Big Manistique Lake
Mackinac & Luce County, T44N/R12W/02
Manistique River Watershed, Last Surveyed 2024

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Environment

Location
Big Manistique Lake is a 10,346-acre lake (Breck 2004) located in the Manistique River Watershed on the border of Luce and Mackinac Counties (Townships 44 and 45 N, Range 11 and 12 W) in Michigan's Upper Peninsula (Figure 1). In Luce County, Helmer (Lakefield Township) resides on the northeast shore of Big Manistique Lake. In Mackinac County, Curtis (Portage Township) resides south-southeast of Big Manistique Lake adjacent to the north shoreline of South Manistique Lake. Big Manistique Lake, the largest of the Manistique Lakes, is the seventh largest inland lake in Michigan (Laarman 1976) and has an average depth of 10-feet and a maximum depth of 23-feet.

Geology and Geography
Big Manistique Lake is located within the Manistique bedrock geological formation which is comprised of a thin dolomite and limestone strip that spans from Delta to Mackinac counties (MDNR 2001). Rock types in this region are predominately sedimentary and provide an abundance of habitat in Big Manistique Lake for lithophilic spawning fish, such as Walleye. Surrounding surficial landforms of Big Manistique Lake consists mostly of moraine (45.6%), and lacustrine/dune (16.6%). Fine `dune' substrates such as sand pose a hazard to nearshore spawning habitat in Big Manistique Lake by filling in interstitial spaces that are occupied by developing fish eggs and embryo. The adjacent landcover of Big Manistique Lake is comprised of forest (40.7%), wetland (37.0%), water (11.6%), agricultural (4.8%), urban (3.8%), grassland/shrub (1.8%), and barren (0.3%) land cover types (Figure 2). The surficial geology in this region is comprised of large course (62.2%) textured materials as well as organic material with no texture (37.8%). Course textured materials are located throughout the lake and assist in providing nearshore spawning habitat. Course textured material also facilitates the exchange of cool groundwater in deeper regions of the lake where cool- and cold-water species reside (e.g., Walleye and Cisco, respectively). Remaining shores consist of untextured materials (sand and organic material) and have low to medium groundwater permeability (Madison and Lockwood 2004). Soil types surrounding Big Manistique Lake are dominated by herbaceous organic matter and sandy loam glacial deposits (USDA 2024).

Island Complexes
Big Manistique Lake has a total of four islands including Foster, Greenfield, Gull, and Burnt that are approximately 8, 2, 1, and 1 acre in size, respectively. One island (i.e., Greenfield) is largely developed, while the remaining three are in their natural state.

Watershed Description
Big Manistique Lake is fed by Helmer Creek from the North and Portage Creek from the South (Figure 1). Helmer Creek flows southwest from North Manistique Lake into Big Manistique Lake. The Tressler Dam, located on Helmer Creek, limits upstream fish passage between the lakes. Portage Creek flows northeast from South Manistique Lake into Big Manistique Lake and contains a water level control

structure used to elevate South Manistique Lake water levels for recreational purposes (Madison and Lockwood 2004). In addition, a dam on Black Creek (tributary to Portage Creek) is located upstream of the Portage Creek confluence and creates the Black Creek Flooding area used for wildlife recreation. The Manistique River, at times referred to as the Lake Branch of the Manistique River, forms the sole outflow on the west side of Big Manistique Lake and drains to Lake Michigan. The Manistique Lake Dam is approximately four miles downstream of the lake and downstream of the confluence with the Fox River. The dam blocks upstream fish passage to Big Manistique Lake from the Manistique River, though fish can migrate between the Fox River and Big Manistique Lake seasonally.

The Big Manistique Lake watershed or `lakeshed' (Figure 3) encompasses 62,191 acres, of which nearly 27 percent is water (MGLP 2023). Approximately 83 percent of the Big Manistique Lake watershed is currently unprotected and is vulnerable to residential and agricultural development. The immediate shoreland area of Big Manistique Lake encompasses a total 977 acres (MGLP 2023). Approximately 93 percent of the immediate shoreland area is unprotected and vulnerable to residential and agricultural development.

Big Manistique Lake Dam Structure

An anecdotal report from a retired game warden from the Seney Wildlife Refuge explained that the original outlet dam was built in 1918 or 1919 using pilings and plank. The dam structure was built and controlled by the Manistique Pulp and Paper Company. Large rafts of cedar ties and bolts were rafted across Big Manistique Lake for construction. Once built, general operation of the dam consisted of letting water loose in early June after high water in the Fox River receded. This dam structure was operated for 5 or 6 years, however, there were complaints from area farmers and other riparian owners that the high water was damaging lake-side timber and holding water in surrounding agricultural areas too late in the spring. The dam was used to some extent in later years to control the lake level throughout the summer but was a continual topic of contention among riparian landowners. Water draining from the Fox River and East Branch of the Fox River `backed up' into Manistique Lake during spring break up and the river was referred to as "the river that flowed backwards".

In 1936 the outlet dam was noted to be owned by the Slack Lumber Company and used to control water levels in the lake. In January of 1948, through a local court, a normal height and level of Big Manistique Lake was established to be 686.0 feet above sea level using data collected by the United States Geological Survey. At this time, the dam was in Luce County at the outflow of Big Manistique Lake.

During the 1950s, Big Manistique Lake water level control continued to be a contentious topic that was routinely discussed with area residents and resort owners at local meetings. Some residents expressed concern that locals were tampering with boards at the outlet structure and requested that the Department of Conservation (now Dept. of Natural Resources) take control of the dam to adjust boards accordingly. Taking control of or adjusting the water level control structure was not considered by the Department of Conservation as this was a locally regulated structure. There was also local interest to have a staff gauge installed at the outlet of the dam to help monitor water levels.

By April of 1975, the water control structure on the lake branch was in disrepair. A new structure was built in 1978 downstream in Schoolcraft County. In June of 1978 the Circuit Court reaffirmed establishment of a legal lake level in Big Manistique Lake of 686.0 feet above sea level. Currently, the water level control structure is regulated by the Manistique Lake Authority. The Manistique Lake

Authority is comprised of members including the Mackinac County Commissioner, Luce County Commissioner, Portage Township board member, Lakefield Township board member, and three appointed resident board members.

Chemical and physical characteristics

Total alkalinity - Total alkalinity is a measure of buffering capacity and plays an important role in determining a waterbody's pH (Wetzel 2001, Wehrly et al. 2015). Alkalinity values in Michigan inland lakes can be classified into low (< 49.5 mg/L CaCO3), medium (49.5 to 141.5) and high (>141.5) categories. Alkalinity has been measured several times in Big Manistique Lake, most notably in the summer of 1936, 1967, 2003, and 2013. In 1936, Alkalinity was recorded at three locations including Helmer Bay, Mud Creek, and in front of the "Cedar Springs Resort". Alkalinity values reported in 1936 were 90.0, 154.0, and 87 mg/L, respectively. In 1967, Alkalinity was sampled and was reported to be 61.6 mg/L at 23 feet deep. Alkalinity was more recently sampled in 2003 and 2013, during routine Status and Trends surveys. Alkalinity in 2003 and 2013 was reported to be 98.0 and 92.0 mg/L, respectively. Results from intermittent alkalinity sampling suggests that Big Manistique Lake has a moderate alkalinity concentration compared to other inland lakes in Michigan (Wehrly et al. 2015). This may signify that Big Manistique Lake has sufficient capacity to buffer against significant changes pH that often occurs during spring snowmelt or run-off.

Nutrients - Phosphorus and nitrogen are two important nutrients which influence production, biomass, and species composition of aquatic and nearby terrestrial plants in lake ecosystems. Concentrations of these two nutrients vary naturally depending on geology, watershed, and the rate at which water cycles through a lake. Human-derived inputs of nutrients can lead to eutrophication leading to an increase in the production of phytoplankton and aquatic macrophytes, which can often become noxious or a nuisance. As plants decompose, oxygen in the water is consumed by microorganisms and can be reduced to levels that compromise fish habitat and subsequently fish abundance. Alternatively, inland lakes that are characterized as having `too few' nutrients tend to have lower levels of primary production and thus much lower growth rates and less biomass per acre (e.g., standing crop).

Total phosphorus occurs in relatively low concentrations in the aquatic environment and as a result tends to be the limiting nutrient for primary producers (phytoplankton, periphyton, and aquatic vegetation) in an aquatic ecosystem. Phosphorus values typically vary quite widely across Michigan inland lakes having low (<0.009 mg/L), medium (0.009 to 0.020 mg/L), and high (>0.020 mg/L) concentrations. Total phosphorus was recorded in Big Manistique Lake in summer of 2003 and 2013 and was reported to be 0.008 mg/L in both years which is low compared to other inland lakes in Michigan (Wehrly et al. 2015).

In contrast to phosphorus, total nitrogen occurs in relatively higher concentrations in aquatic environments and as a result, rarely limits primary production in lakes. Nitrogen values in Michigan inland lakes range from low (<0.403 mg/L), medium (0.403 to 0.750 mg/L), and high (>0.750 mg/L) concentrations (Wehrly et al. 2015). Total nitrogen was recorded in Big Manistique Lake in summer of 2003 and 2013 and was reported to be 0.64 and 0.30 mg/L, respectively. These results suggest that Big Manistique Lake has a low to moderate level of nitrogen compared to other inland lakes in Michigan (Wehrly et al. 2015). Based on the ratio of total nitrogen to total phosphorus (N:P), managers can classify lakes that may be limited by one nutrient versus the other. For example, plants typically require a specific ratio of N:P which tends to be 18:1, where total phosphorus is the limiting nutrient. In 2003 and 2013,

the N:P ratio for Big Manistique Lake was 80:1 and 30:1, respectively suggesting that total phosphorus is the nutrient that limits primary production in Big Manistique Lake.

Dissolved Oxygen - Dissolved oxygen (DO) is a critical component to available habitat in aquatic ecosystems. Dissolved oxygen in lakes derives from the atmosphere as well as from aquatic plants during photosynthesis. Concentration of DO in lakes can limit the distribution and growth of fish in lakes as well as the size composition and biomass of zooplankton. Concentrations of DO begin to limit cool- and warmwater fish populations at approximately 3.0 mg/L and are often lethal below 0.5 mg/L (Schneider 2002). As DO becomes limited, two regions that characterize low levels of DO exist. The hypoxic region, which is characterized by having low levels (e.g., less than 2 to 4 mg/L) of DO and the anoxic region which contains no DO.

Big Manistique Lake was sampled for dissolved oxygen during the summer 1936, 2003, 2013, and 2020 (Table 1). During winter of 2023, a total of seven sites were sampled for additional winter limnological data (Table 2). During all years, the water column sampled contained sufficient levels of dissolved oxygen to support aquatic life. The occurrence of hypoxic regions was rare in summer, but more prominent in the winter. There were no instances of anoxic conditions during the summer months. However, winter samples recorded a few sites where anoxic conditions were present at greater depths. These data may be used to guide habitat improvement efforts by identifying locations where suitable dissolved oxygen exists to support aquatic life. Placing three dimensional structures in Big Manistique Lake may improve recreational angling opportunities in a waterbody with limited structure for fish. There may also be a benefit to placing structures that provide refuge areas to protect forage fish and younger age classes of gamefish (e.g., Walleye, Yellow Perch) from avian predation.

Temperature (stratification) - Thermal stratification occurs in deeper lakes during the summer months and is characterized by three water layers. The uppermost layer (epilimnion) is typically warmer and has adequate levels of sunlight to support photosynthesis. The middle layer (metalimnion) is the region where a more significant change in water temperature occurs. The point at which temperature change or drop is the greatest in this middle layer is called the `thermocline'. The bottom layer (hypolimnion) lies directly below the thermocline and typically contains less dissolved oxygen compared to other layers. Big Manistique Lake was sampled for temperature (stratification) during the summer 1936, 2003, 2013, and 2020 (Table 1). Summer temperature data suggest that Big Manistique Lake does not thermally stratify. A lack of thermal stratification is a result of the shallow depth of this lake. The presence and abundance of cool- and cold-water species may be impacted in the future by shallow water warming that occurs due to climate change.

Transparency - Water transparency, measured using the Secchi disk, provides an index of phytoplankton production and overall lake productivity. For example, lakes with greater transparency are often classified as Oligotrophic, meaning there are low levels of lake productivity (e.g., lower standing crop biomass). Big Manistique Lake was sampled for water transparency during the summer 2003, 2013, and 2020 and was reported to be 8.3, 7.5, and 8.0-ft, respectively. Transparency results suggest that Big Manistique Lake is often as transparent as similar sized waterbodies in the region, but less transparent (more turbid) compared to other inland lakes in Michigan. Moderate levels of transparency may correspond to moderate levels of biomass and primary productivity in Big Manistique Lake. By comparison, North Manistique Lake transparency has been reported to be 13.5-ft which explains

differences in biomass between the two waterbodies. North Manistique Lake is generally more transparent and less productive compared to Big Manistique Lake.

Chlorophyll-a - Summer chlorophyll-a concentrations in the upper water column provide a measure of lake primary production by phytoplankton and can be used to evaluate overall lake productivity. Higher chlorophyl-a concentrations suggest high production of phytoplankton, high nutrient inputs, and higher overall lake productivity. Low chlorophyl-a concentrations suggest phytoplankton production is limited by low nutrient availability, or by high rates of grazing by zooplankton. Chlorophyl-a concentrations vary widely across Michigan inland lakes having low (1.9 ug/L), medium (1.9 to 4.8 ug/L), and high (>4.8 ug/L) values. Chlorophyl-a concentrations were measured in Big Manistique Lake in 2003 and 2013 and were reported to be 3.6 and 2.4 ug/L (medium), respectively. Data from 2003 and 2013 provide baseline chlorophyll-a values prior to the documentation of invasive dreissenid mussels (occurred in 2018). Dreissenid mussels are likely to reduce chlorophyll-a concentration in Big Manistique Lake negatively impacting primary production. Additional monitoring of chlorophyll-a in Big Manistique Lake is recommended and may help explain any significant changes observed in the lake fish community or fish recruitment.

Trophic Status - Trophic status refers to an index that allows managers to characterize Michigan's inland lakes into categories that define the level of primary production in a lake. The Carlson's Trophic State Index (TSI) utilizes measurements of phosphorus, Secchi depth feet (ft), and chlorophyll-a and rescales these values to a 0 to 100 index (Fuller and Jodoin 2016). Threshold values for TSI are broken down into three categories where TSI <38 values are Oligotrophic, from 38 to 48 are Mesotrophic, from 49 to 61 are Eutrophic. In 2003 and 2013, Secchi depth and chlorophyl-a data suggest a TSI value between 38 and 48 (Mesotrophic), while phosphorus value reported in 2003 and 2013 suggest a TSI value less than 38 (Oligotrophic). Therefore, based on values reported from 2003 and 2013, Big Manistique Lake can be characterized as an Oligo-Mesotrophic inland lake with low to moderate levels of productivity.

