Milakokia Lake (Pike Lake)
Mackinac County, T43N R12W Section 33
Undesignated Watershed, Last Surveyed 2017

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Environment

Milakokia Lake (Pike Lake) is a 1,956 acre natural lake located in western Mackinac County (T43N R12W Section 33) in Michigan's Upper Peninsula (Figure 1). In Schoolcraft County, Gulliver (Doyle Township) and Germfask reside to the southwest and northwest of Milakokia Lake, respectively. In Mackinac County, Gould City, Engadine, Naubinway, and Curtis reside to the east and northeast of Milakokia Lake.

Milakokia Lake is located within the Cabot Head Shale and Burnt Bluff bedrock groups within the Lime Island Dolomite formation. Soils surrounding Milakokia Lake consist predominately of leafliver mucky peat, carbondale muck, dawson and loxley peat, quarry soil, and cobbly fine sand. The immediate topography of Milakokia Lake consists of low sand and gravel soils with growth of conifers and lowland hardwoods.

Milakokia Lake is a headwater to the Milakokia River Watershed, which flows approximately 20 miles and drains an area of 60 square miles. There are no permanent tributaries to Milakokia Lake which itself serves as a tributary to the Milakokia River. Beaver Bay, located in the northern region of the lake contains an intermittent waterbody which flows from the north into Milakokia Lake. A small inlet (Quarry Creek) flows into the northwest end of the lake. Additionally, there are several small drainage streams (ditches) located near the east-central shoreline. These intermittent waterbodies, which flow into the lake seasonally, provide spawning habitat for migratory fish species. The Milakokia River begins in the southwest shore of Milakokia Lake and flows south for approximately 3 miles and turns west into Heinz Lake where it is joined by the East Branch of the Milakokia River which joins Sand and Batty Doe lakes. From Heinz Lake, the Milakokia River continues westerly and joins 405 Creek and Nelson Creek prior to flowing south and discharging into Lake Michigan between Port Island Point and Suel Choix Point.

Milakokia Lake is positioned on a northwest to southeast axis with Beaver Bay and Rubys Bay located in the northern region of the lake. The total fetch length from the northwest shore to the southeast shore is approximately 3.1 miles, and the total fetch length from the western shore to the eastern shore is approximately 1.5 miles. Shoal areas in Milakokia Lake consist of muck, sand and gravel, with larger cobble along the northeastern and eastern shore. The maximum depth of Milakokia Lake is 26 feet and most of the lake is less than 15 feet deep. Aquatic vegetation in Milakokia Lake is moderately abundant and consists of pondweed, water lilies, milfoil, and bulrush. Eurasian Watermilfoil (Myriophyllum spicatum), an invasive aquatic species, was first documented in Milakokia Lake in 2013 however, has likely inhabited this waterbody prior to that date. Additionally, a small region of the southeastern shore is noted to be populated with Phragmites spp., also an invasive aquatic grass known to become dominant in wetland riparian areas.

On 29 August 2016, a temperature profile and Secchi Disk depth was recorded in Milakokia Lake. Thermal stratification (which is measured using a temperature profile) in lakes typically occurs in deep lakes during the summer months of the year where three water column `layers' form, which are called the epilimnion, metalimnion, and hypolimnion. The epilimnion consists of the upper layer of the water column which has adequate light levels to support photosynthesis and primary production. The hypolimnion is the bottom most layer of the water column typically characterized by colder water and light levels which are too dark to support photosynthesis. The metalimnion is the layer between the epilimnion and hypolimnion characterized by a quick transition in temperature change. The point at which temperature change is greatest within the metalimnion is referred to as the `thermocline'. Results from the 2016 temperature profile suggest that Milakokia Lake does not thermally stratify during warmer periods of summer, likely due to the shallow depth of the lake. Water transparency, which is measured using a 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. In 2016, Milakokia Lake the Secchi depth reading was 9.0 feet which is 10 percent deeper (more transparent) compared to other large shallow lakes in Northern Lake Michigan (Wehrly et al. 2015).

The limnological or trophic state of a lake refers to the total weight of living biological material (biomass) and is a measure of overall lake productivity. The concept is based on the fact that changes in nutrient levels (measured by total phosphorus) affect changes in algal biomass (measured by chlorophyll-a) which in turn affects changes in lake clarity (measured by water transparency). A Secci disk, as described earlier, is used to measure the depth to which it can easily be observed through the water, (i.e., transparency). Secci disk transparency, chlorophyll-a (an indirect measure of phytoplankton), and total phosphorus (a limiting nutrient) are then used to define the degree of productivity, or trophic status of a lake. Oligotrophic, mesotrophic, and eutrophic lakes are those which exhibit low, medium and high levels of productivity, respectively.

Chlorophyll-a is a pigment used by plants for photosynthesis and when measured during the summer months provides a way to measure levels of primary production by phytoplankton. As mentioned earlier, levels of Chlorophyll-a when accompanied by additional chemical parameters (i.e., Total Phosphorus, Total Nitrogen, Secchi Disk depth) allow managers to gauge a lake's trophic state. Chlorophyll-a concentrations vary widely across Michigan's inland lakes having low (<1.9 ug/L), medium (1.9 to 4.8 ug/L) and high (>4.8 ug/L) concentrations. A chlorophyll-a sample was collected from Milakokia Lake and analyzed in 2016 and was reported to be 3.06 ug/L (medium).
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's inland lakes having low (<9.0 ug/L), medium (9.0 to 20.0 ug/L), and high (>20.0 ug/L) concentrations. In 2016, the total phosphorus value reported in Milakokia Lake was 12.5 ug/L (medium).

In contrast to Total Phosphorus, Total Nitrogen occurs in relatively high concentrations in aquatic environments and as a result, rarely limits primary production in lakes. Nitrogen values typically vary quite widely across Michigan's inland lakes having low (<0.403 mg/L), medium (0.403 to 0.750 mg/L), and high (>0.750 mg/L) concentrations. In 2016, the total nitrogen value reported in Milakokia Lake was 1.53 mg/L (high).

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 ration of N:P which tends to be approximately 18:1 where Total Phosphorus is the limiting nutrient. In 2016, the N:P ratio for Milakokia Lake was 122:1, which suggest that total phosphorus is the nutrient which limits primary production.

