Coldwater Lake
Branch County, T7S/R6W/22,23,26,27,34,35,36; T8S/R6W/1,2,3
Saint Joseph Watershed, Last Surveyed 2014

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Environment

Coldwater Lake is located in Branch County approximately 7 miles south of the City of Coldwater and is the most southern lake of the Coldwater Marble Lake Chain (Figure 1). The chain of lakes includes (from south to north) Coldwater Lake, East Long Lake, Wright (Mud) Lake, Loon Lake, Bartholomew Lake, Archer Lake, Middle Lake, Marble Lake, and First Lake and have a combined surface area of 2,700 acres. The channels between the lakes were dredged to harvest marl for the Wolverine Concrete Company making them navigable by boat. All lakes in the Coldwater-Marble Chain are at approximately the same elevation and the direction of water movement within the system is variable. There are two outlets from this system. The Sauk River flows out of Marble Lake, and the Coldwater River flows out of Coldwater Lake. The other outlet is the Coldwater River which runs north into the Hodunk-Messenger chain of lakes and then into the Saint Joseph River which outlets into Lake Michigan. There are dams on both outlets. These dams are used to maintain the legal lake levels of 984.5 ft above sea level in summer and 983.5 ft above sea level in winter. Coldwater Lake is the largest lake in the county at 1,610 acres. Coldwater Lake has several small inlets including the main channel to East Long Lake along with three small feeder streams and two intermittent streams. The lake reaches a maximum depth of 92 feet and is characterized by extensive shoals and shallow flats. Coldwater Lake is divided from north to south by a long point that terminates into Iyopawa Island. The lake bed is primarily composed of marl with gravel and cobble along some shorelines. Deeper portions of the lake also include some peat with organic muck. Coldwater Lake has a public access site located on the west side near the outlet of the Coldwater River. The site has been utilized for public access since being purchased by DNR in 1941 and was redeveloped in 1981 to include a two-lane concrete boat ramp and parking spaces for 59 vehicles with trailers. Five additional public access sites on the chain include boat launches in the Loon Lake Channel (hard surface, 5 spaces), Middle Lake (hard surface, 10 spaces), Marble Lake (hard surface, 50 spaces), and First Lake at the Quincy-Marble Lake Township Launch (hard surface 50 spaces). Several private launches are available through campgrounds and marinas on Coldwater Lake (Figure 1). Coldwater Lake State Park is a 400-acre park with 6,600 feet of lake-frontage located on the southern shore that provides hike-in fishing and hunting access. Over 120 acres of the park are designated wetlands which provide some of the most natural shoreline on an otherwise highly developed lake.

Coldwater Lake is within a proglacial outwash geological landform with glacial outwash sand and gravel and postglacial alluvium with mostly coarse and some medium textures. Soils are predominantly Matherton-Sebewa-Fox sandy loam with interspersed areas of Hillsdale-Riddle fine loam all with moderately low runoff potential. Darcy groundwater models show low potential for groundwater inputs to the lake. Agriculture is the primary land use practice in the Coldwater-Marble Chain covering 75% of the watershed. Forests (11%) and wetlands (13%) are abundant around East Long Lake and Coldwater Lake State Park.

History

Fisheries surveys were conducted on Coldwater Lake in 1886, 1927, 1967, 1983, and 1994 (Table 1). Targeted surveys were conducted to evaluate the success of Walleye stocking (1986, 1988, 1989, 1992, 1993, and 1994), assess response to changes to bass regulations (1991, 1996, 1997) and evaluate Cisco populations (2005 and 2006). There has been a long history of fish stocking conducted in Coldwater Lake to enhance populations and provide recreational fishing opportunities (Table 2). Bluegill were stocked every year from 1933 through 1945. Smallmouth Bass, Largemouth Bass, and Yellow Perch were stocked periodically from 1933-1944, after which stocking was discontinued. Research indicated populations were sustainable without intensive stocking efforts (Cooper 1948, MDNR 2004). Tiger Muskellunge were stocked on alternating years (with some variation) from 1976 to 1991, totaling approximately 33,000 fish. Adult Walleye were stocked in 1966 through 1968, and fingerlings were stocked every other year from 1982 through 2012 (with some variation). Redear Sunfish were not stocked in Coldwater Lake, but were stocked in several lakes in the surrounding area. However, Coldwater Lake supports a naturally reproducing population of Redear Sunfish that were most likely introduced to the lake by anglers or illegal stocking. Coldwater Lake historically had a robust Cisco population and was open to netting in the 1940s and 1950s.

Coldwater Lake was first surveyed in 1886 using seines and only small Yellow Perch were observed. A more comprehensive survey was conducted in May of 1927 and Largemouth Bass, Smallmouth Bass, Bluegill, Cisco, Yellow Perch, Pumpkinseed, Brown Bullhead, Yellow Bullhead, Northern Pike, Rock Bass, Longnose Gar, and Black Crappie were captured in abundance. Logperch, Brook Silverside, Banded Killifish, Blacknose Shiner, Common Shiner, Iowa Darter, and Bluntnose Minnow were also captured but were less abundant. The bathymetry of Coldwater Lake was mapped on February 14, 1941. A stream survey of the channels of the Coldwater Marble Chain of Lakes was conducted in 1948. The survey identified Northern Pike Spawning habitat that likely supports populations in Coldwater Lake.

A 3-hour electrofishing survey conducted in August of 1967 captured 19 species. Bluegill were the most prevalent fish with 95.3 fish caught per hour. There were good numbers of harvestable size Bluegill; seven percent were greater than 8 inches and 67% were over 6 inches. Largemouth Bass and Smallmouth Bass catch rates were 22 fish per hour and 10 fish per hour respectively. Catch rate for Largemouth Bass were near or below the 25th percentile for lakes surveyed in the SLMMU (50.4 per hour) and statewide (22 per hour). Smallmouth Bass catch rates were near the median of lakes in the SLMMU (9.6 per hour) and statewide (16.2 per hour). Bass were relatively small and less than 14 inches. Only one small Walleye was collected. Other species that were observed in lower numbers include Logperch, Spottail Shiner, Bluntnose Minnow, Golden Redhorse, Yellow Perch, Rock Bass, Pumpkinseed, Northern Pike, Black Crappie, bullhead, Longnose Gar, Green Sunfish, Bowfin, Rock Bass, and Northern Hog Sucker. The electrofishing survey was coupled with gill nets. Catch rates were generally low in gill nets, but similar species were captured using both gear types. Seven Cisco were caught in the gill nets which ranged from 12 to 18 inches in length. Cisco were not captured in the electrofishing survey.

A trap net survey conducted in late May and early June of 1983 included 12 net nights of fishing effort. A total of 429 fish were captured. Bluegill were the most abundant (120 fish captured) and sizes ranged from 4 to 10 inches. Growth rates were above average with a growth index of +0.7 and fish

reached a maximum age of seven. Few Largemouth or Smallmouth Bass were collected and only one Smallmouth Bass was greater than 14 inches. Seven Walleye from the previous year's stocking were collected and lengths ranged from 9 to 11 inches. Anglers reported catching several Walleye that were 12 to 14 inches long during the ice fishery of 1983/1984. The report from this survey indicated the potential for a promising Walleye fishery. Only three Northern Pike were collected, but anglers reported good fishing for this species. Redear Sunfish were the second most abundant species (82 fish captured) and these ranged in size from 5 to 13 inches. The maximum age was 8 years. Other fish captured included good numbers of Rock Bass (80) and bullheads (81), but only a few Yellow Perch (17), Black Crappie (9), Warmouth (10), Bowfin (4), and Common Carp (3).

A survey was conducted in 1994 to evaluate the fish community and obtain Redear Sunfish to use as broodstock in other parts of the state. Gill nets and trap nets were set in May. Bluegill were the most abundant fish collected (728) and ranged in size from three to ten inches (average 6.3 inches). Redear Sunfish were the second most abundant species and averaged nearly 9 inches in length. Eighty-eight male and female pairs were removed from Coldwater Lake to establish a brood stock to be distributed among four different rearing ponds (Wilder Creek Conservation Club pond (Marshall, MI), a Louis Emery Park pond (Hillsdale, MI), a Michigan State University pond (Ingham County, MI), and a Livonia District Pond. The survival of transferred adult fish was low, yet a small number of offspring were produced which were stocked into lakes in direct proximity to a given rearing pond.

Largemouth Bass and Smallmouth Bass were abundant in the 1994 survey. Largemouth Bass exhibited slow growth (growth index -1.7), but Smallmouth Bass were growing faster than the state average (growth index +0.6) as represented by observations of size-at-age. Unlike in earlier surveys, tournament anglers reported good numbers of legal fish of both bass species. Bullheads and Rock Bass were abundant and fast growing. The survival of stocked Walleye was low as only eight were collected however size-at-age estimates indicated above average growth and the average length was 15 inches. Yellow Perch grew well (average length 9 inches) but were captured in low numbers. Seventeen Northern Pike were collected which ranged in size from 16 to 32 inches. Few larger Northern Pike were observed which was attributed to high fishing pressure and harvest rates noted at the time. Black Crappie populations were also experiencing growth rates of a half inch above the state average and averaged 8.5 inches and over 1/3 pound. Other fish species observed included Bowfin, Channel Catfish, Hybrid Sunfish, Spotted Gar, Longnose Gar, and Warmouth. The conclusion of this survey was that Coldwater Lake continued to be one of the premier fishing lakes for this region of Southern Michigan and was termed one of the "crown jewels" of the Jackson Fisheries District. No changes in management were recommended.

A targeted shoreline electrofishing survey was conducted on October 30, 1986 to evaluate the success of Walleye and Tiger Muskellunge stocking efforts. Only four Walleye were caught of which two were recently stocked nine-inch fish. The additional two Walleye were larger (21 and 19 inches) three-year-old fish which were 4.5 inches larger than the state average length for three-year-old fish. Five Muskellunge were captured which originated from the 1986 fall stocking effort and one 29-inch fish was three years old. Survival of age-0 and age-1 Walleye can be evaluated using the Serns index to estimate the number of fish per acre from catch per effort in shoreline electrofishing surveys (Serns 1982, Serns 1983, Ziegler and Schneider 2000). Serns index values less than 11 fish per acre indicate poor year class strength and are lower than expected requirements to establish a population through stocking. Serns surveys were conducted on Coldwater Lake in 1988, 1989, 1992, 1993, and 1994.

Shoreline electrofishing efforts covered 4.25 miles in 1988 and a total of 11 Walleye were captured. All were young-of-year resulting in a Serns index of 0.6/acre. Trap nets were set in the spring of 1989 to evaluate growth and survival of stocked Walleye. Only one Walleye was captured, as well as 24 Yellow Perch, 15 of which were greater than 10 inches. Serns index electrofishing in October/November of 1989 covered 6 quarter mile transects and captured 33 Walleye. The Serns index was 0.2/acre for young-of-year and 0.84/acre for yearlings, much lower than the 11 fish per acre required to sustain a fishery.

