WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Fishery Survey Report for The Red Cedar Chain of Lakes, Barron and Washburn counties, Wisconsin 2023

Waterbody Identification Codes: 2112800, 2109800 and 2109600

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Executive Summary

The Red Cedar Chain of Lakes was surveyed during 2023 to determine the abundance and population demographics (size and age structure, growth and recruitment) of walleye as part of the Treaty assessment protocol for lakes within the Ceded Territory. In addition, the abundance and population demographics were assessed for other sport fish. The combined walleye population estimate for Red Cedar Lake and Balsam Lake was 5,369 fish (95% CI = 1,440 – 2,832 fish) or 2.5 fish/acre (95% CI = 2.2 – 2.8 fish/acre). Adult walleye density in Red Cedar and Balsam lakes combined decreased since 2016 but remained temporally stable since the early 1980's which ranged from 2.2 fish/acre (2005) to 3.9 fish/acre (2016) with a mean population density estimate of 2.8 fish/acre (± 0.4 fish/acre; mean error). Additionally, walleye growth rates and population size structure increased since 2016. A quality adult walleye population was present with moderate abundance and size structure and represents one of the few remaining naturally reproducing populations in Barron and Polk counties. The walleye management objective is to maintain adult walleye density between 2 - 4 fish/acre and have the rolling five-year mean (± standard error) age-0 catch rate during fall electrofishing surveys be > 15 age-0 walleye/mile. The northern pike population in the Red Cedar Chain of Lakes was variable between lakes but generally had low – moderate density with quality size structure and potential for trophy-sized individuals. Largemouth bass and smallmouth bass populations remained relatively unchanged since 2005 with moderate abundance, quality size structure, average growth rates and sustained annual recruitment. The Red Cedar Chain of Lakes supports quality panfish populations characterized by moderate abundance with excellent size structure. Panfish abundances were greatest in Hemlock Lake which was likely due to habitat differences (shallower and more vegetated) compared to Red Cedar Lake and Balsam Lake. Panfish population size structures were underestimated during SE2 surveys compared to the SN1 surveys and are also not representative of angler catches recorded during previous creel surveys. No specific management actions regarding largemouth bass, smallmouth bass, northern pike, bluegill and black crappie are recommended currently.

Introduction

The Red Cedar Chain of Lakes consists of Red Cedar Lake, Balsam Lake and Hemlock Lake, and forms the headwaters of the Red Cedar River in northeastern Barron and southeastern Washburn counties. The Red Cedar drainage flows from Lake Chetac and Birch Lake into the north end of Balsam Lake and exits along the southwestern shoreline of Red Cedar Lake through a county-owned dam with eleven feet of head at Mikana, Wisconsin. The outflow, which forms the Red Cedar River, continues downstream to Rice Lake. Red Cedar Lake is the largest Lake (1,897 acres) in the chain with a maximum depth of 53 feet, average depth of 25.7 feet, multiple islands and complex bathymetry. Balsam Lake is 325 acres with a maximum depth of 49 feet and an average depth of 25.1 feet but limnological features resemble that of Red Cedar Lake. Red Cedar and Balsam lakes have clear to slightly stained water with bottom substrates composed primarily of sand and gravel and are classified as complex-two story lakes (Rypel et al. 2019). In contrast, Hemlock Lake (357 acres) is shallower (maximum depth of 21 feet and average depth of 8.4 feet) with greater densities of submerged vegetation and is classified as a complex-cool-dark lake (Rypel et al. 2019). Hemlock Creek flows into Hemlock Lake along the eastern shoreline and outflows at the western shoreline through a connecting channel to the South Basin of Red Cedar Lake. In addition to the flows from Balsam and Hemlock lakes, there are two tributaries (Sucker Creek and Pigeon Creek) on the east side of Red Cedar Lake. The total drainage area of the Red Cedar Chain of lakes is about 147 mi^2 and the watershed is predominately forest and wetlands (78%; Robertson et al. 2003). The recreational value of these lakes is high with numerous public access locations throughout the chain and highly developed shorelines primarily consisting of lake-home residences. Currently recognized invasive species include curly-leaf pondweed, rusty crayfish and Chinese mystery snail.

The sport fish community in the Red Cedar Chain of Lakes is diverse and includes bluegill, pumpkinseed, green sunfish, black crappie, rock bass, smallmouth bass, largemouth bass, yellow perch, walleye, northern pike, cisco, bullheads and white sucker.

The Red Cedar Chain of Lakes has a rich history of fisheries management activities. Fisheries surveys began as early as 1938 and occurred periodically afterwards through present. The earliest stocking efforts began during 1933 and continued through 2019. Historical stockings included numerous species including (but not limited to) northern pike, largemouth bass, yellow perch, smallmouth bass, bullheads, black crappie, bluegill and walleye.

Red Cedar Lake has been historically known as a walleye fishing destination and is considered within the native range of walleye in Wisconsin (Becker 1983). The historical management of walleye in Red Cedar Lake has been fraught with controversy, primarily centered around walleye stocking (Cornelius 1980). During the early years (1930's), stories swirled of the fantastic walleye fishing on Red Cedar Lake in the “old days”, a timeless tale where fishing success may look better in retrospect than it perhaps was, but the 1939 fisheries survey described the walleye population as naturally reproducing and abundant with mean lengths near 16 inches (Cornelius 1980). Despite this, consistent stocking of walleye fry and small fingerlings occurred between 1933 - 1973. Walleye stocking was discontinued in 1973 due to evidence of sufficient natural recruitment during the 1971 and 1973 surveys, but this was met with considerable public contention. Despite reports of generally poor walleye fishing, the adult population remained naturally reproducing and abundant during the 1980’s (3.9 adults/acre) and 1990’s (2.9 adults/acre). However, walleye stocking was reinstated in 1992 due to concerns of declining adult densities. Small fingerling stocking continued through 2004 and walleye fry were reared and stocked into Red Cedar Lake periodically during 2004 to 2019 using a portable fish hatchery (walleye wagon) by the local Walleye’s for Tomorrow Chapter (Appendix Table 1). The adult walleye population remained relatively abundant during 2005 (2.2 adults/acre) but concerns of declining adult densities (relative to 1980 and 1990 surveys) due to overharvest spurred a regulation change during 2007 from a 15-inch minimum length limit (MLL) with a fluctuating daily bag limit to an 18-inch MLL, three fish daily bag limit. Following this regulation change, the population increased to nearly four adult/acre by 2016. Correspondingly, growth eventually slowed as population density increased and few fish exceeded the 18-inch MLL during the 2016 survey. This sparked public interest in increasing harvest opportunities which led to a regulation change during 2019 to the Ceded Territory default regulation (15-inch MLL, fish between 20-24 inches may not be kept, 3 fish daily bag limit with only 1 fish > 24 inches allowed).

Walleyes in the Red Cedar Chain of Lakes are regarded as one discrete population, with varying levels of inter-lake movement documented during previous population estimate and creel surveys. However, tribal harvest regulations are set on a per-lake basis, reflecting differences in lake size and walleye abundance in each lake. This approach helps manage the population effectively while accounting for the unique characteristics of each lake within the chain. Population estimates are presented at both lake-specific and system-wide scales but should be considered one population.

All fish species follow statewide or Ceded Territory regulations.

The Wisconsin Department of Natural Resources (DNR) surveyed the Red Cedar Chain of Lake to assess the status of the fishery during 2023. A mark-recapture survey was performed to estimate the adult density of walleye. We assessed catch rates of smallmouth bass, largemouth bass, northern pike, bluegill, black crappie and other panfish species to estimate relative abundance. We assessed population characteristics, size structure and growth for all species when possible.

Methods

FIELD SAMPLING

The Red Cedar Chain of Lakes was sampled during 2023 with early spring fyke netting (SN1), early spring (SE1) and late spring (SE2) night electrofishing and fall night electrofishing surveys following the DNR comprehensive Treaty assessment protocol (Appendix Table 2; Cichosz 2021).

The population abundance of adult walleye was estimated using mark-recapture methodology during the SN1 and SE1 surveys. The population size of adult walleye was estimated with Chapman's modification of the Peterson model (Ricker 1975):

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

where N = population estimate; M = the number of fish marked in the first (marking) sample; C = the total number of fish (marked and unmarked) captured in the second (recapture) sample; and R is the number of marked fish captured in the second sample.

Walleyes were captured with fyke nets set at ice out. Fyke nets were deployed April 17th, 2023 on Hemlock Lake and checked every 24 h over 7 days for a total of 35 net nights fished. Fyke netting began April 21st, 2023 on Red Cedar Lake and continued for 9 days and totaled 84 net nights. Lastly, fyke netting on Balsam Lake began April 26th, 2023 and continued for 3 days and totaled 15 net nights. Fyke nets had 4 x 6 ft. frames, 0.5 to 0.75-in bar measure mesh and lead lengths of 75 ft or less. All walleye were measured (total length), weighed, sexed and given a specific mark indicating capture. Adult walleye ≥ 15 inches or sexable (extrusion of eggs or milt; Cichosz 2021) were marked with a fin clip and juvenile walleye < 15 inches were marked with a different fin clip. Aging structures were collected from five walleye of each sex per 0.5-inch length group. Scales were taken from walleye < 12 inches and dorsal spines were taken from fish > 12.0 inches. For the recapture period, walleye collected during the SE1 surveys, were measured, sexed and checked for marks. All northern pike were measured, clipped and aging structures (anal fin rays) were collected from five fish bass per 0.5-inch length group for age and growth analyses.

The SE2 surveys were conducted May 22nd, 2023 on Hemlock Lake, May 23rd, 2023 on Balsam Lake and May 23rd - 24th, 2023 on Red Cedar Lake to assess largemouth bass and panfish populations. The SE2 survey consisted of 0.5-mile index stations where all gamefish and panfish were captured, and 1.5-mile gamefish stations where all gamefish were collected. There were two index stations and two gamefish stations completed on Hemlock and Balsam lakes and four index stations and four gamefish stations completed on Red Cedar Lake. All fish were measured, but weights and aging structures (dorsal spines) were collected from five largemouth bass and smallmouth bass per 0.5-inch length group for age and growth analyses. Catch per unit effort (CPUE; index of relative abundance) was estimated as catch per mile.

Bluegill and black crappie (five per 0.5-inch length group) were aged with otoliths. Fish were collected during SN1 and SE2 surveys.

Fall night electrofishing surveys were conducted September 26th, 2023 on Hemlock Lake, September 27th, 2023 on Balsam Lake and October 2nd, 2023 on Red Cedar Lake to assess the year class strength of naturally recruited age-0 and age-1 walleye. The entire shoreline was sampled on Hemlock and Balsam lakes whereas a subset of the entire shoreline on Red Cedar Lake was sampled and walleyes < 12 inches were collected. The CPUE (catch per mile) of age-0 and age-1 walleye was compared to previous fall evaluations.

POPULATION DEMOGRAPHICS

Population estimates and CPUEs were compared to previous surveys and lake class standards when possible.

Dorsal spines and anal fin rays were cut with a Dremel saw and aged with a dissecting microscope by a single interpreter. Bluegill otoliths were transverse thin-sectioned and aged under a microscope. Black crappie age assignment occurred using whole otoliths or transverse thin sections under a microscope. When data were available, mean length at age was compared to previous surveys, county (Barron and Polk counties) averages and the median length at age for lakes of similar classification (Rypel 2019).

The von Bertalanffy (1938) growth model was determined using mean length at age data to assess growth using the following equation:

$$Lt = L_{inf}\ (1 - e^{-k(t-t_0)})$$

Where L_t is length at time t, L_{inf} is the maximum theoretical length (length infinity), e is the exponent for natural logarithms, k is the growth coefficient, t is age in years and t_0 is the age when L_t is zero.

Growth equations for all species were completed by pooling sexes for comparative purposes to lake class standards and the Barron and Polk counties average estimates, despite known sex-specific growth differences for walleye and other species.

Size structure was assessed using proportional size distribution (PSD) and relative frequency and compared to previous surveys (Neumann et al. 2013). Kolmogorov-Smirnov (KS) tests were used to statistically compare size structures between survey years. The PSD 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.

The instantaneous mortality (Z) and annual mortality ($A = 1-e^{-Z}$) rates of largemouth bass, smallmouth bass and black crappie were determined using a catch curve regression fitted to those ages fully recruited to the gear (Miranda and Bettoli 2007).

The Red Cedar Chain of Lakes has a history of walleye stocking (Appendix Table 1). We aimed to add to previous stocking assessment analyses by evaluating if stocking yielded detectable increases in age-0 walleye catch rates during fall surveys. We simply assessed mean catch rates between fry-stocked and non-stocked years guided by the assumption that higher age-0 walleye catch rates should be observed if fry-stocking contributed significantly to the recruited year class. Small fingerling walleye were stocked during 1992-2004; however, these stocking events were not included due to differences in survey design (survey transects ranged from 6.5 – 9.5 miles compared to 12.4 miles post-2004). Years when fry and small fingerlings were stocked were excluded (2004 & 2011). Walleye fry were reared and stocked into Red Cedar Lake using a portable fish hatchery (walleye wagon) by the local Walleye's for Tomorrow Chapter during 2004 to 2019, although stocking did not occur annually.

