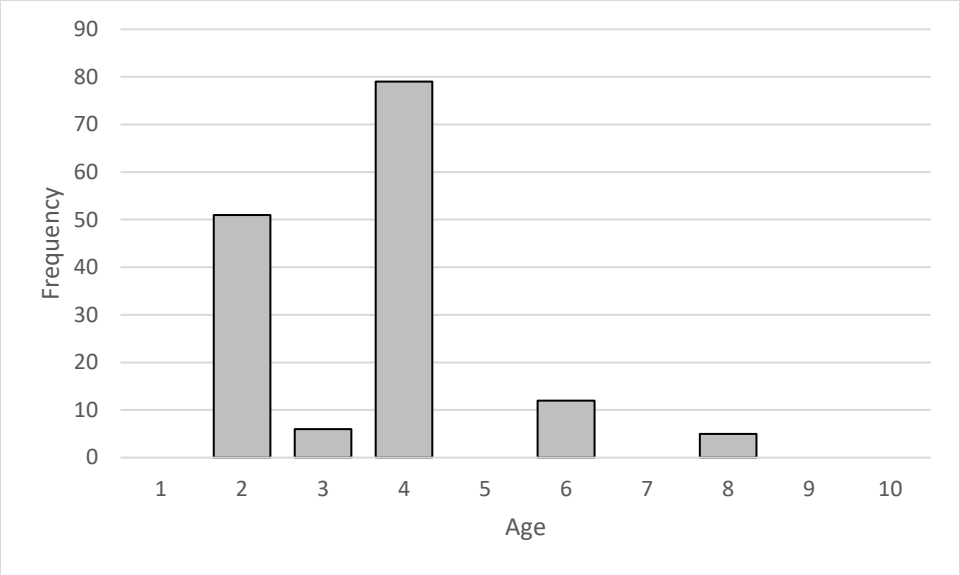


Figure 2. Age frequency distribution of walleye collected from Apple Lake in St. Croix County in 2024.

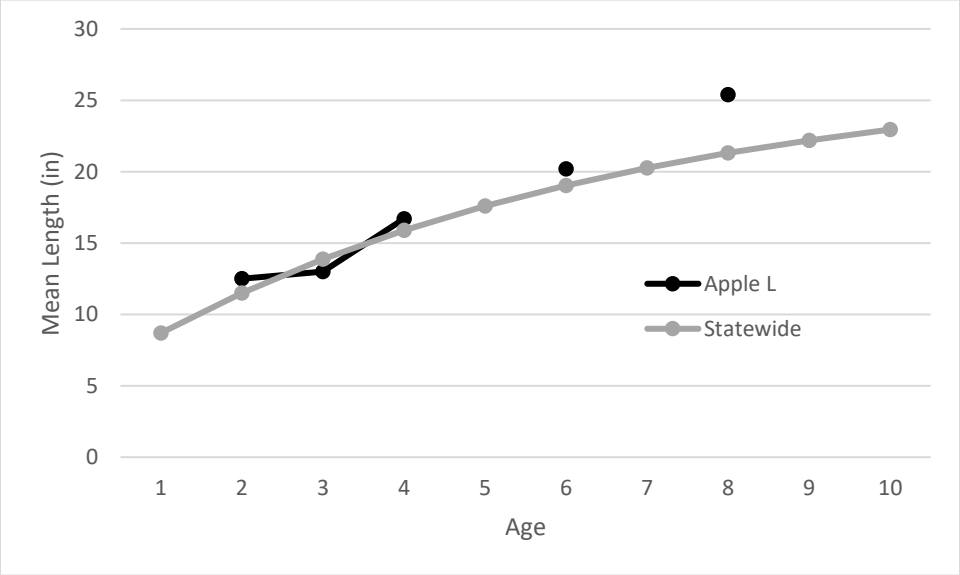


Figure 3. Mean length at age of walleye collected from Apple Lake in St. Croix County in 2024 and median mean length at age of walleye in Complex Warm Dark lakes across Wisconsin.

NORTHERN PIKE

Northern pike were present in relatively low densities during the survey with a total of 68 individuals sampled. This resulted in a catch rate of 1.2 fish per net night (25th percentile) and an adult population estimate of 0.5 adults per acre (95% C.L. 0.4 to 0.8/acre; CV=16.7%) or 70 individual adults. The northern pike population has declined substantially since the 2018 survey in which the population was estimated at 11.1 adults per acre or 1218 adults. Pike exhibited excellent size structure and ranged in length from 16 to 38.5 inches with a mean length of 27 inches (95th percentile; Figure 4). PSD was high at 93 indicating a population skewed towards large

individuals with few small individuals. RSD-P was 31. Approximately 24% of fish were larger than 30 inches. Northern pike were in excellent condition with a mean Wr of 98. The sample size of fish in the 18-to-19-inch range was too low to accurately determine growth rates.

