Comprehensive Fishery Surveys of Swan Lake and Spring Lake
Columbia County, Wisconsin 2018

Waterbody Identification Codes: 179800 (Swan Lake), 180000 (Spring Lake)

Nathan Nye
Senior Fisheries Biologist
Wisconsin Department of Natural Resources
Poynette, Wisconsin
June 2020

EXECUTIVE SUMMARY

Comprehensive fishery surveys were conducted on Swan Lake and Spring Lake during the spring of 2018. Swan Lake results are described here, with results of the Spring Lake survey included in Appendix A beginning on page 75. Swan Lake sampling included early fyke netting for Northern Pike and Walleyes (SN1), early electrofishing to recapture marked Walleyes (SE1), a second netting period targeting Muskellunge (SN2), late spring electrofishing for bass and panfish (SE2) and fall electrofishing to assess Walleye recruitment (FE). In general, gamefish species were present at abundances consistent with other lakes in the Complex Riverine lake class. Gamefish species exhibited good to excellent growth and body condition.

Bluegill, Black Crappie, and Yellow Perch were common and exhibited good growth. Bluegills as large as 9.2 inches were collected. Bluegills averaged over 8 inches by age 6, placing Bluegill growth ahead of area and state averages. High Bluegill total annual mortality compared to other area lakes may be indicative of high harvest pressure. Black Crappies up to 13.0 inches were collected in the survey and Black Crappie growth rates exceeded area and state averages after age 1, likely due to the abundant forage found in Swan Lake. Black Crappies averaged over 10 inches by age 4, and over 11 inches by age 6. Yellow Perch up to 12.0 inches were collected in the survey. Yellow Perch grew faster than the state average, exceeding 8 inches by age 4.

The Chapman Walleye population estimate (PE) of 3.3 adult Walleyes ≥ 15 inches per acre was higher than the 1.5 adults/acre PE from 2009. The adult walleye density was higher than average for a stocked Walleye fishery in Wisconsin (statewide average = 1.7 adults/acre). Walleye natural reproduction was historically low in Swan Lake, but substantial natural year classes may have been produced in 2014 and 2015. Natural reproduction was low in 2016 and 2018. Stocked small fingerling Walleyes survived well in Swan Lake with survival of stocked fish in 2017 and 2019 estimated at 11.0% and 18.2%, respectively. Walleye tag returns indicated Walleye anglers at Swan Lake were harvest-oriented. Most Walleyes tagged in Swan Lake either stayed in Swan Lake or moved upriver into Spring Lake. Only one Walleye was documented moving downriver from Swan Lake. Walleyes in Swan Lake averaged over 15 inches at age 3 (legal harvest size).

Northern Pike were present in Swan Lake and abundance appeared to have increased since 2009 based on the SN1 catch rate. The Schnabel population estimate for sexually mature Northern Pike was 709 fish or 1.7 fish/acre. Twenty-seven percent of Northern Pike larger than 14 inches were also larger than 26 inches and thus legal to harvest (PSD-26 = 27). Northern Pike averaged over 26 inches by age 5.

Largemouth Bass were present and the SE2 catch rate was consistent with past observations except for 2009 when SE2 CPUE was much higher. Largemouth Bass grew quickly and averaged over 14 inches by age 5. Size structure was good, with 35% of the fish larger than 8 inches also being larger than 14 inches (legal harvest size, PSD-14 = 35). Largemouth Bass as large as 21.2 inches were collected. Smallmouth Bass abundance was low but appeared to be increasing recently based on 2017-2019 fall electrofishing data.

Muskellunge were collected in low numbers despite a long history of stocking fall fingerlings in Swan Lake and a history of successful recruitment of those fish in the past. There has been little recruitment of stocked Muskellunge since the late 2000s with many years of zero recruitment. The largest Musky in 2018 measured 48.5 inches and weighed nearly 36 pounds.

Common carp and Gizzard Shad were collected in 2018 but their catch rates did not suggest they were present at nuisance levels.

Lake & location

Swan Lake, Columbia County
T12N, R9E, Sections 1, 2, 11, 12 (Town of Pacific)
T12N, R10E, Sections 5, 6 (Town of Wyocena)

Physical/chemical attributes

Morphometry: 407 acres, maximum depth of 82 feet, 19% of lake area < 3 feet depth, 63% > 20 feet depth (Poff and Threinen 1965). Seven miles of shoreline.
Watershed: 65.7 square miles (41,981 acres, Fox River TMDL 2020).
Lake type: Drainage, seepage; natural lake along the course of the Fox River. No water control structure to regulate water level.
Water Clarity: Turbid in summer (mean July-August Secchi = 5 feet, 1988-2011), clearer in early spring, fall, and winter.
Littoral substrate: Marl, sand, and occasional gravel and cobble.
Trophic status: Eutrophic (https://dnr.wi.gov/lakes/waterquality/ ,Columbia County, Station ID 113076). Listed as 303(d) impaired in 2014 for excess algal growth.
Aquatic vegetation: Seventeen species in 2017 plus filamentous algae with a maximum rooting depth of plants of 13 feet. Eurasian watermilfoil dominated in 2017 but had declined significantly since 2012.
Winterkill: None
Boat Landings: One public boat access point on the south side of the lake; it is managed by the WDNR.
Other Features: Swan Lake has no water control structure and fish can move freely in the upper Fox River from Lake Puckaway up to the Park Lake Dam in Pardeeville, including Lake Puckaway, Buffalo Lake, Swan Lake, and Spring Lake. Hook and line fishing season dates, minimum harvest lengths, and bag limits for Swan Lake can be found in Table 1.

Purpose of survey

Baseline lake survey Tier 1 assessment.

Dates of fieldwork

Fyke netting survey targeting Northern Pike and Walleye: March 27-April 21, 2018 (SN1).
Fyke netting survey targeting Muskellunge: April 24-May 2, 2018 (SN2)
Electrofishing surveys conducted April 22, 2018 (SE1), May 22, 2018 (SE2), and October 4, 2018 (Fall EF).

Fishery

Panfish are abundant (Bluegills, Black Crappies, Yellow Perch), Walleyes, Northern Pike, Largemouth Bass, Yellow Bass, and Channel Catfish are common, and White Bass, Muskellunge, and Smallmouth Bass are present. Numerous other species common to the Fox River were also present.

BACKGROUND

Swan Lake is a 407-acre drainage lake in central Columbia County, positioned between the communities of Portage and Pardeeville. Swan Lake is part of the Fox River, with the inflow entering on the east end, and the outlet on the west end. The lake measures nearly 0.5 mile across at its widest point, and 2.4 miles long from inlet to outlet (Poff and Threinen 1965). Presently, large sections of shoreline along the east and west ends of the lake are low, marshy wetlands that remain undeveloped. The middle sections of the north and south shorelines have seen extensive residential development, and one golf course (Portage Country Club) runs along part of the north shoreline. One WDNR property, the Swan Lake Wildlife Area, borders portions of the west end of the lake.

Swan Lake is essentially a wide, deep trench and there is no water control structure to maintain the water level. The maximum depth is 82 feet at a location just east of the steep bluff toward the west end of the lake. Swan Lake is characterized by shallow flats of varying width around the margins, with steep drop-offs into the central trench-like portion of the lake. Swan Lake lies along a portion of the Fox River that once flowed through a large pre-glacial valley before discharging into the nearby Wisconsin River (Alden 1918). The most recent glaciation resulted in the river changing course and flowing to Lake Michigan, with the divide between the Fox River and Wisconsin River at Portage, Wisconsin measuring a mere 1.3 miles at its narrowest point. The short distance between the two rivers is where Portage derives its name; in historic times traders were able to portage between the two major trade routes (rivers) at this location and a shipping canal later connected the rivers which was rendered inoperable in 1951. Present-day Swan Lake is thought to be an ice block basin in till, formed when large blocks of ice broke away from retreating glaciers, leaving large depressions in the earth when they melted (Zumberge 1952, Boelter and Verry 1977).

Upstream of Swan Lake lie Spring Lake and Park Lake, which is the uppermost impoundment on the Fox River. Spring Lake is a 27-acre seepage and drainage lake which receives inflow from the secondary outlet on Park Lake, and Spring Lake outlets directly to the Fox River and has no water control structure. Fish may move freely between Swan and Spring lakes via the Fox River. Park Lake is a 330-acre artificial impoundment of the Fox River formed by a large dam that maintains a 17-foot head, and this dam is the primary outlet, with the second outlet releasing water to Spring Lake through a small hydroelectric generation dam. Both dams are owned by the Village of Pardeeville.

The bottom substrate of Swan Lake is composed largely of marl with a few areas of sand, gravel, or cobble. Marls are soft, unconsolidated muds largely composed of calcium carbonate that appear gray-white to brown in color (Steidtmann et al. 1924). In Wisconsin, most marl beds lie in the glaciated area and were deposited in lakes of glacial origin with the accumulated shells of freshwater organisms as well as finer-grained calcium carbonate precipitated by the aquatic plant Chara serving as the major sources of calcium carbonate (Steidtmann et al. 1924). The marl in the marshes around Swan Lake was reported as ranging from 8 to 34 feet deep, and under the lake itself between 17 and 40 feet in depth (Steidtmann 1924). The marl substrate was loose, causing swimmers to sink 8-10 inches into the bottom with every step. This caused several lake residents to seek permits over the years to place layers of sand along their shoreline to cover the marl and improve wading and swimming conditions.

Swan Lake is eutrophic, with July-August Secchi, total phosphorous, and chlorophyll TSI values from 1980-2018 somewhat variable but trending neither upward nor downward (Figure 1). Mean July-August Secchi depth was similarly stable, ranging from 3 to 8 feet and averaging 5 feet from 1988-2011 (Figure 2). In 2014, Swan Lake was listed as impaired under Section 303(d) of the Clean Water Act due to excess algal growth and remained listed as of 2018. Recently, a total maximum daily load (TMDL) study was completed for the upper Fox River and the Wolf River and received final approval from the United States Environmental Protection Agency (USEPA) in February 2020. A TMDL is the amount of a pollutant that can be present in a waterway and still allows that waterway to meet its water quality standards. Within the upper Fox and Wolf River basins, those pollutants are phosphorous and suspended solids. The EPA requires that Wisconsin waters not meeting water quality standards be placed on Wisconsin's 303(d) list, and these waters must have a TMDL or comparable water quality restoration plan developed. The upper Fox and Wolf River study area included nearly 6,000 square miles across 16 counties, from Forest County in the north down to Columbia and Dodge counties in the south; the entire Fox River and Wolf River drainages from the headwaters down through Lake Winnebago. The lower Fox River Basin and lower Green Bay are covered under a separate TMDL approved in 2012. Each waterbody in the 89 sub-basin study area (streams, rivers, lakes) was assessed to determine pollutant loads stemming from naturally occurring sources (forests, wetlands), runoff from the surrounding landscape including agricultural sources, and runoff from municipal and industrial wastewater sources as well as stormwater runoff. Results of the study will be used to revise current water quality standards and lead to the adoption of new standards with the goal of improving water quality across the entire watershed. For complete information on the upper Fox and Wolf River TMDL, please visit the dedicated DNR web page found at https://dnr.wi.gov/topic/TMDLs/FoxWolf/.

The aquatic plant community in Swan Lake received its most recent point-intercept survey in 2017. The 2017 survey found 17 macrophyte species, an increase over the 10 species found in 2012, and 7 species found in 2005. Eurasian watermilfoil was the dominant plant species in 2017 but showed a marked decline since the previous survey in 2012. Swan Lake has no recent history of aquatic plant control efforts (herbicide treatment or mechanical harvesting), and the phenomena of declining Eurasian watermilfoil in lakes where it is not actively managed has been observed in several lakes across Wisconsin in recent years with the causative mechanism unknown (WDNR Lakes and Reservoirs Ecologist Michelle Nault, personal communication). Additionally, it was noted that several beneficial native species were encountered in the 2017 survey at low abundance that were not recorded in previous surveys and some of the more prevalent native species such as sago pondweed, coontail, and large-leaf pondweed appeared to be increasing their abundance over time and this is encouraging (Michelle Nault, personal communication). The maximum rooting depth of plants seemed to be consistent over time, ranging from 13 to 17 feet in three aquatic plant surveys since 2005 and this suggested that water clarity hadn't changed dramatically over that time (Michelle Nault, personal communication). Aquatic plant species found in Swan Lake in the 2017 survey are summarized in Table 2, while recent trends in 16 aquatic plant species in the lake in three surveys from 2005-2017 are presented in Figure 3 (provided by Michelle Nault).

Most fish species in Swan Lake sustain themselves entirely through natural reproduction, with two exceptions being Walleye and Muskellunge. Muskellunge were not historically present in Swan Lake and have been stocked over the years to provide additional opportunities for anglers. Walleyes are present throughout the Fox River system, although self-sustaining populations have been present in middle and lower reaches of the river only, with the populations in lakes on the upper Fox River sustained by stocking (Swan Lake, Park Lake) or escapement from stocked waters (Spring Lake). The first attempt to assess the Walleye fishery in Swan Lake occurred in 1952 when late spring fyke netting did not catch any Walleyes. Fingerlings were stocked in 1952, 1956, and 1957, with a June 1957 netting survey yielding only 8 Walleyes, all from the 1952 year class. Walleyes were not stocked again until 1973 (Larson 1978). Walleye natural reproduction was very limited in Swan Lake as indicated by the near-total absence of age 0 fish during fall surveys in non-stocked years (1977 and 1979). Egg netting in April and May 1981 yielded no viable Walleye eggs, with a few dead eggs found on the rocky shoreline along the west bluff (Larson 1981). Meter net tows at the surface and at 3-foot water depths in May and June 1981 (non-stocked year) yielded no Walleye fry and fall electrofishing surveys on October 12-13, 1981 yielded only a handful of age 0 fish, further supporting the idea that Walleye natural reproduction was not sufficient to sustain the fishery (Larson 1981, WDNR unreported data). The limited amount of suitable Walleye spawning habitat (rocky shoreline) in Swan Lake along with a layer of decaying algae on the rocks were cited as the likely reasons for the lack of natural reproduction (Larson 1981).

From 1973-1980, Walleyes were stocked as fingerlings (mean length = 3.3 inches) and successful year classes were produced in stocked years based on the presence of significant numbers of age 0 fish in fall electrofishing surveys (Larson 1985). However, plankton net tows in May and June of 1981 revealed that zooplankton, particularly Cladocerans, were abundant and annual Walleye fry stocking took the place of fingerlings in 1982 (Larson 1985). The number of fry stocked in a given year ranged from 213,444 to 1,200,000 but was generally around 400,000. Fry stocking was successful for many years with age 0 catch rates in fall electrofishing surveys ranging from 15.8 to 93.8 fish/mile from 1984-1998, comparable to naturally produced age 0 catch rates observed in Lake Wisconsin. Fry stocking sustained the fishery until the early 2000s when age 0 fall catch rates crashed with three consecutive failed year classes (2000-2002; range 4.4-9.1 age 0 fish/mile) and one successful year class (2003; 20.6 age 0 fish/mile). Reduced survival of stocked Walleye fry was attributed to competition for zooplankton with young Gizzard Shad, first noted in Swan Lake survey data in 1995. Small fingerling stocking resumed in 2004 and the fall age 0 catch rate rebounded to 36.9 fish/mile. The fall age 0 catch rate was very low in 2005 (2.0 fish/mile), however the water temperature was 73 degrees when the survey occurred in late September and Walleye catch rates for all sizes were the lowest that year of any survey on record. The history of fish stocking in Swan Lake for the past 20 years (1999-2019) is summarized in Table 3.

Prior to the 2018 survey, the only other standing stocking quota was for Muskellunge which were stocked at the rate of one fish per acre as large fingerlings in September of every year since 2011. Other stockings in past years included large fingerling Largemouth Bass (1976), 7 stockings of fry or fingerling Northern Pike between 1973 and 1986, 10 stockings of large fingerling or yearling Tiger Musky between 1986 and 2003, and 22 stockings of large fingerling and true

Muskellunge between 1987 and 2008. Nearly all fish stocked in Swan Lake since the early 1970s have come from either State of Wisconsin fish hatcheries or cooperative rearing facilities.

Rough fish were noted as being present but not overabundant in 1970 and 1980 (Larson 1980). Yellow Bass were noted as being the dominant fish species in Swan Lake in 1980, however a massive die-off of primarily adult Yellow Bass was documented in September 1983 (cause unknown). The population was slow to recover, with improved age 0 Walleye growth in 1984 and increases in Yellow Perch abundance after 1983 attributed to the decline of the Yellow Bass (Larson 1985, Larson 1988).

Fish cribs were added to Swan Lake in 1986 and 1989 to concentrate fish for anglers in a lake with very little bottom structure. Artificial rock reefs to provide Walleye spawning habitat were considered in the 1980s but were not added to the lake due to the overwhelming success of Walleye fry stocking and the low cost to produce the fry relative to the cost of adding reefs with no guarantee of success in establishing natural reproduction (Larson 1985). In more recent years, addition of coarse woody habitat to the littoral zone (fish sticks) occurred on one property in the winter of 2017-2018 and was listed in the 2019 Swan Lake Management Plan as a preferred means of improving fish habitat (Turyk and Arnold 2019). Input gathered from lake residents and users during the planning process indicated some willingness of landowners to install fish sticks along their shorelines, with reduced visual attractiveness of lakeshore properties and the availability of financial assistance for implementing fish sticks projects cited as the main impediments to project implementation (Turyk and Arnold 2019).

METHODS

<u>Data collection-spring netting and electrofishing</u>

Following ice-out, four standard 3-foot frame fyke nets with circular hoops, 0.7-inch bar, and 1.4-inch stretch mesh were set on March 27, 2018. Two additional 3-foot nets and one 4-foot net were set on March 29, and one 3-foot net and one 4-foot net were set March 30. Nets were added, removed, or moved to new locations as necessary until all nets were removed on April 12 and April 13 in advance of a major winter storm that lasted for three days. Five nets were re-set on April 17, and all nets were removed on April 21. The fyke nets targeted Northern Pike and Walleye (SN1) and total effort was 147 net nights. Fyke net descriptions and locations (GPS coordinates) can be found in Table 4.

Gamefish, as defined in Wisconsin Statutes Chapter 29.001 (41), includes all varieties of fish except rough fish and minnows. Panfish are therefore gamefish, and by definition in Wisconsin Statutes Chapter 20.03 (29), panfish includes Yellow Perch, Bluegill, Black Crappie, White Crappie, Pumpkinseed, Green Sunfish, Warmouth, and Orangespotted Sunfish (Orangespotted Sunfish are not present in Swan Lake). For the purposes of this report, sport fish refers to a subset of gamefish including Walleye, Northern Pike, Muskellunge, Largemouth Bass, Smallmouth Bass, and Channel Catfish.

Gamefish were measured to the nearest 0.1 inch and a subsample of each species was weighed to the nearest 0.01 pound. Aging structures were taken from a subsample of Bluegills, Black Crappies, Yellow Perch, Walleyes, Northern Pike, Largemouth Bass, Smallmouth Bass, Channel Catfish and Muskellunge. The type of structure removed from each species is listed in Table 5. The goal was to take structures from 5 fish per half-inch group for Bluegills, Black Crappies, Largemouth Bass, Smallmouth Bass, and Channel Catfish. Five structures per half-inch group from each sex were removed from Walleye, Northern Pike, Muskellunge, and Yellow Perch. Sex was recorded when evident for Walleye, Northern Pike, Muskellunge, and Yellow Perch. Captured Walleyes that were 12.0 inches and larger were marked with a Floy FD-94 T-bar anchor tag and a top caudal fin clip, while fish smaller than 12.0 inches received a bottom caudal fin clip and were not tagged. Tags and fin clips were given for the purpose of a mark-recapture population estimate (PE), as well as to track movement of Walleyes in the upper Fox River based on angler tag returns. Sub-legal Walleyes from 12.0-14.9 inches were tagged because those fish would be expected to reach legal harvest size at some point in the year following tagging. Sexually mature Northern Pike were marked with a top caudal fin clip and immature fish were marked with a bottom caudal fin clip. Largemouth Bass ≥ 8 inches were marked with a top caudal fin clip and fish ≤ 8 inches were marked with a bottom caudal fin clip. Newly captured Muskellunge were marked with PIT tags.

A WDNR standard direct current (DC) boom shocker boat was used to sample fish on Swan Lake with the first electrofishing survey occurring on the night of April 22 (SE1) to recapture Walleyes that were marked during SN1, and to mark Largemouth Bass for a population estimate. Electrofishing output was 220 volts at 17.5 amps with pulse rate set at 58 cycles per second, and the duty cycle was 25%. The entire shoreline was sampled, and all sport fish were collected and measured to the nearest 0.1 inch. Hard structures were removed, and fish were weighed as needed to fill out length bins for age and growth analysis. Walleyes were examined for marks for calculation of the PE and tagging of new Walleyes ≥ 12 inches continued. New Muskellunge were marked with PIT tags. Largemouth Bass were marked with fin clips as during SN1.

The late-spring electrofishing survey (SE2) occurred on May 22, 2018. Electrofishing output ranged from 190-220 volts at 19-20 amps with pulse rate set at 60 cycles per second, and the duty cycle was 25%. The first station began with a randomly chosen starting point and was 2 miles of shoreline in length. All species were collected during the first 0.5 mile, while sport fish only were collected for the remaining 1.5 miles. Subsequent all species and sport fish stations continued in order with each station beginning where the previous station had ended until three all species and three sport fish stations had been completed, encompassing the entire shoreline of the lake. Non-game fish were also collected and measured while sampling the 0.5-mile all species stations except common carp which were counted but not dipped. All gamefish were measured to the nearest 0.1 inch. Aging structures were taken, and weights were recorded from gamefish where necessary to fill out length bins. Largemouth Bass were examined for marks. Walleye tagging continued, as did marking of Muskellunge with PIT tags. Starting and ending GPS coordinates for electrofishing stations can be found in Table 6.

The 2018 fall electrofishing survey of Swan Lake occurred on the night of October 4, and the entire shoreline of the lake was sampled. The purpose of the fall survey was to assess natural Walleye recruitment in Swan Lake, and to collect data on other sport fish species. Walleyes were not stocked in Swan Lake in 2018, nor were they stocked in Park Lake which lies upstream of Swan Lake; all age 0 Walleye collected in the survey were naturally produced. All gamefish were collected and measured to the nearest 0.1 inch. Muskellunge were marked with PIT tags. Other recent fall recruitment surveys occurred in 2016, 2017, and 2019, and those data are presented in this report along with historical fall survey data (1979-2009).

Data Analysis

The Walleye PE (number of adult fish ≥ 15 inches) was calculated using the Chapman modification of the Petersen single-census method where fish are marked during multiple fyke netting events (SN1), followed by a single recapture event (SE1). The formula is noted here:

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

Where N is the estimated population size, M is the number of fish that were marked, C is the number of fish captured on the recapture run and examined for marks, and R represents the number of fish captured on the recapture run that had marks. Once calculated, the estimate was divided by the surface area of the lake to determine adult Walleye density (number of fish ≥ 15 inches / acre). This density was then compared to average densities for stocked and naturally reproducing Walleye fisheries in Wisconsin.

Using fall electrofishing survey data, age 0 Walleye density (fish/acre) was calculated using the Serns method (1982), described here:

Y = 0.234*age 0 Walleye CPUE (fish/mile)

The estimated age 0 density was then multiplied by the surface area of the lake (407 acres) to calculate the total number of age 0 Walleyes in the lake. For stocked years, this number was then divided by the number of small fingerling Walleyes stocked to calculate the percent survival of stocked fish (assuming no natural contribution).

Various data analyses were completed using both Microsoft Excel and R (version 3.5.1) combined with R Studio (version 1.1.136). For all sampling periods, total catch and catch-per-unit of effort (CPUE) was calculated by gear type for all species. Length frequency distributions were generated for gamefish species of interest. Length range, mean, and median lengths were calculated for gamefish species as well. Proportional size distribution (PSD), proportional size distribution of fish sizes often acceptable for harvest (PSD-H, either socially acceptable or legally acceptable under current fishing regulations), and proportional size distribution of preferred length fish (PSD-P) were calculated for all gamefish species of interest with more than 100 stock size individuals collected (Anderson and Neumann 1996, Guy et al. 2007). Length designations for stock, quality, harvestable, preferred, memorable, and trophy sizes of the gamefish species collected from Swan Lake can be found in Table 7; these values were used for calculation of proportional size distribution (Anderson and Neumann 1996, Guy et al. 2007). For Bluegills, proportional size distribution calculations were reported separately for fyke netting and electrofishing due to possible bias, with fyke nets being selective for larger Bluegills (Laarman and Ryckman 1982).

Ages were estimated from calcified structures for a subsample of each species, and age and size data of these fish were used to generate age-length keys and ages were assigned to all fish sampled to estimate the age frequency of the population based on the aged subsample (Isermann and Knight 2005). Age frequency distributions were then generated for each species. Once age frequency distributions were completed for each species, inferences were made about year class strength and mortality when possible. Catch curves were generated for species exhibiting consistent recruitment for calculation of total annual mortality rates. Mean length-at-age was used to make inferences about growth of fish in Spring Lake by comparing the lake to area, regional, and statewide averages. Area averages are calculated from mean length at age values from lakes managed out of the Poynette Fisheries office and surveyed from 2008-2019. Area and regional comparisons are helpful for anglers who are interested in knowing which of the lakes in their area that they might fish in a given day offer the greatest fishing potential for a certain species.

Lakes classification systems have been developed by several states, and newly developed lake classes and comparison tools offer an opportunity not previously available for Wisconsin lakes. After several years of study by several DNR scientists, around 6,000 Wisconsin lakes were grouped into 15 classes based on the fish community in the lake (simple or complex), temperature (cool, warm, harsh), clarity (clear or dark), and hydrology (riverine, two story, trout pond) (Rypel et al. 2019). Comparing fishery performance of a given lake to others within its lake class will help guide future management as well as help to inform members of the public by shaping more realistic expectations of how the fishery in that lake should perform. For instance, one should not expect a Simple-Warm-Dark lake to offer the same fishing experience as a Complex Riverine lake.

Mean length at age was calculated using methods outlined in Bettoli and Miranda (2001), with the formula listed here:

$$\overline{Li} = (\sum N_{ij}\bar{l}_{ij})/N_i$$

Where $\overline{L}_i$ represents the mean length of the *i*th age group, $N_{ij} = N_j(\frac{n_{ij}}{n_j})$, N_j is the number of fish in the *j*th length group, n_{ij} = number of fish of the *i*th age group subsampled in the *j*th length group, n_j is the number of fish subsampled in the *j*th length group, and $N_i = \sum N_{ij}$ over all *j* length groups. The inputs to this equation are derived from the length frequency distribution of the sample and the age-length key.

Relative weights were calculated to evaluate body condition of fish. Relative weight (W_r) is a tool that compares the length of the fish to an expected weight for that length. Standard weights were calculated for individuals of each species that had weights recorded and standard weights were only calculated for individuals larger than the minimum recommended length for each species. (Murphy et al. 1991, Anderson and Neumann 1996). Relative weights for each fish were calculated by dividing a fish's actual weight by the standard weight for a fish of that length. Average relative weight was then calculated for each species, and for each sex separately when sex data were available. Relative weight values between 75 and 100 indicate normal weight for a given length. A relative weight value greater than 100 indicates that a fish is in excellent condition. A relative weight value less than 75 indicates that a fish is in poor condition.

RESULTS AND DISCUSSION

General Fish Community

In total, 14,544 fish representing 33 species and hybrids from 12 families were collected during spring netting and electrofishing on Swan Lake in 2018 with species listed by family in Table 8. Catch and CPUE by gear type are shown for each species collected in Table 9.

Bluegill

In total, 8,648 Bluegills were collected during the spring; the catch rates were 53.1 fish/net night during SN1, 11.6 fish/net night during SN2, and 74.0 fish/mile of shoreline during SE2 (Table 9). The SN1 catch rate was very similar to the last survey in 2009 (55.2 fish/net night). The SE2 catch rate ranked in the 43rd percentile statewide; Bluegills were common in Swan Lake. The Bluegill SE2 catch rate ranked near the bottom when compared to area lakes (Table 10). However, when compared to other lakes in its class (Complex Riverine), Swan Lake compared more favorably in terms of SE2 CPUE, placing well above the class median of 39.0 fish/mile (Figure 4). Compared to the previous survey in 2009, the SE2 Bluegill CPUE was significantly higher (74 fish/mile in 2018 vs. 28 fish/mile in 2009). However, these catch rates are not directly comparable because only two of the three half-mile all species stations sampled in 2018 matched stations sampled in 2009.

In total, 2,886 Bluegills collected during SN1 and 111 collected during SE2 were measured and aging structures (otoliths) were taken from a subsample of 65 fish with lengths between 3.1 and 9.2 inches. Bluegills collected during SN2 were counted and released because sufficient length data were collected during SN1. Overall, lengths ranged from 3.0 to 9.2 inches with mean and median lengths of 5.7 and 5.9 inches, respectively (Table 11). Summaries of length data are reported separately for each sampling period in Table 11. The length frequency distribution for

Bluegills is presented in Figure 5. The PSD, and PSD-7, and PSD-P values from SN1 were 47, 12, and 2, respectively (Table 11). Size structure appeared to be slightly better in 2018 compared to 2009 when the SN1 PSD, PSD-7, and PSD-P values were 52, 9, and zero, respectively. The 2018 PSD values calculated from the SE2 catch were 52, 9, and 1, respectively (Table 11). Too few Bluegills were collected during SE2 in 2009 (n = 42) for meaningful PSD calculations; comparison to 2018 was not possible.

Bluegill mean length-at-age in Swan Lake exceeded area and state averages for ages 2-8, with fish averaging 7.3 inches at age 4, 7.8 inches at age 5, and 9.0 inches at age 6 (Figure 6). Ages ranged from 2 to 8 years (no age 7 fish present), with age 3 fish being the most common (74%) as presented in Figure 7. Recruitment appeared to be relatively steady based on the age frequency distribution, and total annual mortality was 89.7% after age 3 based on the catch curve (Figure 8). This estimate was relatively high compared to several other area lakes and may be indicative of high harvest. Precipitous declines in number-at-age after age 3 coincided with Bluegills reaching sizes anglers found acceptable for harvest by age 4 when some fish already exceeded 8 inches.

Overall, Bluegills larger than 3 inches were in excellent condition with a mean relative weight of 112.7; relative weights are presented in Figure 9. Most Bluegills (78.4%) had relative weight values >100 indicating excellent condition, while very few (3%) had relative weight values <75 indicating poor condition. Relative weight appeared to be highly variable for Bluegills measuring three to five inches, and this has been relatively common among area Bluegill populations. It may be due in part to the pan balances used to weigh panfish being prone to measurement error arising from wind, waves, and accumulating fish slime and water in the pan, and other centrarchid panfish species such as Black and White crappies sometimes exhibit the same variability in relative weight for smaller fish. However, other panfish populations (Black Crappie, Yellow Perch) in Swan Lake did not exhibit the same variability in relative weight.

<u>Yellow Perch</u>

In total, 979 Yellow Perch were collected; catch rates were 0.3 fish/net night during SN1, 14.7 fish/net night during SN2, and 2.7 fish/mile during SE2 (Table 9). Lengths of 887 Yellow Perch measured during SN1 and SN2 ranged from 5.0 to 12.0 inches, and the mean and median lengths were 7.3 and 7.2 inches, respectively (Table 11). The length frequency distribution is presented in Figure 10. The 2018 PSD, PSD-9, and PSD-P values were 26, 8, and 2, respectively. The 2018 PSD value was similar to 2009 when PSD was 25, but the 2018 PSD-P was lower (2009 PSD-P =

8); there were slightly fewer large perch proportionally in 2018 compared to 2009. Compared to other area lakes surveyed since 2009, Swan Lake ranks in the middle of the pack in terms of Yellow Perch size structure (PSD; Table 12). Female PSD values were noticeably higher than males, and females likely made up the bulk of what anglers found acceptable for harvest (Table 12). The SN1 sample had a male: female sex ratio of 2.6:1. Males (n = 641) ranged from 5.1 to 9.8 inches and averaged 6.9 inches while females ranged from 6.0 to 12.0 inches and averaged 8.3 inches. An additional four Yellow Perch were collected during SE2; lengths ranged from 3.3 to 5.2 inches and averaged 3.9 inches (Table 11).

Yellow Perch mean length-at-age was generally between state and region averages, with fish averaging 7.3 inches at age 3, 8.1 inches at age 4, and 8.6 inches at age 5 (Figure 11). Females grew faster and reached larger sizes than males, averaging 8.2 inches at age 3, 8.9 inches at age 4, and 9.7 inches at age 5 compared to 6.9, 7.7, and 7.9 inches for males at ages 3-5. Mean length-at age for male and female Yellow Perch are presented in Figures 12 and 13. Ages were estimated for 109 Yellow Perch and ages ranged from 2 to 6 years overall (Figure 14). Recruitment appeared to be steady and age 3 was the most common age class present in the catch (48.4%), with numbers at age declining quickly thereafter (Figure 14). Male ages ranged from 2 to 6 years, while female ages ranged from 2 to 5 years (Figure 15). Total annual mortality estimated from the catch curve was 73.4% (Figure 16). However, relatively few area lakes have quality Yellow Perch populations that would make comparison of mortality rates across lakes worthwhile. Overall, Yellow Perch in Swan Lake were in excellent condition; relative weight values averaged 104.6 and were slightly higher for females (W_r = 105.6) than males (W_r = 103.4). No fish had a relative weight value ≤ 75, and 60% of weighed fish (n = 63) had relative weight values ≥ 100. Relative weight values are presented in Figure 17.

Black Crappie

In total, 596 Black Crappies were collected; the catch rates were 0.8 fish/net night during SN1, 7.3 fish/net night during SN2, and 8.0 fish/mile during SE2 (Table 9). The SN1 catch rate was lower than the last survey in 2009 (3.9 fish/net night), however this may just be due to lingering cold water temperatures in 2018, as the crappie catch rate picked up significantly during SN2 (no SN2 in 2009 for comparison). The SE2 catch rate ranked in the 50th percentile statewide. During SN1 and SN2, lengths of 513 Black Crappies ranged from 3.3 to 13.0 inches and mean and median lengths were 9.2 and 9.7 inches, respectively (Table 11). The PSD, PSD-9, PSD-P, and PSD-M values were 78, 68, 43, and 1, respectively and these values are indicative of good size structure (Table 11). The PSD and PSD-P values in 2018 were higher than those observed in 2009 (PSD = 58, PSD-P = 11). During SE2, 12 Black Crappies ranged from 6.7 to 11.3 inches, averaging 9.0 inches (Table 11). The length frequency distribution from spring netting and electrofishing is presented in Figure 18.

Mean length-at-age of Black Crappies in Swan Lake was higher than area and state averages for ages 3-8, and some fish exceeded 10 inches as early as age 3. Black Crappies in Swan Lake reached an average length of 8.6 inches by age 3, 10.3 inches by age 4, and 10.8 inches by age 5 (Figure 19). Ages were estimated for 90 Black Crappies, and ages ranged from 1 to 10 years (no age 9 fish present). Age 4 fish were the most common in the distribution (44.2%) and recruitment appeared to be relatively steady based on the lack of missing age classes (Figure 20). By age 4, Black Crappies in Swan Lake reached an acceptable size to be harvested by anglers, and numbers declined quickly thereafter through age 10, the oldest in the distribution. The total annual mortality rate after age 4 was 73.0% based on the catch curve presented in Figure 21. This value was on the higher side compared to other area lakes where estimates of total annual mortality are available (5 total lakes, range = 49.6-82.0%). Black Crappies were in good condition based on relative weights; average relative weight was 104.1 and 67% of weighed fish had relative weights > 100 indicating excellent body condition. By contrast no fish had a relative weight below 75 indicating poor condition. Relative weights of Black Crappies are presented in Figure 22.

Walleye

The total Walleye catch during spring netting and electrofishing in 2019 was 1,005 fish (including recaptures). The catch rates were 2.7 fish/net night during SN1, 6.9 fish/mile during SE1, 5.6 fish/net night during SN2, and 15.9 fish/mile during SE2 (Table 9). The 2018 SN1 catch rate was very similar to the last survey in 2009 (2.4 fish/net night) and was well above the median for the Complex Riverine lake class (Figure 23). For the population estimate, a total of 266 Walleyes ≥ 15 inches was marked during SN1 (M). Twenty-five Walleyes were captured during SE1 (C), and 8 were recaptures (R). The Chapman population estimate was 770 Walleyes ≥ 15 inches (95% CI = 495-1,374) or 1.9 fish/acre (95% CI = 1.2-3.4 fish/acre). This was higher than the 2009 estimate of 1.5 Walleyes ≥ 15 inches per acre. However, water temperatures were still in the low 40s on the night of the SE1 survey, and very few Walleyes were collected relative to the number marked. The coefficient of variation (CV) value is a measure of precision of the estimate, and the CV for the population estimate was 25.6%, which is higher than the 20% or less recommended for reporting a PE (Krebs 1999).

The Walleye fyke net catch rate during SN2 was more than double the catch rate during SN1, and the same was true for SE2 compared to SE1. The PE was calculated a second time with SN1, SE1, and SN2 sampling periods serving as the marking period, and SE2 serving as the recapture event. A total of 459 Walleyes ≥ 15 inches was marked during SN1, SE1, and SE2 (M). During SE2, 62 Walleyes ≥ 15 inches were collected (C), and 21 were recaptures (R). The Chapman population estimate after incorporating SN2 and SE2 data was 1,316 Walleyes ≥ 15 inches (95% CI = 973-1,890) or 3.2 fish/acre (95% CI = 2.4-4.6 fish/acre). The CV value for the second PE was 16.8% which was within the acceptable range of precision for reporting. For reference, the typical stocked Walleye fishery in Wisconsin has around 1.7 Walleyes/acre ≥ 15 inches.

In total, 654 unique Walleyes were measured during spring sampling periods (total catch excluding recaptures) and lengths ranged from 7.4 to 26.4 inches with mean and median lengths both at 16.0 inches (Table 13). The length frequency distribution is presented in Figure 24. For known-sex Walleyes sampled during SN1, SE1, and SN2, males (n = 293) ranged from 13.2-22.2 inches with mean and median lengths of 16.0 and 15.7 inches, respectively. Female Walleyes (n = 155) ranged from 14.4-26.4 inches with mean and median lengths of 19.2 and 18.9 inches, respectively. A few males reached sexual maturity as early as age 2 but most matured at age 3 while females reached sexual maturity as early as age 3, with most likely mature by age 4. Immature Walleyes sampled during SE1 and SN1 (n = 26) ranged from 7.4-16.7 inches with mean and median lengths of 11.4 and 9.4 inches, respectively. Unknown sex fish collected during SN1 that were between 13.5 and 16.7 inches ranged from two to four years of age and were likely immature females.

Walleyes grew relatively quickly in Swan Lake, with mean length-at-age values generally greater than or equal to region and statewide averages. Overall, Walleyes averaged over 15 inches by age 3, some reached 20 inches by age 4, and Walleyes averaged over 20 inches by age 7 (Figure 25). When looking at the sexes separately, female Walleyes grew faster and reached larger sizes than males. Male Walleyes averaged 15.1 inches at age 3, some males exceeded 20 inches by age 6, and they averaged 20.2 inches at age 7 (Figure 26). Females averaged 16.5 inches at age 3 and averaged 20.5 inches at age 6 (Figure 27). A von Bertalanffy growth model was fitted to the data, and the result is presented in Figure 28, including the parameter estimates for L_∞ (22.3 inches), k (0.2963083), and t_0 (-0.7675323).

Age 3 fish were fully recruited to the sampling gear and were the most common in the distribution (33.2%) followed by age 4 (21.9%), and age 5 (21.1%) with age frequency declining steadily thereafter (Figure 29). The near total lack of age 2 fish coincides with a non-stocked year for Swan Lake in 2016, and the few age 2 fish present were a mix of escapees from Park Lake (marked with an LV fin clip) and naturally produced fish. The strength of the 2014 year class (age 4, non-stocked year) relative to the 2013 and 2015 year classes (ages 3 and 5, stocked years) indicated that substantial natural Walleye reproduction and recruitment likely occurred in 2014. In any case, age frequency declined steadily after age 3 when Walleyes had reached the minimum harvest size. The observed variation in recruitment violated the assumption of constant recruitment and a catch curve was not used to calculate total annual mortality. The age frequency distributions for known-sex Walleyes are presented in Figure 30.

Condition of Walleyes in Swan Lake was good based on relative weights, which averaged 96.4 for 165 Walleyes that were weighed (Table 13). Females averaged 100.2, males averaged 92.6, and immature fish averaged 93.1. Four Walleyes (2.4%) had relative weights ≤ 75 indicating poor condition, while 56 Walleyes (33.9%) had relative weights ≥ 100 indicating excellent condition. Relative weights are presented in Figure 31.

Walleye tagging

In total, 583 Walleyes ≥ 12 inches were marked with Floy tags in Swan Lake during the 2018 survey (length range 12.5-26.4 inches). Of those, 84 were between 12.5 and 14.9 inches and 499 were ≥ 15 inches. Between April 30, 2018 and May 25, 2019, 41 tagged Walleyes were reported caught by anglers. Only one fish, the first recapture reported, was caught outside of Swan Lake. It was caught in the Fox River in Marquette County between County Highway O and County Highway CM on April 30, 2018 after being originally tagged on April 9, 2018. The remaining 40 tag returns were all reportedly caught in Swan Lake. Four of the reported fish were under 15 inches and were released. Of the 37 legally harvestable Walleyes reported, 31 were harvested (83.7%) and six were released (16.3%). Tag loss and the non-reporting rate were not estimated and without reliable estimates, exploitation could not be calculated. Based on the tags reported, however, it was clear that the Walleye anglers in Swan Lake were harvest oriented. Additionally, the Walleyes tagged in Swan Lake in 2018 exhibited little movement, with only one tagged fish reported caught by an angler downriver from Swan Lake. An additional three Walleyes tagged in Swan Lake during SN1 were later recaptured by WDNR during the SE2 survey of Spring Lake, upstream of Swan Lake, on May 22, 2018. Additionally, three Walleyes tagged in Spring Lake during SN1 were recovered in Swan Lake later in the Spring (See Appendix A for details).

