**Gulliver Lake**
Schoolcraft County, T41N/R14W/Sec.02
Last Surveyed 2019

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## Environment

Location

Gulliver Lake is an 836-acre natural lake located in Doyle Township in southeastern Schoolcraft County (T41N/R14W/Sec. 02) in Michigan's Upper Peninsula (Figure 1). The town of Gulliver is located near the northeast shore of Gulliver Lake and is approximately 12.0 miles east of Manistique, Michigan. Located near Lake Michigan's northern shore, Gulliver Lake has several nearby attractions including McDonald Lake and Seul Choix Pointe. Seul Choix Pointe is a lighthouse leased by the Gulliver Historical Society from the United States Coast Guard.

Geology and Geography

The geological bedrock formations encompassing Gulliver Lake include the Manistique Group overlayed by the Engadine bedrock group (MDNR 2001). The Manistique Group formation spans the northern shore of Lake Michigan from west to east and is exposed in Fayette, Michigan and can be seen along the northwestern shore of the Garden Peninsula (Dellapenna 1987). Two surface mineral mines exist to the east and to the northeast of Gulliver Lake.

Surficial geology surrounding Gulliver Lake consists mostly (86%) of untextured materials followed by course-textured materials (14%) with poorly drained soil; soil series present include Deer Park, Deford, and Tawas topsoils (USDA 2019). The adjacent land cover is dominated by wetland (58%), forest (20%), agriculture (10%), and urban development (9%). Grassland, water, and barren landcover types comprise the remainder (3%) of landcover types.

Watershed Description

Gentz Creek, Gulliver Lake, and Gulliver Lake Outlet all represent an undesignated watershed within the Northern Lake Michigan Management Unit. Gentz Creek originates approximately three quarters of a mile north of Lex Nelson Road. In 2006, a single waterbody existed (46.003198 -86.033824) and appeared to be supplied by headwater spring originating from the north. However, by 2013, several waterbodies originating from a channelized Gentz Creek have been created in the upper reaches of the drainage.

Gentz Creek flows southeasterly where it travels underneath Lex Nelson Road, US Highway 2, and the Canadian National Railway before serving as a tributary to the northeast shore of Gulliver Lake. Gentz Creek is the sole tributary to Gulliver Lake. Gulliver Lake drains via the Gulliver Lake Outlet, a water-level control structure is located on the southcentral shore of the lake. Gulliver Lake Outlet flows south southwesterly and drains into the northern shore of Lake Michigan after traveling underneath Michigan Shore Road. From Gentz Creek to Lake Michigan there are at least five stream crossing that have the potential to impact fish migration.

Chemical and physical characteristics

Chemical parameters - parameters important to aquatic life in Michigan's inland lakes include dissolved oxygen, nitrogen, and phosphorus. Dissolved oxygen or "DO" is a critical component to aquatic habitat in lakes and streams. Dissolved oxygen is measured by collecting a limnological profile during two periods of the year (winter and summer) when environmental conditions are typically harsh for aquatic organisms. In lakes, DO may be derived from the atmosphere as well as from aquatic plants as a byproduct of photosynthesis. Levels of DO 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 below 3.0 mg/L and are often lethal below 0.5 mg/L (Wehrly et al. 2015). As DO becomes limited, hypoxic (DO less than 4.0 mg/L) or anoxic (no DO) regions may form in the lake.

On 15 March and 19 August 2019, surveys to measure dissolved oxygen (mg/L) were conducted at the deepest point in the lake. On 15 March 2019, DO in Gulliver Lake ranged from 8.9 mg/L at three feet deep to 0.4 mg/L at twenty feet deep (Figure 2). During the winter, Gulliver Lake becomes hypoxic at fifteen feet of water. Dissolved oxygen levels become lethal (below 0.5 mg/L) between eighteen and twenty feet deep. These data suggest that approximately 58 percent (485 acres) of the surface acreage of Gulliver Lake contains depths with sufficient oxygen to support aquatic life during the winter months. On 19 August 2019, DO in Gulliver Lake ranged from 8.1 mg/L at two feet deep to 0.0 mg/L at twenty-one feet deep (Figure 2). During the summer, Gulliver Lake becomes anoxic (no oxygen) between nineteen and twenty feet deep. These data suggest that approximately 74 percent (619 acres) of the surface acreage of Gulliver Lake contains depths with sufficient oxygen to support aquatic life during the summer months.

Nitrogen and phosphorus are important nutrients that influence production and diversity of plants in aquatic ecosystems (Wehrly et al. 2015). Nitrogen and phosphorus are measured during the summer months by obtaining water samples from the lake. Nitrogen and phosphorus have been measured several times in Gulliver Lake in past thirty years (Table 1). The ratio of nitrogen to phosphorus that tends to favor aquatic plant growth ranges from 16:1 to 20:1 (Wehrly et al. 2015). Since 1992, the nitrogen to phosphorus ratio has changed significantly in favor of nitrogen, with phosphorus being the nutrient that limits production in Gulliver Lake (Table 1).

Physical parameters - In addition to chemical parameters, physical parameters are important to aquatic life in Michigan's inland lakes and include water transparency, temperature, and lake morphometry. Water transparency is measured using a Secchi disk which 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). On 19 August 2019, water transparency was reported to be 11.0 feet, which is comparable to other inland waterbodies in the region and across the State of Michigan (Wehrly et al. 2015).

Thermal stratification occurs in deeper lakes during the summer months when three water layers form (epilimnion, metalimnion, and hypolimnion). 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'. On 15 March 2019, Gulliver Lake water temperature ranged from 38.3 °F at three feet deep to 42.3 °F at twenty feet deep (Figure 2). On 19 August 2019, Gulliver Lake water temperature ranged from 72.3 °F near the water

surface to 71.4 °F at twenty-one feet deep (Figure 2). Summer temperature data suggests that Gulliver Lake does not thermally stratify into three layers.

Gulliver Lake is positioned on a west to east axis and contains a large and shallow littoral zone along the western shore. The total fetch length from west to east is approximately 1.8 miles and has an estimated average depth of approximately 12.0 feet. The average width of Gulliver Lake along the west to east axis is approximately 4,465 feet and ranges from 3,152 to 5,969 feet. Based upon the lake fetch length and average depth, the eastern shore of Gulliver Lake has the potential to receive sixteen-inch waves (moderate energy) during a 35 mile per hour windstorm (WI DNR 2021). Given the protected nature of the western and southern shores, those areas would only experience ten to twelve-inch waves (low energy) during a 35 mile per hour windstorm (WI DNR 2021). Based upon the natural moderate to low energy potential in Gulliver Lake, hard armoring materials (e.g., steel, limestone, vinyl, rip rap) should not be used to modify the shoreline.

Development, public ownership, and access

On 19 August 2019, the Gulliver Lake littoral zone and lakeshore were 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 2). Results of this physical habitat survey show that residential development in Gulliver Lake is high compared similar sized waterbodies in the region. Importantly, the extent of shoreline alternation (>25%) in Gulliver Lake is significant and may be resulting in adverse impacts to aquatic resources. The Gulliver Lake shoreline is largely held in private ownership, however there is a public boat launch located (45.988027 -86.042710) on the northwest shore of the lake (Figure 1).

## History

History of the fishery

During the early 20th Century, John Nicholas Lowe 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 had not previously existed. Gulliver Lake was surveyed by J. N. Lowe on 12 August 1929 using a beach seine. A total of six species were captured including Bluntnose Minnow, Common Shiner, Johnny Darter, Mimic Shiner, Sand Shiner, and Yellow Perch. Beach seines are used to capture only small, nearshore fishes.

Management of the Gulliver Lake fishery began during the 1930s when Walleye and Yellow Perch were stocked (Table 3) biennially to establish recreational fisheries. Gulliver Lake's proximity to US 2 drew attention from managers given the potential to develop an accessible recreational attraction. During the winter of 1936 to 1937, Gulliver Lake was mapped by the Michigan Emergency Conservation Works program. In addition to Walleye, a total of 23,000 Yellow Perch, comprised of fall fingerlings and adults, were stocked in Gulliver Lake with the intent to develop additional fisheries. During the early-1930s, Gulliver Lake had developed a reputation for its catches of Walleye and Northern Pike. However, by the late 1930s, catches of Walleye and Northern Pike began to decline, as Smallmouth Bass numbers were reported to be increasing. Fishery changes, increases in development, and agency interest prompted surveys to gather more information about the status of Gulliver Lake fish and aquatic plant community.