Results

EARLY SPRING FYKE NETTING AND ELECTROFISHING

WALLEYE

A total of 3,128 walleyes were collected during the SN1 and SE1 surveys in the Red Cedar Chain of Lakes. In Red Cedar and Balsam lakes, there were 2,998 walleyes collected (SN1 and SE1 surveys; Figure 1). The adult walleye population during 2023 was estimated to be 4,067 fish (95% confidence interval (CI) = 3,517 – 4,618 fish) or 2.2 fish/acre (95% CI = 1.9 – 2.5 fish/acre; coefficient of variation (CV) = 0.07) for Red Cedar Lake and 1,225 fish (95% CI = 841 – 1,609 fish) or 4.2 fish/acre (95% CI = 2.9 – 5.5 fish/acre; CV = 0.16) for Balsam Lake. The combined population estimate for Red Cedar Lake and Balsam Lake was 5,369 fish (95% CI = 1,440 – 2,832 fish) or 2.5 fish/acre (95% CI = 2.2 – 2.8 fish/acre). The adult walleye population estimate for Hemlock Lake was not included due to high estimate error (CV = 0.46). Adult walleye density in Red Cedar and Balsam lakes combined decreased since 2016 but remained temporally stable since the early 1980's which ranged from 2.2 fish/acre (2005) to 3.9 fish/acre (2016) with a historic mean population density estimate of 2.8 fish/acre (± 0.4 fish/acre; mean error; Figure 2). Walleye CPUE in Red Cedar Lake was 17.8 fish/net night and 13.3 fish/net night in Balsam Lake, both of which increased since 2016 and ranged between the 75th - 90th percentile (11.5 - 17.8 fish/net night) for similar complex-two story Wisconsin lakes.

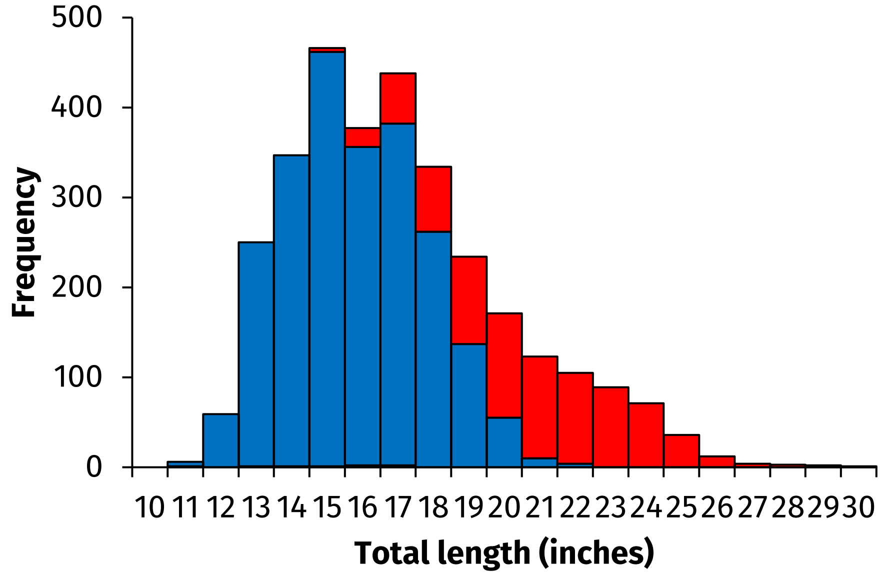

Figure 1. Length frequencies of male (blue) and female (red) walleye collected during the SN1 and SE1 surveys in the Red Cedar Chain of Lakes, Barron and Washburn Counties, WI, 2023.

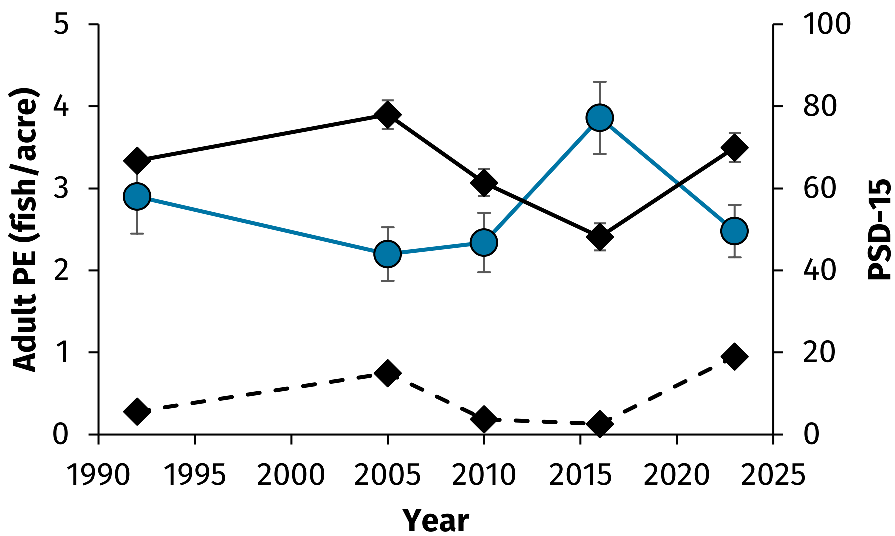

Figure 2. Combined (Red Cedar Lake and Balsam Lake) walleye population estimates (number of fish per acre ± 95% CI; blue circles), PSD-15 (± 95% CI; black diamonds with solid line) and PSD-20 (black diamonds with dashed line) during the 1992, 2005, 2010, 2016 and 2023 fishery surveys.

Walleyes ranged in length from 11.6 – 30.2 inches and the mean lengths of females and males was 21.4 inches and 16.5 inches, respectively (SN1 and SE1 surveys; Figure 1). Walleye PSD-15 (Red Cedar Lake and Balsam Lake combined) was 70, PSD-20 was 19 and PSD-25 was 2. The PSD indices indicated an average size structure (PSD-15 = 30 - 60; Anderson and Weithman 1978). Size structure indices increased since 2016 (PSD-15 = 48) but were similar to 1992 – 2010 (mean PSD-15 = 69 ± 8; standard deviation;

Figure 2). Population relative length frequencies were not considered different between 2016 and 2023 (KS test: D = 0.29, P = 0.36; Figure 3). Despite this, walleye > 18 inches composed a greater proportion of the population size structure during 2023 (38%) than 2016 (8%). Correspondingly, the mean length of females increased by 2.1 inches compared to the 2016 survey (19.3 inches) whereas males increased by only 0.4 inches. The sex ratio was male biased with a male to female ratio of approximately 3:1.

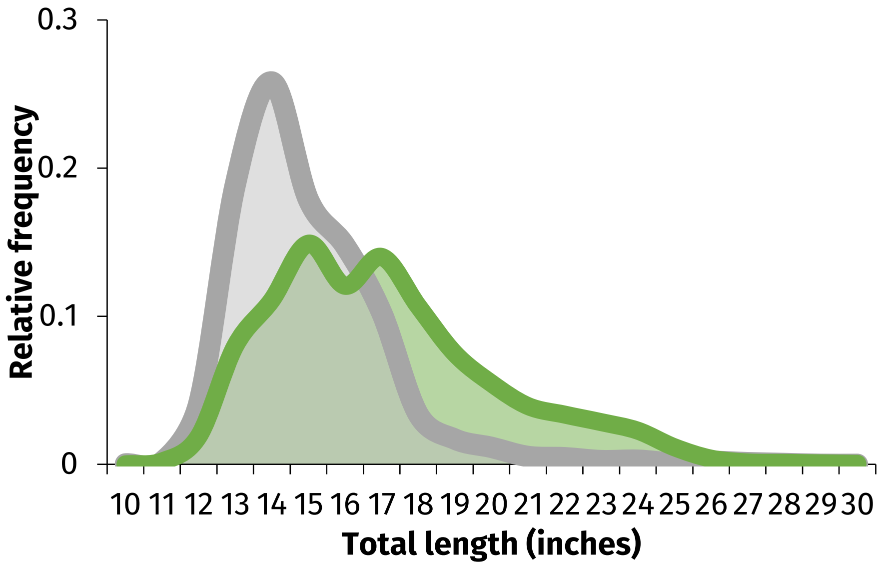

Figure 3. Walleye relative length frequencies during the 2016 (grey) and 2023 (green) SN1 and SE1 surveys in the Red Cedar Chain of Lakes, Barron County, WI.

Walleye growth rates were average but increased since 2016. Walleye ages ranged from 2 to 14, while females ranged from 3 to 13 and males 2 to 14. Mean lengths at age during 2023 were similar to 2005 (average difference in mean length at age: -0.1 inches) and the Barron and Polk counties average (average difference in mean length at age: +0.2 inches) but greater than 2010 (average difference in mean length at age: +0.7 inches), 2016 (average difference in mean length at age: +2.8 inches) and complex-two story Wisconsin lakes (average difference in length at age: +1.3 inches; Figure 4). All comparisons used ages 4 - 12. The von Bertalanffy growth model could not be fit to the observed length at age data.

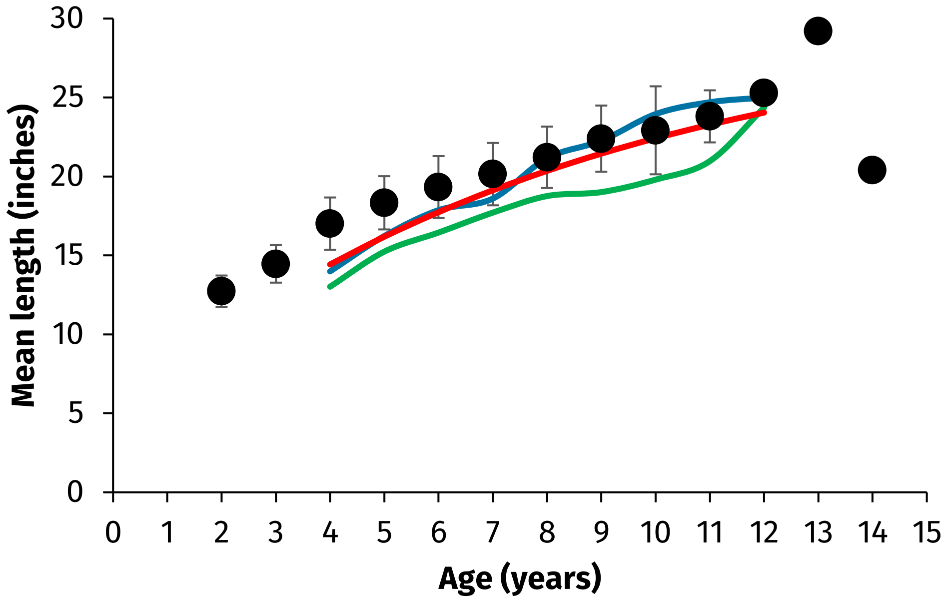

Figure 4. Mean length at age ± standard deviation of walleye (black circles) in the Red Cedar Chain of Lakes. Mean length at age estimates during the 2010 survey are represented by the blue line, 2016 survey by the green line and the median length at age for similar complex-two story Wisconsin lakes by the red line.

Walleye age structure was well distributed and multiple age classes were present. Age 3 – 8 fish composed 86% of the population whereas older age classes (ages 9+) composed 10% (Figure 5). Population age structures remained similar between 2016 and 2023 (KS test: D = 0.22, P = 0.76; Figure 5). The adult population was composed of eleven year classes (ages 4+) which was above management recommendations set forth by the 2022 Wisconsin walleye Management Plan (Donofrio et al. 2022). Natural recruitment appeared sufficient evident by consistent contributions to adult year classes. The breadth of adult age classes present was good and likely beneficial for future reproductive success and population resiliency.

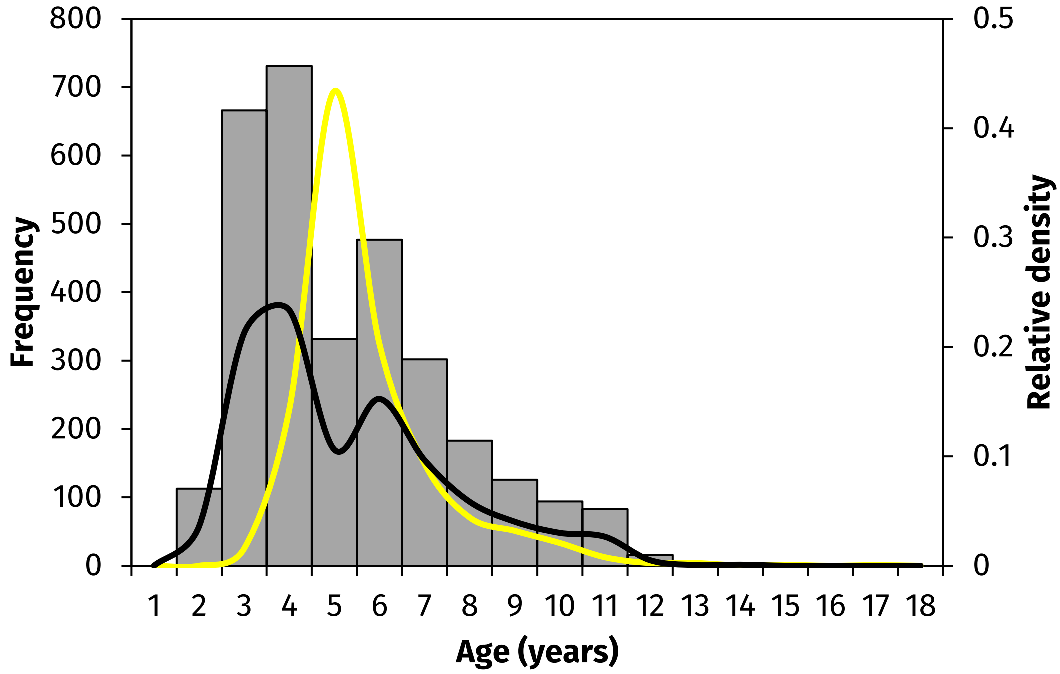

Figure 5. Age structure of walleye in the Red Cedar Chain of Lakes during the 2023 SN1 and SE1 surveys (grey bars). Lines represent relative density curves depicting age structures during 2023 (black line) and 2016 (yellow line).