<u>Fall musky stocking evaluation, Walleye recruitment, and sport fish surveys</u>

During three fall electrofishing surveys conducted as part of the musky feeding study in 2014, staff noted abundant age 0 Walleye were present, but Walleyes were not collected as a regular part of the survey. Walleyes were not stocked in Swan Lake in 2014, but extended growth fingerlings were stocked in Park Lake upstream of Swan Lake and those fish were marked with oxytetracycline (OTC) which leaves a chemical signature in the bones of the fish which can be seen under fluorescent light. A sample of age 0 Walleyes (n = 22) was collected during the final musky electrofishing survey in 2014 and otoliths were removed and analyzed for the presence of OTC markings by staff at the Fisheries Analysis Center at the University of Wisconsin-Stevens Point (UWSP). Only 9% of fish in the sample (n = 2) had visible OTC marks, leading to the conclusions that a) perhaps the OTC marking process was ineffective or b) there was significant Walleye natural reproduction in Swan Lake in 2014. Age data described above indicated the presence of a strong 2014 year class, further supporting the natural year class theory. Small fingerling Walleyes were stocked in Swan Lake in 2015, however Walleye data were not collected during musky recapture surveys in 2015. Age 0 Walleyes were present in great numbers in 2015 and again a sample of age 0 Walleyes was collected (n = 27) during one musky survey and sent to UWSP for analysis. Otoliths from 22 of the fish were determined to be readable, and 50% (n = 11) were determined to have OTC marks, while 50% had no mark. The fact that half of the sample had no OTC mark during a stocked year led to the same conclusions as 2014.

Fall electrofishing surveys were then conducted to assess Walleye recruitment each year from 2016-2019. The years 2016 and 2018 were non-stocked years for Swan Lake, and small fingerling Walleyes were stocked in 2017 and 2019. Park Lake upstream of Swan Lake was stocked with extended growth Walleyes in 2016 and those fish were marked with left-ventral fin clips, however no marked age 0 fish were collected during the 2016 fall electrofishing survey of Swan Lake. Park Lake was also stocked with extended growth Walleyes in 2019, but the fish were not marked. The fall age 0 catch rates in Swan Lake in 2016 and 2018 (non-stocked years) were 0.7 and 0.3 fish/mile, respectively (mean CPUE = 0.5 fish/mile). The age 0 catch rates in 2017 and 2019 (stocked years) were 16.4 and 27.3 fish/mile, respectively (mean CPUE = 21.9 fish/mile). Using the Serns index, the estimated total number of fall age 0 Walleyes produced during 2016-2019 was calculated. Age 0 abundance was estimated at 1,562 in 2017 and 2,600 in 2019, both stocked years. Survival of stocked Walleyes (assuming no naturally produced age 0 fish) was then estimated at 11.0% in 2017 and 18.2% in 2019. By contrast, age 0 abundance in non-stocked years was estimated at 67 fish in 2016 and 29 fish in 2018. Fall Walleye data from 2016-2019 are summarized in Table 14.

A fall age 0 catch rate ≥ 10 fish/mile is considered a successful year class, and by that standard Swan Lake did not produce successful Walleye year classes naturally in 2016 and 2018, but successful year classes were produced in 2017 and 2019 when small fingerling Walleyes were stocked. The lack of marked age 0 Walleyes in Swan Lake in 2016 indicated that any escapement from Park Lake within the first month after Walleyes were stocked was likely minimal and no escapees had yet reached Swan Lake. This supported the idea that the large class of age 0 fish observed in fall 2014 was likely the result of natural reproduction and not escapement of stocked fish from Park Lake. Age 0 fall Walleye catch rates for surveys conducted from 1984 through 2019 are presented in Figure 32. Note the exceptional catch rates of age 0 fish in surveys from the fry stocking period (1984-1999), followed by three straight years of unsuccessful fry stocking from 2000-2002. Additionally, Walleye CPUE-15 generally varied between 2 and 5 fish/mile from 1984-2019 and was higher on average in years following enactment of the statewide 15-inch minimum size limit for Walleyes on January 1, 1990 (Figure 33).

Other sport fish species were collected during recent fall electrofishing surveys, and data for those species are summarized in Table 15. Largemouth Bass fall electrofishing CPUE has been somewhat variable but overall steady (not trending upward or downward) in terms of total CPUE from 1984-2019 (Figure 34). Largemouth Bass size structure has improved since the statewide 14-inch minimum length limit went into effect in 1989 as indicated by higher fall electrofishing CPUE-14 since that time (Figure 34). Smallmouth Bass first appeared in survey records for Swan Lake in the fall of 1995 (one 16.0-16.4-inch fish collected) and fall CPUE has been variable ever since (range 0.0-2.5 fish/mile), decreasing steadily from 2000-2005 and in more recent times increasing from 2017-2019 (Figure 35). Northern Pike fall CPUE has generally been between 0.5 and 2.5 fish/mile but fall catch rates do not indicate an overall increase or decrease in abundance over time (Figure 36). Channel Catfish and Musky are only collected occasionally, with total and adult musky catch rates far lower from 2013-2019 compared to previous years (CPUE, CPUE-30; Figure 37).

Walleye genetics

Fish passage was installed at the dam on the Fox River at Montello in 2014. The WDNR-owned dam forms Buffalo Lake and the fish ladder was installed with Walleye, lake sturgeon, and flathead catfish as the target species for passage. Data from Swan Lake collected in 2014 and 2015 indicated that significant Walleye natural reproduction may have occurred in Swan Lake during those years. To help answer the question of whether influxes of adult fish from further down the Fox River could help to explain increased natural reproduction in Swan Lake, genetic samples (small fin clips) were collected from 50 adult Walleyes in Swan Lake during the spring 2018 survey, and up to 50 samples were to have been collected from age 0 Walleyes during the fall 2018 survey (non-stocked year). However, only two potential age 0 fish were collected in the fall. In total, 52 genetic samples were sent to the University of Wisconsin-Stevens Point for analysis. As of April 2020, only 6 of the samples had been analyzed. Three of the fish were determined to be of Winnebago System origin (Lake Michigan drainage), and three were of Rock-Fox (Mississippi River drainage) origin. For reference, prior to 2018 Lake Michigan strain Walleyes (Lake Puckaway) were stocked in Swan Lake from 2002-2004, an Unspecified strain was stocked in 2005, and Rock-Fox strain Walleyes were stocked in 2006, 2008, 2011, 2013, and 2015. Mississippi Headwaters strain Walleyes were stocked in 2017 (and 2019). Hopefully the remaining 46 samples will help shed more light on the genetic origins of the Swan Lake Walleye population, which appears to be a mix of Lake Michigan and Mississippi River drainage fish.

Largemouth Bass

In total, 344 Largemouth Bass were collected including recaptures; catch rates were 1.2 fish/net night during SN1, 10.1 fish/mile during SE1, 0.4 fish/net night during SN2, and 7.4 fish/mile during SE2 (Table 9). The SE2 CPUE was markedly lower than the most recent previous survey in 2009 (30.9 fish/mile) but was in line with surveys completed in spring 2000-2004 (CPUE range 8.5-18.1 fish/mile, Figure 38). Swan Lake compared favorably within its own lake class (Complex Riverine), placing between the 50th (median) and 75th percentiles; the Largemouth Bass catch rate in Swan Lake was consistent with what one should expect to see from a lake in this class. The catch rate of fish ≥ 8 inches (CPUE-8; stock size) during SE2 was 7.0 fish/mile, and this ranked in the 58th percentile compared to lakes in several Wisconsin drainage basins, while the CPUE-15 (2.6 fish/mile) placed Swan Lake in the 92nd percentile for the same comparison; both metrics compared favorably on a broad scale. Swan Lake compared less favorably on a local level, ranking in the lower half of area lakes when comparing various size-specific CPUE values (Table 16). This was somewhat misleading, however, because Columbia and Sauk counties have several lakes where Largemouth Bass abundance ranks among the highest in the state, and these lakes fall into other lake classes that typically produce higher Largemouth Bass abundances than Complex Riverine lakes. Too few bass were recaptured during SE2 to calculate a meaning full population estimate.

Lengths of 307 unique Largemouth Bass ranged from 4.7 to 21.2 inches, and the mean and median lengths were 12.2 and 11.5 inches, respectively (Table 13). The length frequency distribution is presented in Figure 39. Of the Largemouth Bass ≥ 8 inches in length (stock size), fish ≥ 12 inches were present in good numbers (PSD = 45), as were legally harvestable bass (PSD-14 = 31), and fish ≥ 15 inches (PSD-P = 22). Fish over 20 inches were present as well (PSD-M = 2). Overall, the 2018 PSD values indicated slightly better size structure than was observed in 2009 when the PSD, PSD-14, PSD-P, and PSD-M values were 68, 29, 16, and 1, respectively.

Largemouth Bass mean length-at-age in Swan Lake was higher than area and state averages through age 7, then was essentially equal to the state average and better than the area average for ages 8-11 (Figure 40). Some Largemouth Bass reached legal harvest size of 14 inches in Swan Lake by age 3, and they averaged over 14 inches by age 5 (Figure 40). Mean length at age 6 was 15.3 inches, placing Swan Lake near the top compared to other area lakes (Table 17). Age 3 was the most common in the distribution (37.5%), with age frequency declining steadily thereafter through age 11, with only a single age 16 fish present (Figure 41). Fewer age 10 fish were present relative to ages 9 and 11, indicating that 2008 may have been a weak year class. Total annual mortality estimated from the catch curve in Figure 42 was 37.3% which was not high compared to other area lakes surveyed since 2012 (range 19.2-78.4%, median = 40.9%). Harvest did not appear to be excessively impacting Largemouth Bass in Swan Lake.

Condition of Largemouth Bass in Swan Lake was excellent; relative weights of 119 fish averaged 109.8. Zero fish had a relative weight below 75, and 78% of weighed fish had relative weights greater than 100 (n = 93). There was no apparent relationship between fish length and relative weight. Relative weights of Largemouth Bass in Swan Lake are presented in Figure 43.

Northern Pike

In total, 325 Northern Pike were sampled during the spring including recaptures. The catch rates were 1.0 fish/net night (SN1), 0.6 fish/mile during SE1, 2.6 fish/net night during SN2, and 2.3 fish/mile during SE2 (Table 9). The 2018 SN1 catch rate was notably higher than during the last survey in 2009 (0.3 fish/net night). The 2018 SN1 catch rate placed Swan Lake between the 25th and 50th percentile (median) compared to the rest of its lake class (Complex Riverine; Figure 44). However, lingering cold temperatures throughout SN1 delayed Northern Pike spawning activity, and likely kept the catch rate lower than it would have been if the lake had warmed more quickly. Northern Pike spawning activity peaked during SN2 when catch rate was more than 2.5 times higher than SN1. The SN2 catch rate would have placed Swan Lake between the 50th and 75th percentiles for the lake class. Northern Pike were marked during SN1, SE1, and SN2 and running Schnabel population estimate was calculated daily through the end of SN2. Ultimately, 230 sexually mature Northern Pike were marked and 44 were recaptured. The Schnabel population estimate for sexually mature Northern Pike was 709 fish (95% CI 531-943 fish, CV = 14.7%) or 1.7 mature Northern Pike per acre (95%CI 1.3-2.3 fish/acre).

Lengths of 268 unique Northern Pike ranged from 8.8 to 33.5 inches and the mean and median lengths were 21.9 and 22.0 inches, respectively (Table 13). The length frequency distribution for Northern Pike is presented in Figure 45. The PSD, PSD-26, and PSD-P values were 66, 27, and 19, respectively. The PSD-26 value indicated a good proportion of harvestable-sized fish. Northern Pike grew relatively quickly with mean length-at-age values equal to the region average for ages 1-5, and greater than the statewide average for all ages (Figure 46). Northern Pike averaged over 26 inches by age 5, but faster growing fish exceeded 26 inches by age 3. When looking at the sexes separately, it was evident that females likely make up the bulk of the Northern Pike harvest in Swan Lake. Male mean length-at-age never exceeded 26 inches, although some individual males aged 4-6 did reach that mark (Figure 47). Some females exceeded 26 inches by age 3 and averaged over 26 inches by age 4 with numerous individuals exceeding 30 inches (Figure 48).

Overall, Northern Pike ages ranged from 1 to 7 years, with age 3 fish being the most common (32.3%) and age frequency declining quickly after age 4 as represented in Figure 49. Male and female age frequency distributions are presented in Figure 50. Recruitment appears to be relatively consistent based on the lack of missing year classes, but numbers appeared to be reduced significantly as fish reached legal harvest size. Total annual mortality after age 3 was

61% based on the catch curve (Figure 51). When looking at the sexes separately, male ages ranged from 1 to 6 years and the male age frequency distribution peaks at age 3. Female ages ranged from 2 to 7 years and the age frequency distribution peaks at age 4. Some of the decrease in age frequency after age 3 can be explained by harvest, particularly for females. However, relatively few males appeared to reach legal harvest size and it may be that natural mortality was just higher in this population.

Condition of Northern Pike was good; relative weights of 195 fish averaged 99.0. Relative weights for Northern Pike were generally lower for males which averaged 91.9, while females averaged 107.8, and unknown sex fish averaged 91.1. One weighed Northern Pike (0.5%) had a relative weight value below 75 indicating poor body condition and it was an immature age 1 fish. Forty percent (n = 78) of weighed Northern Pike had relative weight values ≥ 100 indicating excellent condition and most were females. Relative weights are presented in Figure 52.

<u>Channel Catfish</u>

In total, 158 Channel Catfish were collected during the spring including recaptures. The catch rates were less than 0.1 fish/net night (SN1), zero fish/mile during SE1, 2.2 fish/net night during SN2, and 2.0 fish/mile during SE2 (Table 9). Three nets on the east end of the lake produced 83% of the SN2 Channel Catfish catch (nets 1A, 16, and 19; Table 4). In total, 152 unique Channel Catfish ranged from 7.9-29.9 inches with average and median lengths of 22.3 and 22.4 inches, respectively. The length frequency distribution is presented in Figure 53. Size structure was good based on PSD values; the PSD, PSD-P, and PSD-M values were 99, 30, and 3, respectively. The largest channel catfish sampled weighed nearly 14 pounds. Channel catfish in Swan lake averaged over 20 inches by age 8, and over 25 inches by age 13 (Figure 54). The catch was dominated by older fish with peaks in the age frequency at age 8 and age 11, with the age frequency declining steadily thereafter through age 17 (Figure 55). Younger fish (ages 2-6) were all present, but it appeared that they were not fully vulnerable to the sampling gear. Condition was good based on relative weights which averaged 99.1. Only 3% (n = 3) of weighed Channel Catfish had a relative weight below 75 (poor condition) while 41% (n = 35) had relative weights ≥ 100 (excellent condition). Relative weights are presented in Figure 56.

<u>Muskellunge</u>

The history of Musky stocking in Swan Lake includes true Muskellunge stocked in 24 of 32 years from 1987-2018, and Tiger Muskellunge (Northern Pike x Muskellunge hybrid) stocked in 9 of

18 years from 1986-2003. All stocking consisted of either fall fingerlings or yearlings. The standing quota as of 2018 was one large fingerling per acre every year. From 2013-2016 the stocked Muskellunge were part of a study comparing survival of muskies started on pellet food and finished on live forage (minnows) versus muskies reared entirely on minnows which has been the traditional rearing method in Wisconsin state fish hatcheries. Starting fish on pellet food with a 30-day finish period on minnows could significantly reduce rearing costs, so determining if any difference in survival existed between pellet fish and minnow fish was a top priority. Many stocked musky lakes across Wisconsin were part of the study, with some lakes receiving all minnow-reared fish, some receiving a 50-50 mix of minnow and pellet-reared fish, and some lakes receiving all pellet-reared fish. Swan Lake fell into the treatment group that received all pellet-started, minnow-finished muskies and those fish were marked with a right-ventral fin clip and a PIT tag at Wild Rose State Fish Hatchery each year on the day of stocking in late September.

Three fall electrofishing surveys targeting muskies were completed at Swan Lake each year from 2013-2015 and two surveys were completed in 2016. The surveys occurred from early October through early November roughly two to five weeks after stocking and were meant to assess short-term survival of stocked fingerlings. The mean age 0 musky catch rates were 0.2 fish/mile in 2013, 0.1 fish/mile in 2014, and zero fish/mile in both 2015 and 2016. No more than two age 0 muskies were collected in any one survey.

In total, 24 Muskellunge were collected during the spring of 2018 and the catch rates were 0.1 fish/net night during both SN1 and SN2, 0.6 fish/mile during SE1, and 0.4 fish/mile during SE2. The 2018 SN1 catch rate matched the catch rate from the previous survey in 2009, but the SE1 and SE2 catch rates fell well below what was observed in 2009 (4.6 fish/mile SE1, 1.3 fish/mile SE2). Also, SN2 netting did not occur in 2009. A population estimate was not completed in 2009, and in 2018, too few adult muskies were marked to warrant a recapture survey in 2019. Additionally, catch rates of muskies from fall electrofishing surveys from 1986-2019 indicated a downward trend after 2009, with zero adult muskies captured in the last three surveys (2017-2019; Figure 37). Based on spring netting and electrofishing catch rates and fall electrofishing catch rates, musky abundance appeared to have declined significantly since 2009.

Nineteen unique muskies collected in the spring of 2018 ranged from 11.0-48.5 inches with mean and median lengths of 35.4 and 41.2 inches, respectively (Table 18). Three muskies weighed in excess of 35 pounds. Muskies sampled in 2018 are listed individually in Table 18. Four muskies were age 1 fish stocked in the fall of 2017. One musky was age 3 and was a PIT-tagged recapture that was stocked in the fall of 2015 at a length of 10.4 inches. Two muskies were age 7, one was age 8, seven were age 10, and four were age 11. The relative lack of muskies aged one to 9 compared to ages 10 and 11 which made up 56% of the sample indicates that there has been little to no musky recruitment in Swan Lake for an extended period. Only one fish out of the 1,548 stocked during the 2013-2016 musky study was recaptured in Swan Lake during the 2018 comprehensive survey. Two additional age 2 muskies stocked in 2016 were collected in Spring Lake in 2018 (See Appendix A). Musky condition was good based on relative weights which averaged 104.1; relative weights of muskies are presented in Figure 57.

Other Desirable Fish Species and Rough Fish

Yellow Bullhead (n = 1,491), White Bass (n = 172), Pumpkinseed (n = 154), and Yellow Bass (n = 121) helped to round out the diverse angling opportunities available in Swan Lake. Measured Yellow Bullheads (n = 329) ranged from 5.1-13.2 inches in length with mean and median lengths of 8.4 and 8.3 inches, respectively. White Bass ranged from 8.5-16.3 inches in length with mean and median lengths of 13.8 and 14.3 inches, respectively, and the length frequency distribution is presented in Figure 58. White Bass size structure was good with PSD, PSD-P, and PSD-M values of 99, 77, and 26, respectively. Measured Pumpkinseeds (n = 61) ranged from 3.2-7.3 inches with mean and median lengths of 5.2 and 4.9 inches, respectively. Measured Yellow Bass (n = 120) ranged from 3.1-10.7 inches with mean and median lengths of 5.9 and 4.3 inches, respectively. Twenty-three percent of the total Yellow Bass catch was ≥ 9 inches, and the length frequency distribution is presented in Figure 59. Smallmouth Bass were also present at low abundance. Six Smallmouth Bass collected during spring sampling ranged from 8.4-17.5 inches, averaging 12.8 inches. Size statistics for these species are summarized and presented in Tables 11 and 13.

Common Carp were not found in large numbers during the 2018 survey. The catch rates were less than 0.1 fish/net night during SN1, 0.1 fish/net night during SN2, and 1.3 fish/mile during SE2 (observation rate). Gizzard shad were more numerous, but at much lower abundance than in connected Spring Lake which is discussed in Appendix A. Gizzard Shad catch rates in Swan Lake were 0.6 fish/net night during both SN1 and SN2, and 2.7 fish/mile during SE2. By contrast the Gizzard Shad catch rates during SN1 and SE2 in Spring Lake in 2018 were 1.4 fish/net night and 115.0 fish/mile, respectively.

CONCLUSIONS AND RECOMMENDATIONS

Swan Lake has a diverse, balanced fish community and provides good fishing for a variety of species thanks to its connection to the Fox River. Fish grow relatively quickly thanks to abundant forage. Some fish migrate in and out of Swan Lake seasonally, with fish moving to areas both upstream and downstream of Swan Lake.

Bluegill was the most common species sampled in 2018, and abundance appeared to be similar to 2009, while size structure (PSD) was slightly better in 2018. Bluegill electrofishing CPUE was lower than most other area lakes but compared very favorably with other lakes in the Complex Riverine lake class. This means that in 2018 the fishery of Swan Lake was performing as should be expected compared to other lakes with similar characteristics. Total annual mortality of Bluegills in Swan lake was higher than other area lakes and may be indicative of high harvest. However, Bluegill growth was very good, and the fast-growing fish quickly replace what is lost to harvest. The management goal for Bluegills in Swan Lake is to maintain a balanced population that provides a good harvest opportunity for anglers. One measurable objective is to maintain an electrofishing catch rate between the 50th (median) and 75th percentiles for the Complex Riverine lake class. The second objective is to maintain PSD between 20 and 60, and PSD-P between 5 and 20, which are the values suggested by Willis et al. (1993) for a balanced Bluegill population. Swan Lake is currently meeting the abundance objective, but falls a little short on the size structure objective, specifically in terms of PSD-P.

Black Crappies were common in Swan Lake, but tools for comparing crappie abundance, size structure, and growth across lake classes are still being developed. Black Crappies in Swan Lake grew fast, pacing well ahead of area and state averages, reaching 10 inches as early as age 3. Anglers have a legitimate opportunity to catch preferred-length crappies in Swan Lake (≥10 inches) and may occasionally encounter memorable-length crappies (≥12 inches). Total annual mortality after age 4 was relatively high compared to many other area lakes but was very similar to connected Spring Lake. The high annual mortality may be explained in part by harvest, as Black Crappies were nearly 11 inches in length by age 5 on average. The high mortality could also be explained in part by the fact that crappies are generally not a long-lived species. Becker (1983) identified both crappie species (Black and White) as being relatively short-lived. However, that line of thinking may be changing with increased amounts of crappie age estimation using otoliths instead of scales or spines; otolith analysis indicates crappies may live to be much older than previously thought. In any case, good population size structure overall indicated overharvest was not likely occurring. The management goal for Black Crappies in Swan Lake is to provide anglers with a quality crappie fishing experience including the opportunity to catch memorable-sized fish. The specific objective is to maintain crappie PSD between 40 and 70, PSD-P between 10 and 40, and PSD-M between 0 and 10 (Willis et al. 1993, Guy et al. 2007). In 2018 these objectives were being met or exceeded for Black Crappies in Swan Lake.

Yellow Perch were common in Swan Lake, but again tools for comparing Yellow Perch abundance, size structure, and growth across lake classes are still being developed. Yellow Perch mean length-at-age in Swan Lake was between the region and state averages, and a few large individuals were present. In terms of size structure, Swan Lake ranked in the middle of the pack compared to other lakes in Columbia, Sauk, and northwestern Dane County surveyed since 2009 where enough data were collected to calculate PSD values. Interestingly, the lakes with the best size structure appeared to be mesotrophic to oligotrophic with relatively clear water and relatively low perch abundance (Devils Lake, White Mound Lake). These lakes had longer-lived perch and somewhat slower growth overall. The next group of lakes was riverine lakes (Lake Wisconsin, Swan Lake) that were eutrophic, had relatively turbid water, complex fish communities, and had higher abundance perch populations with somewhat faster growth but lower maximum ages. The final group with the poorest size structure was lakes that are warm, dark, turbid lakes that had either simple or complex fish communities, were eutrophic, and had varying Yellow Perch abundance. Growth in these lakes ranged from slow to moderate compared to other area lakes, and life expectancy was generally shorter.

The management goal for Yellow Perch is to provide a balanced perch population that enhances the overall panfishing experience for anglers. The specific objective is to maintain a PSD $\geq$ 25 and a PSD-9 $\geq$ 10. Currently, the PSD objective is being met, and the PSD-9 objective is nearly being met. Because the overall suite of panfish species were performing well overall in 1918 in Swan Lake (especially Black Crappies), no regulation changes for panfish are recommended at this time.

Walleyes provided a quality fishing opportunity in Swan Lake where the angler base was harvest-oriented. Walleyes grew quickly in Swan Lake, reaching the legal harvest size of 15 inches by age 3. Some Walleyes reached 20 inches by age 4 and averaged over 20 inches by age 7. The 2018 population of adult fish was higher than the average stocked fishery in Wisconsin, numbering approximately 3.3 Walleyes ≥ 15 inches per acre (stocked fishery average = 1.7 fish/acre) which was very good for a stocked fishery. Walleyes tagged in Swan Lake in 2018 largely stayed in Swan Lake based on tag return information, with more fish exhibiting upstream movement (n = 3) than downstream movement (n = 1). Potential movement of Walleyes in the upper Fox River has been of great interest to fishery managers since fish passage was installed at Montello in 2014. Expect further study of Walleye movements in the upper Fox River including Lake Puckaway, Buffalo Lake, and Swan Lake in the future.

Minimal Walleye natural reproduction occurred in Swan Lake in non-stocked years, however fall age 0 electrofishing CPUE in those years did not surpass the 10 fish/mile criteria that defines successful natural reproduction. Successful natural reproduction may have occurred in 2014 and 2015 (no targeted fall Walleye sampling occurred) but did not occur in 2016 or 2018. The Walleye fishery is sustained almost entirely by stocking, and small fingerling Walleyes stocked in June survive and recruit to the fishery. Small fingerling survival to the fall was estimated at 11.0% in 2017 and 18.2% in 2019. Genetic testing of samples collected during the spring of 2018 indicated half of the Swan Lake fish were of Winnebago system origin (Lake Michigan drainage) and half were of Rock-Fox origin (Mississippi River drainage). However, the sample size was small, and most of the samples from 2018 have not yet been analyzed. Lake Michigan strain Walleyes originating from Lake Puckaway were stocked from 2002-2004, and the current Lake Michigan strain Walleyes in Swan Lake may have been descended from those fish. It is also possible that those fish migrated up to Swan Lake from further downriver, something that was made possible by the installation of a fish ladder at the Montello Dam on Buffalo Lake, completed in 2014. The Rock-Fox strain fish match what was stocked in Swan Lake between 2006-2015. Since 2017, Mississippi Headwaters strain Walleyes have been stocked in Swan Lake. Lake Michigan strain Walleyes have been unavailable for several years due to VHS concerns. If Lake Michigan strain Walleyes become available in the future, they are the preferred strain for stocking in Swan Lake. If Lake Michigan strain Walleyes are unavailable, Mississippi Headwaters strain Walleyes are the preferred alternative. Small fingerlings should continue to be the size class of Walleyes stocked in Swan Lake.

The primary management goal for Walleyes is to provide a quality harvest opportunity for anglers. The objective is to maintain a population of at least 2 adult Walleyes per acre (≥15 inches). Currently the objective is being met and no regulation change is recommended at this time. A second objective is to maintain a fall age 0 electrofishing CPUE ≥ 10 fish/mile in stocked years, and to evaluate natural Walleye reproduction in non-stocked years. To that end, a fall electrofishing survey should be conducted annually at Swan Lake.

Northern Pike provided an additional quality gamefish opportunity for anglers at Swan Lake. Northern Pike abundance may be increasing based on fyke net catch rates in 2018 compared to 2009. Spawning habitat in the form of wetland areas connected to Swan Lake and the Fox River is plentiful, and the depth of Swan Lake as well as the connection to the river provide cool water refuge areas for pike during hot summers. In 2018 the Northern Pike population in Swan Lake was around 1.7 sexually mature fish per acre. Northern Pike in Swan Lake grew relatively quickly, with some fish exceeding 26 inches by age 3, and averaging over 26 inches by age 5. Females grew faster and attained larger sizes than males and provide the bulk of the harvest opportunities for anglers. The management goal for Northern Pike is to provide a balanced population that offers anglers opportunities for harvest. The first objective is to maintain a spring netting catch near the median for the lake class (Complex Riverine, 2.0 fish/net night). The second objective is to maintain PSD between 30 and 60, with a PSD-26 value ≥ 20 (harvestable fish). In 2018, the size structure objective was essentially met. The PSD was a little high, but that should be expected since the spring netting survey targets spawning adult fish, most of which are quality size or greater (21 inches). The abundance objective was not met, with the CPUE across both netting periods combined being 1.4 fish/net night. However, Northern Pike abundance may be on the rise and the population should be re-evaluated after the 2028 survey; no management changes for Northern Pike are recommended at this time.

Largemouth Bass abundance in Swan Lake in 2018 was lower than 2009 and was lower than other lakes in Columbia, Sauk, and northwestern Dane counties. However, abundance was right where it should be compared to other lakes in the Complex Riverine lake class and was more in line with what was observed in Swan Lake 2000-2004. Largemouth Bass growth was good compared to area lakes and on a statewide level. Largemouth Bass in Swan Lake reached the minimum harvest size of 14 inches as early as age 3 and averaged over 14 inches by age 5. Size structure was good with 35% of the fish over 8 inches being legal harvest size or larger. Anglers may even catch memorable-sized Largemouth Bass (≥20 inches). Overall, size structure was slightly better in 2018 compared to 2009. Moving forward, the management goal for Largemouth Bass is to maintain a balanced population while offering anglers a harvest opportunity. The first objective is to maintain a Largemouth Bass SE2 catch rate at or above the lake class median. The second objective is to maintain PSD between 40 and 70, PSD-P between 10 and 40, and PSD-M between zero and 10. These are the PSD metrics outlined in Willis et al. (1993) for a balanced Largemouth Bass population. As of 2018 all objectives were being met and no management changes are recommended at this time.

Muskellunge were present at very low abundance in 2018 despite decades of regular stocking, and too few adult muskies were marked in 2018 to attempt a recapture survey in 2019. The 2018 survey captured only 19 unique muskies out of six weeks of netting effort and two spring electrofishing surveys which both covered the entire shoreline of the lake. By contrast, the previous survey in 2009 captured 45 muskies, with most collected during the two spring electrofishing surveys (the 2009 survey did not include SN2 netting). The few adults sampled in 2018 were impressive with some approaching 50 inches and exceeding 35 pounds. However, age data indicated that the adult population in 2018 was dominated by age 10 and 11 fish which would have been stocked in 2007 and 2008. Ages 2, 4, 5, 6, and 9 were missing from the distribution and ages 1, 3, 7, and 8 had only one or a few individuals present. Muskies were not stocked in 2007, 2009, or 2010, so there is some aging error associated with the 2018 age estimates, but despite that the takeaway message that the adult population is composed of old fish remains the same. Muskies were stocked every year from 2011-2018, and ages 1-7 should have been present in greater numbers than the older fish. Instead, four of seven year classes from that period are completely missing with the other three barely present. Multiple electrofishing surveys each fall from 2013-2016 (11 total surveys) within a few weeks of fall fingerling musky stocking failed to capture more than two age 0 muskies in any single survey, and the final five surveys caught zero age 0 muskies (2015 and 2016). This indicates that either muskies were experiencing some sort of large-scale mortality shortly after stocking or occupying habitats where our electrofishing gear could not sample them. By contrast, similar surveys of Lake Redstone during the 2013-2016 musky feed study yielded dozens of age 0 muskies from both treatment groups (pellet and minnow; Lake Redstone received muskies from both treatment groups) during every visit.

In any case muskies have not been recruiting in Swan Lake in recent years, in contrast with years prior to 2010. Reasons for this are not abundantly clear. The forage base is diverse and abundant and thermal stress shouldn't be an issue. Northern Pike appear to have increased in abundance in Swan Lake in between 2009 and 2018 based on fyke netting catch rates, and it is possible that some interaction with Northern Pike was occurring. Inskip (1986) described numerous examples of negative interactions between Northern Pike and Muskellunge where populations of the latter decreased co-incident with increases in populations of the former. Predation by Northern Pike (particularly during early life stages of both species), competition, and hybridization were all identified as possible mechanisms of interference between the two species. However, the author pointed out that causative data were often limiting beyond simply identifying the decline in Muskellunge while Northern Pike increased. Additionally, most instances involved colonization of native Muskellunge lakes by newly introduced Northern Pike, which was not the case at Swan Lake. Particularly lacking are data from situations where Muskellunge fail to recruit in lakes where they once did successfully when stocked at fall fingerling sizes (≥ 10 inches). If any direct interaction is occurring between Northern Pike and Muskellunge, it may be that adult Northern Pike are reducing Muskellunge numbers via predation, with newly stocked naive Muskellunge (raised in lined ponds with no cover and no predators) serving as easy targets for Northern Pike. Coincidentally Lake Redstone, where fall surveys indicated good short-term survival of stocked fingerlings as well as recruitment to ages 2 and older, has a Northern Pike population that is very small.

It is also possible that Muskellunge are dispersing from Swan Lake to upstream or downstream areas. A few Muskies originally stocked in Swan Lake in 2016 were sampled in Spring Lake in 2018, and the 2011 survey of Spring Lake saw 6 muskies collected which would have been stocked in Swan Lake originally. There are no data to suggest large-scale downstream movements of Muskies from Swan Lake. Either way, data supporting the dispersal theory are very limited. Because regular stocking has failed to produce anything close to the desired adult population (0.3 adults ≥ 30 inches per acre or approximately 125 adult fish), it is recommended that Muskellunge stocking be discontinued in Swan Lake.

Channel Catfish are common in Swan Lake and provide an opportunity for anglers not found in most lakes in Columbia, Sauk, and northwestern Dane counties. Channel Catfish larger than 20 inches were relatively common, and angler may encounter individuals approaching 30 inches in length. Anglers reporting tagged Walleyes in 2018 also reported catching good numbers of Channel Catfish while Walleye fishing, and winter anglers enjoy night fishing for Catfish on Swan Lake, particularly later in the ice season. Channel Catfish have been stocked in low numbers in Spring Lake just upstream from Swan Lake in recent years, but the wide range of age classes present in Swan Lake in 2018 indicated the population is sustained by consistent natural reproduction and recruitment, and this is not surprising because Swan Lake is part of the Fox River.

Smallmouth Bass and Gizzard Shad were first documented in Swan Lake survey data in 1995. Prior to that no survey record or mention of either species could be found on file. One possibility is that those species passed the Buffalo Lake Dam at Montello during a flooding event, potentially the widespread flooding in the summer of 1993, and were able to reach Swan Lake by 1995. Prior to re-design and reconstruction in 2014, the Buffalo Lake Dam would occasionally overtop during flood events, making this theory plausible (WDNR Fisheries Biologists David Bartz and Kendall Kamke, personal communication). Smallmouth Bass have been present at low abundance since 1995 and appeared to be increasing in number in recent years based on fall electrofishing catch rates from 2017-2019. A single stocking of Smallmouth Bass in Spring Lake in Pardeeville in 1996 may also have contributed to the Smallmouth Bass population in Swan Lake, with stocked fish leaving Spring Lake for better habitat in Swan Lake and ultimately establishing a small, self-sustaining population there. During electrofishing surveys of Swan Lake, Smallmouth Bass have typically been captured in the two areas of rocky shoreline in the lake. One is along the south shore between the public boat landing and the east end of the lake, and the other is along the bluff on the north shore toward the west end of the lake. Annual fall electrofishing surveys will help to track trends in Smallmouth Bass abundance in the future.

Common Carp and Gizzard Shad were present in Swan Lake in 2018 but at low abundances. Newly arrived Gizzard Shad may have played a role in the failure of Walleye fry stockings in the early 2000s, but empirical data are lacking. While Gizzard Shad are not abundant today, they still serve as an important component of the forage community for predatory gamefish. Swan Lake produces the some of the largest Gizzard Shad of any lake in the area, with some specimens approaching 16 inches in length. Common Carp and Gizzard Shad do not appear to be present at nuisance levels in Swan Lake as of 2018, and no specific management strategy is needed at this time.

In terms of habitat improvement in Swan Lake, addition of coarse woody habitat in the littoral zone (fish sticks) should continue. Between developed shoreline areas and the low marshy non-forested wetlands that border the undeveloped areas, Swan Lake is largely devoid of coarse woody habitat in the littoral zone. The WDNR is a willing partner with Swan Lake Wildlife Area serving as both a potential source of trees as well as a location where fish sticks may be installed. Fish sticks installations provide habitat for a variety of aquatic organisms and help to protect shorelines from wave erosion. The shoreline of Swan Lake has seen considerable damage through the years from erosion caused by wind waves (long east-west fetch) as well as waves generated by motorized watercraft on this narrow lake. Addition of fish sticks would be one means by which riparian landowners could protect their shorelines while providing higher quality fish habitat than armoring the banks with rip rap.

ACKNOWLEDGEMENTS

Fisheries Technicians Scott Harpold, Jody Derks, and Derek Lavigne assisted with field surveys as did Fitchburg Fisheries Team Supervisor David Rowe and retired WDNR Fisheries Technician Daniel Fuller. Dr. Wes Larson and Jenna Ruzich from UWSP also assisted with field work. Dr. Larson provided interpretation of genetic analysis of walleye samples collected during the survey. Dr. Daniel Isermann at the UWSP Fisheries Analysis Center analyzed Walleye otoliths for the presence of OTC marks. Fisheries Technicians Kimberly Kuber, Casey Weber, Andrew Notbohm, and Alex Bentz assisted with age estimation. WDNR Oshkosh Fisheries Team Supervisor Kendall Kamke and Fisheries Biologist David Bartz provided historical insights on flooding in the upper Fox River. David Rowe and Southern District Fisheries Supervisor Tim Simonson reviewed this manuscript and provided vital feedback which made this a strong report. Thank you all.

REFERENCES

Alden, W.C. 1918. Map showing the surficial deposits of southeastern Wisconsin. Wisconsin Geological Survey.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in B. R. Murphy and D.W. Willis editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Bettoli, P.W., and L.E. Miranda. 2001. Cautionary note about estimating mean length at age with subsampled data. North American Journal of Fisheries Management 21: 425-428.

Boelter, D.H., and E.S. Verry. 1977. Peatland and water in the northern lake states. USDA Forest Service Technical Report NC-31, 22pp. North Central Forest Experiment Station, St. Paul, MN.

Guy, C.S., R.M. Neumann, D.W. Willis, and R.O. Anderson. 2007. Proportional size distribution (PSD): a further refinement of population size structure index terminology. Fisheries 32(7): 348.

Inskip, P.D. 1986. Negative associations between abundances of muskellunge and northern pike: evidence and possible explanations. American Fisheries Society Special Publication 15: 135-150. American Fisheries Society, Bethesda, MD.

Isermann, D.A., and C.T. Knight. 2005. A computer program for age-length keys incorporating age assignment to individual fish. North American Journal of Fisheries Management, 25: 1153-1160.

Krebs, C.J. 1999. Ecological Methodology. Addison-Welsey Educational Publishing, Menlo Park, CA, second edition.

Laarman, P.W., and J. R. Ryckman. 1982. Relative size selectivity of trap nets for eight species of fish. North American Journal of Fisheries Management 2: 33-37.

Larson, T., and C. Sebero. 1978. Preliminary evaluation: the contribution of stocked walleye fingerlings to the fishery of Swan Lake, Wisconsin. Wisconsin Department of Natural Resources, Madison, WI. 7 pp.

Larson, T. 1980. Swan Lake Survey 1979-80. Wisconsin Department of Natural Resources, Madison, WI. 18 pp.

Larson, T. 1985. F-187 Final Report, walleye Fry Stocking, Swan Lake. Wisconsin Department of Natural Resources, Madison, WI. 5 pp.

Larson, T. 1988. General Survey, Swan Lake 1986-1987. Wisconsin Department of Natural Resource, Madison, WI. 6 pp.

Murphy, B. R., D. W. Willis, and T. A. Springer. 1991. The relative weight index in fisheries management: status and needs. Fisheries 16(2): 30-38.

Poff, R., and C. W. Threinen. 1965. Surface water resources of Columbia County. Wisconsin Conservation Department, Madison, Wisconsin. 56pp.

Serns, S.L. 1982. Relationship of walleye fingerling density and electrofishing catch per effort in northern Wisconsin lakes. North American Journal of Fisheries Management 2(1): 38-44.

Turyk, N., and C. Arnold. 2019. Swan Lake Management Plan, Columbia County, Wisconsin. 92 pp.

Zumberge, J.H. 1952. The lakes of Minnesota, their classification and origin. Minnesota Geological Survey Bulleting No. 35, University of Minnesota Press, 99pp.

TABLES AND FIGURES

Table 1. Current fishing regulations for Swan Lake, Columbia County, Wisconsin.

Species	Season Dates	Length and Bag Limits
Catfish	Open All Year	No minimum length limit and the daily bag limit is 10.
Panfish (Bluegill, Pumpkinseed, Sunfish, Crappie, and Yellow Perch)	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth Bass and Smallmouth Bass	First Saturday in May through the first Sunday in March	The minimum length limit is 14" and the daily bag limit is 5.
Northern Pike	First Saturday in May through the first Sunday in March	The minimum length limit is 26" and the daily bag limit is 2.
Muskellunge	First Saturday in May through the first Sunday in March	The minimum length limit is 40" and the daily bag limit is 1.
Walleye, Sauger, and hybrids	First Saturday in May through the first Sunday in March	The minimum length limit is 15" and the daily bag limit is 5.
Bullheads	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Rough fish	Open All Year	No minimum length limit and the daily bag limit is unlimited.