Total Alkalinity is a measure of buffering capacity and plays an important role in determining the pH and consequently, overall lake productivity. Alkalinity values in Michigan inland lakes can be classified into low (< 49.5 mg/L as CaCO3), medium (49.5 to 141.5) and high (> 141.5) categories. In 2016, Alkalinity in Milakokia Lake was 68 mg/L (medium).

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 fish populations at approximately 4.0 mg/L and are often lethal below 0.5 mg/L. On 29 August 2016, DO measurements from the surface to the lake bottom ranged from 9.1 to 8.8 mg/L. Results from the DO profile collected in 2016 suggest that a sufficient amount of oxygen exists throughout the entire water column to support aquatic life. Similar data exist from 1947, when DO ranged from 9.7 to 8.8 mg/L in Milakokia Lake.

Trophic status refers to an index which 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 (ug/L), Secchi depth feet (ft), and chlorophyll-a (ug/L) 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 values <38 are Oligotrophic, from 38 to 48 are Mesotrophic, from 49 to 61 are eutrophic, and >61 are hypereutrophic. In 2016, the Total Phosphorus, Secchi depth, Chlorophyll-a values were reported to be 12.5 ug/L, 9.0 feet, and 3.06 ug/L, respectively (average TSI = 42.3, Mesotrophic).

Milakokia Lake is a recreational destination which has offered fishing, hunting, and camping opportunities for several decades. A large proportion of Milakokia Lake shoreland is under private ownership (94.9 percent), though some public land exists in the form of a State Forest Campground and boat launch located on the northeast shore (GPS location: 46.085718 -85.796157). An additional boat launch, maintained by Newton Township, is located on the north end of the lake, west of Beaver Bay (GPS location: 46.090986 -85.833012).

Residential development provides an index of the potential influence human activities have in areas adjacent to shoreland resources. Building structures (dwellings) in riparian areas, removing vegetation or woody debris, armoring shorelines, and building docks all have the potential to impact lake ecosystems and negatively affect fish populations and water quality. Dwelling density values along Michigan inland lake shorelines can be classified as low (<4.8 dwellings per mile), medium (4.8 to 30.4 dwellings per mile) and high (>30.4 dwellings per mile). The number of dwellings per mile along the shoreline of Milakokia Lake was measured in 2016 to have 11.1 dwellings per mile (medium).

The density of boat docks, measured as the number of docks per mile of shoreline, provides an index of the nearshore disturbance level as well as the potential boat activity level. Construction of docks often is accompanied by the removal of large woody debris and aquatic vegetation which disrupts nearshore sediment and reduces available refuge habitat for aquatic organisms. Dock density values along Michigan inland lake shorelines can be classified as low (<1.9 docks/mile), medium (1.9 to 21.9 docks/mile), and high (>21.9 docks/mile). The number of docks in Milakokia Lake was measured in 2016 to have 7.8 docks per mile (medium).

The degree to which lake shorelines have been armored, to reduce the impacts of wave action, provides an index of the extent to which shorelines may have been modified from their natural state. Shoreline armoring, is measured as the percent of shoreline armored across all transects. The amount of shoreline armored in Michigan's inland lakes varies considerably across the state with lakes having low (<0.6 percent), medium (0.6 to 30.1 percent) and high (>30.1 percent) armoring. The extent to which Milakokia Lake shoreline has been armored was measured in 2016 and was reported to be 8.7 percent (medium).

Large woody debris is an important habitat component providing structure for aquatic organisms (e.g., fish, aquatic insects) during various life periods and providing stability of the lake bottom (e.g., sediments, vegetation). Trees growing adjacent to shoreland fall into the water and become a primary source for large woody debris habitat, however humans have greatly impacted the degree to which large woody debris exists in many lakes. Humans often remove woody debris from shoreline areas reducing critical lake habitat. Furthermore, humans reduce recruitment of new large woody debris by removing trees from shoreland areas during landscaping. The amount of large woody debris in Michigan's inland lakes can be broken down into three categories; low (<1.1 trees per mile), medium (1.1 to 22.7 trees per mile), and high (>22.7 trees per mile). The amount of large woody debris in Milakokia Lake was measured in 2016 and was reported to be 20.4 trees per mile (medium).

History

Milakokia Lake was first surveyed in 1926 by J.N. Lowe in an effort to collect fish specimens for educational purposes, as Lowe was a biologist instructor at what is now Northern Michigan University. Species were captured using a beach seine and included; Yellow Perch, Mimic Shiner, Sand Shiner, Common Shiner, Bluntnose Minnow, Fathead Minnow, Johnny Darter, and Iowa Darter. An additional general inventory survey was conducted in 1930 to gather additional fish specimens. The Civilian Conservation Corps mapped the bathymetry of Milakokia Lake sometime in the 1930s. Fisheries Management began in Milakokia Lake in the early 1930s when Walleye and Yellow Perch were stocked in an effort to establish a fishery for those species.

During the 1940s, Walleye had been stocked in the previous decade without measurable success. Additional plants of Walleye occurred in 1942; however other species were also stocked in Milakokia Lake in the 1940s. For example, in 1947 and 1949, Smallmouth and Largemouth Bass were stocked at the request of fisherman and area residents who stated that neither species existed in this lake previously. A total of 91 adult Northern Pike were stocked in 1941 to supplement a popular Northern Pike sport fishery. Milakokia Lake resort owners expressed interest in angling opportunities for panfish which prompted stocking 3,000, 5 inch Bluegill in 1949; however it is suspected that those fish did not survive. Public concern grew during the mid- and late-1940s regarding illegal poaching of Northern Pike. Northern Pike often became vulnerable to poachers during spring when water levels in

nearby intermittent streams were low and as a result stranded adult fish seeking marsh habitat for spawning. Issues with poaching and fluctuating water levels in streams utilized by Northern Pike for spawning resulted in the placement of a temporary water level control structure in 1949.

