Silver Lake
Oceana County, T15 N, R 18 W, Sections 19, 20, 29, 30
Silver Creek Watershed

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Environment

Silver Lake is a 690-acre kidney-shaped natural lake in Golden Township, in western Oceana County, approximately 7 miles south of Pentwater, Michigan. Silver Lake is located on Little Sable Point, approximately one mile inland from Lake Michigan. Towering sand dunes separate Silver Lake from Lake Michigan. Silver Lake is relatively shallow, with a maximum depth of depth of 23 feet and a mean depth of 16.2 feet (Fusilier 2001), with approximately 4.2 miles of shoreline. Silver Lake has a predominantly sand bottom with only a very narrow band of aquatic macrophytes around the lake; thus, aquatic vegetation and fish habitat is very limited. The shoreline is highly developed, with roads and approximately 200 homes/cottages fronting the western, southern, and northern shorelines of the lake.

Silver Lake State Park, established in 1951, also has significant frontage on Silver Lake. The State Park provides the only public boat ramp on the lake (although there are several small road-end accesses where wading anglers or cartop watercraft owners can access the lake). The State Park includes nearly 3000 acres overall, with 4 miles of Lake Michigan shoreline. The State Park campground and boat launch are located on the southeast shoreline of the lake, with approximately 1,500 feet of frontage. The State Park frontage also encompasses the entire western shoreline of the lake, which is approximately 1.6 miles in length. This portion includes the entire active dune complex, and the only emergent wetland adjacent to Silver Lake, in the southwestern corner of the lake.

The dunes that separate Silver Lake from Lake Michigan are not static. According to one study conducted by the Michigan Department of Natural Resources (MDNR) Parks and Recreation Division (MDNR Files, Cadillac office), between 1838 and 1977, sand covered approximately 468 acres of land and Silver Lake, significantly shrinking the size of Silver Lake. The dunes remain active, continuing to shrink the size of Silver Lake and threatening to cover homes on the northern shore of the lake. While the "official" size of Silver Lake is 690 acres, it is currently smaller than that due to the dune encroachment. Scrutiny of satellite imagery shows that since the early 1990s, over 100 feet of lake surface has been lost along the northern portion of the dune/lake interface. Also, while the "official" maximum depth of Silver Lake is listed at 23 feet, in recent years the lake has been shallower, with around 21 feet being the deepest. According to Jody Johnston (Silver Lake State Park Manager, personal communication), sand being blown off the dunes is the most likely reason for the loss of lake depth.

Silver Creek is the outlet of Silver Lake, flowing for approximately 1.3 miles from Silver Lake to Lake Michigan. There is a dam on Silver Creek that controls water levels on Silver Lake and blocks the migration of most fish from Lake Michigan; although salmon and Steelhead have occasionally leaped the dam and made it into Silver Lake (O'Neal 2016). The dam was first constructed in the early 1950s. The court-ordered levels for Silver Lake are 586.4 feet in the summer and 585.9 feet in the winter. The

legal lake levels were first established in 1962 but were reset by the Oceana County Circuit Court at the current levels in 1995 (Fusilier 2001).

The Silver Creek watershed (including Silver Lake) covers 13,703 acres (Fusilier 2001), all of which lies in Oceana County. The primary tributaries to Silver Lake include Au Sable Creek (also known as Golden Creek or the Golden Drainage Ditch) and Hunter Creek. Both streams are Designated Trout Streams. Hunter Creek was last surveyed in 1994 and hosts self-sustaining populations of Brown and Brook Trout. There are two dams and impoundments upstream from Silver Lake on Au Sable Creek/Golden Creek/Golden Drainage Ditch. The Upper Silver Lake Dam is the first dam upstream from Silver Lake, and was constructed in 1964, with 22' of head. Directly upstream of Upper Silver Lake is another impoundment, which was created by the construction of a dam in 1972. At that time, it was known as Upper Silver Lake II but has since been renamed as "Lake Holiday". Neither impoundment has any public access. The upper portion of the watershed consists of nearly all privately-owned land that is a mix of agricultural and forest. The area directly to the east of Silver Lake is heavily developed with homes and businesses. Both impoundments are also very heavily developed.