Table 2. Listing of aquatic plant species and frequency of occurrence in the 2017 point-intercept aquatic plant survey of Swan Lake, Columbia County, Wisconsin. Data courtesy of Michelle Nault, personal communication.

Species-Scientific Name	Species-Common Name	Percent Frequency-All Vegetated Sites[1]	Percent Frequency-Littoral Sites[2]
Myriophyllum spicatum	Eurasian Watermilfoil	50.4	26.8
Ceratophyllum demersum	Coontail	26.1	13.8
Stuckenia pectinata	Sago Pondweed	22.7	12.1
Potamogeton amplifolius	Large-leaf Pondweed	15.1	8.0
Potamogeton crispus	Curly-leaf Pondweed	5.9	3.1
Filamentous algae	Filamentous Algae	4.2	2.2
Chara globularis	Chara	4.2	2.2
Elodea canadensis	Common Waterweed	2.5	1.3
Potamogeton zosteriformis	Flat-stem Pondweed	2.5	1.3
Zannichellia palustris	Horned Pondweed	2.5	1.3
Nuphar variegata	Spatterdock	1.7	0.9
Schoenoplectus tabernaemontani	Softstem Bulrush	1.7	0.9
Chara contraria	Chara	1.7	0.9
Najas flexilis	Slender Naiad	0.8	0.4
Potamogeton gramineus	Variable Pondweed	0.8	0.4
Schoenoplectus acutus	Hardstem Bulrush	0.8	0.4
Typha angustifolia	Narrow-leaved Cattail	0.8	0.4
Vallisneria americana	Wild Celery	0.8	0.4

[1]All vegetated sites includes all sites where aquatic vegetation was found, regardless of species or amount.
[2]Littoral sites includes all sites shallower than the maximum depth of plants (13 feet).

Table 3. Recent stocking history for Swan Lake, Columbia County, Wisconsin 1999-2019.

Year	Species	Strain (Stock)	Age Class	Number Stocked	Mean Length (inches)	Source Type
1999	WALLEYE	UNSPECIFIED	FRY	1,069,550	0.4	DNR
1999	TIGER MUSKY	UNSPECIFIED	YEARLING	276	14.6	DNR
1999	MUSKELLUNGE	UNSPECIFIED	YEARLING	222	14.7	DNR
1999	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	225	11.8	DNR
2000	WALLEYE	UNSPECIFIED	FRY	400,000	0.5	DNR
2000	MUSKELLUNGE	UNSPECIFIED	YEARLING	249	14.3	DNR
2000	TIGER MUSKY	UNSPECIFIED	YEARLING	159	12.0	DNR
2000	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	270	11.0	DNR
2001	WALLEYE	UNSPECIFIED	FRY	400,000	0.5	DNR
2001	MUSKELLUNGE	UNSPECIFIED	YEARLING	314	13.6	DNR
2001	TIGER MUSKY	UNSPECIFIED	YEARLING	130	12.0	DNR
2001	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	270	9.0	DNR
2002	WALLEYE	LAKE MICH	FRY	485,000	0.5	DNR
2002	MUSKELLUNGE	UNSPECIFIED	YEARLING	163	13.8	DNR
2002	TIGER MUSKY	UNSPECIFIED	YEARLING	121	13.0	DNR
2002	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	270	10.2	DNR
2003	WALLEYE	LAKE MICH	FRY	406,000	1.0	DNR
2003	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	270	10.9	DNR
2003	TIGER MUSKY	UNSPECIFIED	YEARLING	454	13.5	DNR
2003	MUSKELLUNGE	UNSPECIFIED	YEARLING	416	14.0	DNR
2004	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	812	10.5	DNR
2004	WALLEYE	LAKE MICH	SM FINGERLING	20,300	1.5	DNR
2005	WALLEYE	UNSPECIFIED	SM FINGERLING	32,308	2.2	DNR PONDS
2006	MUSKELLUNGE	UPPER CHIPP	LG FINGERLING	447	10.8	DNR
2006	WALLEYE	ROCK-FOX	SM FINGERLING	15,185	2.9	DNR PONDS
2008	MUSKELLUNGE	UPPER CHIPP	LG FINGERLING	406	10.8	DNR
2008	WALLEYE	ROCK-FOX	SM FINGERLING	7,308	1.3	DNR
2008	MUSKELLUNGE	UPPER WIS	LG FINGERLING	338	10.7	DNR
2010	WALLEYE	ROCK-FOX	SM FINGERLING	3,209	1.8	DNR
2011	MUSKELLUNGE	UPPER WIS	LG FINGERLING	812	9.4	DNR
2011	WALLEYE	ROCK-FOX	SM FINGERLING	7,308	1.5	DNR
2012	MUSKELLUNGE	UPPER WIS	LG FINGERLING	400	9.7	DNR
2013	MUSKELLUNGE	UPPER WIS	LG FINGERLING	408	10.7	DNR
2013	WALLEYE	ROCK-FOX	SM FINGERLING	7,308	1.7	DNR
2014	MUSKELLUNGE	UPPER WIS	LG FINGERLING	405	8.9	DNR
2015	MUSKELLUNGE	UPPER WIS	LG FINGERLING	329	10.9	DNR
2015	WALLEYE	ROCK-FOX	SM FINGERLING	14,281	1.6	DNR
2016	MUSKELLUNGE	UPPER WIS	LG FINGERLING	406	10.3	DNR
2017	MUSKELLUNGE	UPPER WIS	LG FINGERLING	406	10.9	DNR
2017	WALLEYE	MISS HW	SM FINGERLING	14,262	1.7	DNR
2018	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	406	12.3	DNR
2019	MUSKELLUNGE	UNSPECIFIED	LG FINGERLING	406	11.6	DNR
2019	WALLEYE	MISS HW	SM FINGERLING	14,252	2.1	DNR

Table 4. Fyke net descriptions and locations (GPS coordinates) used during SN1 and SN2 on Swan Lake, Columbia County, Wisconsin in 2018.

Net Number	Period	Lead Length (ft)	Frame Height (ft)	Date Set	Final Lift	Latitude	Longitude
1	SN1	50	3	03/27/2018	04/05/2018	43.54740	-89.34613
2	SN1	50	3	03/27/2018	04/07/2018	43.54508	-89.35545
3	SN1	50	3	03/27/2018	04/20/2018	43.54723	-89.34413
4	SN1	50	3	03/27/2018	04/07/2018	43.54458	-89.35128
5	SN1	75	4	03/29/2018	04/02/2018	43.54018	-89.38651
6	SN1	50	3	03/29/2018	04/21/2018	43.53889	-89.38577
7	SN1	50	3	03/29/2018	04/02/2018	43.54454	-89.36290
8	SN1	50	3	03/30/2018	04/21/2018	43.54400	-89.37797
9	SN1	75	4	03/30/2018	04/13/2018	43.54642	-89.38102
10	SN1	50	3	04/02/2018	04/03/2018	43.54068	-89.38560
11	SN1	75	4	04/02/2018	04/12/2018	43.54202	-89.38048
12	SN1	50	3	04/03/2018	04/10/2018	43.54758	-89.35954
13	SN1	50	3	04/05/2018	04/12/2018	43.54834	-89.36317
14	SN1	50	3	04/10/2018	04/21/2018	43.54095	-89.38297
15	SN1	50	3	04/10/2018	04/21/2018	43.54417	-89.36217
16	SN2	50	3	04/23/2018	04/27/2018	43.54439	-89.35307
17	SN2	50	3	04/23/2018	04/29/2018	43.54100	-89.38391
18	SN2	50	3	04/23/2018	04/30/2018	43.54402	-89.33954
19	SN2	50	3	04/27/2018	05/02/2018	43.54519	-89.34763
20	SN2	50	3	04/28/2018	05/02/2018	43.54518	-89.35760
21	SN2	75	4	04/28/2018	05/02/2018	43.54836	-89.36834
22	SN2	50	3	04/29/2018	05/02/2018	43.54785	-89.35883
1A	SN2	50	3	04/23/2018	04/28/2018	43.54740	-89.34613
5A	SN2	75	4	04/23/2018	04/30/2018	43.54018	-89.38651
9A	SN2	75	4	04/23/2018	04/28/2018	43.54642	-89.38102
11A	SN2	75	4	04/30/2018	05/02/2018	43.54202	-89.38048
13A	SN2	75	4	04/23/2018	05/02/2018	43.54842	-89.36304
15A	SN2	50	3	04/30/2018	05/02/2018	43.54417	-89.36217

Table 5. Calcified structures used to estimate ages of fish collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

Species[1]	Size Category	Structure
Black Crappie	ALL	Otolith
Bluegill	ALL	Otolith
Largemouth Bass	≤8 inches	Scale
Largemouth Bass	≥8 inches	Dorsal Spine
Smallmouth Bass	≤8 inches	Scale
Smallmouth Bass	≥8 inches	Dorsal Spine
Muskellunge	ALL	Anal Fin Ray
Northern Pike	ALL	Anal Fin Ray
Yellow Perch	ALL	Anal Fin Spine
Walleye	ALL	Dorsal Spine
Channel Catfish	ALL	Pectoral Spine

Table 6. Locations of electrofishing stations (GPS coordinates) sampled during SE2 on Swan Lake, Columbia County, Wisconsin in 2018.

Sample Date	Start Time	Substation Name[1]	Distance Shocked	Volts	Amps	Pulse Rate	Duty Cycle (percent)	Start Latitude	Start Longitude	End Latitude	End Longitude
05/22/2018	2101	1A ALL SPECIES	0.5	200	19	60	25	43.54497	-89.3561	43.54488	-89.3494
05/22/2018	2145	1B SPORT FISH	1.5	220	20	60	25	43.54488	-89.3494	43.54863	-89.3564
05/22/2018	2300	2A ALL SPECIES	0.5	200	19	60	25	43.54863	-89.3564	43.54847	-89.3643
05/22/2018	2327	2B SPORT FISH	1.5	200	19	60	25	43.54847	-89.3643	43.54358	-89.3796
05/23/2018	0027	3A ALL SPECIES	0.5	200	19	60	25	43.54358	-89.3796	43.54095	-89.3845
05/23/2018	0107	3B SPORT FISH	2.5	190	19	60	25	43.54095	-89.3845	43.54527	-89.3561

[1.]Sport fish includes Largemouth Bass, Smallmouth Bass, Walleye, Northern Pike, Muskellunge, and Channel Catfish

Table 7. The PSD length categories (inches) for selected fish species that were collected from Swan Lake in 2018 (Anderson and Neumann 1996, Guy et al. 2007).

Species	Stock	Quality	Harvest[1]	Preferred	Memorable	Trophy
Bluegill	3	6	7	8	10	12
Black Crappie	5	8	9	10	12	15
Channel Catfish	11	16		24	28	36
Largemouth Bass	8	12	14	15	20	25
Smallmouth Bass	7	11	14	14	17	20
Muskellunge	20	30	40	38	42	50
Northern Pike	14	21	26	28	34	44
Walleye	10	15	15	20	25	30
White Bass	6	9		12	15	18
Yellow Bass	4	7		9	11	13
Yellow Bullhead	4	7		9	11	14
Yellow Perch	5	8	9	10	12	15

[1.]Lengths of fish found socially or legally acceptable for harvest by anglers.

Table 8. Families and species of fish collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

Family-Scientific	Family-Common	Number of Species Collected	Species List (common names)
Amiidae	Bowfins	1	Bowfin
Atherinopsidae	Silversides	1	Brook Silverside
Catostomidae	Suckers	7	Bigmouth Buffalo, Highfin Carpsucker, Quillback Carpsucker, River Carpsucker, Shorthead Redhorse, Silver Redhorse, White Sucker
Centrarchidae	Sunfishes	8	Black Crappie, Bluegill, Green Sunfish, Largemouth Bass, Pumpkinseed, Pumpkinseed x Bluegill hybrid, Rock Bass, Smallmouth Bass
Clupeidae	Shads	1	Gizzard Shad
Cyprinidae	Minnows	2	Common Carp, Golden Shiner
Esocidae	Pikes	3	Grass Pickerel, Northern Pike, Muskellunge
Ictaluridae	Catfishes	4	Black Bullhead, Brown Bullhead, Channel Catfish, Yellow Bullhead
Lepisosteidae	Gars	1	Longnose Gar
Moronidae	Temperate Basses	2	White Bass, Yellow Bass
Percidae	Perches	2	Walleye, Yellow Perch
Scianidae	Drums	1	Freshwater Drum

Table 9. Summary of catch and catch-per-unit effort (CPUE) by gear type for SN1, SE1, SN2, and SE2 sampling on Swan Lake, Columbia County, Wisconsin in 2018.

Species	Catch SN1	Catch SN2	Catch SE1	Catch SE2	Total catch	CPUE (fish/nn) SN1	CPUE (fish/nn) SN2	CPUE (fish/mile) SE1	CPUE (fish/mile) SE2	CPUE (fish/hr.) SE1	CPUE (fish/hr.) SE2
Bigmouth Buffalo	12	1		1	14	0.1	0.0		0.7		1.1
Black Bullhead	11	8		0	19	0.1	0.1		0.0		0.0
Black Crappie	124	460		12	596	0.8	7.3		8.0		13.3
Bluegill	7,806	731		111	8,648	53.1	11.6		74.0		123.3
Bowfin	64	55		0	119	0.4	0.9		0.0		0.0
Brook Silverside	0	0		1	1	0.0	0.0		0.7		1.1
Brown Bullhead	0	2		0	2	0.0	0.0		0.0		0.0
Channel Catfish	5	139	0	14	158	0.0	2.2	0.0	2.0	0.0	4.0
Common Carp	6	8		2	16	0.0	0.1		1.3		2.2
Freshwater Drum	0	33		4	37	0.0	0.5		2.7		4.4
Gizzard Shad	82	36		4	122	0.6	0.6		2.7		4.4
Golden Shiner	0	2		0	2	0.0	0.0		0.0		0.0
Grass Pickerel	16	0		0	16	0.1	0.0		0.0		0.0
Green Sunfish	18	1		0	19	0.1	0.0		0.0		0.0
Highfin Carpsucker	0	0		1	1	0.0	0.0		0.7		1.1
Largemouth Bass	183	27	71	52	333	1.2	0.4	10.1	7.4	24.5	14.9
Longnose Gar	0	4		0	4	0.0	0.1		0.0		0.0
Muskellunge	8	9	4	3	24	0.1	0.1	0.6	0.4	1.4	0.9
Northern Pike	153	145	4	16	318	1.0	2.3	0.6	2.3	1.4	4.6
Pumpkinseed	151	3		0	154	1.0	0.0		0.0		0.0
PKSxBLG hybrid	5	1		0	6	0.0	0.0		0.0		0.0
Quillback Carpsucker	49	42		5	96	0.3	0.7		3.3		5.6
River Carpsucker	44	4		0	48	0.3	0.1		0.0		0.0
Rock Bass	32	59		5	96	0.2	0.9		3.3		5.6
Shorthead Redhorse	0	1		0	1	0.0	0.0		0.0		0.0
Silver Redhorse	0	1		0	1	0.0	0.0		0.0		0.0
Smallmouth Bass	0	0	0	7	7	0.0	0.0	0.0	1.0	0.0	2.0
Walleye	392	355	48	111	906	2.7	5.6	6.9	15.9	16.6	31.7
White Bass	6	166		0	172	0.0	2.6		0.0		0.0

Table 9. Continued	Catch SN1	Catch SN2	Catch SE1	Catch SE2	Total catch	CPUE (fish/nn) SN1	CPUE (fish/nn) SN2	CPUE (fish/mile) SE1	CPUE (fish/mile) SE2	CPUE (fish/hr.) SE1	CPUE (fish/hr.) SE2
White Sucker	12	2		3	17	0.1	0.0		2.0		3.3
Yellow Bass	0	11		110	121	0.0	0.2		73.3		122.2
Yellow Bullhead	965	526		0	1,491	6.6	8.3		0.0		0.0
Yellow Perch	46	929		4	979	0.3	14.7		2.7		4.4
Totals	10,190	3,761	127	466	14,544						

Table 10. Size-specific CPUE (fish/mile) of Bluegills from spring electrofishing surveys of lakes in Columbia, Sauk, and northwestern Dane counties, 2011-2019 and the lake class 25th, 50th (median), and 75th percentile CPUE values for Complex Riverine lakes.

Lake[1]	County	Survey Year	Gear Type	ALL	CPUE3	CPUE6	CPUE7	CPUE8	CPUE9	CPUE10
Silver	Columbia	2016	Big Boom	338.2	337.3	4.9	0.0	0.0	0.0	0.0
Tarrant	Columbia	2018	Miniboom	267.0	263.0	37.0	22.0	7.0	0.0	0.0
Blass	Sauk	2017	Miniboom	190.0	131.3	50.0	27.3	1.3	0.0	0.0
White Mound	Sauk	2013	Big Boom	155.0	149.0	52.0	32.0	21.0	7.0	0.0
Mirror	Sauk	2014	Big Boom	143.3	141.3	62.0	14.7	0.0	0.0	0.0
Dutch Hollow	Sauk	2016	Big Boom	141.3	130.7	69.3	30.7	6.0	0.7	0.0
Fish	Dane	2015	Big Boom	135.0	135.0	46.0	8.0	0.0	0.0	0.0
Seeley	Sauk	2016	Miniboom	134.6	129.8	93.0	15.8	0.0	0.0	0.0
Mud (Marx Pond)	Dane	2015	Miniboom	120.7	102.0	38.0	0.0	0.0	0.0	0.0
White Mound	Sauk	2019	Big Boom	102.0	81.0	48.0	22.0	7.0	2.0	0.0
George	Columbia	2013	Miniboom	101.0	90.9	53.5	19.2	0.0	0.0	0.0
West	Columbia	2019	Miniboom	86.7	65.3	2.7	1.3	0.0	0.0	0.0
Crystal	Dane	2015	Big Boom	79.3	79.3	62.0	28.7	0.0	0.0	0.0
Swan	**Columbia**	**2018**	**Big Boom**	**74.0**	**74.0**	**38.7**	**6.7**	**0.7**	**0.0**	**0.0**
Park	Columbia	2011	Big Boom	60.0	57.0	9.0	1.0	0.0	0.0	0.0
Wisconsin	Col/Sauk	2017	Big Boom	59.8	58.8	29.0	15.0	1.2	0.0	0.0
Virginia	Sauk	2016	Miniboom	53.9	46.1	38.8	26.7	4.2	1.2	0.6
Spring	Columbia	2018	Big Boom	32.0	31.0	2.0	0.0	0.0	0.0	0.0
Crystal	Columbia	2014	Miniboom	20.0	9.5	2.9	2.9	2.9	1.9	0.0
Delton	Sauk	2014	Big Boom	18.0	18.0	7.0	1.0	0.0	0.0	0.0
Devils	Sauk	2013	Big Boom	12.0	12.0	6.0	3.0	3.0	2.0	0.0
Area Mean				120.7	111.2	38.9	14.4	2.7	0.7	0.0
Area Median				101.0	81.0	38.7	14.7	0.0	0.0	0.0
Lake Class 25th percentile				14.8						
Lake Class Median				39.0						
Lake Class 75th percentile				128.5						

[1]The Crystal Lake surveyed in 2014 was a 28-acre lake located at the Peter Helland Wildlife Area, Town of Wyocena, Columbia County, Wisconsin.

Table 11. Summary of lengths (inches), PSD, ages, and relative weight of panfish, temperate basses, and Yellow Bullheads sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

Species	Period	n Unique Fish	n Measured	Length Range	Mean Length	Median Length	Mode	PSD	PSD-H	PSD-P	Age Range	Mean Relative Weight
Bluegill	SN1, SN2	8,537	2,886	3.0-9.2	5.7	5.9	6.1	47	12	2		
Bluegill	SE2	111	111	3.3-8.0	5.6	6.0	6.2	52	9	1		
Bluegill	ALL	8,648	2,997	3.0-9.2	5.7	5.9	6.1	48	12	2	2-8	112.7
Yellow Perch-male	SN1, SN2	643	643	5.0-9.8	6.9	6.9	6.5	12			2-6	103.4
Yellow Perch-female	SN1, SN2	244	244	6.0-12.0	8.3	8.3	8.2	66	27	7	2-5	105.6
Yellow Perch-all	SN1, SN2	887	887	5.0-12.0	7.3	7.2	6.5	26	8	2	2-6	104.6
Yellow Perch	SE2	4	4	3.3-5.2	3.9							
Black Crappie	SN1, SN2	584	513	3.3-13.0	9.2	9.7	10.3	78	68	43		
Black Crappie	SE2	12	12	6.7-11.3	9.0	9.4	9.4					
Black Crappie	ALL	596	525	3.3-13.0	9.2	9.7	10.3	78	68	43	1-10	104.1
Pumpkinseed	ALL	154	61	3.2-7.3	5.2	4.9	6.1					
White Bass	ALL	172	172	8.5-16.3	13.8	14.3	14.7	99		77		
Yellow Bass	ALL	121	120	3.1-10.7	5.9	4.3	3.7					
Yellow Bullhead	ALL	1,491	328	5.1-13.2	8.4	8.3	8.0					

Table 12. The PSD, mean and median length, and largest fish sizes for Yellow Perch collected during surveys of eight lakes in Columbia, Sauk, and northwestern Dane counties, 2010-2019.

Lake	County	Survey Year	Gear Type	n Collected	n Measured	PSD	PSD9	PSDP	PSDM	Mean Length	Median Length	Largest Fish
Swan	**Columbia**	**2009**	**Net**	**124**	**124**	**25**	**13**	**8**	**0**	**7.0**	**6.5**	**10.5**
Redstone	Sauk	2010	Net	127	127	9	1	0	0	6.3	9.2	9.0
Park	Columbia	2011	Net	1,122	675	8	3	1	0	6.1	5.7	10.5
Devils	Sauk	2013	Net	106	106	63	51	37	10	9.0	9.1	13.5
Mirror	Sauk	2014	Net	267	267	6	2	0	0	6.2	6.0	9.9
Crystal	Dane	2015	Net	590	590	23	3	0	0	7.4	7.5	9.8
Wisconsin	Col/Sauk	2017	Net	281	281	13	3	1	0	7.0	6.9	11.3
Swan	**Columbia**	**2018**	**Net**	**887**	**887**	**26**	**8**	**2**	**0**	**7.3**	**7.2**	**12.0**
White Mound	Sauk	2019	Fyke, EF	131	130	71	42	16	0	8.6	8.7	11.9

Table 13. Summary of lengths (inches), PSD, ages, and relative weight of sport fish sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

Species	Period	n Unique Fish	n Measured	Length Range	Mean Length	Median Length	Mode	PSD	PSD-H	PSD-P	Age Range	Mean Relative Weight
Walleye-male	SN1,SE1,SN2	293	293	13.2-22.2	16.0	15.7	15.5				2-9	92.6
Walleye-female	SN1,SE1,SN2	155	155	14.4-26.4	19.2	18.9	21.1				3-11	100.2
Walleye-immature	SN1,SE1	26	26	7.4-16.7	11.4	9.4	8.1				1-4	93.1
Walleye	SE2	84	84	7.4-19.6	12.7	14.3	8.5					
Walleye	ALL	654	654	7.4-26.4	16.0	16.0	15.9	85	85	12	1-11	96.4
Largemouth Bass	SN1,SN2	190	190	6.0-21.2	12.5	11.3	9.9					
Largemouth Bass	SE1	69	69	4.7-14.7	10.4	10.6	10.9					
Largemouth Bass	SE2	48	48	9.4-20.7	14.2	14.5	14.5					
Largemouth Bass	ALL	307	307	4.7-21.2	12.2	11.5	10.6	44	35	22	2-16	109.8
Northern Pike-male	SN1,SE1,SN2	119	119	10.3-29.7	20.0	20.7	20.7				1-7	91.9
Northern Pike-female	SN1,SE1,SN2	99	99	15.3-33.5	26.0	27.2	28.6				2-7	107.8
Northern Pike-all	SN1,SE1,SN2	253	253	8.8-33.5	21.9	22.0	20.3				1-7	
Northern Pike	SE2	15	15	15.5-30.4	22.0	21.6						
Northern Pike	ALL	268	268	8.8-33.5	21.9	22.0	21.6	66	27	19	1-7	99.0
Channel Catfish	ALL	152	152	7.9-29.9	22.3	22.4	21.4	99		30	2-17	99.1
Muskellunge	ALL	19	19	11.0-48.5	35.4	41.2					1-11	104.1
Smallmouth Bass	ALL	7	7	8.4-17.5	12.8	12.2					2-7	100.0

Table 14. Catch rates of Walleyes during fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin, 2016-2019.

Year	Total CPUE (fish/mile)	Age 0 CPUE (fish/mile)	CPUE-15 (fish/mile)	CPUE-20 (fish/mile)	Serns Index	Estimated Total Age 0 Walleyes[1]	Number Stocked	Estimated Survival
2016	15.0	0.7	3.7	0.3	0.1638	67		
2017	25.1	16.4	5.4	0.1	3.8376	1,562	14,262	11.0%
2018	14.1	0.3	3.4	0.0	0.0702	29		
2019	33.7	27.3	4.1	0.1	6.3882	2,600	14,252	18.2%

[1]Serns index (Serns 1982).

Table 15. Total CPUE (fish/mile), length range (inches), and mean length of Largemouth Bass, Smallmouth Bass, Northern Pike, Muskellunge, and Channel Catfish collected during fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin, 2016-2019.

Species	2016[1]	2017[2]	2018	2019
Largemouth Bass		19.5 (5.7-20.9, 13.1)	3.7 (10.1-17.5, 13.2)	13.9 (3.1-20.3, 12.2)
Smallmouth Bass		0.4 (9.6-15.9, 13.5)	0.9 (10.9-16.4, 13.0)	1.6 (7.2-16.2, 12.1)
Northern Pike		2.1 (13.0-29.3, 22.8)	1.0 (17.2-29.0, 23.4)	1.6 (11.1-24.6, 14.6)
Muskellunge	0.1 (43.7)			0.6 (11.4-20.1, 13.7)
Channel Catfish		0.1 (21.7)	0.4 (10.4-23.4, 15.8)	0.1 (20.6)

[1.]Only Walleyes and Muskellunge were collected during fall electrofishing surveys in 2016.
[2.]Total CPUE (length range, mean length). Single values in parenthesis indicates only one individual was captured.

Table 16. Size-specific CPUE of Largemouth Bass from spring electrofishing surveys of lakes in Columbia, Sauk, and northwestern Dane counties, 2011-2019, and the lake class 25th, 50th (median), and 75th percentile CPUE values for Complex Riverine lakes.

				CPUE								
Lake[1]	County	Survey Year	Gear Type	ALL	<8"	8	10	12	14	15	18	20
White Mound	Sauk	2019	Big Boom	273.2	30.0	243.2	190.0	102.4	5.2	2.0	1.6	0.8
White Mound	Sauk	2013	Big Boom	224.8	33.6	191.2	175.6	128.0	62.4	24.4	2.8	0.0
Virginia	Sauk	2016	Miniboom	207.9	6.7	201.2	197.0	172.7	2.4	0.0	0.0	0.0
Crystal	Columbia	2014	Miniboom	190.5	5.7	184.8	123.8	23.8	0.0	0.0	0.0	0.0
Tarrant	Columbia	2018	Miniboom	81.0	5.0	76.0	65.0	44.0	31.0	13.0	0.0	0.0
Dutch Hollow	Sauk	2016	Big Boom	79.2	3.0	76.2	68.2	43.3	11.3	5.7	0.7	0.0
Silver	Columbia	2016	Big Boom	71.8	12.7	59.1	45.6	23.0	10.3	5.6	0.0	0.0
Devils	Sauk	2013	Big Boom	55.8	3.9	51.9	45.0	32.2	0.6	0.3	0.3	0.0
George	Columbia	2013	Miniboom	49.5	4.0	45.5	32.3	13.1	1.0	1.0	0.0	0.0
Fish	Dane	2015	Big Boom	35.3	8.9	26.5	25.5	23.9	15.6	10.8	2.1	0.3
Blass	Sauk	2017	Miniboom	32.7	4.0	28.7	23.3	12.0	6.7	2.7	0.0	0.0
Seeley	Sauk	2016	Miniboom	28.1	5.3	22.8	22.8	14.9	8.8	4.4	0.0	0.0
Crystal	Dane	2015	Big Boom	23.7	1.6	22.1	20.3	11.3	7.6	6.0	2.1	0.5
Mud (Marx Pond)	Dane	2015	Miniboom	18.7	14.0	4.7	1.3	0.7	0.0	0.0	0.0	0.0
Mirror	Sauk	2014	Big Boom	18.2	1.2	17.0	15.2	11.2	9.0	6.2	0.3	0.0
Park	Columbia	2011	Big Boom	13.3	5.0	8.3	7.3	4.3	2.8	1.8	0.3	0.3
Wisconsin	Col/Sauk	2017	Big Boom	7.8	1.3	6.5	5.8	5.2	3.7	2.4	0.0	0.0
Delton	Sauk	2014	Big Boom	7.8	0.3	7.5	2.9	1.2	0.2	0.0	0.0	0.0
Swan	**Columbia**	**2018**	**Big Boom**	**7.4**	**0.0**	**7.0**	**7.0**	**5.0**	**3.9**	**2.6**	**0.9**	**0.4**
Spring	Columbia	2018	Big Boom	7.0	1.0	6.0	4.0	4.0	4.0	3.0	0.0	0.0
West	Columbia	2019	Big Boom	2.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area Mean				68.4	7.1	61.2	51.3	32.2	8.9	4.4	0.5	0.1
Area Median				32.7	4.0	26.5	23.3	13.1	4.0	2.6	0.0	0.0
Lake Class 25th percentile				1.5								
Lake Class Median				3.7								
Lake Class 75th percentile				14.5								

[1]The Crystal Lake surveyed in 2014 was a 28-acre lake located at the Peter Helland Wildlife Area, Town of Wyocena, Columbia County, Wisconsin.

Table 17. Mean length at age 6 (MLA-6; inches) of Largemouth Bass in lakes in Columbia, Sauk, and northwestern Dane counties surveyed 2009-2019.

Lake	County	Survey Year	MLA-6
Spring	Columbia	2018	15.6
Wisconsin	Columbia/Sauk	2017	15.5
Delton	Sauk	2014	15.4
Swan	**Columbia**	**2018**	**15.3**
Park	Columbia	2011	15.2
White Mound	Sauk	2013	14.8
Wisconsin	Columbia/Sauk	2012	14.7
Swan	Columbia	2009	14.6
Redstone	Sauk	2010	14.5
Lazy	Columbia	2011	14.4
Mirror	Sauk	2014	14.2
Fish	Dane	2015	13.1
Crystal	Dane	2015	13.1
White Mound	Sauk	2019	12.8
Virginia	Sauk	2016	12.5
Dutch Hollow	Sauk	2016	12.2
Devils	Sauk	2013	10.8
Area Mean			14.0
Area Median			14.5

Table 18. Individual Muskellunge sampled during the spring 2018 fishery surveys of Swan Lake, Columbia County, Wisconsin.

Sample Date	Length (in)	Weight (lb.)	Sex	Estimated Age
04/02/2018	11.0	0.2	U	1
04/07/2018	11.1	0.2	U	1
04/07/2018	11.2	0.2	U	1
04/02/2018	12.5	0.4	U	1
05/22/2018	29.5	6.9	U	3
04/05/2018	36.2	13.7	M	7
04/11/2018	43.8	23.2	F	7
04/22/2018	44.3		F	8
04/28/2018	39.5	19.6	M	10
04/26/2018	41.2	19.9	M	10
04/12/2018	41.3	21.9	F	10
05/22/2018	41.4	21.7	U	10
04/26/2018	44.4	32.5	F	10
04/25/2018	46.5	34.8	F	10
04/26/2018	47.1	35.5	F	10
04/22/2018	38.2	15.4	M	11
04/26/2018	39.3	16.8	F	11
04/27/2018	46.4	36.7	F	11
04/26/2018	48.5	35.9	F	11

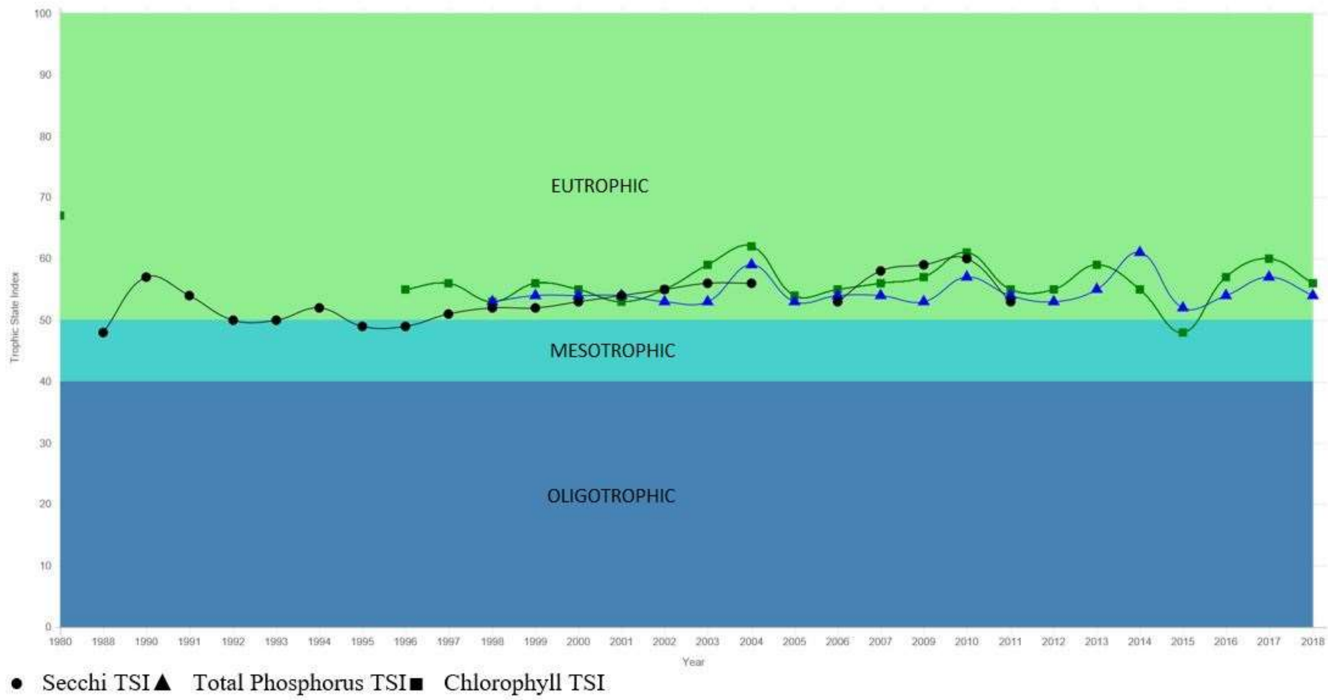


Figure 1. Secchi, total phosphorous, and chlorophyll trophic state index (TSI) for Swan Lake, Columbia County, Wisconsin 1980-2018 (https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=113076).

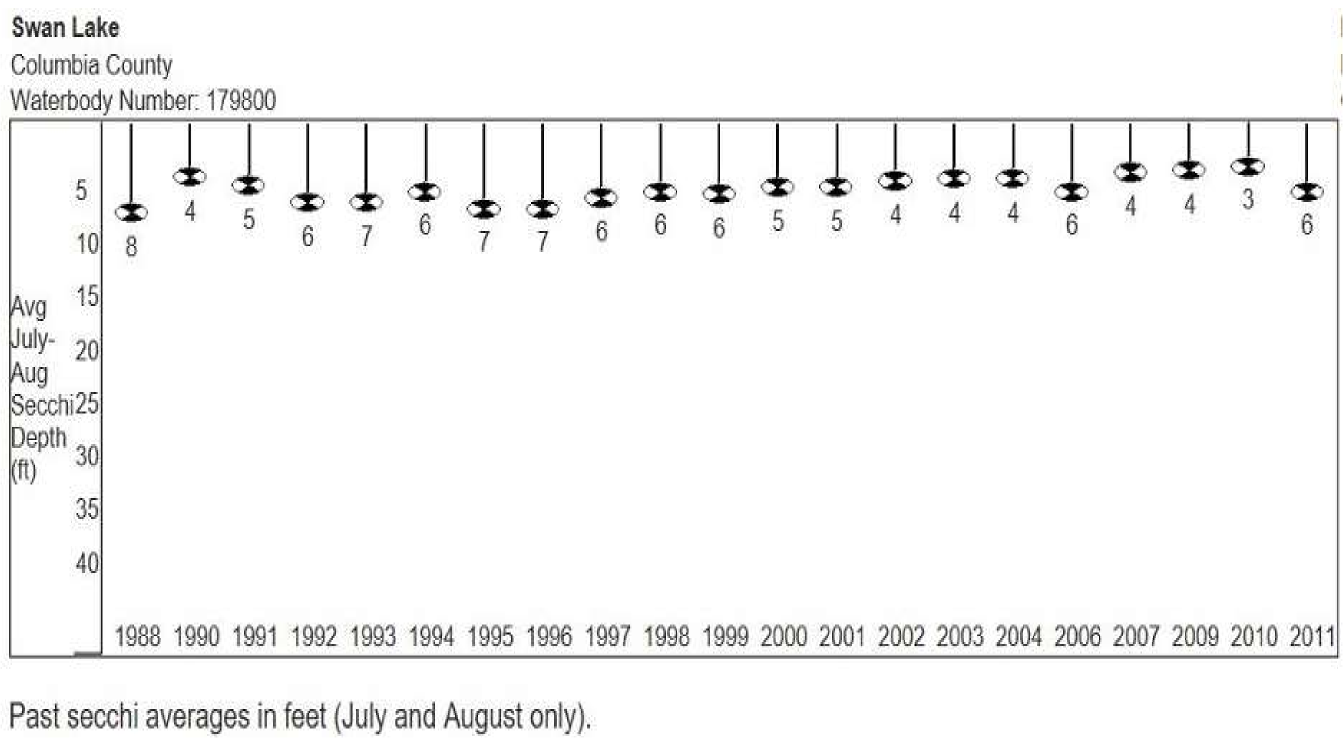


Figure 2. Mean July-August Secchi depth for Swan Lake, Columbia County, Wisconsin, 1988-2011 (https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=113076).

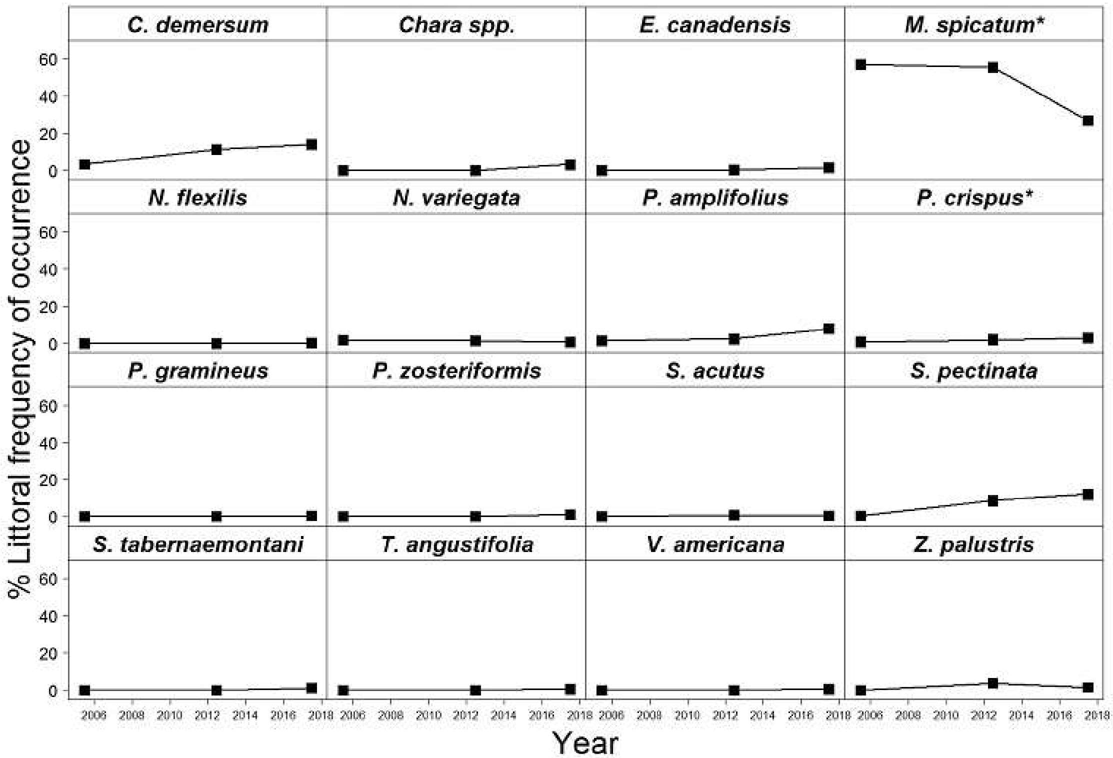
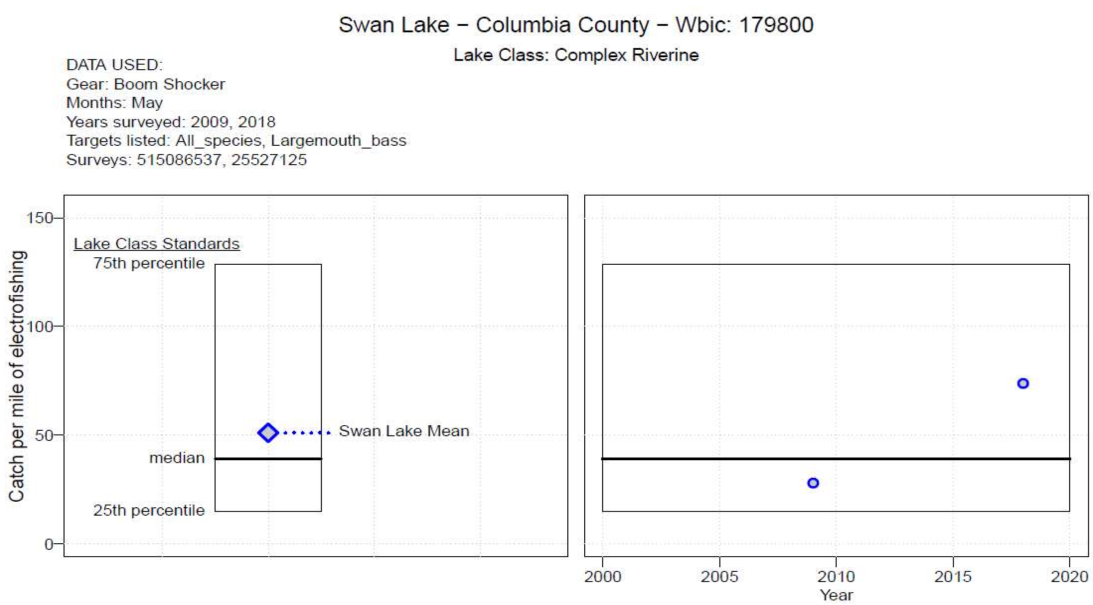


Figure 3. Trends in percent littoral frequency of occurrence for 16 aquatic plant species at Swan Lake, Columbia County, Wisconsin 2005-2017 (Michelle Nault, personal communication).