Survival of walleye stocked in 1992 was assessed through 6 miles of electrofishing surveys conducted in October of 1992. Fifty fingerling Walleye were collected and the young-of-year Serns index was only 3.8/acre. Some of the stocked Walleye did survive, as a postcard creel survey conducted in 1992 received 10 responses from anglers reporting a total of 38 Walleye captured. Biologists determined that stocking was creating a marginal fishery and decided to continue efforts with fingerling Walleye. Electrofishing surveys (6 miles of shoreline) occurred again in October of 1993. The resulting Serns index was lower for both young-of-year (0.9/acre) and yearlings (0.3/acre). Despite low numbers, the growth of Walleye was good, their mean length estimates were well above the state average for young-of-year (2.6 inches longer) and yearlings (1.9 inches longer). Six adult Walleye were captured in 1993 which ranged from 21 to 25 inches in length and exhibited growth well above the state average (growth index +2.3). Trap net surveys were conducted in April 1994 to assess the population of Walleye. Only 23 fish were captured, but all age classes caught were growing at rates similar to the state average (growth index +0.2). Recommendations at the time were to discontinue Walleye stocking because of poor survival. A creel survey conducted in February of 1996 during the annual City of Quincy tip-up festival recorded only 2 Walleye in the catch. Ten percent of the anglers interviewed were targeting Walleye. Anglers evaluated the fishery as poor (76% of responses) but were in favor of continuing stocking (100% of responses). Walleye stocking was resumed in 1997 and continued every other year through 2012. Coldwater Lake has not been stocked since 2012 due to limitations in rearing resources and concerns regarding the survival of stocked Walleye in Coldwater Lake.

In 1993, the statewide minimum size limit for Largemouth Bass changed from 12 inches to 14 inches. The catch rate and size of bass captured by anglers in tournaments was evaluated in 1991 (before the change) and 1996 and 1997 (after the change). In September of 1991, 60 Largemouth Bass were captured in a tournament. All fish were over 12 inches, 21 of the fish were 12 to 14 inches, and 39 were greater than 14 inches. In August 1996, 24 boats (40 anglers total) caught 10 Largemouth Bass (14 to 18.7 inches) and one Smallmouth Bass (19 inches). Anglers reported catching and releasing 78 12-inch fish and 65 13-inch fish. In July 1997, 38 tournament boats captured 43 legal bass >14 inches (range 14 to 19 inches). An additional 100 sub legal bass were reported. Both the number of 12 to 14-inch fish and the proportion of 12 to 14-inch fish that made up catch over 12 inches increased from 1991 to 1996 and 1997. This may indicate that the increased size limit resulted in an increase in the number of 12 to 14-inch fish that were protected by the new regulation. In general, anglers supported the change and the number of violations reported by Law Enforcement Division declined from 1996 to 1997. The 14-inch minimum size limit remains in place to the present.

Limnological sampling of Coldwater Lake was conducted September 8, 2005 to evaluate the environmental suitability for Cisco in Coldwater Lake. Temperature and dissolved oxygen profiles suggest cisco habitat was limited during summer stratification. Gill net surveys in November of 2006

included the use of 8 gill nets set for three nights. No cisco were collected. Cisco were last reported in Coldwater Lake in 1967. The status of the Cisco population is unclear but limited oxygenated cold-water during stratification indicates that the population may no longer be present in Coldwater Lake.

Current Status

A fish population survey was conducted on Coldwater Lake during 2014. The goal of the survey was to evaluate the fish community and determine if Walleye should continue to be stocked in the lake. The survey design followed standard methods for conducting a random lake survey as described in the Michigan Department of Natural Resources (MDNR) Status and Trends protocol (Wehrly et al. Draft). Netting efforts took place from May 19 through May 22, 2014. Four gill nets were set overnight on each of three nights (total of 12 nets). Eight large-mesh fyke nets were set overnight on each of three nights (total of 24 nets). Four small mesh fyke nets were deployed on each of two nights (total of 8 net nights). Six beach seine hauls were conducted to quantify minnow and inshore prey species abundance levels. Six ten-minute electrofishing transects were performed at night on May 29, 2014 (total of one hour of electrofishing effort). All fish were identified, counted, and measured (total length). Weights for all fish species were calculated using length-weight regression equations compiled by Schneider et al. (2000). The relative stock density for each fish species was assessed using catch per effort (CPE) calculated as the number of fish caught: per net night (gill and fyke nets), per hour of electrofishing (boomshocker), or per haul (seine). CPE data from this survey were compared to a summary of CPE data from lakes surveyed in the Status and Trend Program from 2002 through 2007 on a statewide and regional (Southern Lake Michigan Management Unit (SLMMU)) level. Age structures (scales or spines) were collected from ten fish in each inch class for all sportfish. Weighted age compositions using length and age keys for each game fish species were calculated as described by Schneider (2000b). The difference between the state average mean length for each age class and mean length-at-age from surveys was used to calculate size differences for each age class. Age classes represented by a minimum of 5 fish were averaged to provide an index of fish growth (Schneider 2000b). Growth index scores of +/- 1 are considered similar to the state average while scores less than -1 and greater than +1 are considered below or above the state average respectively. Bluegill size structure was rated using an index based on the mean length, growth, and the proportion of fish >6 inches, >7 inches, and >8 inches (Schneider 2000a, Schneider 1990). Mortality was estimated for abundant fish species with adequate age data using catch curve analysis (Ricker 1975).

A shoreline survey of Coldwater Lake was conducted on August 14, 2014 and included counts of dwellings, docks, armored shoreline and woody debris. A temperature and dissolved oxygen profile was collected on August 10, 2015 for 1-foot increments at the deepest spot in the lake. Shoreline surveys of Coldwater Lake included 71 transects of 1,000 feet each (and one additional transect along an island) for a total of approximately 71,000 feet. The number of docks (large and small), dwellings, submerged trees, and the percent of the shoreline that was armored (riprap or seawalls) were recorded for each transect. Detailed methods for limnological, shoreline, and fish sampling can be found in Wehrly et al. (Draft).

A total of 5,507 fish weighing 1,306 lbs. were collected in the May 2014 survey (Table 3). Bluegill were the most abundant fish species captured making up 26% of the total catch (1,421 fish). Bluegill ranged in size from one to nine inches and the mean length was 3.8 inches. Growth was average with

an index score of -0.4. Bluegill size structure received a rank of acceptable as calculated from fyke net catch (score = 3.8) and growth index (score = 3.0) but was ranked very poor using electrofishing catch data (score = 1.25). The lower score for the electrofishing survey included an abundance of one to five-inch Bluegill which were caught in that survey. Hybrid sunfish (576 fish) were much more common than pure Redear Sunfish (186 fish). Black crappie ranged from four to thirteen inches (mean 7.4 inches) but were not captured in high numbers (46 fish). Yellow Perch averaged 6.2 inches (range 2-12 inches). A total of 84 were captured and 8% were greater than 10 inches. Growth of Yellow Perch was average with an index score of -0.1. Other panfish observed included Rock Bass, Pumpkinseed, and Warmouth.

Largemouth Bass were abundant in Coldwater Lake. A total of 100 Largemouth Bass were captured that averaged 8.9 inches (range 2-17 inches). Seven of the Largemouth Bass were legal size (>14 inches) making up 6% of the total Largemouth Bass catch. Most bass reached legal size at age 6, and fish up to 12 years old were captured. The growth index was -0.5 indicating average growth rates compared to statewide Largemouth Bass populations. Northern Pike were the second most abundant predator in Coldwater Lake; 85 were caught in surveys totaling 270.1 lbs. (21% of total catch by weight) contributing the greatest portion of the fish biomass in surveys. Northern Pike averaged 23.6 inches (range 15-34 inches) and exhibited average growth with an index of -0.3. Only eight Smallmouth Bass were collected, and these ranged from three to fourteen inches. A growth index score could not be calculated due to the low sample size, but the individuals caught were smaller than the state averages for their respective age groups. Only one of the Smallmouth Bass captured was of legal size at just above 14 inches. Longnose Gar, Spotted Gar, and Bowfin were other native predators captured in the survey. Longnose Gar were captured in similar numbers to Northern Pike (75 fish across gears), and fewer Spotted Gar (23 fish) and Bowfin (5 fish) were captured. Predators comprised 45% of the total biomass captured in the survey. No Walleye were captured in any gears in the 2014 survey. Predators typically make up 20-50% of the biomass in lakes with desirable fish communities (Schneider 2000a). Predator abundance in Coldwater lake was near the high end of what is considered balanced. Yellow and Brown Bullheads were also collected and ranged from 2 to 15 inches. In addition, two Tadpole Madtoms were caught. No suckers or carp were observed in the 2014 survey.

There was an abundance of prey species collected in the small mesh fyke nets and seines. Spotfin Shiner were the second most common overall and the most abundant minnow with 1,085 captured. Other minnows included Bluntnose Minnow (n = 492), Sand Shiner (281), Blacknose Shiner (281), Brook Silverside (85), Spottail Shiner (84), Banded Killifish (35), Golden Shiner (6), and Blackchin Shiner (1). In addition, a small number of darters were collected including Logperch, Johnny Darter, and Iowa Darter. Although numerically abundant, these species are small-bodied resulting in low contribution to the biomass in the lake.

Coldwater Lake limnological parameters were measured on August 14, 2014 and an integrated epilimnetic water sample was collected for laboratory processing. The Secchi disk reading was 13.5 feet indicating light penetration to 27 feet of depth. Water color was measured as 16 and 18 mg/L and categorized as low (Shaw et al. 2004). The water of Coldwater Lake was clear and vegetation was relatively sparse. Many shoals were open containing marl or gravel substrates. Qualitative assessment of submerged vegetation reported Chara and White Waterlily as common at many sites, with Native Milfoil, Narrow-Leaf Pondweed, and Sago Pondweed as sparse. Emergent vegetation was present at many locations including Bullrush and Cattail. The invasive species Starry Stonewort was present in

the lake and an active chemical control program is in place for treatment (authorization of the Marble-Coldwater Lake Board under Michigan Department of Environmental Quality permit number ANC9801893). Treatments appear to be localized and targeted towards invasive species control and improvements to navigation canals and channels for boating.

Ammonia concentrations were 0.03 mg/L, combined nitrate and nitrite concentrations were 0.0048 mg/L, total nitrogen was 0.649 mg/L, and total phosphorus was 0.0059 mg/L. The resulting nitrogen to phosphorous ratio was 110, indicating that Coldwater Lake is phosphorus limited (Downing and McCauley 1992). Nitrogen levels are high in Coldwater Lake possibly a result of agricultural practices in the watershed and associated nitrogen fertilizer runoff into the lake and feeder streams. Alkalinity was 132 mg/L indicating hard water with good buffering capabilities were evident as marl substrates were present in the lake (Shaw et al. 2004). Lower phosphorus levels in the water may occur as phosphorus is known to precipitate with marl. Chlorophyll a concentrations were 2.63 ug/L indicating relatively low levels of algal production in Coldwater Lake (Forsberg and Ryding 1980). Based on the parameters measured in 2014, Coldwater Lake is classified as oligotrophic using the criteria described by Forsberg and Ryding (1980).

Temperature loggers were placed in Coldwater Lake from April 15, 2014 through November 19, 2014 and again from March 21, 2016 through November 21, 2016. Temperatures ranged from 32.3 to 85.7 degrees F in 2014 and 36.4 to 87.8 degrees F in 2016 (Figure 2). The peak temperature for each year occurred on July 22, 2014 and July 27, 2016. Temperature and dissolved oxygen profiles were taken on August 10, 2015 temperature and dissolved oxygen began to decline at a depth of 18 feet (Figure 3). The air temperature was 79 degrees F and the water surface temperature was 77.4 degrees F. The pH was 8.5 at the water surface declining with depth to 7.6 at the bottom. Oxygen concentrations remained above 5 ppm until a depth of 29 feet (water temperature 56.5 degrees F). Thereafter, dissolved oxygen decreased to 3 ppm at a depth of 60 feet (water temperature 49 degrees F) and depths below 60 feet were anoxic.