Walleye recruitment during 2023 was low compared to previous fall surveys (Figure 6). Sixty age-0 walleye were collected during the 2023 fall electrofishing survey with a CPUE of 3.8 fish/mile and 33 age-1 walleye were collected with a CPUE of 2.1 fish/mile. Age-0 walleye ranged in length from 4.2 – 7.6 inches and age-1 walleye from 7.9 – 11.0 inches. Catch rates of age-0 walleye have trended downward since 2016 and 2023 was the second lowest CPUE recorded since 1997 and well below both the historic age-0 walleye CPUE for Red Cedar Lake (34.5 fish/mile) and the average for naturally reproducing walleye lakes in Barron County (13.5 ± 7.4 fish/mile; mean ± mean error; indexed using 19 fall surveys from Red Cedar Lake, Duck Lake and Silver Lake during 2009 – 2023; Figure 6). The catch rate of age-1 walleye was low but remained within the range of catch rates observed over the past decade (0.8 – 7.8 fish/mile).

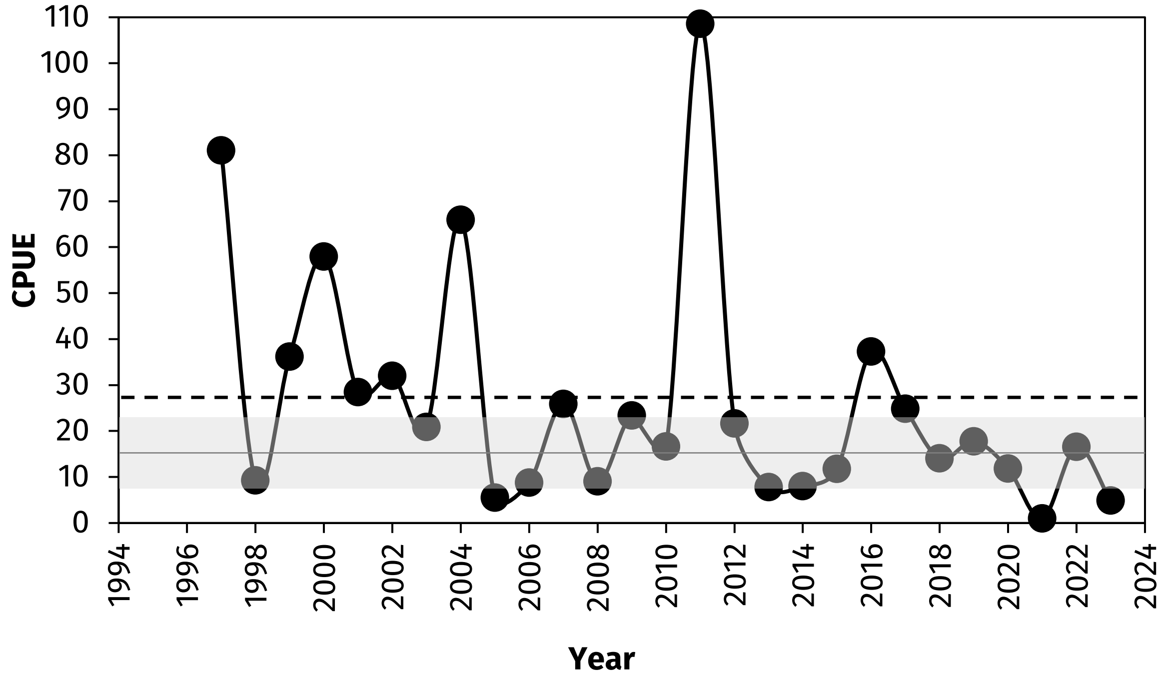

*Figure 6. Age-0 (black circles, solid line) walleye CPUE (fish/mile) indexed from fall electrofishing surveys during 1997 - 2023. The Barron County average age-0 walleye CPUE from naturally reproducing lakes (*indexed using 18 fall surveys from Red Cedar Lake, Duck Lake and Silver Lake during 2009 – 2022) *is represented by the grey line and shaded areas represent mean error. Dashed line represents the historic mean age-0 walleye CPUE for Red Cedar Lake.*

Fall catch rates of age-0 walleye did not differ between fry-stocked and non-stocked years (Figure 7). Mean catch rates of age-0 walleye during fry-stocked years was 15.1 fish/mile (±4.7 fish/mile; 95% confidence interval) and 12.4 fish/mile (± 4.9 fish/mile; 95% confidence interval) during non-stocked years.

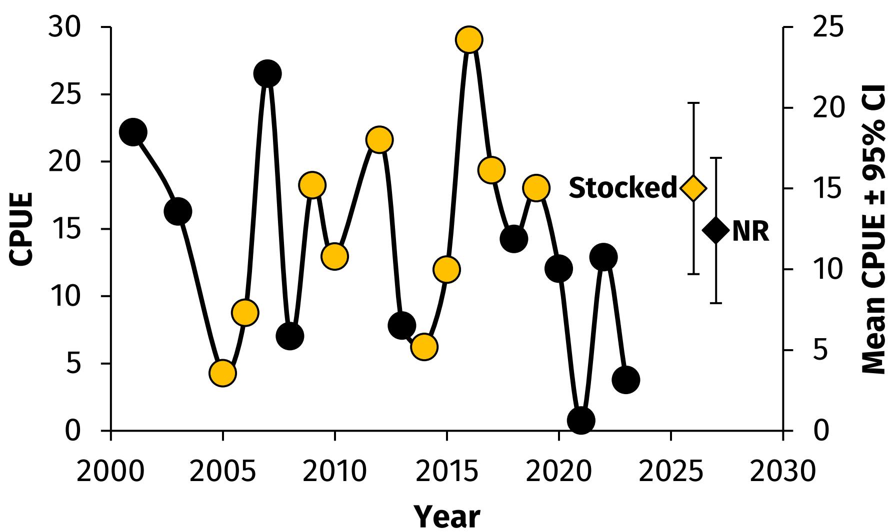

Figure 7. Age-0 walleye CPUE (fish/mile) during fry-stocked years (orange points) and non-stocked years (black points) indexed from fall electrofishing surveys on Red Cedar Lake during 2001 - 2023. Diamonds represent mean age-0 walleye CPUE ± 95% confidence intervals for fry-stocked (orange) and non-stocked years (black).

NORTHERN PIKE

There were 327 northern pike collected during the SN1 surveys with a CPUE of 2.4 fish/net night on the Red Cedar Chain of Lakes. The CPUE was 1.1 fish/net night on Red Cedar Lake and 0.5 fish/net night on Balsam Lake, both of which resembled the 50th percentile (1.1 fish/net night) for similar complex-two story Wisconsin lakes. The CPUE on Balsam Lake decreased since 2016 (0.9 fish/net night) whereas CPUE on Red Cedar Lake increased since 2016 (0.5 fish/net night). Despite variable catch rates, both lakes remained low density. The CPUE was 6.6 fish/net night on Hemlock Lake which was slightly greater than the 90th percentile (5.4 fish/net night) for similar complex-cool-dark Wisconsin lakes and increased since 2016 (1.3 fish/net night). Greater northern pike abundance in Hemlock Lake was likely driven by habitat differences compared to Red Cedar Lake and Balsam Lake.

Northern pike ranged in length from 12.4 to 39.5 inches and had an average length of 19.7 inches. Males ranged in length from 12.4 to 25.2 inches with a mean length of 17.8 inches and females ranged from 13.6 to 39.5 inches with a mean length of 21.0 inches (Figure 8). The northern pike PSD-21 was 21 on Hemlock Lake, 51 on Red Cedar Lake and 29 lake-wide (too few fish sampled on Balsam Lake to calculate PSD). Variation in PSD-21 between lakes could be driven by density dependence, although movement of northern pike between lakes is likely, but currently unknown. Size structure was moderate and remained similar to 2016 (lake-wide PSD-21 = 25). The PSD-28 was 5 which also resembled 2016 (PSD-28 = 4).

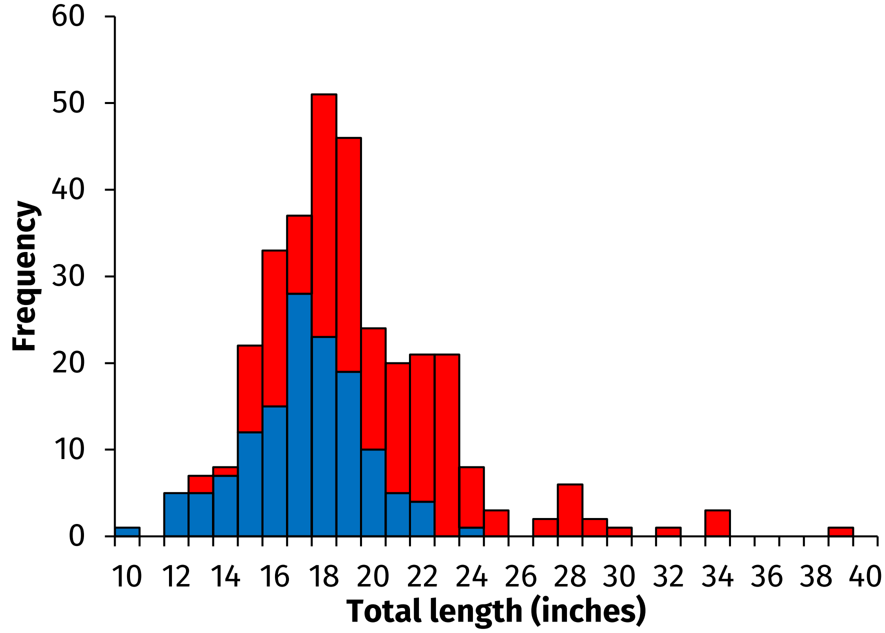

Figure 8. Length frequencies of male (blue) and female (red) northern pike collected during the SN1 surveys in the Red Cedar Chain of Lakes, Barron and Washburn Counties, WI, 2023.

Northern pike growth rates were average. Northern pike ages ranged from 2 to 12, while females ranged from 2 to 12 and males 2 to 5. Mean lengths at age during 2023 were similar to mean estimates from the 2016 survey (average difference in mean length at age: +0.5 inches), Barron and Polk counties (average difference in mean length at age: -0.9 inches) and the median for complex-two story lakes (average difference in mean length at age: +0.7 inches; Figure 9). All comparisons used ages 2 - 8. The von Bertalanffy growth model could not be fit to the observed length at age data.

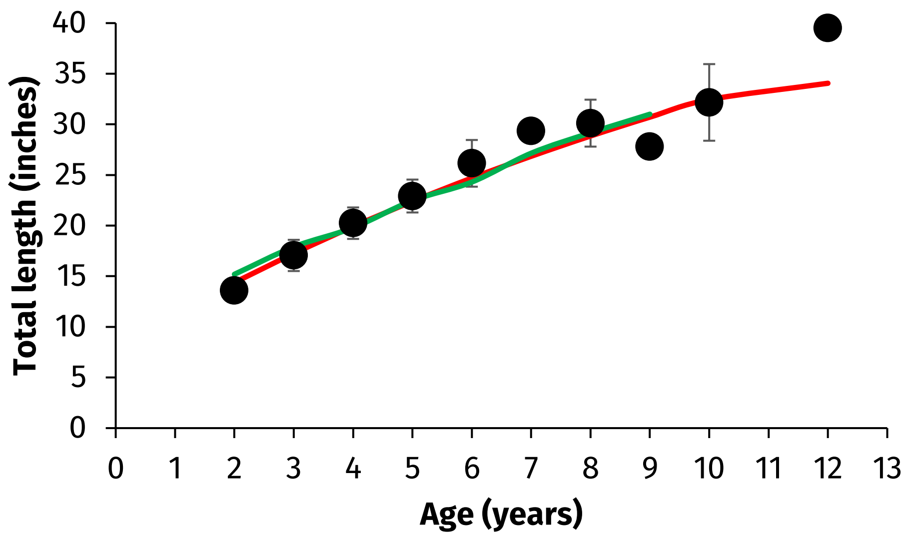

Figure 9. Mean length at age ± standard deviation of northern pike (black circles) in the Red Cedar Chain of Lakes. Mean length at age estimates during the 2016 survey are represented by the green line and the median length at age for similar complex-two story Wisconsin lakes by the red line.

Northern pike age structure was composed primarily of young fish where age 2 – 5 fish composed 94% of the population. Population age structure was well distributed with multiple age classes present and good longevity. Age structure remained relatively unchanged from 2016 (Figure 10).