Percentile	Lake Class CPE	Swan Lake Mean
25th	14.778	
Median	39	51
75th	128.5	

Year	Average CPE
2009	28
2018	74

Figure 4. Bluegill electrofishing CPUE lake class comparison for Swan Lake, Columbia County, Wisconsin. The lake class is Complex Riverine.

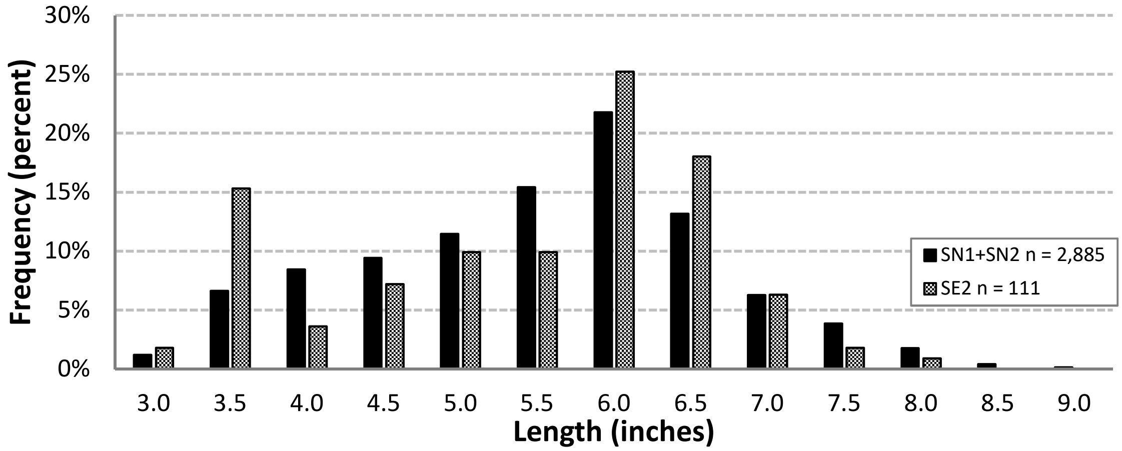


Figure 5. Length frequency distribution of Bluegills sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

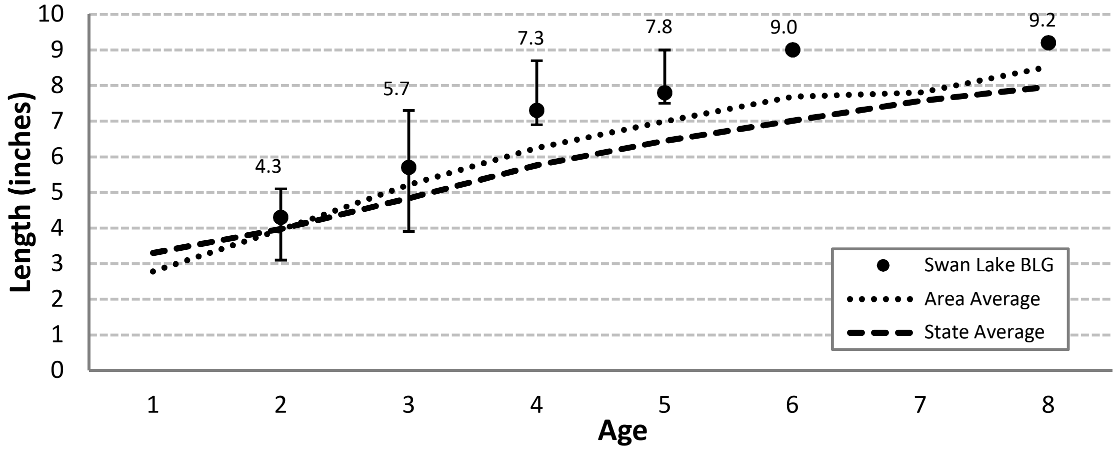


Figure 6. Mean length-at-age of Bluegills collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

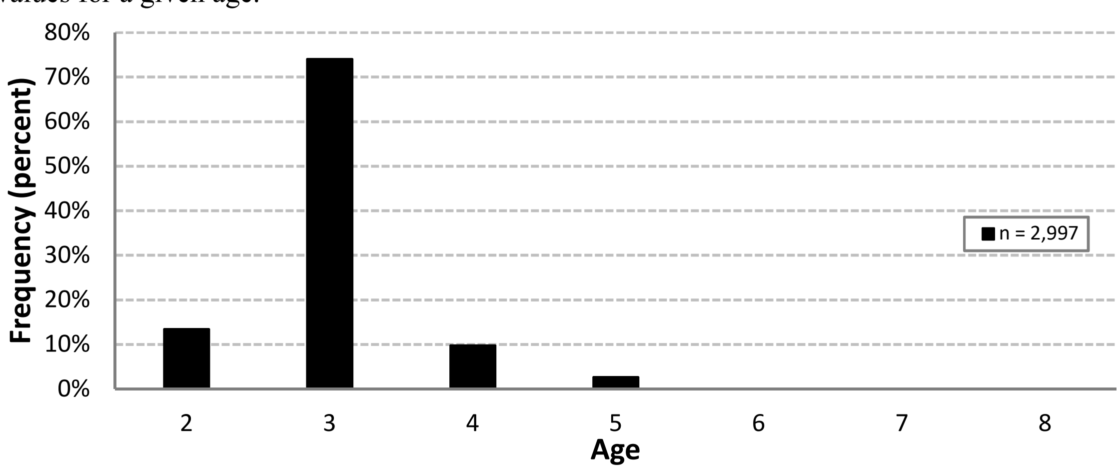


Figure 7. Age frequency distribution of Bluegills sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

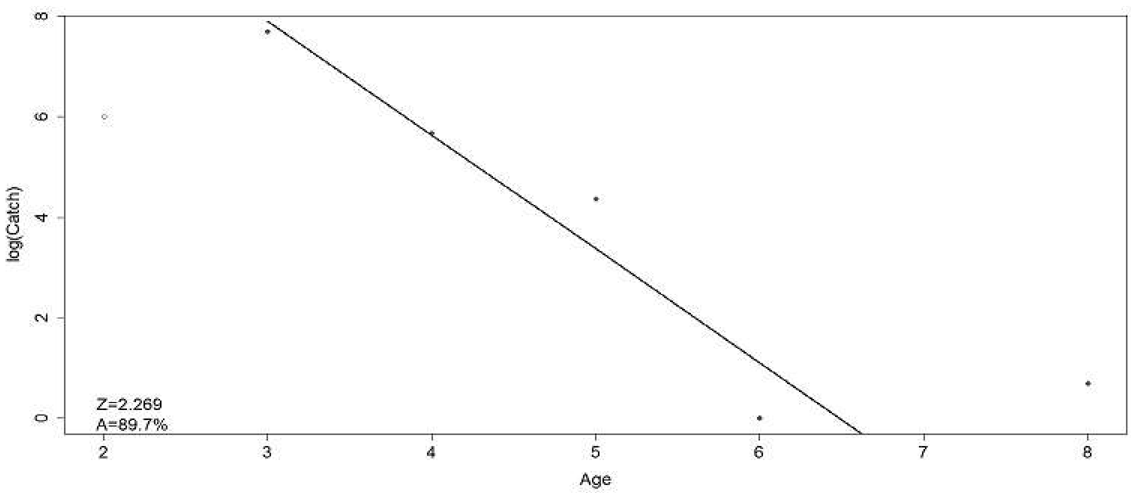


Figure 8. Catch curve for Bluegills sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

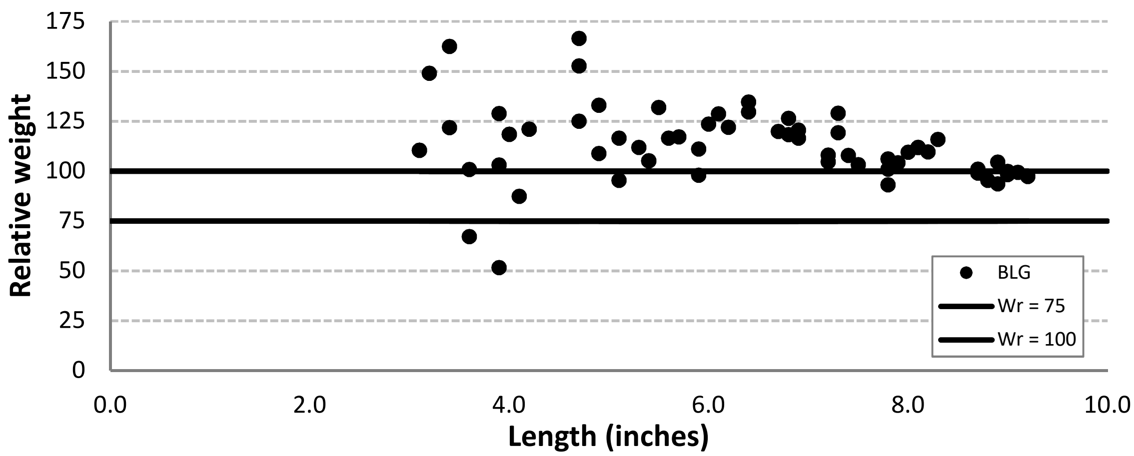


Figure 9. Relative weights of Bluegills collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

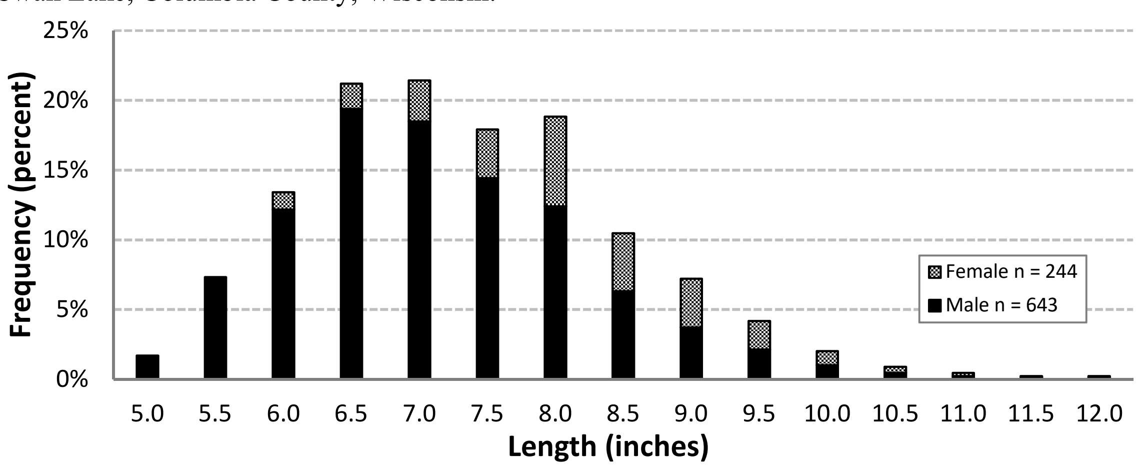


Figure 10. Length frequency distribution of Yellow Perch sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

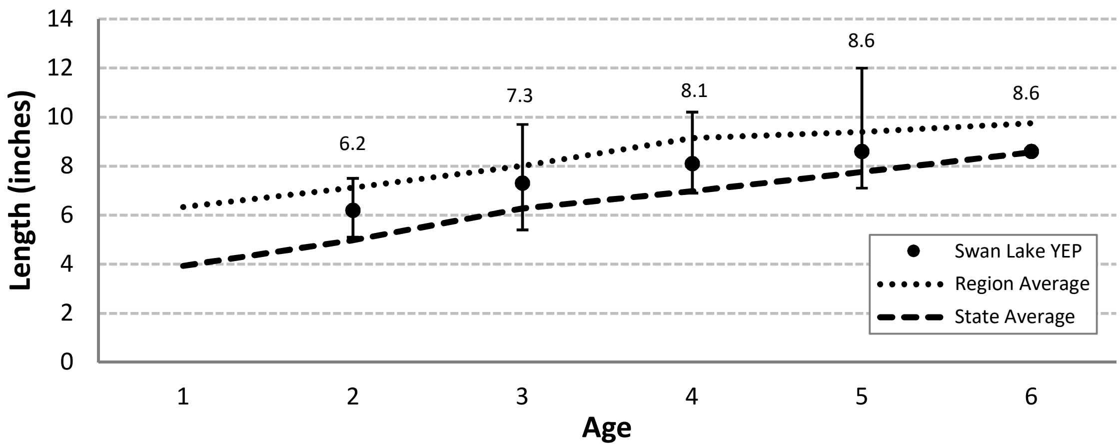


Figure 11. Mean length-at-age of Yellow Perch collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

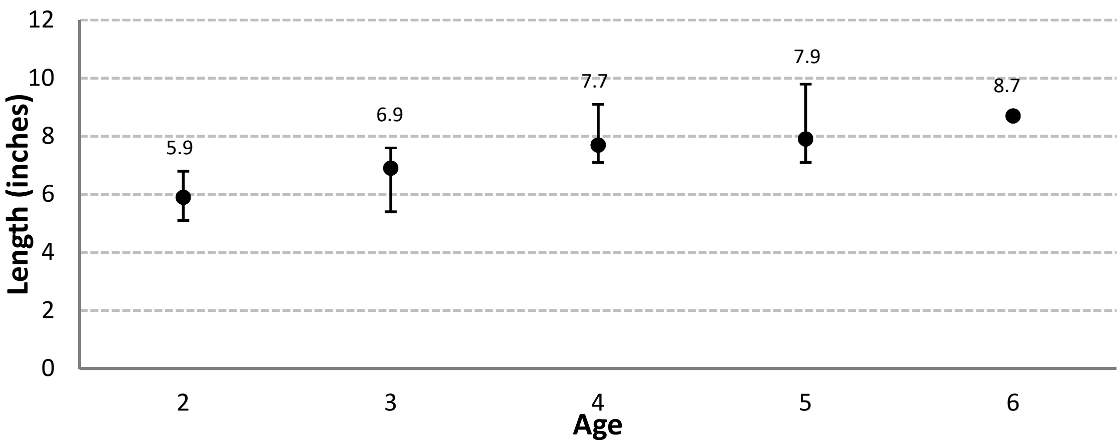


Figure 12. Mean length-at-age of male Yellow Perch collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

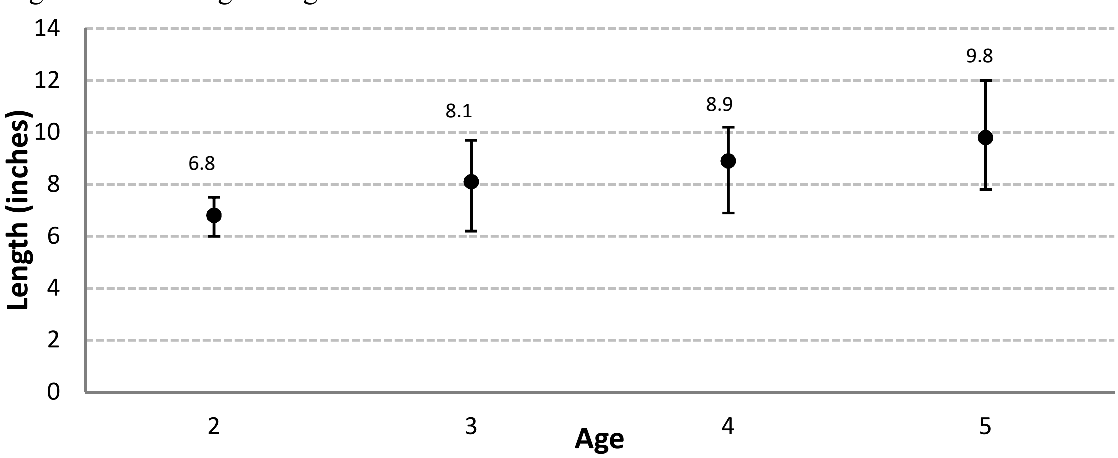


Figure 13. Mean length-at-age of female Yellow Perch collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

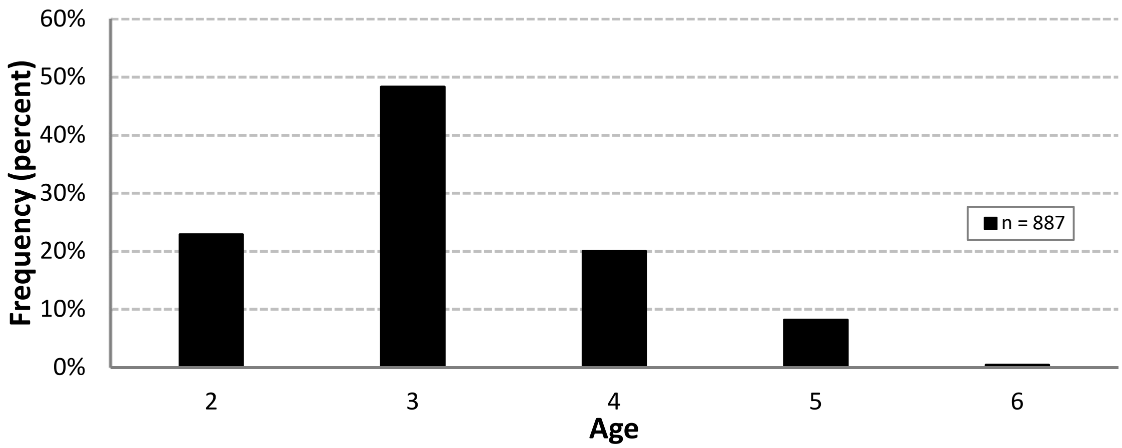


Figure 14. Age frequency distribution of Yellow Perch sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

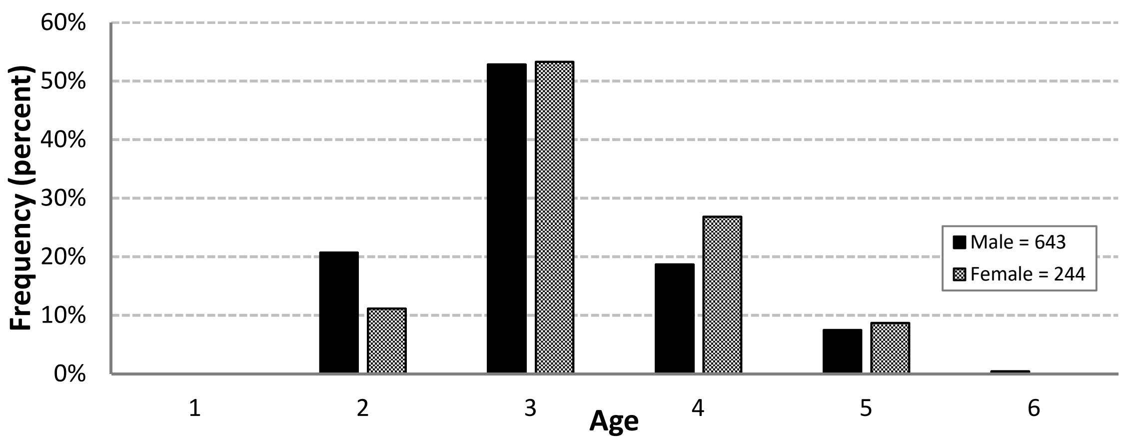


Figure 15. Age frequency distribution of male and female Yellow Perch sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

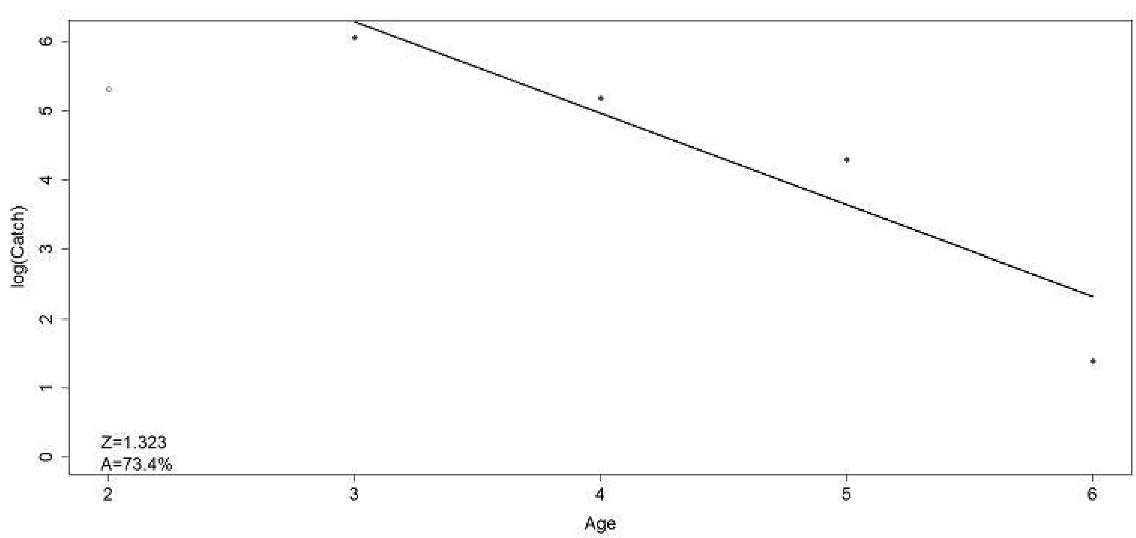


Figure 16. Catch curve for Yellow Perch sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

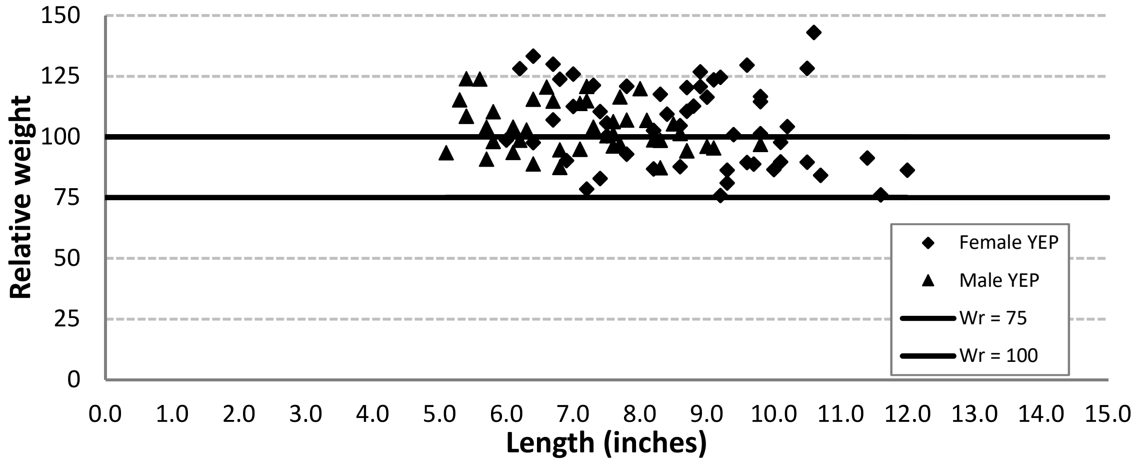


Figure 17. Relative weights of Yellow Perch collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

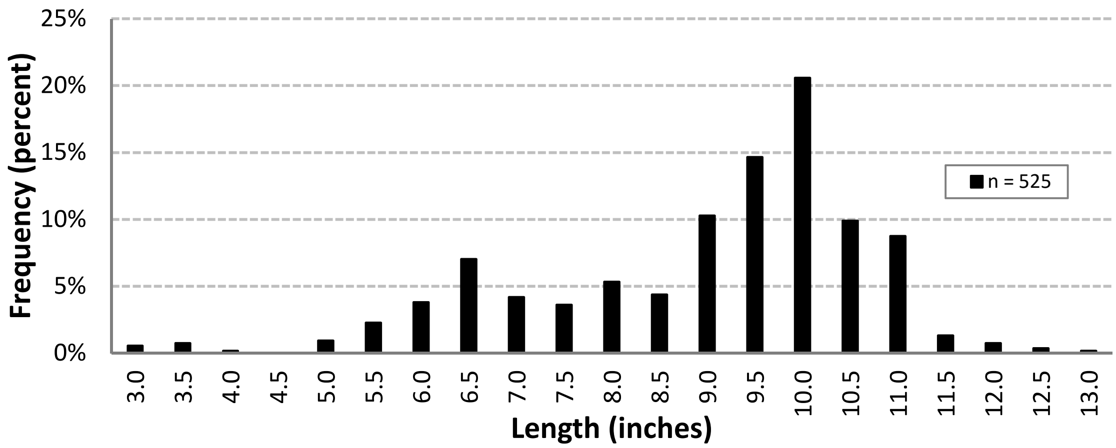


Figure 18. Length frequency distribution of Black Crappies sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

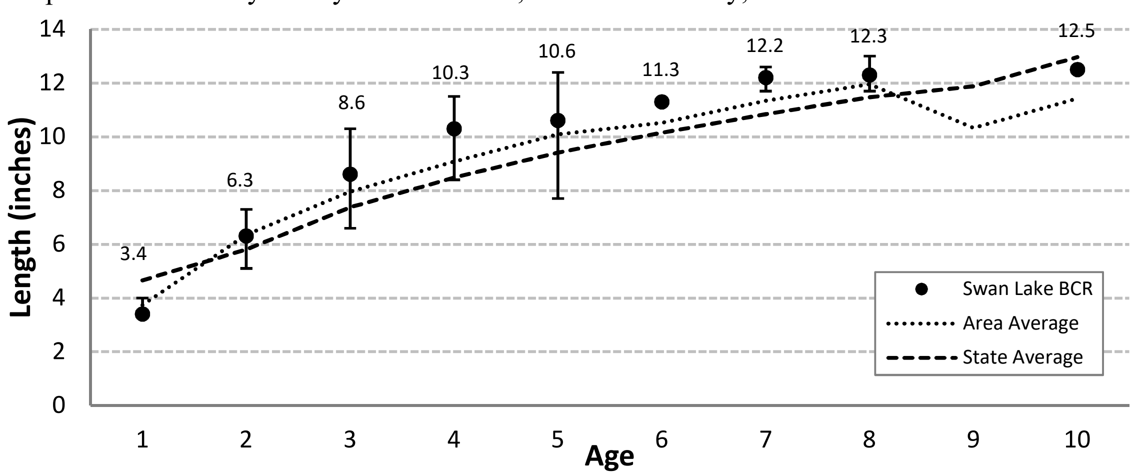


Figure 19. Mean length-at-age of Black Crappies collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

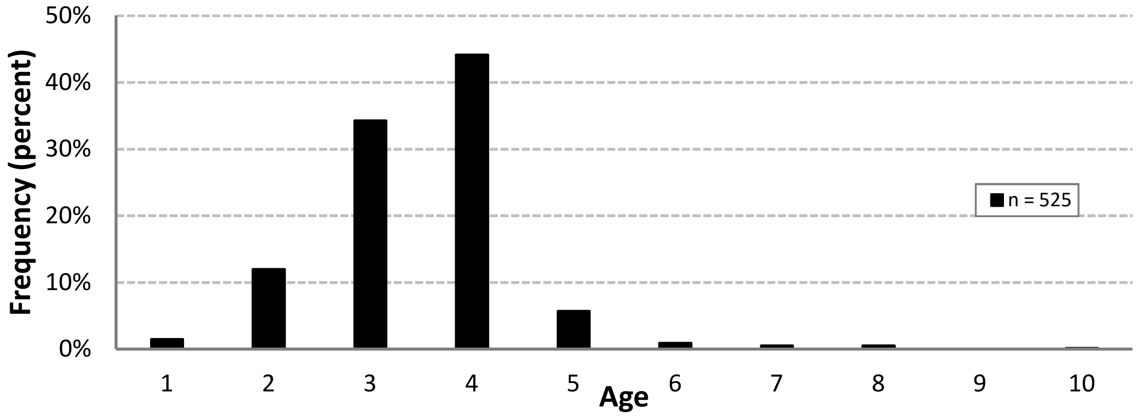


Figure 20. Age frequency distribution of Black Crappies sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

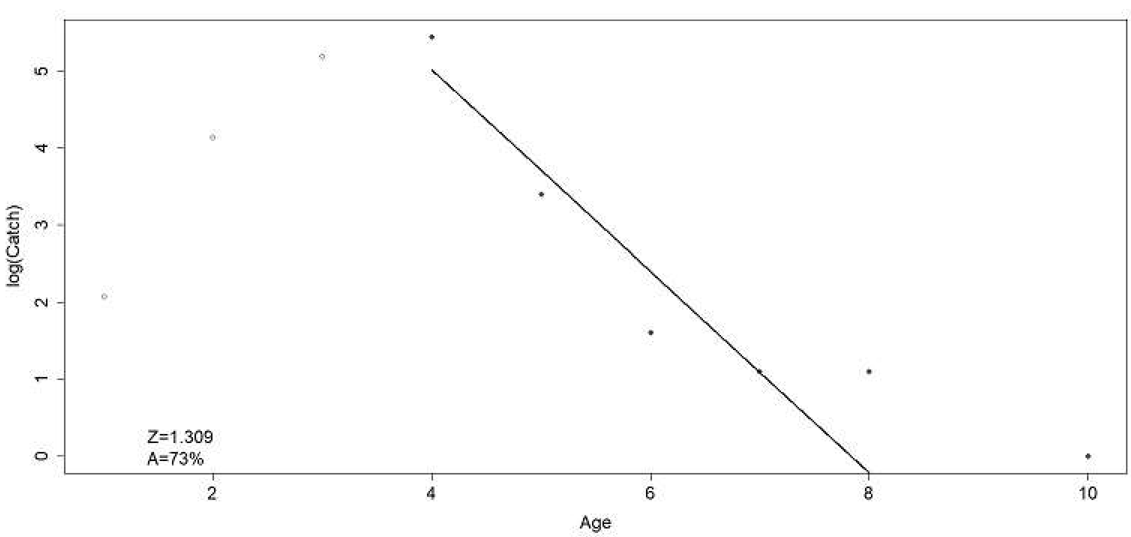


Figure 21. Catch curve for Black Crappies sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

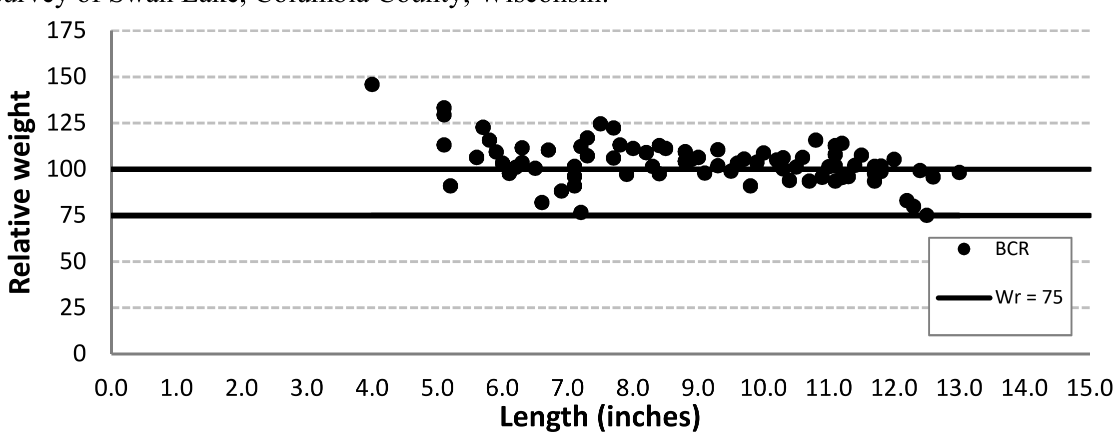


Figure 22. Relative weights of Black Crappies collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

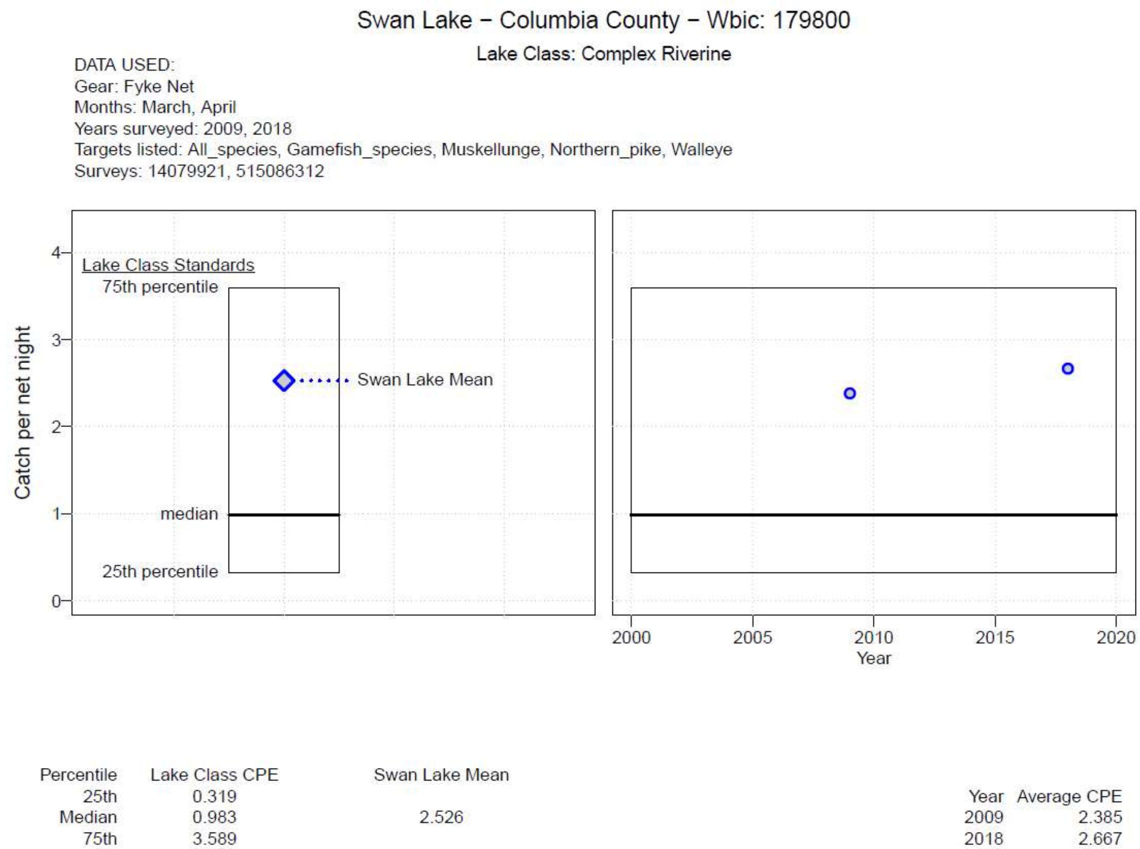


Figure 23. Walleye fyke net CPUE lake class comparison for Swan Lake, Columbia County, Wisconsin. The lake class is Complex Riverine.

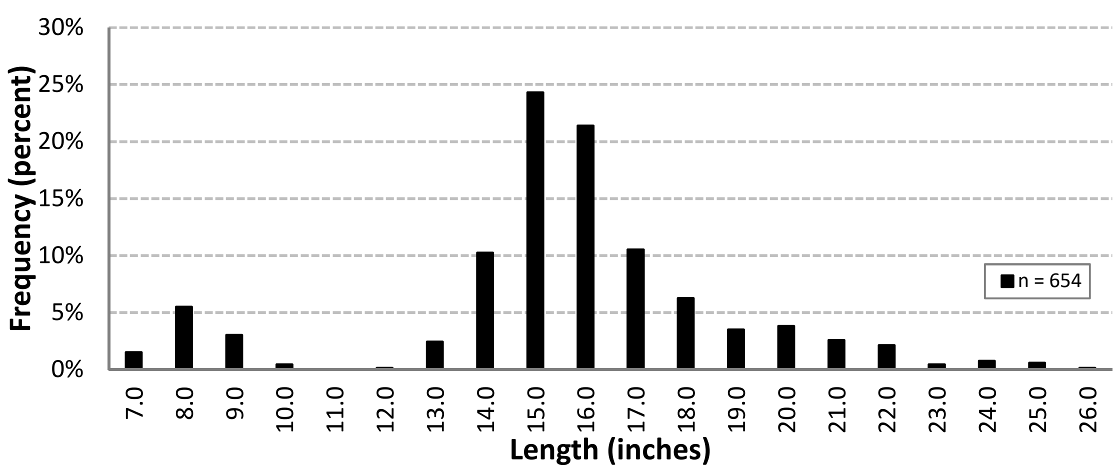


Figure 24. Length frequency distribution of Walleyes sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

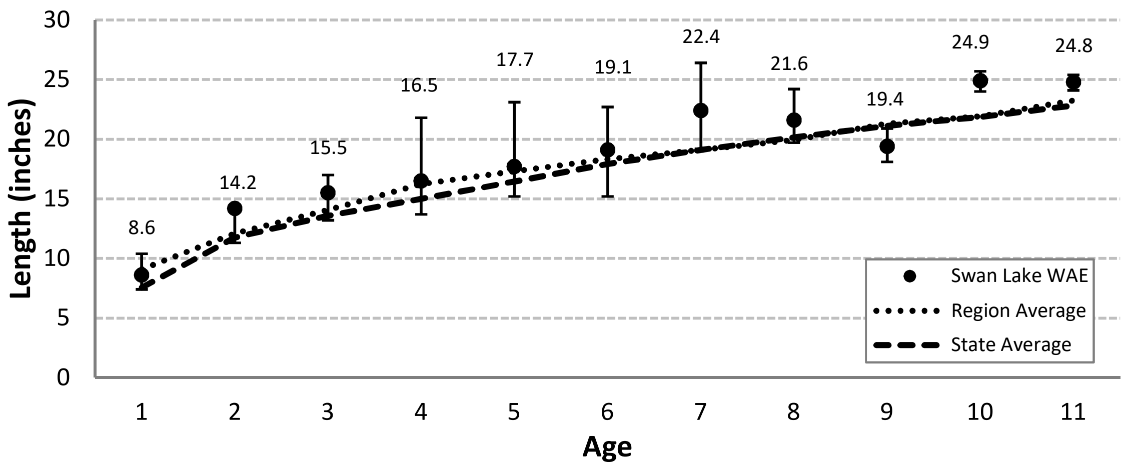


Figure 25. Mean length-at-age of Walleyes collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

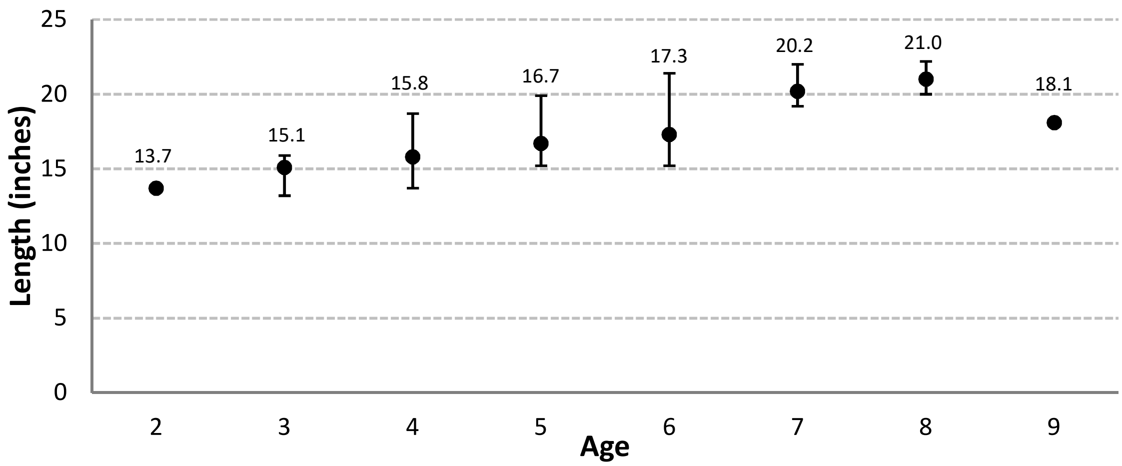


Figure 26. Mean length-at-age of male Walleyes collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

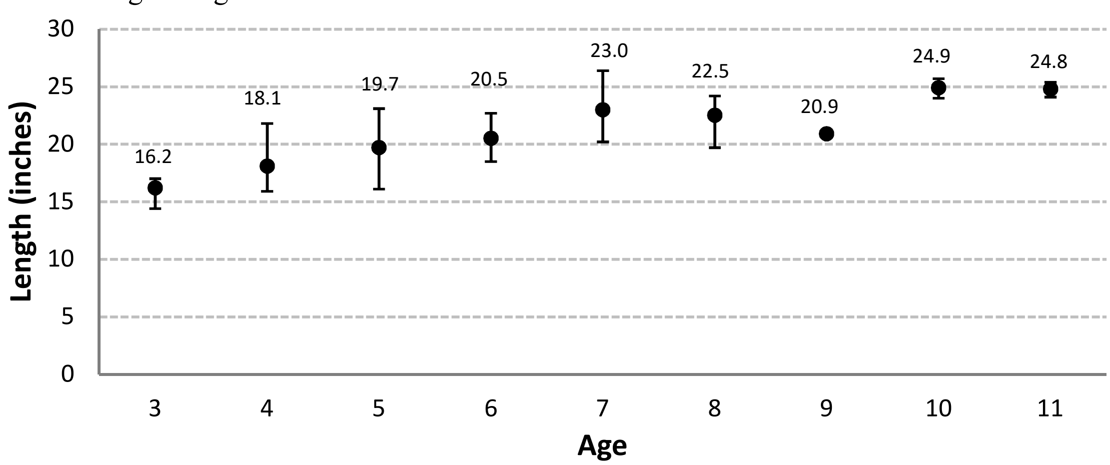


Figure 27. Mean length-at-age of female Walleyes collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

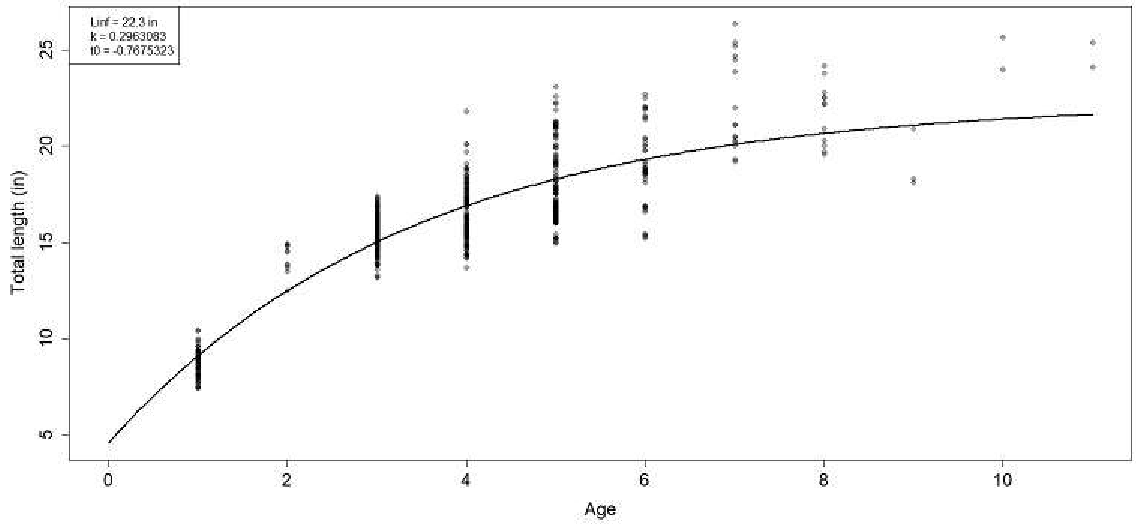


Figure 28. Ages and lengths of Walleyes collected during the 2018 comprehensive fishery survey of Swan Lake with a von Bertalanffy growth curve fitted to the data.