Development, public ownership, and access

On 24 July 2013, The Big Manistique Lake littoral zone and lakeshore were visually surveyed to quantify physical habitat parameters including residential development (dwellings per mile), boat dock density (docks per mile), large woody debris (submerged logs per mile) and the average percent shoreline armored (Table 3). Results of this physical habitat survey show that the residential development along the shoreline of Big Manistique Lake is high, and beneficial nearshore habitat (submerged logs) is low or limited (Table 3). The extent of shoreline development (>30%) in Big Manistique Lake is significant, and in some years may result in adverse impacts to aquatic resources. During 2020 and several years prior, the Great Lakes landscape experienced increased precipitation resulting in higher-than-normal water levels in many inland lakes. Increased water levels can result in increased shoreline erosion, especially in areas where armoring is present and natural shoreline principles have not been adopted.

Lands adjacent to the Big Manistique Lake shoreline are largely held in private ownership, with some public owned parcels located in the west and northwest region of the lake. There are a total of four public boat access sites for Big Manistique Lake, two in Luce County and two in Mackinac County (Figure 1).

History of Fishery Resources

Management of Big Manistique Lake began during the late 1890s when 841,000 Lake Whitefish were stocked (Table 4) by the Peninsula Fish Company of Detroit. From the late-1800s to the 1920s Lake Whitefish made up most of the fish stocked in Michigan to rehabilitate depressed populations and in inland waters to create new commercial food fisheries (Whelan 2004). Reports from a Detroit newspaper stated that South Manistique (Whitefish) Lake was targeted to produce a Lake Whitefish fishery and nearly $150,000 was invested ($5.5 million today, adjusted for inflation). However, that venture was presumed to be unsuccessful and later there were efforts to breed Lake Sturgeon in the lake. Remnant populations of Lake Whitefish, Lake Sturgeon and Cisco exist today in Big Manistique Lake; however, it is unknown whether these historical stocking events contributed to existing populations or if these were novel introductions. In 1910, a total of 1,000 fingerling Smallmouth Bass were stocked in Big Manistique Lake suggesting a change in management strategy for inland lake fisheries.

During the early 20th century, John Nicholas Low was a fisheries biologist who taught at the Northern State Teachers College (now Northern Michigan University). J.N. Lowe had assembled fish collections from several waterbodies in Michigan's Upper Peninsula to document fish communities in lakes where information did not exist. Big Manistique Lake was surveyed by J.N. Lowe in July of 1922 and 1926. Species captured included Yellow Perch, Walleye, Smallmouth Bass, Bluegill, Mimic Shiner, Sand Shiner, Common Shiner, Bluntnose Minnow, Common White Sucker, Spottail Shiner, Logperch, Johnny Darter, and Mottled Sculpin. During this time, Big Manistique Lake was noted to contain Yellow Perch (abundant), Walleye, and Northern Pike. One Northern Pike captured during the 1926 assessment weighed 25 pounds.

By the 1920s, management of inland lake fisheries in Michigan shifted with the establishment of the Department of Conservation (now the Department of Natural Resources) and the adoption of more science-driven fisheries management actions. The Department of Conservation held public trust authorities and had power to enforce regulations such as closed seasons, size limits, and possession limits (Whelan 2004). Following the establishment of the Department of Conservation, warm- and cool-water fishes were stocked throughout Michigan to replenish diminished stocks or create new fishing opportunities.

During the 1930s Yellow Perch and Walleye were routinely stocked in Big Manistique Lake. A total of 500,600 Yellow Perch were stocked that included spring fry and fall fingerlings and a total of 2,860,000 spring fry Walleye were stocked. The status of these species in Big Manistique Lake was unknown prior to stocking, however, the intent was likely to establish a recreational fishery as this was a common practice during this period. During the 1930s and 1940s, warm- and cool-water species such as Bluegill, Largemouth Bass, Walleye, Smallmouth Bass, and Yellow Perch were stocked in many inland lakes in Michigan. However, by the early 1940s stocking of these species had already been largely reduced given their unique ability to reproduce naturally beyond state hatchery capabilities (Cooper 1948). By 1946, the Michigan Fish Commission had a policy to curtail stocking of many of these species given the "incontestable evidence that the average planting of these species has involved an insignificant number of fish compared to the number already present" (Cooper 1948, pp. 8). By 1941, stocking fish in Big Manistique Lake ceased for nearly three decades.

In 1933, President Franklin Delano Roosevelt instituted the Emergency Conservation Work program, better known today as the Civilian Conservation Corp or "CCC". During the winter of 1935 and 1936,

Big Manistique Lake and surrounding areas were mapped by the Michigan Emergency Conservation Work program, out of Camp Newberry.

By the mid- to late-1930s, all three Manistique lakes were noted to have `good fishing' with South Manistique (Whitefish) Lake being a possible exception. Area residents held a theory that many gamefish migrated from South Manistique (Whitefish) Lake to Big Manistique Lake and did not return, resulting in poor fishing in South Manistique (Whitefish) Lake. During this period, there were multiple fish mortalities reported in Big Manistique Lake, most notably in the early- and late-1930s and the cause was undetermined. Biologists suspected that high temperature, coupled with low water levels may have been responsible for the mortalities observed. Fish mortalities, concerns with low water levels, and a growing recreational interest in the area prompted fisheries managers to conduct a more thorough evaluation of the Manistique lakes. A biological survey was conducted by the Institute of Fisheries Research on North (Round) and Big Manistique lakes during the summer of 1936 and on South Manistique (Whitefish) Lake in 1937 (Roelofs 1941). This surveyed collected information about water chemistry, aquatic vegetation, and the fish community in the Manistique lakes.

Big Manistique Lake was noted to contain a wide variety of aquatic plant species compared to the other Manistique lakes (Table 5), with extensive weed beds, some of which "covered several hundred acres". Surveying the fish community during this time consisted of conducting several nearshore seine hauls to document natural reproduction of gamefishes, as well as provide qualitative information about the forage fish (e.g., minnows) community. A variety of fish species were captured in the Manistique lakes (Table 6) and biologists stated that there appeared to be adequate food, cover, and spawning habitat for game species. However, little was known about the success of stocking Walleye or whether natural reproduction was occurring in the lake. Biologist mentioned that natural reproduction should `not be overlooked' as, for most species, natural reproduction is adequate to replenish a lake to its maximum carrying capacity. A recommendation was made at that time to investigate whether natural reproduction of Walleye was occurring. There was also continued interest in documenting the migration of Walleye from South Manistique Lake to Big Manistique Lake and to determine whether these migrants returned to South Manistique Lake. During this period, fisheries biologists and local constituents were discussing a recommendation to install water level control structures at the outlet of Big Manistique Lake and the outlet of South Manistique Lake. These structures were intended to help maintain sufficient water levels in both waterbodies.

During the 1940s, the Department of Conservation Fisheries Division received letters from area resort owners requesting that additional fish stocking occur in Big Manistique Lake. According to one letter (March of 1941), the lake had been netted for commercial purposes resulting in a `very poor' fishing season in 1940. The letter also included a list of resorts that were located on Big Manistique Lake at that time including Edd's Kamp, Grindins Cottages, Mavakiki Lodge, Greenfield's Beach, Bosler's Cottages, Helmer Resort, Timberline Resort, Buckeye Beach, Ostrander's Forest Inn, Longs Resort, Jones Resort, Cedar Spring Resort, Emery Resort, and MacDougalls. There were also four additional resorts that were noted to be in the early stages of development. Biologists from the Michigan Department of Conservation responded by requesting that additional information be shared with law enforcement regarding any commercial netting operations. Regarding stocking, biologists stated that adult Northern Pike were to be transferred from the Seney National Wildlife Refuge to Big Manistique Lake, provided an effective netting method could be developed. Later that same year, a total of 386 adult Northern Pike were transferred to Big Manistique Lake. Additionally, a total of 1,050,000 spring

fry Walleye were stocked from 1940 to 1941. Area resort owners may not have known that these plants of Walleye had occurred at the time of their request. Following stocking of Northern Pike and Walleye in 1941, no fish were stocked in Big Manistique Lake from 1942 to 1969.

From June through July of 1941 several incidences of dead fish in Big Manistique Lake were reported prompting an investigation by a pathologist from the Institute of Fisheries Research. Initially, the occurrence of dead fish was thought to be a result of a large lightning strike that had been observed by area residents. However, the fish morality event continued to occur through June and into July of that same year suggesting that lightening was not the cause. The fish mortality investigation was performed during early July and `sick fish' were noted to still be present. At that time species impacted included Common White Sucker, Northern Pike, Walleye, Smallmouth Bass, Cisco, Common Shiner, Lake Whitefish, and Yellow Perch. The pathologist noted that Big Manistique Lake water levels had dropped two feet resulting in a 20 percent loss in lake level. That drop in lake level, coupled with an unusual warm period likely produced a temperature-shock to fish that they were unable to withstand. During this time, resort owners had constructed a dam at the outlet of Big Manistique Lake to hold lake levels constant. However, the dam was approximately seven feet short of spanning the outlet and therefore was only partially effective. Given the shallow nature of Big Manistique Lake, it was again recommended that a dam be installed at the outlet of the lake to maintain a normal level to protect against significant drops in water level that may be stressful to fish.

During the mid-1940s anglers reportedly captured Northern Pike in Big Manistique Lake with lesions or sores on their flanks. The Institute of Fisheries Research provided a report (Washburn 1945) documenting that samples of Northern Pike, provided by anglers in Big Manistique Lake, were infected with `red sore disease'. The prevalence of disease may have been a result of stress associated with transferring adult Northern Pike from the Seney Wildlife Refuge as this was later documented in other nearby waterbodies in Michigan (Bauman 2018).

In spring of 1947, the Institute of Fisheries Research conducted a survey of the outlet of South Manistique Lake to document fish migration from the south lake to Big Manistique Lake. The species of interest at this time were Walleye and Northern Pike, however, observations for other species were made as well. In prior years, a barrier had existed in Portage Creek, limiting the migration of fishes from South Manistique Lake to Big Manistique Lake. However, at this time, there was no barrier present. Interested local people were concerned that fish were migrating from South Manistique Lake to Big Manistique Lake resulting in poor fishing in South Manistique Lake. To evaluate these contentions, a temporary weir was installed to monitor fish movements between the two lakes. The study was determined to have been initiated late in the season and may have missed a large portion of migrating fish species. That said, a total of 1,051 fish were captured (marked and released) including Walleye (1,036), four Northern Pike, one Rock Bass, and ten Redhorse suckers. During the first month of weir operation the structure was damaged routinely by vandals resulting in a cessation of the evaluation by the end of May of that same year. Department of Conservation research staff noted that fish did indeed migrate from the south lake to Big Manistique Lake, however the experiment would need to continue through fall to document whether fish returned to the south lake. A summary of this survey was provided by Reynolds (1948).

During the late-1940s, members of a local tourist association were interested in discussing the present fishing conditions in Big Manistique Lake with staff from the Department of Conservation. The

association shared several concerns regarding poor fishing, illegal commercial harvest (presumably of gamefish), over-harvest of minnows, the impacts of avian predators on young Walleye, and the lack of stocking. Reports of illegal commercial harvest were reported to be rumors and `hearsay'. Department of Conservation staff noted that many complaints originated from anglers that were targeting the lake during July and August, which tends to be a poor fishing period for species such as Walleye despite there being a sizeable population in the lake. Many residents and resort owners also attributed the decline in the fishery to the cessation in stocking that had occurred earlier in the decade. However, the stocking policy was at that time: if natural reproduction is occurring, that should maintain a sufficient level of harvest to provide an attractive fishery for anglers. Staff were skeptical of poor fishing reports as more experienced and local anglers were reporting that Walleye fishing in Big Manistique Lake was `pretty good' from May to June and during the Fall. Positive reports from experienced anglers, in addition to survey work showing a sizeable population of Walleye existed in Big Manistique Lake led to skepticism by the Department of Conservation. Department of Conservation staff at that time were concerned that stocking was only being requested for `promotional purposes' rather than for sound ecological reasons. There were additional fisheries concerns at this time regarding the presence of avian predators and their potential impact on fish populations, especially juvenile Walleye. Avian predation was a newly documented concern but would continue to be discussed during the late-1990s, early-2000s, and to present day. By 1949, information and data provided to local tourist associations by the Department of Conservation did not resolve their concerns. Therefore, the Department of Conservation requested that additional surveys be conducted in future years to document the status of gamefish populations in Big Manistique Lake.

Fisheries management in Big Manistique Lake during the 1950s consisted of stocking requests, additional occurrences of fish disease, biological surveys, and concerns with lake water levels. During the early 1950s, the Department of Conservation was contacted by area stakeholders who requested that additional stocking of Walleye occur in Big Manistique Lake. For example, in 1951, a State Representative, on behalf of the Manistique Lakes Resort Owners Association, sent a letter to the Department of Conservation requesting that stocking occur in Big Manistique Lake to improve the fishing for tourists. The association was concerned that the amount of harvest was causing a serious situation with respect to the fish supply available and that vacationers would not continue to visit if stocking did not occur. During this period, Big Manistique Lake was noted to have good Walleye and Northern Pike fishing especially during the early seasons (May and June), but fishing tended to decline through July and August. Creel work conducted during this time showed that catch rates for species such as Walleye were above the state average. In response to this letter, the Department of Conservation held a meeting (November 1951) with stakeholders to present information about the history of biological work completed in Big Manistique Lake, and to provide possible reasons for poor fishing that typically occurs during July and August. Additional discussion was devoted to the topics of water level fluctuations and a request for increased law enforcement presence to monitor anglers that were reportedly keeping limits beyond that allowed. There were approximately 50 to 60 people in attendance and the information shared was reported to be well received.

Although the meeting held in November of 1951 was reported to go well, a State Representative contacted (March 1953) the Department of Conservation again stating that the Manistique Lakes needed stocking. Fishing reports during that time for Walleye seemed favorable. The month of June in 1952 was noted as being very good, while August was noted as `spotty'. Northern Pike fishing during 1952 was noted as good throughout most of the year despite documentation of "black spot" disease in some

fish. Conservation officers' notes also supported that fishing for Walleye was good during the early 1950s (except August). Fishing for Walleye during the early season of 1953 was reported to be "excellent". During this time, many residents had favorable fishing reports, while tourists reported poor captures that seemed to correspond to the summer months when fishing is expectedly slow. Local fisheries biologists noted during this time that a considerable amount of effort on behalf of law enforcement was being devoted to the Manistique lakes area to alleviate concerns of overharvest. These law enforcement efforts led to the apprehension of two men that had illegally harvested 80 pounds of Walleye and suckers using a 90-foot seine.