During the 1950s, Smallmouth Bass fishing was noted to have improved as a result of recent stocking. Bluegill stocking occurred in 1954 and 1957 with reports of Bluegill being caught in Beaver Bay. Walleye in the 5 to 6 pound category we caught in 1956 suggesting that previous stocking may have been successful. The last year Walleye had been stocked was 1942, suggesting also that natural recruitment of Walleye was occurring in Milakokia Lake. Poaching of Northern Pike near spawning marshes continued to be a problem which prompted letters being sent to agency staff in hopes of preventing harm to the population. According to records from the 1950s residents would gather near spawning marshes to observe annual Northern Pike spawning runs, which would last over two weeks. Spawning runs of Northern Pike were documented to occur as early as the first two weeks in April (1958) and as late and the first two weeks in May (1950). In 1956, the temporary water control structure was replaced with a permanent structure.

During the 1960s no stocking records were reported for Milakokia Lake. Fishing during this period, as reported by agency staff, was good for Smallmouth Bass, Northern Pike, Bullhead and Yellow Perch. In 1963 and 1966, `jumbo' Yellow Perch were reported to be captured in Milakokia Lake. Excellent Bullhead fishing was also reported during the 1960s. In 1966, `black-spot' and `red-sore' were reported in Northern Pike captured in Milakokia Lake, however no additional cases have been reported since. Reports of poaching Northern Pike during the vulnerable period of spawning continued through the 1960s.

During this period, agency staff continued to annually monitor Northern Pike spawning runs in collaboration with area residents and resort owners. As part of the Accelerated Public Works Program, the Department of Conservation (now Michigan Department of Natural Resources) (MI DNR) collaborated with the Mackinac County Road Commission and area resort owners to begin a "Pike Marsh Project". These projects aimed to improve natural reproduction of Northern Pike by improving access to marsh habitat around inland lakes (namely, Milakokia Lake and North Manistique Lake). By 1964, easements had been acquired and improvements to area spawning marshes had taken place. During this time, MI DNR staff recommended that the state of Michigan acquire areas near Bryan Grade and Quarry Creek. Possession of these areas would allow permanent operation of the water control structures which aided Northern Pike reproduction. Additional recommendations made at this time included the construction of concrete water control structures to replace the `sand-bags' that were placed and removed each year. During this period, spawning runs of Northern Pike typically occurred during the middle of April. In the early 1960s an easement was granted to gain access to and operate a water control structure in Quarry Creek which was controlled using sand bags.

During the 1970s records indicate that a dam was built at the outlet of Milakokia Lake and riparian owners were concerned about fluctuating lake water levels. MI DNR staff responded to public complaints stating that the dam was built without permission and that riparian owners should seek council to establish a court ordered water level as well as form a council that appoints a representative to maintain the established water level. In addition to water level, a concern regarding the overabundance of aquatic vegetation was shared with MI DNR staff.

In 1972 property owners of Milakokia Lake expressed a desire to stock Walleye into Milakokia Lake. Previous attempts (1930s and 1940s) to introduce Walleye were met with some success; however natural reproduction was not sufficient to sustain the population. At this time, MI DNR staff recommended against additional attempts to introduce Walleye into Milakokia Lake given that a predator population had already been established and reports of good fishing were common for Northern Pike, Yellow Perch, Brown Bullhead and Smallmouth Bass. Additional requests for stocking were followed by Milakokia residents expressing interest in paying for and stocking 10,000 Walleye. Records which indicate whether or not 10,000 Walleye were stocked are not available. However, discussion of stocking prompted additional management focus on Walleye during the mid-1970s. For example, the Milakokia Lake Property Owners Association worked in collaboration with MI DNR staff to develop rearing ponds (borrow pits) for fingerling Walleye production. It is unknown if these ponds were utilized, however, fingerling Walleye obtained from Curtis, Michigan (Big Manistique Lake) were planted in 1976, 1977, and 1978 (total 1,850,000) at an average rate of 315 per acre.

In 1979, the MI DNR was provided with the opportunity to acquire property adjacent to the water control structure at Quarry Creek Marsh and included 320 feet of lake frontage. At that time, staff determined that marsh areas in Milakokia Lake were not sufficient to impact Northern Pike populations given that the size of the Quarry Creek Marsh was approximately two acres. In a draft agency policy the recommended marsh size was 1 acre of marsh per 30 acres of inland lake (based on a 1975 policy). Therefore, Milakokia Lake would require approximately 65 acres to significantly impact Northern Pike natural recruitment. Given that the Quarry Creek and Bryan Grade marsh areas were less than ten acres total, district staff deferred the request to purchase the adjoining land until Northern Pike policies were revised. It is unknown if the purchase was ever made.

By the end of the 1970s, management focus had shifted from annual maintenance of the Northern Pike spawning marshes to a Walleye introduction program. This shift in focus was due in part to the guiding policy for spawning marshes, which suggested marshes were too small to significantly impact Northern Pike populations. Also, easements which provided access to private property to operate and maintain water control structures near the marshes had all expired. A shift in focus from Northern Pike to Walleye management was also led by members of the Milakokia Lake Property Owners Association. Members of the association expressed interest in establishing a Walleye fishery in the lake in hopes of providing additional angling opportunities while improving the size structure of Yellow Perch (through predation).

During the 1980s, Walleye planted during the previous decade were expected to begin recruiting to the Milakokia Lake population offering additional angling opportunities. Surveys conducted in 1981 suggested that some natural recruitment of Walleye was occurring; however growth was nearly two inches below state average. In 1985, improvement in Walleye numbers were documented during an additional survey which mirrored the survey conducted in 1981. At this time, MI DNR staff recommended that additional Walleye stocking occur. During this time, a total of 4,450,000 spring fry Walleye were stocked into Milakokia Lake at an average rate of 379 fish per acre.

In 1982, the Milakokia Lake Property Association expressed concern over the disrepair of the water control structures used to aid in annual spring migrations of Northern Pike during spawning. The association expressed interest in establishing a cooperative effort, similar to that which had existed in the past, to continue assuring access of Northern Pike to spawning marshes. An agency response soon

followed in the form of an inspection of both the Bryan Grade and Quarry Creek marshes. MI DNR staff noted that the Mackinac County Road Commission or lake residents had already improved both structures and removed debris. In addition to a site inspection, MI DNR staff provided an operational guide-line for marshes for future years.