The lake shoreline was highly developed. A total of 72-1,000 ft. shoreline survey transects were conducted to record the number of submerged trees, docks, dwellings, and percent of the shoreline that was armored with riprap or seawalls. Observations were compared to other lakes in the Southern Lake Michigan Management Unit (SLMMU) and to statewide summaries produced using Status and Trends survey records from 2002 through 2007 (Wehrly et al Draft). The recent survey counted 283 docks on Coldwater Lake (average 57.6 per mile) which is well above the 75th percentile for SLMMU and statewide. Eighty-four submerged trees (average 6.1 per mile) were counted and most were located along the state park on the southern end of the lake. The number of trees per mile was close to the median for SLMMU and between the 25th percentile and the median for lakes statewide. Dwellings were rather dense along the shoreline with a total of 645 counted (average 47.4/mile; >75th percentile for lakes in the SLMMU and statewide). A large portion of the shoreline was armored (62%) which would be expected given the high number of houses and docks. The percentage of shoreline armoring is well above the state and SLMMU 75th percentile and demonstrates that very little natural shoreline exists on the lake.

Analysis and Discussion

Coldwater Lake has a diversity of sportfish species which provide a variety of recreational angling opportunities. Angler reports and observations indicate that Coldwater Lake receives a good deal of fishing pressure throughout the summer and winter. The shoreline of Coldwater Lake was highly developed, with significant armoring. Seawalls have been identified as one of the major threats to inland lake ecosystems within Michigan's Wildlife Action Plan (Eagle et al. 2005). Fish and other organisms rely on the nearshore fringe wetland habitats for spawning, feeding, and cover. Seawalls disrupt the connection between the aquatic ecosystem and upland habitat. Shoreline alterations result in reduced abundance and diversity of fish (Bryan and Scarnecchia 1992) and frogs (Woodford and Meyer 2002). Seawalls reduce the natural energy dissipating capacity causing increases in erosive energy in other parts of the lake (O'Neal and Soulliere 2006). The impact from seawalls can be cumulative (Burns 1991; Jennings et al. 1999). Undeveloped shoreline does exist along the southern end of the lake and along inlets. Fish can access wetland habitat in adjacent waterbodies (i.e. East Long Lake). To overcome limitations in Coldwater Lake, Northern Pike most likely utilize wetland habitats in adjacent connected lakes for spawning habitat. Lakefront property owners should consider alternative erosion control techniques to armoring. Coldwater Lake shorelines have gently sloping littoral zones which can be ideal candidates for productive natural shoreline development. Several programs (e.g., the Michigan Shoreland Stewards Program) exist to provide guidance to interested riparian land owners and cost share opportunities are available to promote natural vegetation and development of shoreline wetland habitat.

The Largemouth Bass population in Coldwater Lake provides for an average fishery and growth and abundance estimates are similar to the state average. Largemouth Bass growth was average and improved from 1994 (-1.7) to 2014 (-0.5). Largemouth Bass up to 7 years old were captured and estimates of size at age were similar to state average values (Figure 4). One 17-inch fish was captured that was 12 years of age. Largemouth Bass did not reach legal size (14 inches) until 6 years of age which was similar statewide average values. The CPE from electrofishing (78 bass/hour) was similar to statewide and regional SLMMU averages (between the median and the 75th percentile). Only 6% of the population was over 14 inches. Legal fish up to 17 inches were available but only in low numbers (Figure 5).

Schneider (2000a) observed that fish communities where predators composed >50% of the total biomass of the lake generally provided poor quality fisheries. Predators made up 45% of the total fish biomass during the 2014 survey on Coldwater Lake. The fish community seems to be approaching a tipping point as predator biomass is high and near the threshold. Largemouth Bass populations would benefit from either increases in prey fish biomass or decreases in predator biomass which would lower the contribution of predators to the overall lake-wide biomass of fish. Small or medium sized Largemouth Bass were not overly abundant and mortality rates were average. Therefore, it is unlikely that predator reductions would be achieved by increasing the harvest of smaller Largemouth Bass. It may be more effective to reduce other predator species in Coldwater Lake (eg. Walleye), especially those whose populations are principally maintained by stocking.

Coldwater Lake is a popular location to hold bass tournaments and is tied with Lake Ponemah and White Lake as the twelfth lake with the most fishing tournaments in the state in 2016. Twenty-nine tournaments were registered in the Michigan Tournament Fishing Information System in 2016 and 32 were registered in 2017. Tournaments have been occurring on Coldwater Lake for a long time and were surveyed to evaluate regulation changes in the 1990s as previously discussed. The large size of

the lake, ample parking at public access sites, and multiple venues available at local marinas help facilitate and attract tournaments. Largemouth Bass tournaments live release all fish captured and handling techniques have improved leading to lower mortality of captured fish (Siepker et al 2007, Ostrand et al 2011). Although fish are often relocated from the capture site to a centralized weigh in location, they usually disperse quickly when released and return to the place of capture within a few days (Wilde 2003). Despite the potential amount of fishing pressure associated with bass tournaments, there is no evidence of overharvest in Coldwater Lake. Catch curve analysis estimated total annual mortality at 55.6% which is low compared to the range reported by Allen et al. (2008) for North American Largemouth Bass populations (Figure 6). It is rare for tournaments to impact bass fisheries (Allen et al 2004, Gwinn and Allen 2010, Diana et al 2016). Tournament angling during critical spawning periods has shown that fish angled from the nest during tournaments will abandon those nests resulting in nest failure (Siepker et al. 2009, Diana et al 2012). However, it is unclear if individual nest failures lead to impacts on the total fish population as in compensation, there may have been higher survival from other nests or the captured fish could nest again and still successfully produce progeny (Parkos et al 2011).

Smallmouth Bass were less abundant than Largemouth Bass and only eight were caught in 2014 surveys. The CPE from electrofishing was low (5.0/hour) and less than the 25th percentile for SLMMU (7.8/hour) and above the 25th percentile statewide (4.8/hour). Only one legal Smallmouth Bass was captured in 2014. Despite their presence in Coldwater Lake, Smallmouth Bass do not contribute significantly to recreational fisheries.

Growth rates of Northern Pike were average (-0.3) and had improved relative to observations in 1994 (-3.3). In Coldwater Lake, Northern Pike reached legal size (24 inches) at 5 years of age (Figure 7). In 2014 there was a decrease in the number of fish per inch group above the 24-inch size limit (Figure 8). This decrease most likely represents the effects of harvest as Northern Pike were most abundant in the 20 to 24-inch range. Studies in Minnesota (Pierce et. al 1995; Pierce and Tomcko 2003) observed annual mortality rates for Northern Pike in 13 lakes to average 48% (range 0.36 to 0.65). Mortality estimates for Northern Pike were near the high end of the reported range (63.6%) and this mortality is primarily occurring for fish which are 5 to 8 years of age (Figure 9). Despite apparent high harvest rates, fish over 24 inches made up 22 percent of the population and fish as large as 34 inches were captured in the survey. The Northern Pike population in Coldwater Lake has contributed to a satisfactory fishery despite high harvest of older age classes. The current regulation is adequately protecting age classes up to 24 inches and allowing sustainable harvest of larger size fish.

Coldwater Lake has suitable water temperatures and dissolved oxygen concentrations to support Walleye, yet no Walleye were captured in the 2014 survey. Past Serns surveys have noted poor survival of newly stocked Walleye with very few observations of adult Walleye. Walleye are sustained by stocking as evidenced by the lack of Walleye recovered in surveys from year classes that were not stocked. This is not uncommon in Southern Michigan where lakes almost always require stocking to maintain Walleye fisheries. Walleye have been stocked in Coldwater Lake as spring fingerlings which average two inches and are stocked in June. Spring fingerling Walleye are extremely vulnerable to predation and can be negatively influenced by abundant Largemouth Bass populations (Santucci and Wahl 1993; Nate et al. 2003; Inskip and Magnuson 1983; Fayram et al. 2005). Since Largemouth Bass are the most abundant predator in Coldwater Lake and prey resources

are limited (high predator to prey ratio), Largemouth Bass are likely preying heavily on newly stocked Walleye, contributing to low survival and recruitment of Walleye to the fishery.

In recent years, the SLMMU has produced fall fingerling Walleye that range from 4.6 to 8.6 inches in length and are stocked in the fall (October). Fall fish are much larger than spring fingerlings and are less vulnerable to predation. If Walleye stocking in Coldwater Lake is to continue, the use of fall fingerlings should be considered. Fall fingerlings are expensive to produce and numbers are limited by production pond space and the availability of minnows as food. A total of 6,440 fish would be required to stock Coldwater Lake at the recommended density of 4 fish per acre. The SLMMU has increased the production of fall fingerling Walleye to average approximately 15,000 fish annually. Coldwater Lake would require 43% of these fish thereby limiting options for other more viable systems. Stocking at a lower rate may be considered but likely would not produce a viable fishery. The predator prey ratio is already high in Coldwater Lake and stocking additional predators could result in reductions in growth rates of predator species such as Northern Pike or Largemouth Bass.

Bluegill catch rates in fyke nets (24.7/net night) were similar to the 75th percentile of populations throughout the state (26.6/ net night) and was between the 25th percentile (20.5/net night) and the median (35.2/net night) for the SLMMU. The CPE of smaller Bluegill in seines of 13.7 fish/haul was higher than the 75th percentile of lakes in the SLMMU but between the median and the 75th percentile of lakes statewide. Bluegill electrofishing CPE values better represent the abundance of juvenile fish. Boomshocking CPE was 383 fish/hour and was similar to the SLMMU and statewide lake averages.

The size structure of Bluegill was somewhat depressed and 45% of fish were 1-3 inches. There were some quality sized fish available for harvest, but only 16% of Bluegill captured were larger than 6 inches. Growth, predation, and harvest all potentially influence size structure. Growth was below the state average for fish 1 to 4 years of age but was greater than average for older Bluegill (Figure 10). The more abundant smaller Bluegill may be competing for resources thereby reducing growth. Aquatic vegetation is limited in the littoral zone of Coldwater Lake and vegetation provides hiding places for juvenile fish, and the invertebrates that live on vegetation. Invertebrates are important food sources for young Bluegills and densities are related to vegetation density (Savino et al 1992; Shoup et al 2003; Shoup et al 2012). The lack of vegetated cover may not only have reduced available prey resources but may increase predation risk. Small Bluegill avoiding predation will be more susceptible to size selective suboptimal feeding and reduced growth (Mittelbach 1981; Mittelbach 1984; Savino and Stein 1982; Savino et al 1992; Shoup 2003). A combination of competition for resources, predation risks, and suboptimal feeding patterns are most likely responsible for observed poor growth of young Bluegill in Coldwater Lake.

It takes 5 years for Bluegill in Coldwater Lake to reach 6 inches in length. Competition may limit growth of younger fish, as Bluegill become larger and less vulnerable to predation, the shift to more available prey such as large zooplankton (e.g. Daphnia) may facilitate increases in growth. Alternatively, as fish become large enough to harvest, competition may be reduced as overall numbers are thinned resulting in increased growth. Annual mortality estimates for adult Bluegill were 54% which were not exceptionally high, typically ranging from 59 to 87% (Coble 1998; Crawford and Allen 2006). The relative scarcity of large Bluegills does not seem to be due to overharvest but is likely due to reduced growth of younger fish and increased timelines to reach larger sizes.