By the mid-1950s, the Michigan Department of Conservation had received many conflicting reports regarding the status of the Walleye fishery in Big Manistique Lake and many requests were made to stock additional Walleye and Northern Pike. To show concerned anglers and resort owners that Walleye were indeed in Big Manistique Lake, a demonstration trap-net survey was scheduled during the Fall of 1955. Prior to the survey, the Michigan Department of Conservation notified resort owners and area residents of the survey and had encouraged them to attend and participate. From 26 to 30 November of 1955 a total of 12 trap-net night efforts were expended to gather a catch rate estimate of Walleye. Species captured included Walleye, Redhorse sucker, Northern Pike, Yellow Perch, Rock Bass, Smallmouth Bass, Largemouth Bass, Brown Bullhead, Pumpkinseed Sunfish, and Cisco. Walleye total length averaged 16 inches and ranged from 8.8 to 23.9 inches. The estimated catch rate (or relative abundance) of Walleye was 34 fish per trap-net night. During this time, a catch rate of 20 Walleye per trap-net night was considered `very good' and accompanied favorable fishing reports. In comparison, Lake Gogebic, another of the better-known lakes managed for Walleye in Michigan produced 35 Walleye per trap-net night. Biologists concluded at that time that an ample population of Walleye was present to support present and future fishing pressure in Big Manistique Lake. Biologists also noted that despite having been notified prior to the demonstration survey, there were no resort owners or other interested parties present to observe the catch. The lack of public participation in the demonstration survey added to staff concerns that resort owners were only interested in stocking for promotional purposes. In April of 1956, the Michigan Department of Conservation provided a total of 30 copies of the 1955 demonstration survey report to area resort association members.

By Fall of 1956, another letter, signed by nine resort owners, was received by the Department of Conservation stating that Big Manistique Lake should be stocked. The letter stated that `resorts have returned to the state a considerable amount of money for which we have a legitimate right to claim some return." The letter also stated that "dwindling catches" are discouraging their clientele `luring them elsewhere'. This letter was drafted despite the recent demonstration survey that was conducted showing a high catch rate of highly sought-after species (namely, Walleye). That following year, in 1957, a representative of the Manistique lakes area requested that Muskellunge be stocked in Big Manistique Lake. However, there are no records that Muskellunge were ever stocked in the lake during this time.

Additional fish mortalities were reported during 1955 impacting several thousand Common White Sucker and a small number of Cisco. Mortalities were reported during July and August and the cause was presumed to be related to low water levels in conjunction with warm summer water temperature.

During the 1960s, fisheries management in Big Manistique Lake was multifaceted. During this period there were annual spring netting surveys being conducted, incidences of fish morality, reports of lamprey

attached to gamefish, and a new relationship was being formed between the Department of Conservation, area residents, and anglers.

Beginning in the early 1960s, the Michigan Department of Conservation began conducting spring netting assessments to evaluate gamefish populations in Big Manistique Lake. Species captured from 1964 through 1969 included Northern Pike, Yellow Perch, Walleye, Smallmouth Bass, Largemouth Bass, Bluegill, Pumpkinseed Sunfish, Rock Bass, Cisco, Common White Sucker, Redhorse sucker, Black Bullhead, Brown Bullhead, Brook Trout, and Mudpuppy. Spring capture rates of all species varied considerably during this time and multiple gear types were used including fyke nets (only in 1964) and trap nets. Capture rates of Walleye in trap nets averaged 161.3 fish per net night and ranged from 34.9 to 552.0 fish per net night. Capture rates of Cisco in trap nets averaged 1.7 fish per net night and ranged from 0.7 to 3.6 fish per net night. Walleye, Common White Sucker, and Redhorse sucker dominated catches during this period. During this time, "rough" species including Common White Sucker, Redhorse sucker, and bullhead were most often removed from the lake and given to area residents. The Department of Conservation would notify area residents through the local newspaper and through radio broadcasts and handed out these species on a `first come first serve' basis. Nearly 10,000 suckers were captured during this period, a majority of which were removed from the lake. From the 1960s to 1980s, manual removal of these species was common practice and was intended to reduce competition between "rough" species and gamefish. It is unlikely these efforts were successful as catch rates for these "rough" species continued to increase through the 1970s. However, these early netting efforts were successful in identifying more productive areas for netting Walleye in future years.

In the 1960s there were occurrences of `red sore disease' in Northern Pike that were captured by anglers, similar to that observed in previous years. Tapeworms were reported in the digestive tracts of some Walleye and a majority (90%) of the Cisco and there were additional reports of fish mortalities (late 1960s) impacting Yellow Perch and Bluntnose Minnow. Several unidentified parasitic lamprey were reportedly attached to gamefish caught by anglers. There were concerns that these may have been invasive Sea Lamprey, however, fisheries biologist later identified all of these as Silver Lamprey, which are a native species. Silver Lamprey were documented to occur in both South Manistique Lake and Big Manistique Lake during this time.

Fishing reports from anglers during the 1960s were largely favorable, especially from those that fished during the early harvest season. One angler from Seney reported that 5 Walleye were captured in 5 casts, and many sublegal Walleye were also reported captured by other anglers during this period. A Curtis resident reported that fishing for Walleye in Big Manistique Lake during this period was the best that he could recall, and a number of Northern Pike and jumbo Yellow Perch were also reported captured.

By the end of the 1960s, the Department of Conservation had established a relationship with a group of residents that operated a small hatchery in Curtis, Michigan. As part of this relationship, the Department of Conservation, assisted by residents, conducted annual spring netting operations in Big Manistique Lake to gather eggs and milt from adult Walleye. Fertilized Walleye eggs were then transferred to the Thompson State Fishery Hatchery for Walleye stocking in the Upper Peninsula, and a remainder of the fertilized eggs were transferred to the hatchery in Curtis for stocking of the Manistique lakes. During netting operations in 1968, a total of 3,500 Walleye were captured and 47 liters of eggs were transferred to the Thompson State Fish Hatchery, while 28 liters of eggs were provided to the Curtis Hatchery. Later that year, hatched eggs (spring fry) from the Curtis Hatchery were taken to South Manistique Lake and

Big Manistique Lake and were distributed along gravel shoals. This collaborative stocking effort may have been experimental at this time as there are no records of fish being stocked in Big Manistique Lake during this period (only written documentation).

Fisheries management in Big Manistique Lake changed considerably during the 1970s, most notably as annual spring netting operations continued to monitor the abundance of Walleye and other gamefishes while collecting gametes (i.e., eggs and milt) from Walleye to rehabilitate the Little Bay de Noc Great Lakes Walleye population. Hatched eggs were also used to stock inland lakes in the Upper Peninsula including, but not limited to, Big Manistique Lake. During the 1970s, a total of 8,184,846 million Walleye were stocked in Big Manistique Lake and were comprised of spring fry and spring fingerlings. A total of 4,600 fingerling Northern Pike were also stocking in Big Manistique Lake during this period.

Spring netting operations for Walleye occurred annually from 1970 to 1987 as survey nets were set immediately following ice out. Traditional trap-nets were used with the greatest effort, however commercial trap nets (larger than traditional) and fyke nets were also used. From 1970 to 1977 the catch rate of Walleye in trap nets averaged 57.5 Walleye per net night and ranged from 33.2 to 79.6 Walleye per net night (Table 7). Other notable species captured during these annual spring netting efforts included Brook Trout, Burbot, and Lake Sturgeon (1974). During the late 1800s, Lake Sturgeon were reportedly `being bred' in South Manistique (Whitefish) Lake for commercial purposes so it is possible that some of these unique fish migrated to Big Manistique Lake. The capture of a single Lake Sturgeon in 1974 could have indicated that there was a remnant population of the species in the lake, or that this lone fish was a decedent of historical commercial fisheries efforts. Regardless of the origin, Lake Sturgeon would again receive additional attention in the 1980s.

Similar to the 1960s, fishing reports from Big Manistique Lake in the 1970s were largely favorable for Northern Pike, Walleye, and Yellow Perch. Several large Northern Pike that ranged in size from 14 to 20 pounds were reportedly captured during this period. Most favorable reports during this period originated from those anglers targeting the early spring or fall months of the year, as opposed to the summer months (July and August). However, by the late 1970s, anglers drafted letters to the Department of Conservation stating that many sub-legal Walleye were being captured in Big Manistique Lake. Many fish were reported to be 13 inches (legal size 15 inches), so sorting had to occur in attempt to capture harvestable fish. There were also complaints that larger adult Walleye were being removed from the population during spring netting surveys, however all Walleye captured during this time were returned to the lake with minimal mortalities observed.

By 1978, age-3 and age-4 Walleye in Big Manistique Lake were growing 4.1 and 2.9 inches below the state average, respectively. For comparison, age-3 Walleye were growing 1.3 inches above the state average in 1937 and were approximately equal to, but slightly below (-0.30), the state average in 1967. Growth rates from the late 1970s suggest that Walleye would take several years longer to recruit to legal size (15 inches) compared to normal. Significant reductions in growth like that observed in Big Manistique Lake are often attributed to over-stocking, especially in waterbodies where natural reproduction is known to occur annually. Concerns pertaining to Walleye growth, abundance, and harvest levels prompted additional survey work.

To evaluate the size, abundance, and annual harvest of Walleye in Big Manistique Lake several survey efforts were conducted from 1978 to 1980. These survey efforts included a capture, mark-recapture

netting effort during annual spring egg take operations as well as a creel census estimate. The estimated abundance of Walleye in Big Manistique was 20,000 adults or about 2.0 adult Walleye per acre, which was similar to the density of adult Walleye in Lake Gogebic at that time. Angler exploitation, or annual harvest at this time was estimated to be about 6,000 adult Walleye (30% exploitation rate). Harvest rates of Walleye varied considerably from one year to the next. For example, the number of Walleye harvested during the 1978 to 1979 season was ten times higher compared to the 1979 to 1980 season. Generally, Walleye harvested during this period were considered `small', slow growing, and numerous as reported during creel census surveys. Due to the abundance of undersized Walleye and slow growth rates documented, the minimum size limit for harvest was reduced to 13 inches in 1979 and stocking ceased after May of 1980.

During the 1980s, spring Walleye egg collection surveys continued in Big Manistique Lake through 1987. From 1982 to 1987 the catch rate of Walleye in trap nets averaged 112.2 fish per net night and ranged from 79.1 to 149.5 fish per net night (Table 7). Eggs were annually collected from adult Walleye for stocking other inland lakes in the Upper Peninsula, however there were concerns that egg-take operations had the potential to impact natural reproduction in Big Manistique Lake. Monitoring for natural recruitment in Big Manistique Lake did not become routine until the 1990s, however discussion occurred sooner. Walleye management during this period focused on 1) monitoring the growth and relative abundance in response to the 13-inch minimum size limit regulation, and 2) continuing to manage Walleye in Big Manistique Lake as a self-sustaining population. A total of 300,000 Walleye were stocked in 1980 and stocking of Walleye did not occur thereafter until 2005.

By the early to mid-1980s, Lake Sturgeon rehabilitation and re-introduction efforts began to occur across the Great Lakes region as hatchery practices for this species improved greatly. In 1981, local biologists drafted a prescription to begin stocking Lake Sturgeon in Big Manistique Lake. From 1983 to 1988, 16,642 Lake Sturgeon were stocked in Big Manistique Lake with the goal of rehabilitating the remnant stock. The strain of Lake Sturgeon stocked in Big Manistique is not documented, however it is likely these fish were sourced from Black Lake in Cheboygan, Michigan as well as Lake Winnebago, Wisconsin.

During May and June of 1987, Big Manistique Lake was surveyed to evaluate the Walleye and Yellow Perch population as well as to monitor the success of Lake Sturgeon recently stocked. Assessment gear used include trap nets, fyke nets, and a 1,000-ft Great Lake experimental gill net. Trap nets were fished a total of 124 net nights of effort and were used to gather information about the relative abundance of Walleye. Fyke nets were fished a total of 34 net nights to gather information about the relative abundance of forage species (e.g., minnows) and the large experimental gill net was set for four hours to gather information about Yellow Perch. Yellow Perch were not captured in experimental gill net sets, confirming some suspicion that predation by stocked fish was hindering the natural production of this species. The catch rate of Walleye was 1.9 fish per net night which was comparable to other inland lakes where similar gear was used to target Walleye during this time of year (May and June). Additional fisheries management goals for Big Manistique Lake during this time were to 1) develop a public access site at the end of County Road 459 at the north central shoreline, 2) re-survey Big Manistique within ten years to monitor the gamefish population and Lake Sturgeon stocking efforts.

During the 1990s, management of Big Manistique Lake consisted of stocking, general fish community surveys, and new assessments were conducted to evaluate natural reproduction of Walleye. During this period, Lake Sturgeon (14,625) and Smallmouth Bass (10,000) were stocked in Big Manistique Lake.

During early June of 1997, a general fish community survey was conducted on Big Manistique Lake. Assessment gear included trap nets, fyke nets, and a 1,000-ft Great Lakes experimental gill net. Trap and fyke nets were fished for a total of 32 and 64 net nights, respectively. The experimental gill net was set for four hours. Compared to the 1987 survey, panfish and Northern Pike numbers appeared to increase yet average size declined. Smallmouth Bass numbers were comparable to the number captured during the 1987 survey. Yellow Perch numbers increased steadily, yet size of fish captured was slightly smaller. During this period, anglers reported jumbo perch being caught during the fall and spring seasons. Walleye numbers declined slightly; however additional surveys were being conducted in the fall of each year suggesting that strong year-classes were being produced in Big Manistique Lake. Managers noted after the 1997 survey that survey nets had recently been treated and were very dark, which may have impacted the catchability of some species. There were no Lake Sturgeon captured during this assessment. However, a Lake Sturgeon was captured using hook and line by a young angler fishing Portage Creek in the spring of 1992 suggesting a limited presence or small population existed in the lake.

Beginning in the early 1990s, Big Manistique Lake and many other inland waterbodies were routinely surveyed in the fall for young Walleye. Fall electrofishing surveys were routinely conducted in inland lakes to evaluate the success of stocked Walleye or to determine the primary recruitment source of populations (i.e., stocked vs. natural reproduction). The number of Age-0 (or young-of-year) Walleye captured per mile of electrofishing were and continue to be used as an index of relative abundance (Serns 1982, Serns 1983) or to predict year-class strength (Ziegler and Schneider 2000). Walleye reproduction status in Big Manistique Lake at this time was considered "consistent" with year-classes being produced often enough to support a recreational fishery.

During the 2000s, management topics for Big Manistique Lake involved stocking, cormorant control, and water levels. By the late 1990s, the Double-Crested Cormorant began to redistribute into areas of the Great Lakes in greater number than had been historically reported. The increase in cormorant abundance was concerning given their ability to prey upon forage fish and gamefish. These concerns prompted additional stocking requests of preferred game species in the early 2000s. Several public meetings were held in early 2000s to share and gather information regarding the concerns with the Big Manistique Lake fishery. The primary concerns included those listed above in addition to the undocumented commercial harvest of minnows and the impact that may have had on the fishery.