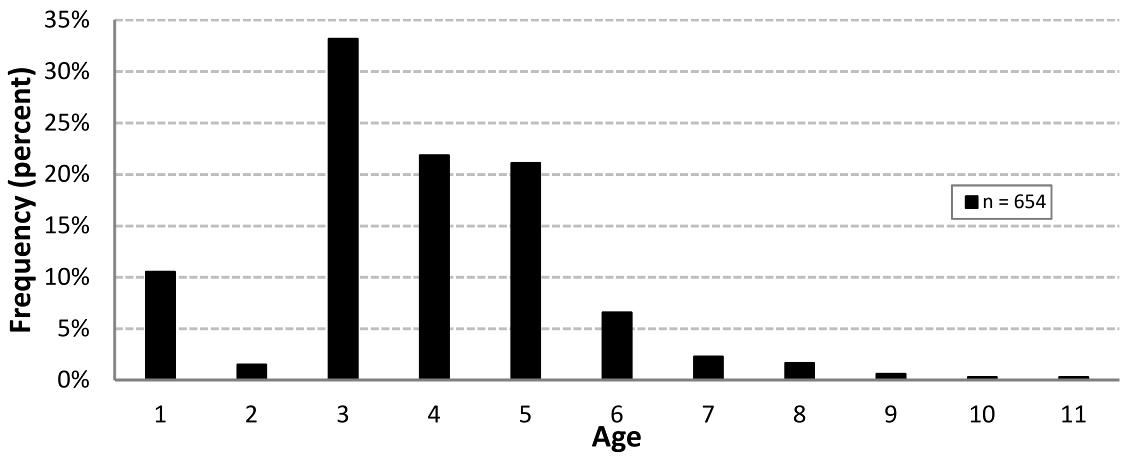


Figure 29. Age frequency distribution of Walleyes sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

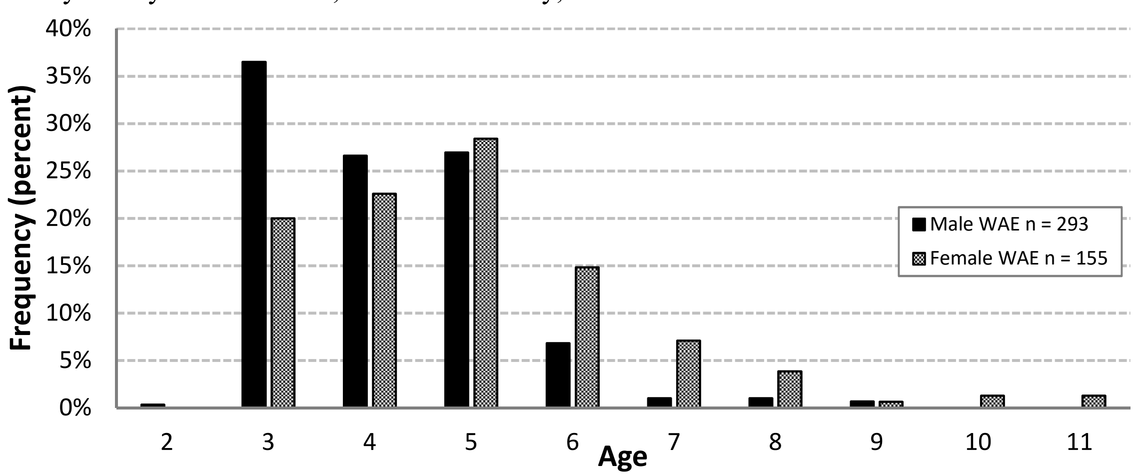


Figure 30. Age frequency distribution of male and female Walleyes sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

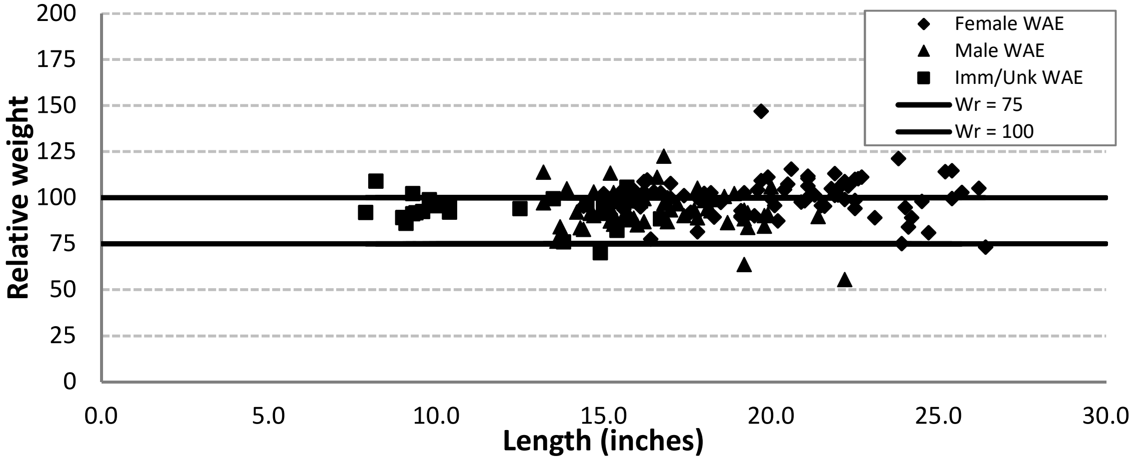


Figure 31. Relative weights of Walleyes collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

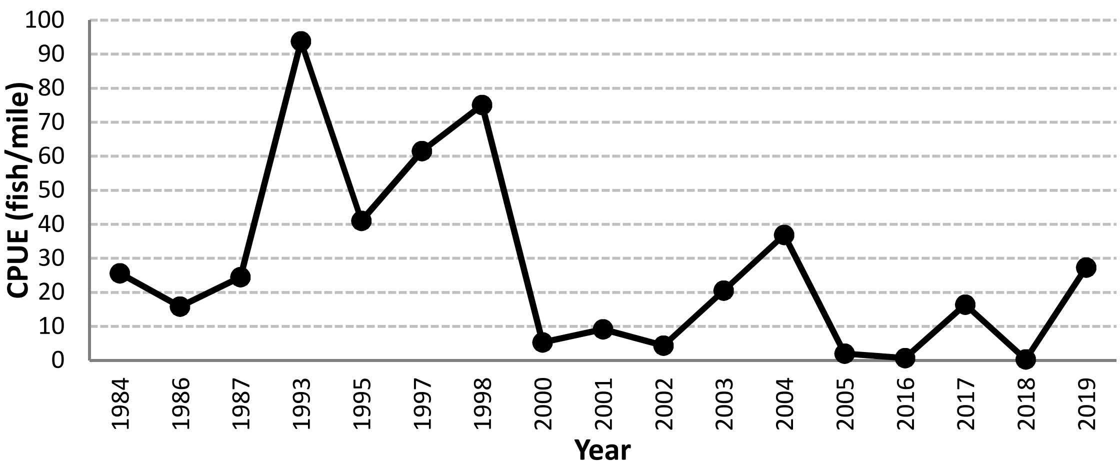


Figure 32. Age 0 Walleye catch-per-unit effort from fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin 1984-2019. Fry were stocked 1984-2003 and small fingerling stocking began in 2004. No Walleye stocking occurred in Swan Lake in 2016 and 2018.

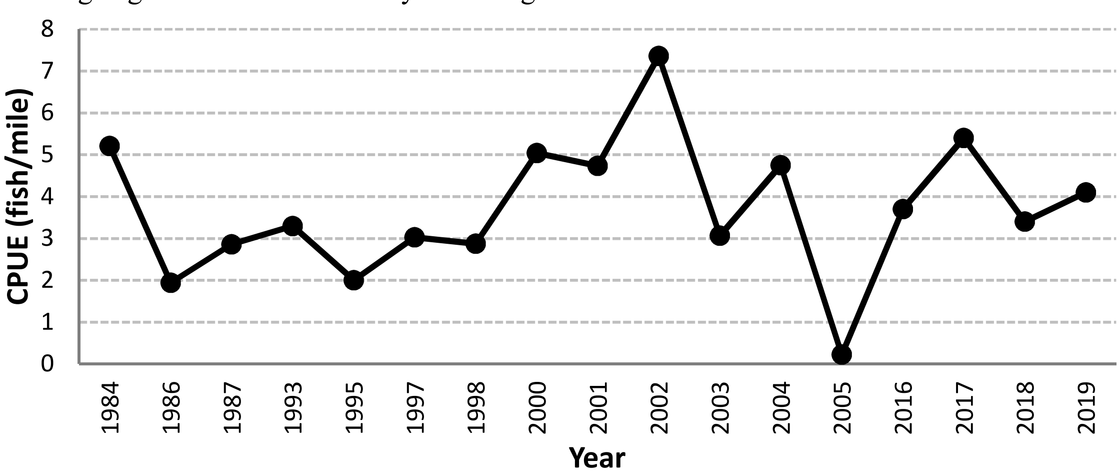


Figure 33. Catch-per-unit effort of Walleyes ≥ 15 inches in fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin 1984-2019.

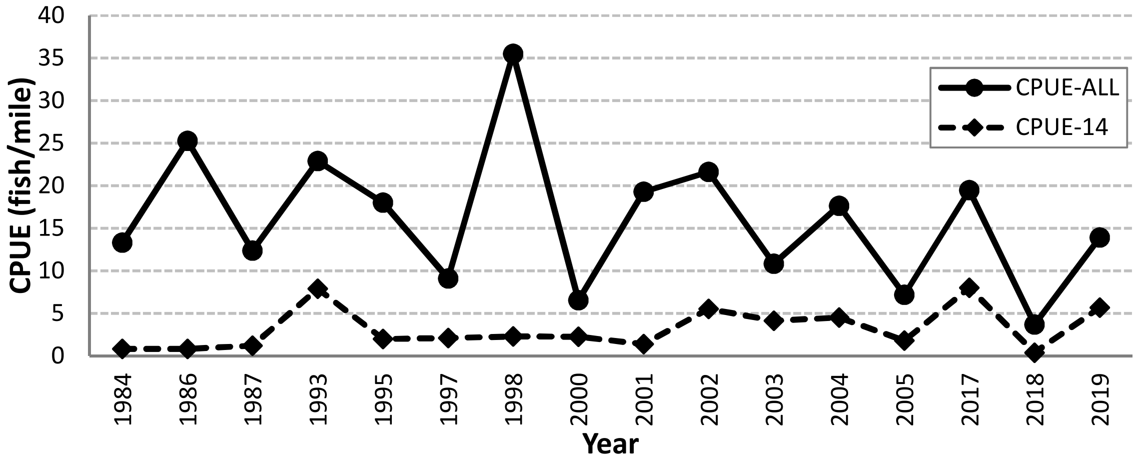


Figure 34. Catch-per-unit effort of Largemouth Bass in fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin 1984-2019.

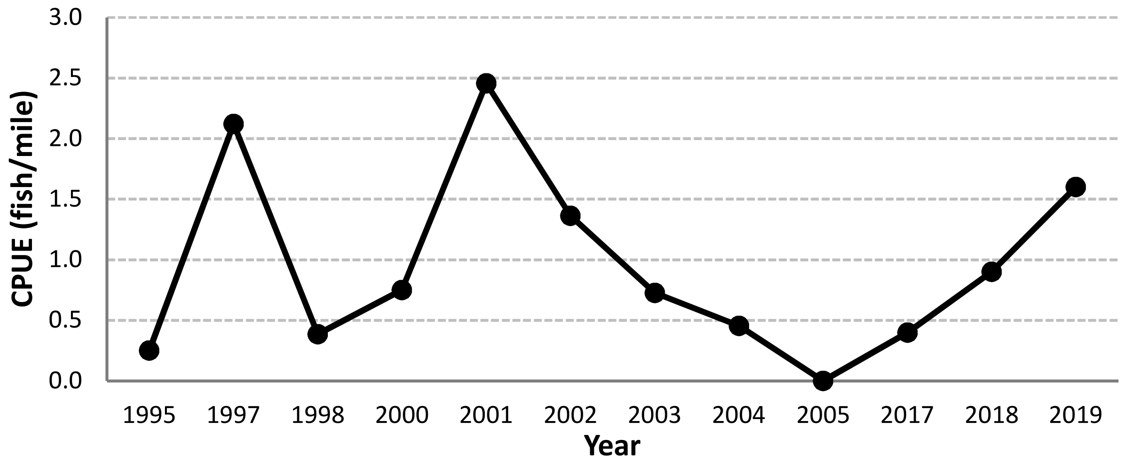


Figure 35. Catch-per-unit effort of Smallmouth Bass in fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin 1995-2019.

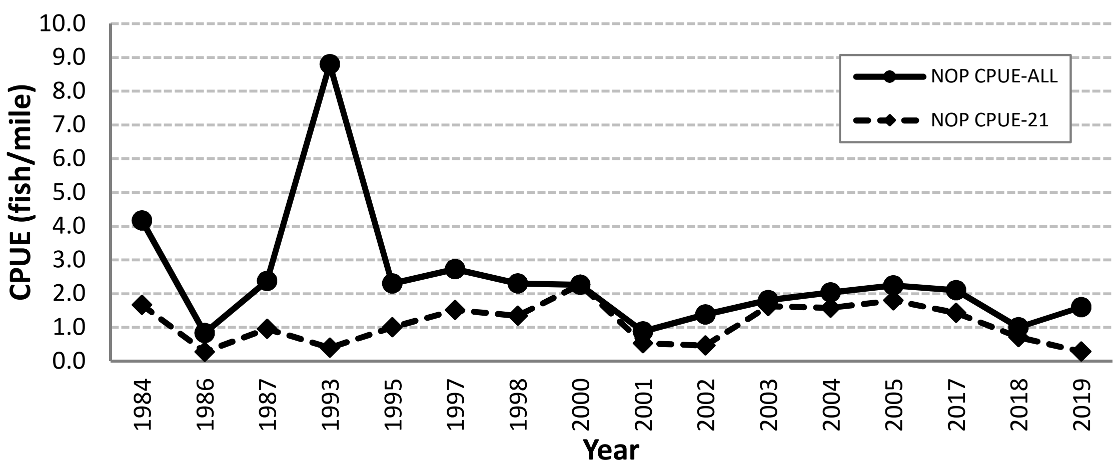


Figure 36. Catch-per-unit effort of Northern Pike in fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin 1984-2019.

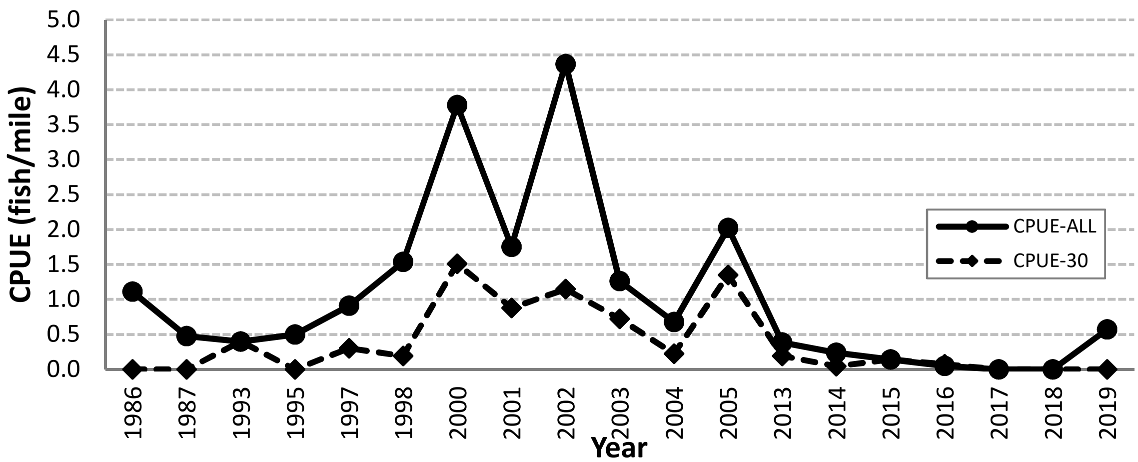
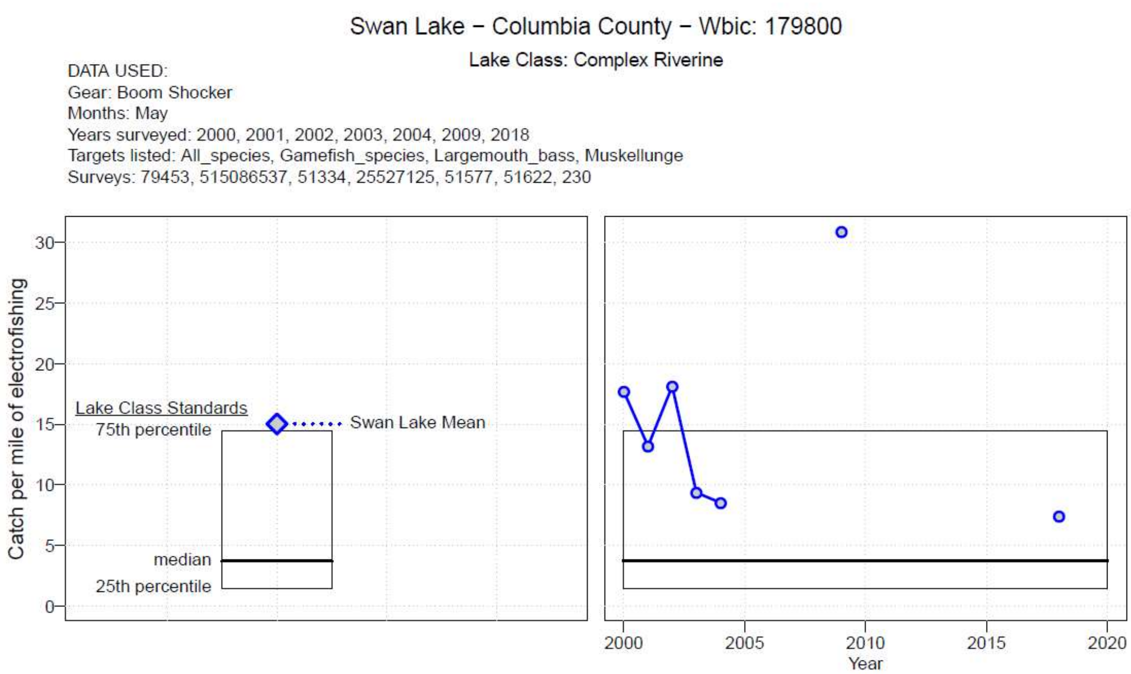


Figure 37. Catch-per-unit effort of Muskellunge in fall electrofishing surveys of Swan Lake, Columbia County, Wisconsin 1984-2019.



Year	Average CPE
2000	17.708
2001	13.2
2002	18.143
2003	9.366
2004	8.527
2009	30.923
2018	7.386

Percentile	Lake Class CPE	Swan Lake Mean
25th	1.46	
Median	3.715	15.036
75th	14.463	

Figure 38. Largemouth Bass electrofishing CPUE lake class comparison for Swan Lake, Columbia County, Wisconsin. The lake class is Complex Riverine.

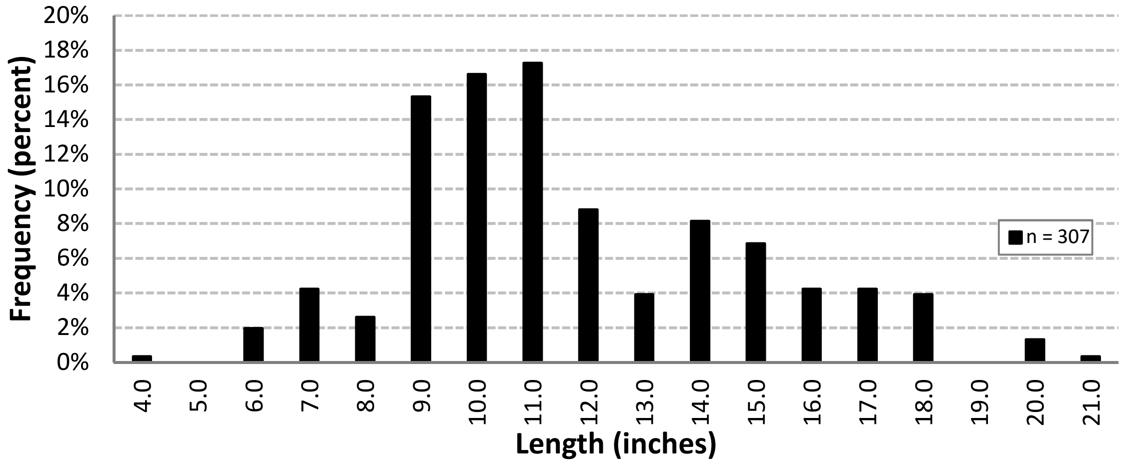


Figure 39. Length frequency distribution of Largemouth Bass sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

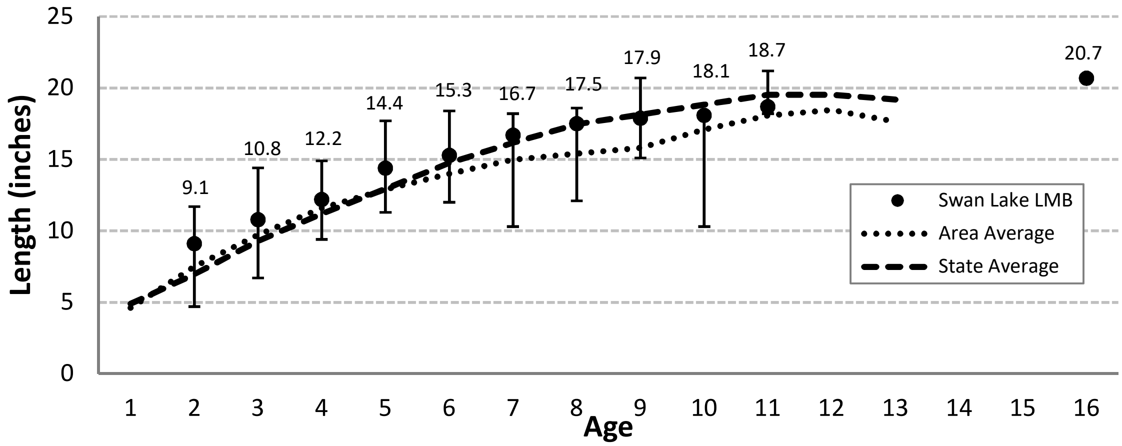


Figure 40. Mean length-at-age of Largemouth Bass collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

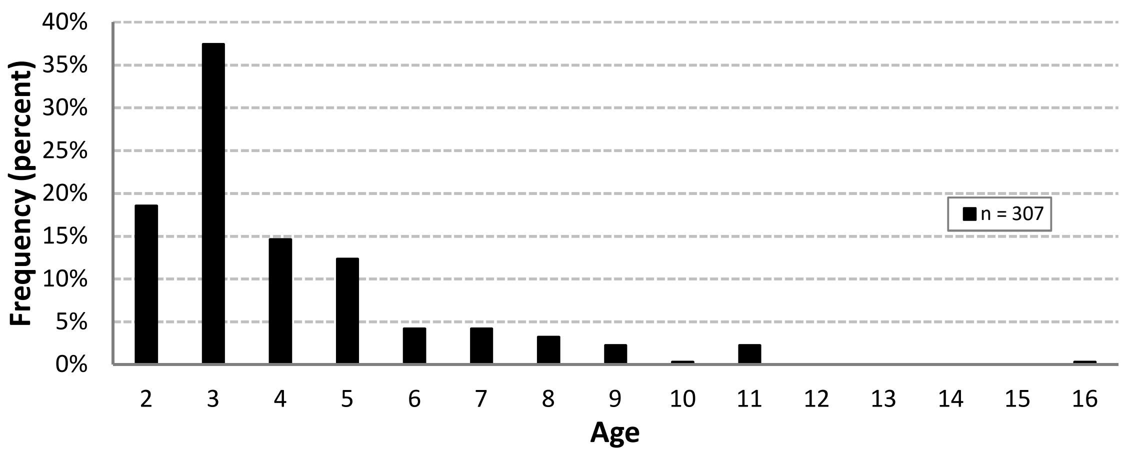


Figure 41. Age frequency distribution of Largemouth Bass sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

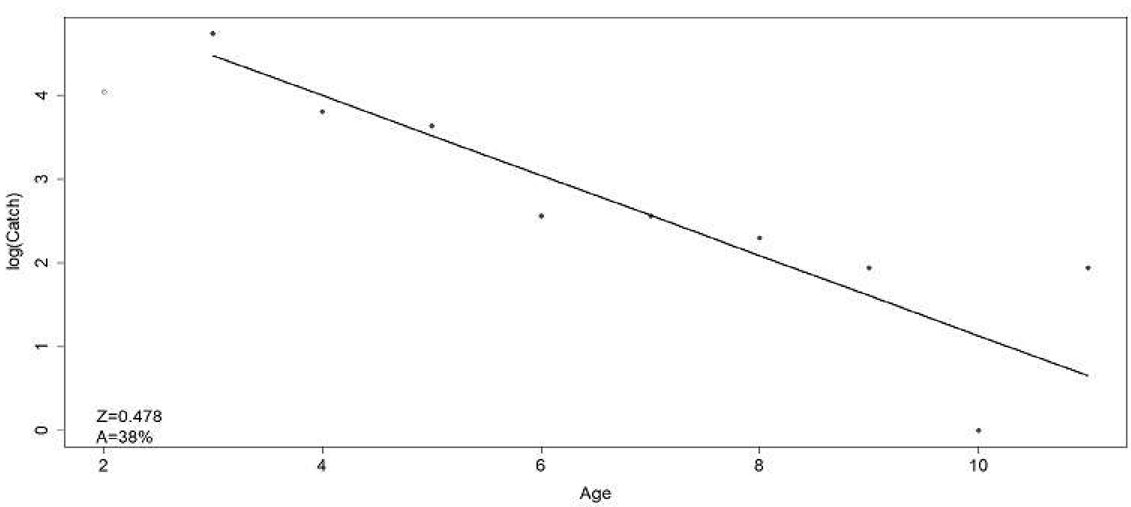


Figure 42. Catch curve for Largemouth Bass collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

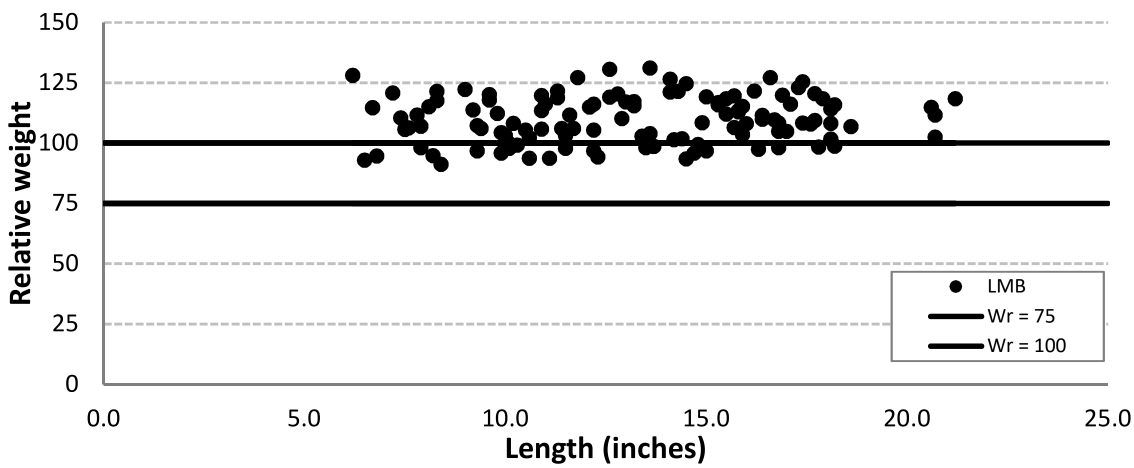
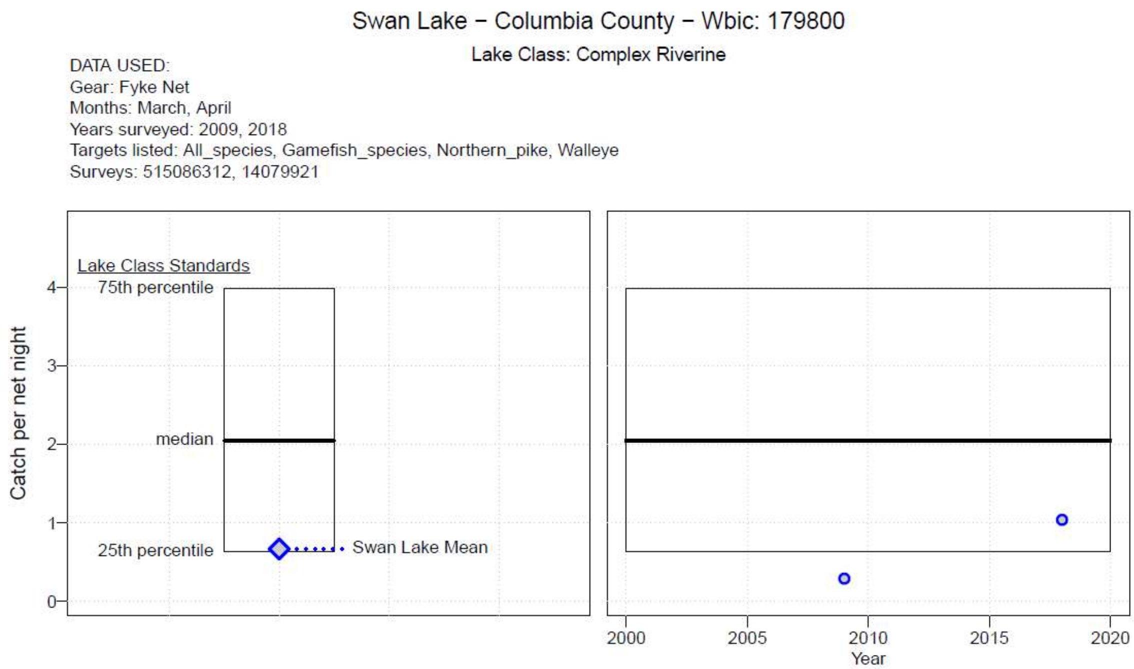


Figure 43. Relative weights of Largemouth Bass collected during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.



Percentile	Lake Class CPE	Swan Lake Mean
25th	0.631	
Median	2.043	0.663
75th	3.98	

Year	Average CPE
2009	0.286
2018	1.041

Figure 44. Northern Pike fyke net CPUE lake class comparison for Swan Lake, Columbia County, Wisconsin. The lake class is Complex Riverine.

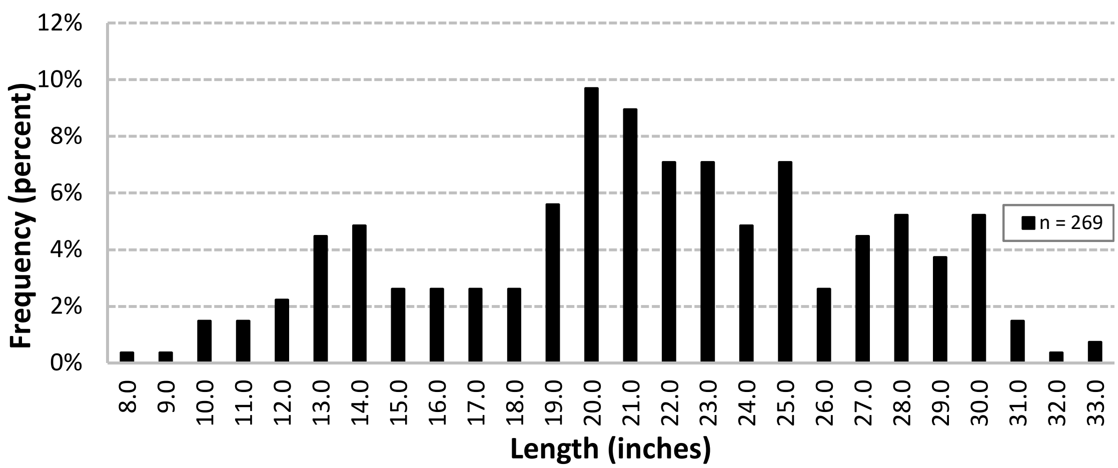


Figure 45. Length frequency distribution of Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

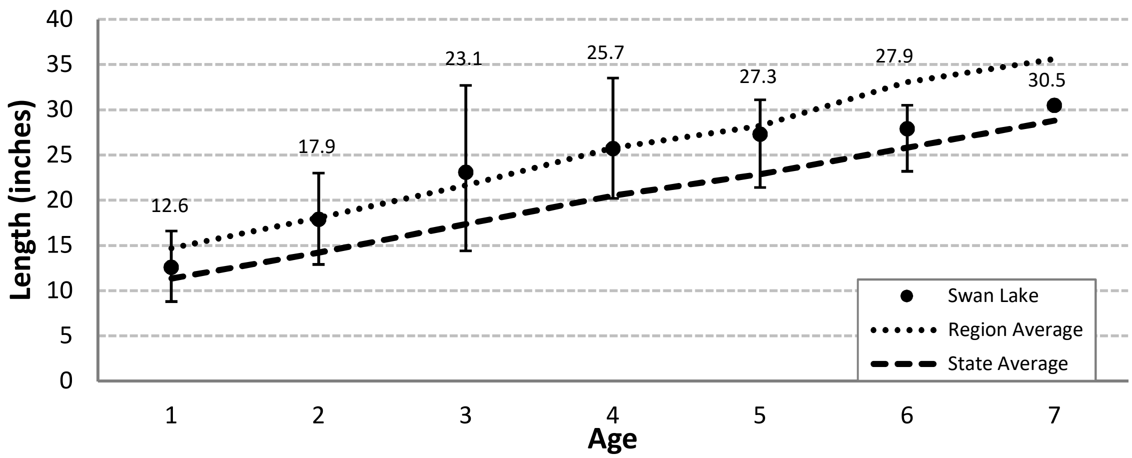


Figure 46. Mean length-at-age of Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

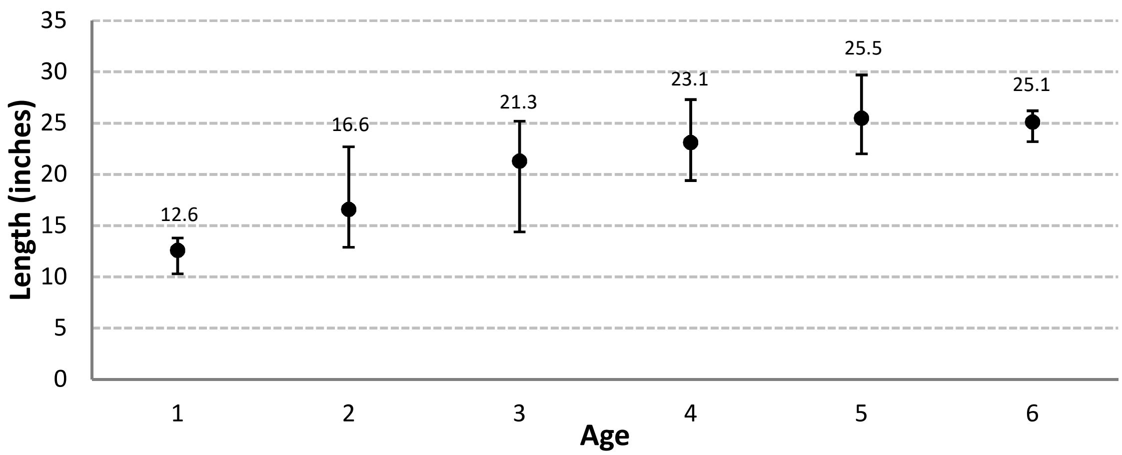


Figure 47. Mean length-at-age of male Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

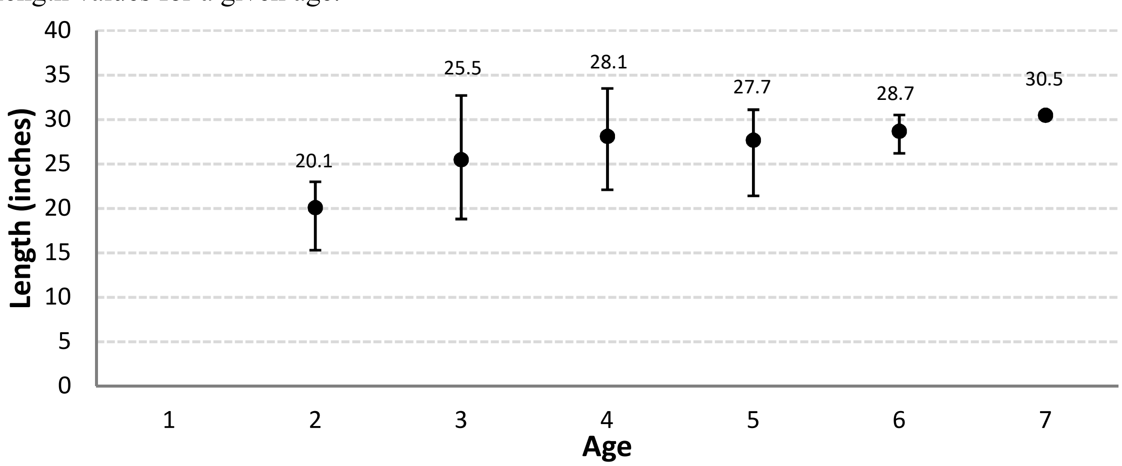


Figure 48. Mean length-at-age of female Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

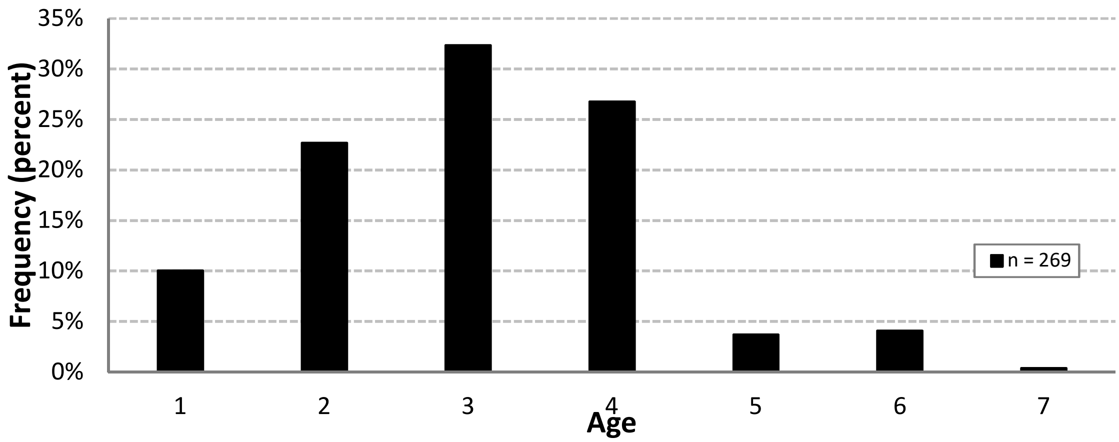


Figure 49. Age frequency distribution of Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