During the 1940s, Gulliver Lake was noted as having `some cottages' with room for more development. By 1941, there were a total of 40 cottages, one resort, and one livery on Gulliver Lake. In 1940, a survey was conducted by the Michigan Department of Conservation (hereafter referred to as "MI DNR") to gather fish and aquatic plant community information. Species captured included Cisco, Common White Sucker, Northern Pike, Pumpkinseed, Rock Bass, Smallmouth Bass, Walleye, and Yellow Perch. Plant species observed included Waterweed, Sedge, Musk Grass, Water Milfoil, Yellow Water Lily, White-stemmed Pondweed, Robbin's Pondweed, Rush, and Cattail.

Prior to the 1940 survey, more than two million Walleye had been stocked and managers noted at that time that spawning had not yet been documented. Managers recommended stocking of Walleye be discontinued so the population could be surveyed in future years to evaluate whether stocked fish have begun to spawn in Gulliver Lake. Notable spawning of Yellow Perch was documented during this period and therefore managers recommended stocking be discontinued for Yellow Perch. Managers also recommended that regulation changes may be needed in Gulliver Lake to reflect the change in fish community from a Northern Pike and Walleye to a Smallmouth Bass fishery.

During the 1940 survey, a total of 35 Northern Pike were captured with a range in total length of 18.4 to 29.2 inches (average, 19.9 inches). Managers at this time noted that Northern Pike spawning habitat was limited to the mouth of Gentz Creek, and that some adults may be utilizing the creek itself for spawning. Managers also noted at this time that "the lake maintained a good pike population for many years" and that spawning habitat available should be adequate. Despite documenting sufficient habitat for Northern Pike, a total of 215 adult Northern Pike were stocked in Gulliver Lake the following year. This stocking event may have been initiated to balance a high harvest rate, however there is no documentation to support this.

During the 1950s a total of 35,000-inch-long Bluegill were stocked in Gulliver Lake. In 1952 (n=144) and 1953 (n=153), a total of 297 fish shelters were placed in Gulliver Lake along the ten-foot contour depth to improve in-lake habitat. In June of 1950, an early-summer fish kill was reported on Gulliver Lake. Common White Sucker and Smallmouth Bass were noted as the species to have been impacted by the fish kill and mortalities were believed to be associated with post-spawn stress. A water level control structure was constructed in 1955 and a legal lake level (above mean sea level) was established in Gulliver Lake 23 September 1957 at 614.5 feet (summer) and 613.8 feet (winter). Following the established lake level, a staff gauge was established in August of 1960 to monitor lake water level.

During the 1960s, fisheries management in Gulliver Lake was relatively diverse compared to the previous three decades. In 1961, trap and fyke nets were set in Gulliver Lake without documentation of the survey purpose. This survey may have been conducted to evaluate the growth of various gamefishes. Bluegill, Common White Sucker, Northern Pike, Pumpkinseed, Rock Bass, Smallmouth Bass, Walleye and Yellow Perch were captured. During the late 1960s surveys were also conducted to capture and remove Common White Sucker. During those manual removal surveys, Bluegill, Cisco, Northern Pike, Rock Bass, Smallmouth Bass, Walleye and Yellow Perch were also captured. There is no documentation pertaining the biomass of Common White Suckers removed from Gulliver Lake during the 1960s. Muskellunge (1966) and Tiger Muskellunge (1969) were introduced into Gulliver Lake during the late 1960s likely to expand angling opportunities.

In 1961, managers noted that Gulliver Lake cottage development had been `very extensive' in the past five years. This development was attributed to the development of roads around the lake that increased access. During this period, the southwest and north shores were largely undeveloped but had been subdivided.

During the 1970s Tiger Muskellunge and Walleye were stocked in Gulliver Lake. Fisheries surveys were conducted in 1970, 1972, and 1976. In 1972, there were two fish-kill events reported in Gulliver Lake during June and August impacting Common White Sucker, Northern Pike, Pumpkinseed, Rock Bass, and Yellow Perch. Dissolved oxygen was measured during the August event and ranged from 9.5 to 9.0 mg/L at the water surface to 12-feet deep. The cause of the fish kill was unknown.

Prior to the 1976 survey, anglers had concerns about the decline in the Walleye fishery and reported an increase in the abundance of Northern Pike. Also, managers were interested in gaining information about Tiger Muskellunge and Muskellunge stocked during the late 1960s. Therefore, a survey was conducted in May of 1976 to gather more recent information about the Gulliver Lake fishery. The 1976 survey included the use of a variety of gear types to evaluate the fish community. Bluegill, Northern Pike, Pumpkinseed, Tiger Muskellunge, Walleye, Largemouth Bass, Rock Bass, Smallmouth Bass, and Yellow Perch were captured. This survey was the first to document the capture of Largemouth Bass in Gulliver Lake. Results from the 1976 survey were summarized in a report completed in 1978.

In the 1978 report, managers recommended Tiger Muskellunge stocking in Gulliver Lake be discontinued due to a low number of captures. By the 1970s, more than two million spring fry Walleye had been stocked with the intent to develop a self-sustaining population. While modest catches were reported, the desired fishery had not materialized. These results may explain why, in 1978, managers recommended Gulliver Lake be managed for Northern Pike, Smallmouth Bass, and Yellow Perch. Bluegill stocking in the 1950s was considered to have been unsuccessful given the lack of Bluegill captured during the recent survey. There were low numbers of Cisco and Smallmouth Bass captured, however, these numbers were comparable to the 1940 survey. Northern Pike were noted to be in `fair' condition with an average size of 20.8 inches. Northern Pike growth was still below state average which managers attributed to intra-specific (same species) competition.

During the 1976 survey, managers documented the presence of black grubs in both Northern Pike and Yellow Perch. Yellow grub was present in Yellow Perch and Rock Bass, and bass tapeworm had been found in several Smallmouth Bass. During the 1976 survey, managers also reviewed Gulliver Lake physical habitat. A review of the Gulliver Lake map created during the late 1930s depicted several points and bays around the perimeter of the lake. However, by 1976, managers noted these features were non-existent and that the water level control structure likely inundated nearshore areas with sediment. Also, managers noted that the fish shelters created during the early 1950s were `deteriorated or no longer functional'.

During the 1980s Walleye were the only species stocked into Gulliver Lake. Fisheries assessments conducted during the 1980s included manual removals and fall index surveys used to quantify the abundance and survival of stocked Walleye. By the late 1980s, angler reports were positive with a variety of large fish being captured in Gulliver Lake including Smallmouth Bass, Rock Bass, Walleye, and two Northern Pike in excess of forty inches.

Similar to surveys conducted during the 1960s, manual removal surveys targeting Common White Sucker were conducted in 1983 and 1984. Managers hypothesized that a removal of Common White Sucker would result in improved panfish angling opportunities (namely for Yellow Perch). In 1983, nearly ten thousand pounds of Common White Sucker were removed over an eleven-day period. Managers suspected that this survey yielded only half of the Common White Sucker biomass and recommend additional removals be conducted the following year (1984). Additional species captured during the 1983 survey included Brown Bullhead, Northern Pike, Pumpkinseed, Rainbow Trout, Rock Bass, Smallmouth Bass, Walleye, and Yellow Perch. Managers noted at this time that fish opportunity appeared to be `poor', except for the Smallmouth Bass. Northern Pike were noted to be `skinny' and Yellow Perch seemed `scarce'. Rock Bass were noted to be large and abundant. Per management recommendations, a similar manual removal survey was conducted in 1984 targeting Common White Sucker. Approximately 1,033 pounds of Common White Sucker were removed suggesting that the 1983 manual removal was much more effective than previously thought.

During the 1980s, MI DNR conducted two fall index surveys to quantify the survival of Walleye stocked as spring-fry. In 1985, a total of three young of year Walleye were captured suggesting limited to low survival of stocked fingerlings. At the time of the 1985 fall survey, Smallmouth Bass and Pumpkinseed were growing comparable to the state average, while Yellow Perch and Northern Pike were growing below state average. Northern Pike captured were noted to appear `thin and emaciated'. An additional fall recruitment survey was conducted in 1988 when a total of eight young of year Walleye were captured suggesting similar results as the 1985 survey. During the 1980s, Walleye were stocked three years consecutively and then biennially following Division protocols. Initial assessments to monitor survival of stocked Walleye yielded less than promising results despite stocking nearly four million spring-fry and more than sixty-thousand spring-fingerlings. However, additional surveys would be required during the 1990s to evaluate adult abundance to confirm the success or failure of these plants.