Sharing operational guide-lines for Northern Pike was followed by a reaffirmation that the current management focus for Milakokia Lake would be for Walleye, rather than Northern Pike. This again, was due to the expired easements and recommended minimum size of the marshes needed to significantly impact Northern Pike spawning. From this time, association members continued to annually provide access to spawning routes so continued natural reproduction of Northern Pike could occur. Efforts taken by association members to continue maintaining water control structures near marshes were supported by MI DNR staff.

In the late 1980s, letters were received by riparian land owners claiming that the fishing in Milakokia Lake had deteriorated since Walleye had been planted in the lake. The disappearance of Bullhead, Northern Pike, and Yellow Perch were among the concern documented in the letter. Results from surveys conducted in 1981 and 1985 confirm that numbers of each of these species had declined. Additional information gathered from the 1985 confirmed that natural reproduction of Walleye was occurring in Milakokia Lake and growth rates were improved compared to 1981. Therefore, it was determined at this time to reduce the rate at which Walleye would be stocked into Milakokia Lake, as well as continue to advocate for and provide assistance to association members involved with maintaining Northern Pike spawning marshes. MI DNR staff and association members expected Walleye numbers to decrease while still providing sufficient angling opportunities for Walleye while improving Yellow Perch numbers. Additionally, continued operation of spawning marshes by association members was expected to improve Northern Pike numbers in Milakokia Lake.

By the end of the 1980s area resort owners expressed interest in the construction and deployment of fish cribs, which were used to concentrate panfish and improve recreational fishing. MI DNR policies regarding the recommended dimensions and materials were shared, however it is unknown if structures were ever placed into Milakokia Lake.

During the 1990s, Milakokia Lake continued to focus fisheries management on Walleye, Northern Pike, Yellow Perch and Smallmouth Bass. In each year (1990 and 1993), a total of 750,000 Walleye were stocked (at reduced rates compared to 1982 and 1985 plants) into Milakokia Lake at a rate of 383 spring fry per acre. These were the last recorded stocking events for Walleye in Milakokia Lake. Smallmouth Bass were stocked in 1998 as a result of concerns from land owners that this species was difficult to locate when fishing. Based on agency records, 1998 was the last year Milakokia Lake was stocked (for any species).

In June of 1994 (prior to the previous survey), MI DNR staff were contacted in regards to a fish kill in Milakokia Lake. Fish, which included Walleye and other species were found dead and noted to have `vision problems'. Riparian residents described severe ground tremors and huge clouds of dust which were believed to be caused by `blasting' at a limestone quarry located on the west side of the lake.

In late June of 1994 Milakokia Lake was surveyed to evaluate gamefish populations. This survey mirrored surveys conducted in 1981 and 1985. Overall, captures from this survey suggested that

Walleye were spawning naturally and recent stocking may have caused slow growth in young Walleye and Yellow perch which both compete for plankton. Catch per unit effort (CPUE) for Walleye had declined recently compared to the 1981 and 1985 surveys. Smallmouth Bass and Northern Pike CPUEs increased compared to the 1985 survey. Results from this most recent survey are difficult to interpret given the unknown magnitude of the fish kill which had occurred only weeks prior.
In July of 1994, staff from the Michigan Department of Environmental Quality - Air Quality Division visited the limestone quarry located near Milakokia Lake. A `blast' demonstration confirmed that a dust cloud is produced as a by-product of a blast and wind then carries the cloud towards Milakokia Lake. However it is unknown if the cloud produced resulted in the fish kill observed earlier in the year.

In 1998, a Walleye recruitment assessment was conducted on Milakokia Lake to evaluate the abundance of young of year Walleye. This survey lasted 196 seconds as young Walleye were too abundant to catch. In total, 138 Walleye were captured before the survey was ended. A recruitment class of this size indicates that natural reproduction is strong (perhaps too strong) and future stocking was deemed not necessary.

During the 2000s, no active management strategies in the form of stocking were in place for Milakokia Lake. However, Milakokia Lake was surveyed in 2001 and 2007. In 2001, in an effort to standardize survey protocols statewide, Milakokia Lake was surveyed using a variety of fisheries sample gear meant to target all species which inhabit the lake. Results from this survey were impressive, given the effort put forth, and findings from this survey mimic those reported in prior years. Natural recruitment of Walleye in Milakokia Lake is excellent and populations of Northern Pike and Yellow Perch were growing above and at state average, respectively. Additionally, large numbers of Bluegill were captured which in previous years were absent. This increase in Bluegill captured was likely due to the variety of gear types used during this more thorough survey.

Milakokia Lake was again surveyed in 2007 to gather information about the status of the lake's fish community. A total of 988 fish were captured which included 12 species. Piscivore or gamefish species such as Walleye, Northern Pike, Smallmouth Bass, Rock Bass, and Yellow Perch comprised 95 percent of catch by number and 93 percent of the biomass. Benthic species, such as bottom dwelling Common White Sucker and Johnny Darter comprised 3 percent of the catch by number and 7 percent of the biomass. Lastly, pelagic species (Planktivores-insectivores) such as shiners, minnows, and panfish comprised 2 percent of the catch by number and nearly zero percent of the biomass. Results from this survey suggested that Milakokia Lake offered an attractive mixed bag fishery with several species for anglers to target from predators to panfish. No active management such as stocking was recommended at that time. A recommendation was made by agency staff to comprehensively survey Milakokia Lake in the next 7 to 10 years.

During the 2010s, Milakokia Lake continues to be managed as a mixed bag fishery offering angling opportunities for Walleye, Northern Pike, Yellow Perch, Smallmouth Bass and Brown Bullhead. No stocking has occurred in the recent decade.

Current Status

Four surveys were used to determine the current status of the Milakokia Lake fishery. A Status and Trends survey was completed by MI DNR in 2016 to gather fish community, water chemistry, and

habitat information. In 2015 and 2016, night electrofishing assessments were conducted to evaluate natural recruitment of Walleye. Also, a comprehensive survey was completed in spring of 2017 to quantify the abundance of Walleye and Northern Pike in Milakokia Lake. Information from general surveys conducted in 1981, 1985, 1994, 2001 and 2007 were also referenced in the Analysis and Discussion section to evaluate long-term trend capture information. A complete stocking history for Milakokia Lake can be found in Table 1.