Hybrid and Redear Sunfish were abundant in the 2014 survey. Hybrids were not observed in high numbers in previous surveys and their prevalence appears to be increasing. Catch rates of Redear Sunfish in large mesh fyke nets were 7.4/net night in 2014. Hybrid catch rates were 22.6/net night, and Bluegill were 24.7/net night. Hybridization rates may be increasing in Coldwater Lake. It is possible that hybrids in past surveys were misidentified leading to underestimation of their numbers. Hybrid Sunfish (max 11 inches, 41% > 8 inches) were significantly larger than Bluegill (max 9 inches, 16% > 8 inches). Redear Sunfish were also larger than Bluegill (max 12 inches, 61% > 8 inches). Redear Sunfish had higher growth rates than Bluegill with an index score of +1.1 and lengths-at-age that were well above that of Bluegill. Very few Redear or Hybrid Sunfish under 4 inches were collected. Small (< 3 inches) Hybrid and Redear Sunfish are difficult to distinguish from Bluegill. Bias in identification of small fish as Bluegill may have contributed to overestimation of the abundance of small Bluegill. As stated earlier high densities of small Bluegill resulted in lower calculated index values for Bluegill size structure. There is evidence in some systems that Redear Sunfish hybrids do not successfully reproduce (Childers and Bennett 1961). The presence of Redear Sunfish and their hybrids has resulted in increased size structure in other systems creating fishing opportunities, the long-term effects of out-breeding depression on native Bluegill populations remain uncertain (Braunscheidel and Towns 2017). Estimated annual mortality was much lower for Redear Sunfish (33.6%) than it was for Bluegill (54%). Redear Sunfish survived longer and were older, up to a maximum of 10 years of age compared to Bluegill with a maximum age of seven. Redear Sunfish may be underutilized by anglers. It is unclear if they are not preferred for harvest or if Redear Sunfish are utilizing different habitat types or prey that would make them less vulnerable to angling.

Pumpkinseed and Black Crappie contributed to the fisheries in Coldwater Lake, but were less abundant than Bluegill, Redear Sunfish or Hybrids. Low numbers of Pumpkinseed (0.4/net night) and Black Crappie (1.8/net night) were captured in large mesh fyke nets. Catch rates for both species were below the SLMMU 25th percentile, but between the 25th and the median and statewide values.

Average numbers of Yellow Perch were present in Coldwater Lake. Catch rates in gill nets (1.6/net night) were average in Coldwater Lake and were between the 25th percentile and the median catch rates for the SLMMU and statewide. Yellow Perch growth (-0.1) was average and had declined since the 1983 (+0.8) and 1994 (+1.6) surveys. Yellow Perch were captured up to age 7 and fish over age 4 were larger than the statewide average length at age (Figure 11). Larger Yellow Perch were common and 8.3% were greater than ten inches and the maximum size was 12.8 inches.

Management Direction

Coldwater Lake continues to support a variety of quality fishing opportunities for Largemouth Bass, Northern Pike, and panfish. No management changes are recommended for these species. Growth rates were close to the state average and good numbers of harvestable sized fish were available. There is evidence of competition for prey resources and harvest rates were high, however, it is unlikely that restrictive regulations or increases in predator stocking would improve size structure.

Walleye stocking in Coldwater Lake should be discontinued. Consistent stocking efforts have not resulted in recruitment to fisheries. It is possible that larger fall fingerling Walleye would survive better than spring fingerlings which were previously used in stocking efforts, however, increases in the abundance of predators in Coldwater Lake would likely produce a negative influence on growth rates

of Largemouth Bass and lead to increases in predation on panfish populations in the lake. Fall fingerlings produced by SLMMU are limited in availability and currently allocated to other more successful lakes in the region.

SLMMU will continue to promote natural shoreline alternatives for erosion control. Habitat is limited in Coldwater Lake. The abundance of submerged vegetation is naturally low, and the shoreline is highly armored and developed. Increases in the availability of nearshore weed beds and emergent fringe wetlands would provide important habitats for fish spawning, increase invertebrate food resources, provide cover from predation, and stabilize eroding shorelines. Natural shoreline management can be promoted through the permit review process and in outreach efforts with local lakefront property owners.

References

Allen, M.S., C.J. Walters, and R. Myers. 2008. Temporal Trends in Largemouth Bass Mortality, with Fishery Implications. North American Journal of Fisheries Management 28:418-427.

Allen, M.S., M. W. Rogers, R. A. Myers, and W. M. Bivin. 2004. Simulated Impacts of Tournament-Associated Mortality on Largemouth Bass Fisheries. North American Journal of Fisheries Management 24:1252-1261.

Braunscheidel, J.J., and G.L. Towns. 2017. Effects of Redear Sunfish Introduction on Bluegill and Pumpkinseed in Joslin Lake, Washtenaw County, Michigan 1988-2003. Michigan Department of Natural Resources, Fisheries Report 22, Lansing, MI.

Bryan, M. D., and D. L. Scarnecchia. 1992. Species richness, composition, and abundance of fish larvae and juveniles inhabiting natural and developed shorelines of a glacial Iowa lake. Environmental Biology of Fishes 35:329-341.

Burns, D. C. 1991. Cumulative effects of small modifications to habitat. Fisheries 16(1):12-17.

Childers, W.F., G.W. Bennett. 1961. Hybridization between three species of sunfish (Lepomis). Illinois Natural History Survey Division. Biological Notes No. 46.

Coble, D.W. 1998. Effects of angling on bluegill populations: management implications. North American Journal of Fisheries Management 8: 277-283.

Cooper, G.P. 1948. Fish stocking policies in Michigan. Michigan Department of Natural Resources, Fisheries Report 1167, Ann Arbor, MI.

Crawford, S. and Allen, M.S. 2006. Fishing and natural mortality of bluegills and redear sunfish at Lake Panasoffkee, Florida: implications for size limits. North American Journal of Fisheries Management, 26: 42-51.

Diana, M.J., A.L. Larsen, M.J. Siepker, and D.H. Wahl. 2012. Effects of Tournament Compared with Catch and Release Angling on Nest Abandonment of Largemouth Bass, North American Journal of Fisheries Management. 32: 832-837.

Diana, M.J.; DeBoom, Corey S.; Diffin, Brett J.; Einfalt, Lisa M.; Gring, Jeffery P.; Wood, Kaleb B.; Bogner, David M.; Garavaglia, James A.; Effert, Eden L.; and Wahl, David H. 2016. Surveys and investigations for sportfish management in lakes and rivers in Illinois, Annual Report July 1, 2015 through June 30, 2016. Illinois Natural History Survey, 2016-08.

Downing, J.A. and E. McCauley. 1992. The nitrogen : phosphorus relationship in lakes. Lmnol. Oceanography. 37: 936-945.

Eagle, A.C., E.M. Hay-Chmielewski, K.T. Cleveland, A.L. Derosier, M.E. Herbert, and R.A. Rustem, eds. 2005. Michigan's Wildlife Action Plan. Michigan Department of Natural Resources, Lansing.

Forsberg, C., and S. O. Ryding. 1980. Eutrophication parameters and trophic state indices in 30 Swedish waste-receiving lakes. Archives fur Hydrobiologie. 88:189-207.

Fayram, A.H., M.J. Hansen and T.J. Ehlinger. 2005. Interactions between Walleyes and Four Fish Species with Implications for Walleye Stocking. North American Journal of Fisheries Management 25:1321-1330.

Gunderman, B.. 2011. East Long Lake 2011 Survey Report. Michigan Department of Natural Resources. Fish Collection System Document 8897.

Gwinn, D., and M. S. Allen. 2010. Exploring population level effects of fishery closures during spawning: an example using largemouth bass. Transactions of the American Fisheries Society 139:626-634.

Inskip, P. D., and J. J. Magnuson. 1983. Changes in fish populations over an 80-year period: Big Pine Lake, Wisconsin. Transactions of the American Fisheries Society. 112:378-389.

Jennings, M. J., M. A. Bozek, G. R. Hatzenbeler, E. E. Emmons, and M. D. Staggs. 1999. Cumulative effects of incremental shoreline habitat modification on fish assemblages in north temperate lakes. North American Journal of Fisheries Management 19:18-27.

MDNR (Michigan Department of Natural Resources). 2004. Introduction to Michigan fish stocking guidelines. Chapter 1 in Dexter, J.L. Jr., and R.P. O'Neal, editors. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor, MI.

Mittelbach GG. 1981. Foraging efficiency and body size: a study of optimal diet and habitat use by bluegills. Ecology. 62(5):1370-1386.

Mittelbach GG. 1984. Predation and resource partitioning in two sunfishes (Centrarchidae). Ecology. 65(2):499-513.

Nate, N. A., M. A. Bozek, M. J. Hansen, C. W. Ramm, M. T. Bremigan, and S. W. Hewett. 2003. Predicting the occurrence and success of walleye populations from physical and biological features of northern Wisconsin lakes. North American Journal of Fisheries Management. 23:1207-1214.

O'Neal, R. P., and G. J. Soulliere. 2006. Conservation guidelines for Michigan lakes and associated natural resources. Michigan Department of Natural Resources, Fisheries Special Report 38, Ann Arbor.

Ostrand K.G., M.J. Siepker, D.H. Wahl. 2011. Effectiveness of livewell additives on largemouth bass survival. Journal of Fish and Wildlife Management 2:22-28.

Parkos J.J., D.H. Wahl, and D.P. Philipp. 2011. Influence of behavior and mating success on brood-specific contribution to fish recruitment in ponds. Ecological Applications, 21: 2576-2586.

Pierce, R.B. and Tomcko, C.M. 2003. Interrelationships among production, density, growth, and mortality of northern pike in seven north-central Minnesota lakes. Transactions of the American Fisheries Society. 132: 143-153.

Pierce, R.B., Tomcko, C.M. and Schupp, D.H. 1995. Exploitation of northern pike in seven small north-central Minnesota lakes. North American Journal of Fisheries Management. 15: 601-609.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd Can., 191: 1-382.

Santucci, V. J. Jr., and D. H. Wahl. 1993. Factors influencing survival and growth of stocked walleye in a centrarchid dominated impoundment. Canadian Journal of Fisheries and Aquatic Sciences 50:1548-1558.

Savino, J. F., and R. A. Stein. 1982. Predator-prey interaction between Largemouth Bass and Bluegills as influenced by simulated, submersed vegetation. Transactions of the American Fisheries Society 111:255-266.

Savino, J.F., E.A. Marschall, and R.A. Stein. 1992. Bluegill growth as modified by plant density: an exploration of underlying mechanisms. Oecologia, 89: 153-160.

Schneider, J.C. 1990. Classifying Bluegill populations from lake survey data. Michigan Department of Natural Resources, Fisheries Technical Report 90-10, Ann Arbor.

Schneider, J.C. 2000a. Interpreting fish population and community indices. Chapter 21 in Schneider, James C. (ed) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

Schneider, J.C. 2000b. Weighted average length and weighted age composition. Chapter 15 in Schneider, James C. (ed) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

Schneider. J. C., P.W. Laarman, and H. Gowing. 2000. Length-weight relationships. Chapter 17 in Schneider, James C. (ed) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

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

Serns, S.L. 1983. Relationship between electrofishing catch per effort and density of Walleye. North American Journal of Fisheries Management. 3: 451-452.