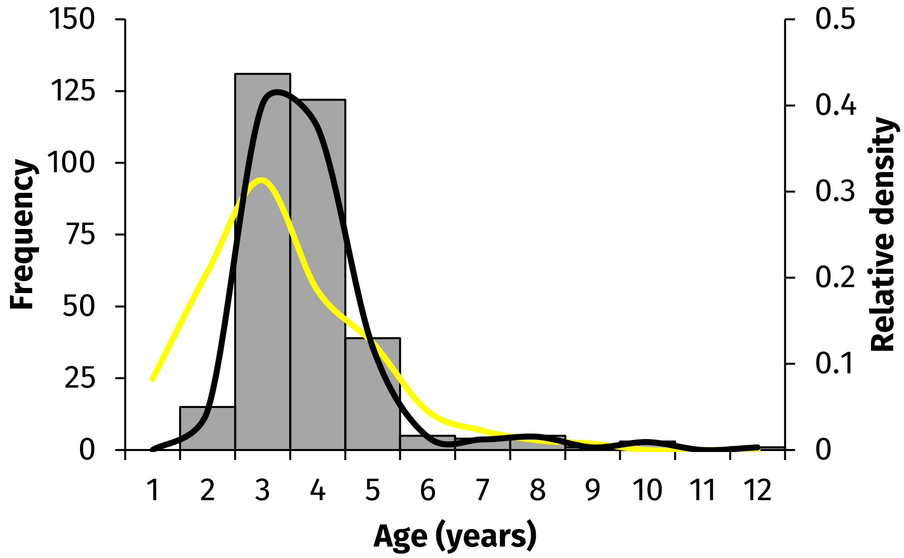

Figure 10. Age structure of northern pike in the Red Cedar Chain of Lakes during the 2023 SN1 surveys (grey bars). Lines represent relative density curves depicting age structures during 2023 (black line) and 2016 (yellow line).

LATE SPRING ELECTROFISHING

LARGEMOUTH BASS

There were 187 largemouth bass collected during the SE2 surveys across the Red Cedar Chain of Lakes with a CPUE of 9.8 fish/mile on Balsam Lake, 17.3 fish/mile on Hemlock Lake and 11.3 fish/mile on Red Cedar Lake. Interannual variation of largemouth bass CPUE between lakes was consistent with similar temporal patterns of relative abundance (Figure 11). Thus, despite differences in habitat availability, relative abundances of largemouth bass were considered similar between lakes. The lake-wide CPUE during 2023 was 12.5 fish/mile which resembled catch rates during previous surveys and the 75th percentile for similar complex-two story Wisconsin lakes. This is indicative of an average density population that remained stable since 2005.

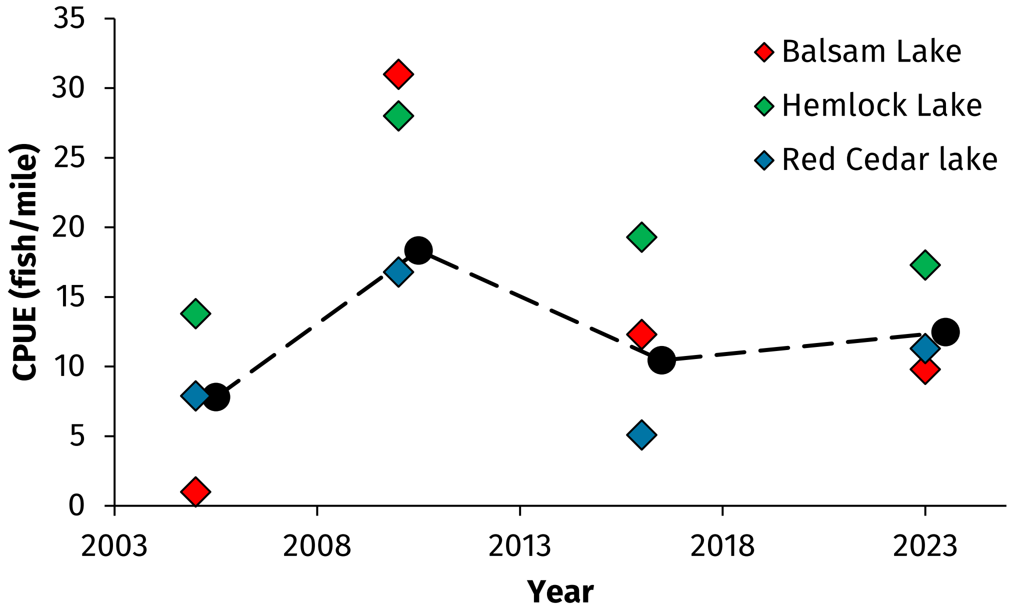

Figure 11. Largemouth bass CPUE in Red Cedar Lake, Balsam Lake and Hemlock Lake during 2005 – 2023. Lake-wide CPUE during 2005 - 2023 are represented by black circles.

Largemouth bass ranged in length from 6.6 - 20.3 inches and the mean length was 14.0 inches (± 2.6 inches; standard deviation), which remained similar to 2016 (13.7 inches ± 2.2 inches; standard deviation) and near the 99^{th} percentile (14.2 inches) for similar complex-two story Wisconsin lakes. The PSD-12 was 83 and PSD-14 was 55, which indicated a quality size structure (Figure 12) and both indices remained similar to 2016 (PSD-12 = 83 and PSD-14 = 50). The proportion of the population susceptible to harvest by the recreational fishery (≥ 14 inches) was 54%.

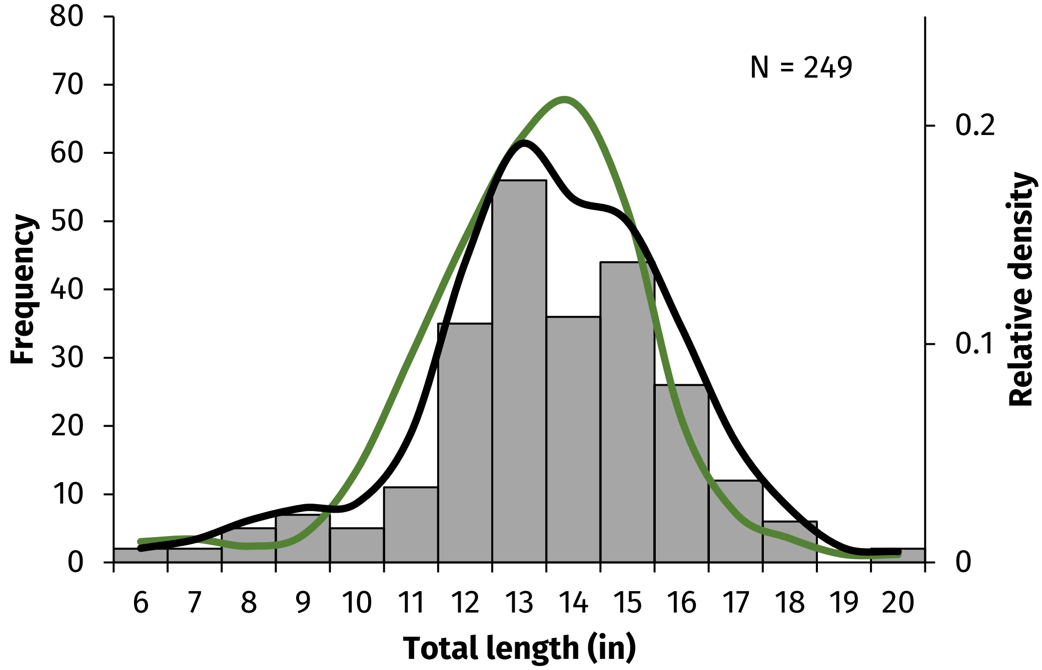

Figure 12. Length frequency of largemouth bass in the Red Cedar Chain of Lakes during the 2023 SE2 survey. Lines represent relative density curves depicting length frequencies during 2023 (black lines) and 2016 (green line).

Largemouth bass growth did not differ between Red Cedar Lake, Hemlock Lake and Balsam Lake and combined growth on the Red Cedar Chain of Lakes was average. Mean length at age improved since 2016 (average difference in mean length at age estimates: +1.3 inches; ages 2 - 11) and was greater than the median length at age standard for similar complex-cool-dark Wisconsin lakes (average difference in length at age estimates: +1.0 inches; ages 2 - 12), similar complex-two story lakes (average difference in length at age estimates: +0.9 inches; ages 2 - 12) and the Barron and Polk counties estimates (average difference in mean length at age estimates: +1.1 inches; ages 2 – 12; Figure 13). The predicted theoretical maximum length for largemouth bass using the von Bertalanffy growth model was 19.6 inches with k and t_0 estimated to be 0.24 and -0.26, respectively (Figure 13).

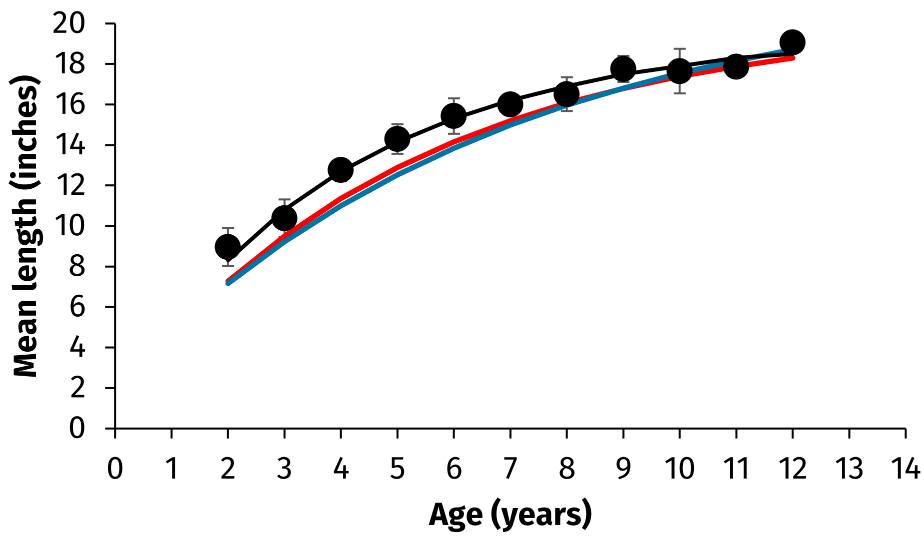

Figure 13. Largemouth bass mean length at age ± standard deviation and the von Bertalanffy growth curve (black line) during the 2023 fisheries survey on the Red Cedar Chain of Lakes. The median length at age estimates for complex-two story Wisconsin lakes are presented by the red line and complex-cool-dark Wisconsin lakes by the blue line. Largemouth bass were collected during SE2 and SN1 surveys. The mean length at age estimates during 2016 were similar to the lake class standards and not represented in the plot.

Largemouth bass age structure was well distributed with multiple age classes present and good longevity. Age 3 – 8 fish composed 92% of the population whereas older age classes (ages 9+) composed 6% (Figure 14). Recruitment appeared sufficient evident by the breadth of adult year classes present and higher catch rates of young fish (ages 3-4) during 2023 compared to 2016. Age structure declined compared to 2016 which could have been driven by higher recruitment during recent years. Despite variation in age structure temporally, size structure did not differ between 2016 and 2023 which was likely the result of increased growth rates.

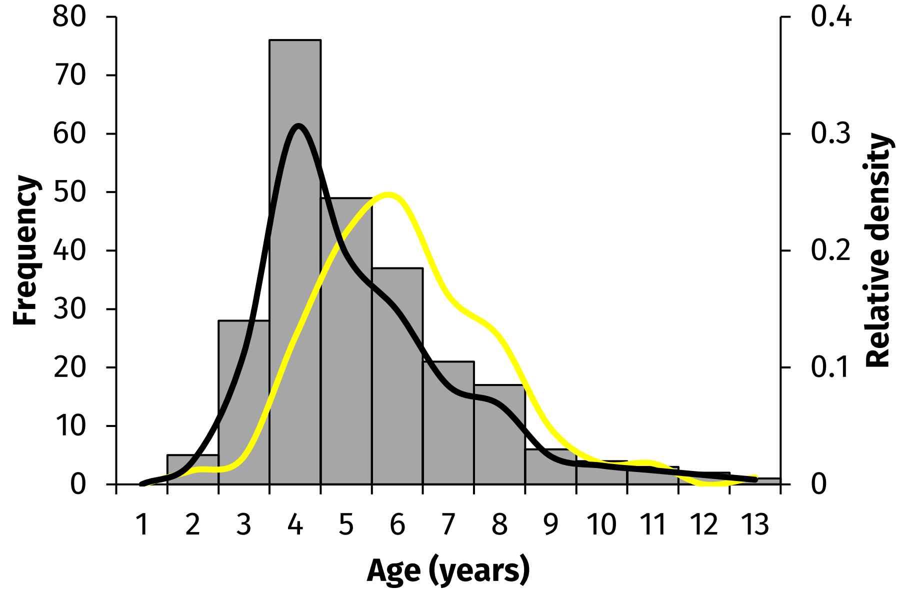

Figure 14. Age structure of largemouth bass in the Red Cedar Chain of Lakes during the 2023 SE2 surveys (grey bars). Lines represent relative density curves depicting age structures during 2023 (black line) and 2016 (yellow line).

Total annual mortality estimated from a catch curve regression model was 38.4% (ages 4 – 13; R^2 = 0.99; Figure 15).