In April of 1988 MI DNR conducted an electrofishing assessment to evaluate the adult Walleye population as well as evaluate Yellow Perch growth following manual removals. Only one Walleye was captured during this assessment and based on age analysis, the fish was suspected to have been from the 1986 stocking event. Despite removing more than eleven-thousand pounds of Common White Sucker from Gulliver Lake, Yellow Perch were still growing nearly two inches below state average.

During the 1990s, an average of nearly 30,000 spring-fingerling Walleye were stocked into Gulliver Lake every other year (Table 3). Following the initial re-introduction phase of stocking Walleye during the early 1980s, Gulliver Lake was still in need of an assessment to evaluate the success of Walleye stocking and evaluate the general fish community. There were two main types of surveys conducted in Gulliver Lake during the 1990s. The fist type of survey was a fall index survey used to quantify the abundance and survival of young-of-year Walleye stocked. Index surveys for young-of-year Walleye were conducted in 1993, 1996, and 1998. A total of 7, 2, and 14 young-of-year were captured in 1993, 1996, and 1998, respectively. Results from this survey demonstrated that spring fingerlings stocked into Gulliver Lake had higher survival rates when stocked at lower densities (7 spring fingerlings per acre compared to 50 per acre) but numbers were still low, indicating poor survival of stocked Walleye.

The second type of survey was a general survey used to gather information about the entire fishery community rather than just one species. General fish community surveys were conducted in Gulliver Lake 1990, 1995, and 1999. These surveys were all conducted in May of each year and, in addition to providing general fish community information, data from adult Walleye were also collected. In 1990, a total of ten species were captured including Bluegill, Brown Bullhead, Common Shiner, Common White Sucker, Northern Pike, Pumpkinseed, Rock Bass, Smallmouth Bass, Walleye, and Yellow Perch. Managers noted that survival of stocked Walleye appeared to be `good' and a continuation in stocking was recommended. However, there was no indication that Walleye were naturally reproducing in Gulliver Lake. All gamefish species captured were growing comparable to or slightly below state average, while Yellow Perch were growing more than an inch below state average. The average size of Northern Pike captured was 21.1 inches and approximately fifteen percent of the catch met or exceeded legal size.

In 1995, a total of nine species were captured including Bluegill, Brown Bullhead, Common White Sucker, Northern Pike, Pumpkinseed, Rock Bass, Smallmouth Bass, Walleye, and Yellow Perch. Managers had noted that Northern Pike had been emaciated ever since manual removal surveys were conducted in the 1980s to reduce the number of Common White Sucker. The average size of Northern Pike in 1995 was 20.3 inches and only two percent of the catch were legal size. Large numbers of Bluegill and Rock Bass were captured; however, Yellow Perch were less abundant. Bluegill were noted to be in excellent condition and were considered an `under-utilized' fishery. Walleye numbers appeared lower than expected, so managers recommended that additional stocking occur in Gulliver Lake 1996.
In 1999, a total of eight species were captured including Bluegill, Common White Sucker, Northern Pike, Pumpkinseed, Rock Bass, Smallmouth Bass, Walleye, and Yellow Perch. Northern Pike were noted as being `extremely thin' and Walleye were also noted as being `skinny'. Numbers of fish captured as well as fish biomass was greatly reduced in 1999 compared to the 1995 survey. There was a significant decline in the number of Bluegill and Common White Sucker specifically. A total of 337 Bluegill and 571 Common White Sucker were captured during the 1995 survey. However, in 1999, the total number of Bluegill and Common White Sucker captured was 1 and 86 fish, respectively. Managers noted at this time that Northern Pike growth and condition declined and never recovered from the manual removal surveys conducted during the 1980s. Managers suspected that rather than improve growth rates of Yellow Perch, manual removal of Common White Suckers instead reduced the abundance of an important forage species in Gulliver Lake.

Prior to the 1999 survey, managers had documented minimal return of young-of-year or adult Walleye despite large numbers of fish stocked during the previous two decades. Of those fish captured, all Walleye captured corresponded to a previous stocking year. Despite the poor capture of stocked fish, angler reports during the late 1980s and early 1990s suggested that fish were surviving to adulthood and catches were promising. By 1995, all Walleye captured during surveys corresponded to years when Walleye were stocked in Gulliver Lake. This led managers to increase the stocking rate in 1996 (68,000 spring fingerlings) to more than twice the average rate in hopes of establishing a self-sustaining population. Also, in 1998 there were 5,000 spring fingerling Walleye stocked into Gulliver Lake that had received an oxytetracycline (OTC) mark. An OTC mark provided managers the ability to differentiate `wild versus stocked' when Walleye were captured during assessments post-stocking. Only 14 percent of Walleye captured exhibited an OTC mark suggesting that natural reproduction may

have been occurring in Gulliver Lake at that time. By 1999, Walleye stocked in 1996 would have been near 15 inches total length and would have been susceptible to survey gear. However, no three-year old Walleye were captured, suggesting that the large stocking event failed. Managers theorized that competition between stocked and naturally reproduced Walleye resulted in a year-class failure of Walleye stocked in 1996.

Based on survey results from Gulliver Lake in 1999, managers concluded the following: 1) the Gulliver Lake forage base was greatly reduced compared to 1995, 2) natural reproduction of Walleye may be occurring, and 3) the large stocking effort of 1996 did not contribute to the Walleye fishery. Therefore, managers recommended at this time that Walleye stocking be stopped for 5 years to provide the fish community the opportunity to rebound from the decrease in forage. Following these conclusions, Walleye stocking ceased in 1998 (Table 3). While surveys were being conducted to evaluate the general fish community in Gulliver Lake, a resident brought a Zebra Mussel specimen to the Newberry Customer Service Center in the summer of 1995. This specimen was the first documented occurrence of the invasive mussel in Gulliver Lake.

During the 2000s, Gulliver Lake was surveyed once (in 2004) in accordance with Status and Trends survey protocols (Wehrly et al. 2015). A total of fourteen species were captured including Bluegill, Bluntnose Minnow, Common Shiner, Common White Sucker, Fathead Minnow, Iowa Darter, Johnny Darter, Logperch, Northern Pike, Pumpkinseed, Rock Bass, sculpin, Smallmouth Bass, and Yellow Perch. The average size of Northern Pike had increased since 1999, however there were still occurrences of emaciated `skinny' Northern Pike. Common White Sucker were also noted as being `skinny' for their length suggesting that the forage base was still recovering. During the 1980s and 1990s Walleye were stocked at high densities in attempt to establish a self-sustaining fishery in Gulliver Lake. However, it is likely that Walleye stocking rates, in addition to the oligotrophic nature (nutrient poor) of the lake, had caused a decline of the Gulliver Lake forage base. Prior to and during the Walleye stocking era, manual removal surveys were conducted to reduce the abundance of Common White Sucker. It is likely these manual removals negatively impacted natural reproduction of Common White Sucker, which is a common forage item for a variety of gamefish (e.g., Northern Pike, Walleye) at various life periods. Additional information gathered from the 2004 survey found that quality nearshore fish habitat was lacking on.

Following the 2004 Status and Trends survey, managers recommended two actions: First, obtain adult Northern Pike and Common White Sucker for parasite analysis. These data were thought to provide beneficial information about the emaciated fish captured in Gulliver Lake. Second, managers recommended that a landowner and agency collaboration be formed to help improve nearshore habitat in Gulliver Lake. Given the poor status of the forage base, brush bundles and other habitat structures were expected to improve the abundance and diversity of nearshore forage fishes (e.g., minnows).

During the 2010s, area residents and anglers were interested in obtaining recent fish community and habitat information pertaining to Gulliver Lake. On 19 July 2017, MI DNR staff attended a Gulliver Lake Property Owners Association meeting to discuss surveys scheduled to be conducted in 2019. In summer of 2017 and 2019, shoreline habitat workshops were held in Curtis, Michigan to provide information to lake riparian owners about the Natural Shoreline Partnership and the benefits of natural shorelines. In addition to habitat workshops, MI DNR scheduled a series of surveys to be conducted in

2019. Surveys conducted in 2019 are summarized in the following "Current Status" section of this document.

## Current Status

During spring and summer 2019, MI DNR conducted several surveys to assess the Gulliver Lake fish community. During the early spring, Gulliver Lake was surveyed to quantify the abundance of Walleye and Northern Pike during a period of the year when they are most vulnerable to impoundment gear. Following the spring survey, Gulliver Lake was sampled again during the early summer in accordance with Status and Trends survey protocols (Wehrly et al. 2015) to gather more general fish community data from all species, especially panfish. As described in the Environment section of this document, physical and chemical habitat data were collected from Gulliver Lake in March and August of 2019. Surveys described above, in additional to data collected by MI DNR during historical surveys, were all used to evaluate the status of the Gulliver Lake fishery.