Shaw, B., C. Mechenich, and L. Klessig. 2004. Understanding lake data. University of Wisconsin - Extension, Publication G3582, Madison.

Shoup DE, Carlson RE, Heath RT. 2003. Effects of predation risk and foraging return on the diel use of vegetated habitat by two size-classes of bluegills. Transactions of the American Fisheries Society. 132(3):590-597.

Shoup, D. E., M. A. Nannini, and D. H. Wahl. 2012. The effect of vegetation density on juvenile Bluegill diet and growth. Journal of Freshwater Ecology 27:199-209.

Siepker, M. J., S. J. Cooke, D. H. Wahl, and D. P. Philipp. 2009. Individual reproductive success of largemouth bass and smallmouth bass subjected to different components of competitive angling events. Transactions of the American Fisheries Society 138:818-825.

Siepker, M. J.,K.G.Ostrand, S. J. Cooke, D. H.Wahl, and D. P. Philipp. 2007. A review of the effects of catch-and-release angling on black bass, Micropterus spp.: implications for conservation and management of populations. Fisheries Management and Ecology 14:91-101.

Wilde, G. R. 2003. Dispersal of tournament-caught black bass. Fisheries 28(7):
10-17.

Wehrly, K.E., G.S. Carter, and J.E. Breck. DRAFT. Chapter XX: Inland Lake Status and Trends Program Sampling Protocols. Michigan Department of Natural Resources, Fisheries Special Report Draft, Ann Arbor.

Woodford, J. E., and M. W. Meyer. 2002. Impact of lakeshore development on green frog abundance. Biological Conservation 110:277-284.

Ziegler, W., and J. C. Schneider. 2000. Guidelines for evaluating walleye and muskie recruitment. Chapter 23 in Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

VII. Attachments

Table 1. Surveys conducted on Coldwater Lake by DNR Fisheries. The reason for the survey describes the goal or species targeted by survey efforts.

Year	Gear Types	Month	Reason for Survey
1886	Seine	Unknown	Species Presence
1927	Gill Net	May	General Fisheries Survey
1967	Electrofishing, Gill Net	July/August	General Fisheries Survey
1983	Trap Net	May, June	General Fisheries Survey
1994	Gill Net, Trap Net	May	General Fisheries Survey
1941	Depth measurements on ice	Winter	Bathymetric Mapping
1948	Unspecified	Unknown	Fish Survey of Adjacent Channels
1986	Electrofishing, Gill Net	October	Assess Stocked Walleye Survival
1988	Electrofishing	October/November	Assess Stocked Walleye Survival
1989	Trap Nets	Spring	Assess Stocked Walleye Survival
1989	Electrofishing	October/November	Assess Stocked Walleye Survival
1992	Electrofishing	October	Assess Stocked Walleye Survival
1993	Electrofishing	October	Assess Stocked Walleye Survival
1994	Electrofishing	October	Assess Stocked Walleye Survival
1992	Postcard Creel	Spring	Assess Stocked Walleye Survival
1994	Trap Net	April	Assess Stocked Walleye Survival
1996	Creel	February	Assess Stocked Walleye Survival
1991	Creel	September	Assess Largemouth Bass Regulations
1996	Creel	August	Assess Largemouth Bass Regulations
1997	Creel	July	Assess Largemouth Bass Regulations
2006	Gill Net	November	Assess Cisco Population
2005	Limnology	July	Assess Cisco Population

Table 2. Stocking history for fish released in Coldwater Lake from 1933 through the present. Walleye were stocked as spring fingerlings unless otherwise noted.

Year	Walleye	Tiger Muskellunge	Smallmouth Bass	Largemouth Bass	Yellow Perch	Bluegill
1933	--	--	2,000	--	--	80,000
1934	--	--	--	3,500	--	140,000
1935	--	--	--	--	60,000	150,000
1936	--	--	6,000	--	--	20,000
1937	--	--	--	5,000	--	100,000
1938	--	--	--	6,000	50,000	100,000
1939	--	--	2,000	2,500	15,000	150,000
1940	--	--	2,000	1,000	--	50,000
1941	--	--	1,500	2,500	--	95,000
1942	--	--	2,500	2,500	--	27,750
1943	--	--	1,000	4,000	--	22,000
1944	--	--	--	5,500	--	40,000
1945	--	--	--	--	--	30,000
--	--	--	--	--	--	--
--	--	--	--	--	--	--
--	--	--	--	--	--	--
1966	550a	--	--	--	--	--
1967	--	--	--	--	--	--
1968	475a	--	--	--	--	--
1969	340f	--	--	--	--	--
1970	--	--	--	--	--	--
1971	--	--	--	--	--	--
1972	--	--	--	--	--	--
1973	--	--	--	--	--	--
1974	--	--	--	--	--	--
1975	--	--	--	--	--	--
1976	--	3,200	--	--	--	--
1977	--	--	--	--	--	--
1978	--	--	--	--	--	--
1979	--	--	--	--	--	--
1980	--	3,200	--	--	--	--
1981	--	--	--	--	--	--
1982	64,000	6,100	--	--	--	--
1983	--	--	--	--	--	--
1984	20,000	4,480	--	--	--	--
1985	--	--	--	--	--	--
1986	54,438	3,228	--	--	--	--
1987	--	--	--	--	--	--

Table 2. Continued

1988	25,368	--	--	--	--	--
1989	34,027	6,400	--	--	--	--
1990	--	--	--	--	--	--
1991	--	6,400	--	--	--	--
1992	80,844	--	--	--	--	--
1993	200,556	--	--	--	--	--
1994	248,793	--	--	--	--	--
1995	--	--	--	--	--	--
1996	--	--	--	--	--	--
1997	54,320	--	--	--	--	--
1998	161,000	--	--	--	--	--
1999	--	--	--	--	--	--
2000	185,647	--	--	--	--	--
2001	--	--	--	--	--	--
2002	178,935	--	--	--	--	--
2003	--	--	--	--	--	--
2004	9,969	--	--	--	--	--
2005	--	--	--	--	--	--
2006	217,953	--	--	--	--	--
2007	--	--	--	--	--	--
2008	200f	--	--	--	--	--
2009	--	--	--	--	--	--
2010	--	--	--	--	--	--
2011	80,370	--	--	--	--	--
2012	80,638	--	--	--	--	--

a = adult f = fall fingerling

Table 3. Total fish caught, total weight, mean length, and length range for all gears in Coldwater Lake surveys conducted in May of 2014.

Species	Number Caught	Total Weight (lbs)	Mean Length (inches)	Length Range
Banded Killifish	35	0.1	2.0	1 - 2
Black Crappie	46	12.8	7.4	4 - 13
Blackchin Shiner	1	0.0	1.5	1 - 1
Blacknose Shiner	281	1.1	2.2	1 - 2
Bluegill	1,421	101.1	3.8	1 - 9
Bluntnose Minnow	492	2.0	2.1	1 - 3
Bowfin	5	19.1	21.5	14 - 25
Brook Silverside	85		3.2	2 - 3
Brown Bullhead	48	52.4	13.2	7 - 15
Golden Shiner	6	0.7	7.0	5 - 8
Green Sunfish	1	0.0	3.5	3 - 3
Hybrid Sunfish	576	213.2	7.5	1 - 11
Iowa Darter	3	0.0	1.5	1 - 1
Johnny Darter	3	0.0	1.8	1 - 2
Largemouth Bass	110	57.3	8.9	2 - 17
Logperch	17	0.3	3.5	2 - 4
Longnose Gar	75	203.7	30.2	18 - 45
Northern Pike	85	270.1	23.6	15 - 34
Pumpkinseed	12	1.7	5.1	2 - 7
Redear Sunfish	186	110.7	8.8	4 - 12
Rock Bass	227	60.4	6.5	1 - 10
Sand Shiner	281	0.9	2.1	1 - 2
Smallmouth Bass	8	5.0	9.7	3 - 14
Spotfin Shiner	1,085	5.9	2.5	1 - 3
Spottail Shiner	84	0.5	2.6	1 - 3
Spotted Gar	23	37.1	22.7	17 - 31
Tadpole Madtom	2	0.0	2.0	1 - 2
Warmouth	48	10.4	6.0	2 - 9
Yellow Bullhead	177	127.0	11.2	2 - 14
Yellow Perch	84	13.0	6.2	2 - 12
Total	**5,507**	**1,306.4**	**5.1**	**1 - 45**

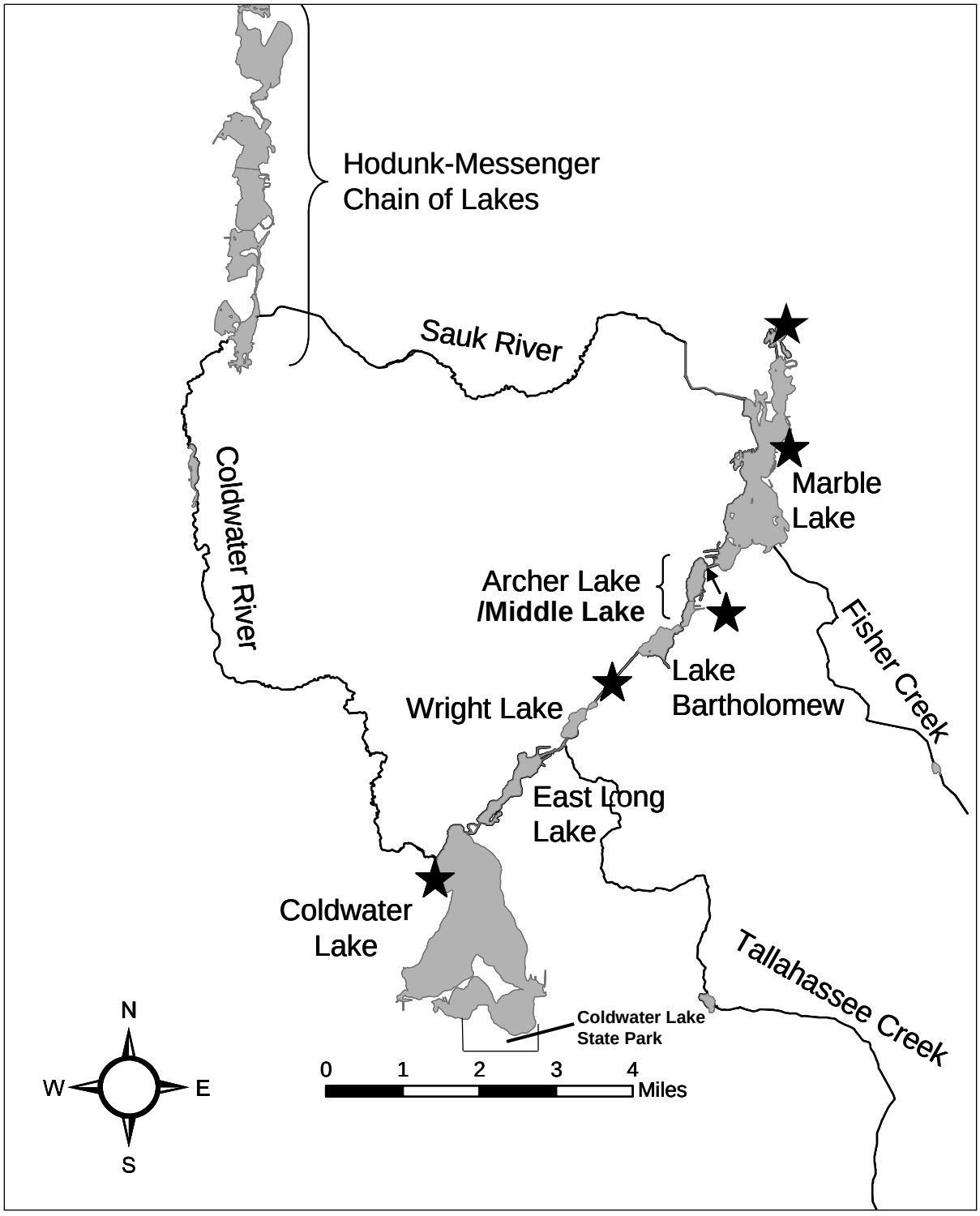

Figure 1. Map of Coldwater Lake and the Coldwater/Marble Chain of Lakes adapted from Gunderman (2011). Stars represent public boat access sites.