A total of 12,035 fish were captured during the 2016 Status and Trends survey which included 18 species (Table 2). Piscivore or gamefish species such as Walleye, Northern Pike, Smallmouth Bass, and Yellow Perch comprised 10 percent of the catch by number and 73 percent of the total biomass. Benthic species, such as bottom dwelling Common White Sucker, Redhorse Sucker Johnny Darter, and Logperch comprised 1 percent of the catch by number and 24 percent of the total biomass. Lastly, pelagic species (planktivores-insectivores) such as shiners, minnows, and panfish comprised 89 percent of the catch by number and 3 percent of the total biomass. Results showed that the standing crop of Milakokia Lake was approximately 85 pounds per acre. Catch per unit effort (fish per net night) for each species captured during this survey can be found in Table 3.

A total of 86 Northern Pike averaging 24.2 inches comprised 0.7 percent of the catch by number and 15.7 percent of the catch by biomass. Northern Pike ranged in size from 13 to 33 inches in length and 48.0 percent of the catch exceeded the minimum size for harvest (24 inches). Age and growth analysis indicated that two, three, and five year old Northern Pike were growing nearly 2.0 inches above state average. Age distribution indicated annual recruitment has occurred with 8 (Age 2 to 9) year-classes represented in the catch suggesting that mortality is normal in this population. Catch per unit effort (1.76 fish per net night) of Northern Pike increased in 2017 compared to 2007 (1.49 fish per net night).

A total of 99 Walleye averaging 15.5 inches comprised 0.8 percent of the catch by number and 9.4 percent of the catch by biomass. Walleye size ranged from 6 to 24 inches in length and 57.0 percent of the catch exceeded the minimum size for harvest (15 inches). Age and growth analysis indicated that one, three, and four year old Walleye were growing at rates comparable to state average. Age distribution indicated strong annual recruitment has occurred with 13 (Age 1 to 15) year-classes represented suggesting that mortality is low to normal in this population. Age 10 (2006) and 12 (2004) year old Walleye were absent from the catch. Catch per unit effort (2.02 fish per net night) increased in 2017 compared to 2007 (1.19 fish per net night).

A total of 399 Yellow Perch averaging 5.9 inches comprised 3.3 percent of the catch by number and 1.3 percent of the catch by biomass. Yellow Perch ranged from 1 to 10 inches in length and 9.0 percent of the catch exceeded the acceptable size for harvest (6 inches). Age and growth analysis indicated that three and four year old Yellow Perch were growing at rates comparable to state average. Age distribution indicated annual recruitment has occurred with 6 (Age 1 to 6) year-classes represented. Catch per unit effort (8.14 fish per net night) increased by a factor of 13 compared to 2007 (0.63 fish per net night).

A total of 23 Smallmouth Bass averaging 16.6 inches comprised 0.2 percent of the catch by number and 3.6 percent of the catch by biomass. Smallmouth Bass ranged from 10 to 21 inches in length and 91.0 percent of the catch exceeded the minimum size for harvest (14 inches). Insufficient numbers of Smallmouth Bass were collected to provide a growth index with respect to the state average. Age

distribution indicated intermittent recruitment with 9 (Age 2 to 11) year-classes represented. Age 1 and 7 year old Smallmouth Bass were absent from the catch. Catch per unit effort (0.47 fish per net night) declined slightly compared to 2007 (0.65 fish per net night).

A total of 513 Brown Bullhead averaging 14.2 inches comprised 4.3 percent of the catch by number and 41.9 percent of the catch by biomass. Brown Bullhead ranged from 10 to 16 inches in length and 100 percent of the catch exceeded the acceptable size for harvest (7 inches). Catch per unit effort (10.47 fish per net night) declined by 35 percent compared to 2007 (16.05 fish per net night).

In 2015 and 2016, the MI DNR conducted fall electrofishing surveys to evaluate natural recruitment of Age 0 (fall fingerling) and Age 1 (yearling) Walleye. During each survey, three sections (each 2.0 miles in length) of shoreline were electrofished for a total of 6.0 miles of shoreline sampled per year. In 2015, a total of 103 Walleye were captured including 83 fall fingerlings ranging in length from 5 to 9 inches. A total of 17 yearlings were captured with an average length of 10.5 inches. Age and growth analysis indicated that fall fingerlings were growing slightly below state average. Estimates of abundance for fall fingerling and yearling Walleye were 13.8 and 2.8 fish per mile, respectively (or 3.2 and 0.6 per acre). In 2016, a total of 291 Walleye were captured including 256 fall fingerling fish ranging in length from 4 to 7 inches. Age and growth analysis indicated that fall fingerling Walleye were growing over an inch below the state average. A total of 20 yearlings were captured ranging in length from 9 to 11 inches. Age and growth analysis indicated that yearling Walleye were growing slightly above state average. Estimates of abundance for fall fingerling and yearling Walleye were 42.7 and 3.33 fish per mile, respectively (or 10.0 and 0.7 per acre).

In 2017, the MI DNR conducted a spring survey to generate a population estimate for adult Northern Pike and Walleye. A total of 4,409 fish were captured during this survey which included 9 species (Table 2). Catch per unit effort (fish per net night) for each species captured during this survey can be found in Table 3. A total of 1,589 Walleye were captured which included 1,262 males (79%), 239 females (15%), and 88 were of unknown (6%) sex. The estimated adult Walleye abundance in Milakokia Lake was calculated to be 1.3 adults per acre (or approximately 2,543 adults). A total of 490 Northern Pike were captured which included 340 males (69%), 25 females (25%), and 29 were of unknown (6%) sex. The estimated adult Northern Pike abundance in Milakokia Lake was calculated to be 0.6 adults per acre (or approximately 1,174 adults).

A total of 754 (including recaptures) Northern Pike averaging 22.7 inches comprised 17.1 percent of the catch by number and 26.4 percent of the catch by biomass. Northern Pike ranged in size from 12 to 39 inches in length and 35.0 percent of the catch exceeded the minimum size for harvest (24 inches). Age and growth analysis indicated that age classes 1 through 6 are growing at or above state average (Smith et al. 2016). Age distribution indicated annual recruitment has occurred with 10 (Age 1 to 10) year-classes represented in the catch suggesting that mortality is low to normal for this population.