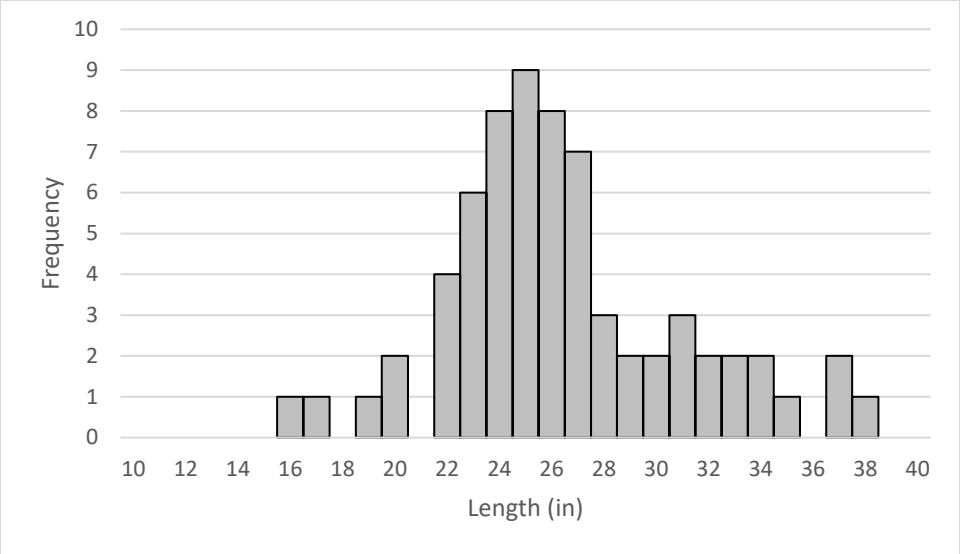


Figure 4. Length frequency distribution of northern pike collected from Apple Lake in St. Croix County in 2024.

LARGEMOUTH BASS

Largemouth bass were the dominant gamefish species in terms of densities in Apple Lake in 2024. A total of 293 largemouth bass were captured during the survey. Catch rates were high at 59 fish per mile and fell above the 75th percentile for Complex Warm Dark lakes across Wisconsin. The bass population within the lake has increased substantially since the 2018 survey during which catch rates were 5.7 fish per mile (10th percentile). The size structure of bass was excellent with fish ranging in length from 2.9 to 21.1 inches with a mean length of 13.0 inches (95th percentile; Figure 5). PSD of largemouth was 75 and RSD-14 was 32. Approximately 15% of bass were larger than 15 inches and 5 fish were ≥ 20 inches (trophy size). Bass were also in excellent condition with a mean relative weight of 99.

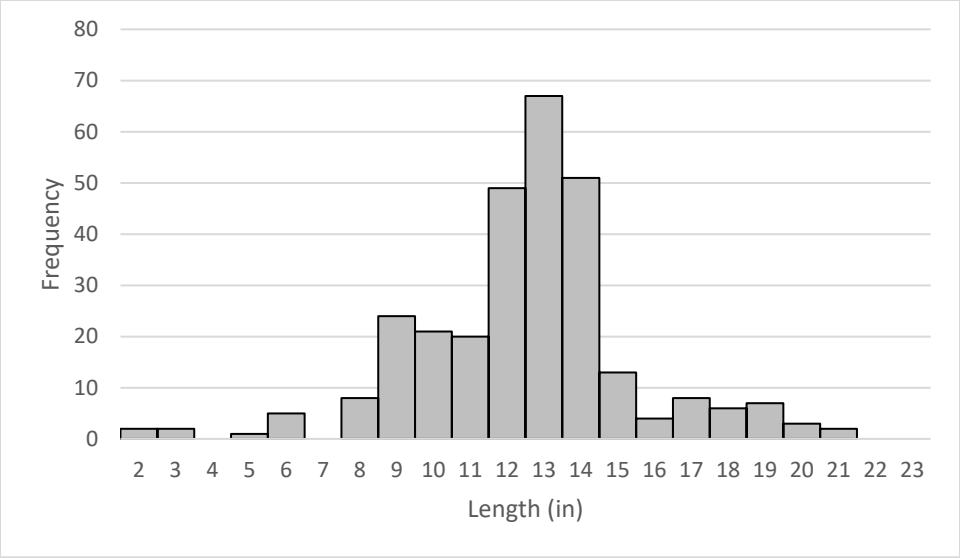


Figure 5. Length frequency distribution of largemouth bass collected from Apple Lake in St. Croix County in 2024.