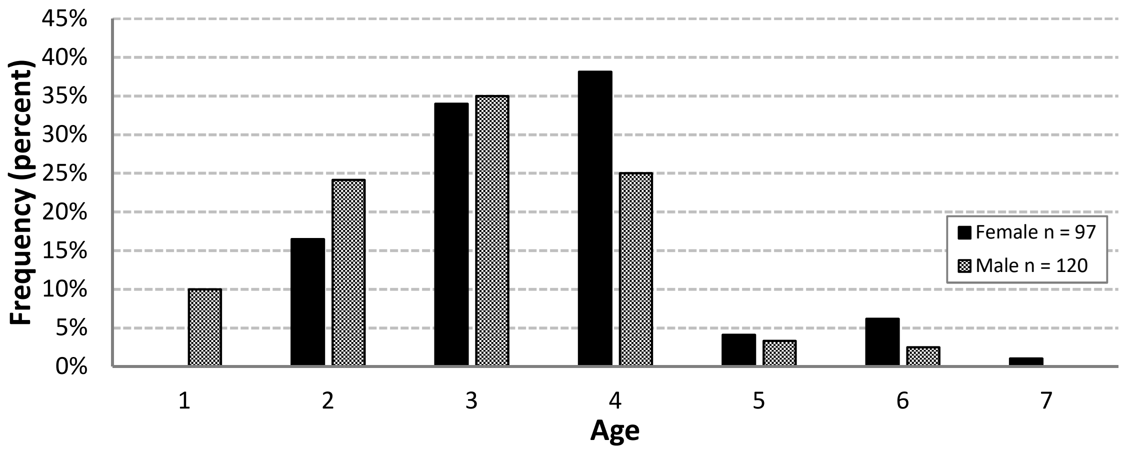


Figure 50. Age frequency distribution of known-sex Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

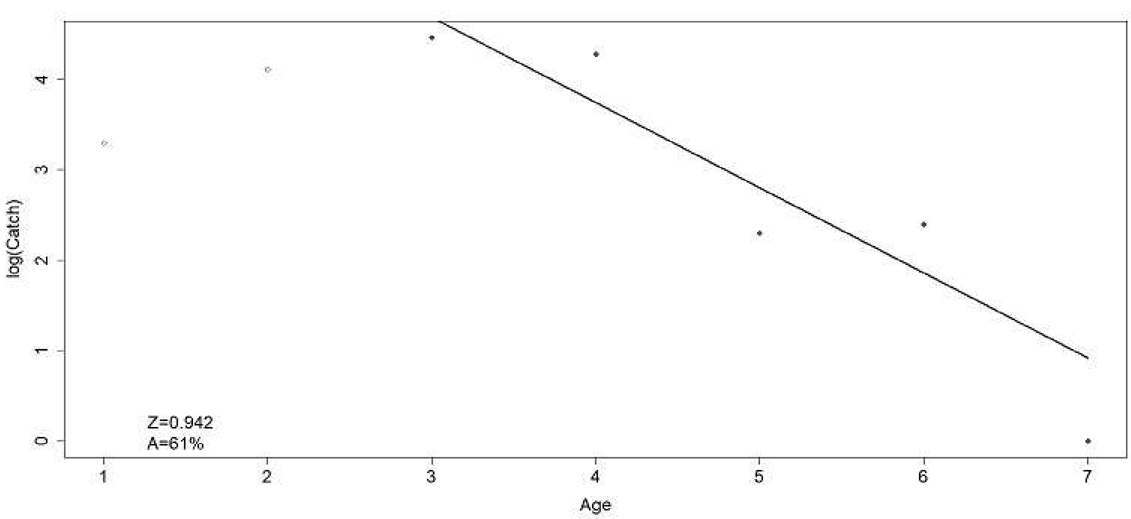


Figure 51. Catch curve for Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

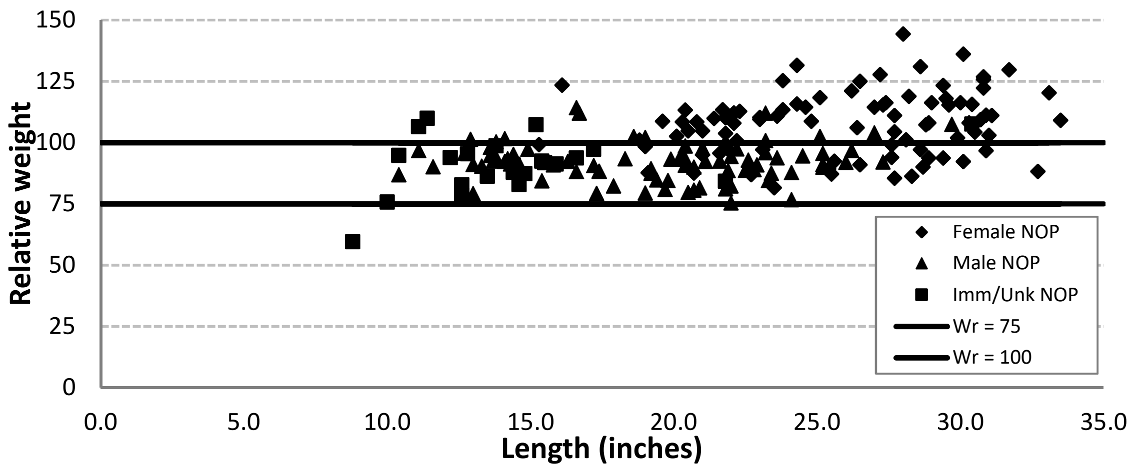


Figure 52. Relative weights of Northern Pike sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

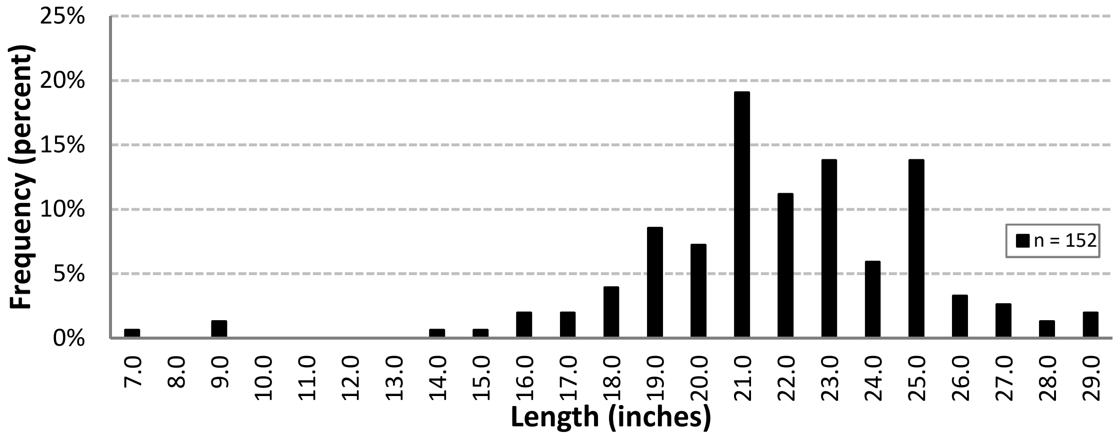


Figure 53. Length frequency distribution of Channel Catfish sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

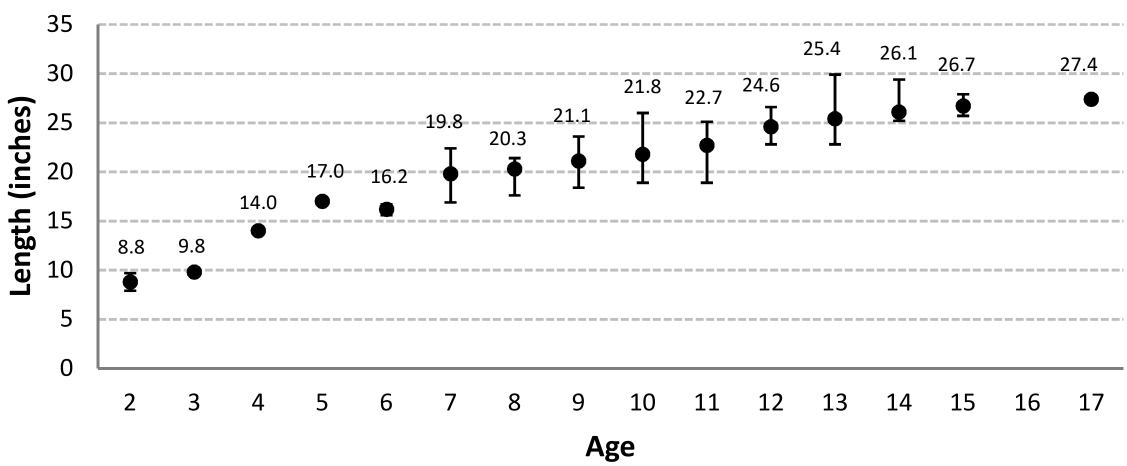


Figure 54. Mean length-at-age of Channel Catfish sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

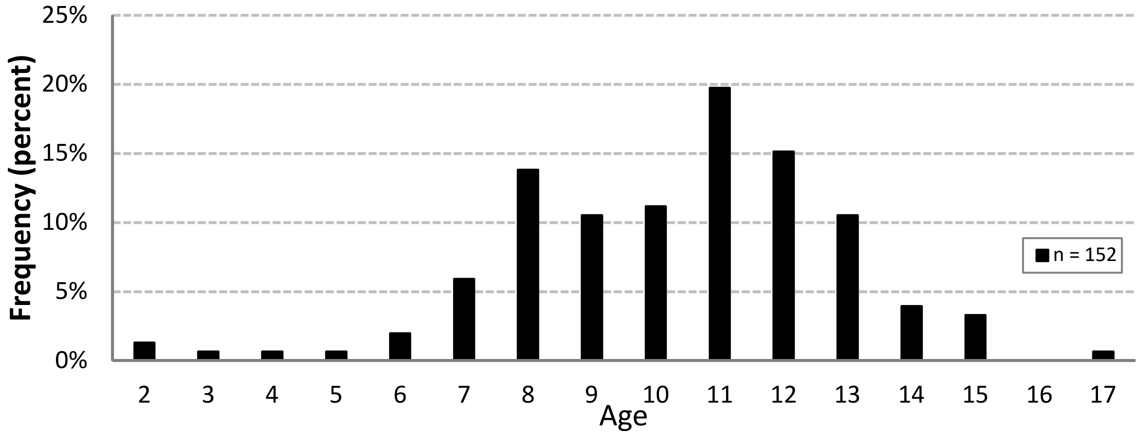


Figure 55. Age frequency distribution of Channel Catfish sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

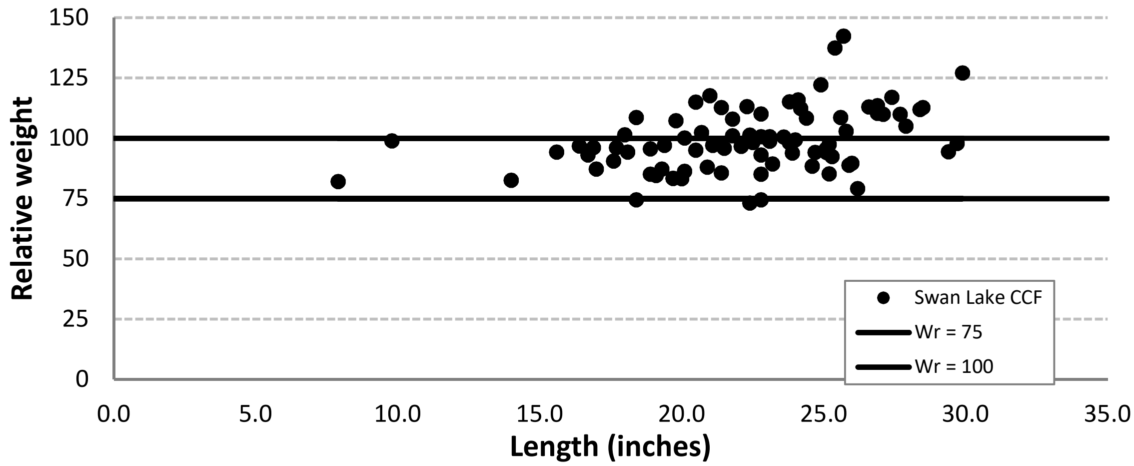


Figure 56. Relative weights of Channel Catfish sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

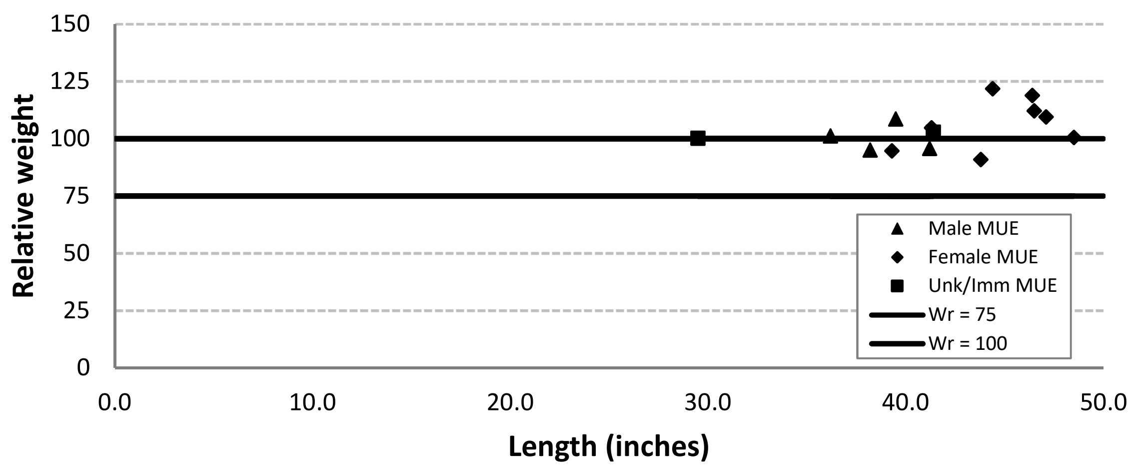


Figure 57. Relative weights of Muskellunge sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

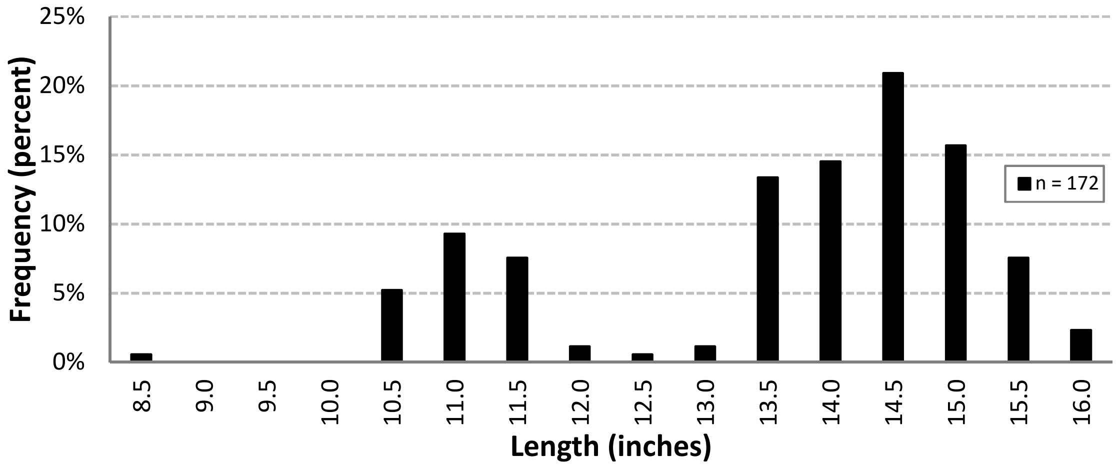


Figure 58. Length frequency distribution of White Bass sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

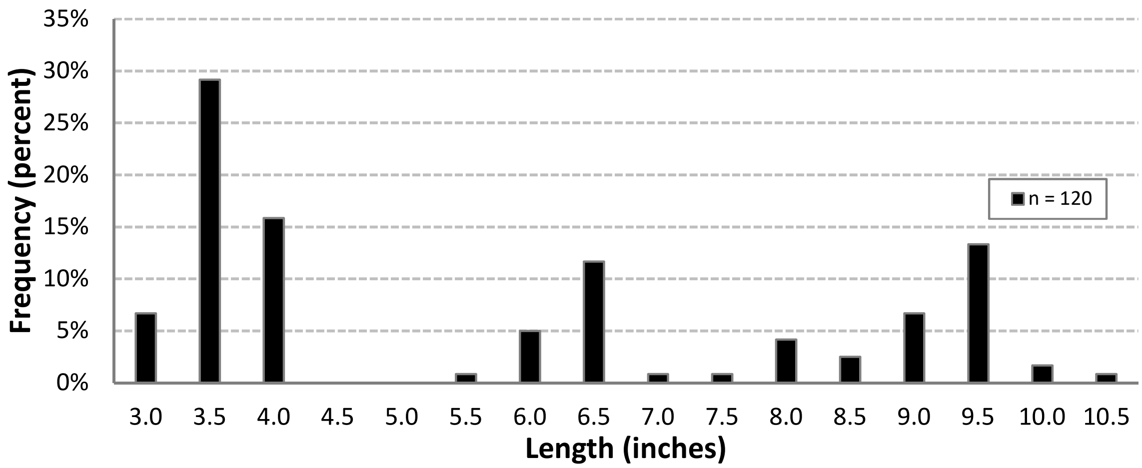


Figure 59. Length frequency distribution of Yellow Bass sampled during the 2018 comprehensive fishery survey of Swan Lake, Columbia County, Wisconsin.

APPENDIX A-Comprehensive Fishery Survey of Spring Lake
Columbia County, Wisconsin 2018

Waterbody Identification Code: 180000

Nathan Nye
Senior Fisheries Biologist
Wisconsin Department of Natural Resources
Poynette, Wisconsin
June 2020

EXECUTIVE SUMMARY

A comprehensive fishery survey was conducted on Spring Lake during the spring of 2018, including early fyke netting for Northern Pike and Walleyes (SN1), early electrofishing to recapture marked Walleyes (SE1), and late spring electrofishing for bass and panfish (SE2). Species diversity was high with 26 species representing 11 families collected in 2018.

Bluegills were abundant in Spring Lake in 2018 with a total of 5,378 fish collected, and most fish were collected during SN1. The CPUE during SE2 was 32 fish/mile, which is low compared to other area lakes, but is near the median for the lake class (Complex Riverine). Lengths ranged from 2.6-8.2 inches and ages ranged from 2-7 years. Bluegill PSD, PSD-7 and PSD-P values for the total Bluegill catch (netting and electrofishing) were 33, 7, and <1, respectively indicating that size structure is only average at best. Growth was also average compared to other lakes in the area and statewide, and Bluegill averaged over 7 inches by age 6. Bluegills were in average condition; relative weights averaged 89.1.

Black Crappies were abundant in Spring Lake in 2018 with a total of 941 fish collected. Lengths ranged from 4.1-12.3 inches and ages ranged from 2-8 years. Black Crappie growth is average with fish averaging 8.0 inches at age 4, 9.3 inches at age 5, and 10.2 inches at age 6. The PSD, PSD-9, and PSD-P values were 34, 12, and 4, respectively. The Black Crappie age frequency declines after age 4 when fish reached a suitable size for harvest. Black Crappies were in good condition; relative weights averaged 92.6

Largemouth Bass present with a total of 88 unique fish sampled. The SE2 catch rate of Largemouth Bass was 7.0 fish/mile, which was above the median for the lake class (Complex Riverine) but relatively poor compared to other area lakes. Lengths ranged from 5.7-18.4 inches, ages ranged from 2-7 years, and 17% of the total Largemouth Bass catch was ≥14 inches (minimum harvest size). Largemouth Bass growth was average overall, but Spring Lake has the highest mean length at age 6 of any lake in Columbia and Sauk counties at 15.6 inches. Largemouth Bass were in excellent condition; relative weights averaged 104.9.

Walleyes have not been not stocked recently in Spring Lake, but 64 unique Walleyes were sampled in 2018, 44 of which were ≥ 15 inches (1.8 adults/acre). Lengths ranged from 7.1-24.5 inches and ages ranged from 1-10 years. The Walleyes in Spring Lake were a mixture of fish that migrated up the Fox River from Swan Lake as well as fish that escaped Park Lake via the dam. Walleyes in Spring Lake exceeded the minimum length limit by age 3 when they averaged 16.5 inches. Fifty-four Walleyes ≥ 12 inches were marked with Floy tags and Walleyes were documented moving from Spring Lake to Swan Lake and vice versa. Walleyes were in good condition; relative weights averaged 96.8.

Northern Pike were present with a total of 46 unique fish sampled. Lengths ranged from 15.5-29.1 inches, ages ranged from 1-5 years, and 20% of the Northern Pike sampled were larger than the minimum harvest size (26 inches). Northern Pike growth was average to above average in Spring Lake compared to region and statewide averages for mean length at age and some Northern Pike exceed 26 inches by age 3. Northern Pike were in good condition; relative weights averaged 98.4.

Common carp and Gizzard Shad were both common in 2018 and both likely contribute to reduced water clarity and quality in Spring Lake.

Physical/Chemical attributes:

Morphometry: 24 acres, maximum depth of 32 feet, mean depth of 14 feet, and 1.29 miles of shoreline (1970 WDNR Lake Map)
Watershed: 57 square miles, including 10 acres of adjoining wetland (Poff and Threinen 1965)
Lake type: Drainage, seepage
Water clarity: Turbid
Littoral substrate: 65% muck, 35% sand
Aquatic vegetation: Eurasian water milfoil present (1995 voucher), 7 other species present (1978 survey). No recent aquatic vegetation survey data available.
Winterkill: Infrequent
Boat landing: One paved ramp with parking for up to five vehicles with trailers; electric trolling motors only, no gas engines permitted on the lake.
Other features: Fishing regulations follow general statewide regulations for all gamefish and rough fish (Table 1).

Purpose of Survey

Tier 1 assessment baseline lake survey

Dates of fieldwork

Fyke netting survey conducted March 20 through April 2, 2018 (SN1).
Electrofishing surveys conducted April 22 (SE1) and May 22, 2018 (SE2).

Fishery

Bluegill and Black Crappie are common. Walleye, Yellow Perch, Northern Pike, Largemouth Bass, Pumpkinseed, Muskellunge, and Channel Catfish are present. Other non-sportfish species included Bigmouth Buffalo, Bowfin, Common Carp, Freshwater Drum, Gizzard Shad, Golden Shiner, Highfin Carpsucker, Quillback Carpsucker, White Sucker, Yellow Bass, and Yellow Bullhead.

BACKGROUND

Spring Lake is a 24-acre drainage and seepage lake located in Pardeeville, Wisconsin. It has a maximum depth of 32 feet, an average depth of 14 feet, and 1.3 miles of shoreline including the outlet channel to the Fox River. Spring Lake receives discharge from Park Lake via a small hydroelectric dam owned and operated by the Village of Pardeeville. Spring Lake outlets to the Fox River approximately 0.9 river miles downstream of the Park Lake Dam. From there, the Fox River flows for four miles through a large wetland complex down to where the Fox River enters Swan Lake. There is no water control structure on Spring Lake. The single public access point on Spring Lake is located on the south shore consisting of a small parking area, boat ramp, and fishing pier. No gas-powered boat motors are allowed on Spring Lake. The Pardeeville sewage treatment plant is located near the south shore of the lake. Around 23 homes are located along the northern shore of the lake, but the remainder of the shoreline is undeveloped.

In 1970, Spring Lake was chemically treated for carp with rotenone as part of the Fox River Project, with a total of 1,650 lbs. of carp removed. In addition, 750 lbs. of suckers and 5,200 lbs. of panfish and gamefish were also removed. Spring Lake was restocked with panfish and gamefish in 1970 and 1971, including Northern Pike, Walleye, Yellow Perch, Bluegill, “sunfish”, and Largemouth Bass (Table 2). More recent stockings included 100 fingerling tiger Muskellunge (Northern Pike x Muskellunge hybrid) in 1988, 250 large fingerling Smallmouth Bass in 1996, and low numbers of various panfish and gamefish species of private hatchery origin from 2012-2019 (Table 2). The Pardeeville Lakes Management District provides annual funding for the stocking of Park and Spring lakes with the funding allocated mainly to Park Lake (90%) with the remainder going to Spring Lake (10%).

Nutrient input from the Pardeeville sewage treatment plant was identified as having a detrimental effect on water quality in Spring Lake in the late 1970s, specifically contributing to high biological oxygen demand (BOD). This effect was most pronounced in summer when areas of the lake as shallow as 10 feet in depth became anoxic. Efforts were made to require the Village of Pardeeville to maintain a constant flow of water through the hydroelectric generation unit on Park Lake to provide a constant supply of oxygenated water flowing into Spring Lake.

A fisheries survey consisting of late spring fyke netting and electrofishing was conducted in late May and early June 1978. The lake was dominated by panfish; three nights of fyke netting with 5 nets, along with 1.8 hours of night electrofishing produced a catch of 563 bluegill, 378 Pumpkinseed, 265 Green Sunfish, 164 Black Crappie, and 45 Yellow Perch. Predatory game fish were present in relatively low abundance, with 28 Largemouth Bass, 10 Northern Pike, and one Walleye caught. Black Bullheads were common, while Bowfin, Brown Bullhead, Common Carp, Golden Shiner, Longnose Gar, Rock Bass, Warmouth, White Sucker, Yellow Bass, and Yellow Bullhead were present. Seven aquatic plant species were identified during the 1978 survey. *Elodea* and *Ceratophyllum* (coontail) were abundant, *Nymphaea* (water lily), *Lemna* (duckweed), and *Potamogeton crispus* (curly-leaf pondweed) were common, and *Typha* (cattail) and *Juncus* (rushes) were scarce.

A single night of electrofishing with a mini-boom shocker on September 28, 2004 was conducted to investigate effects of a possible winterkill the previous winter. While it was noted that the lake was “alive with fish, too many to collect”, relatively few fish were collected. The catch included 89 Bluegill, 16 Largemouth Bass, eight Walleyes, and a single Northern Pike. Also present in low abundance were Black Crappie, Bowfin, Common Carp, Freshwater Drum, Gizzard Shad, Golden Shiner, Pumpkinseed, Quillback Carpsucker, White Sucker, Yellow Bass, and Yellow Perch. Age and growth analysis in 2004 concluded that Bluegill exhibited average growth to age 3 (5.3-inch average) but were below average growth at age 5 (6.0-inch average). The small sample of Largemouth Bass indicated average growth to about 12 inches by age 4, with a 20.5-inch individual aged at 10 years.

METHODS

<u>Data collection-spring netting and electrofishing</u>

Spring Lake was surveyed concurrently with Swan Lake in 2018 due to their proximity to each other and the open connection provided by the Fox River that allows fish to move freely between the lakes. Following ice-out, four standard 3-foot frame fyke nets with circular hoops, 0.7-inch bar, and 1.4-inch stretch mesh were set on March 20, 2019. Two nets were moved to new locations on March 23, and one net was moved to a new location on March 25. One net was removed on March 29, and the remaining three nets were removed on April 2. The fyke nets targeted Northern Pike and Walleye (SN1) and total effort was 84 net nights. Fyke net descriptions and locations (GPS coordinates) can be found in Table 3.

Gamefish, as defined in Wisconsin Statutes Chapter 29.001 (41), includes all varieties of fish except rough fish and minnows. Panfish are therefore gamefish, and by definition in Wisconsin Statutes Chapter 20.03 (29), panfish includes Yellow Perch, Bluegill, Black Crappie, White Crappie, Pumpkinseed, Green Sunfish, Warmouth, and Orangespotted Sunfish (Orangespotted Sunfish are not present in Swan Lake). For the purposes of this report, sport fish refers to a subset of gamefish including Walleye, Northern Pike, Muskellunge, Largemouth Bass, Smallmouth Bass, and Channel Catfish.

Gamefish were measured to the nearest 0.1 inch and a subsample of each species was weighed to the nearest 0.01 pound. Aging structures were taken from a subsample of Bluegills, Black Crappies, Largemouth Bass, Northern Pike, and Walleyes. The type of structure removed from each species is listed in Table 4. The goal was to take structures from 5 fish per half-inch group for Bluegills, Black Crappies, and Largemouth Bass, and 5 structures per half-inch group for each sex for Northern Pike and Walleye. Sex was recorded when evident for Northern Pike and Walleye. All captured Walleyes were marked with a top caudal fin clip for the population estimate (PE). Northern Pike were also marked with a top caudal fin clip. Largemouth Bass ≥ 8 inches were marked with a top caudal fin clip and those ≤ 8 inches were marked with a bottom caudal fin clip. Walleyes ≥ 12 inches were marked with Floy FD-94 T-bar anchor tags in both Swan and Spring lakes in 2018. This was done to learn more about Walleye movement in the upper Fox River system between Swan and Spring lakes, as well as potential movement from Swan Lake downstream to Buffalo Lake, Lake Puckaway, and beyond.

A WDNR standard direct current (DC) boom shocker boat was used to sample fish on Spring Lake with the first electrofishing survey occurring on the night of April 22 (SE1) to recapture Walleyes that were marked during SN1, and to mark Largemouth Bass for a population estimate. Electrofishing output was 220 volts at 19 amps with pulse rate set at 58 cycles per second, and the duty cycle was 25%. The entire shoreline was sampled, and all sport fish were collected and measured to the nearest 0.1 inch. Hard structures were removed, and fish were weighed as needed to fill out length bins for age and growth analysis. Walleyes were examined for marks for calculation of the PE. Largemouth Bass were marked with fin clips as described above.

The late-spring electrofishing survey (SE2) occurred on May 22, 2019. Electrofishing output ranged from 195 volts at 20 amps with pulse rate set at 60 cycles per second, and the duty cycle was 25%. The entire shoreline was sampled beginning and ending at the public boat landing and all species were collected except for common carp which were counted but not dipped. All fish collected were measured to the nearest 0.1 inch. Aging structures were taken, and weights were recorded from gamefish and panfish as necessary to fill out length bins. Largemouth Bass were examined for marks.

Data Analysis

Too few Walleyes were collected during SE1 and too few Largemouth Bass were collected during SE2 for calculation of a PE for either species. Various data analyses were completed using both Microsoft Excel and R (version 3.5.1) combined with R Studio (version 1.1.136). For SN1, SE1, and SE2 total catch and catch-per-unit of effort (CPUE) was calculated by gear type for all species. Length frequency distributions were generated for gamefish species of interest. Length range and mean, median, and mode lengths were also calculated for gamefish species of interest. Proportional size distribution (PSD), proportional size distribution of fish sizes often acceptable for harvest (PSD-H, either socially acceptable or legally acceptable under current fishing regulations), and proportional size distribution of preferred length fish (PSD-P) were calculated for all gamefish species with more than 100 stock size individuals collected (Anderson and Neumann 1996, Guy et al. 2007). Length designations for stock, quality, harvestable, preferred, memorable, and trophy sizes of the gamefish species collected from Spring Lake can be found in Table 5; these values were used for calculation of proportional size distributions (Anderson and Neumann 1996, Guy et al. 2007). For Bluegills, proportional size distribution calculations are reported separately for fyke netting and electrofishing due to possible bias, with fyke nets being selective for larger Bluegills (Laarman and Ryckman 1982).

Ages were estimated from calcified structures for a subsample of each species, and age and size data of these fish were used to generate age-length keys and ages were assigned to all fish sampled to estimate the age frequency of the population based on the aged subsample (Isermann and Knight 2005). Age frequency distributions were then generated for each species. Once age frequency distributions were completed for each species, inferences were made about year class strength and mortality when possible. Catch curves were generated for species exhibiting consistent recruitment for calculation of total annual mortality rates. Mean length-at-age was used to make inferences about growth of fish in Spring Lake by comparing the lake to area, regional, and statewide averages. Area averages are calculated from mean length at age values from lakes managed out of the Poynette Fisheries office and surveyed from 2008-2019. Area and regional comparisons are helpful for anglers who are interested in knowing which of the lakes in their area that they might fish in a given day offer the fishing potential for a certain species.

Lakes classification systems have been developed by several states, and newly developed lake classes and comparison tools offer an opportunity not previously available for Wisconsin lakes. After several years of study by several DNR scientists, around 6,000 Wisconsin lakes were grouped into 15 classes based on the fish community in the lake (simple or complex), temperature (cool, warm, harsh), clarity (clear or dark), and hydrology (riverine, two story, trout pond) (Rypel et al. 2019). Comparing fishery performance of a given lake to others within its lake class will help guide future management as well as help to inform members of the public by shaping more realistic expectations of how the fishery in that lake should perform. For instance, one should not expect a Simple-Warm-Dark lake to offer the same fishing experience as a Complex Riverine lake.

Mean length-at-age was calculated using methods outlined in Bettoli and Miranda (2001), with the formula listed here:

$$\overline{Li} = (\sum N_{ij}\bar{l}_{ij})/N_i$$

Where $\overline{L}_i$ represents the mean length of the *i*th age group, $N_{ij} = N_j(\frac{n_{ij}}{n_j})$, N_j is the number of fish in the *j*th length group, n_{ij} = number of fish of the *i*th age group subsampled in the *j*th length group, n_j is the number of fish subsampled in the *j*th length group, and $N_i = \sum N_{ij}$ over all *j* length groups. The inputs to this equation are derived from the length frequency distribution of the sample and the age-length key. The midpoints of each length group were used for the values of $\bar{l}_{ij}$. The mean length at age 6 (MLA-6) is a metric used to compare growth in Largemouth Bass populations in Wisconsin, and this metric was calculated for Spring Lake and compared to values for several other lakes in Columbia and Sauk counties sampled since 2010.

Relative weights were calculated to evaluate body condition of fish. Relative weight (W_r) is a tool that compares the length of the fish to an expected weight for that length. Standard weights were calculated for individuals of each species that had weights recorded and standard weights were only calculated for individuals larger than the minimum recommended length for each species. (Murphy et al. 1991, Anderson and Neumann 1996). Relative weights for each fish were calculated by dividing a fish's actual weight by the standard weight for a fish of that length. Average relative weight was then calculated for each species, and for each sex separately when sex data were available. Relative weight values between 75 and 100 indicate normal weight for a given length. A relative weight value greater than 100 indicates that a fish is in excellent condition. A relative weight value less than 75 indicates that a fish is in poor condition.

RESULTS AND DISCUSSION

General Fish Community

In total, 7,345 fish representing 26 species and hybrids from 11 families were sampled during spring netting and electrofishing on Spring Lake in 2018. Catch and CPUE by gear type are shown for each species collected in Table 6. Size structure statistics are presented in Table 7.

Bluegill

In total, 5,378 Bluegills were collected during the spring; the catch rates were 111.4 fish/net night during SN1 and 32.0 fish/mile of shoreline during SE2 (Table 6). The SE2 catch rate ranked in the 24th percentile statewide; Bluegills are relatively low in abundance in Spring Lake compared to other lakes in Wisconsin. When compared to lakes within the same lake class (Complex Riverine) the 2018 Spring Lake CPUE value falls below the median CPUE of 39 fish/mile, although the average of the past two surveys (59.5 fish/mile for 2011 and 2018) remains well above the median (Figure 1). Size-specific electrofishing catch rates in 2018 were down across the board when compared to 2011 leaving Spring Lake near the bottom of the pack compared to other area lakes (Table 8). In total, 1,837 Bluegills collected during SN1 and SE2 were measured and aging structures (otoliths) were taken from a subsample of 54 fish. Overall, lengths ranged from 2.6 to 8.2 inches with mean and median lengths of 5.5 and 5.4 inches, respectively (Table 7). Summaries of length data are reported separately for each sampling period in Table 7. The length frequency distribution for Bluegills is presented in Figure 2. Too few Bluegills were collected during SE2 for meaningful PSD calculations. The PSD, and PSD-7, and PSD-P values from SN1 were 33, 7, and <1, respectively (Table 7).

Bluegill mean length-at-age in Spring Lake in 2018 was very close to area and state averages all ages (Figure 3). Bluegills in Spring Lake begin to exceed 7 inches by age 4, but don't average over 7 inches until age 6. The drop in numbers after age 3 doesn't necessarily coincide with the fish reaching an attractive size for harvesters; age 4 Bluegills only averaged 6.6 inches. The turbid nature of Spring Lake coupled with an abundant Gizzard Shad population may help to limit Bluegill growth. Ages ranged from 2 to 7 years, with age 3 fish being the most common (75.6%) and numbers at age declining steeply thereafter as presented in Figure 4. The lack of missing year classes for ages 3 and older indicates recruitment is likely steady and total annual mortality after age 3 was 70% based on the catch curve (Figure 5).

Overall, Bluegills larger than 3 inches were in good condition with a mean relative weight of 89.1; relative weights are presented in Figure 6. Relative weight appeared to be highly variable for Bluegills measuring three to five inches, and this is relatively common among area Bluegill populations. Twelve Bluegills had relative weights ≥ 100 indicating excellent condition and 8 Bluegills had relative weights ≤ 75 indicating poor condition. Bluegills in poor condition ranged from 3.2-5.3 inches and were part of the group of smaller fish that had highly variable relative weights.

Black Crappie

In total, 951 Black Crappies were collected during the spring; the catch rates were 19.6 fish/net night during SN1 and 10.0 fish/mile of shoreline during SE2 (Table 6). These values were slightly lower than the SN1 and SE2 catch rates observed in 2011 (24.5 fish/net night and 19.2 fish/mile). In total, 845 Black Crappies collected during SN1 and SE2 were measured and aging structures (otoliths) were taken from a subsample of 63 fish collected during SN1. Overall, lengths ranged from 4.1 to 12.3 inches with mean and median lengths of 7.4 and 7.4 inches, respectively (Table 7). Summaries of length data are reported separately for each sampling period in Table 7. The length frequency distribution for Black Crappies is presented in Figure 7. The PSD, and PSD-7, and PSD-P values for all crappies were 34, 12, and 4, respectively (Table 7).

Black Crappie mean length-at-age in Spring Lake in 2018 was very close to state averages but slightly below area averages for all ages (Figure 8). Black Crappies in Spring Lake begin to exceed 10 inches as early as age 3, but growth is not that fast for most fish. Black Crappies averaged 8.0 inches at age 4, 9.3 inches at age 5, and 10.2 inches at age 6. Recruitment appears to be steady with no missing year classes noted in the age frequency distribution for fish collected during SN1 (Figure 9). The drop in numbers after age 4 coincided with the fish reaching an attractive size for anglers to harvest, and the total annual mortality rate after age 4 was 69.2% based on the catch curve (Figure 10). The total annual mortality value closely matched the observed value for Swan Lake in 2018 (73.0%).

Overall, Black Crappies larger than 4 inches were in good condition with a mean relative weight of 92.6; relative weights are presented in Figure 11. Relative weight appeared to be highly variable for Black Crappies measuring four to six inches, and this is relatively common among area Black Crappie populations. Thirteen Black Crappies had relative weights ≥ 100 indicating poor condition and only three Black Crappies had relative weights ≤ 75 indicating poor condition.

Largemouth Bass

Largemouth Bass was the fourth most abundant sport fish species sampled during the survey. In total, 91 Largemouth Bass were collected including recaptures; catch rates were 1.4 fish/net night during SN1, 13.3 fish/mile during SE1, and 7.0 fish/mile during SE2 (Table 6). The total SE2 catch rate in Spring Lake put it near the bottom compared to other lakes in Columbia and Sauk counties (Table 9). However, when compared to the rest of its lake class (Complex Riverine), Spring Lake compared much more favorably, placing well above the median SE2 catch rate of 3.7 fish/mile (Figure 12). The catch rate of fish ≥ 8 inches (CPUE8; stock size) during SE2 was 6.0 fish/mile, and this ranked in the 52^{nd} percentile (middle of the pack) in a comparison of lakes across several Wisconsin drainage basins, but once again ranked near the bottom compared to lakes in Columbia and Sauk counties (Table 9). The two-county comparison is a bit misleading however, as Columbia and Sauk counties are home to several lakes with high to extremely high bass abundance.

Lengths of 88 unique Largemouth Bass ranged from 5.7 to 18.4 inches, and the mean and median lengths were 10.8 and 10.2 inches, respectively (Table 7). The length frequency distribution is presented in Figure 13. Too few Largemouth Bass were collected for calculation of PSD values, and too few Largemouth Bass were marked and recaptured for calculation of a population estimate. However, it should be noted that 17% of bass sampled (n = 15) were larger than the 14-inch minimum length limit. Also, recapture of fin-clipped Largemouth Bass in Swan Lake on March 28, 2018 (the first lift-day of SN1 in Swan Lake) indicated that there was movement of Largemouth Bass from Spring Lake to Swan Lake in early spring 2018 (no bass had yet been marked in Swan Lake).

Largemouth Bass growth was nearly equal to area and state averages through age 6 but was lower than the state average and near the area average for ages 7-10 (Figure 14). However, mean length-at-age values for ages 5 and older were based on low numbers of fish within each age class, and ages 7-9 saw high variability in length within each age. Some Largemouth Bass reached legal harvest size in Spring Lake (14 inches) at age 5, and age 6 Largemouth Bass averaged 15.6 inches, the highest mean length at age 6 value among Columbia and Sauk County lakes surveyed since 2009 (Table 10).