Silver Lake has a history of water quality issues, including fish kills and algae blooms. Because of its shallow nature, Silver Lake also has had an abundance of aquatic vegetation at times, including invasive Eurasian milfoil. Excessive Eurasian milfoil in inland lakes can lead to several fisheries problems including poor growth rates and stunting for a number of species targeted by anglers, in addition to interfering with other popular activities including boating, waterskiing, and swimming.

The primary citizen group for Silver Lake is the Friends of Silver Lake (FOSL). FOSL is a non-profit group that was established in 2012 (Bill DeJong, FOSL, personal communication). Also, the Silver Lake Improvement Board (SLIB) has been in existence for many years and oversees the aquatic nuisance weed treatments on Silver Lake. The SLIB also oversees the fund created by taxes on lakefront landowners. The funds are used primarily for chemical control of aquatic nuisance plants and algae.

History

Fish Stocking

The first records of fish stocking in Silver Lake date back to 1904 and 1909, when Largemouth Bass, Smallmouth Bass, and Yellow Perch were stocked by the Michigan Fishery Commission (MFC; Table 1). Walleye were first stocked in 1930 and continued through the mid-1940s. Other species stocked included warmwater/coolwater species including Bluegill, Largemouth Bass, Smallmouth Bass, and Walleye (Table 1). Rainbow Trout were stocked once, in 1941, and Brook Trout were also stocked once, in 1965. Northern Pike were stocked in 1973 and 1974. Walleye were stocked again in 1975 and became the primary managed species in the lake from that point forward with regular stockings (Table 1). Since 1991, all Walleye stocked have been spring fingerlings at densities ranging from 50/acre to 165/acre with more recent years being relatively consistent at 50/acre.

Historical Fisheries Issues

There are a number of prominent fisheries issues documented in the history of Silver Lake. At some point (exactly when is unknown), Common Carp were introduced to Silver Lake. It is likely that they arrived in Silver Lake from Lake Michigan prior to the lake level control dam being installed in the

early 1950s. There is considerable correspondence throughout the 1940s and 1950s from the public about manually removing the nuisance Common Carp from the lake (Michigan Department of Natural Resources (MDNR) files, Cadillac). Despite extensive discussions, it does not appear that any manual removals were ever conducted. Silver Lake continues to have a large population of Common Carp.

Walleye fishing is another prominent topic in the history of Silver Lake. Prior to the installation of the dam on Silver Creek, Walleye were known to migrate back and forth from Lake Michigan. It is therefore likely that Walleye were native to Silver Lake. After being stocked several times from 1930 to 1942, Walleye were not stocked again until 1975. Despite this, correspondence (MDNR files, Cadillac) indicates that Walleye fishing was good at times, so the Walleye must have been sustaining themselves through natural reproduction. There were reports of exceptional Walleye fishing in 1942. In the late 1940s and early 1950s there was discussion of constructing an artificial Walleye spawning reef made of gravel. Eventually, riparian landowners nixed the plan out of fear that the gravel would foul the sand beaches favored by tourists (MDNR files, Cadillac). During the period when Walleye were not stocked, landowners frequently requested stocking. In correspondence from 1971, MDNR Fisheries Biologist Lud Frankenberger considered Walleye to be one of the "most important species" for anglers to pursue in Silver Lake.

Detailed angler reports from 1949 (MDNR files, Cadillac) were as follows: Northern Pike were rare and small but had been previously more abundant and larger. Walleye were rare, but there had been several good years previously. Smallmouth Bass were common, and Largemouth Bass were occasionally taken. Bluegill were common, with a 7 to 8- inch average length. Black Crappie were rare but had been previously more abundant. Yellow Perch were abundant and mostly small, but some individuals ranged up to 13 inches. Rock Bass were common, with "good size". White Suckers were abundant, and minnows were common. White Bass were rare. Note- this is the only reference to White Bass anywhere in the Silver Lake file. They have never been caught in any fisheries survey of the lake. It is possible that White Bass were native to Silver Lake, with migrations from Lake Michigan occurring. The installation of the dam would have ended the possibility of migration from Lake Michigan. Unfortunately, detailed records of the native fish populations of Silver Lake do not exist.