Spring 2019 survey - Beginning on 23 April 2019, MI DNR conducted a discretionary survey to quantify the growth and abundance of adult Walleye and Northern Pike. Two gear types were used including large-mesh fyke nets and trap nets. Twelve large-mesh fyke nets and three trap nets were set for three nights each, totaling 36 and 9 net nights, respectively. Surface water temperature ranged from 41.0°F to 44.0°F during the spring netting effort. Gamefish species including Bluegill, Largemouth Bass, Northern Pike, Rainbow Trout, Rock Bass, Smallmouth Bass, Walleye, and Yellow Perch were measured to the nearest tenth of an inch. Aging structures (10 per inch group) were collected from all Walleye and Northern Pike for age and growth analysis. To assess age and growth, the first three dorsal spines were collected from all Walleye and anal fin rays were removed from all Northern Pike captured. A total of 848 fish weighing 1,365 pounds and representing eleven species were captured during the 2019 spring survey (Table 4).

Walleye - A total of 11 Walleye were captured with an average total length of 23.8 inches. Walleye sized ranged from 22.0 to 25.0 inches and one hundred percent of fish captured were greater than legal size (>15.0 inches). There were too few Walleye captured to make robust conclusions about age and growth. However, age analysis indicated that 2012, 2011, 2005, and 2004 year-classes were represented in the catch. Due to the low abundance of adult Walleye captured in Gulliver Lake during the Spring survey, no population estimate was generated.

Northern Pike - A total of 34 Northern Pike were captured with an average total length of 21.1 inches (Table 4). Northern Pike ranged in size from 9.0 to 26.0 inches and twenty one percent of the fish captured were equal to or greater than legal size (24.0 inches) (Table 4). Age and growth analysis indicated that Northern Pike in Gulliver Lake reach legal size at approximately five years of age. The average size of Northern Pike captured specifically in large mesh fyke nets was 22.6 inches. Catch per unit effort of Northern Pike captured in large mesh fyke nets was 0.6 adults per net night. The average size of 3-, 4-, and 5-year-old Northern Pike in Gulliver Lake was 20.7, 21.2, and 25.1 inches, respectively. Age 3-, 4-, and 5-year-old Northern Pike were growing above the 25th percentile yet below the 75th percentile and age 3- and 5-year-old Northern Pike were comparable to the median size of Northern Pike in the State of Michigan (Table 5).

Largemouth Bass - A total of 14 Largemouth Bass were captured with an average total length of 14.4 inches (Table 4). Largemouth Bass size ranged from 12.0 to 18.0 inches with 64 percent of the catch meeting or exceeded the minimum size for harvest (14.0 inches).

Additional game fish species captured during the spring survey included Bluegill (n=2), Rainbow Trout (n=1), Rock Bass (n=77), Smallmouth Bass (n=3) and Yellow Perch (n=1). Forage species captured included Brown Bullhead (n=457), Common Carp (n=1), and Common White Sucker (n=247).

Status and Trends 2019 survey - Beginning on 24 June 2019, MI DNR conducted a netting survey in accordance with Status and Trends random survey protocols (Wehrly et al. 2015). The purpose of this survey was to gather fish community data in relation to the quality and quantity of physical habitat in Gulliver Lake. A variety of gear types were used including 3 experimental gill nets, 3 large-mesh fyke nets, 2 small-mesh fyke nets, 1 trap net, and 1 seine. Small- and large-mesh fyke nets, as well as the trap net, were set for three nights. Experimental gill nets were set for two nights and a total of 5 seine hauls were conducted near shore. During the netting survey, surface water temperature ranged from 66.0°F to 69.0°F. On 28 July 2019, three 10-minute boat electrofishing transects were sampled to provide additional fish community information. Prior to the electrofishing survey, surface water temperature was reported to be 78.0°F.

Gamefish species including Black Crappie, Bluegill, Largemouth Bass, Northern Pike, Pumpkinseed, Rock Bass, Smallmouth Bass, and Yellow Perch were measured to the nearest tenth of an inch. Aging structures (10 per inch group) were collected from each gamefish species for age and growth analysis. Scales were collected from panfish species less than 6.0 inches and bass less than 10.0 inches. Anal fin spines were collected from panfish greater than 6.0 inches, bass greater than 10.0 inches, and all Northern Pike. All other species were enumerated and measured to the nearest inch.

A total of 1,083 fish weighing 258.8 pounds and representing 19 species were captured during the Status and Trends survey (Table 6). Piscivore species, such as Black Crappie, Northern Pike, Yellow Perch, Rock Bass, Smallmouth Bass, and Largemouth Bass comprised 19.2 percent of the catch by number and 52.6 percent of the total biomass. Planktivore-insectivore species such as sunfishes, minnows, and darters comprised 75.6 percent of the catch by number and 2.3 percent of the total biomass. Benthivores such as Brown Bullhead, Common Carp, and Common White Sucker comprised 5.2 percent of the catch by number and 45.1 percent of the catch by biomass. The total standing crop (Schneider 2000) for Gulliver Lake in 2019 was approximately 45.4 pounds of fish per acre.

Northern Pike - A total of 44 Northern Pike averaging 21.3 inches comprised 4.1 percent of the catch by number and 35.1 percent of the catch by biomass (Table 6). Northern Pike size ranged from 17 to 26 inches with 11 percent of the catch meeting or exceeded the minimum size for harvest (24.0 inches). The age distribution of Northern Pike indicated recruitment from the 2017-, 2016-, and 2015-year classes. Age 2 Northern Pike were growing approximately 1.0 inch above state average. Age 3- and 4-year-old Northern Pike were generally growing slightly below (0.5 inches) state average, however too few fish were captured to make robust conclusions about growth for these age classes. The catch per unit effort of Northern Pike in large mesh fyke nets, experimental gill nets, and trap nets was 1.2, 5.0, and 1.0 fish per net night, respectively (Table 7).

Smallmouth Bass - A total of 18 Smallmouth Bass averaging 10.6 inches comprised 1.7 percent of the catch by number and 5.7 percent of the catch by biomass (Table 6). Smallmouth Bass size ranged from 5.0 to 17.0 inches with 17 percent of the catch meeting or exceeding the minimum size for harvest (14.0 inches). Age classes 1 through 7 were represented in the catch indicating annual recruitment of Smallmouth Bass. Catch per unit effort of Smallmouth Bass in large-mesh fyke nets and electrofishing was 1.0 fish per net night and 0.27 fish per minute, respectively. Although sample size was limited, age and growth analyses indicate Smallmouth Bass in Gulliver Lake are growing at rates comparable to the state average. Smallmouth Bass in Gulliver Lake typical reach legal size between three and four years old.

Yellow Perch - A total of 48 Yellow Perch averaging 5.1 inches comprised 4.4 percent of the catch by number and 0.9 percent of the catch by biomass (Table 6). Yellow Perch size ranged from 2.0 to 9.0 inches with 4 percent of the catch meeting or exceeding the preferred size for harvest (6.0 inches). Although sample size was limited, Yellow Perch from age classes 2, 3, and 5 were growing equal to or slightly below state average. Catch per unit effort of Yellow Perch in trap nets and experimental gill nets was 0.33 and 1.67 fish per net night, respectively.

Rock Bass - A total of 97 Rock Bass averaging 6.3 inches comprised 9.0 percent of the catch by number and 10.2 percent of the catch by biomass (Table 6). Rock Bass size ranged from 1.0 to 11.0 inches with 54.0 percent of the catch meeting or exceeding the preferred size (6.0 inches). Age- and length-distribution data indicate strong annual recruitment of Rock Bass the previous ten years. Rock Bass were generally growing at or slightly below state average until age five, and then growth increases at or slightly above state average thereafter. Catch per unit effort of Rock Bass in large mesh fyke nets was 6.7 fish per net night.

Other Panfish - Additional panfish species captured included Black Crappie, Bluegill, and Pumpkinseed. However, these species were underrepresented in the catch and did not contribute significantly to the catch by number or biomass.