A total of 2,494 Walleye (including recaptures) averaging 17.7 inches comprised 56.6 percent of the catch by number and 57.5 percent of the catch by biomass. Walleye ranged in size from 5 to 26 inches in length and 89.0 percent of the catch exceeded the minimum size for harvest (15 inches). Age and growth analysis indicated that age 1 Walleye are growing below state average, while ages 2 to 5 are growing at or slightly above state average. Walleye 6 years or older are typically growing at or

slightly below state average. Age distribution indicated annual recruitment has occurred with 16 (Age 1 to 16) year-classes represented in the catch suggesting that mortality is low for this population.

Analysis and Discussion

Standing crop biomass (measure of lake productivity) of Milakokia Lake was calculated to be approximately 85 pounds per acre (all species). This is normal for a mesotrophic lake in the Upper Peninsula of Michigan. Comparatively, North Manistique Lake has an average standing crop biomass of approximately 41 pounds per acre. North Manistique Lake is an oligotrophic lake (nutrient poor) with low productivity compared to Milakokia Lake. As a result, Milakokia Lake supports larger populations of fish per acre of lake.

Results from the 2016 Status and Trends survey suggest that the Milakokia Lake fish community composition has changed compared to results from surveys conducted from 1981 to 2007. Results show that predator catch per unit effort (CPUE) has increased (12 percent) and benthivore CPUE has decreased (7 percent) suggesting that the fish community in Milakokia Lake is becoming dominated by predators (namely Bullhead, Northern Pike, and Walleye). This increase in predator CPUE is likely the result of an abundant Brown Bullhead population which has increased in capture frequency since 2007 (Table 3).

Northern Pike population estimate data are lacking for Michigan's inland lakes due to the difficulty in sampling lakes soon after ice out or while ice is still covering much of an inland lake. However, sampling during the Walleye spawning season does provide managers with the opportunity to obtain a large amount of data about the Northern Pike populations compared to that gathered during other surveys conducted later in the season. Due to the large number of captures and recaptures that occurred during the 2017 population estimate survey, a respectable abundance estimate was produced. Results from the 2017 population estimate survey suggest that the current abundance of adult Northern Pike (0.6 adult Northern Pike per acre) is low (Smith et al. 2016). Additional metrics for evaluating Northern Pike populations include mean length at ages 3 to 5 (Table 4) in addition to the adult abundance estimate. Growth rates of Northern Pike in Milakokia Lake exceed the statewide 75th percentile for 3, 4, and 5 year old fish. Therefore, under guidance of the State of Michigan's Northern Pike Management Plan (Smith et al. 2016) current regulations for Northern Pike in Milakokia Lake are appropriate.

The Walleye population in Milakokia Lake is self-sustaining with successful annual recruitment, above average growth rates for ages 2 to 5 years old, and low annual mortality with adults reaching 16 years old. Fall recruitment assessments, geared towards quantifying the abundance of young Walleye, suggest that strong natural recruitment could be stunting the size of naturally produced fall fingerling Walleye. However, this temporary delay in growth due to intra-specific competition (within species) is quickly corrected prior to reaching two years old. One year old Walleye were found to be growing slightly below the state average according to results from the 2017 spring population estimate survey, which is also due to competition for forage by other young Walleye. Growth of Walleye, ages 2 to 5, is slightly above state average which suggests that sufficient forage is available during this life period when juveniles are reaching maturity and begin spawning. Growth of Walleye 6 years old and older (to 12 years old) is at or lower than the state average which may be normal for populations in northern Michigan, but could also indicate that at 19 inches long (or 6 years old), forage resources for larger Walleye become limited. Managers should continue to monitor the fish population to identify gaps in

the forage base that limit growth of larger adult Walleye. Adult Walleye abundance in Milakokia Lake is comparable to stocked and naturally producing populations in northern Michigan (Table 6). Historically, Milakokia Lake was stocked until sufficient evidence was gathered demonstrating that natural reproduction was occurring. Based on results from the Status and Trends, the spring adult abundance estimate, and two fall Walleye recruitment surveys, it is recommend that Milakokia Lake not be stocked with Walleye (or any other predator). Furthermore, no changes should be made to the current regulations for Walleye on Milakokia Lake.

Diversity and proportional density of panfish in Milakokia Lake is low consisting of Yellow Perch, Rock Bass, Bluegill and the occasional Pumpkinseed Fish. Two likely explanations for low numbers of panfish are that 1) panfish numbers are reduced as a result of the density of Walleye, Northern Pike, and Brown Bullhead and 2) gear used during our assessments and the time of year these surveys were conducted are not conducive to providing the data needed to make a robust statement about the abundance and growth of this group of fishes. In recent years Yellow Perch have represented a larger proportion of the panfish biomass followed by Rock Bass. Future survey efforts should be multifaceted such that additional data relative to panfish abundance are collected to determine the extent to which predators may be regulating the abundance of panfish.

Abundance of Smallmouth Bass in Milakokia Lake has remained stable over several decades (Table 3). Fish captured during the 2016 Status and Trends, and 2017 spring population estimate were low in terms of number captured but large in size. For example, an average of only 20 Smallmouth Bass were captured during each assessment, however, more than 90 percent of those captured were greater than or equal to harvestable size (14 inches). While Smallmouth Bass do not represent a large proportion of the available gamefish present in Milakokia Lake, the frequency and size with which they occur provides additional options for those seeking Smallmouth Bass angling opportunities.

The abundance and size of Brown Bullhead found in Milakokia Lake are unique characteristics compared to other inland lakes in Michigan. For example, in 2016 over 500 Brown Bullhead were captured with an average length (14.2 inches) greater than that required for entry into the Master Angler program (14.0 inches). Nearly 2 percent of fish captured were a size (16 inches) which would likely exceed 3 pounds (Preigel 1966) which is approaching the Michigan state record (3 pounds 12.3 ounces). The abundance and size of Brown Bullhead in Milakokia Lake may help reduce the abundance of young fish (Walleye, and Yellow Perch), which subsequently reduces intra-specific competition. Reducing competition of young fish, which are shown to have reduced growth rates in Milakokia Lake particularly during their first year, is essential to provide balance in an aquatic ecosystem. Therefore, Brown Bullhead should be recognized as an important component to the Milakokia Lake food web providing unique angling opportunities and balancing the abundance and health of other gamefish and panfish species.