Beginning in April of 2000, a survey was conducted in Big Manistique Lake to assess the adult Walleye population. Trap nets were set for 53 net nights capturing a total of 1,470 Walleye (27.7 fish per net night). The average size of Walleye captured was 17.1 inches and ranged from 3.0 to 26.0 inches. The estimated number of Walleye in Big Manistique Lake at that time was 9,350 adult Walleye. Managers noted at the time of this survey that only one location in the lake was surveyed and therefore, this was likely an underestimate of the true abundance.

Beginning 31 July of 2000, a general netting survey was conducted in Big Manistique Lake to assess the general fish community using trap, fyke, and inland gill nets. Trap, fyke, and inland gill nets were set

for a total effort of 20, 32, and 2 net nights, respectively. Catches of Yellow Perch were noted to be down from previous years, however growth rates exceeded 2-inches above the state average suggesting that a good fishery would result soon. Survey staff noted that two net nights of effort were lost due to a net being stolen by a nearby landowner. The missing net may have resulted in high catches of Yellow Perch as these nets were set in habitat more conducive to capture Yellow Perch. A total of 35 Walleye were captured and 91 percent met the minimum size for harvest (15 inches). A total of 12 age classes of Walleye were represented in the catch suggesting that harvest pressure was relatively low despite concerns by anglers that harvest was limiting catches of Walleye in Big Manistique Lake.

The population estimate and general survey conducted in 2000 demonstrated that a viable recreational fishery existed in Big Manistique Lake in the absence of stocking (since 1980). Fall recruitment surveys, that had been conducted routinely since 1992, suggested that natural recruitment was occurring annually. The estimated annual abundance of natural produced fall fingerling Walleye in Big Manistique Lake from 1992 to 2000 was considered high suggesting that stocking was not necessary.

Following those early 2000s meetings, the public was concerned that the fishery was in decline and any prior relationship that existed between the Department of Natural Resources (DNR) and angler groups was deteriorating. Angler groups formed and held venues to raise funds for short- and long-term goals geared to restore the Big Manistique Lake fishery. Short-term projects included stocking fall fingerling Walleye, obtaining grants for developing fishing structures, and maintaining fundraising. Long-term goals included restarting the Curtis Hatchery program, installing fishing piers, and stocking of other preferred species such as Bluegill, Yellow Perch, and Black Crappie. Of note, Black Crappie had not been previously captured in the Manistique Lakes. There was also interest in a seeking alternate fishing regulations and in bringing back a popular Walleye sporting event (e.g., Walleye Jamboree). The public interest in stocking fall fingerling Walleye occurred while natural recruitment was strong in Big Manistique Lake.

In 2003, a Large Lake Survey was conducted in Big Manistique Lake. The Large Lakes Survey Program was initiated by the DNR with the goal of developing an assessment program for highly valued gamefish including Walleye, Northern Pike, Smallmouth Bass, and Muskellunge (Hanchin 2017). These primary objectives of the program were to estimate abundance, growth, mortality, and harvest of these gamefish. More than twenty large lakes were surveyed as part of the Large Lakes Survey Program from 2000 to 2008. The average trap net catch rate for Walleye among all lakes was 11.8 fish per net night and ranged from 0.4 to 44.5 fish per net night. The Big Manistique Lake trap net catch rate for Walleye was 38.1 fish per net night, which was more than 200 percent higher compared to the large lake average. The average fyke net catch rate for Walleye among all lakes was 7.8 fish per net night and ranged from <0.1 to 38.8 fish per net night. The Big Manistique Lake fyke net catch rate for Walleye was 9.0 fish per net night, which was 15 percent higher compared to the large lake average. The adult Walleye abundance in Big Manistique Lake was estimated to be 7,384 individuals with an annual mortality rate of 31 percent (Hanchin and Kramer 2007).

The Large Lake Survey Program also estimated the total annual harvest of Walleye in Big Manistique Lake which ranged from 14.8 to 22.8 percent (Hanchin 2017). These results suggested that the Big Manistique Lake Walleye population was not being overharvested at that time. Following the Large Lakes Survey that was conducted in several large lakes in Michigan, a statewide coolwater fish regulation was passed (in October 2003) reverting the Walleye minimum size limit for harvest back to

15 inches, from 13 inches. In 2003, age-3 and age-4 Walleye in Big Manistique Lake were growing 1.4 and 2.3 inches above state average, respectively.

During the 2003 Large Lake survey, data were also gathered from Northern Pike, Smallmouth Bass, and Yellow Perch. A total of 213 Northern Pike were captured ranging in size from 12.0 to 49.0 inches in total length. The average total length of Northern Pike captured was 24.9 inches and growth was reported to be more than three inches above the state average. A total of 221 Smallmouth Bass were captured ranging in size from 7.0 to 19.0 inches in total length. The average total length of Smallmouth Bass captured was 14.0 inches and growth was reported to be above the state average. A total of 849 Yellow Perch were captured ranging in size from 5.0 to 13.0 inches with an average total length of 7.3 inches.

Surveys conducted during the early 2000s showed that adult Walleye were present in Big Manistique Lake (although at a lower density) and that annual recruitment of naturally produced fall fingerlings was strong. However, angler groups continued to pursue stocking to improve a fishery that was perceived to be declining due to avian predation, over-harvest, and due to the closure of the Curtis Hatchery program. Several letters were drafted on behalf of angler groups and were sent to the DNR Fisheries Division, the DNR Natural Resources Commission, as well as the State Governor's office. Monetary funds were also being raised by angler groups to stock fall fingerling Walleye. During this time, DNR staff and citizens were concerned that stocking would occur without notification from angler groups.

By the mid-2000s, an agreement had been made between angler groups and DNR Fisheries Division to permit a modest level of stocking of fall fingerlings under permit, provided the appropriate strain (Bays de Noc) could be obtained. The field of conservation genetics was now being incorporated into inland lake stocking plans to protect the genetic health of wild Walleye populations (Dexter and O'Neil 2004). In instances where stocking was necessary, managers were (and continue to be) encouraged to use specific strains to preserve the fitness of stocks where natural reproduction was occurring. Fall fingerlings were then purchased entirely by private funds and a total of 13,300 were stocked in Big Manistique Lake from 2005 to 2009. Additionally in 2005, the DNR Fisheries Division stocked 1 million spring fry Walleye.

By the mid- to late-2000s, water levels continued to be a concern among area residents and a letter was sent by residents to the DNR Natural Resource Commission for guidance. However, the dam is (and continues to be) owned and operated by a multi-county board and there is no legal jurisdiction over the operation of the water level control structures by the DNR.

By the late-2000s, particularly in 2006 and 2007 Walleye fishing reports were largely favorable in Big Manistique Lake. Reports from the winter of 2006 suggested that Walleye were concentrated in one region of the lake and anglers were concerned that some individuals were over-harvesting. In the spring of 2007, Walleye fishing was reported as "hot" with many anglers reporting limits. There were also favorable reports for Northern Pike and Yellow Perch at this time accompanied by concerns of illegal over-harvest. Anglers were also reporting that cormorant numbers were `down' compared to previous years and that the fishing had improved and was comparable to that experienced during the 1990s. The increase in catch of Walleye was likely a result of significant natural reproduction that had occurred several years prior, particularly from 1999 to 2003 when large numbers of naturally produced fall fingerlings were reported during fall recruitment surveys. By 2007, a statewide cormorant harassment and removal program had been initiated throughout the region. Increases in natural recruitment of

Walleye may also be attributed to this program as the number of cormorants reportedly declined during this period.

Anglers noted that in 2009, the winter ice fishery did not produce for Walleye as it had in the recent past. However, reports for other species were favorable. For example, anglers reported a good Cisco fishery with a lot of Cisco in the 14- to16-inch range. Also, Yellow Perch were noted to be `scattered' but large fish were present. By late 2009, angler groups contacted DNR Fisheries Division via letter to request additional stocking of spring fry Walleye. This angler group reported that fishing had been in decline the previous three years and that if stocking could not continue the following recommendations should be considered: 1) shorten the ice fishing season to reduce harvest during the latter two weeks, 2). Restrict harvest of Walleye 22.0 inches or greater, 3). Restrict fishing during the spawning season, and 4). Restrict tournament fishing to `catch and immediate release' only.

Fisheries Division responded to this letter in December 2009 stating that the prescription was to stock 200,000 spring fingerling Walleye in 2007, 2009, and 2011 to supplement natural reproduction that occurs in Big Manistique Lake. In 2007, Fisheries Division imposed a moratorium on hatchery production of all Walleye, Northern Pike, and Muskellunge due to Viral Hemorrhagic Septicemia. Walleye stocking throughout much of Michigan ceased during those years. Limited stocking occurred in 2008 and 2009 due to the uncertainty of Viral Hemorrhagic Septicemia.

In 2009, the Walleye season had been extended in the Upper Peninsula to March 15th to provide additional angling opportunities. However, anglers were concerned that in Big Manistique Lake, Walleye congregate in small areas, causing adults to be more susceptible to overharvest. Therefore, in 2009 DNR Fisheries Division conducted a creel census to quantify the amount of Walleye harvest that occurred from February 1st to March 15th in Big Manistique Lake. The total number of Walleye harvested in winter of 2009 was estimated to be 1,251 individuals.

In 2010, DNR Fisheries Division conducted an additional creel assessment in Big Manistique Lake during the last two weeks of ice season when a total of 91 adult Walleye were harvested; still well below recommend harvest or exploitation rates. Angler harvest mortality of Walleye in Big Manistique Lake was noted to be low, so overexploitation was unlikely to be occurring with this extended winter season. Angler exploitation of Walleye on other inland lakes ranges from 4 to 29 percent. Given the low exploitation rate, current minimum size limit of 15.0 inches, and daily possession limits (5 fish), current regulations were stated to be sufficient to protect the Walleye population in Big Manistique Lake.

Angler reports from the early 2010s were favorable for Walleye and Yellow Perch. Several anglers reported that Walleye fishing had been the best it has been during the previous 10 years. In 2011, anglers reported "fantastic" Walleye catches with fish ranging from 14.0 to 22.0 inches. Yellow Perch were also being caught in the size range of 12.0 to 14.0 inches. Favorable reports for Walleye and Yellow Perch were likely the result of multiple factors. For example, the cormorant harassment program had begun to show positive results in other inland lakes in the region. Additionally, annual recruitment assessments documented several large year-classes of naturally produced Walleye for several years by this time. This period of favorable fishing reports and good natural recruitment were accompanied by additional fall fingerling Walleye stocking requests. A total of 12,500 fall fingerling Walleye were stocked from 2010 to 2019 by a private angler group (under permit).

In August of 2010, there were several reports of a low-level sucker die-off in Big Manistique Lake. Mortalities were likely caused by unseasonal high water temperatures during June of that year. In May of 2011, a young angler reportedly captured a 57-inch Lake Sturgeon in Portage Creek while sucker fishing. In May of 2013 a permit was acquired by a local angler group to improve woody habitat in the nearshore areas of Foster Island. The proposed work entailed submerging 10 to 12 trees from Foster Island to the adjacent littoral zone. There is no documentation that this project was completed.

In 2013, DNR Fisheries Division conducted a Status and Trends assessment of Big Manistique Lake. The purpose of the Status and Trends inland lake assessment was to gather general information about the fish community using standardized methods. A total of 30,331 fish weighing 1,533 pounds and representing 24 species were captured during the 2013 survey (Table 8). Of note, one five-year-old Black Crappie was captured documenting the first occurrences of this species in Big Manistique Lake.

A total of 201 Walleye were captured with an average total length of 14.1 inches. The size of Walleye captured ranged from 6 to 24 inches and 56 percent were of harvestable size. In 2013, age-3 and age-4 Walleye in Big Manistique Lake were growing at or slightly below state average (+0.6 and -1.3 inches, respectively). Growth of Walleye during this time may suggest that the lake was nearing carrying capacity which correlates with a time when angler reports were largely favorable for Walleye. The number of Northern Pike and Yellow Perch captured increased compared to 2003, while Cisco numbers declined. The number of Smallmouth Bass captured was relatively unchanged compared to the 2003 assessment.

From the 2010s to present day, the DNR Fisheries Division continued to conduct annual recruitment assessment for fall fingerling Walleye and work with local angler groups to issue stocking permits. Zebra mussel and Round Goby were first documented in Big Manistique Lake in 2018 and 2019, respectively. Since the introduction of Zebra Mussels, angler groups and area citizens have reported that the clarity of the water in Big Manistique Lake has increased. Changes in water clarity, the presence of Round Goby and cormorants, and concerns for the recreational fishery prompted additional surveys to be prescribed to gather more recent information about the Big Manistique Lake Walleye fishery. During this time anglers expressed interest in a `protected slot limit' regulation for Walleye to help protect adult abundance. In April of 2024, a public meeting was held to share historical and current information about the Big Manistique Lake fishery. There were 50 to 60 individuals in attendance and topics discussed included tribal harvest, invasive and newly documented species, cormorant control, nearshore habitat, and the status of the Walleye fishery. Public input gathered from this meeting, in addition to correspondence with local anglers, prompted this report and will guide fisheries management in Big Manistique Lake for the near future.

Current Status

Unfavorable fishing reports and recent environmental changes including the introduction of invasive and naturalized species, increasing cormorant abundance, fluctuations in water levels, and climate change have prompted more recent surveys to assess gamefish populations. Recent surveys used to make inferences about gamefish populations include a spring census estimate for Walleye and Northern Pike and annual fall recruitment surveys for Walleye. Past surveys, including Status and Trends assessments, a Large Lake survey, spring census estimates, and fall Walleye recruitment surveys are also referenced in the Analysis and Discussion section.

Adult Walleye and Northern Pike Survey
In April 2023, DNR Fisheries Division conducted a capture mark-recapture survey to quantify the abundance of adult Walleye in Big Manistique Lake. Trap nets, fyke nets, and a boat electrofishing unit were used for the initial marking period that occurred from April 21st to the 25th. Trap and fyke nets were set for a total effort of 49 and 123 net nights, respectively. Surface water temperature ranged from 38.0 to 41.9 °F during the capture-mark period. Boat electrofishing included three nights of sampling for a total effort of 28,160 seconds (7.82 hours) encompassing 15.4 miles of shoreline. The final recapture run was conducted at night on 27 April 2023 using four electrofishing boats for a total effort of 44,986 seconds (12.50 hours) encompassing 28.5 miles.