Largemouth bass annual recruitment was consistent with the exceptions of two weak year classes in 2023 (age-1) and 2018 (age-6) (Figure 6). Strong year classes were present in 2020 (age-4) and 2019 (age-5). According to aging results, survival from stocked year classes back to 2014 was evident, which was the stocked year following the winterkill. The high stocking rate in 2017 (Table 1; Figure 6) resulted in similar year class strength as lower stocking rate years, indicating that many of the stocked largemouth bass in 2017 did not survive at a higher rate than years with lower stocking rates. Stocking ceased in 2017 and natural reproduction has produced strong year classes and consistent reproduction. Growth of largemouth bass as expressed by mean length at age, was average overall and mean length at age of fish at younger ages (< age 6) exceeded the statewide average growth rates (Figure 7). Total annual mortality of largemouth bass was low at 14% (F = 2.03, p = 0.0001).

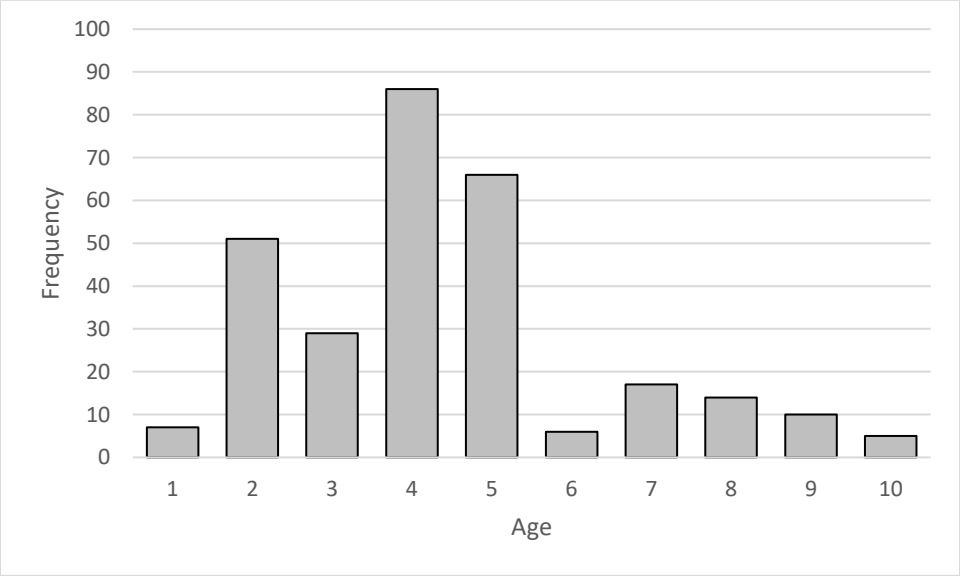


Figure 6. Age frequency distribution of largemouth bass collected from Apple Lake in St. Croix County in 2024.

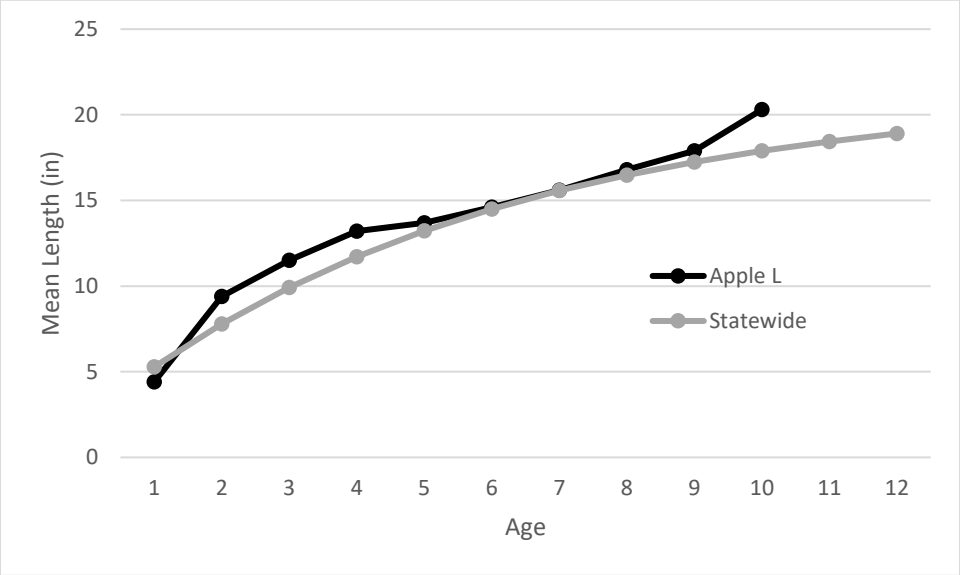


Figure 7. Mean length at age of largemouth bass collected from Apple Lake in St. Croix County in 2024 and median mean length at age of largemouth bass in Complex Warm Dark lakes across Wisconsin.