Forage species captured during this survey included Bluntnose Minnow, Common Shiner, Golden Shiner, Iowa Darter, Johnny Darter, Logperch, Sand Shiner, and Spottail Shiner. Since 1929, a total of 26 species have been captured during surveys of Gulliver Lake. Common White Sucker, Northern Pike, Pumpkinseed, Smallmouth Bass, Walleye, and Yellow Perch occur most often in capture data through time. Lake Herring or Cisco have not been captured in Gulliver Lake since the early to mid-1980s. Black Crappie and Golden Shiner are recent captures in Gulliver Lake and were likely introduced via angler bait buckets.

## Analysis and Discussion

Gulliver Lake is a highly developed, medium-sized, shallow lake with a diverse fish community containing species typical of Michigan's Upper Peninsula lakes. Opportunities exist to rehabilitate the ecological health of the Gulliver Lake watershed and improve the recreational fishery. To rehabilitate the health of the lake ecosystem and improve angler satisfaction, area stakeholders (including MI DNR) should adopt stewardship principles that benefit nearshore habitat and implement fish management strategies that adjust the size structure and biomass of gamefish. Establishing stewardship principals and management recommendations requires a review of the information gathered relative to all (chemical, physical, and biological) components of the Gulliver Lake fishery.

Chemical - Comparing nutrient concentrations in Gulliver Lake in 2019 to previous years (1992 and 2004) shows that a change has occurred in nutrient source and composition. The concentration of total phosphorus in Gulliver Lake is considered `normal-high' but has changed very little since 1992 and 2004. However, the concentration of nitrogen has more than doubled since 1992 and 2004 and is now classified as `high' relative to similar sized waterbodies in the region and across the state of Michigan. Over time, the nitrogen to phosphorus ratio (or N:P ratio) has changed in favor of higher concentrations of nitrogen with respect to stable levels of phosphorus. In 1992, the N:P ratio was reported to be 31:1, which is above what might be considered optimal for primary production (16:1, Wehrly et al. 2015). A high N:P ratio in freshwater lakes is common in the Upper Peninsula and is indicative of an oligotrophic (i.e., nutrient poor) system where nutrients often originate from natural runoff from undeveloped or infertile watersheds (Downing and McCauley 1992). More recently in 2019, the N:P ratio was reported to be 73:1 suggesting an increase in nitrogen inputs has occurred relative to inputs of phosphorus. A disproportionate shift in available nutrients may impact primary production in Gulliver Lake and might help explain food-web imbalances (e.g., emaciated gamefish). Human activities, such as the application of nitrogen-rich lawn fertilizers, can increase nutrient levels at both the local and watershed scales. These types of activities may explain the change and imbalance of nitrogen to phosphorus reported in Gulliver Lake. A thorough investigation into the watershed nutrient budget may help identify the source inputs that explain these changes.

Physical - Human activities associated with elevated levels of development include shoreline armoring, removal of beneficial woody habitat, dwelling and dock construction, and the manipulation of aquatic vegetation (Wehrly et al. 2015). These activities can have cumulative adverse impacts on the ecological function and overall health of inland lakes (Engel and Pederson 1998).

Hard materials (e.g., steel, vinyl, concrete) used for shoreline armoring increases wave energy nearshore resulting in the re-suspension of fine sediment negatively impacting native vegetation, mussel respiration and fish reproduction. Changes in nearshore energy can also create conditions favorable to invasive plants such as Eurasian Watermilfoil and Curley-leaf Pondweed (Engel and Pederson 1998). Lastly, shoreline armoring redirects wave energy to adjacent shorelines of neighboring landowners resulting in additional erosion. Currently, 28 percent of the Gulliver Lake shoreline has been altered from its natural state which exceeds recommend levels (25 percent, O'Neal and Soulliere 2006). Therefore, opportunities exist to rehabilitate impacted shoreline areas and reconfigure anticipated erosion-protection projects using more modern bioengineering principles.

Natural, undeveloped lakes throughout northern Michigan and Wisconsin have large woody debris densities ranging from 470 to 1,545 logs per mile of shoreline (O'Neal and Soulliere 2006). The density of woody debris along the Gulliver Lake shoreline was estimated to be 50 logs per mile, which is much less than what is observed in waterbodies in the region. These data suggest Gulliver Lake has less nearshore habitat available for macroinvertebrates, larval fish, and juvenile fish that may be needed to support healthy gamefish populations. There are common yard-maintenance practices that occur on inland lakes that impact density of wood habitat. For example, inland lake landowners deploy dock structures and `clean up' the shoreline in the spring removing beneficial submerged brush, logs and vegetation that serve as spawning and refuge habitat for a variety of forage fish (e.g., minnows). Also, large trees are often felled and removed to increase the `view' which reduces or eliminates recruitment of beneficial woody material that in turn benefits aquatic organisms. Protection

and rehabilitation strategies that maintain or increase the abundance of woody debris nearshore are well developed (WI DNR 2014), are documented to support gamefish populations (Sass 2009) and should be adopted in Gulliver Lake to the extent possible.

Biological - Prior to conducting surveys in Gulliver Lake in 2019, anglers and area residents expressed concern about the occurrence of `skinny' Northern Pike and the lack of Walleye in Gulliver Lake. Fisheries surveys had not been conducted in Gulliver Lake since 2004, so more recent information was needed to help provide insight on how best to manage the Gulliver Lake fishery presently and into the future. Two surveys were conducted in 2019 to 1) provide information about the gamefish population and 2) evaluate the status and trends of the entire lake fish community. Results from these surveys suggest that 1) gamefish populations are low, 2) there are occurrences of emaciated fish, and 3) biomass of forage species is low.

Walleye - Based on the 2019 Spring survey, Gulliver Lake is providing only incidental captures of Walleye. Given the lake history, there may be opportunities in the future to expand Walleye angling opportunities in Gulliver Lake. The periods of Walleye management in Gulliver Lake that are most notable occurred during the 1930s and 1980s when managers attempted to create a self-sustaining population by stocking. More than two million spring-fry were stocked during the 1930s. Despite the lack of documentation of natural reproduction, an attractive fishery did develop in Gulliver Lake. Information from this period suggested that some level of natural reproduction occurred. However, by the 1970s numbers of Walleye had declined according to anglers, prompting additional requests for stocking.

During the 1980s, nearly four million spring-fry Walleye were stocked in Gulliver Lake as a second attempt to create a self-sustaining population. Stocking continued into the 1990s as surveys were being conducted to evaluate survival of stocked Walleye and document any natural reproduction that might be occurring. Similar to the 1930s, some level of natural reproduction was documented to be occurring in Gulliver Lake during the 1980s and 1990s.

Natural reproduction of Walleye was occurring in Gulliver Lake during the mid-1990s. Additionally, surveys showed that the largest plant of Walleye (in 1996) failed to contribute significantly to the number of fall fingerling Walleye in the lake. Managers hypothesized that the failures in stocking success resulted from competition with naturally reproduced young Walleye. At that point, stocking was ceased in Gulliver Lake. Some level of natural reproduction continued, which explains the most recent captures of Walleye during the 2019 spring survey. This small number of adult fish captured in 2019 represent progeny hatched naturally during the early 2000s when stocking was not occurring.

Low catch rates of forage and the occurrence of emaciated gamefish suggest the food web in Gulliver Lake is currently unbalanced. Until these components of the fish community are addressed, Gulliver Lake should not be stocked with additional gamefish at this time as they are likely to put increased pressure on the forage base. When forage species increase in abundance and the size structure of Northern Pike is improved, then additional angling opportunity may be provided by judiciously stocking spring- or fall-fingerling Walleye at modest rates.

Northern Pike - Density, size distribution, and age distribution data for Northern Pike in Gulliver Lake were collected during the spring survey to assess the fishery and evaluate current harvest regulations.

Additionally, data were gathered during the Status and Trends survey conducted later in the same year. Currently in Gulliver Lake, up to two Northern Pike equal to or greater than 24 inches are allowed in the daily bag limit. This regulation is the `standard' and is typically for Northern Pike populations that grow comparable to the state average and have a moderate density. This regulation can also help maintain average abundance and size structure.

Several metrics are used to evaluate the density of Northern Pike based on target reference points set forth in the statewide management plan (Smith et al. 2016). For example, Michigan lakes with a low density of Northern Pike have average lengths in fyke net catches of 22 inches or greater. In Gulliver Lake, the average length of Northern Pike captured in fyke nets was 19.8 inches, suggesting that this is not a `low density' population. Additionally, the density or abundance of Northern Pike can be expressed as a catch rate, which offers a measure of relative abundance. Spring fyke and trap net catch rates of Northern Pike in Gulliver Lake suggest that the population is moderately abundant (within the boundaries of the median). To evaluate density further, there were also Northern Pike captured in fyke, experimental gill, and trap nets during the Status and Trends survey conducted later in the same year. Catch rates in Gulliver Lake from these three gear types suggest that the Northern Pike population is of `moderate' to `high' density.