Gamefish species including Walleye, Northern Pike, and Cisco were measured to the nearest tenth of an inch. The first three dorsal spines were removed from all Walleye captured for age analysis and to serve as a `mark' during the mark and recapture periods. Anal fins were removed from all Northern Pike for age analysis and to serve as a `mark' during the mark and recapture periods. A total of 5 age structures per half-inch group were collected by sex from Walleye and Northern Pike. For all other species, the first 100 captured were measured to the nearest inch and the remaining were enumerated. A brief synopsis of all panfish including Yellow Perch, Bluegill, Rock Bass, Pumpkinseed Sunfish, and Black Crappie will be provided in the Analysis and Discussion section.

Fall Recruitment Surveys
On 27 September 2023, a Walleye recruitment survey was conducted at night on Big Manistique Lake using three boat electrofishing units. From 1992 to 2021, data were collected from a standardized 3.4-mile transect, hereafter referred to as the "historical" transect, located along the southern shore. Beginning in 2022, a larger proportion of the shoreline was surveyed to improve survey design by expanding the sample area. In 2023, the Big Manistique Lake shoreline was sampled for a total effort of 8.59 hours that included 20.08 miles of shoreline. Additional areas sampled in 2022 and 2023 included the historical transect that had been sampled from 1992 to 2021.

Aging structures (10 per inch group) were collected from all Walleye for age analysis. Scale samples were collected from all Walleye less than 10 inches total length. The first three dorsal spines were collected from all Walleye greater than 10 inches total length. Captures of Walleye are reported as the number of Age-0 (young-of-year) and Age-1 Walleye per mile of shoreline sampled (Table 9). Capture rates were then compared to long-term regional and lake-specific summary statistics including the average, minimum, maximum, 25th percentile, median, and 75th percentile values (Table 10). Historical survey results (1992 to 2023) are also referenced in the analysis and discussion sections. A brief synopsis of the presence of cormorants in Big Manistique Lake is provided in the Analysis and Discussion section.

Analysis and Discussion

Big Manistique Lake is a large, moderately productive shallow lake that contains a diverse fish community compared to other inland lakes in Michigan's Upper Peninsula. Big Manistique Lake has a highly developed shoreline and has limited physical habitat (e.g., large woody debris) compared to other inland lakes in the region. Despite habitat limitations, Big Manistique Lake contains remnant populations of State Threatened species including Cisco and Lake Sturgeon. The lake is currently managed to provide a popular mixed-bag fishery for popular gamefishes including Walleye, Northern Pike, Smallmouth Bass, and Yellow Perch. Gamefish populations are supported by natural reproduction,

although some stocking does occur through private entities in collaboration with the DNR Fisheries Division.

Adult Walleye and Northern Pike Census Survey

During the 2023 spring census survey, a total of 14,754 fish weighing 25,397 pounds were captured representing 17 species (Table 11). Species captured include those typical for surveys conducted during the early spring. Of note, a total of 33 Black Crappie were captured suggesting that this introduced species may be increasing in abundance compared to 2013. The capture of Black Crappie is a concern to area managers given that the increase in catch rate of Black Crappie is correlated with a decrease in catch rate of young Walleye (Broda et al. 2022).

Walleye - A total of 6,270 individual Walleye were captured including 4,900 males (78%), 935 females (15%), and 435 (7%) of unknown sex. In spring of 2023, the estimated density of Walleye in Big Manistique Lake was calculated to be 2.1 adults per acre (or 21,604 adults). Walleye total length ranged from 5 to 26 inches with an average total length of 16.6 inches (Table 11). Male total length ranged from 12 to 21 inches with an average total length of 16.7 inches (Table 12). Female total length ranged from 15 to 26 inches with an average total length of 18.8 inches (Table 12). The percentage of Walleye captured that were legal size was 88 percent with an estimated total annual mortality rate of 32 percent (Age 3 to 15). Age and growth analysis indicates that Walleye in Big Manistique Lake are growing above the State of Michigan average until age 5, where growth then begins to decline relative to the State of Michigan average (Figure 4). Finally, a total of 15 continuous year-classes (ages 1 to 15) were represented in the 2023 spring census survey (Figure 4).

A total of four adult Walleye census surveys have been conducted in Big Manistique Lake in 1978, 2000, 2003, and most recently in 2023. Periods of lower abundance were reported in 2000 and 2003 when the population was estimated to be 9,350 and 7,384 adult Walleye, respectively. Periods of higher abundance were reported in 1978 and 2023 when the population was estimated to be 20,000 and 21,604 adult Walleye, respectively. The 2023 census survey suggests a healthy abundance of adult Walleye exists in Big Manistique Lake. Age and growth analysis from the 2023 census survey also shows that Walleye reach the minimum size for harvest in approximately 3 years demonstrating that sufficient forage is available in the lake. Additionally, growth that exceeds the state of Michigan growth rate suggests the Big Manistique Lake Walleye population could increase in future years provided sufficient natural recruitment occurs. Natural recruitment of Walleye has been monitored in Big Manistique Lake since the early 1990s and is typically consistent and strong. However, in recent years recruitment of Age-0 Walleye has declined and has been relatively low since 2019. Managers are encouraged to continue monitoring natural recruitment to document the strength of these young age classes. If natural reproduction continues to decline, alternative regulations should be considered to protect the broodstock (or spawning stock) population until reasonable recruitment levels are observed.

In the State of Michigan Inland Walleye Management Plan, there are several regulation options that may be used to manage the Big Manistique Lake Walleye population. For example, an experimental Protected Slot Limit regulation may be used to reduce the exploitation rate and increase the spawning stock biomass to increase the protection and sustainability of a naturally reproducing population (Herbst et al. 2021). Angler groups have expressed an interest in experimental Protected Slot Limit regulations for Big Manistique Lake for several years. Angler support and the recent (2023) census estimate make an experimental Protected Slot Limit regulation worthy of consideration. This regulation would protect

40 percent of the adult Walleye (both male and female), allowing protected fish more time to successfully spawn before being susceptible to harvest. The management goals of an experimental Protected Slot Limit would be to: 1) increase adult abundance, 2) increase natural recruitment, and/or 3) improve size structure of Walleye in a large popular lake with declining recruitment.

Northern Pike - A total of 121 individual Northern Pike were captured including 58 males (48%), 48 females (40%), and 15 (12%) were of unknown sex. An insufficient number of recaptures were obtained to calculate a density estimate for adult Northern Pike. Northern Pike total length ranged from 10 to 41 inches with an average total length of 23.3 inches (Table 11). Male Northern Pike total length ranged from 13 to 27 inches with an average total length of 22.2 inches (Table 13). Female Northern Pike total length ranged from 12 to 41 inches with an average total length of 26.4 inches (Table 13). The percentage of Northern Pike captured that were legal size was 40 percent. Age and growth analysis indicates that Northern Pike in Big Manistique are growing comparable to or above the state average (Figure 5), except 6- and 7-year-old Northern Pike were growing slightly below the state average. Finally, a total of 10 age classes were represented (1 to 9, and 13) in the 2023 spring census survey (Figure 5).

Density, size distribution, and age distribution data for Northern Pike in Big Manistique Lake were collected to assess the fishery and evaluate current harvest regulations. A density estimate was not calculated given the low number of recaptures encountered during the survey. In Big Manistique Lake, up to 2 Northern Pike greater than or equal to 24 inches are allowed to be harvested daily. This is the State of Michigan default regulation for Northern Pike that serves to maintain population size structure and encourage above average growth of younger fish.

Several metrics can be used to evaluate the density of Northern Pike based on reference target points set forth in the statewide management plan (Smith et al. 2016). For example, comparisons of average size and fyke net catch per unit effort (CPUE) can be used to evaluate density. Michigan lakes with low densities of Northern Pike have average lengths in fyke catches of 22 inches or greater (Smith et al. 2016). Northern Pike captured in Big Manistique Lake averaged 23.8 inches suggesting a low density. Additionally, moderate density lakes have average lengths of 18 to 20 inches with less than 40 percent proportional stock density (Gabelhouse 1984; Smith et al. 2016). The average length of fish captured in Big Manistique Lake was 23.3 inches and the proportional stock density was 6 percent suggesting a low to moderate density. The CPUE (0.73 fish per fyke net night) for Northern Pike captured using fyke nets is above the state's 25th percentile, but below the median catch rate, again suggesting a low to moderate density exists in Big Manistique Lake.

Growth metrics used to evaluate populations of Northern Pike also include comparing average total length at ages 3 through 5 to the state's 25th and 75th percentile size range (Smith et al. 2016). Average total length of Northern Pike in Big Manistique Lake for ages 3 through 5 are comparable to or above the state's 75th percentile range (Table 14). Based upon data collected from Big Manistique Lake in spring of 2023 and target reference points set forth in the statewide management plan, the Northern Pike fishery in Big Manistique Lake has above average growth. Additionally, Northern Pike in Big Manistique Lake reach the current statewide minimum size of 24 inches at three-and-a-half to four years old. By comparison, the typical average length at age indicates that Northern Pike in Michigan reach 24 inches between age 4 and 5 (Smith et al. 2016). This finding would suggest that sufficient forage resources are available in Big Manistique Lake for Northern Pike to be growing comparable to or above the state average.

Based upon data collected in spring of 2023, the Big Manistique Lake Northern Pike population should be categorized as having "low" to "moderate" density with above average growth. Based upon this categorization, the current statewide default regulation for Northern Pike is sufficient to continue maintaining population size structure while encouraging above average growth of younger fish. Caution should be used when evaluating Northern Pike populations using data collected during a Walleye spawning period. Northern Pike typically spawn prior to and during ice-break up which usually occurs a week or so prior to Walleye spawning. Therefore, it may be that our survey methods did not capture the best representation of the Northern Pike spawning population. For example, larger and older females may be underrepresented in our sample data given that those individuals tend to retreat from spawning grounds sooner relative to their male counterparts.

Panfish - A total of 686 panfish were captured including five species (Table 15). Yellow Perch dominated the catch. A total of 544 Yellow Perch were captured that ranged from 4 to 12 inches in total length (Table 15). The average size of Yellow Perch captured was 7.3 inches and approximately 50 percent of fish captured met or exceeded the minimum preferred size for harvest.

Fall Walleye Recruitment Surveys

Fall shoreline electrofishing surveys are used to index juvenile Walleye year-class strength and to determine the primary recruitment source of populations (i.e., stocked vs. natural reproduction) (Herbst et al. 2021). Since 1992, DNR Fisheries Division has conducted nighttime fall electrofishing surveys to assess year-class strength of age-0 and age-1 Walleye in Big Manistique Lake. During the 2023 fall Walleye recruitment survey, a total of 155 Walleye were captured ranging in size from 6.0 to 22.0 inches in total length (Table 16). The average size of Walleye captured was 8.8 inches and approximately 10 percent of fish captured exceeded the minimum size for harvest (i.e., 15.0 inches). Based on the length distribution, the total number of Age-0 (young-of-year) and Age-1 Walleye captured was 125 and 14, respectively.

The number of Age-0 and Age-1 Walleye captured per mile of shoreline sampled was 6.2 and 0.7, respectively (Table 9). The catch rate of Age-0 (young of year) Walleye in Big Manistique Lake was below regional and lake-specific 25th percentile values. The catch rate of Age-1 Walleye was slightly above the regional and lake-specific 25th percentile, but below median values for both categories (Table 10).

Catch rates of naturally reproduced Age-0 Walleye have been relatively low since 2019, and were highest during the 1999 to 2004, and 2007 period. It is unknown if Big Manistique Lake is experiencing a natural lower level of recruitment, or if the recent introduction of invasive and naturalized species (Zebra Mussels and Round Goby, Black Crappie, respectively) has begun to impact natural reproduction. Inland lakes with natural reproduction of Walleye tend to experience `boom' and `bust' years but typically produce a significant year-class once every 5 to 7 years. The presence of significant natural reproduction once every 5 to 7 years is typically sufficient to maintain a recreational fishery given that adult Walleye live to 15 years of age.

Big Manistique Lake could be experiencing reduced recruitment due to the recent invasion of Zebra Mussels (2018) and Round Goby (2019). The pattern of reduced Walleye recruitment resulting from aquatic invasive species is not unique to Michigan lakes. Walleye populations in other Great Lakes

states and provinces have also been negatively impacted (Chu et al. 2004; Hansen et al 2020). Limitations imposed by the introduction of aquatic invasive species warrants additional attention to prevention and control efforts. The population of Black Crappie appears to be increasing since their first capture by survey gear in 2013. Black Crappie were illegally introduced relatively recently, and other systems have documented reduced Walleye recruitment as catch rates of Black Crappie increase (Broda et al. 2022).

Lower than expected recruitment in recent years has provided local angler groups the opportunity to supplement the population by stocking 6,400 fall fingerling Walleye (Bays de Noc strain) in Big Manistique Lake in 2022 and 2023. Based on the recent growth data collected during the 2023 spring census survey, these stocked individuals should recruit to legal size by 2025 and 2026 and will be available to anglers. Repeated occurrences of lower natural recruitment also warrant consideration of alternative regulations for adult Walleye. As mentioned earlier, an experimental Protected Slot Limit regulation may increase spawning stock biomass increasing the likelihood of stronger natural recruitment in future years.

Double Crested Cormorant
By the late 1990s, cormorants began to redistribute into areas of the Great Lakes in greater numbers than had been historically reported. This expansion was a cause for concern by anglers and area fisheries managers given the potential predation pressure this species has on gamefish, notably juvenile Walleye.

The DNR Fisheries Division received numerous reports regarding the growing number of cormorants in the central and eastern Upper Peninsula. Concerns pertaining to the growing cormorant population were shared by anglers, stakeholders, and reports of large flocks were corroborated by DNR Fisheries Division and Law Enforcement Division staff. During this period, agency officials and stakeholders advocated for control of cormorants in the region.

Cormorant management programs began on some inland lakes within Mackinac County around 2005. Following the onset of the harassment/removal program, angler reports dissipated for several years. By 2009, the Big Manistique Lake fishery was considered by anglers to be `excellent', and managers continued to receive positive reports about the recreational fishery through 2014. In May 2016, cormorant depredation programs in Michigan were rescinded by federal order. Within two years of the federal order, department staff and area stakeholders began to receive reports of a growing number of cormorants in Big Manistique Lake. In December of 2020, the U.S. Fish and Wildlife Service published a ruling that addressed management of conflicts related to cormorants. A new permit system was established for state and tribal agencies that would allow lethal control of cormorants to protect both free-swimming (wild) and stocked fish. However, funding is currently not available to expand cormorant management to inland lakes in Michigan.

To date, residents and stakeholders routinely share daily reports regarding the growing number of cormorants. Many of these concerns were and continue to be shared with DNR Fisheries Division. Area law enforcement staff also continue to provide input regarding the growing number of cormorants in Big Manistique Lake. Several officers have confirmed angler reports, stating that throughout the summer it is routine to see flocks exceeding 100 cormorants in Big Manistique Lake. Cormorants are noted to be a concern on all three Manistique lakes; however, the greatest concern is Big Manistique Lake given the island roosting/nesting habitat that is available there. The DNR Fisheries Division has also confirmed

reports that there is/are nesting/roosting populations of cormorant on Big Manistique Lake. In April of 2023, during a spring adult Walleye census estimate survey, cormorants were observed inhabiting all three islands located on the northwest region of the lake.