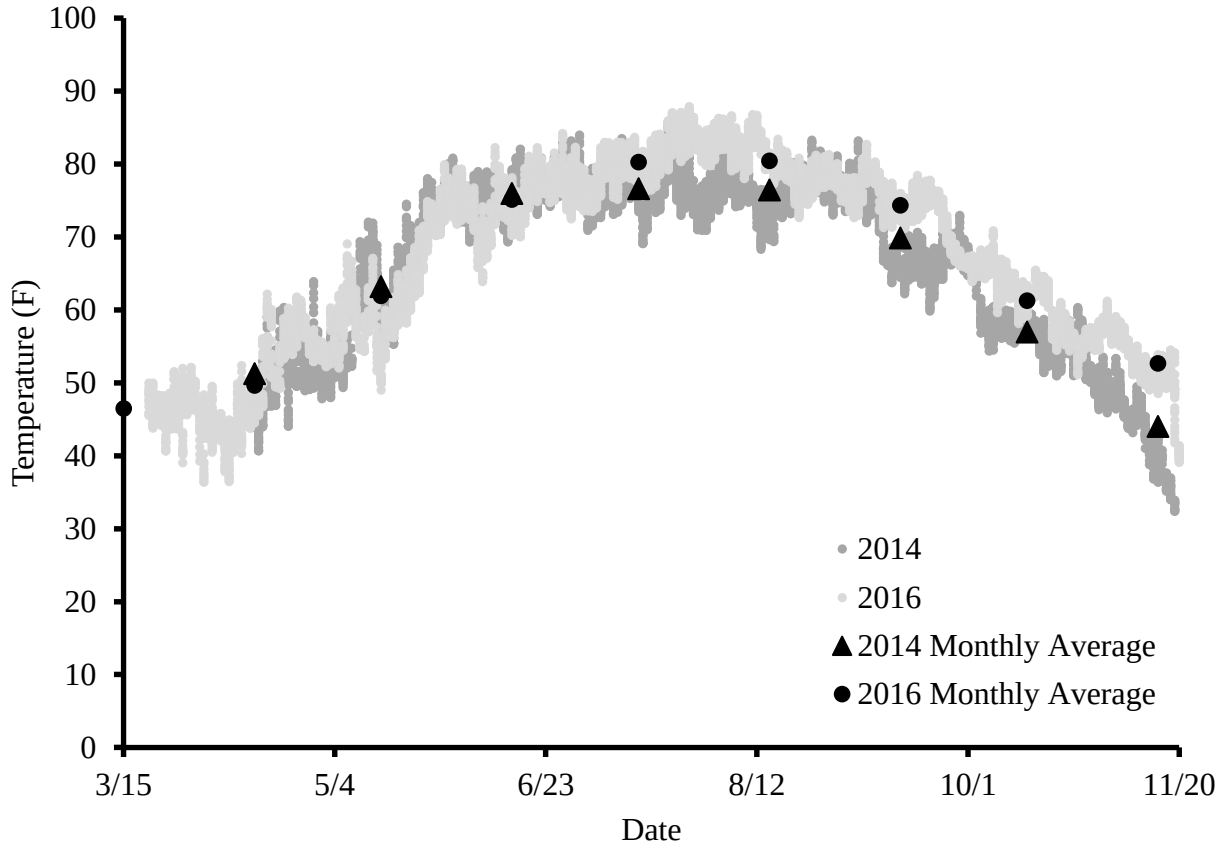

Figure 2. Hourly temperature readings and monthly average temperature in 2014 and 2016 from temperature loggers deployed in Coldwater Lake.

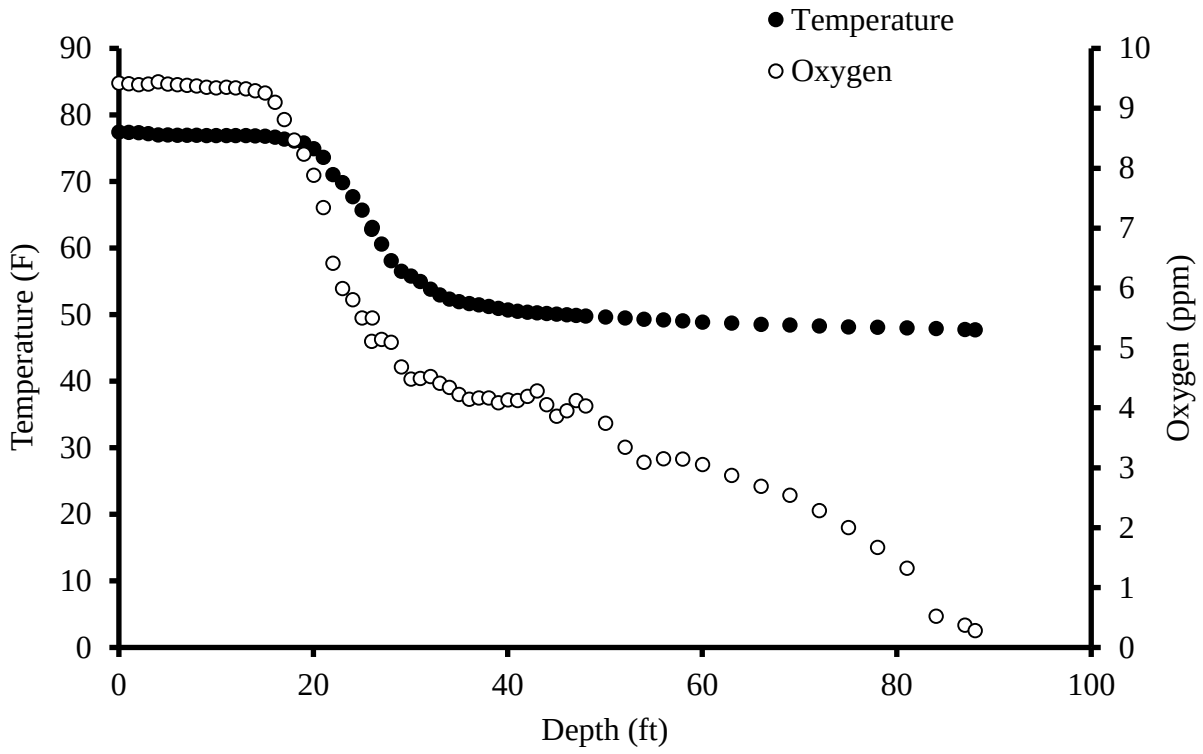

Figure 3. Temperature and Oxygen profile for Coldwater Lake conducted on August 10, 2015.

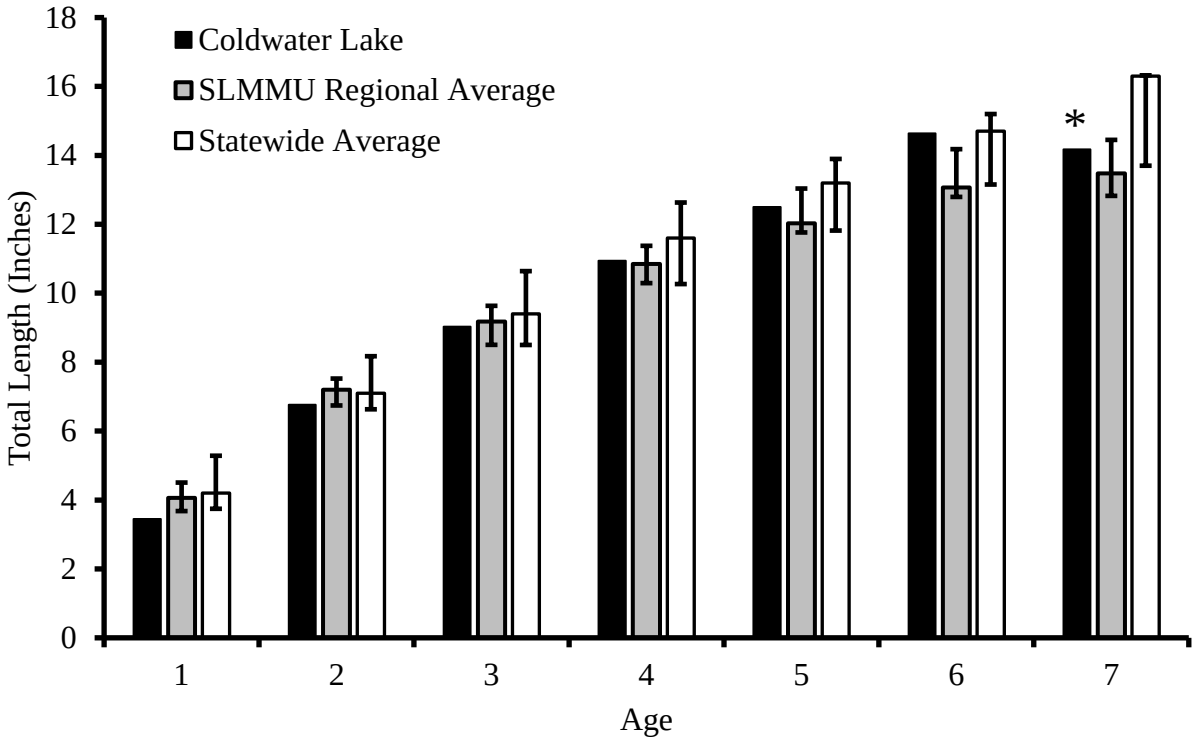

Figure 4. Mean length for each age class of Largemouth Bass captured in surveys conducted on Coldwater Lake in 2014. Asterix indicates year classes represented by less than 5 individuals. Error bars represent the 25th (lower) and 75th (upper) percentile of surveys conducted in the respective region.