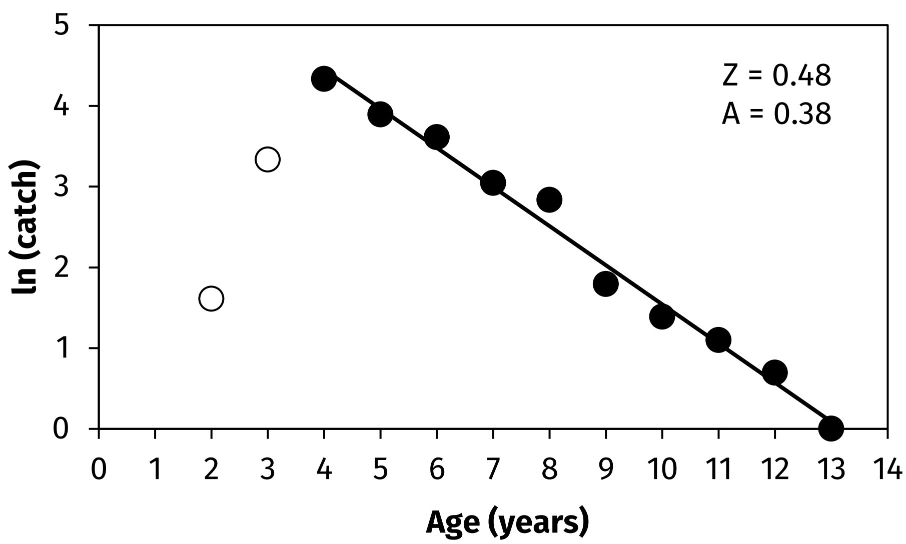

Figure 15. Catch curve analysis plot representing the natural logarithm of the catch for each largemouth bass age class used in the analysis (black circles) and not (white circles). Z = instantaneous total mortality, A = annual total mortality rate.

SMALLMOUTH BASS

There were 112 smallmouth bass collected during the SE2 surveys across the Red Cedar Chain of Lakes with a CPUE of 3.8 fish/mile in Balsam Lake, 0.8 fish/mile in Hemlock Lake and 13.4 fish/mile in Red Cedar Lake (Figure 16). Smallmouth Bass CPUE in Hemlock Lake was low and similar to previous surveys (0.6 ± 0.2 fish/mile; mean ± standard deviation) which was likely driven by habitat availability (shallow and vegetated compared to Red Cedar Lake and Balsam Lake). The lake-wide CPUE (Red Cedar Lake and Balsam Lake) during 2023 was 9.9 fish/mile. This is indicative of an average-density population that remained temporally stable since 2005.

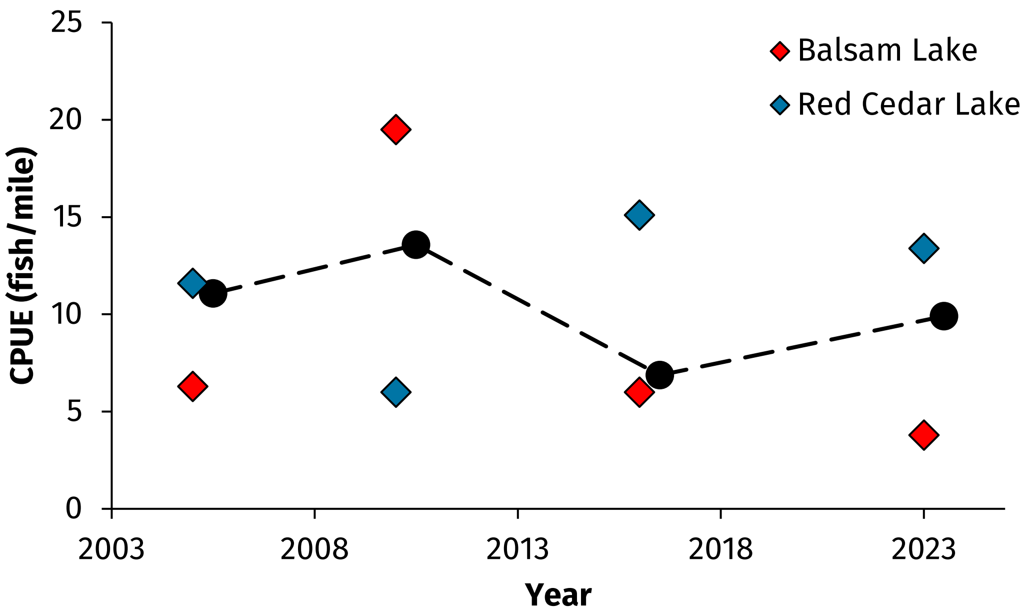

Figure 16. Smallmouth bass CPUE in Red Cedar Lake and Balsam Lake during 2005 – 2023. Lake-wide CPUE during 2005 - 2023 are represented by black circles. Hemlock Lake CPUE was < 1 fish/mile during 2005 – 2023 and not included in the plot or lake-wide estimates.

Smallmouth bass ranged in length from 7.0 - 18.8 inches and the mean length was 13.5 inches (± 2.4 inches; standard deviation; Figure 17), which was similar to 2016 (12.2 inches ± 2.3 inches; standard deviation) and resembled the 99th percentile (13.6 inches) for similar complex-two story Wisconsin lakes. The PSD-11 was 84 and PSD-14 was 45, which indicated quality size structure and both indices improved since 2016 (PSD-11 = 69 and PSD-14 = 27). The proportion of the population susceptible to harvest by the recreational fishery (≥ 14 inches) was 45%.

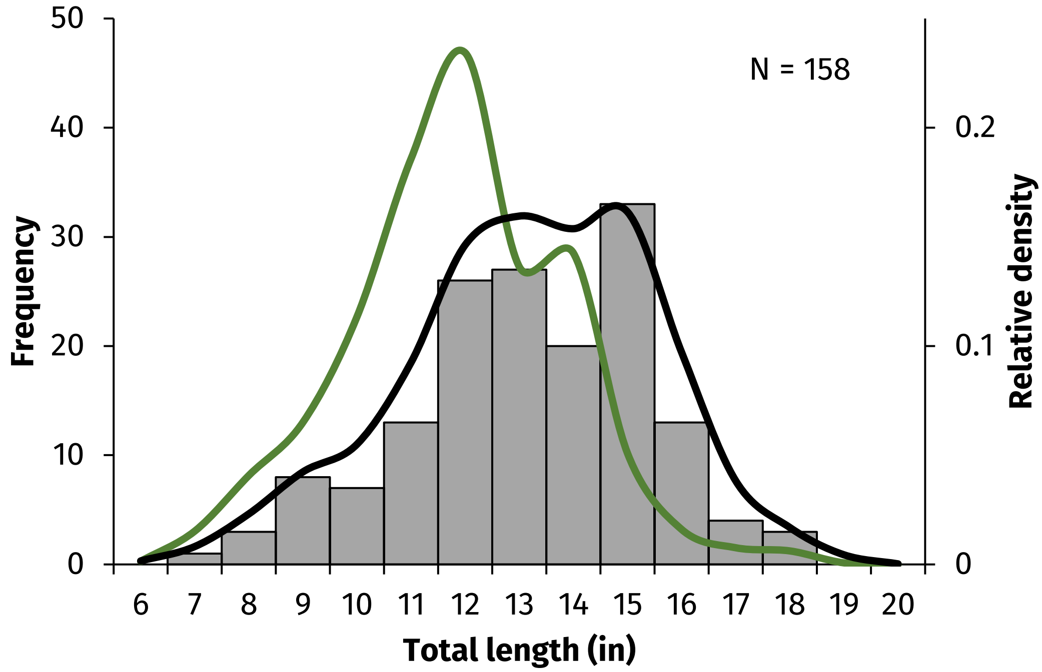

Figure 17. Length frequency of smallmouth bass in the Red Cedar Chain of Lakes during the 2023 SE2 survey. Lines represent relative density curves depicting length frequencies during 2023 (black lines) and 2016 (green line).

Smallmouth bass growth did not differ between Red Cedar Lake and Balsam Lake (only three fish sampled on Hemlock Lake). The combined growth of smallmouth bass on the Red Cedar Chain of Lakes was average. Mean length at age improved since 2016 (average difference in mean length at age estimates: +1.3 inches; ages 3 - 7) but remained similar to the median length at age standard for similar complex-cool-dark Wisconsin lakes (average difference in length at age estimates: +0.1 inches; ages 3 - 10) and similar to complex-two story lakes (average difference in length at age estimates: +0.1 inches; ages 3 – 10; Figure 18). The predicted theoretical maximum length for smallmouth bass using the von Bertalanffy growth model was 17.9 inches with k and t_0 estimated to be 0.36 and 0.60, respectively (Figure 18).

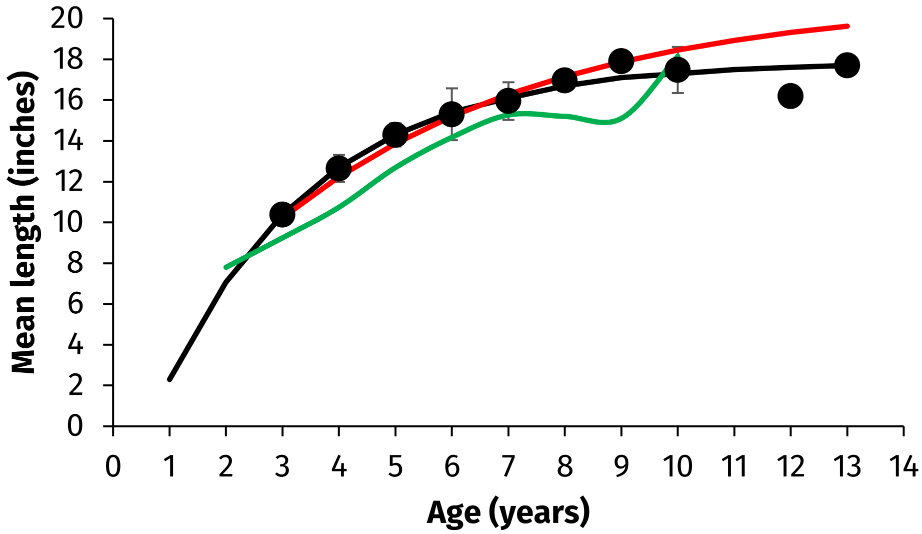

Figure 18. Smallmouth bass mean length at age ± standard deviation and the von Bertalanffy growth curve (black line) during the 2023 fisheries survey on the Red Cedar Chain of Lakes. The median length at age estimates for complex-two story Wisconsin lakes is presented by the red line and mean length at age estimates during 2016 by the green line. The median length at age estimates for complex-cool-dark Wisconsin lakes were similar to complex-two story lakes and thus not presented in the plot.

Smallmouth bass age structure was well distributed with multiple age classes present and good longevity. Age 3 – 6 fish composed 81% of the population whereas older age classes (ages 7+) composed 19% (Figure 19). Recruitment appeared sufficient based on the breadth of adult year classes present and greater numbers of age-3 smallmouth bass observed during 2023 compared to 2016. Age structure remained largely unchanged since 2016, but growth rates improved since 2016 which likely contributed to greater size structure during 2023.

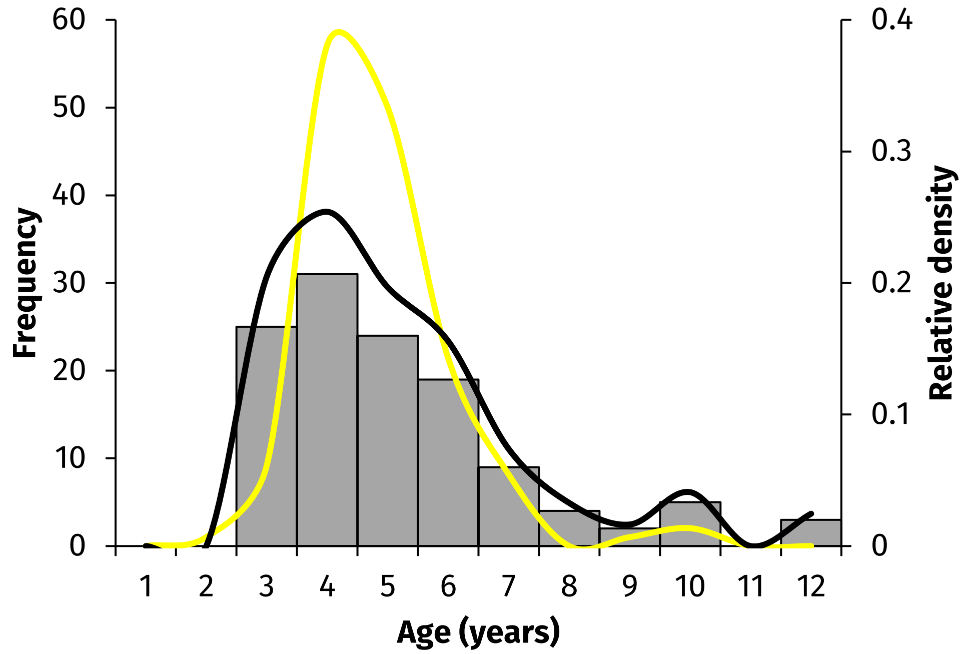

Figure 19. Age structure of smallmouth bass in the Red Cedar Chain of Lakes during the 2023 SE2 surveys (grey bars). Lines represent relative density curves depicting age structures during 2023 (black line) and 2016 (yellow line).