Currently, the presence and abundance of cormorants in Big Manistique Lake can be categorized into three groups: 1) annual nesting/roosting colony, 2) annual migration use, and 3) daily use in the summer not associated with migration. The number of cormorants that pertain to these three categories is estimated to be 1) 100 nests, 2) 200 to 500 migratory cormorants, and 3) 200 daily use cormorants, respectively. Until funds are available to administer an inland cormorant management program, harassment by volunteers in collaboration with the DNR Fisheries Division will be necessary to reduce the predation pressure on juvenile gamefishes.

Management Direction

Physical Habitat - Managers will provide guidance to stakeholder groups to improve structure in Big Manistique Lake. A reasonable goal would be to place 20 to 40, 3-dimensional structures in Big Manistique Lake at a depth contour consistent with the presence of oxy-thermal habitat. Structures placed are intended to provide structure that would improve angling opportunity in the lake where such habitat does not currently exist. Additionally, structures placed may provide refuge areas for young gamefish protecting them from avian predation.

Managers will provide information pertaining to the benefits of protecting natural shorelines. Where erosion exists, riparian landowners are encouraged to adopt natural shoreline principles adopted by the Michigan Natural Shorelines Partnership (MNSP 2024). Additionally, managers will distribute information related to the Michigan Shoreland Stewards program (MSSP 2024). The DNR Fisheries Division will engage with the Department of Environment, Great Lakes, and Energy to evaluate shoreline modification projects and identify strategies that minimize impacts to aquatic resources. Special attention will be given to shoreline areas where catches of spawning gamefishes were documented during spring surveys.

Chlorophyll-a - The DNR Fisheries Division will continue to monitor chlorophyl-a concentrations through implementation of the Status and Trends Survey program. Additional monitoring strategies could include involvement by the Michigan Cooperative Lakes Monitoring Program (MiCorps 2024). Managers are encouraged to engage with stakeholders and introduce them to the volunteer Lake Monitoring program. A continuation in chlorophyl-a monitoring would provide long term trend information relative to the recent introduction of invasive Zebra Mussels.

Invasive Species - The recent documentation of invasive species in the Manistique lakes region warrants attention be given to outreach and prevention measures. Managers will provide information to landowners and anglers groups pertaining to programs that prevent new invasive species introductions, limit the dispersal of recently confirmed invasive species, and strengthen statewide invasive species early detection and response work. Funding for such programs is available through the Michigan Invasive Species Grant Program (MISGP 2024).

Walleye Regulations - The adult Walleye population density in Big Manistique Lake was estimated to be 2.1 adults per acre in 2023. Fall fingerlings have been stocked since 2004 by private entities to help bolster a population that has seen highly variable levels of natural recruitment. Reduced recruitment in

recent years suggests that regulatory changes may be beneficial to conserve the population. A protected slot limit of 18 to 23 inches and a reduced daily bag limit of 3 Walleye, with only one fish over 23 inches, is supported by angler groups and should be considered for Big Manistique Lake.

Walleye Recruitment - The DNR Fisheries Division will continue to routinely monitor natural recruitment of Walleye in Big Manistique Lake. These assessments will provide information needed to evaluate the contribution of either naturally produced or stocked Walleye.

Double Crested Cormorant - Under permit, Fisheries Division has requested that contracted officials conduct removal efforts in Big Manistique Lake. If conditions allow such efforts to occur, contracted officials will conduct removal efforts on Big Manistique Lake in spring of 2025. The goal of these efforts is to depopulate the island nesting/roosting population that exists there.

Aside from the nesting/roosting population, there is likely to be two migration periods: one in the spring (April 15th to June 1st) and one in the fall (September 15th to November 1st). Local angler groups have expressed interest to conduct harassment efforts on Big Manistique Lake. Volunteer harassment efforts occurred in the summer of 2024, and there is additional interest to expand their effort in the spring of 2025. The DNR Fisheries Division supports these efforts and has a limited supply of materials needed to equip volunteers for additional harassment efforts. Plans for 2025 are a short-term solution to prevent avian predation on juvenile fishes until funding for a larger inland lake cormorant management program can be realized.

References

Bauman, J. M. 2018. North Manistique (Round) Lake Status of the Fishery Report 2018-247. Michigan Department of Natural Resources, Lansing.

Breck, J. E. 2004. Compilation of databases on Michigan lakes. Michigan Department of Natural Resources, Fisheries Technical Report 2004-2, Ann Arbor.

Broda, S. P., Z. S. Feiner, J. T. Mrnak, S. L. Shaw, and G. G. Sass. 2022. Black Crappie Influences on Walleye Natural Recruitment in Northern Wisconsin Lakes. North American Journal of Fisheries Management 42(5):1202-1214.

Chu, C., C. K. Minns, J. E. Moore, and E. S. Millard. 2004. Impact of oligotrophication, temperature, and water levels on Walleye habitat in the Bay of Quinte, Lake Ontario. Transactions of the American Fisheries Society 133:868-879.

Cooper, G. P. 1948. Fish stocking policies in Michigan: Contribution from the Michigan Institute of Fisheries Research. Michigan Department of Conservation, Fisheries Research Report 1167, Ann Arbor.

Dexter, J. L., Jr., and R. P. O'Neal, editors. 2004. Michigan fish stocking guidelines II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 32, Ann Arbor.

Fuller, L. M., and Jodoin, R. S. 2016. Estimation of a Trophic Index for selected inland lakes in Michigan, 1999-2013: U.S. Geological Survey Scientific Investigations Report 2016-5023, 16p.

Gabelhouse, D. W. 1984. A Length-Categorization System to Assess Fish Stocks. North American Journal of Fisheries Management 4: 273-285.

Hanchin, P. A., and Kramer, D. R. 2007. The fish community and fishery of Big Manistique Lake, Luce and Mackinac counties, Michigan in 2003-04 with emphasis on walleyes, northern pike, and smallmouth bass. Michigan Department of Natural Resources, Fisheries Special Report 43, Ann Arbor.

Hanchin, P. A. 2017. A summary and analysis of the Large Lakes Survey Program in Michigan in 2001-2010. Michigan Department of Natural Resources, Fisheries Report 25, Lansing.

Hansen, G. J. A., T. D. Ahrenstorff, B. J. Bethke, J. D. Dumke, J. Hirsch, K. E. Kovalenko, J. F. LeDuc, R. P. Make, H. M. Rantala, and T. Wagner. 2020. Walleye growth declines following zebra mussel and Bythotrephes invasion. Biological Invasions 22:1481-1495.

Herbst, S. J., D. B. Hayes, K. Wehrly, C. Lesage, D. Clapp, J. Johnson, P. Hanchin, E. Martin, F. Lupi, and T. Cwalinski. 2021. Management Plan for Walleye in Michigan's Inland Waters. Michigan Department of Natural Resources, Lansing.

Laarman, P. W. 1976. The sport fisheries of the twenty largest inland lakes in Michigan. Michigan Department of Natural Resources, Fisheries Research Report 1843, Ann Arbor.

Madison, G., and R. N. Lockwood. 2004. Manistique River assessment. Michigan Department of Natural Resources, Fisheries Special Report 31, Ann Arbor.

MDNR (Michigan Department of Natural Resources). 2001. Bedrock Geology of Michigan. Land and Minerals Division.

MGLP (Midwest Glacial Lakes Partnership) 2023. Midwest Glacial Lakes Partnership. Accessed April 2023.

MiCorps. 2024. Michigan Clean Water Corps: https://www.micorps.net/lake-monitoring/. Accessed 10/2024.

MISGP. 2024. Michigan Invasive Species Grant Program: https://www.michigan.gov/invasives/grants/misgp. Accessed 10/2024.

MNSP. 2024. Michigan Natural Shorelines Partnership: https://www.shorelinepartnership.org. Accessed 10/2024.

MSSP. 2024. Michigan Shoreline Stewards Program: https://www.shorelinepartnership.org/shoreland-stewards.html. Accessed 10/2024.

Reynolds, Dexter B. 1948. Observations of the Movements of Yellow Pikeperch (Stizostedion v. vitreum), Northern Pike (Esox Lucius), and other species in South and Big Manistique lakes, Luce and Mackinac Counties. Institute of Fisheries Research Report No. 1159.

Roelofs, E. W. 1941. A Fisheries Survey of the Manistique Lakes, Luce and Mackinac Counties. Institute of Fisheries Research, Report No. 702.

Schneider, J. C. 2002. Fish as indicators of Lake Habitat Quality and a Proposed Application. Michigan Department of Natural Resources Fisheries Research Report 2061, 2002.

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 unit of effort and density of walleye yearlings. North American Journal of Fisheries Management 3:451-452.

Smith, K. M., C. K. Kovacs, M. V. Thomas, and J. S. Diana. 2016. Management plan for Northern Pike in Michigan. Michigan Department of Natural Resources, Fisheries Report 15, Lansing.

USDA. 2024. United States Department of Agriculture Natural Resources Conservation Service: https://websoilsurvey.nrcs.usda.gov/app/. Accessed 10/2024.

Washburn, George N. 1945. Examination of diseased Northern Pike from Manistique Lake, Mackinac County. Institute of Fisheries Research, Memorandum No. 182.

Wehrly, K. E., D. B. Hayes, and T. C. Wills. 2015. Status and trends of Michigan inland lake resources, 2002-2007. Michigan Department of Natural Resources, Fisheries Report 08, Lansing.

Wetzel, R. G. 2001. Limnology: Lake and River Ecosystems (3rd Edition). Academic Press.

Whelan, G. E. 2004. A Historical Perspective on the Philosophy behind the Use of Propagated Fish in Fisheries Management: Michigan's 130-Year Experience. American Fisheries Society Symposium 44:307-315.

Ziegler, W., and J. C. Schneider. 2000. Guidelines for evaluating Walleye and Muskie Recruitment. Chapter 23 in Manual of Fisheries Survey Methods, Michigan Department of Natural Resources, Fisheries internal documents, Ann Arbor.

Table 1. Limnological profiles including depth (in feet), temperature (°F), and dissolved oxygen (mg/L) collected in Summer from Big Manistique Lake, Mackinac County in 1936, 2003, 2013, and 2020.

Temperature (°F)					Dissolved Oxygen (mg/L)				
Depth	1936	2003	2013	2020	Depth	1936	2003	2013	2020
0	71.6	73.0			0	8.5	9.0		
1			75.9	62.4	1			11.5	9.3
2			75.9	62.3	2			11.4	9.3
3		73.0	75.9	62.5	3		9.0	11.3	9.3
4			75.9	62.5	4			11.3	9.2
5			75.9	62.6	5			11.3	9.2
6		73.0	75.9	62.6	6		9.0	11.3	9.2
7			75.9	62.6	7			11.3	9.2
8			75.9	62.6	8			11.2	9.2
9		73.0	75.8	62.6	9		8.9	11.2	9.2
10	71.2		75.8	62.6	10			11.2	9.3
11			74.7	62.6	11			11.0	9.3
12		73.0	74.4	62.6	12		8.9	10.8	9.2
13	69.8	73.0	74.3	62.6	13		8.9	10.6	9.2
14		73.0	73.9	62.6	14		8.9	10.1	9.3
15		73.0	73.7	62.6	15		8.8	9.9	9.3
16	69.4		73.4	62.6	16	9.1		9.8	9.3
17			73.1	62.6	17			9.4	9.2
18			72.5	62.9	18			6.5	1.5

Table 2. Several winter limnological profiles including depth (in feet), location number (1 through 7), temperature (°F), and dissolved oxygen (mg/L) collected from Big Manistique Lake, Mackinac County in 2023.

	Temperature (°F)							Dissolved Oxygen (mg/L)						
Depth	1	2	3	4	5	6	7	1	2	3	4	5	6	7
0														
1														
2														
3	34.2	34.3	34.4	34.8	35.0	34.6	34.7	13.9	13.8	12.7	12.9	13.2	12.4	13.2
4	33.8	34.7	35.3	35.4	35.8	36.2	35.0	12.0	13.4	13.1	13.1	12.4	11.3	13.2
5	34.0	35.6	35.8	36.1	36.7	37.0	36.3	10.4	13.2	13.0	13.2	10.3	10.6	13.0
6	34.6	36.5	36.7	37.2	37.2	38.1	37.8	9.6	11.3	8.8	12.8	7.7	10.1	12.7
7	34.9	37.2	37.1	38.1	37.7	38.5	39.2	9.5	7.7	7.2	11.5	5.8	8.3	11.4
8	35.9	37.9	37.8	38.6	38.2	39.1		9.1	4.8	5.7	8.8	4.6	6.3	
9	36.5	38.4	38.2	39.2	38.9	39.6		8.8	5.2	5.0	5.0	3.3	4.9	
10	36.9	39.0	38.6	39.5	39.2	39.8		8.5	5.0	4.9	3.3	2.3	4.7	
11	37.8	39.8	39.0	39.7	39.6	40.1		7.0	3.6	4.5	3.2	4.3	5.6	
12	38.2	41.2	39.4	40.0	39.9	40.3		6.6	1.5	3.1	2.5	5.6	6.5	
13	38.9	41.7	39.8	40.2	40.1	40.4		5.5	0.7	2.2	1.3	3.9	7.2	
14			40.5	40.4	40.3	40.6				1.0	0.9	4.5	7.4	
15		42.0	41.3	40.6	40.5	40.7			0.8	0.4	1.6	4.6	7.8	
16			42.1	41.1	40.8	41.0					5.5	4.5	7.3	
17			42.3	42.0	41.4	41.4				0.7	5.6	4.3	6.5	
18			42.6	42.5	42.5	41.7				0.6	4.6	1.4	6.3	
19					43.7							0.9		
20														

Table 3. Physical indicators including dwelling density (per mile), boat docks (per mile), shoreline armoring (average percent armored), and large woody debris (per mile) measured in Big Manistique Lake, the regional average (Avg. Northern Lake Michigan Management Unit), 25th percentile, 75th percentile, and status.

Physical Indicator	Manistique Lake	Avg.	25th Percentile	75th Percentile	Status
Dwelling Density	22.7	13.1	1.3	22.1	High
Boat Docks	14.1	9.5	1.3	16.4	Moderate
Shoreline Armoring	31.5	10.1	0.0	15.4	High
Large Woody Debris	17.2	209.1	21.5	241.0	Low

Table 4. County, species stocked, year of stocking, number stocked, and the size of fish stocked (age, or total length (inches)) in Big Manistique Lake, Michigan.