BLUEGILL

Bluegill were the dominant panfish species and were present in high densities with a total of 2,423 bluegill sampled throughout the survey period which resulted in a catch rate of 520.8 fish per mile (95th percentile). Abundance of bluegill appears stable relative to the previous survey in which the electrofishing catch rate was 521 fish per mile. Bluegill size structure appeared to be skewed towards small individuals. Fish ranged in length from 1.9 to 8.4 inches with a mean length of 4.9 inches (90th percentile; Figure 8). PSD of bluegill was 30 and RSD-P was 2.

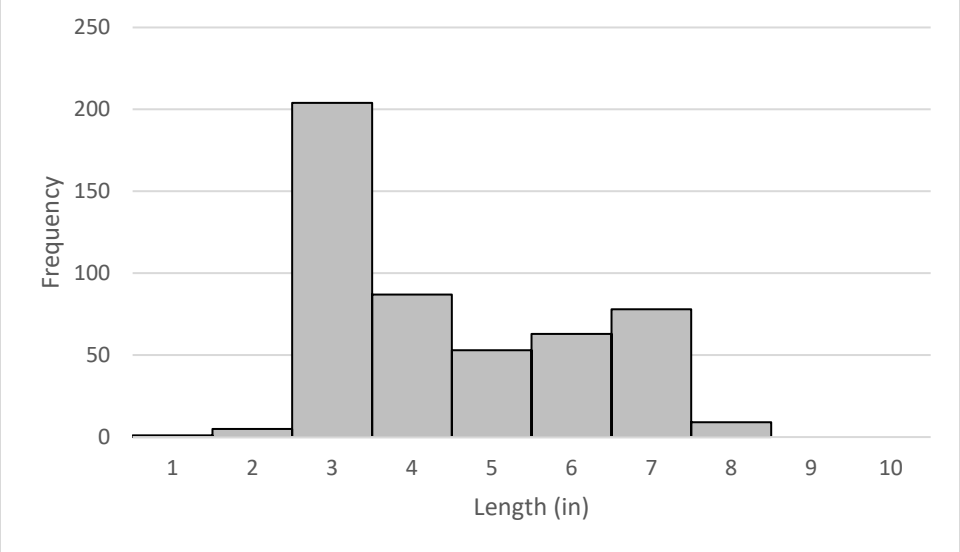


Figure 8. Length frequency distribution of bluegill collected from Apple Lake in St. Croix County in 2024.

Natural reproduction of bluegill was consistent based on age analysis. However, recruitment of bluegill was high during 2023, 2018 and 2016 while weak year classes occurred in 2021 and 2019 (Figure 9). Maximum age of bluegill was 9 years (Figure 9). Growth rates of bluegill were average and comparable to median bluegill growth rates in similar lakes with the exception of older age classes, during which growth rates decline (Figure 10). On average, bluegill reached 7 inches in 6 years. Total annual mortality of bluegill was 23.7% (*F = 3.5, p = 0.0001).*

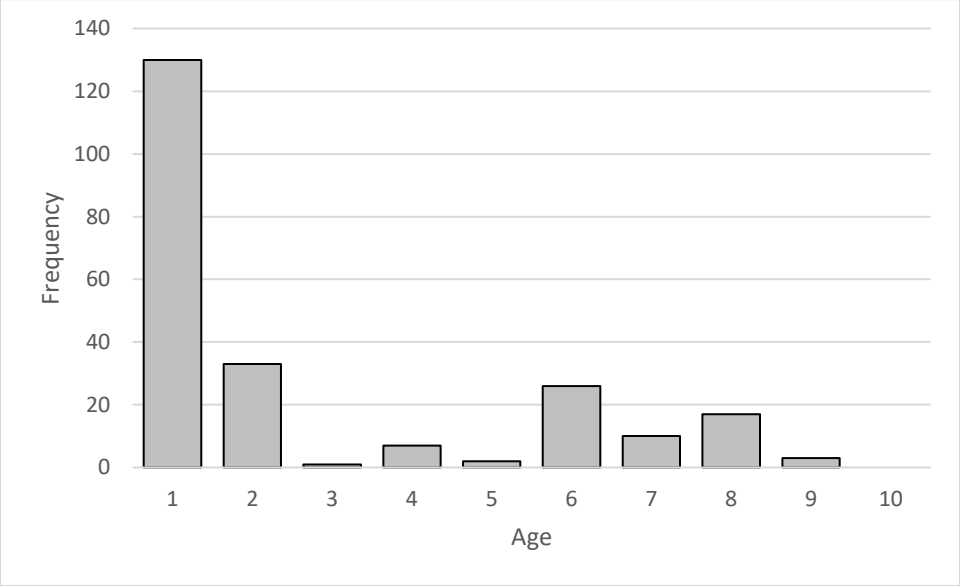


Figure 9. Age frequency distribution of bluegill collected from Apple Lake in St. Croix County in 2024.