In addition to metrics used to assess density, there are also metrics used to assess the growth of Northern Pike in Michigan's inland lakes. Growth metrics used to evaluate Northern Pike captured during the spring survey include comparing average total lengths 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 Gulliver Lake for ages 3 through 5 range from the 25th percentile to the median suggesting that growth is slow at four years old and comparable to the State average at three and five years old. Based upon data collected from both 2019 surveys, the Gulliver Lake Northern Pike population should be categorized as having a `moderate' to `high' density with `slow' to `average' growth. These results coupled with evidence of emaciated fish and anecdotal reports of many undersized fish suggests that the Gulliver Lake Northern Pike population likely resembles a high density, slow growing population.

Based on population target reference points, anecdotal reports, and the occurrence of emaciated fish captured during surveys there may be alternate regulations suitable for the Gulliver Lake Northern Pike population. The first alternate regulation would be a "Protected Slot Limit" where two fish may be harvested outside of the protected 24-to-34-inch size range. The Protected Slot Limit regulation is meant to maintain average abundance and improve size structure. The second regulation option would be a "No Minimum Size Limit" regulation where five fish of any size may be harvested, with only one fish exceeding 24 inches being allowed. The No Minimum Size Limit regulation is meant to reduce overabundance, improve growth rate, and maximize sustainable harvest.

Largemouth and Smallmouth Bass - Bass in Gulliver Lake provide an attractive fishery for alternate gamefish species. Largemouth Bass captured during the spring assessment were relatively low in abundance, however, their size was impressive with more than 60 percent of fish captured exceeding 14 inches. The electrofishing capture rate of Smallmouth Bass in Gulliver Lake was high relative to similar sized waterbodies in the region and growth rates were comparable to the state average. Collectively, Largemouth Bass and Smallmouth Bass should be providing an acceptable fishery for anglers.

Bluegill - Catches of Bluegill were low during both surveys conducted in 2019 and have been low since the late-1990s. These data suggest the Bluegill population is not providing an attractive fishery and reasons for the decline are unknown. There are several possibilities that might help explain why Bluegill numbers have declined. During the 1990s, a significant number of Walleye were stocked which may have increased predation on Bluegill until adult numbers were too low to support annual reproduction. Also, since Bluegill were initially introduced into Gulliver Lake, habitat needed for successful reproduction may not have ever existed in the quantity and quality needed to rebound from an increase in predation.

Lastly, there are historical anecdotal reports that chemicals (i.e., copper sulfate) had been applied nearshore to eliminate or reduce the abundance of freshwater snails that contribute to swimmer's itch. The use of copper sulfate for the treatment of freshwater snails is currently not permitted in Michigan due to the potential for adverse impacts to sunfishes such as Bluegill. The use of copper products during Bluegill (or Centrarchid) spawning can raise three concerns: 1) direct mortality from exposure, 2) sub-lethal impacts on fish health, and 3) irritation of adult fish resulting in nest abandonment and associated egg and fry mortality. Due to the potential impacts to sunfishes (i.e. Bluegill) area residents should not use copper products for the treatment of swimmer's itch and should consult with the Department of Environment, Great Lakes, and Energy (or EGLE) for alternatives.

Other Panfish - During the Status and Tends Survey, catch rates of Rock Bass were high relative to similar sized waterbodies in the region. Additionally, many Rock Bass captured met or exceeded the preferred minimum size for harvest. Therefore, Rock Bass should be providing a sufficient fishery for anglers seeking this species. In 2001, a Master Angler record was awarded to an angler that captured a 12-inch Rock Bass in Gulliver Lake. During the most recent survey, 11-inch fish were captured, suggesting that similar-sized Master Angler fish may be available.

Forage or Minnows - There were a total of 8 forage (or food) species captured in Gulliver Lake during the 2019 Status and Trends Survey. Of these eight, there are three that can provide insight about the relative abundance of forage species in Gulliver Lake. Bluntnose Minnow, Common Shiner, and Golder Shiner were all captured in Gulliver Lake, and have also been captured in similar sized waterbodies across the state of Michigan. A comparison of catch rates of these species may provide a useful baseline for evaluating the relative abundance of these forage species. For example, catch rates of Bluntnose Minnow, Common Shiner, and Golden Shiner in Gulliver Lake ranged from the 25th percentile (low) to the median when compared to other Michigan lakes. These results suggest that the relative abundance of these three species is comparable or slightly below the state average. Generally, though, there were more species and a greater abundance of forage fish captured during the 2019 Status and Trends Survey compared to the 2004 Status and Trends survey, which is promising. These data suggest that while relative abundance may be low, the abundance and diversity of forage species are increasing. The placement of brush bundles nearshore may also benefit the forage fish community in future years as physical habitat surveys showed limited nearshore habitat for these species.

## Management Direction

Chemical & Physical

1). Interested riparians should consider volunteering with the Michigan Clean Water Corp (MiCorps; https://micorps.net) involvement to begin annually monitoring long-term water quality of Gulliver Lake. MiCorps is a network of volunteer water quality monitoring programs in Michigan created to

collect and share water quality data to use for aquatic resources management and protection. Beneficial data collected by MiCorps volunteers include chlorophyll-a concentration, temperature, dissolved oxygen, secchi depth, and total phosphorus. These data may provide additional insight about nutrient levels in Gulliver Lake. Collecting data in collaboration with MiCorps also provides managers and volunteers the ability to compare data across a larger region which may help explain any year-to-year variability observed.

2). In Michigan, development of 25 percent or less of a lake is recommended to provide reasonable riparian access and recreational use while preserving ecological integrity, sustaining natural resources for future generations, and protecting the public trust (O'Neal and Soulliere 2006, MI DNR 2008). Landowners and managers are encouraged to collaborate and identify regions of Gulliver Lake where rehabilitation of the shoreline may be feasible. Additionally, future shoreline modification projects should incorporate `soft' engineering practices similar to those identified by the Michigan Natural Shorelines Partnership (MNSP 2021).

3). Large woody debris, in the form of submerged trees and brush bundles should be installed on the northern, northeastern, eastern, and southeastern shores. Introduction of shoreline habitat is intended to increase surface area for macroinvertebrates to benefit forage and panfish species (e.g., shiners, sunfish). Landowners are encouraged to follow "Fish Sticks" project designs (WI DNR 2014) in accordance with state inland lake and stream regulations.

Biological
1). MI DNR managers are encouraged to work with area anglers and residents to consider two management regulation change options that may benefit the Gulliver Lake Northern Pike population. These regulations are the "Protected Slot Limit" or "No Minimum Size Limit" regulation types. Provided the Unit work plan allows, MI DNR managers are encouraged to re-survey Gulliver Lake five years after any regulation changes to document any changes or benefits to the Northern Pike population.

2). MI DNR managers and staff from the Department of Environment, Great Lakes and Energy are encouraged to provide area residents with alternative information with respect to eliminating or reducing the impacts of swimmer's itch. This information is intended to eliminate any need for additional treatments using copper products that may be impacting sunfish reproduction in Gulliver Lake.

3). During future survey efforts, MI DNR managers are encouraged to coordinate with Michigan State University Fish Health Lab to collect fish samples for parasite analysis. These data may provide additional insight pertaining to the occurrence of emaciated fish (e.g., Common White Sucker and Northern Pike).

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Figure 1. Map of Gulliver Lake, located in Schoolcraft County, Upper Peninsula of Michigan.