Total annual mortality estimated from a catch curve regression model was 28.7% (ages 4 – 12; R^2 = 0.77; Figure 20).

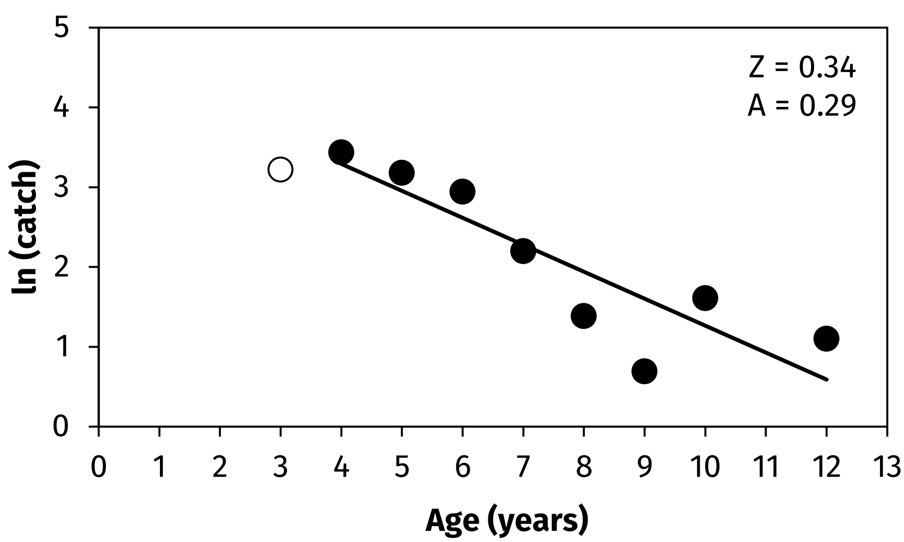

Figure 20. Catch curve analysis plot representing the natural logarithm of the catch for each smallmouth bass age class used in the analysis (black circles) and not (white circles). Z = instantaneous total mortality, A = annual total mortality rate.

BLUEGILL

There were 367 bluegills collected during the SE2 surveys across the Red Cedar Chain of Lakes with a CPUE of 75 fish/mile in Balsam Lake, 196 fish/mile in Hemlock Lake and 48 fish/mile in Red Cedar Lake (Figure 21). Bluegill CPUE on Hemlock Lake resembled the 75th percentile for similar complex-cool-dark Wisconsin lakes whereas Red Cedar Lake and Balsam Lake were both below the 75th percentile for similar complex-two story Wisconsin lakes. Bluegill CPUE in Hemlock Lake increased through time and was consistently greater than both Red Cedar Lake and Balsam Lake (Figure 21). The lake-wide CPUE during 2023 was 92 fish/mile which was greater than the mean bluegill CPUE for lakes in Barron and Polk counties (54.0 ± 4.7 fish/mile; ± SE) and indicative of an average-density population that remained temporally stable since 2010.

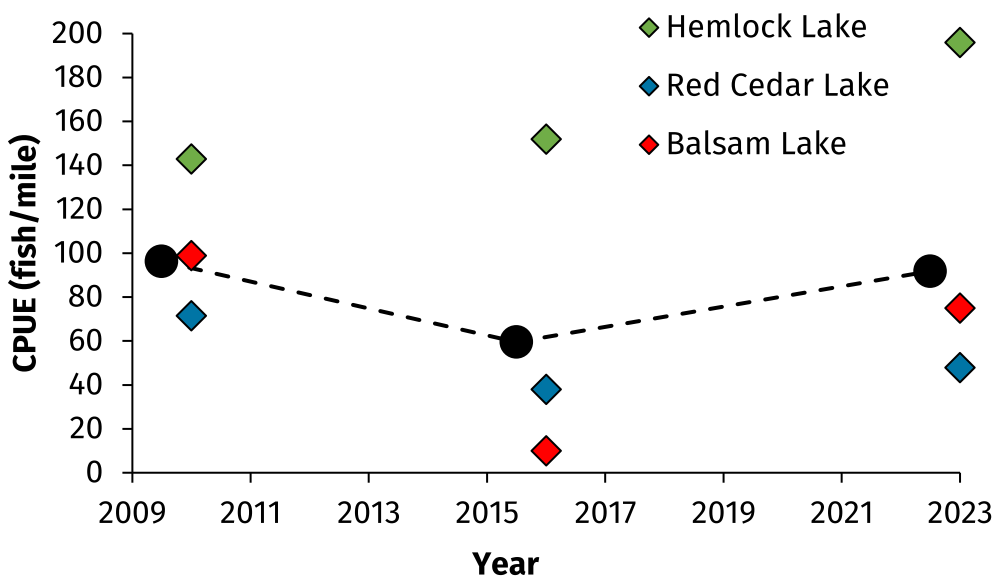

Figure 21. Bluegill CPUE (fish/mile) in Red Cedar Lake, Balsam Lake and Hemlock Lake during 2010 – 2023. Lake-wide CPUE during 2010 - 2023 are represented by black circles.

Bluegill lengths ranged from 3.0 – 9.0 inches with an average length of 5.9 inches whereas bluegill mean lengths were 6.0 inches, 6.3 inches and 5.6 inches in Hemlock Lake, Balsam Lake and Red Cedar Lake, respectively (Figure 22). The lake-wide bluegill PSD-6 was 57 and PSD-8 was 8 whereas PSD-6 for Hemlock Lake was 58, Red Cedar Lake was 41 and Balsam Lake was 73 and PSD-8 for Hemlock Lake was 7, Red Cedar Lake was 5 and Balsam Lake was 12. The PSD-6 and PSD-8 index values were within the generally accepted recommendations for balanced bluegill populations (PSD-6 = 20-60; PSD-8 = 5 -20) by Anderson (1985). This is suggestive of quality overall size structure.

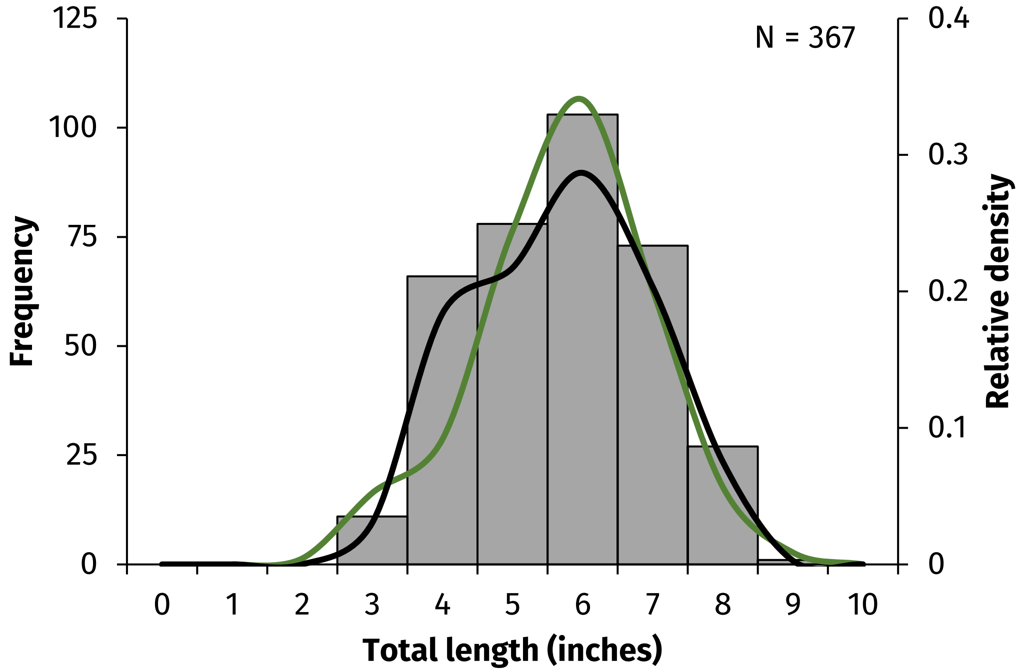

Figure 22. Length frequency of bluegill in the Red Cedar Chain of Lakes during the 2023 SE2 survey. Lines represent relative density curves depicting length frequencies during 2023 (black lines) and 2016 (green line).

Mean Length at age did not differ between Hemlock Lake, Red Cedar Lake and Balsam Lake and subsequently aging data from individual lakes were combined for further growth comparisons. Mean length at age was similar to 2016 (average difference in mean length at age estimates: -0.7 inches; ages 2 - 7) and the median length at age standards for similar complex-two story Wisconsin lakes (average difference in length at age estimates: +0.1 inches; ages 2 – 7; Figure 23) and complex-two story Wisconsin lakes (average difference in length at age estimates: -0.1 inches; ages 2 – 7; Figure 23). The von Bertalanffy growth model could not be fit to the observed age-length data.

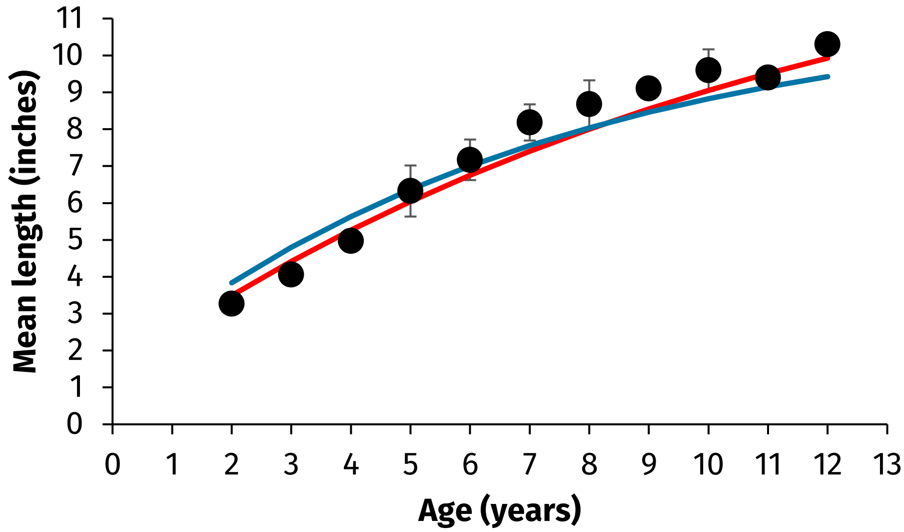

Figure 23. Bluegill mean length at age ± standard deviation during the 2023 fisheries survey on the Red Cedar Chain of Lakes. The median length at age estimates for complex-two story Wisconsin lakes is presented by the red line and complex-cool-dark Wisconsin lakes by the blue line. Bluegill were collected during SE2 and SN1 surveys. Mean length-at-age estimates during 2016 were similar to 2023 and not included in plot.

Bluegill age structure was well distributed with multiple age classes present and had good longevity. Recruitment appeared sufficient evident by the breadth of adult year classes present. Age 3 – 7 fish composed 94% of the population whereas older age classes (ages 8+) composed 4% (Figure 24). Bluegill age structure indexed from the SE2 survey underrepresented the true population age structure as individuals greater than 9 years of age were collected during the SN1 survey. Hemlock Lake was the only lake with bluegill greater than 9 years of age (5 individuals from SN1 survey) which could be driven by habitat differences compared to Balsam Lake and Red Cedar Lake. Bluegill greater than 9 inches were on average 8.4 years of age whereas bluegill greater than 10 inches were on average 11.0 years of age.

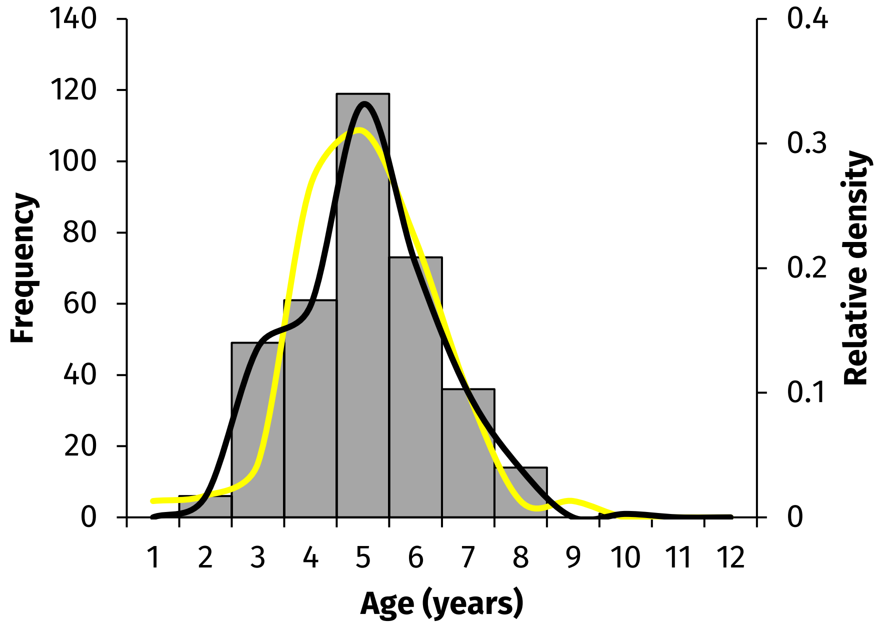

Figure 24. Age structure of bluegill in the Red Cedar Chain of Lakes during the 2023 SE2 surveys (grey bars). Lines represent relative density curves depicting age structures during 2023 (black line) and 2016 (yellow line).