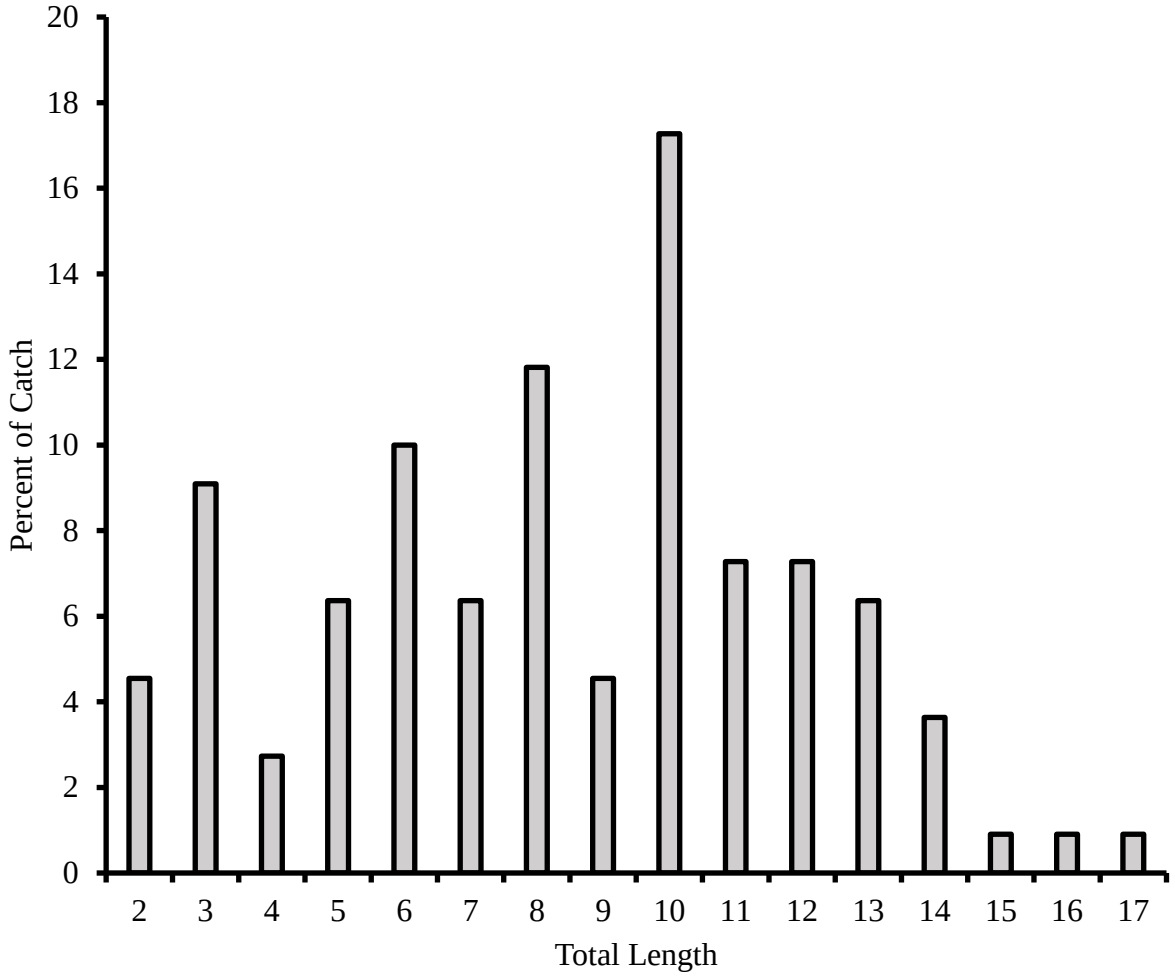

Figure 5. Length frequency of Largemouth Bass captured in surveys conducted on Coldwater Lake in 2014. Total length bins are denoted by the minimum size of each one-inch bin (e.g. 2 represents 2.0 to 2.9-inch fish).

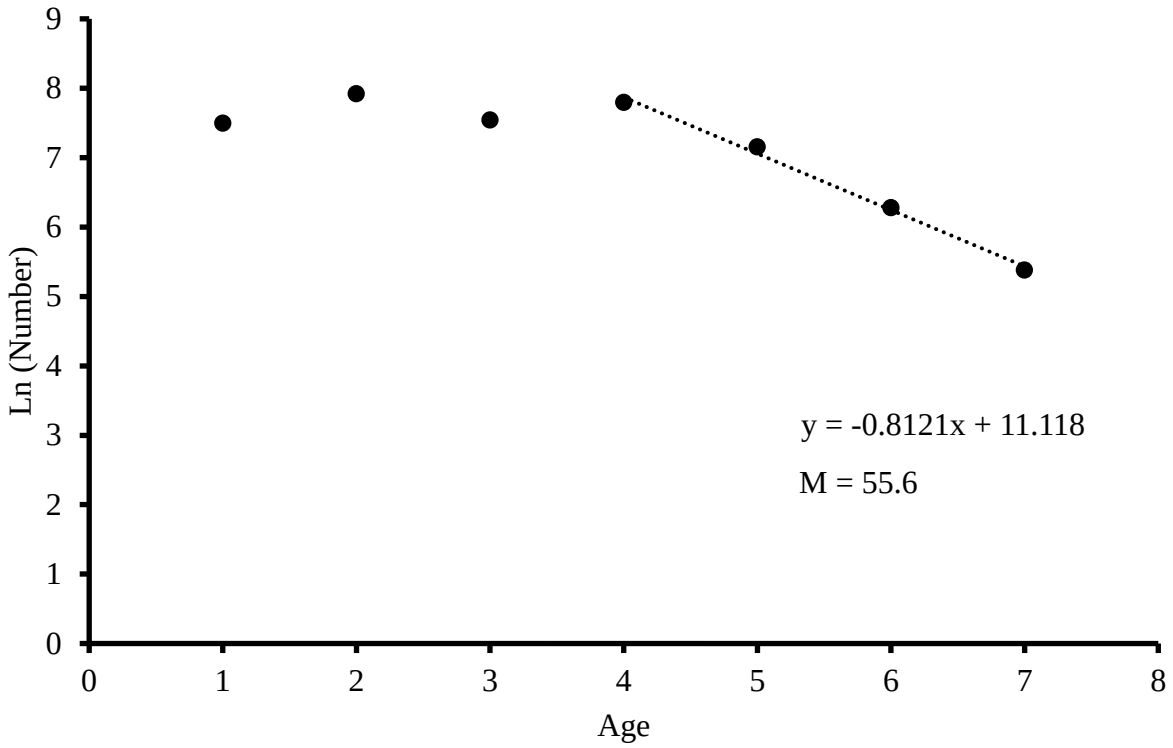

Figure 6. Annual mortality estimates for Largemouth Bass in Coldwater Lake estimated from surveys conducted in 2014. The y-axis represents the natural log of the total number of fish captured for each age.

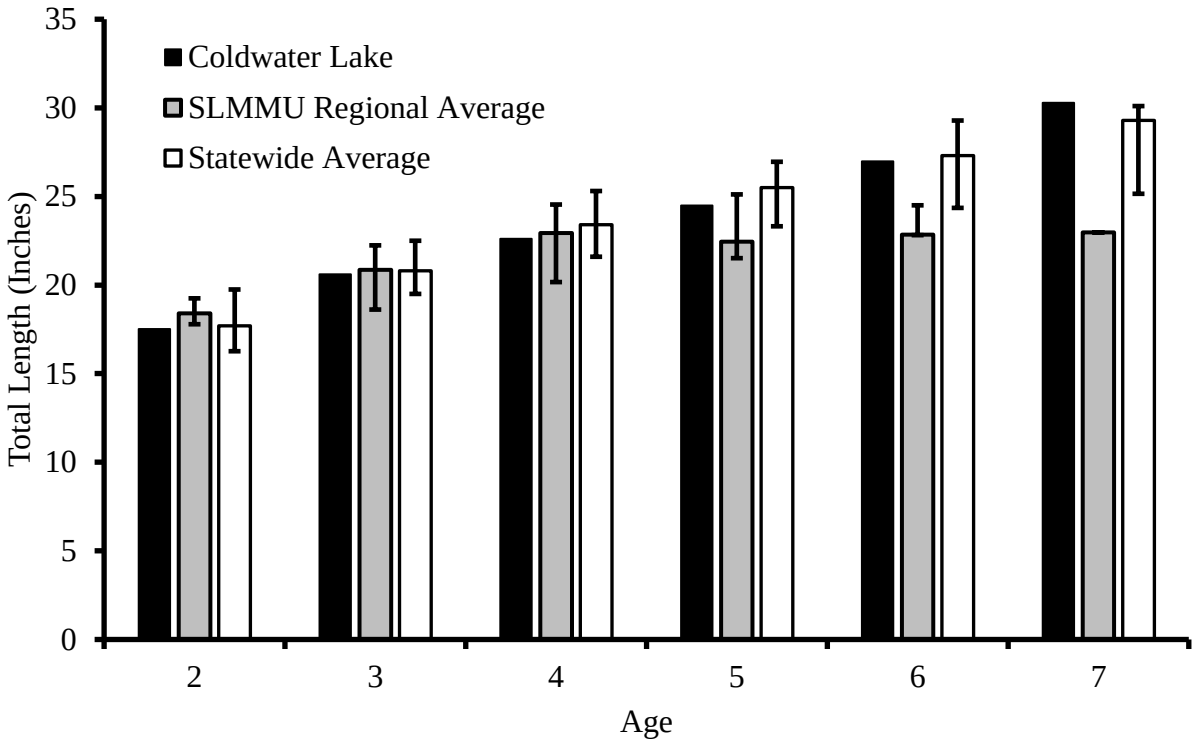

Figure 7. Length at age for Northern Pike captured in a 2014 fish survey of Coldwater Lake. Black bars represent Coldwater Lake mean size for each age class, grey bars represent the SLMMU regional average, and white bars represent the statewide average. Error bars represent the 25th (lower) and 75th (upper) percentile of surveys conducted in the respective region.