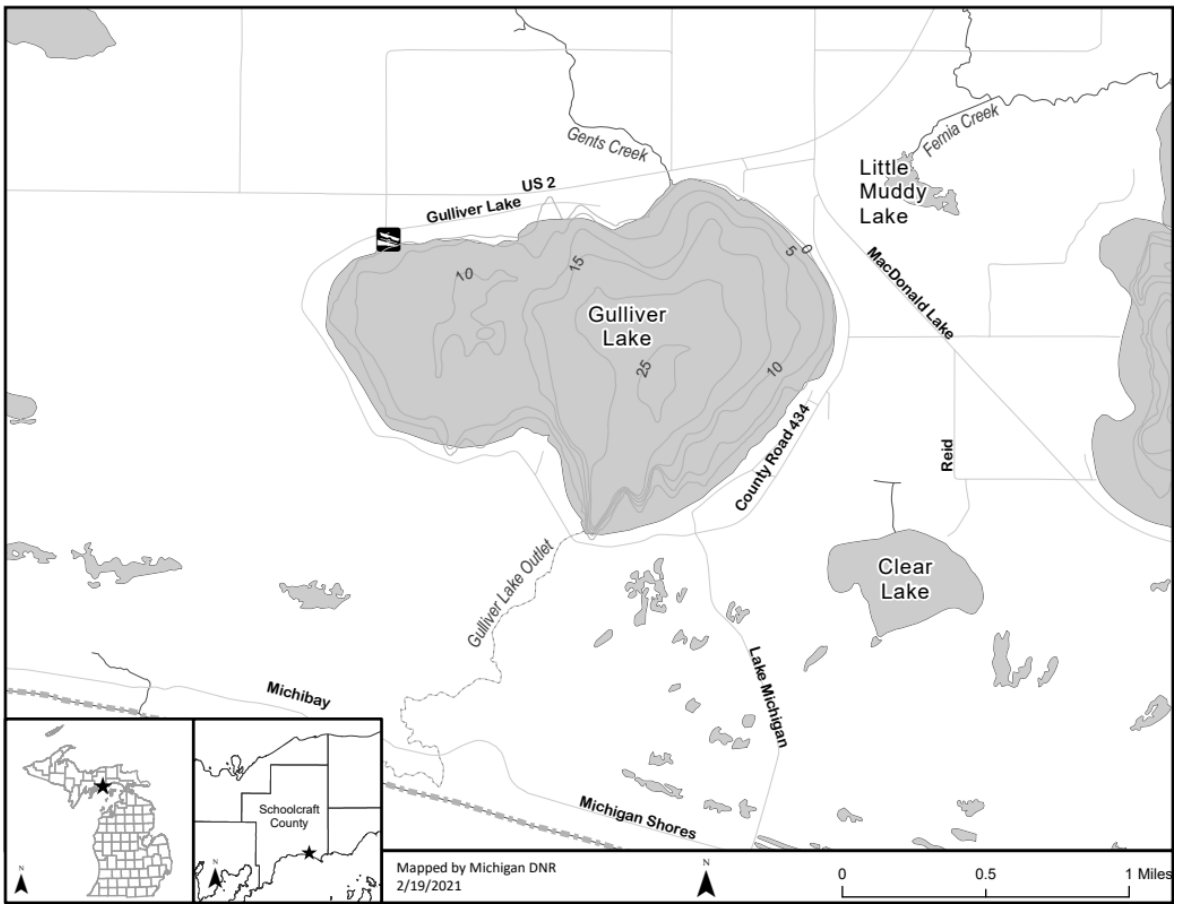

Figure 2. Temperature (°F) and dissolved oxygen (mg/L) of water in Gulliver Lake (Schoolcraft County, Michigan) recorded 15 March 2019 (Left) and 19 August 2019 (Right). Data points depicted as circles represent temperature, while data points depicted as triangles represent dissolved oxygen.

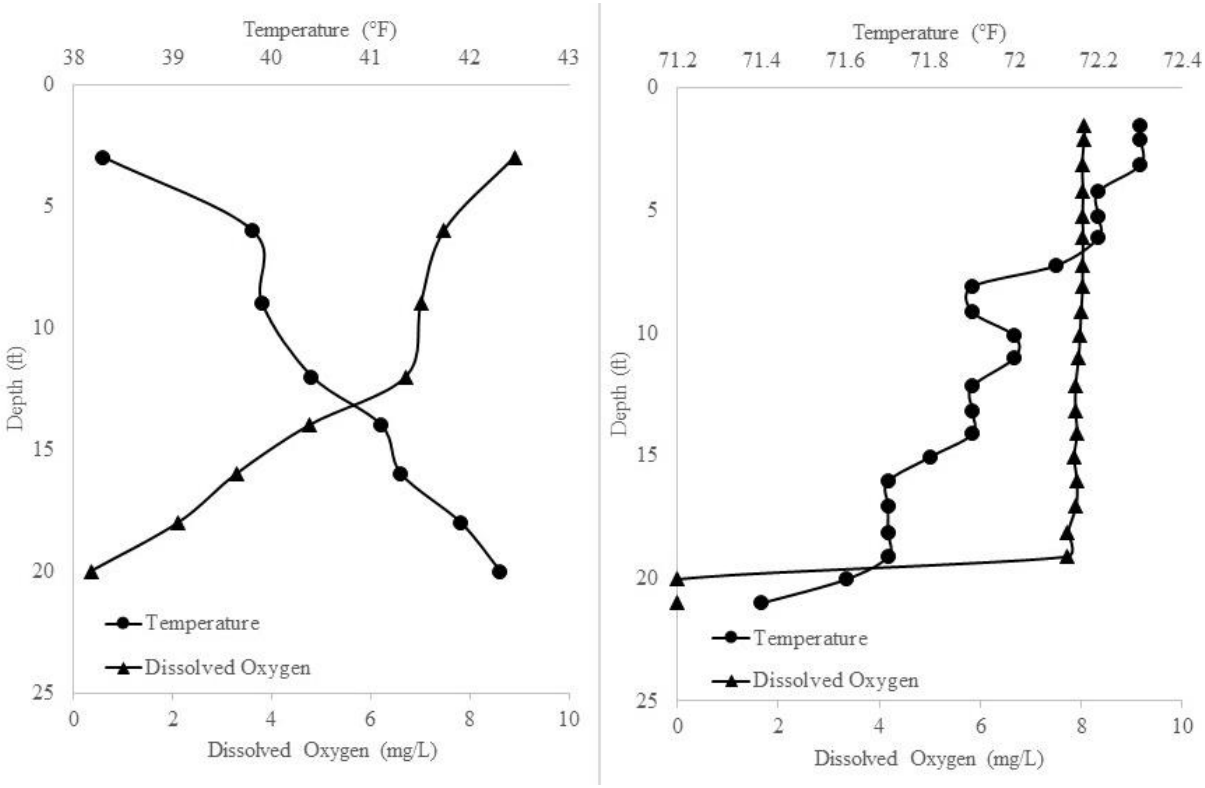

Table 1. Chemical parameters including nitrogen (mg/L), phosphorus (mg/L), and nitrogen to phosphorus ratio in 1992, 2004, and 2019 measured in Gulliver Lake, and the regional average (Northern Lake Michigan Management Unit).

| Chemical Parameter | 1992 | 2004 | 2019 | Region |
|---|---|---|---|---|
| Total Nitrogen (mg/L) | 0.577 | 0.413 | 1.310 | 0.642 |
| Total Phosphorus (mg/L) | 0.018 | 0.006 | 0.018 | 0.019 |
| Nitrogen: Phosphorus Ratio | 32:1 | 69:1 | 73:1 | 34:1 |

Table 2. Physical indicators including dwelling density (per mile), boat docks (per mile), shoreline armoring (average % armored), and large woody debris (per mile) measured in Gulliver Lake, and the regional average (Northern Lake Michigan Management Unit).

| Physical Indicator | Gulliver Lake | Region |
|---|---|---|
| Dwelling Density (dwellings per mile) | 31.1 | 15.1 |
| Boat Docks (docks per mile) | 17.6 | 11.3 |
| Shoreline Armoring (% armored) | 27.8 | 16.9 |
| Large Woody Debris (logs per mile) | 50.1 | 223.2 |

Table 3. Historical stocking record for Gulliver Lake (Schoolcraft County) by species, year, date, number (N) stocked, and life stage at stocking.