BLACK CRAPPIE

There were 62 black crappies collected during the SE2 surveys across the Red Cedar Chain of Lakes with a CPUE of 13 fish/mile in Balsam Lake, 28 fish/mile in Hemlock Lake and 11 fish/mile in Red Cedar Lake. The lake-wide CPUE during 2023 was 16 fish/mile which was similar to the mean black crappie CPUE for lakes in Barron and Polk counties (9.6 ± 1.9 fish/mile; ± SE; indexed from 110 lakes in Barron and Polk counties) and indicative of an average-density population (Figure 25). Relative abundances have been temporally variable between and within lakes but generally increased since 2010.

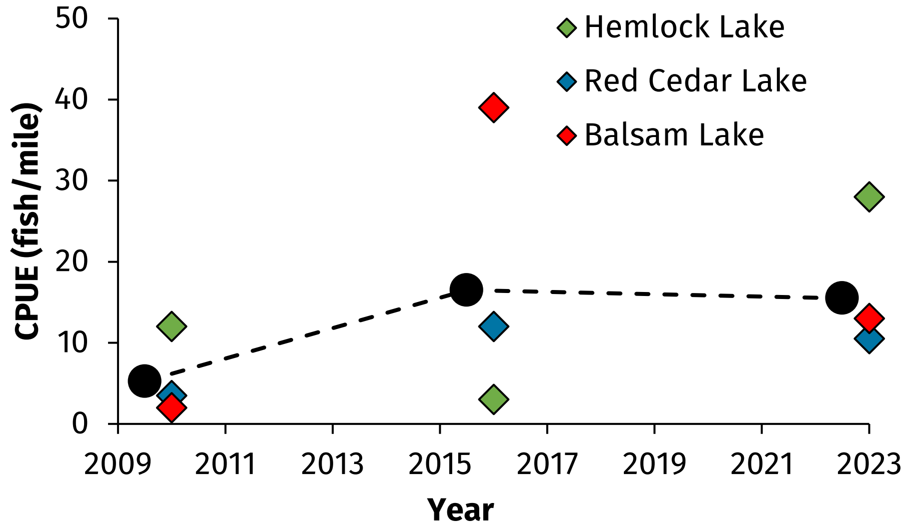

Figure 25. Black crappie CPUE in Red Cedar Lake, Balsam Lake and Hemlock Lake during 2010 – 2023. Lake wide CPUE during 2010 - 2023 are represented by black circles.

Black crappie lengths ranged from 2.5 – 14.7 inches with an average length of 8.8 inches whereas black crappie mean lengths were 8.5 inches, 8.9 inches and 9.2 inches in Hemlock Lake, Balsam Lake and Red Cedar Lake, respectively (Figure 26). The lake-wide black crappie PSD-8 was 94 and PSD-10 was 33 and are suggestive of quality size structure. Size structure decreased since 2016 (PSD-8 = 98 and PSD-10 = 73) but a quality population remains and is not of concern at this moment (Figure 26).

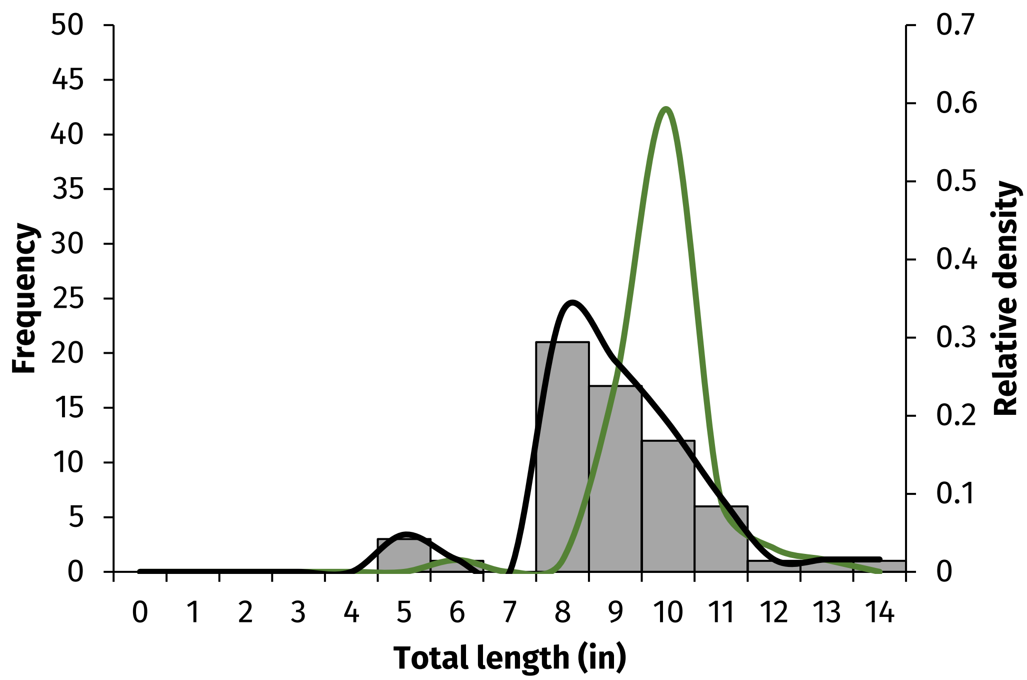

Figure 26. Length frequency of black crappie in the Red Cedar Chain of Lakes during the 2023 SE2 survey. Lines represent relative density curves depicting length frequencies during 2023 (black lines) and 2016 (green line).

Black crappie growth did not differ between Red Cedar Lake, Balsam Lake and Hemlock Lake. The combined growth of black crappie on the Red Cedar Chain of Lakes was average. Mean length at age was similar to 2016 (average difference in mean length at age estimates: +0.4 inches), median length at age standard for similar complex-cool-dark Wisconsin lakes (average difference in length at age estimates: +0.8 inches) and similar complex-two story lakes (average difference in length at age estimates: +0.1 inches; Figure 27). The predicted theoretical maximum length for black crappie using the von Bertalanffy growth model was 12.8 inches with k and t_0 estimated to be 0.42 and 0.58, respectively (Figure 27). Despite this, black crappie exceeding 13 inches in length were observed during the 2023 survey.

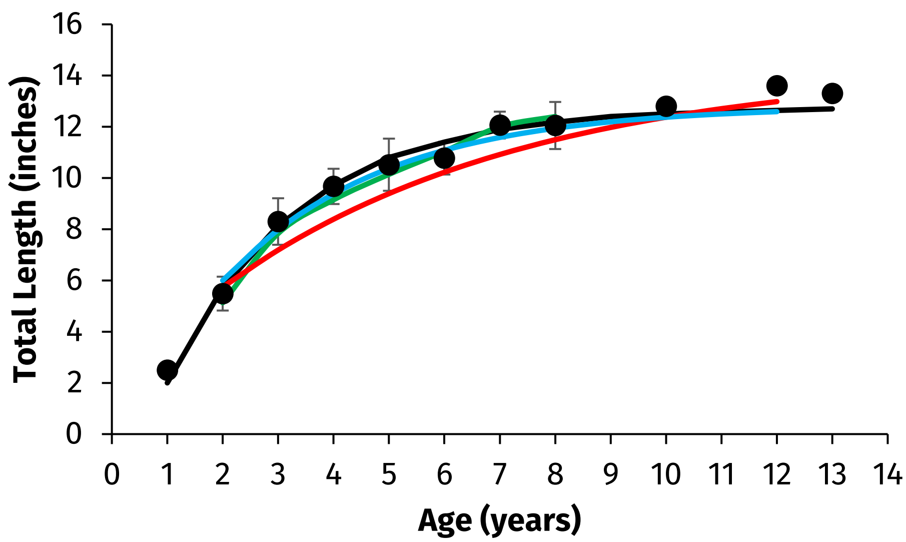

Figure 27. Black crappie mean length at age ± standard deviation and the von Bertalanffy growth curve (black line) during the 2023 fisheries survey on the Red Cedar Chain of Lakes. The median length at age estimates for complex-two story Wisconsin lakes is presented by the red line, complex-cool-dark Wisconsin lakes by the blue line and mean length at age estimates during 2016 by the green line.

The adult population was composed of nine age classes ranging from age 3 to age 13. Age 2 – 5 fish composed 90% of the population and age-3 fish composed 52% of the population (Figure 28). The adult population was primarily composed of young fish (age-3 fish; mean length = 8.3 inches) but sustained annual recruitment was evident by the breadth of adult age classes present. Year-class specific relative abundances were variable which could be evident of sporadic recruitment and variable growth and survival conditions annually. Longevity was evident with fish surpassing 10 years of age and growth was relatively fast until seven years of age (approximately 12 inches in length).

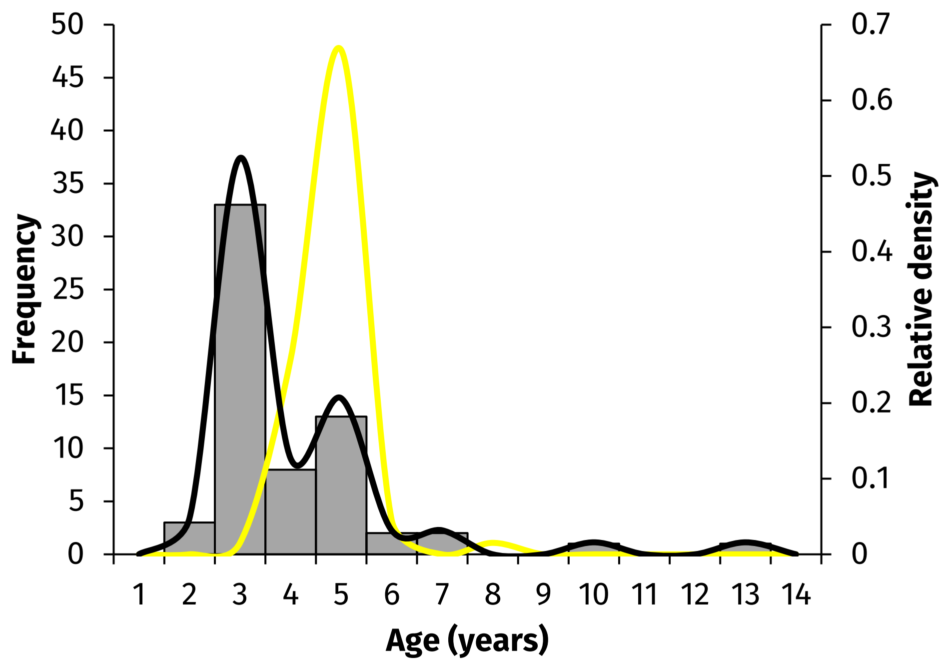

Figure 28. Age structure of black crappie in the Red Cedar Chain of Lakes during the 2023 SE2 surveys (grey bars). Lines represent relative density curves depicting age structures during 2023 (black line) and 2016 (yellow line).

Total annual mortality estimated from a catch curve regression model was 46.2% (ages 3 – 9; R^2 = 0.89; Figure 29). Total annual mortality of black crappie was moderate but was likely overestimated as the largest and oldest individuals in the population are under-represented during SE2 surveys.

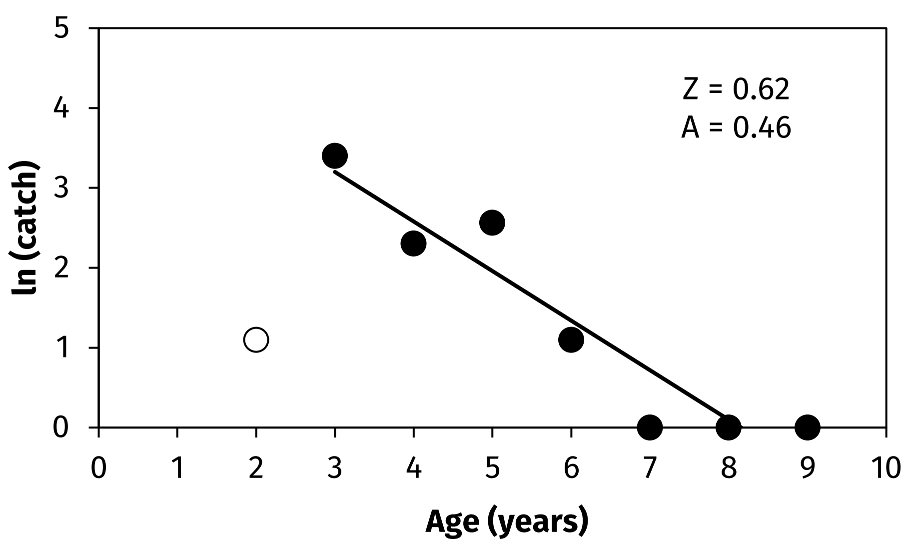

Figure 29. Catch curve analysis plot representing the natural logarithm of the catch for each black crappie age class used in the analysis (black circles) and not (white circles). Z = instantaneous total mortality, A = annual total mortality rate.

Discussion

The Red Cedar Chain of Lakes continues to support a naturally reproducing walleye fishery. A quality adult walleye population was present with moderate abundance and size structure and represents one of the few remaining naturally reproducing populations in Barron and Polk counties.