Management Direction

Milakokia Lake is a large, relatively shallow mesotrophic lake with a shoreline that is largely intact containing habitat capable of producing and maintaining a healthy aquatic community. Physical attributes of this lake (e.g., nutrient levels and rocky substrate) and the low level of shoreline development, provide the conditions necessary for anglers seeking a mixed-bag fishery where all fish populations are supported by natural reproduction. The management goals of this lake are to 1) continue collaboration and engagement with riparian owners and association members to serve as a

broker of information pertaining to shoreland protection and invasive species management, 2) utilize fisheries management principles which promote protection of self-sustaining gamefish populations, 3) maintain healthy balance of predators and prey to provide a mixed bag fishery including Northern Pike, Walleye, Smallmouth Bass, Brown Bullhead, and Yellow Perch, 4) contact representatives from the Department of Environmental Quality to evaluate nutrient levels in Milakokia Lake and 5) develop an open line of communication with representatives of the limestone quarry which resides on the west side of Milakokia Lake.

The following recommendations can be made to accomplish these goals:

1. Provide educational information pertaining to shoreland protection. For example "Natural Shoreline Landscapes on Michigan's Inland Lakes: Guidebook for property owners". Provide information from Michigan State University Extension agents about upcoming shoreland protection workshops. Encourage continued collaboration between stakeholder groups and Cooperative Invasive Species Management Area to monitor and reduce the occurrence of invasive species.

2. Routinely evaluate the Milakokia Lake fish community every 5 to 10 years using Status and Trends large lake survey protocols, in addition to fall juvenile recruitment and spring population estimate assessments. Conduct annual (spring, summer, winter) creel assessment on Milakokia and other neighboring lakes.

3. Utilize survey data, in conjunction with species management plans, to evaluate whether regulations changes are needed to counter an overabundant predator population.

4. The level of Total Nitrogen in Milakokia Lake is higher than in neighboring inland lakes. These levels although not known to be harmful, are likely contributing to higher primary production rates (standing crop biomass) and should be targeted in the future for additional sampling.

5. Encourage stakeholder groups to reach out to representatives of the limestone quarry with annual lake updates. Managers are encouraged to share survey reports with representatives of the limestone quarry.

References

Fuller, L. M, and R. S. Jodoin. 2016. Estimation of Trophic State Index for selected inland lakes in Michgan, 1999-2003: U.S. Geological Survey Scientific Investigations Report 2016-5023, 16p.

Priegel, G. R. 1966. Age-length and length-weight relationship of bullheads from Little Lake Butte Des Morts, 1959. Wisconsin Department of Natural Resources Technical Library.

Schneider, J. C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

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.

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. Institute for Fisheries Research, Ann Arbor.

Figure 1. Map of Milakokia Lake, Mackinac County (1956 acres).

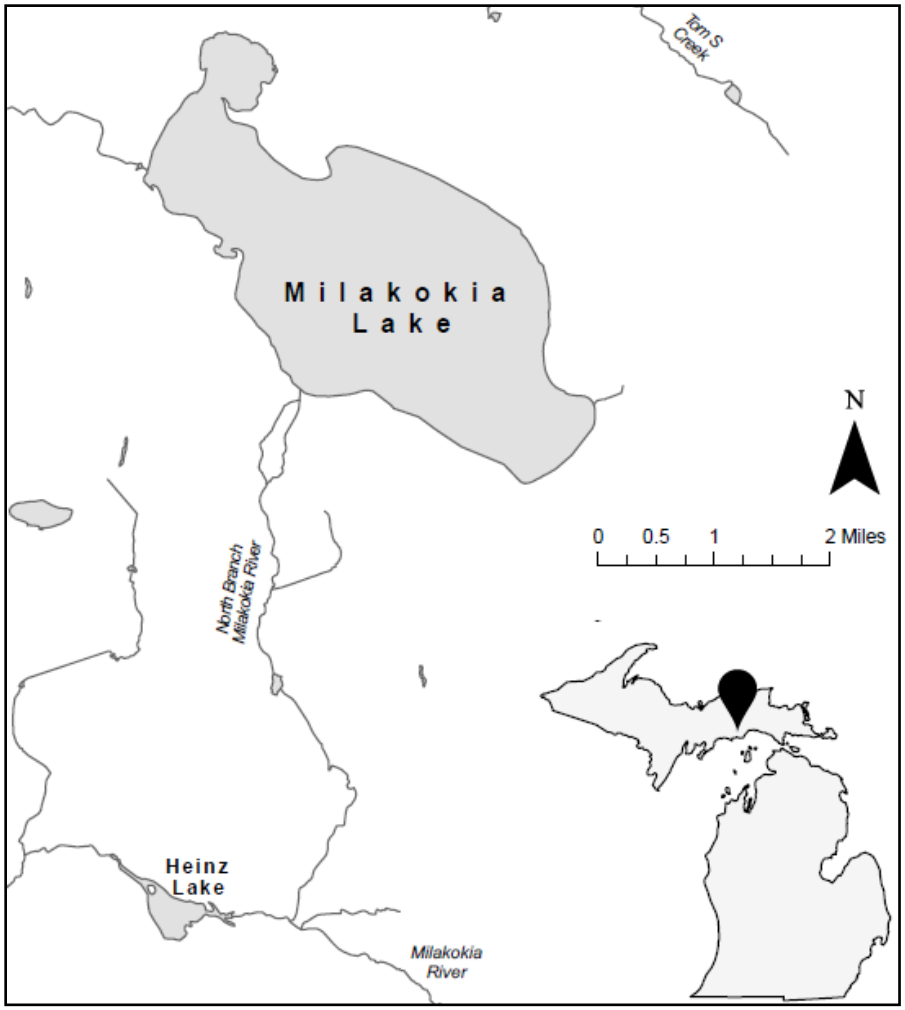

Table 1. Species, strain, year, and the number stocked (N stocked) into Milakokia Lake, Mackinac County from 1933 to 1998 (65 years).