Age 3 was the most common age in the age frequency distribution in 2019 (41%), with numbers at age dropping steadily thereafter through age 10 (Figure 15). It should be noted that the SN1 catch was dominated by smaller bass (8-11 inches), and that most of the bass sampled during SN1 were caught in the first few days of netting, with numbers tailing off for the remainder of the netting period. The Largemouth Bass catch was then dominated by larger fish during SE1 and SE2. Those observations coupled with the appearance of fin-clipped bass in Swan Lake prior to any fish being marked there suggested that bass (especially younger bass) may have used Spring Lake as a wintering area and then migrated back to Swan Lake shortly after ice-out. Declines in number at age did not coincide with fish reaching harvest size, and the age frequency may not be indicative of the year-round bass population in Spring Lake, therefore total annual mortality was not estimated.

Largemouth Bass in Spring Lake were in excellent condition; relative weights averaged 104.6. No fish had a relative weight below 75, and 78% of weighed fish had relative weights greater than 100. Excellent body condition of Largemouth Bass may be attributed to the diverse and abundant forage base found in the lake. There was no apparent relationship between fish length and relative weight, and relative weights are presented in Figure 16.

<u>Walleye</u>

Walleyes are not stocked in Spring Lake but are found there due to the lake's connections to stocked Walleye lakes both upstream and downstream. Walleyes may move freely back and forth between Swan Lake and Spring Lake via the Fox River. Walleyes may also pass downstream from Park Lake to Spring Lake by passing into the Fox River through the main dam that forms Park Lake. Walleyes that pass through this dam may then freely swim to either Spring Lake or Swan Lake. It is unclear whether Walleyes can pass safely downstream through the second outlet on Park Lake, a small hydroelectric generation structure that discharges directly into Spring Lake.

The total Walleye catch during spring netting and electrofishing in 2018 was 75 fish including recaptures; catch rates were 1.1 fish/net night during SN1, 5.0 fish/mile during SE1, and 16.0 fish/mile during SE2 (Table 6). Walleye was the fifth most abundant sport fish species by number collected during the survey (Table 6). Too few Walleyes were marked and subsequently recaptured to provide a meaningful population estimate. However, 44 unique Walleyes ≥ 15 inches were sampled during the survey which equated to 1.8 adults/acre, very similar to the adult population estimate in Swan Lake. In total, 54 Walleyes ≥ 12 inches were marked with Floy tags in Spring Lake. Three Walleyes that were originally tagged in Spring Lake were subsequently recaptured in Swan Lake during either SN1 (n = 1 male) or SN2 (n = 2 females). Conversely, three Walleyes that were originally tagged in Swan Lake during SN1 were subsequently recaptured in Spring Lake during SE2 (all females). These recaptures indicated that Walleye movement between Swan and Spring lakes is not uncommon. Downstream movement may be triggered by a search for suitable spawning habitat, with upstream movement occurring post-spawn as spent adults search for good feeding and recovery areas.

In total, 64 unique Walleyes were measured during spring sampling (total catch excluding recaptures) and lengths ranged from 7.1 to 24.5 inches with mean and median lengths of 16.4 and 17.0 inches, respectively (Table 7). The length frequency distribution is presented in Figure 17. In general, Walleye mean length-at-age in Spring Lake was very similar to what was observed in Swan Lake. Walleye mean length-at-age in Spring Lake was greater than or equal to region and state averages for all observed ages, with Walleyes reaching legal harvest size at age 3 when they averaged 16.5 inches (Figure 18). Age 1 Walleyes (6.3%, n = 4) likely came from Swan Lake which was stocked with small fingerlings in 2017. Age 2 fish (17.2%, n = 11) were all escapees from Park Lake as indicated by their left ventral (LV) fin clips which were given prior to the fish being stocked as extended growth fingerlings in the fall of 2016. Age 3 fish were fully recruited to the sampling gear and were the most common in the distribution (25%) with numbers at age declining gradually through age 6 before dropping steeply to ages 7 and older (Figure 19). Recruitment of Walleyes in Spring Lake relies on escapees from Park Lake and immigration of fish from Swan Lake and is too variable for application of a catch curve.

Condition of Walleyes in Spring Lake was good based on relative weights (Figure 20). The average relative weight was 96.8 and 32% of weighed Walleyes had a relative weight ≥ 100 indicating excellent condition. Conversely, zero Walleyes had a relative weight ≤ 75 (poor condition).

Northern Pike

In total, 61 Northern Pike were sampled during the spring including recaptures; the catch rates were 1.0 fish/net night (SN1), 5.0 fish per mile during SE1, and 5.0 fish per mile during SE2 (Table 6). Northern Pike were marked during SN1 but too few fish were subsequently recaptured to calculate a meaningful population estimate. Lengths of 46 unique Northern Pike from all sampling periods ranged from 15.5 to 29.1 inches and the mean and median lengths were 22.6 and 22.9 inches, respectively (Table 7). The length frequency distribution for Northern Pike is presented in Figure 21. Nine Northern Pike (19.5%) were larger than the 26-inch minimum length limit. Mean length-at-age of Northern Pike in Spring Lake is greater than or equal to region and state averages except for age 5 which fell between the region and state average (Figure 22). Northern Pike did not average over 26 inches by age 5 (the oldest pike sampled) but some pike exceeding 26 inches were present for ages 3-5 (Figure 22). Ages ranged from 1 to 5 years, with age 3 fish being the most common (37%) as presented in Figure 23. Recruitments appears to be steady with no missing year classes in the range of observed ages. Declines in the age frequency after age 3 coincided with some Northern Pike reaching legal harvest size.

Condition of Northern Pike was very good; the average relative weight for all fish was 98.4. Relative weights for Northern Pike were generally lower for males which averaged 95.7, while females averaged 107.3 and unknown sex fish averaged 91.6. Forty-two percent of weighed Northern Pike (n = 18) had relative weight values ≥ 100 indicating excellent condition, and zero fish had a relative weight ≤ 75 (poor condition). Relative weights are presented in Figure 24.

<u>Channel Catfish</u>

In total, 50 Channel Catfish were sampled during the spring; the catch rates were 1.0 fish/net night (SN1) and 0.8 fish/mile during SE1 (Table 6). Lengths ranged from 6.3 to 29.7 inches and mean and median lengths were 16.7 and 17.4 inches, respectively (Table 7). The length frequency distribution for channel catfish is presented in Figure 25. Age structures were not collected, and weights were not recorded for channel catfish sampled in Spring Lake, however this information was collected for Swan Lake and that dataset likely provides a suitable representation of mean length-at-age and relative weight for both lakes.

<u>Other Desirable Fish Species and Rough Fish</u>

Pumpkinseed, Yellow Bass, and Yellow Perch were present, and size data for these species are summarized in Table 7. Three Muskellunge were collected during the survey; one during SE1 and two during SE2. All were identified by their PIT tags as age 2 fish that were stocked in Swan Lake on September 21, 2016. Lengths ranged from 19.9-21.6 inches, averaging 20.9 inches. Two of the muskies still had visible RV clips, the secondary mark given to fish in the pellet-started, minnow-finished treatment group from the musky feeding study that ran from 2013-2016. Swan Lake received all pellet-started, minnow-finished muskies during the study.

Common carp catch rates were 0.6 fish/net night during SN1 and 68 fish/mile during SE2. Gizzard shad were abundant with catch rates of 1.4 fish/net night during SN1 and 115 fish/mile during SE2. The Gizzard Shad SE2 catch rate in Spring Lake was more than 42 times greater than in neighboring Swan Lake (2.7 fish/mile).

CONCLUSIONS AND RECOMMENDATIONS

Spring Lake has a diverse fish community compared to most lakes in Columbia and Sauk counties because of its open connection to the Fox River. The fish community is dominated in number by planktivores, but sport fish are not uncommon, and the lake provides a diverse array of fishing opportunities for anglers with only minimal stocking from private sources. There are no impediments to fish movement between Spring Lake and Swan Lake via the Fox River, and seasonal movements of Walleye, Muskellunge, and Largemouth Bass were documented during the 2018 survey, with large-scale movement of Bluegills between the lakes also likely based on catch data. Because of the open connection to Swan Lake and the transient nature of fish within the system, intensive species-specific management is not recommended for Spring Lake. Instead, Spring Lake should fall under the general management regime of Swan Lake, the primary lake in the system, with the understanding that management goals and objectives established for Swan Lake will result in similar impacts in Spring Lake. In terms of abundance metrics, Spring Lake is performing as should be expected relative to the other lakes in its lake class (Complex Riverine). Fyke net catch rates of Walleyes and Northern Pike, as well as electrofishing catch rates of Largemouth Bass and Bluegills were all between the 25^{th} and 75^{th} percentiles for the lake class, with most species being near or above the 50^{th} percentile (median). Supplementing the gamefish populations in Spring Lake by stocking state-raised fish is not needed.

Detrimental species, specifically Common Carp and Gizzard Shad, were common in Spring Lake in 2018 and in past years, and likely contribute to the turbid condition of the lake. Carp churn up bottom sediments through their feeding activities, re-suspending sediment in the water column while also destabilizing the bottom and leading to a loss of rooted aquatic vegetation. Gizzard Shad may also negatively impact water quality when present at high densities by re-suspending phosphorous when they eat detritus which is high in phosphorous and then defecate into the water column. This results in re-suspension of the nutrients which are then available to help fuel algal blooms. These species are common within the Fox River system and any concerted efforts to control them in Spring Lake are not likely to succeed because the populations will simply be replenished from the Fox River.

Bluegill was the most abundant species collected during the survey, although most of those fish were collected in fyke nets on the first day of the survey. The low SE2 catch rate was puzzling considering the unusually high number of Bluegills sampled during SN1. However, more than half of the Bluegills sampled during the entire survey were collected on the first lift day during SN1 when 3,030 Bluegills were collected from four nets (CPUE = 757.5 fish/net night, high net of 1,444 fish). After the first lift day, Bluegill CPUE fell to a more manageable 52.6 fish/net night for the remainder of SN1. One hypothesis is that Spring Lake may serve as a wintering area for Bluegills that come up from the much deeper Swan Lake as well as the Fox River to inhabit a slightly warmer environment in Spring Lake before dispersing back down the Fox River in the spring.

That hypothesis is weakened by the fact that Bluegill growth is so different in Spring Lake compared to Swan Lake. Bluegill growth in Spring Lake is on par with area and state averages, but fish don't begin to exceed 7 inches until age 4, don't average over 7 inches until age 6, and don't begin to exceed 8 inches until age 6 as well. By contrast Bluegills in Swan Lake begin to exceed 7 inches by age 3, average over 7 inches by age 4, and average nearly 8 inches by age 5. Some individuals exceed 8 inches at age 4, and 9 inches at age 5. If most of Bluegills sampled in Spring Lake were truly overwintering fish from Swan Lake, one would expect the growth trajectories for the two lakes to be much more similar. Due to slower growth and poorer size structure in Spring Lake compared to Swan Lake, harvest appears to impact Spring Lake to a lesser degree with total annual mortality after age 3 of 70% in Spring Lake compared to 90% in Swan Lake. Significantly higher Gizzard Shad abundance in Spring Lake compared to Swan Lake may explain some of the difference in Bluegill growth between the lakes. Young Gizzard Shad eat zooplankton and can have a direct negative impact on growth or recruitment of other fish populations, particularly centrarchids, by competing for food with early life stages (Largemouth Bass) or throughout their entire life cycle (Bluegills; Dettmers and Stein, 1992, Aday et al. 2003, Aday et al. 2005).

Black Crappies are common in Spring Lake and appear to be more abundant than in Swan Lake when comparing SN1 catch rates (19.6 fish/net night vs. 0.8 fish/net night). Black Crappie growth is at or slightly below area and state averages throughout life. A higher density population coupled with highly turbid conditions in Spring Lake may help to explain slower growth compared to Swan Lake. Total annual mortality rates are very similar after age 4 when comparing Spring Lake (69.2%) and Swan Lake (73.0%), and both lakes may be facing similar levels of harvest pressure. Anglers have the opportunity to catch the occasional Black Crappie over 12 inches in Spring Lake, but the bulk of the fish anglers are likely to harvest are between 8 and 10 inches.

The Largemouth Bass population in Spring Lake is the product of both natural reproduction and stocking of low numbers of fish from private sources. While the SE2 bass catch rate in 2018 was noticeably lower than 2011, it was still above the median for the lake class; bass are not low in abundance relative to similar lakes. Fin-clipped Largemouth Bass caught in fyke nets in Swan Lake on the first day of SN1 were fish that were caught and marked in Spring Lake one week earlier, and subsequently migrated out of Spring Lake and downstream through the Fox River to Swan Lake. Largemouth Bass growth is average in Spring Lake compared to other lakes in the local area and statewide, and the fishery does provide harvest opportunities for anglers. Largemouth Bass in Spring Lake may face challenges from gizzard shad who compete for zooplankton with young Largemouth Bass that may ultimately impact recruitment or early growth. The highly turbid nature of Spring Lake also provides a challenge by reducing visibility for this sight-feeding predator. These factors may help explain only average growth despite the low-density population and an abundance of forage. Stocking of state-raised Largemouth Bass is not recommended, but private stocking may continue contingent upon review of annual stocking permit applications.

The population of Walleyes in Spring Lake provides a nice opportunity for anglers and is entirely the result of Walleye escapement from Park Lake via the dams and immigration of stocked fish from Swan Lake, both of which were documented in 2018. Despite the lack of intensive management, the Walleye population in Spring Lake is around 1.8 adult Walleyes per acre based on the number of adult fish sampled during the survey, and this number is very similar to Swan Lake. Walleye growth is good in Spring Lake due to abundant forage and Walleyes reach the minimum harvest size of 15 inches by age 3. Walleye stocking in Swan Lake and escapement from Park Lake are enough to maintain the bonus Walleye fishery in Spring Lake, and Walleye stocking is not recommended from either state or private sources.

The Northern Pike population in Spring Lake is the result of natural reproduction and low-level stocking. Northern Pike habitat is actually very good in both Swan and Spring lakes, with both providing deeper cool water refuge areas during summer as well as abundant spawning habitat in the form expansive wetlands connected to the Fox River. Northern Pike in Spring Lake grow quickly due to the diverse and abundant forage community in the lake, and they provide a harvest opportunity for anglers with around 20% of the population exceeding the minimum harvestable size. Northern Pike have not been intensively managed in Spring Lake in the past and based on the results of this survey this should not change. Stocking of state-raised northern Pike is not needed nor is it recommended, but private stocking may continue contingent upon review of annual stocking permit applications.

Other species of note provide additional angling opportunities in Spring Lake. Channel catfish are present and are a mixture of naturally produced and stocked fish, providing anglers with the opportunity to catch individuals up to nearly 30 inches in length. Yellow Bass are common with some individuals exceeding 10 inches. Muskellunge stocked in Swan Lake move up to Spring Lake at times, and although all muskies sampled in Spring Lake in 2018 were juveniles, past surveys indicated the presence of low numbers of adult muskies up to 46 inches in length. A diverse array of native rough fish is present, providing a nice mixed-bag opportunity for anglers as well.

ACKNOWLEDGEMENTS

Fisheries Technicians Scott Harpold, Jody Derks, and Derek Lavigne assisted with field surveys as did Fitchburg Fisheries Team Supervisor David Rowe. Fisheries technicians Kimberly Kuber, Casey Weber, Andrew Notbohm, and Alex Bentz assisted with age estimation. David Rowe and Southern District Fisheries Supervisor Tim Simonson reviewed this manuscript and provided vital feedback which made this a strong report. Thank you all.

REFERENCES

Aday, D. D., R. J. H. Hoxmeier, and D. H. Wahl. 2003. Direct and indirect effects of gizzard shad on bluegill growth and population size structure. Transactions of the American Fisheries Society 132(1): 47-56.

Aday, D. D., D.E. Shoup, J.A. Neviackas, J.L. Kline, and D. H. Wahl. 2005. Prey responses to bluegill and gizzard shad foraging: implications for growth of juvenile largemouth bass. Transactions of the American Fisheries Society 134(5): 1091-1102.

Anderson, R.O., and R.M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in B. R. Murphy and D.W. Willis editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Bettoli, P.W., and L.E. Miranda. 2001. Cautionary note about estimating mean length at age with subsampled data. North American Journal of Fisheries Management 21: 425-428.

Dettmers, J. M., and R. A. Stein. 1992. Food consumption by larval gizzard shad: zooplankton effects and implications for reservoir communities. Transactions of the American Fisheries Society 121(4): 494-507.

Guy, C.S., R.M. Neumann, D.W. Willis, and R.O. Anderson. 2007. Proportional size distribution (PSD): a further refinement of population size structure index terminology. Fisheries 32(7): 348.

Isermann, D.A., and C.T. Knight. 2005. A computer program for age-length keys incorporating age assignment to individual fish. North American Journal of Fisheries Management, 25: 1153-1160.

Laarman, P.W., and J.R. Ryckman. 1982. Relative size selectivity of trap nets for eight species of fish. North American Journal of Fisheries Management 2: 33-37.

Marshall, D.W., M. Otto, J.C. Panuska, S.R. Jaeger, D. Sefton, and T.R. Baumberger. 2006. Effects of hypolimnetic releases on two impoundments and their receiving streams in southwest Wisconsin. Lake and Reservoir Management 22(3): 223-232.

Murphy, B.R., D.W. Willis, and T.A. Springer. 1991. The relative weight index in fisheries management: status and needs. Fisheries 16(2): 30-38.

Rypel, A.L., T.D. Simonson, D.L. Oele, Joanna D.T. Griffin, T.P. Parks, D. Seibel, C.M. Roberts, S. Toshner, L.S. Tate, and J. Lyons. 2019. Flexible classification of Wisconsin lakes for improved fisheries conservation and management. Fisheries 44(5) 225-238.

TABLES AND FIGURES

Table 1. Current fishing regulations for Spring Lake, Columbia County, Wisconsin.

Species	Season Dates	Length and Bag Limits Through 2020
Catfish	Open All Year	No minimum length limit and the daily bag limit is 10.
Panfish (Bluegill, Pumpkinseed, Sunfish, Crappie, and Yellow Perch)	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth Bass and Smallmouth Bass	First Saturday in May through the first Sunday in March	The minimum length limit is 14" and the daily bag limit is 5.
Northern Pike	First Saturday in May through the first Sunday in March	The minimum length limit is 26" and the daily bag limit is 2.
Muskellunge	First Saturday in May through December 31	The minimum length limit is 40” and the daily bag limit is 1.
Walleye, Sauger, and hybrids	First Saturday in May through the first Sunday in March	The minimum length limit is 15" and the daily bag limit is 5.
Bullheads	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Rough fish	Open All Year	No minimum length limit and the daily bag limit is unlimited.

Table 2. Fish stocking history of Spring Lake, Columbia County, Wisconsin.

Year	Species	Strain (Stock)	Age Class	Number Stocked	Average Length (inches)	Source Type
1970	NORTHERN PIKE	UNSPECIFIED	YEARLING AND ADULT	149	15.0	
1970	WALLEYE	UNSPECIFIED	YEARLING	549	9.0	
1970	YELLOW PERCH	UNSPECIFIED	YEARLING AND ADULT	31	9.0	
1971	NORTHERN PIKE	UNSPECIFIED	YEARLING	450	12.0	FIELD TRANSFER
1971	NORTHERN PIKE	UNSPECIFIED	FRY	75,000		DNR HATCHERY
1971	YELLOW PERCH	UNSPECIFIED	ADULT	22,140	4.0	FIELD TRANSFER
1971	BLUEGILL	UNSPECIFIED	ADULT	765	4.0	FIELD TRANSFER
1971	SUNFISH	UNSPECIFIED	ADULT	525	4.0	FIELD TRANSFER
1971	WALLEYE	UNSPECIFIED	FRY	150,000		DNR HATCHERY
1971	LARGEMOUTH BASS	UNSPECIFIED	FRY	6,000	1.0	
1988	NOP X MUE	UNSPECIFIED	FINGERLING	100	9.0	DNR COOP PONDS
1996	SMALLMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	250	4.0	PRIVATE HATCHERY
2006	NORTHERN PIKE	UNSPECIFIED	LARGE FINGERLING	150	13.0	PRIVATE HATCHERY
2012	CHANNEL CATFISH	UNSPECIFIED	LARGE FINGERLING	50	5.0	PRIVATE HATCHERY
2012	NORTHERN PIKE	UNSPECIFIED	YEARLING	50	11.0	PRIVATE HATCHERY
2014	NORTHERN PIKE	UNSPECIFIED	LARGE FINGERLING	10	12.0	PRIVATE HATCHERY
2014	CHANNEL CATFISH	UNSPECIFIED	LARGE FINGERLING	10	5.0	PRIVATE HATCHERY
2015	NORTHERN PIKE	UNSPECIFIED	LARGE FINGERLING	105	12.5	PRIVATE HATCHERY
2015	BLUEGILL	UNSPECIFIED	LARGE FINGERLING	300	4.0	PRIVATE HATCHERY
2015	LARGEMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	55	5.0	PRIVATE HATCHERY
2017	LARGEMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	50	4.0	PRIVATE HATCHERY
2017	NORTHERN PIKE	UNSPECIFIED	LARGE FINGERLING	40	12.0	PRIVATE HATCHERY
2017	YELLOW PERCH	UNSPECIFIED	LARGE FINGERLING	150	4.0	PRIVATE HATCHERY
2017	BLUEGILL	UNSPECIFIED	LARGE FINGERLING	150	4.0	PRIVATE HATCHERY
2019	LARGEMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	140	4.0	PRIVATE HATCHERY
2019	BLACK CRAPPIE	UNSPECIFIED	LARGE FINGERLING	80	3.0	PRIVATE HATCHERY
2019	BLUEGILL	UNSPECIFIED	LARGE FINGERLING	90	4.0	PRIVATE HATCHERY
2019	SMALLMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	100	4.0	PRIVATE HATCHERY
2019	CHANNEL CATFISH	UNSPECIFIED	LARGE FINGERLING	35	6.0	PRIVATE HATCHERY

Table 3. Fyke net descriptions and locations (GPS coordinates) used during SN1 on Spring Lake, Columbia County, Wisconsin in 2018.

Net Number	Lead Length (feet)	Frame Height (feet)	Set Date	Final Lift Date	Latitude	Longitude
1	50	3	03/20/2018	03/23/2018	43.53841	-89.30211
2	50	3	03/20/2018	03/23/2018	43.54009	-89.30185
3	50	3	03/20/2018	03/25/2018	43.54065	-89.30793
4	50	3	03/20/2018	03/29/2018	43.54107	-89.30758
5	50	3	03/23/2018	04/02/2018	43.53932	-89.30524
6	50	3	03/23/2018	04/02/2018	43.53873	-89.30359
7	50	3	03/25/2018	04/02/2018	43.54920	-89.30412

Table 4. Calcified structures used to estimate ages of fish collected during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

Species	Size Category	Structure
Black Crappie	ALL	otolith
Bluegill	ALL	otolith
Largemouth Bass	≤8 inches	scale
Largemouth Bass	≥8 inches	dorsal spine
Northern Pike	ALL	anal fin ray
Walleye	ALL	dorsal spine

Table 5. Length categories (inches) of proportional size distribution (PSD) for selected fish species that were collected from Spring Lake in 2018 (Anderson and Neumann 1996, Guy et al. 2007).

Species	Stock	Quality	Harvest[1]	Preferred	Memorable	Trophy
Bluegill	3	6	7	8	10	12
Black Crappie	5	8	9	10	12	15
Largemouth Bass	8	12	14	15	20	25
Northern Pike	14	21	26	28	34	44
Walleye	10	15	15	20	25	30

[1]Lengths of fish found socially or legally acceptable for harvest by anglers.

Table 6. Summary of catch and catch-per-unit effort (CPUE) by sampling period during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

Species	CATCH SN1	SE1	SE2	Total	CPUE Fish/nn SN1	Fish/mile SE1	Fish/mile SE2	Fish/hr. SE1	Fish/hr. SE2
Bluegill	5,346		32	5,378	111.4		32.0		53.3
Black Crappie	941		10	951	19.6		10.0		16.7
Gizzard Shad	66		115	181	1.4		115.0		191.7
Yellow Bullhead	131		0	131	2.7		0.0		0.0
Pumpkinseed	99		2	101	2.1		2.0		3.3
Common Carp	27		68	95	0.6		68.0		113.3
Largemouth Bass	68	16	7	91	1.4	13.3	7.0	32.0	11.7
Walleye	53	6	16	75	1.1	5.0	16.0	12.0	26.7
Yellow Bass	51		16	67	1.1		16.0		26.7
Northern Pike	50	6	5	61	1.0	5.0	5.0	12.0	8.3
Channel Catfish	49	1	0	50	1.0	0.8	0.0	2.0	0.0
Quillback Carpsucker	19		16	35	0.4		16.0		26.7
White Sucker	24		9	33	0.5		9.0		15.0
Freshwater Drum	13		11	24	0.3		11.0		18.3
Green Sunfish	22		0	22	0.5		0.0		0.0
Yellow Perch	9		3	12	0.2		3.0		5.0
Pumpkinseed x Bluegill hybrid	10		0	10	0.2		0.0		0.0
Rock Bass	6		0	6	0.1		0.0		0.0
Black Bullhead	4		1	5	0.1		1.0		1.7
Bigmouth Buffalo	3		1	4	0.1		1.0		1.7
Longnose Gar	2		2	4	0.0		2.0		3.3
Muskellunge	0	1	2	3	0.0	0.8	2.0	2.0	3.3
Bowfin	2		0	2	0.0		0.0		0.0
Grass Pickerel	2		0	2	0.0		0.0		0.0
Brown Bullhead	0		1	1	0.0		1.0		1.7
Golden Shiner	0		1	1	0.0		1.0		1.7
Totals	6,997	30	318	7,345					

Table 7. Summary of lengths (inches), PSD, ages, and relative weight of fish sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

Species	Period1	n Unique fish	n Measured	Length Range	Mean Length	Median Length	Mode Length	PSD	PSD-H	PSD-P	Age Range	Mean Relative Weight
Bluegill	SN1	5,346	1,805	3.1-8.2	5.5	5.4	5.0	33	7	<1		
Bluegill	SE2	32	32	2.6-6.5	4.2	4.0	3.5					
Bluegill	ALL	5,378	1,837	2.6-8.2	5.5	5.4	5.0	33	7	<1	2-7	89.1
Black Crappie	SN1	941	835	4.1-11.4	7.4	7.4	7.2	34	12	4		
Black Crappie	SE2	10	10	6.8-12.3	8.5	7.3						
Black Crappie	ALL	951	845	4.1-12.3	7.4	7.4	6.9	34	12	4	2-8	92.6
Largemouth Bass	SN1	66	66	5.7-17.7	9.9	9.7	9.6					
Largemouth Bass	SE1	15	15	10.5-18.4	14.1	14.9	12.1					
Largemouth Bass	SE2	7	7	7.7-17.3	12.7	14.3						
Largemouth Bass	ALL	88	88	5.7-18.4	10.8	10.2	9.6				2-11	104.9
Walleye	SN1	45	45	7.1-24.5	15.6	16.5	17.0					
Walleye	SE1	5	5	15.9-24.4	19.6	18.5						
Walleye	SE2	14	14	7.1-22.4	18.1	18.4	22.4					
Walleye	ALL	64	64	7.1-24.5	16.4	17.0	17.0				1-10	96.8
Northern Pike	SN1	37	37	14.8-29.7	23.8	24.3	23.6					
Northern Pike	SE1	4	4	15.1-29.1	21.6	21.9						
Northern Pike	SE2	5	5	10.6-19.1	15.5	15.8						
Northern Pike	ALL	46	46	15.5-29.1	22.6	22.9					1-5	98.4
Pumpkinseed	ALL	101	98	3.5-6.3	4.7	4.6	3.6					
Yellow Bass	ALL	67	62	3.3-11.2	7.3	8.0	8.3					
Channel Catfish	ALL	50	50	6.3-29.7	16.7	17.4	18.4					
Yellow Perch	ALL	12	12	3.0-7.0	5.2	5.5	5.7					

Table 8. Size-specific CPUE of Bluegills from spring electrofishing surveys of lakes in Columbia, Sauk, and northwestern Dane counties, 2011-2019 and the lake class 25th, 50th (median), and 75th percentile CPUE values for Complex Riverine lakes.

Lake[1]	County	Survey Year	Gear Type	ALL	CPUE3	CPUE6	CPUE7	CPUE8	CPUE9	CPUE10
Silver	Columbia	2016	Big Boom	338.2	337.3	4.9	0.0	0.0	0.0	0.0
Tarrant	Columbia	2018	Miniboom	267.0	263.0	37.0	22.0	7.0	0.0	0.0
Blass	Sauk	2017	Miniboom	190.0	131.3	50.0	27.3	1.3	0.0	0.0
White Mound	Sauk	2013	Big Boom	155.0	149.0	52.0	32.0	21.0	7.0	0.0
Mirror	Sauk	2014	Big Boom	143.3	141.3	62.0	14.7	0.0	0.0	0.0
Dutch Hollow	Sauk	2016	Big Boom	141.3	130.7	69.3	30.7	6.0	0.7	0.0
Fish	Dane	2015	Big Boom	135.0	135.0	46.0	8.0	0.0	0.0	0.0
Seeley	Sauk	2016	Miniboom	134.6	129.8	93.0	15.8	0.0	0.0	0.0
Mud (Marx Pond)	Dane	2015	Miniboom	120.7	102.0	38.0	0.0	0.0	0.0	0.0
White Mound	Sauk	2019	Big Boom	102.0	81.0	48.0	22.0	7.0	2.0	0.0
George	Columbia	2013	Miniboom	101.0	90.9	53.5	19.2	0.0	0.0	0.0
West	Columbia	2019	Miniboom	86.7	65.3	2.7	1.3	0.0	0.0	0.0
Crystal	Dane	2015	Big Boom	79.3	79.3	62.0	28.7	0.0	0.0	0.0
Swan	Columbia	2018	Big Boom	74.0	74.0	38.7	6.7	0.7	0.0	0.0
Park	Columbia	2011	Big Boom	60.0	57.0	9.0	1.0	0.0	0.0	0.0
Wisconsin	Col/Sauk	2017	Big Boom	59.8	58.8	29.0	15.0	1.2	0.0	0.0
Virginia	Sauk	2016	Miniboom	53.9	46.1	38.8	26.7	4.2	1.2	0.6
Spring	**Columbia**	**2018**	**Big Boom**	**32.0**	**31.0**	**2.0**	**0.0**	**0.0**	**0.0**	**0.0**
Crystal	Columbia	2014	Miniboom	20.0	9.5	2.9	2.9	2.9	1.9	0.0
Delton	Sauk	2014	Big Boom	18.0	18.0	7.0	1.0	0.0	0.0	0.0
Devils	Sauk	2013	Big Boom	12.0	12.0	6.0	3.0	3.0	2.0	0.0
Area Mean				120.7	111.2	38.9	14.4	2.7	0.7	0.0
Area Median				101.0	81.0	38.7	14.7	0.0	0.0	0.0
Lake Class 25th Percentile				14.8						
Lake Class Median				39.0						
Lake Class 75th Percentile				128.5						

[1]The Crystal Lake surveyed in 2014 was a 28-acre lake located at the Peter Helland Wildlife Area, Town of Wyocena, Columbia County, Wisconsin.

Table 9. Size-specific CPUE of Largemouth Bass from spring electrofishing surveys of lakes in Columbia, Sauk, and northwestern Dane counties, 2011-2019, and the lake class 25th, 50th (median), and 75th percentile CPUE values for Complex Riverine lakes.

Lake[1]	County	Survey Year	Gear Type	CPUE ALL	<8"	8	10	12	14	15	18	20
White Mound	Sauk	2019	Big Boom	273.2	30.0	243.2	190.0	102.4	5.2	2.0	1.6	0.8
White Mound	Sauk	2013	Big Boom	224.8	33.6	191.2	175.6	128.0	62.4	24.4	2.8	0.0
Virginia	Sauk	2016	Miniboom	207.9	6.7	201.2	197.0	172.7	2.4	0.0	0.0	0.0
Crystal (Peter Helland)	Columbia	2014	Miniboom	190.5	5.7	184.8	123.8	23.8	0.0	0.0	0.0	0.0
Tarrant	Columbia	2018	Miniboom	81.0	5.0	76.0	65.0	44.0	31.0	13.0	0.0	0.0
Dutch Hollow	Sauk	2016	Big Boom	79.2	3.0	76.2	68.2	43.3	11.3	5.7	0.7	0.0
Silver	Columbia	2016	Big Boom	71.8	12.7	59.1	45.6	23.0	10.3	5.6	0.0	0.0
Devils	Sauk	2013	Big Boom	55.8	3.9	51.9	45.0	32.2	0.6	0.3	0.3	0.0
George	Columbia	2013	Miniboom	49.5	4.0	45.5	32.3	13.1	1.0	1.0	0.0	0.0
Fish	Dane	2015	Big Boom	35.3	8.9	26.5	25.5	23.9	15.6	10.8	2.1	0.3
Blass	Sauk	2017	Miniboom	32.7	4.0	28.7	23.3	12.0	6.7	2.7	0.0	0.0
Seeley	Sauk	2016	Miniboom	28.1	5.3	22.8	22.8	14.9	8.8	4.4	0.0	0.0
Crystal	Dane	2015	Big Boom	23.7	1.6	22.1	20.3	11.3	7.6	6.0	2.1	0.5
Mud (Marx Pond)	Dane	2015	Miniboom	18.7	14.0	4.7	1.3	0.7	0.0	0.0	0.0	0.0
Mirror	Sauk	2014	Big Boom	18.2	1.2	17.0	15.2	11.2	9.0	6.2	0.3	0.0
Park	Columbia	2011	Big Boom	13.3	5.0	8.3	7.3	4.3	2.8	1.8	0.3	0.3
Wisconsin	Col/Sauk	2017	Big Boom	7.8	1.3	6.5	5.8	5.2	3.7	2.4	0.0	0.0
Delton	Sauk	2014	Big Boom	7.8	0.3	7.5	2.9	1.2	0.2	0.0	0.0	0.0
Swan	Columbia	2018	Big Boom	7.4	0.0	7.0	7.0	5.0	3.9	2.6	0.9	0.4
Spring	**Columbia**	**2018**	**Big Boom**	**7.0**	**1.0**	**6.0**	**4.0**	**4.0**	**4.0**	**3.0**	**0.0**	**0.0**
West	Columbia	2019	Big Boom	2.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area Mean				68.4	7.1	61.2	51.3	32.2	8.9	4.4	0.5	0.1
Area Median				32.7	4.0	26.5	23.3	13.1	4.0	2.6	0.0	0.0
Lake Class 25th Percentile				1.5								
Lake Class Median				3.7								
Lake Class 75th Percentile				14.5								

[1]The Crystal Lake surveyed in 2014 was a 28-acre lake located at the Peter Helland Wildlife Area, Town of Wyocena, Columbia County, Wisconsin.

Table 10. Mean length at age 6 (MLA-6) of Largemouth Bass in lakes in Columbia, Sauk, and northwestern Dane counties surveyed 2009-2019.

Lake	County	Survey Year	MLA-6
Spring	**Columbia**	**2018**	**15.6**
Wisconsin	Columbia/Sauk	2017	15.5
Delton	Sauk	2014	15.4
Swan	Columbia	2018	15.3
Park	Columbia	2011	15.2
White Mound	Sauk	2013	14.8
Wisconsin	Columbia/Sauk	2012	14.7
Swan	Columbia	2009	14.6
Redstone	Sauk	2010	14.5
Lazy	Columbia	2011	14.4
Mirror	Sauk	2014	14.2
Fish	Dane	2015	13.1
Crystal	Dane	2015	13.1
White Mound	Sauk	2019	12.8
Virginia	Sauk	2016	12.5
Dutch Hollow	Sauk	2016	12.2
Devils	Sauk	2013	10.8
Area Mean			14.0
Area Median			14.5

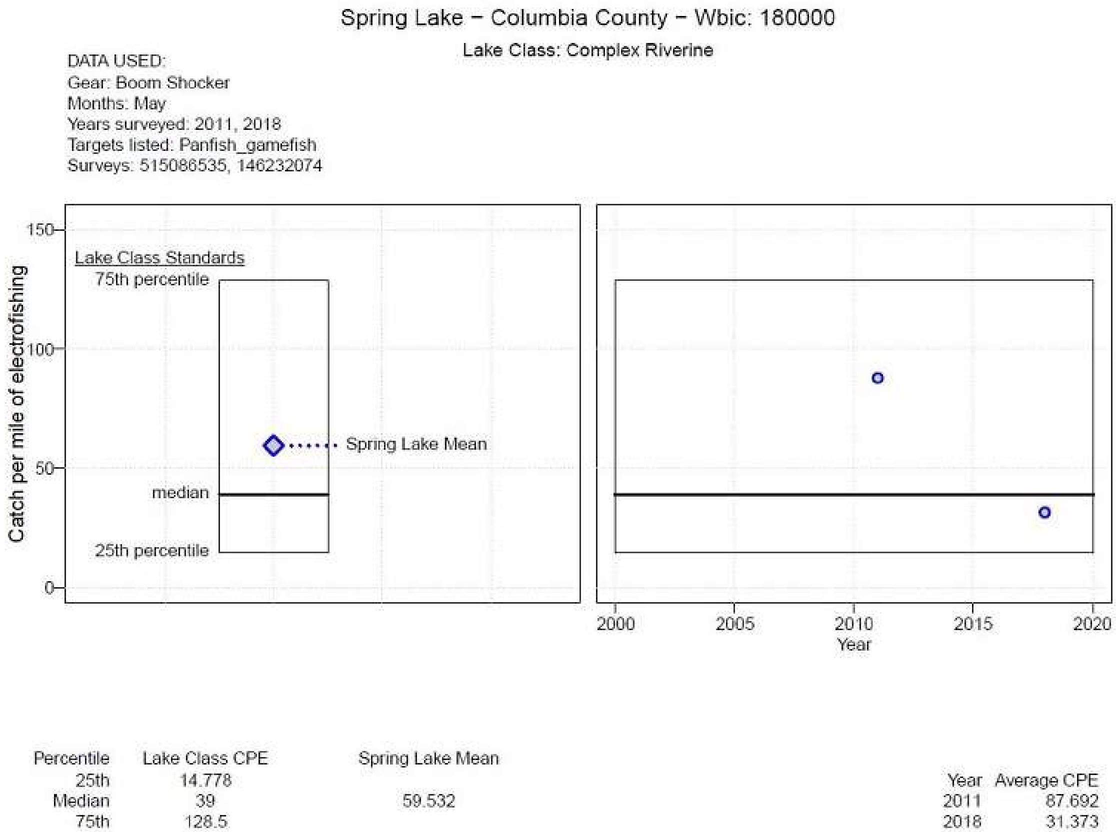


Figure 1. Bluegill SE2 electrofishing CPUE lake class comparison for Spring Lake, Columbia County, Wisconsin. Lake class is Complex Riverine**.**

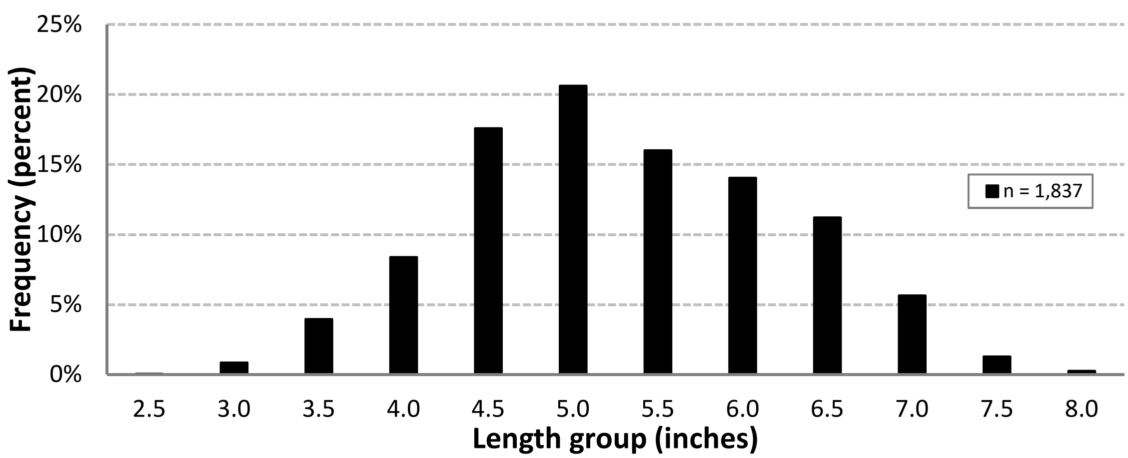


Figure 2. Length frequency distribution of Bluegills sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

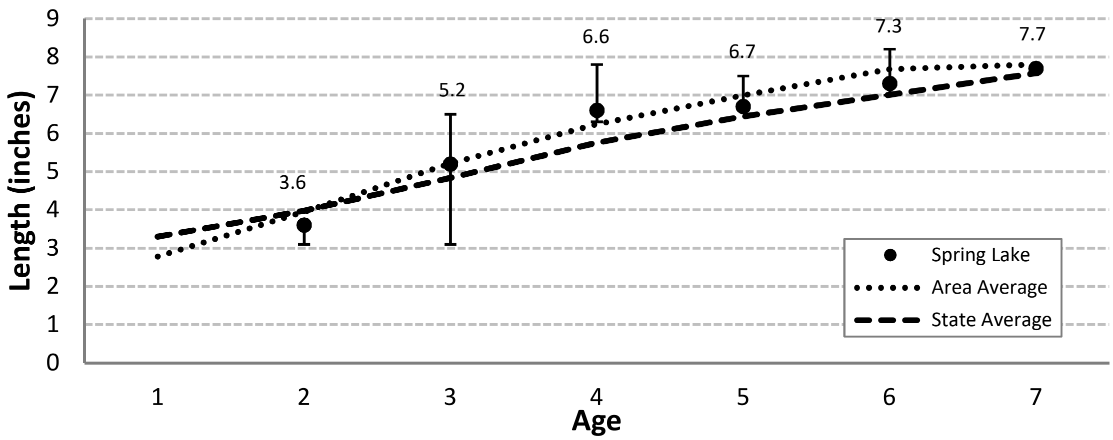


Figure 3. Mean length-at-age of Bluegills sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

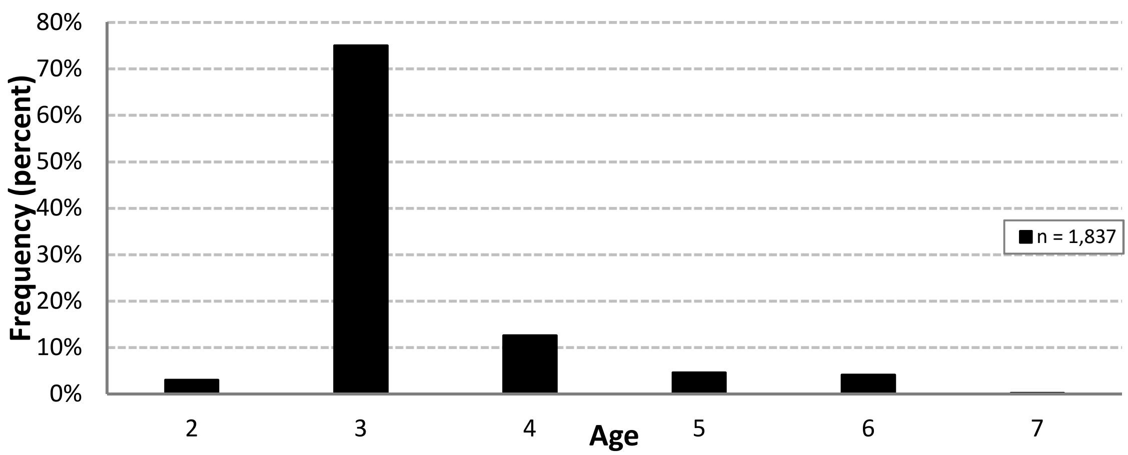


Figure 4. Age frequency distribution of Bluegills sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

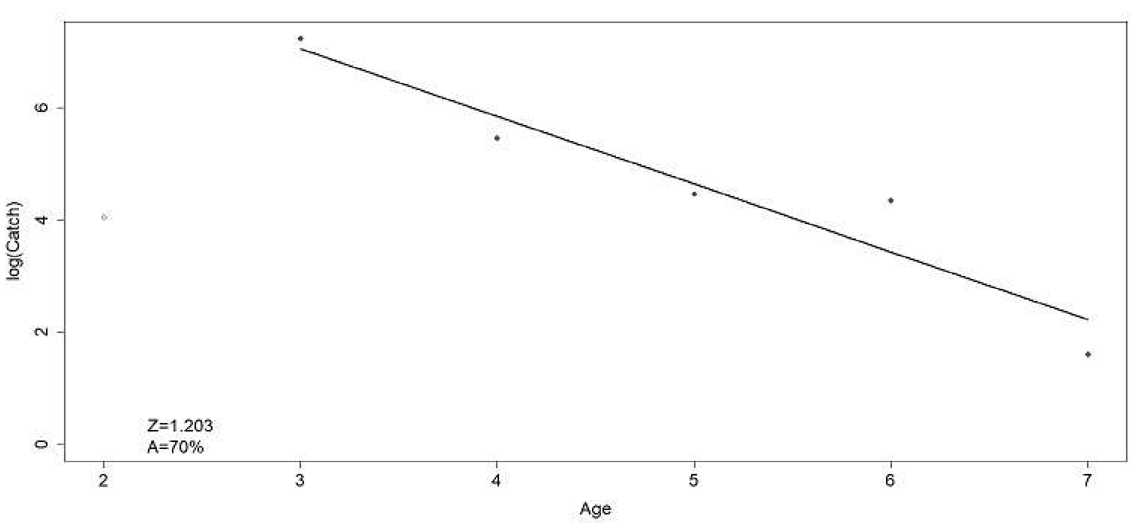


Figure 5. Catch curve for Bluegills sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

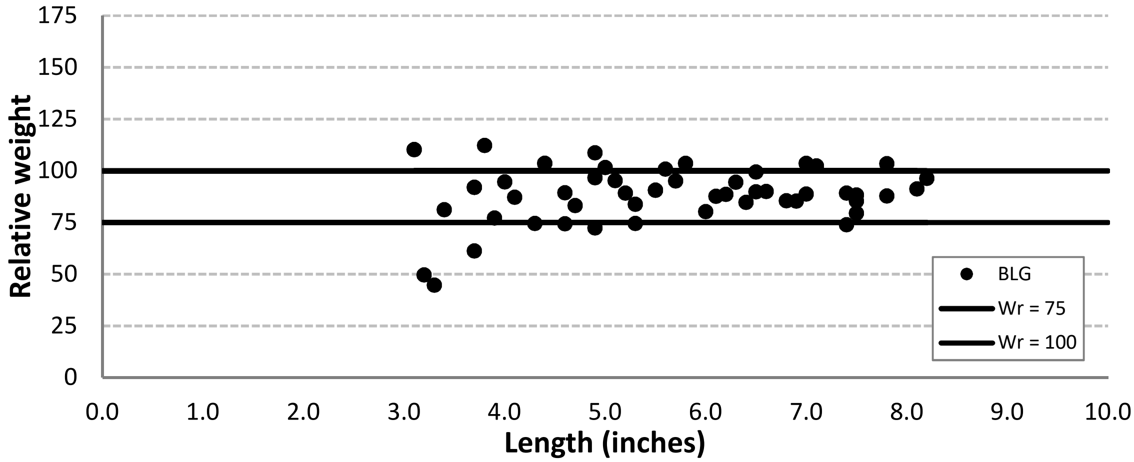


Figure 6. Relative weights of Bluegills sampled during the 2018 comprehensive fishery survey of Spring Lake, Sauk County, Wisconsin.