County	Species	Year	Number Stocked	Size at Stocking
Mackinac	Lake Whitefish	1893	841,000	
Mackinac	Smallmouth Bass	1910	1,000	Fingerlings
Luce	Yellow Perch	1933	3,600	7 month
Mackinac	Walleye	1933	300,000	Swim-up fry
Mackinac	Yellow Perch	1933	3,000	7 month
Mackinac	Yellow Perch	1934	8,000	7 month
Mackinac	Yellow Perch	1934	450,000	Swim-up fry
Luce	Walleye	1935	450,000	Swim-up fry
Luce	Walleye	1936	300,000	Swim-up fry
Luce	Yellow Perch	1936	8,000	7 month
Luce	Yellow Perch	1936	10,000	Adults
Mackinac	Yellow Perch	1936	10,000	8 month
Luce	Walleye	1937	510,000	Swim-up fry
Mackinac	Walleye	1938	400,000	Swim-up fry
Luce	Walleye	1939	300,000	Swim-up fry
Luce	Yellow Perch	1939	8,000	7 month
Mackinac	Walleye	1939	600,000	Swim-up fry
Luce	Walleye	1940	150,000	Swim-up fry
Luce	Walleye	1940	600,000	Swim-up fry
Luce	Northern Pike	1941	42	Adults
Luce	Northern Pike	1941	67	Adults
Mackinac	Northern Pike	1941	277	Adults
Mackinac	Walleye	1941	300,000	Swim-up fry
Mackinac	Walleye	1970	300,000	Fingerling
Luce	Northern Pike	1971	1,450	Fingerling
Luce	Northern Pike	1971	2,900	Fingerling
Luce	Walleye	1971	3,931	Fingerling
Mackinac	Northern Pike	1971	250	Fingerling
Mackinac	Walleye	1971	7,000	Fingerling
Mackinac	Walleye	1971	600,000	Fingerling
Luce	Walleye	1972	7,300	Fingerling
Mackinac	Walleye	1972	2,035	Fingerling
Mackinac	Walleye	1972	5,500	Fingerling
Mackinac	Walleye	1972	500,000	Swim-up fry
Luce	Walleye	1973	1,700	Fingerling
Mackinac	Walleye	1973	300,000	Swim-up fry

Table 4. Continued.

County	Species	Year	Number Stocked	Size at Stocking
Luce	Walleye	1974	100,000	Swim-up fry
Mackinac	Walleye	1974	14,900	Fingerling
Mackinac	Walleye	1974	300,000	Swim-up fry
Luce	Walleye	1975	400,000	Fingerling
Mackinac	Walleye	1975	3,500	Spring fingerling
Mackinac	Walleye	1975	650,000	Fingerling
Mackinac	Walleye	1975	650,000	Fingerling
Luce	Walleye	1976	1,000,000	Fingerling
Mackinac	Walleye	1976	1,00,0000	Fingerling
Mackinac	Walleye	1977	20,000	Fall fingerling
Mackinac	Walleye	1977	1,050,000	Fingerling
Mackinac	Walleye	1978	350,000	Fingerling
Mackinac	Walleye	1979	568,980	0.4
Mackinac	Walleye	1979	350,000	0.0
Mackinac	Walleye	1980	100,000	0.4
Mackinac	Walleye	1980	200,000	0.0
Luce	Lake Sturgeon	1983	2,900	0.0
Luce	Lake Sturgeon	1984	10,000	3.4
Luce	Lake Sturgeon	1988	3,742	4.5
Luce	Lake Sturgeon	1990	6,989	3.4
Luce	Lake Sturgeon	1993	7,636	4.2
Luce	Smallmouth Bass	1998	10,000	2.3
Luce	Muskellunge	2004	3,239	7.7
Mackinac	Walleye	2005	1,000,000	0.3
Mackinac	Walleye	2005	4,700	8.1
Mackinac	Walleye	2007	2,000	8.0
Mackinac	Walleye	2008	3,250	7.0
Luce	Walleye	2009	3,350	7.0
Mackinac	Walleye	2011	1,500	8.0
Mackinac	Walleye	2012	2,500	7.5
Mackinac	Walleye	2013	2,500	9.0
Mackinac	Walleye	2017	3,000	5.9
Mackinac	Walleye	2019	3,000	6.0
Mackinac	Walleye	2022	6,400	6.6
Mackinac	Walleye	2023	6,400	6.0

Table 5. Common and scientific name of plants documented in North Manistique Lake (North), Big Manistique Lake (Big), and South Manistique Lake (South) 1936 (Roelofs 1941).

Common Name	Scientific Name	North	Big	South
Sweet Flag	*Acorus calamus*		Rare	
Waterweed	*Anacharis canadensis*		Rare	Few
Water Shield	*Brasenia Schreberi*			Rare
Coontail	*Ceratophyllum demersum*			Abundant
Musk Grass	*Chara sp.*	Abundant	Abundant	
Spike Rush	*Eleocharis sp.*	Rare	Rare	
Mare's Tail	*Hippuris vulgaris*		Rare	
Iris	*Iris versicolor*			Rare
Duckweed	*Lomna and/or Spirodela*			Rare
Water Marigold	*Megalodonta beckii*			Rare
Water Milfoil	*Myriophyllum spicatum*		Rare	Rare
Bushy Pondweed	*Najas flexilis*		Few	
White Water Lily	*Nymphaea odorata*			Few
Yellow Water Lily	*Nuphar*		Rare	Common
Reed Grass	*Phragmites*		Rare	
Pondweed	*Potamogeton angustifolius*		Rare	
Pondweed	*Potamogeton friesii*		Rare	Rare
Pondweed	*Potamogeton gramineus*	Rare	Few	Rare
Floating-leaf Pondweed	*Potamogeton natans*	Few	Few	Few
Pondweed	*Potamogeton nodosus*		Rare	
Sago Pondweed	*Potamogeton pectinatus*	Common	Abundant	
Pondweed	*Potamogeton richardsonnii*		Few	Rare
Pondweed	*Potamogeton robbinsii*			Rare
Pondweed	*Potamogeton strictifolius*			Rare
Pondweed	*Potamogeton tenuifolius*		Rare	
White Water Buttercup	*Ranunculus aquatilis*		Rare	
Stiff Water Crowfoot	*Ranunculus longirostris*		Rare	
Widgeon Grass	*Ruppia maritima*		Common	
Arrowhead	*Sagittaria cuneata*		Rare	
Arrowhead	*Sagittaria latifolia*	Rare	Rare	Few
Big Bullrush	*Scirpus acutus*	Common	Abundant	Abundant
Three-square	*Scirpus americanus*	Rare	Rare	Rare
Bur-reed	*Sparganium sp.*		Rare	Rare
Cattail	*Typha latifolia*		Rare	Few
Bladderwort	*Utricularia vulgaris var. americana*		Rare	Rare
Wild Celery	*Vallisneria americana*		Few	
Wild Rice	*Zisania aquatica*			Common

Table 6. Qualitative occurrence of fish species in the Manistique lakes in 1936 (Roelofs 1941).

Fish	North Manistique Lake	Big Manistique Lake	South Manistique Lake
Northern Pike		Few	Rare
Yellow Perch	Abundant	Abundant	Common
Walleye	Common	Common	Common
Smallmouth Bass	Few	Few	Few
Largemouth Bass			Few
Green Sunfish		Rare	
Bluegill			Few
Pumpkinseed Sunfish		Rare	Few
Rock Bass	Few	Rare	Few
Cisco	Common	Few	Few
Common White Sucker	Abundant	Common	Common
Redhorse species	Few		
Brown Bullhead		Few	Few
Mimic Shiner	Few	Abundant	Few
Sand Shiner	Few	Abundant	Common
Bluntnose Minnow	Abundant	Abundant	Common
Spottail Shiner		Common	
Central Mudminnow			
Common Shiner		Common	Abundant
Golden Shiner		Rare	Few
Central Mudminnow		Rare	
Mottled Sculpin		Rare	Rare
Johnny Darter		Common	Few
Iowa Darter		Rare	
Logperch			Few

Table 7. Year, number (No.) of net nights, Walleye average (Avg.) size (total length, inches), Walleye size range, number of Walleye (WAE) caught, catch rate (number of Walleye per net night), total liters (L) of eggs taken to Thompson State Fish Hatchery, and total liters of eggs provided to Curtis Hatchery, and the number of Walleye stocked in Big Manistique Lake (Mackinac, Luce County) from 1968 to 2023.

Year	No. Net Nights	Avg. Size	Size Range	WAE Caught	WAE Catch Rate (No./Net Night)	Eggs Taken (L)	Eggs to Curtis Hatchery (L)	No. of WAE Stocked
1968						47.3	28.4	
1970	24T	15	10 to 24	1,407	58.6			
1971	24T		10 to 22	796	33.2			610,931
1972	36T		8.9 to 29.1	2,080	57.8			514,835
1973	20T	18.4	12 to 22	800	40			301,700
1974	34T	16.9	8.5 to 23.7	2,375	69.8			414,900
1975	30T		10 to 24	2,246	74.9			1,703,500
1976	68T		8 to 24	3,108	45.7			2,000,000
1977	61T		9 to 23	4,856	79.6			1,070,000
1978	39T, 10F	13.9	8 to 25	4,403	89.9*			350,000
1979	44T, 44F	15.9	10.7 to 25.9	6,230	72.4*			918,980
1980	40T, 15F	14.8	10.2 to 24.3	3,809	69.2*	61.35	10	300,000
1981	114T, 1F	14.9	12.2 to 24.2	8,253	72.4*			
1982	43T	14.4	9.5 to 25.1	4,210	97.9	97.46		
1983	64T	14.4	5.3 to 26.4	5,065	79.1	123.4	9	
1984	24T	15.9	12 to 22	2,609	128.2	55.5	30.5	
1985	24T	19.6	11 to 26	3,588	149.5	170	8	
1986	36T	16.8	14 to 23	4,243	132.6	97	20	
1987	39T	17.0	10 to 26	3,344	85.7	110.5	28	
2000	53T	17.1	3.0 to 26.0	1,470	27.7			
2003	98T	19.4	7.0 to 26.0	3,735	38.1			
2003	106F	18.6	7.0 to 26.0	952	9.0			
2023	49T	17.8	7.0 to 24.0	2,597	53.0			
2023	123F	16.6	6.0 to 26.0	3,093	25.2			

T = Trap net, F = Fyke net, * indicates that trap and fyke net catch rates were pooled and may not be directly comparable to trap net effort.

Table 8. Catch summary by species, total caught, total weight (pounds, lbs.), range in length (inches, in.), and mean total length (in.) of fish captured during the Status and Trends Survey conducted in Big Manistique Lake from 10 June to 29 August 2013.

Species	Total Caught	Total Weight (lbs.)	Length Range (in.)	Mean Length (in.)
Black Crappie	1	0.2	7 to 7	7.5
Bluegill	96	6.2	2 to 9	4.2
Bluntnose Minnow	287	2.8	1 to 3	2.6
Brown Bullhead	36	25.2	3 to 14	9.4
Cisco (Lake Herring)	9	1.3	7 to 10	8.0
Creek Chub	5	0.1	3 to 3	3.5
White Sucker	248	432.4	7 to 21	16.5
Emerald Shiner	176	0.6	1 to 3	2.6
Iowa Darter	6	0.0	1 to 2	1.8
Johnny Darter	1	0.0	1 to 1	1.5
Largemouth Bass	30	30.2	4 to 17	9.4
Logperch	195	2.6	2 to 3	3.1
Mimic Shiner	20,308	61.8	1 to 2	2.2
Central Mudminnow	2	0.0	2 to 4	3.5
Northern Pike	105	333.0	17 to 40	23.9
Pumpkinseed	50	4.5	2 to 8	4.9
Rock Bass	229	35.4	1 to 10	5.4
Sand Shiner	551	1.3	0 to 2	1.9
Shorthead Redhorse	51	103.6	10 to 21	17.1
Silver Redhorse	33	87.4	10 to 22	19.3
Smallmouth Bass	98	97.3	3 to 19	11.0
Spottail Shiner	600	3.0	1 to 3	2.5
Walleye	201	216.3	6 to 24	14.1
Yellow Perch	7,013	88.0	1 to 14	5.8

Table 9. Year, number of young-of-year (YOY) and yearling (YR) Walleye per mile (Mi) in Big Manistique Lake, Mackinac County, Michigan.

Year	YOY/Mi	YR/Mi
1992	22.9	10.6
1993	58.0	2.9
1996	18.3	1.4
1998	4.6	1.1
1998	56.3	1.3
1999	139.7	0.0
2000	104.3	3.0
2003	134.7	0.0
2004	93.2	5.3
2005	6.8	7.1
2006	25.1	0.0
2007	107.9	3.7
2008	4.2	16.7
2010	18.9	2.5
2011	76.0	1.6
2012	48.0	0.3
2013	19.1	8.2
2014	2.4	0.6
2016	24.3	1.2
2017	42.6	4.3
2018	11.9	0.0
2019	10.0	0.6
2020	3.4	1.2
2021	5.0	0.0
2022	14.0	0.6
2023	6.2	0.7

Table 10. Fall survey catch rate of Walleye by age, source for comparison, and the average (Avg.), minimum (Min.), maximum (Max.), 25th percentile, median, and 75th percentile catch rate in Big Manistique Lake (BML), Mackinac County (1992 to 2023).

Age	Source	Avg.	Min.	Max.	25th Percentile	Median	75th Percentile
Age-0	Regional	38.5	2.4	139.7	10.0	22.9	56.3
	BML 1992 to 2023	40.7	2.4	139.7	6.6	21.0	62.5
Age-1	Regional	3.3	0.0	16.7	0.6	1.4	4.5
	BML 1992 to 2023	2.9	0.0	16.7	0.5	1.3	3.8

Table 11. Catch summary by Species, total caught, total weight (pounds, lbs.), range in length (inches, in.), and mean total length (in.) of fish captured during the spring census survey conducted in Big Manistique Lake from 21 April to 27 April 2023.

Species	Total Caught	Total Weight (lbs.)	Length Range (in.)	Mean Length (in.)
Black Crappie	33	6.8	4 to 13	7.3
Black Bullhead	4	1.6	8 to 11	9.3
Bluegill	25	3.8	3 to 8	5.7
Brown Bullhead	8	2.9	5 to 13	8.9
Cisco	6	2.8	6 to 14	10.8
Creek Chub	1	0.2		8.5
White Sucker	6,301	11,620.0	9 to 19	16.6
Greater Redhorse	10	14.8	12 to 18	16.9
Largemouth Bass	3	5.0	12 to 16	14.5
Northern Pike	123	416.3	10 to 41	23.3
Pumpkinseed Sunfish	20	5.2	3 to 10	6.2
Rock Bass	64	14.6	4 to 8	6.6
Shorthead Redhorse	128	175.6	11 to 20	14.8
Silver Redhorse	54	189.0	18 to 25	22.2
Smallmouth Bass	5	8.5	12 to 16	14.7
Walleye	7,425	12,837.0	5 to 26	16.6
Yellow Perch	544	92.8	4 to 12	7.3

Table 12. Size distribution of individual male, female, and unknown-sex Walleye captured from all gear types in Big Manistique Lake during the 2023 spring census estimate survey.