Species	Strain	Year	Number Stocked
Walleye		1933	150000
Yellow Perch		1933	2000
Yellow Perch		1934	300000
Walleye		1935	180000
Yellow Perch		1936	10000
Walleye		1936	180000
Yellow Perch		1936	11000
Walleye		1938	250000
Yellow Perch		1938	5000
Walleye		1939	240000
Walleye		1940	150000
Northern Pike		1941	91
Walleye		1942	780000
Large/Smallmouth Bass		1947	23000
Bluegill		1949	3000
Large/Smallmouth Bass		1949	20000
Bluegill		1954	2728
Bluegill		1954	4000
Bluegill		1957	243
Walleye		1976	1000000
Walleye		1977	200000
Walleye		1978	650000
Walleye		1981	300,000
Walleye		1981	700,000
Walleye		1982	1,000,000
Walleye	Bay De Noc	1985	1,000,000
Walleye	Manistique	1986	700,000
Walleye	Bay De Noc	1989	750,000
Walleye	Bay De Noc	1990	750,000
Walleye	Bay De Noc	1993	750,000
Smallmouth bass		1998	4,992

Table 2. Number of species captured during previous assessments including the 2016 Status and Trends and 2017 Walleye and Northern Pike population estimate surveys.

Species	1981	1985	1994	2001	2007	2016	2017
Bluegill	0	0	0	461	1	2	17
Bluntnose Minnow	0	0	0	0	18	1,068	0
Brown Bullhead	14	1	9	3	690	513	193
Common Shiner	0	0	0	0	0	195	0
Common White Sucker	155	41	28	13	24	147	630
Emerald Shiner	0	0	0	0	0	3	0
Golden Shiner	0	0	0	0	0	2	1
Greater Redhorse	0	0	0	0	0	1	0
Johnny Darter	0	0	0	0	2	1	0
Logperch	0	0	0	0	0	6	0
Northern Pike	8	6	9	26	64	86	754
Pumpkinseed Fish	1	4	46	39	0	1	10
Rock Bass	14	17	140	666	79	50	54
Sand Shiner	0	0	0	0	0	8,276	0
Smallmouth Bass	3	1	11	15	28	23	16
Spottail Shiner	0	0	0	0	2	1,163	0
Walleye	63	72	34	31	51	99	2,494
Yellow Perch	41	18	301	417	27	399	240
Longnose Sucker	1	0	0	0	0	0	0
Largemouth Bass	0	0	1	0	0	0	0
TOTAL	300	160	579	1,671	986	12,035	4,409

Table 3. Species Catch per Unit Effort (CPUE) from 1981 to 2017.

	Catch Per Unit Effort						
Species	**1981**	**1985**	**1994**	**2001**	**2007**	**2016**	**2017**
Bluegill	0.00	0.00	0.00	11.82	0.02	0.04	0.13
Bluntnose Minnow	0.00	0.00	0.00	0.00	0.42	21.80	0.00
Brown Bullhead	0.37	0.03	0.23	0.08	16.05	10.47	1.53
Common Shiner	0.00	0.00	0.00	0.00	0.00	3.98	0.00
Common White Sucker	4.08	1.11	0.72	0.33	0.56	3.00	5.00
Emerald Shiner	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Golden Shiner	0.00	0.00	0.00	0.00	0.00	0.04	0.01
Greater Redhorse	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Johnny Darter	0.00	0.00	0.00	0.00	0.05	0.02	0.00
Logperch	0.00	0.00	0.00	0.00	0.00	0.12	0.00
Northern Pike	0.21	0.16	0.23	0.67	1.49	1.76	5.98
Pumpkinseed Fish	0.03	0.11	1.18	1.00	0.00	0.02	0.08
Rock Bass	0.37	0.46	3.59	17.08	1.84	1.02	0.43
Sand Shiner	0.00	0.00	0.00	0.00	0.00	168.90	0.00
Smallmouth Bass	0.08	0.03	0.28	0.38	0.65	0.47	0.13
Spottail Shiner	0.00	0.00	0.00	0.00	0.05	23.73	0.00
Walleye	1.66	1.95	0.87	0.79	1.19	2.02	19.79
Yellow Perch	1.08	0.49	7.72	10.69	0.63	8.14	1.90
Longnose Sucker	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth Bass	0.00	0.00	0.03	0.00	0.00	0.00	0.00

Table 4. Northern Pike age, State average (AVG) total length (TL inches) (Smith et al. 2016), Milakokia Lake AVG TL in, and the number aged per group.

Age	State AVG TL (in)	Milakokia Lake AVG TL (in)	Number aged
1	12.0	14.4	20
2	17.3	21.3	31
3	20.7	22.5	75
4	22.7	24.7	92
5	24.6	25.9	12
6	26.3	27.4	22
7	28.2	-	5
8	31.9	-	6
9	34.9	-	1
10	36.6	-	1

Table 5. Walleye age, State average (AVG) total length (TL inches) (Schneider 2000), Milakokia Lake AVG TL in, and the number aged per group.

Age	State AVG TL (in)	Milakokia Lake AVG TL (in)	Number aged
1	7.1	6.3	9
2	10.4	11.1	45
3	13.9	14.9	41
4	15.8	16.4	71
5	17.6	18.0	29
6	19.2	18.9	14
7	20.6	19.0	42
8	21.6	19.2	14
9	22.4	20.1	22
10	23.1	20.4	19
11	-	21.5	29
12	-	21.6	19
13	-	21.8	6
14	-	22.6	5
15	-	23.3	4
16	-	23.2	1

Table 6. Waterbody, county, and the estimated number of adult Walleye per acre (Based on mark-recapture assessments) in the central and eastern upper peninsula of Michigan.

Waterbody	County	Adult Walleye per Acre
South Manistique Lake	Mackinac	1.91
Brevoort Lake	Mackinac	1.30
Indian Lake	Schoolcraft	1.28
Milakokia Lake	Mackinac	1.25
Big Manistique Lake	Mackinac	1.15
North Manistique Lake	Luce	0.89
Steuben Lake	Schoolcraft	0.86