| Species | Year | Date | Number | Age |
|---|---|---|---|---|
| Walleye | 1933 | | 150000 | Swim-up fry |
| Yellow Perch | 1933 | | 3000 | 7 month |
| Walleye | 1934 | | 360000 | Swim-up fry |
| Yellow Perch | 1934 | | 2000 | 7 month |
| Walleye | 1935 | | 150000 | Swim-up fry |
| Yellow Perch | 1935 | | 10000 | 8 month |
| Walleye | 1936 | | 300000 | Swim-up fry |
| Yellow Perch | 1936 | | 5000 | Adults |
| Walleye | 1937 | | 450000 | Swim-up fry |
| Walleye | 1938 | | 300000 | Swim-up fry |
| Walleye | 1939 | | 360000 | Swim-up fry |
| Yellow Perch | 1939 | | 3000 | 7 month |
| Walleye | 1940 | | 300000 | Swim-up fry |
| Northern Pike | 1941 | | 215 | Adults |
| Bluegill | 1950 | | 20000 | |
| Bluegill | 1954 | | 7500 | |
| Bluegill | 1954 | | 7500 | |
| Muskellunge | 1966 | | 260 | Spring fingerling |
| Tiger Muskellunge | 1969 | | 2000 | Fingerling |
| Tiger Muskellunge | 1971 | | 1500 | Fingerling |
| Walleye | 1973 | | 20000 | Swim-up fry |
| Tiger Muskellunge | 1974 | | 1500 | Fingerling |
| Walleye | 1984 | 05/14/1984 | 750,000 | Swim-up fry |
| Walleye | 1984 | 05/18/1984 | 44,150 | Swim-up fry |
| Walleye | 1984 | 05/24/1984 | 200,000 | Swim-up fry |
| Walleye | 1985 | 05/17/1985 | 693,680 | Swim-up fry |
| Walleye | 1985 | 05/20/1985 | 306,620 | Swim-up fry |
| Walleye | 1985 | 10/08/1985 | 151 | Spring fingerling |
| Walleye | 1986 | 05/06/1986 | 1,000,000 | Swim-up fry |
| Walleye | 1986 | 05/16/1986 | 850,000 | Swim-up fry |
| Walleye | 1986 | 07/16/1986 | 36,341 | Spring fingerling |
| Walleye | 1988 | 06/28/1988 | 30,656 | Spring fingerling |
| Walleye | 1991 | 06/30/1991 | 26,545 | Spring fingerling |
| Walleye | 1993 | 07/09/1993 | 20,000 | Spring fingerling |
| Walleye | 1995 | 06/27/1995 | 24,985 | Spring fingerling |
| Walleye | 1996 | 07/05/1996 | 68,927 | Spring fingerling |
| Walleye | 1998 | 06/29/1998 | 5,603 | Spring fingerling |

Table 4. Species, number (N), percent by number (% by N), weight (WGT, in pounds), percent by weight (% by WGT), total length (TL) range in inches (in.), and average total length (Avg.TL) of fish captured during 2019 fisheries survey conducted in Gulliver Lake, Schoolcraft County. Results include fish capture results from all gear types combined during the Spring 2019 survey.

| Species | N | % by N | WGT (lbs.) | % by WGT | Range TL (in.) | Avg.TL (in.) |
|---|---|---|---|---|---|---|
| Bluegill | 2 | 0.2 | 0.1 | 0.0 | 3.0 to 4.0 | 4.0 |
| Brown Bullhead | 457 | 53.9 | 481.1 | 35.2 | 11.0 to 14.0 | 13.2 |
| Common Carp | 1 | 0.1 | 12.6 | 0.9 | 30.5 to 30.5 | 30.5 |
| White Sucker | 247 | 29.1 | 699.1 | 51.2 | 6.0 to 22.0 | 19.3 |
| Largemouth Bass | 14 | 1.7 | 23.3 | 1.7 | 12.0 to 18.0 | 14.4 |
| Northern Pike | 34 | 4.0 | 75.8 | 5.6 | 9.0 to 26.0 | 21.1 |
| Rainbow Trout | 1 | 0.1 | 4.1 | 0.3 | 22.5 to 22.5 | 22.5 |
| Rock Bass | 77 | 9.1 | 15.1 | 1.1 | 3.0 to 11.0 | 5.6 |
| Smallmouth Bass | 3 | 0.4 | 4.8 | 0.3 | 13.0 to 15.0 | 14.3 |
| Walleye | 11 | 1.3 | 48.7 | 3.6 | 22.0 to 25.0 | 23.8 |
| Yellow Perch | 1 | 0.1 | 0.0 | 0.0 | 4.5 to 4.5 | 4.5 |

Table 5. Age (years), average size of Gulliver Lake Northern Pike, number (N) aged from Gulliver Lake, State of Michigan (SOM) mean total length (TL, inches) of Northern Pike at age, State of Michigan 25th percentile length (inches) at age, State of Michigan median length at age, and State of Michigan 75th percentile length (inches) at age. Boxed cells indicate Gulliver Lake Northern Pike rating compared to State of Michigan.

| Age | Gulliver Lake Mean TL | N aged | SOM Mean TL | SOM 25th Percentile | SOM Median | SOM 75th Percentile |
|---|---|---|---|---|---|---|
| 1 | 10.2 | 2 | 12.0 | | | |
| 2 | | | 17.3 | | | |
| 3 | 20.7 | 20 | 20.7 | 19.1 | 20.6 | 22.2 |
| 4 | 21.2 | 4 | 22.7 | 20.9 | 22.7 | 24.5 |
| 5 | 25.1 | 7 | 24.6 | 22.8 | 24.4 | 26.2 |
| 6 | 26.8 | | 26.3 | | | |
| 7 | | | 28.2 | | | |
| 8 | | | 31.9 | | | |
| 9 | | | 34.9 | | | |
| 10 | | | 36.6 | | | |

Table 6. Species, number (N), percent by number (% by N), weight (WGT, in pounds), percent by weight (% by WGT), total length (TL) range in inches (in.), and average total length (Avg.TL) of fish captured during 2019 fisheries survey conducted in Gulliver Lake, Schoolcraft County. Results include fish capture results from all gear types combined during the 2019 Summer Status and Trends survey.

| Species | N | % by N | WGT (lbs.) | % by WGT | Range TL (in.) | Avg.TL (in.) |
|---|---|---|---|---|---|---|
| Black Crappie | 1 | 0.1 | 0.9 | 0.3 | 11.5 to 11.5 | 11.5 |
| Bluegill | 3 | 0.3 | 0.1 | 0.1 | 2.0 to 5.0 | 3.5 |
| Bluntnose Minnow | 15 | 1.4 | 0.2 | 0.1 | 1.0 to 4.0 | 2.7 |
| Brown Bullhead | 28 | 2.6 | 25.9 | 10 | 9.0 to 14.0 | 12.5 |
| Common Carp | 1 | 0.1 | 19.4 | 7.5 | 35.0 to 35.0 | 35.5 |
| Common Shiner | 31 | 2.9 | 0.4 | 0.1 | 1.0 to 3.0 | 3.0 |
| White Sucker | 27 | 2.5 | 71.6 | 27.7 | 6.0 to 21.0 | 18.7 |
| Golden Shiner | 6 | 0.6 | 0.1 | 0 | 2.0 to 3.0 | 2.9 |
| Iowa Darter | 83 | 7.7 | 0.1 | 0 | 1.0 to 2.0 | 1.6 |
| Johnny Darter | 50 | 4.6 | 0.2 | 0.1 | 1.0 to 2.0 | 1.9 |
| Largemouth Bass | 1 | 0.1 | 1.6 | 0.6 | 14.5 to 14.5 | 14.5 |
| Logperch | 8 | 0.7 | 0.1 | 0 | 2.0 to 3.0 | 3.3 |
| Northern Pike | 44 | 4.1 | 91 | 35.1 | 17.0 to 26.0 | 21.3 |
| Pumpkinseed | 1 | 0.1 | 0.8 | 0.3 | 9.5 to 9.5 | 9.5 |
| Rock Bass | 97 | 9.0 | 26.5 | 10.2 | 1.0 to 11.0 | 6.3 |
| Sand Shiner | 616 | 56.9 | 3 | 1.2 | 1.0 to 2.0 | 2.4 |
| Smallmouth Bass | 18 | 1.7 | 14.9 | 5.7 | 5.0 to 17.0 | 9.5 |
| Spottail Shiner | 5 | 0.5 | 0 | 0 | 2.0 to 2.0 | 2.5 |
| Yellow Perch | 48 | 4.4 | 2.2 | 0.9 | 2.0 to 9.0 | 5.1 |

Table 7. Summary of Gulliver Lake catch per unit effort (CPUE) of Northern Pike (NOP) compared to statewide capture rates according to gear type, including only sites and gears with catches greater than zero. Catch per unit effort for large mesh fyke net, gill net, and trap net is number of fish per lift. Table reproduced from Wehrly et al. (2015).

| Gear | Gulliver Lake NOP CPUE | Low | 25th | Median | 75th | High | Max. |
|---|---|---|---|---|---|---|---|
| LM Fyke Net | 1.2 | <0.33 | 0.33 | 0.75 | 1.55 | >1.55 | 12.95 |
| Exp. Gill Net | 5.0 | <1.00 | 1.00 | 1.89 | 4.00 | >4.00 | 14.5 |
| Trap Net | 1.0 | <0.27 | 0.27 | 0.67 | 1.33 | >1.33 | 21 |