Walleye recruitment (indexed by age-0 CPUE) in the Red Cedar Chain of Lakes has declined precipitously since 2016, which initially appeared worrisome. However, sustained annual recruitment was evident as all adult age classes were represented in the current population age structure, which remained similar to 2016 and was not reflective of an aging population that lacked recruitment. Similarly, the adult size structures did not differ between 2016 and 2023. Rather, a decrease in population density since 2016 corresponded with faster growth rates and greater abundances of walleye > 18 inches in the current population. It appears that walleye recruitment remains satisfactory to sustain a quality population despite declines in age-0 catch rates during fall electrofishing surveys. More recently however, the age-0 walleye catch rate increased significantly during 2024 compared to the previous decade which was the first strong naturally recruited year class observed since 2011. The walleye fishery in the Red Cedar Chain of Lakes should continue to be supported by natural recruitment.

Walleye stocking on the Red Cedar Chain of Lakes has contributed minimally to the adult walleye population over time. Analyses during 2005 and 2006 using OTC-marked fish indicated some contribution from the walleye wagon fry stocking. Of the millions of fry stocked, an estimated 2,364 fingerlings were recruited during 2005 and 1,661 fingerlings during 2006 (Benike 2006). However, the overall contribution (percent of stocked fish to the overall year class) of these recruited stocked fish was heavily dependent on the magnitude of natural recruitment that coincided. In 2005, an estimated 28,963 walleye fingerlings were naturally recruited which composed 92% of the year class. Conversely, in 2006, an estimated 615 walleye fingerlings were naturally recruited which composed only 27% of the year class (Benike 2006). This highlights that the actual number of fish recruited to a year class from the walleye wagon fry stocking efforts was insignificant compared to the numbers contributed during strong natural recruitment years. Catch rates of age-0 walleye were comparable between stocked and non-stocked years; however, it's likely most of the age-0 walleye sampled during stocked years were natural recruits. Natural recruitment is important in sustaining the walleye population and effective management strategies should focus on maintaining conditions that sustain natural recruitment to ensure the long-term health of the walleye population.

The Red Cedar Chain of Lakes has had a history of regulation changes aimed at improving the walleye population. Public interest in liberalizing harvest opportunities once again led to a regulation change during 2019 to the Ceded Territory default regulation (15-inch MLL, fish between 20-24 inches may not be kept, 3 fish daily bag limit with only 1 fish > 24 inches allowed). This regulation change was also presumably successful at increasing angler harvest opportunities as the adult walleye density decreased by approximately 36% since 2016 (Figure 2). Subsequently, growth rates and population size structure increased since 2016. Creel data were not available to assess how angler harvest dynamics changed temporally but generally harvest rates are greater under the Ceded Territory default regulation compared to the 18-inch minimum length limit. The decline in adult walleye density was likely driven by the 2019 regulation change and increased angler harvest as opposed to recruitment failures, which was not apparent as discussed above. Changing walleye harvest regulations on the Red Cedar Chain of Lakes has been successful in manipulating adult walleye densities toward specific management goals.

The Red Cedar Chain of Lakes is a bright spot among walleye populations in the species native range where natural recruitment has generally declined or failed leading to population declines (Embke et al. 2019; Sass 2025). The walleye population has sustained consistent natural reproduction through time and adult densities ranged from 3.9 adults/acre in 1980 to 2.5 adults in 2023. Sporadic rates of natural recruitment and manipulation of harvest regulations are primary factors responsible for temporal variability in adult densities. Despite this, the adult population has remained relatively stable since the 1980's. Public reports of poor walleye fishing on Red Cedar Lake persist today (similar to the 1930's, 1970's and 1980's) even though the adult population has remained relatively unchanged since the first population estimate survey in the 1980's, and likely since surveys began during the 1930's. However, natural variability in population dynamics is inevitable even in the absence of direct management actions (manipulation of angler harvest through regulations).

Walleyes likely remain the main focus of the recreational fishery with relatively high exploitation rates. The management goal for walleye in the Red Cedar Chain of Lakes is to maintain an abundant, resilient and naturally reproducing adult population and provide quality angling opportunities. Objectives are to maintain adult densities between 2 - 4 fish/acre which will be assessed on a 6-year rotation. Secondarily, the rolling five-year mean (+ standard error) age-0 catch rate during fall electrofishing surveys should be above 15 fish/mile. Fall electrofishing surveys will continue annually. The current walleye harvest regulation (15-inch MLL, fish between 20-24 inches may not be kept, 3 fish daily bag limit with only 1 fish > 24 in allowed) will be maintained as this regulation is conservative in managing harvest, promotes greater population size structure and reproductive potential by protecting larger fish, but also allows some harvest opportunity. More liberal harvest regulations were not considered due to high angler catch and harvest rates and the potential to overharvest. If management objectives are not met, then alternate management actions may be considered. Efforts to preserve existing natural shorelines and walleye spawning habitat are encouraged.

The northern pike population in the Red Cedar Chain of Lakes was variable between lakes which was likely due to habitat variability. Higher northern pike abundances in the shallower, more productive and vegetated Hemlock Lake were observed compared to the deeper, less productive and less vegetated Red Cedar and Balsam lakes. Abundances in Red Cedar Lake and Balsam Lake remained low and relatively unchanged since 2016. However, nearly a four-fold increase in abundance was observed in Hemlock Lake but the drivers of population increase remain unknown. There have been significant changes in the submerged aquatic plant community over time in Hemlock Lake (Blumer and Wood 2019), but it remains speculative if the plant community reconfiguration yielded habitat improvements for northern pike. It is also possible that survey timing and water temperatures during the SN1 Surveys (2016 water temperatures ranged from 42° - 43°F whereas 2023 ranged from 40° to 42°F) could have led to greater catch rates as higher catches are typically observed earliest in the spring with cooler water temperatures. Alternatively, survey duration during 2016 was nearly double that during 2023, which could have yielded lower catch rates during 2016. Despite this, population size structure, growth and age structure remained unchanged from 2016 and still offers quality angling opportunities for anglers with potential for trophy sized fish (over 40 inches). The current harvest regulation (no MLL, 5 fish daily bag limit) for northern pike will be maintained and no additional management actions are recommended at this time.

Largemouth bass and smallmouth bass populations remain relatively unchanged since 2005 with moderate abundance, quality size structure, average growth rates and sustained annual recruitment. Both species displayed good longevity with potential for memorable to trophy sized individuals (Anderson and Neumann 1996). Annual mortality estimates were moderate for largemouth bass (38.4%) and smallmouth bass (28.7%) and the variation between the two could be reflective of angler harvest (assuming equal natural mortality rates between species), although harvest by the recreational fishery is presumably low for both species. The bass populations remain healthy and likely continues to support popular recreational fisheries and no management actions are recommended currently. Population relative abundance, size structure, condition and growth should be evaluated again during the next survey. The current harvest regulation (14-inch MLL, 5 fish daily bag limit) for bass will be maintained as both populations remained relatively unchanged from 2016 with 54% and 45% of the largemouth bass and smallmouth bass populations, respectively, being susceptible to harvest.

The Red Cedar Chain of Lakes supports a quality bluegill population. Population abundance was average but highest in Hemlock Lake likely due to habitat differences (shallower and more vegetated) compared to Red Cedar Lake and Balsam Lake. Bluegill had average growth rates, but good survival and longevity of adults and supported trophy sized individuals that exceed 10 inches. Population size structure was average but was likely underrepresented by the SE2 survey. Despite this, mean lengths in each lake exceeded the 95th percentile for similar Wisconsin lake classes and population size structure was higher than the Barron and Polk counties average (PSD-6 = 45 ± 26; standard deviation; indexed using 103 lakes). The Red Cedar Chain of Lakes should continue to support trophy-sized bluegill (over 10 inches) as long as survival and longevity remain good.

The Red Cedar Chain of Lakes supports a popular recreational bluegill fishery. During the 2005-2006 creel survey, directed fishing effort for bluegill was highest on Hemlock Lake (compared to Red Cedar Lake and Balsam Lake) at 45.6 hours/acre. This estimate represents the fourth highest directed effort estimated during a creel survey in Barron and Polk counties with an average directed effort estimate of 24.8 hours/acre (estimated using 19 lakes creel surveys during 2003 – 2023; used only most recent survey per lake). The bluegill harvest rate was the highest (1.97 bluegill harvested/hour) estimated from any other creel survey in Barron and Polk counties with an average harvest rate of 1.1 bluegill harvested/hour (estimated using 19 lakes creel surveys during 2003 – 2023; used only most recent survey per lake). Fishing effort for bluegill likely remains high in the Red Cedar Chain of Lakes with Hemlock Lake likely receiving the highest effort/acre. Despite the high angler effort, the bluegill population has maintained good size structure and did not meet criteria (mean length < 6 inches and mean length at age-3 ≥ 4.2 inches) set forth by the DNR Panfish Team for lakes having a size structure problem due to angler harvest and thus restrictive harvest regulations are not being considered currently.

The Red Cedar Chain of Lakes supports a black crappie population with moderate abundance that increased slightly since 2010, although relative abundance estimates were variable between and within lakes which could have been driven by habitat differences and sporadic recruitment. Recruitment appears at least sufficient to yield detectable year classes annually. Population size structure remained good, despite declining since 2016, with mean lengths of black crappie in each lake exceeding the 90th percentile for similar Wisconsin lake classes. Targeted fishing effort for black crappie likely remains high, similar to 2005-2006 (23.3 hours/acre on Hemlock Lake). The moderate density population offer anglers quality opportunities for harvest with potential for trophy-sized individuals.

Both bluegill and black crappie populations are also likely important contributors to the fish community as a forage base, in addition to cisco, yellow perch and various minnow species, for predatory fishes. Future fishery surveys should continue to monitor population abundance and size structure of black crappie and bluegill due to their importance to the overall fish community and recreational fishery. The current panfish regulation (25 fish daily bag limit in aggregate) should continue to promote both quality recreational fisheries and sustainable population dynamics. No specific management actions for black crappie and bluegill are recommended.

Management Recommendations

1. Maintain adult walleye density between 2 - 4 fish/acre and the rolling five-year mean (+ standard error) age-0 catch rate during fall electrofishing surveys > 15 age-0 walleye/mile. Adult walleye population estimate surveys will occur on a 6-year rotation and fall walleye natural recruitment surveys will be conducted annually.
2. Largemouth bass and smallmouth bass will continue to be managed with a 14-inch MLL and 5 fish daily bag limit. If warranted, otoliths could be collected during the next survey to improve estimates of age, growth and mortality.
3. No specific management actions regarding northern pike, bluegill and black crappie are recommended currently. Otoliths should be collected from bluegill and black crappie during the next survey to maintain the current level of aging accuracy and precision.
4. A creel survey should be completed at least once every twelve years to assess the effectiveness of the current regulations and ensure combined angler/tribal exploitation remains below 35%.
5. The next comprehensive fisheries survey is scheduled for 2029. The stock abundance, size structure, age structure, growth and recruitment of walleye should be closely monitored as Red Cedar Lake is one of the few remaining self-sustaining populations in Barron and Polk counties.
6. Efforts to protect and maintain natural shorelines and nearshore walleye spawning habitat is encouraged where applicable. Inputs of coarse woody habitat is also encouraged but locations should be carefully considered as to not fragment walleye spawning habitat. The maintenance and restoration of vegetative buffers would be beneficial. This website healthylakeswi.com is a great resource to learn about this recommendation.
7. Invasive species monitoring and control programs should continue.

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Appendices

Table 1. Walleye stocking in Red Cedar Lake during 2000 – 2019.

YEAR	SPECIES	AGE CLASS	NUMBER STOCKED	AVG. LENGTH (IN.)
2000	walleye	Small Fingerling	110,469	2.1
2002	walleye	Small Fingerling	92,050	1.5
2004	walleye	Small Fingerling	177,181	1.9
2004	walleye	Fry	2,000,000	0.5
2005	walleye	Fry	2,000,000	0.5
2006	walleye	Fry	2,000,000	0.5
2009	walleye	Fry	1,500,00	0.5
2010	walleye	Fry	2,500,000	0.5
2011	walleye	Small Fingerling	35,857	2.3
2011	walleye	Fry	2,200,000	0.5
2012	walleye	Fry	1,490,000	0.5
2014	walleye	Fry	2,400,000	0.5
2015	walleye	Fry	2,640,000	0.5
2016	walleye	Fry	2,880,000	0.5
2017	walleye	Fry	2,700,000	0.5
2019	walleye	Fry	2,750,000	0.5

Table 2. Survey types, gear used, target water temperature and target species.

SURVEY TYPE	GEAR USED	TARGET WATER TEMPERATURE (°F)	TARGET SPECIES
Spring Netting 1 (SN1)	Fyke Net	~45	walleye, northern pike
Spring Electrofishing 1 (SE1)	Boat Electrofishing	45-50	walleye
Spring Netting 2 (SN2)	Fyke Net	50-55	muskellunge, black crappie, yellow perch
Spring Electrofishing 2 (SE2)	Boat Electrofishing	55-70	largemouth bass, smallmouth bass, bluegill and other panfish, non-game species
Spring Netting 3 (SN3)	Fyke Net	65-80	bluegill, black crappie
Fall Electrofishing (FE)	Boat Electrofishing	50-60	Juvenile walleye and muskellunge