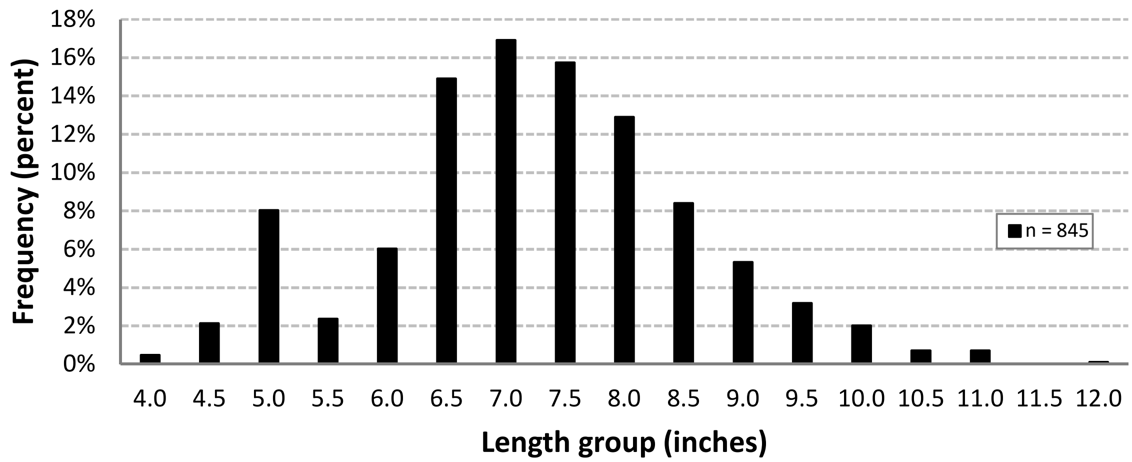


Figure 7. Length frequency distribution of Black Crappies sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

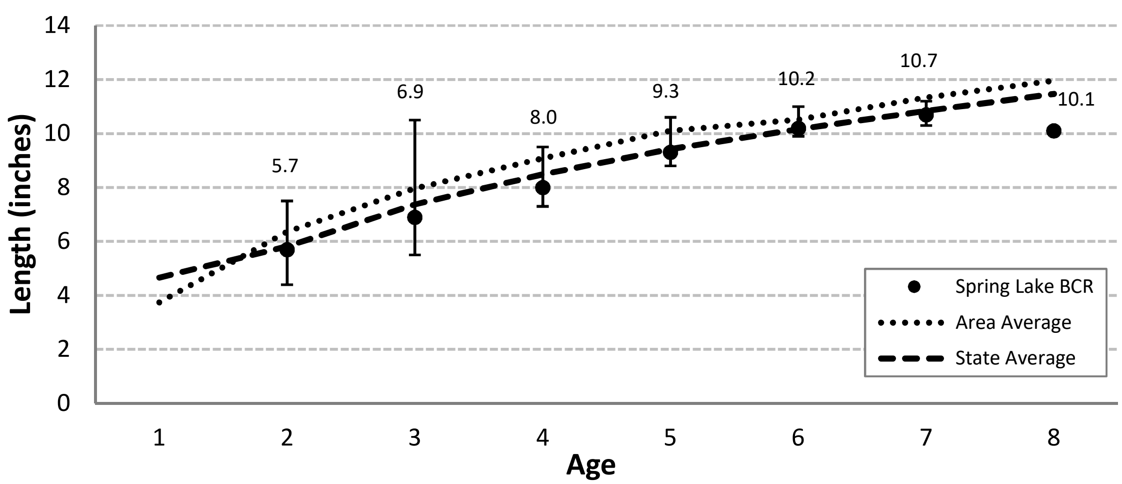


Figure 8. Mean length-at-age of Black Crappies sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

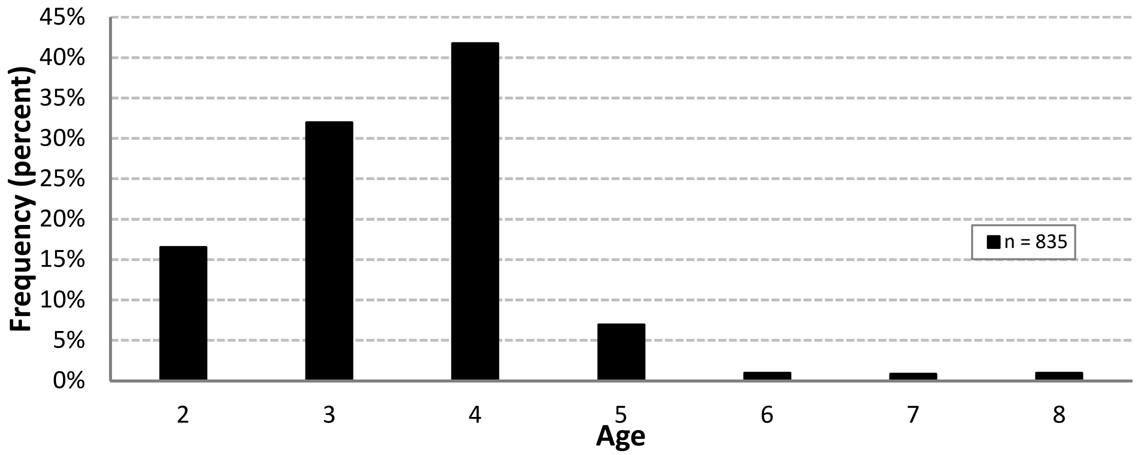


Figure 9. Age frequency distribution of Black Crappies sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

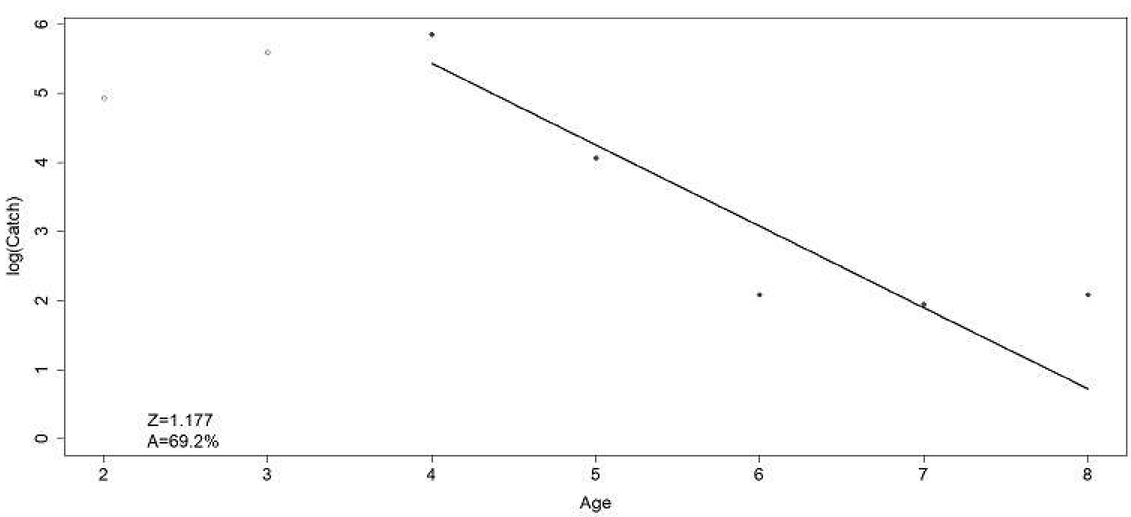


Figure 10. Catch curve for Black Crappies sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

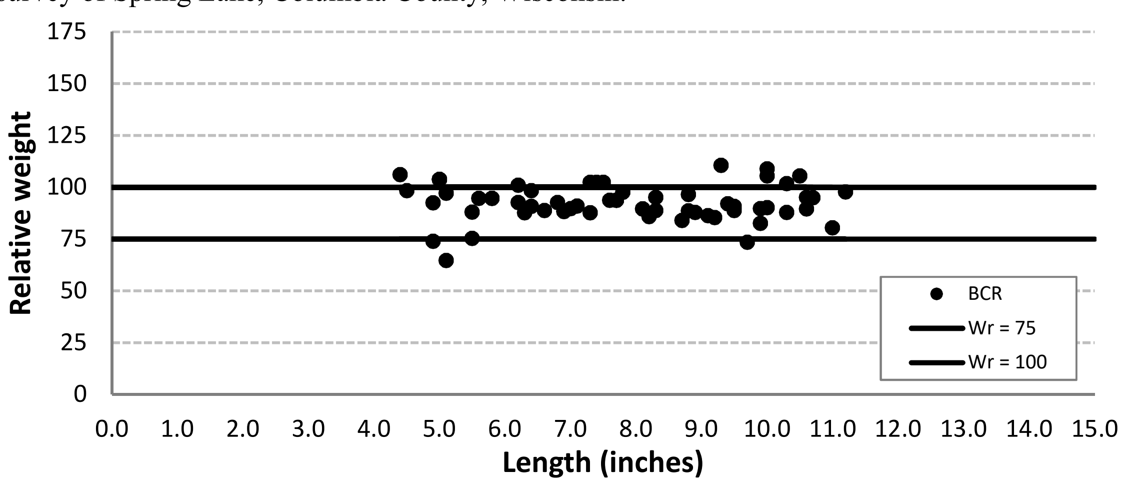


Figure 11. Relative weights of Black Crappies sampled during the 2018 comprehensive fishery survey of Spring Lake, Sauk County, Wisconsin.

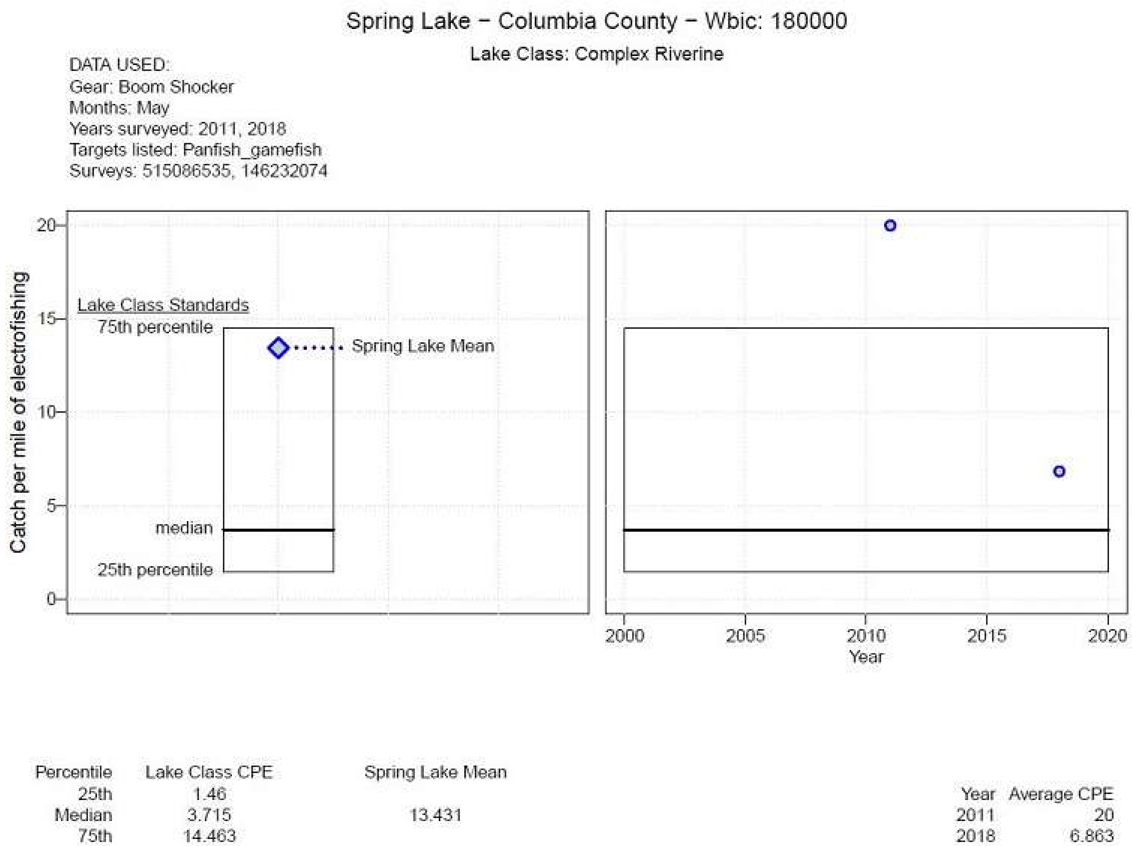


Figure 12. Largemouth Bass SE2 electrofishing CPUE lake class comparison for Spring Lake, Columbia County, Wisconsin. Lake class is Complex Riverine.

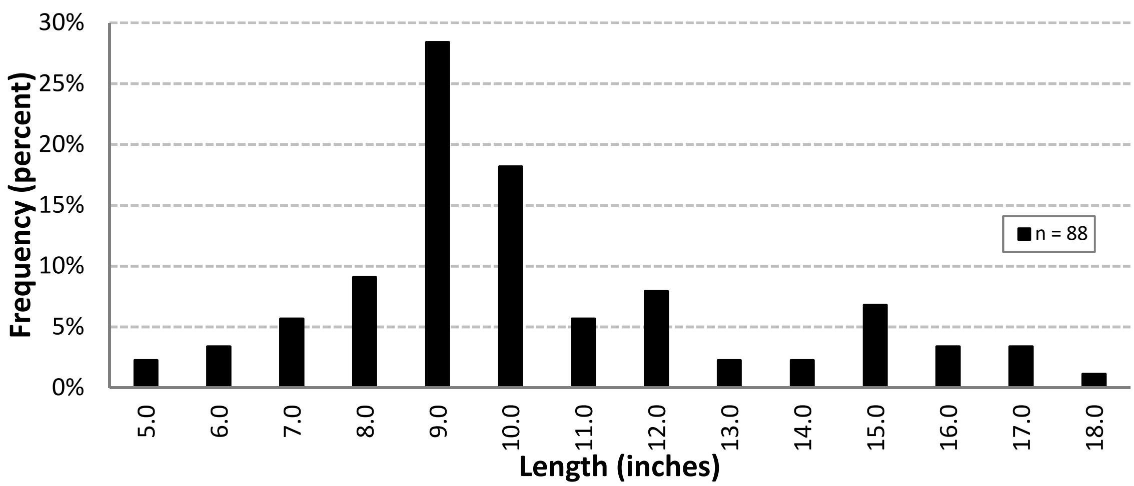


Figure 13. Length frequency distribution of Largemouth Bass sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

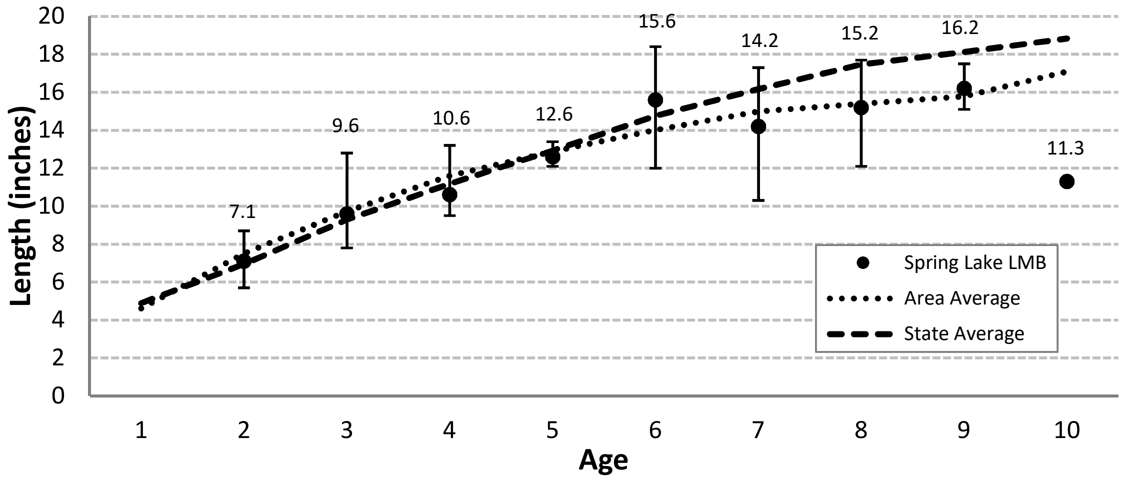


Figure 14. Mean length-at-age of Largemouth Bass sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

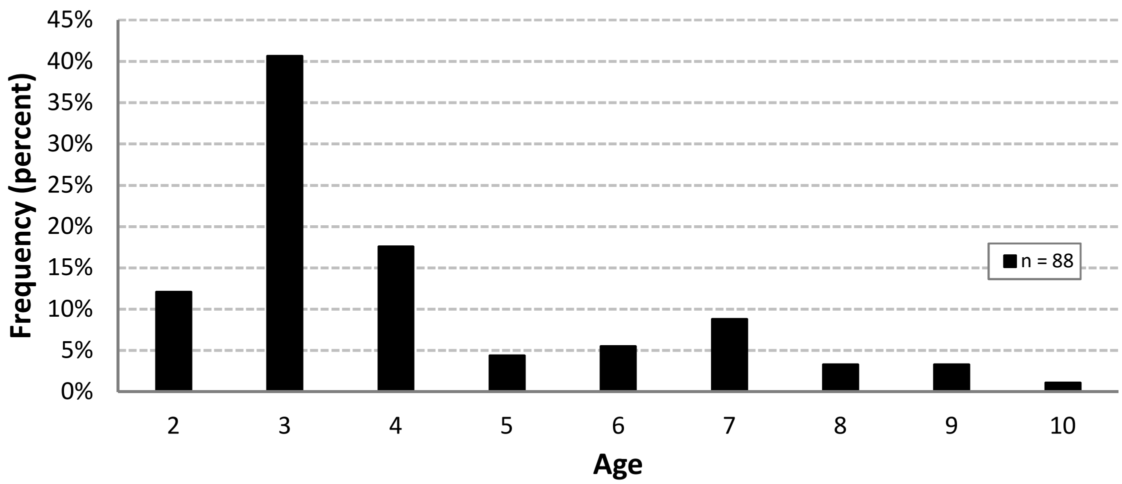


Figure 15. Age frequency distribution of Largemouth Bass sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

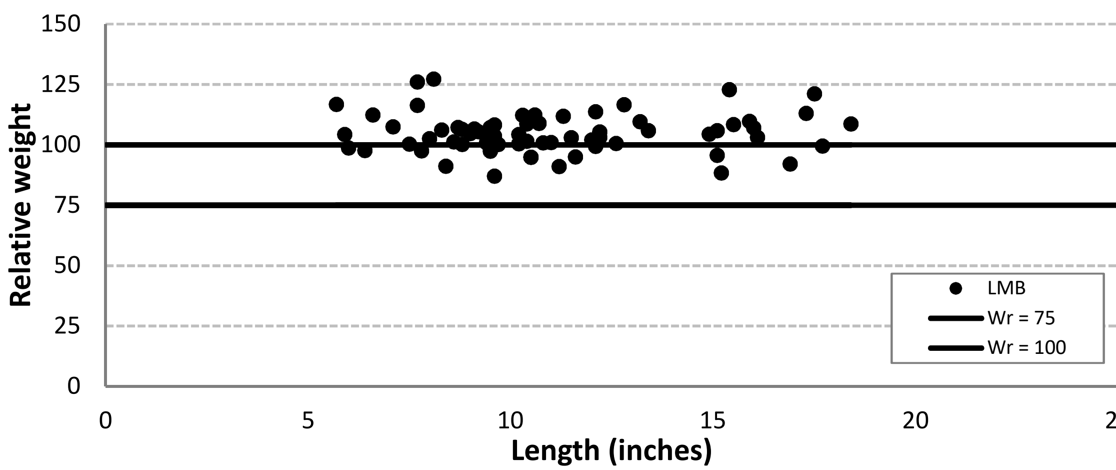


Figure 16. Relative weights of Largemouth Bass sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

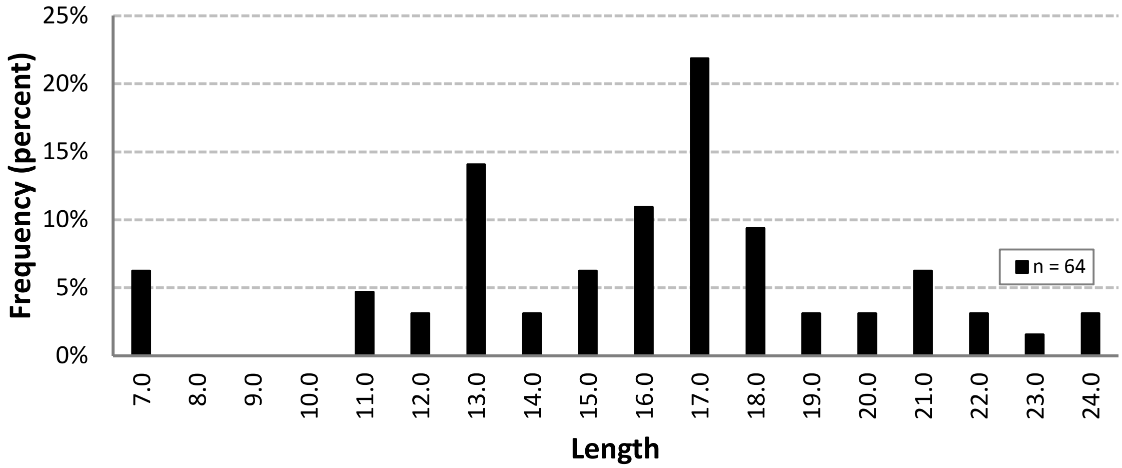


Figure 17. Length frequency distribution of Walleyes sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

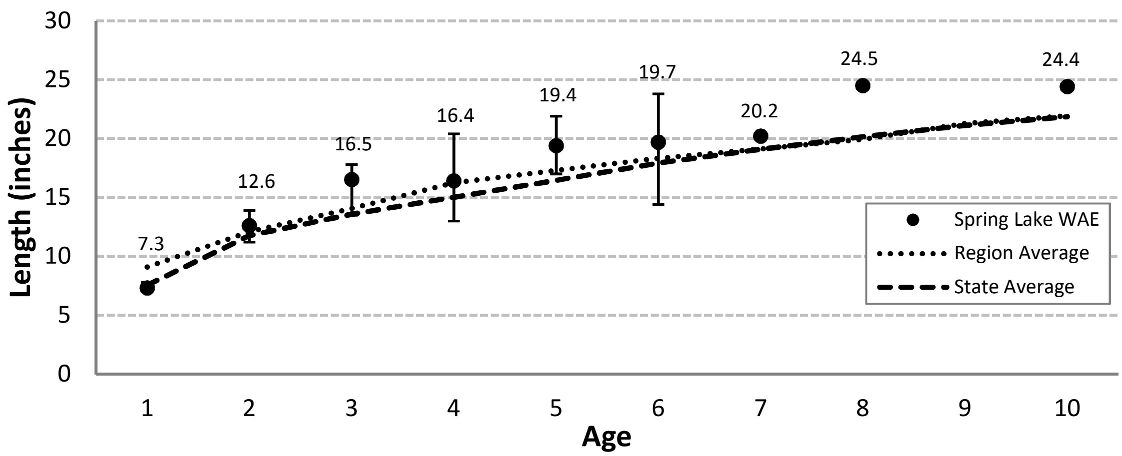


Figure 18. Mean length-at-age of Walleyes sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

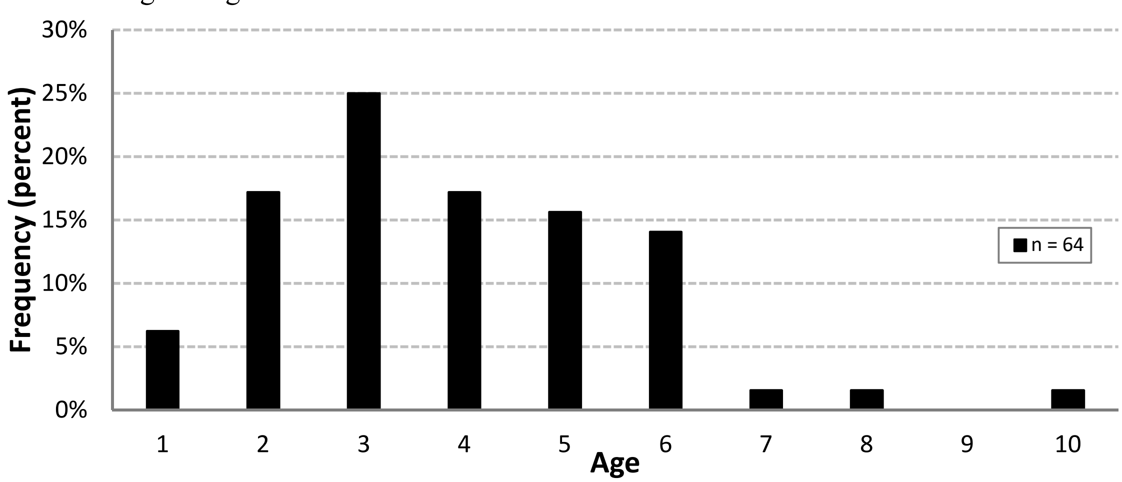


Figure 19. Age frequency distribution of Walleyes sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

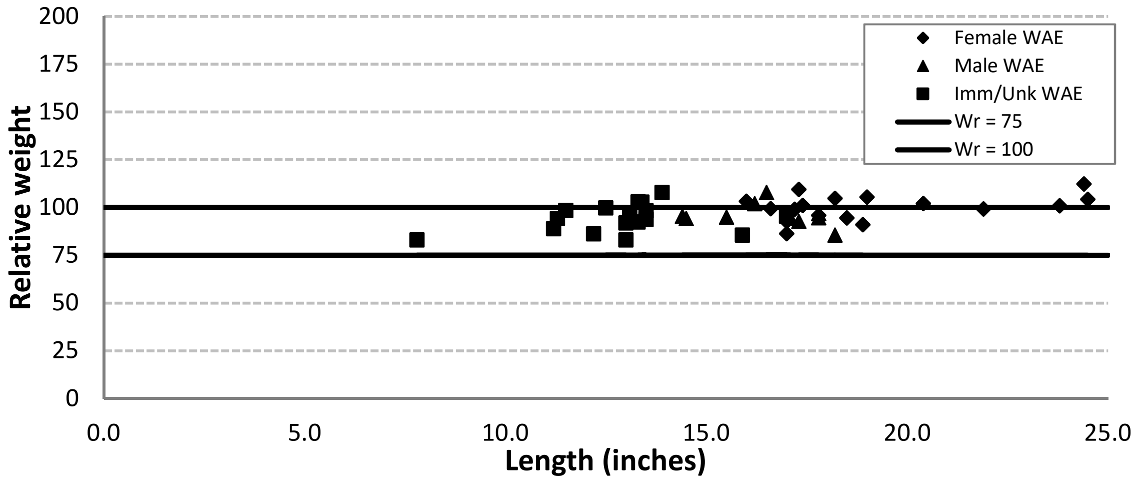


Figure 20. Relative weights of Walleyes sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

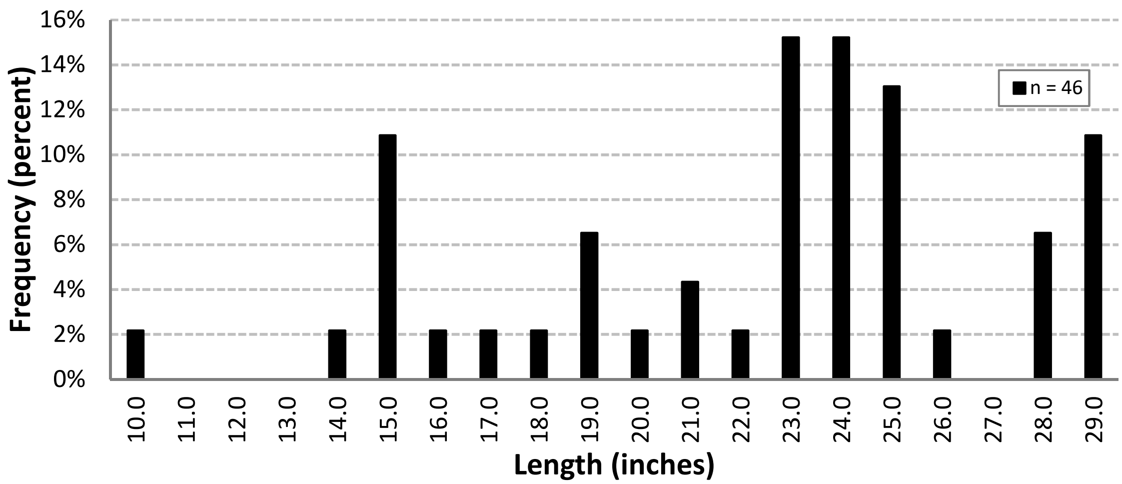


Figure 21. Length frequency distribution of Northern Pike sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

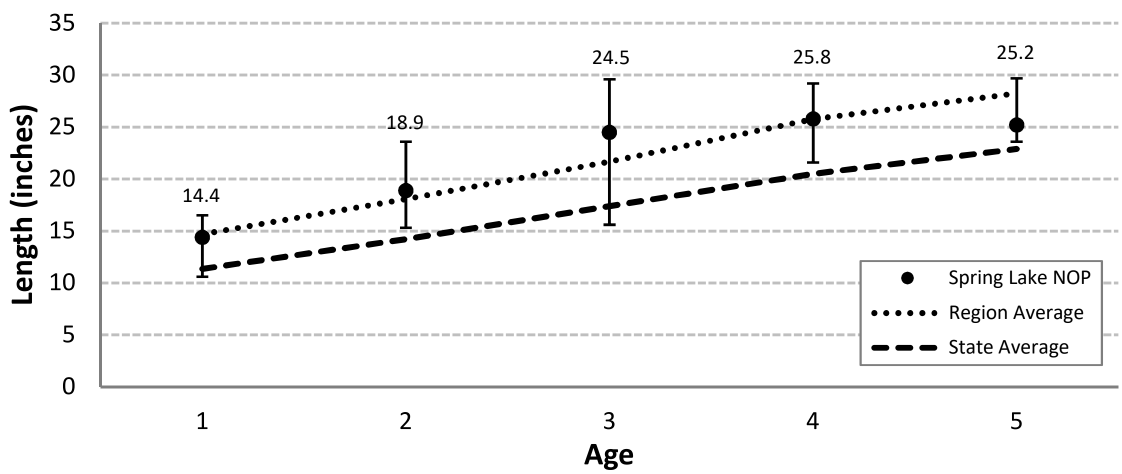


Figure 22. Mean length-at-age of Northern Pike sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin. Error bars represent the range of length values for a given age.

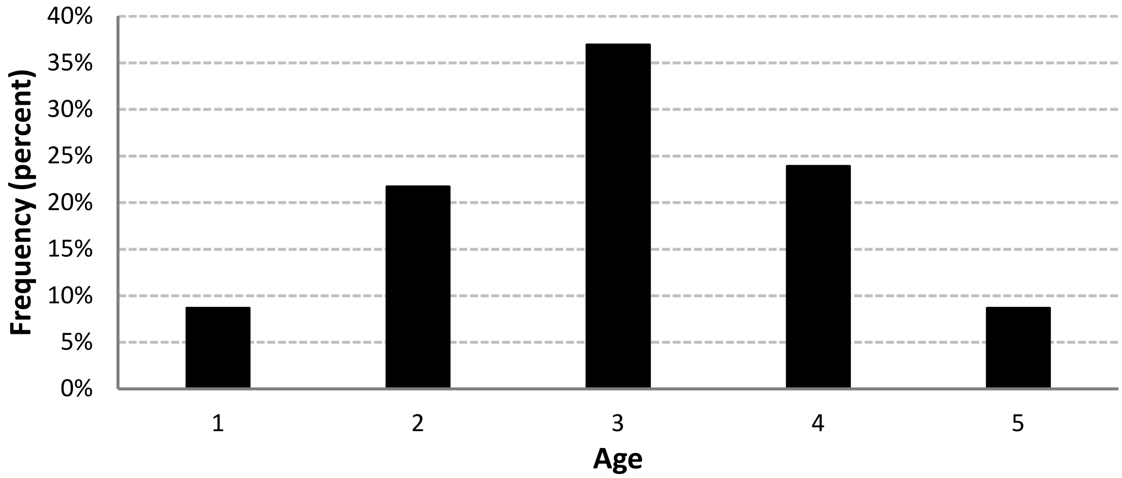


Figure 23. Age frequency distribution of Northern Pike sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

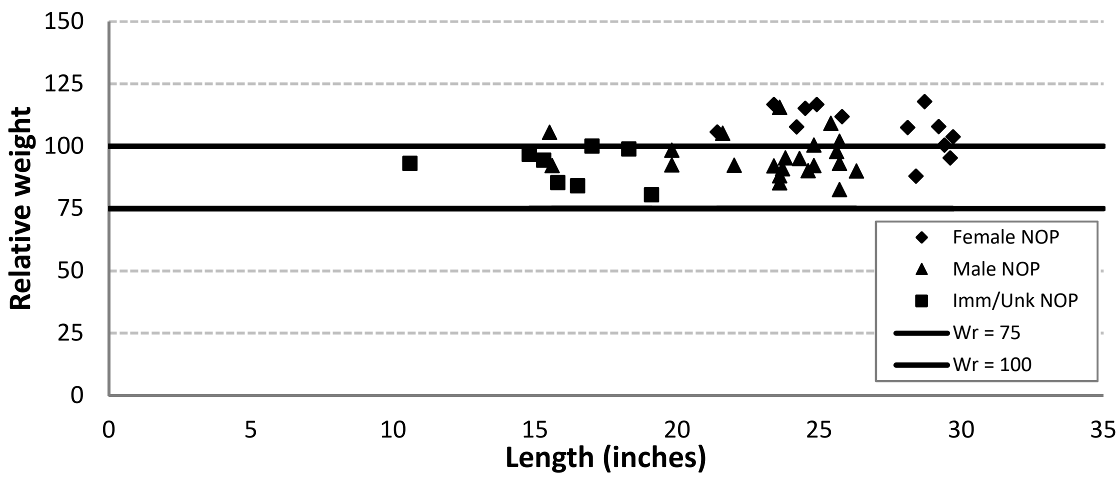


Figure 24. Relative weights of Northern Pike sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.

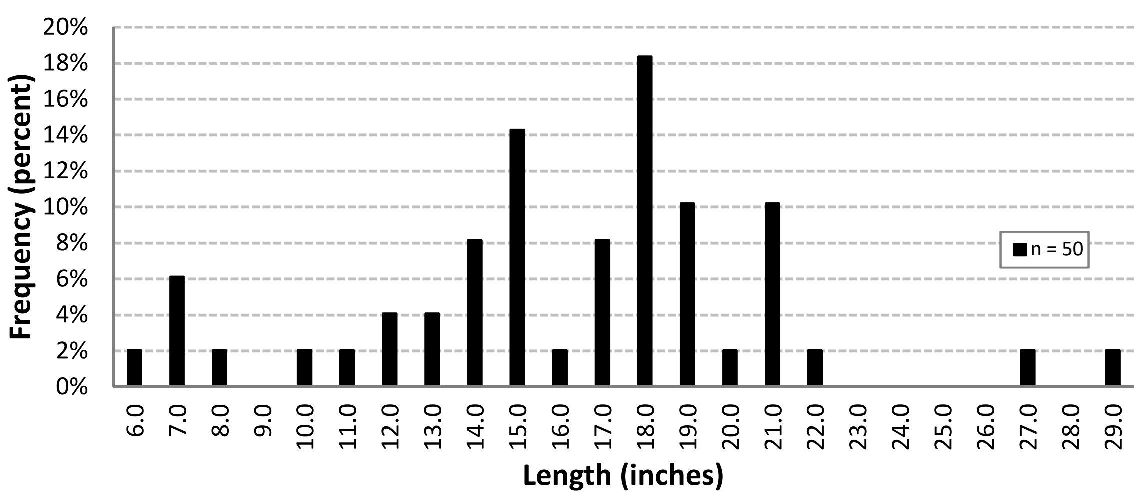


Figure 25. Length frequency distribution of Channel Catfish sampled during the 2018 comprehensive fishery survey of Spring Lake, Columbia County, Wisconsin.