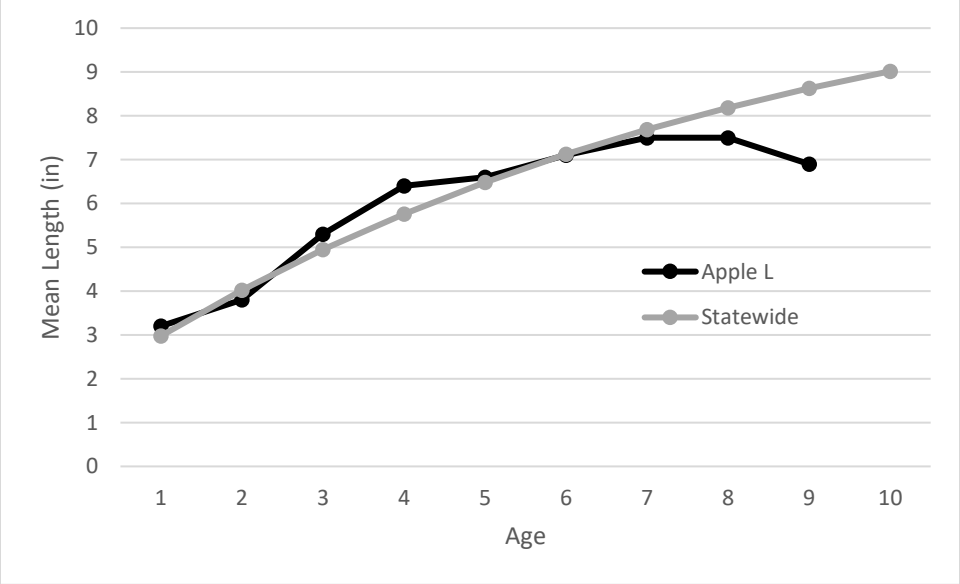


Figure 10. Mean length at age of bluegill collected from Apple Lake in St. Croix County in 2024 and median mean length at age of bluegill in Complex Warm Dark lakes across Wisconsin.

BLACK CRAPPIE

A total of 301 black crappie were captured throughout the survey which resulted in a catch rate of 1 fish per net night (10th percentile) during the fyke netting survey or 224 fish per mile during electrofishing. According to the electrofishing catch rates, the crappie population has increased from 45 per mile in 2018. The crappie population exhibited somewhat poor size structure skewed towards small individuals and no fish larger than 11 inches were captured. Crappie ranged in length from 2.4 to 10.4 inches with a mean length of 5.8 inches (75th percentile; Figure 11).

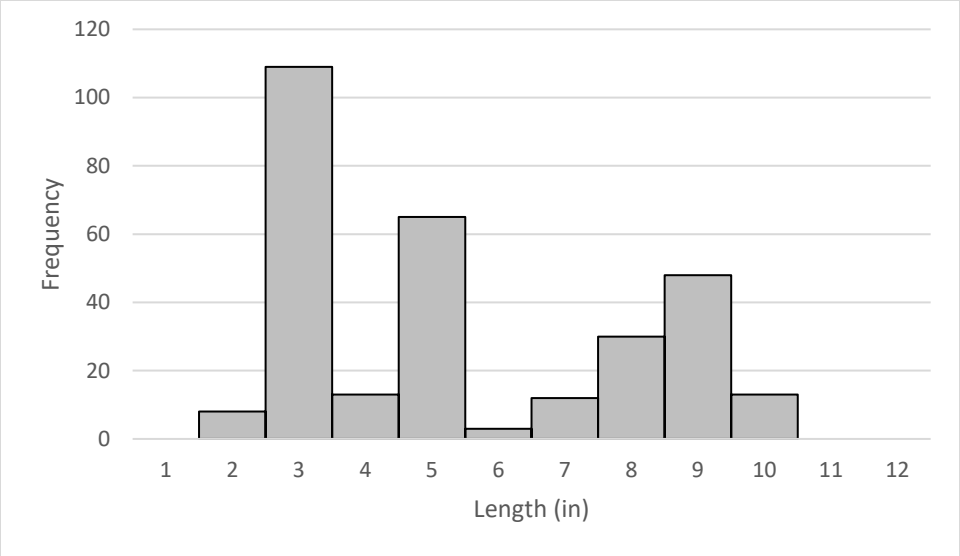


Figure 11. Length frequency distribution of black crappie collected from Apple Lake in St. Croix County in 2024.