Inch Bin	Male	Female	Unknown
5	0	0	2
6	0	0	11
7	0	0	195
8	0	0	45
9	0	0	0
10	0	0	1
11	0	0	18
12	42	0	111
13	57	0	31
14	228	0	2
15	592	14	4
16	1,144	83	7
17	1,166	177	4
18	1,217	161	2
19	399	145	2
20	52	167	0
21	3	102	0
22	0	60	0
23	0	14	0
24	0	9	0
25	0	2	0
26	0	1	0

Table 13. Size distribution of individual male, female, and unknown-sex Northern Pike captured from all gear types in Big Manistique Lake during the 2023 spring census estimate survey.

Inch Bin	Male	Female	Unknown
10			2
11			1
12		1	
13	1		2
14			1
15	1		
16	2		
17	1		
18	4		2
19	3	2	
20	6	3	
21	4	4	1
22	6	6	
23	15	2	2
24	7	6	
25	3	1	1
26	2	1	1
27	3	7	1
28		5	
29		2	
30		2	
31			1
35		1	
38		1	
39		2	
40		1	
41		1	

Table 14. Big Manistique Lake (Mackinac/Luce County, spring 2023) and statewide average length at age for Northern Pike ages 1 to 13 and calculated metrics based on length quartiles for ages 3 to 5. Average lengths based on anal fin ray data. State average calculated from 109 populations sampled during March-May 1990 to 2015 (Smith et al. 2016).

Age	State Average Length (in)	Big Manistique Lake Average Length (in)	25th Percentile (in)	75th Percentile (in)
1	11.7	12.1		
2	17.7	19.2		
3	20.8	22.6	19.1	22.2
4	23.4	24.5	20.9	24.5
5	25.5	26.1	22.8	26.2
6	27.3	25.5		
7	29.3	28.6		
8	31.2	31.0		
9		39.8		
13		41.5		

Table 15. Size distribution of panfish captured in Big Manistique Lake during the 2023 spring census estimate survey.

Inch Bin	Black Crappie	Bluegill	Pumpkinseed	Rock Bass	Yellow Perch
3		3	1		
4	6	9	5	9	21
5	7	5	5	11	128
6	6	1	1	20	125
7	7	5	5	16	132
8	5	2	2	8	79
9	1				40
10			1		11
11					6
12					2
13	1				

Table 16. Length distribution (inch group) and the total number of Walleye captured in Big Manistique Lake, Mackinac County, Michigan on 27 September 2023. Walleye captured in top box within each column indicates Age-0 (young-of-year), and bottom box indicates Age-1.

Inch Group	Total Walleye Captured
1	0
2	0
3	0
4	0
5	0
6	16
7	94
8	15
9	0
10	0
11	2
12	11
13	1
14	0
15	2
16	2
17	5
18	3
19	1
20	0
21	2
22	1
TOTAL	155

Figure 1. Map of Big Manistique Lake, Mackinac County, Michigan.

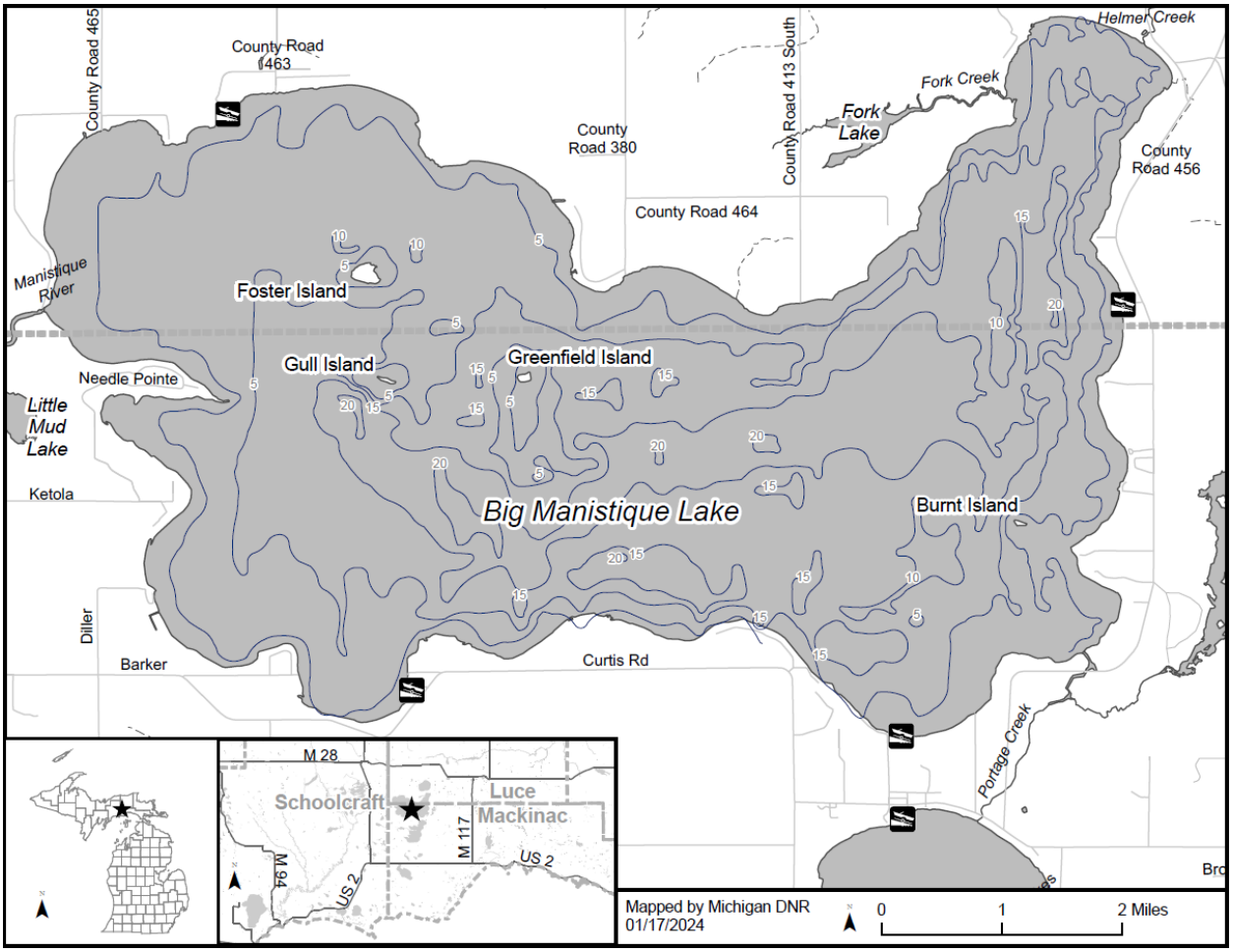

Figure 2. Land use map for the Manistique lakes region.

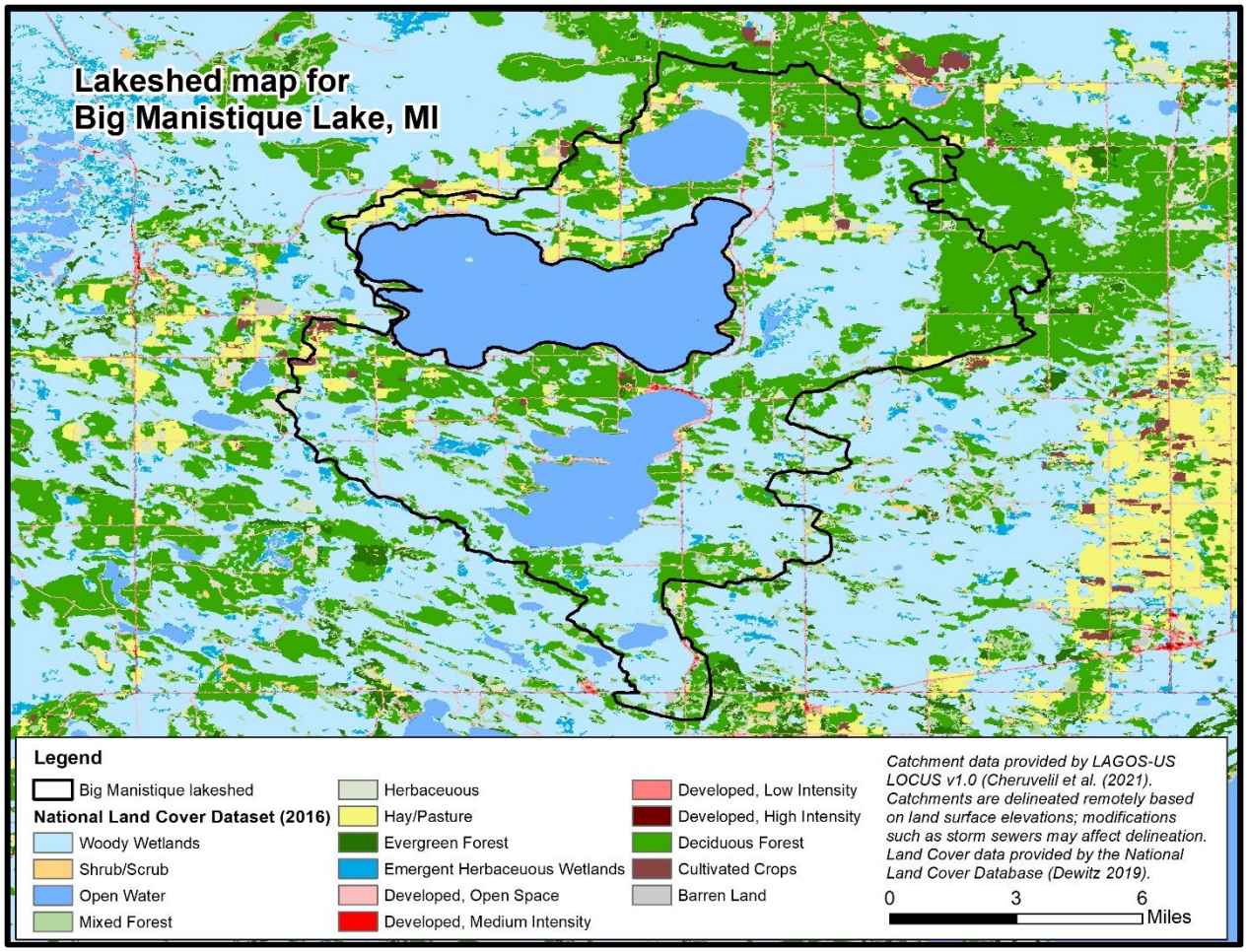

Figure 3. Catchment or ‘lakeshed’ map for the Manistique lakes region.

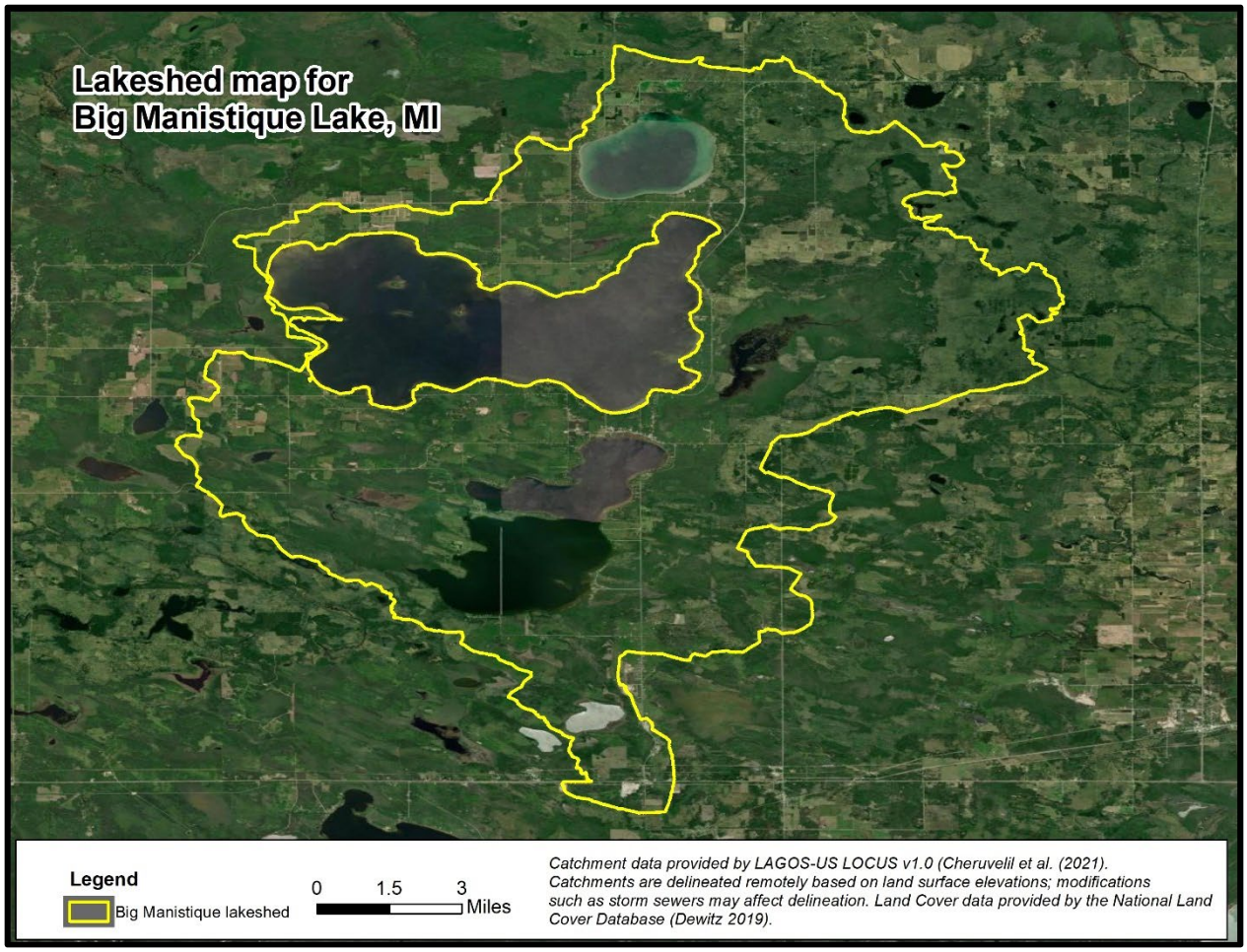

Figure 4. Average total length (inches) of Walleye by age group in Big Manistique Lake (spring 2023) compared to the State of Michigan average length at age.

Figure 5. Average total length (inches) of Northern Pike by age group in Big Manistique Lake (spring 2023) compared to the State of Michigan average length at age.

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