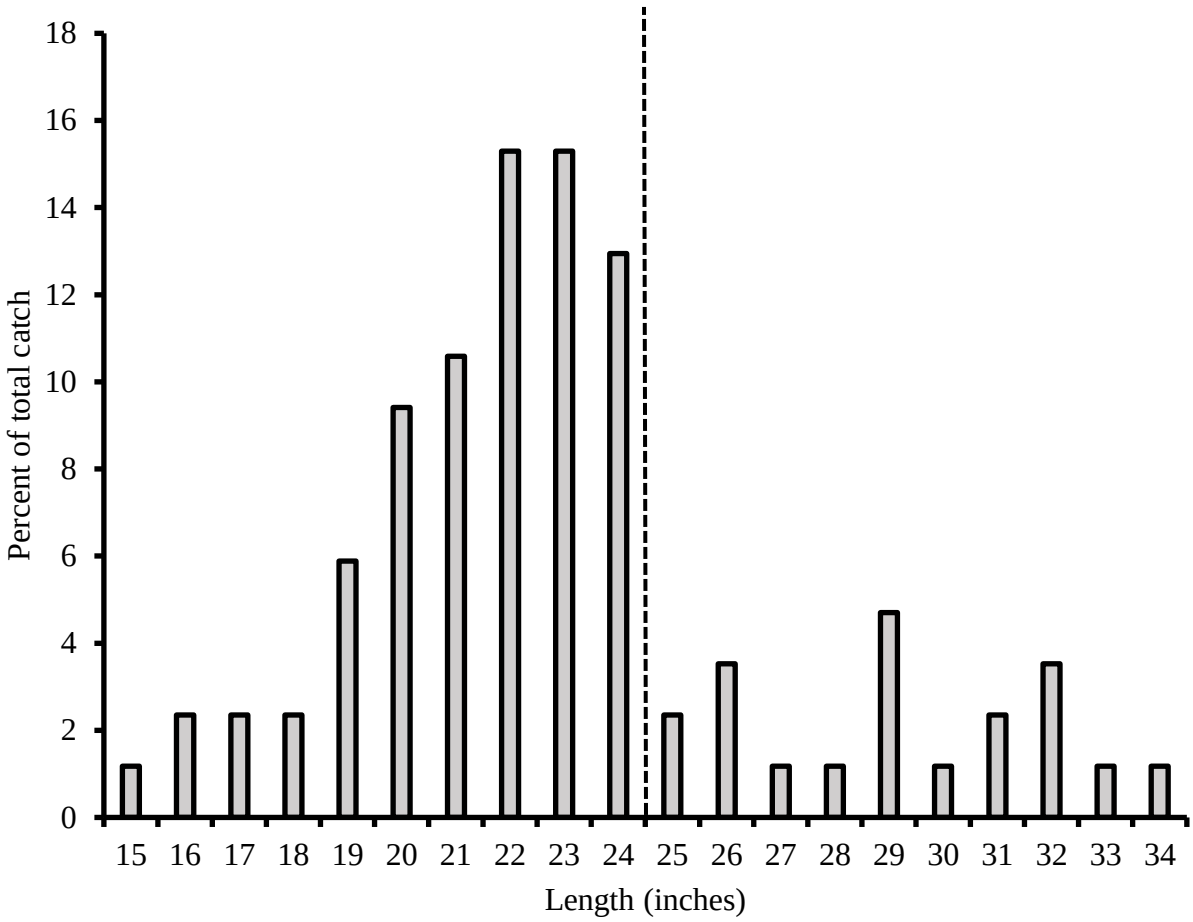

Figure 8. Length frequency of Northern Pike in Coldwater Lake. The dashed line represents the 24-inch minimum size limit for harvesting Northern Pike.

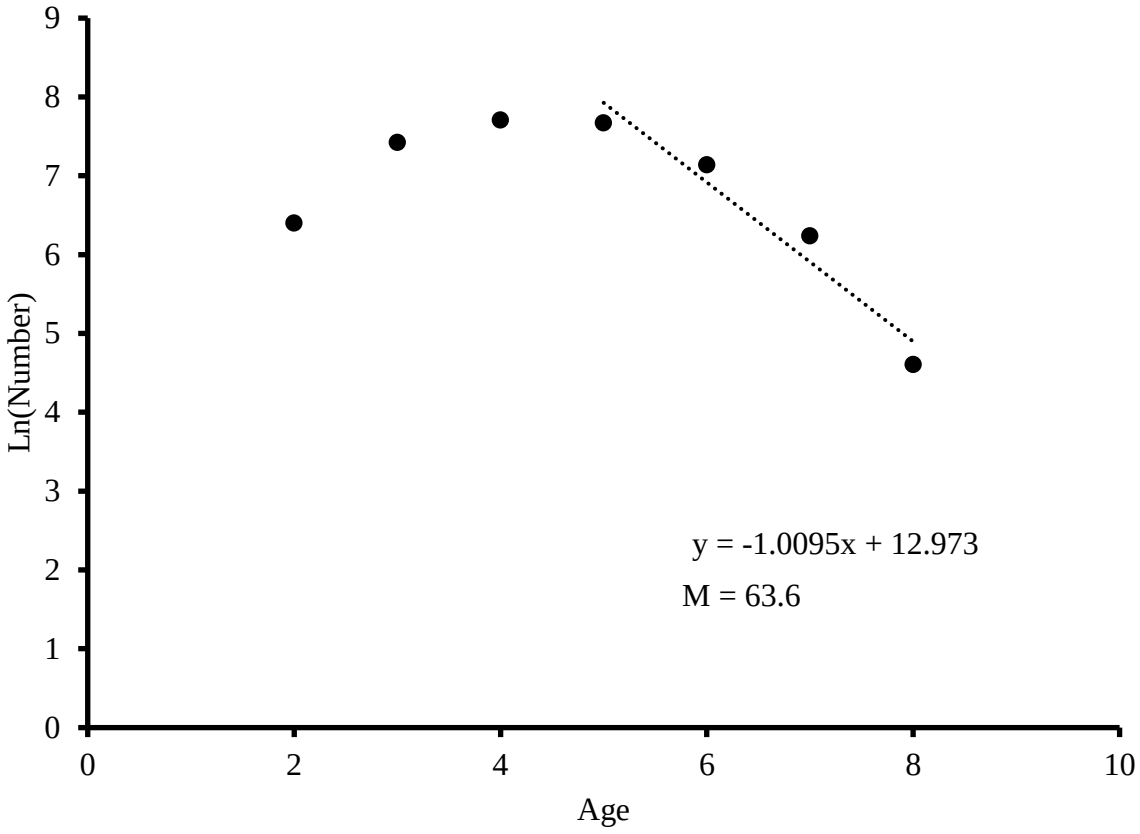

Figure 9. Annual mortality estimates for Northern Pike in Coldwater Lake estimated from surveys conducted in 2014. The y-axis represents the natural log of the total number of fish captured for each age.

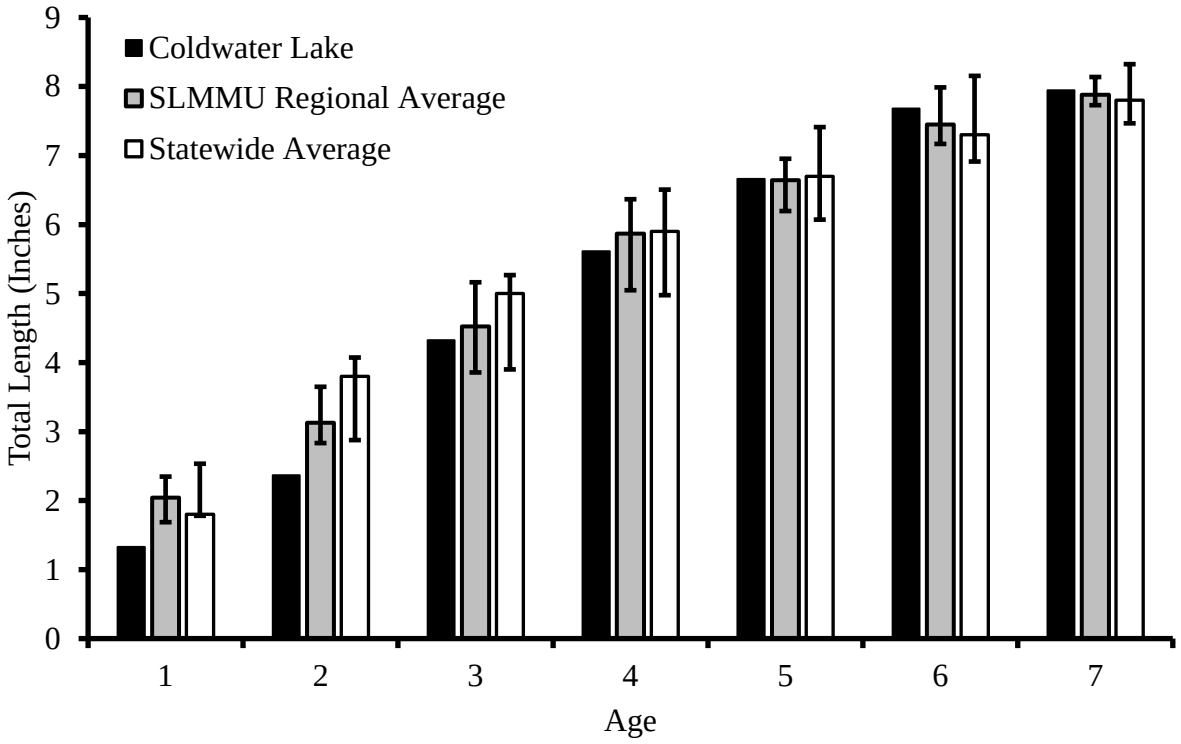

Figure 10. Length at age for Bluegill captured in surveys conducted in Coldwater Lake in 2014. Black bars represent Coldwater Lake mean size for each age class, grey bars represent the SLMMU regional average, and white bars represent the statewide average. Error bars represent the 25th (lower) and 75th (upper) percentile of surveys conducted in the respective region.

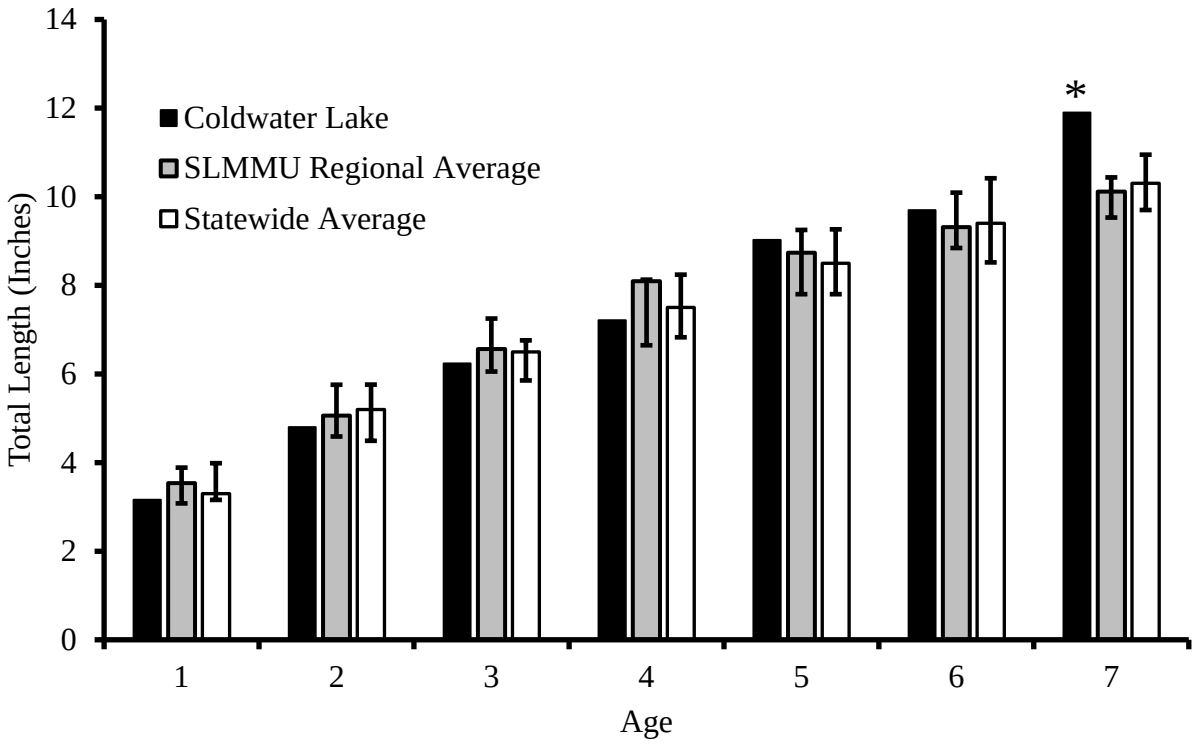

Figure 11. Length at age for Yellow Perch captured in surveys conducted in Coldwater Lake in 2014. Asterix indicates year classes represented by less than 5 individuals. Black bars represent Coldwater Lake mean size for each age class, grey bars represent the SLMMU regional average, and white bars represent the statewide average. Error bars represent the 25th (lower) and 75th (upper) percentile of surveys conducted in the respective region.