Natural reproduction of black crappie occurred annually and produced strong year classes in 2023, 2019 and 2015 (Figure 12). Weak year classes occurred in 2021, 2018 and in 2015. The presence of the 2014-year class indicated some survival from the winterkill event in the winter of 2013-2014. Maximum age of black crappie was age-10 (Figure 12). Growth rates of black crappie as expressed by mean length at age were average when compared to median mean length at age of black crappie in similar lakes from ages 1 to 4 and then decline at older ages and were below average (Figure 13). Black crappie reached 10 inches in 7 years, on average. Total annual mortality was 28.2% (*F = 10.3, p = 0.0001).*

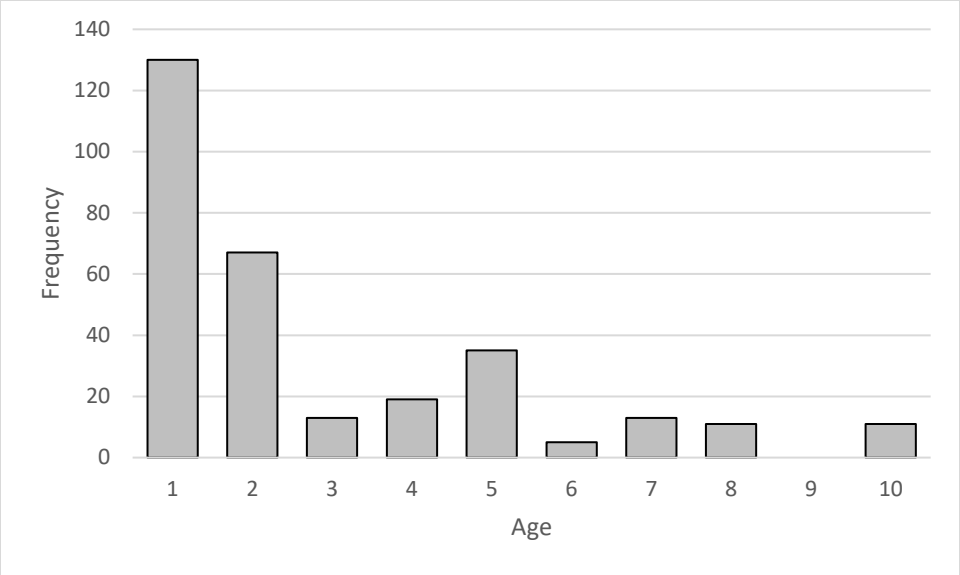


Figure 12. Age frequency distribution of black crappie collected from Apple Lake in St. Croix County in 2024.

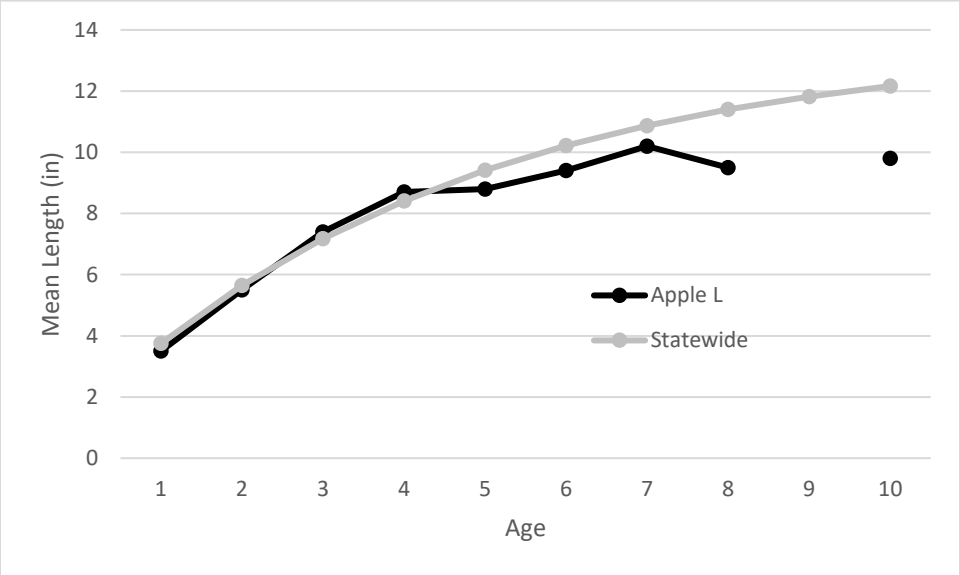


Figure 13. Mean length at age of black crappie collected from Apple Lake in St. Croix County in 2024 and median mean length at age of black crappie in Complex Warm Dark lakes across Wisconsin.

BLACK BULLHEAD

Black bullhead were less abundant in 2024 than during the 2023 removal efforts. The catch rate during the fyke netting removal in 2023 was 44.4 fish per net night (100th percentile) with a total of 1774 fish removed or 1023 lbs. The average length of black bullhead during that time was 10.6 inches (75th percentile) and fish ranged from 9.8 to 11.7 inches. No juvenile fish were captured in 2023. Additional removal was conducted via night electrofishing on 5/16/2023 and 660 fish or 407 lbs. were removed which resulted in a catch rate of 137.5 fish per mile. Another night of electrofishing in the fall of 2023 resulted in very few bullhead encountered and only eight fish were removed at that time. The 2024 netting survey resulted in the removal of 1,167 black

bullhead which equated to a catch rate of 13.3 fish per net night (75th percentile) which was a substantial decrease from the 2023 netting catch rate. Bullhead were also removed during 2024 spring electrofishing and an additional 60 fish were removed in early April for a catch rate of 7.1 fish per mile. Electrofishing in May removed an additional 102 bullhead for a catch rate of 24.9 fish per mile which was considerably lower than catch rates during May 2023. A total of 3,669 bullhead have been removed from 2023 through 2024. All black bullhead appear to the result of 1-2-year classes. A single 2.9-inch bullhead was captured in spring 2024.

Discussion

The walleye population has expanded since 2018 and is present in low densities but exhibits excellent size structure. The stocking rate of walleye is low at five fish per acre in even years and is resulting in a fishable population of adult fish. The minimum size of a fishable population as defined by the DNR Fisheries program is 1.5 adult fish per acre. Additionally, the size structure of adult walleye was excellent with 61% of fish larger than the minimum length limit (15 inches). Growth rates of stocked fish were also moderate and fish were in excellent condition. Interestingly, a limited amount of successful natural reproduction occurred in 2021, however these naturally reproduced fish exhibited slower growth rates when compared to the stocked year classes of fish. While walleye stocking is producing an excellent fishable population, angler harvest of walleye is very low. Angler exploitation of walleye was estimated at 3.2% which was similar to exploitation in nearby Pine Lake in 2022, during which exploitation was estimated at 5.4% (Yallaly 2023). These exploitation estimates are very low when compared to other exploited walleye populations (Quist et al. 2010), indicating that stocked walleye are not an important component of angler harvest in lakes in St. Croix County.

Northern pike are likely a larger component of angler harvest in Apple Lake based on the size structure and reductions in the population size from 2018. The size of the adult population has drastically declined from 11.1 fish per acre in 2018 to 0.5 fish per acre in 2024. Additionally, only three fish less than 20 inches were captured in the 2024 survey which may indicate limited natural reproduction has occurred during the past several years. Based on PSD estimates, the size structure is heavily skewed towards large individuals. Only one stocking event of northern pike has occurred in Apple Lake after the winterkill of 2014 which indicates that a portion of northern pike survived the winterkill and successfully produced year classes since then. However, water levels within Apple Lake have been low for several years prior to the 2024 survey which may have resulted in severe reductions in suitable pike spawning habitat. Pike prefer to spawn in shallow water on flooded vegetation including grasses and sedges (Crossman and Casselman 1987; Raat 1988). Access to this habitat has likely been limited in Apple Lake with most vegetation stranded on dry land and access to back bays restricted. Therefore, stocking may be needed during periods of low water levels to maintain the northern pike population in the absence of natural recruitment.

Largemouth bass populations have successfully recovered since the winterkill. Densities are now considered high and catch rates have increased dramatically since the 2018 survey. Growth rates of bass were average with faster growth rates for younger fish. Bass were in excellent condition and exhibited excellent size structure with several trophy sized (> 20 inches) individuals present within the sample. Since stocking ceased in 2017, natural reproduction of bass has resulted in consistent recruitment. The stocking event that occurred in 2014 following the winterkill resulted in a year class and fish are still present in the lake from that stocking event. The large stocking event of approximately 50,000 fingerlings in 2017 did not result in a strong year class, indicating low survival from that stocking event which may have been due to high intraspecific competition. Mortality of largemouth bass was low which is common with bass populations across their range. Angler harvest of bass is generally low as most anglers prefer catch and release tactics with bass species (Yallaly and Schurrer 2022) as has been documented on area lakes. However, low angler harvest of bass can result in reductions in size structure and growth rates of bass populations due to density dependent factors (Hansen et al. 2015).

Bluegill densities have remained stable while black crappie densities have increased from 45 fish per mile in 2018 to 224 fish per mile in 2024. Both species exhibited good growth rates that were comparable to statewide average growth rates, except at larger sizes when growth was below average. After bluegill reached approximately 7.6 inches, growth was minimal. Similarly, black crappie growth slowed considerably after reaching 8.8 inches. While mean length of bluegill was within the 90th percentile and black crappie mean length was within the 75th percentile for similar lakes in Wisconsin, mean length of both species has declined since 2018. Strong year classes of bluegill and black crappie may result in high intraspecific competition which may influence growth rates, especially at larger sizes. Additionally, in most years that resulted in strong bluegill year classes, largemouth bass year classes were weak and vice versa. This is consistent with population demographics of largemouth bass and bluegill being closely linked and resulting in strong influences on the other species. Black bullhead catch rates significantly declined since onset of the bullhead removal project that began in 2023. A total of 3,669 black bullhead have been removed by DNR staff during 2023 and 2024 which has resulted in the decline in catch rates. Recruitment of black bullhead has not occurred since the winterkill as evidenced by the lack of year classes within the population. Lack of reproduction and recruitment along with the well-established predator populations and aeration systems preventing low dissolved oxygen levels, black bullhead likely will not have the ability to rebound. Black bullhead are well adapted to survive low dissolved oxygen levels when other species cannot and can thus experience population explosions when these conditions occur (Cooper and Washburn 1949, Rahel 1984). Lack of natural predators and ample forage resources can result in large year classes.
The Apple Lake fishery has successfully recovered after the winterkill ten years ago. Centrarchid populations have expanded considerably since the last survey in 2018. The largemouth bass population offers an excellent fishery with trophy potential

while bluegill and black crappie offer harvest opportunities with high density populations. Low stocking rates of walleye have resulted in a low-density fishery; however, few anglers appear to take advantage of this harvest opportunity. Northern pike abundance has dramatically declined to very low levels since the previous survey in which densities were high. Limited natural reproduction has likely occurred since water levels have dropped and stranded preferred spawning habitat and restricted access to bays where spawning and rearing likely occurred. Stocking may be needed to maintain the population while these conditions persist, especially with potentially high rates of angler harvest.

Recommendations

No regulation changes are proposed for the lake. Regulations are currently liberal and encourage harvest of species which is desirable from a management perspective to improve or maintain growth rates and size structure of fish populations. Northern pike stocking is needed during periods of low water levels to maintain the population. Near shore habitat installation projects in the form of fish sticks would benefit fish habitat and subsequent populations.

1. Encourage angler harvest of walleye to utilize the stocked resource.
2. Collaborate with the lake district and consider northern pike stocking in 2025 and while low water levels persist.
3. Consider dredging channels to backwater bays while water levels are low to maintain connectivity for fish populations to access additional spawning and nursery habitat.
4. Encourage angler harvest of panfish and largemouth bass within the current harvest regulations to maintain or improve size structure and growth rates.
5. Continue to increase the amount of coarse woody habitat within the littoral zone with the addition of fish sticks and tree drops.
6. Continue to maintain and operate the winter aeration system to aid in prevention of winterkill.

References

Cooper, G.P. and G.N. Washburn. 1949. Relation of dissolved oxygen to winter mortality of fish in Michigan Lakes. Transactions of the American Fisheries Society 76(1):23-33.

Crossman, E.J. and J.M. Casselman. 1987. An annotated bibliography of the pike, *Exox Lucius* (Osteichthyes: Salmoniformes). R. Ont. Mus. Life Sciences. Misc. Publ.

Hansen, J.F., Sass, G.G., Gaeta, J.W., Hansen, G.J.A., Isermann, D.A., Lyons, J. and Vander Zanden, M.J. 2015. Largemouth bass management in Wisconsin: intra- and interspecific implications of abundance increases. In: Tringali, M.D., Long, J.M.,

Birdsong, T.W., Allen, M.S. (Eds.), Black Bass Diversity: Multidisciplinary Science for Conservation. Am. Fish. Soc. Symp. 82, 193-206.

Koenigs, R.P., R.M. Bruch and K.K. Kamke. 2013. Impacts of Anchor Tag Loss on Walleye Management in the Winnebago System. North American Journal of Fisheries Management 33:909-916.

Quist, M.C., J.L Stephen, S.T. Lynott, J.M. Goeckler and R.D. Schultz. 2010. Exploitation of walleye in a Great Plains reservoir: harvest patterns and management scenarios. Fisheries Management and Ecology 17:522-531.

Raat, A.J.P. 1988. Synopsis of biological data on the northern pike *Esox Lucius* Linnaeus, 1758. FAO Fish. Synopsis. 30, Rev.2. FAO, Rome.

Rahel, F.J. 1984. Factors structuring fish assemblages along a bog lake successional gradient. Ecology 65(4):1276-1289.

Yallaly, K.L. 2022. Pine Lake, St. Croix County 2022 Fisheries Survey Report. Wisconsin Department of Natural Resources, Fisheries Survey Report, Madison.

Yallaly, K.L. and D. Schurrer. 2023. Lake Menomin 2021-2022 Creek Survey report. Wisconsin Department of Natural Resources, Fisheries Survey Report, Madison