Silver Lake has a history of fish kills, with many episodes reported over the years. The kills have ranged in severity from minor to relatively major events. Well documented fish kills occurred in 1950, 1952, 1959, 1969, and 2011. The 2011 fish kill included an estimated 4,000 Common Carp and was diagnosed as an outbreak of Koi Herpesvirus.

Beginning in 1972, there is correspondence in the file regarding an overall lack of predators in the lake, and "hordes of stunted perch and bluegills, along with a large number of rough fish". Presumably as a result of these complaints, an Antimycin/Fintrol (fish toxicant) treatment was conducted by MDNR Fisheries Division personnel in May of 1975 to reduce (not eradicate completely) the number of stunted perch in the lake. The treatment was believed to have been successful, and Walleye fry were stocked shortly thereafter.

There is ample correspondence in the file throughout the 1970s regarding algae, nuisance aquatic plants, and water quality issues. The West Michigan Shoreline Regional Development Commission newsletter from June 1977 discusses Silver Lake and the watershed. It mentions "rapidly deteriorating" water quality in the watershed, due to impoundment, heavy riparian development

including septic contamination, and the agricultural nature of the upper part of the watershed (MDNR files, Cadillac).

The first chemical treatments for nuisance aquatic vegetation on Silver Lake took place in 1988, much to the dismay of Silver Lake anglers and MDNR Fisheries staff. Correspondence in the file from anglers describes a perceived decline in the fish populations of Silver Lake, and the decline was linked to the chemical treatments of aquatic vegetation. There are multiple written requests from MDNR Fisheries Biologists John Trimberger and Rich O'Neal requesting that further chemical treatments of aquatic plants not be conducted (or be conducted sparingly, targeting only Eurasian milfoil), due to the direct and indirect impacts on native plants and fish populations. MDNR conducted a postcard creel survey in 1996 that resulted in many complaints from anglers that the removal of virtually all aquatic vegetation in Silver Lake had dramatically impacted the fishing through reduced catch rates. Prominent local angler and outdoor writer Chuck Stafford also penned a letter to MDEQ (Michigan Department of Environmental Quality, the precursor to the Department of Environment, Great Lakes, and Energy or EGLE of today) protesting the "excessive weed treatments which are affecting the fishery". Despite the protests, chemical treatments have continued since then, including whole-lake treatments with Sonar (Fluridone) in 2002, 2005, and 2009, and spot treatments with 2, 4-D in several other years (Ryan Crouch, EGLE, personal communication). Spot treatments for Eurasian Milfoil were conducted in 2012, 2015, 2018, and 2019. Despite the treatment in 2019, some Eurasian Milfoil was left untreated to provide habitat for fish (Jennifer Jones, Restorative Lake Sciences, personal communication).

Water quality issues on Silver Lake came to a head in September 2011, when the FOSL sent a petition to SLIB about water quality issues. The petition, signed by nearly 600 people, requested that the SLIB, in cooperation with other local and state agencies, investigate the water quality issues plaguing Silver Lake. In particular, the petition stated: "In the past 50 years, the water quality has degraded to the point that there is excessive weeds and algae, contamination of fish and possibly other wildlife, health concerns and in general degradation of water quality negatively impacting the recreational uses of the lake". The petition also described the lake condition in the summer of 2011: "the circumstances of the summer of 2011 highlight the problems in the lake. Several thousand fish died of unknown causes. The clarity of the water was so poor that it was not possible to see the bottom of the lake for the entire summer. The surface of the lake has had a constant layer of algae to the point that it has not been possible to swim in many areas of the lake. And there continues to be excess weeds".

As a result of the outcry, a water quality study of Silver Lake and its watershed was commissioned. The study cost over $500,000 and was funded by a number of sources. The study was undertaken by a team of researchers from Grand Valley State University (GVSU) and the US Geological Survey (USGS). Completed in 2015, the study found that Silver Lake was in a eutrophic state and was being enriched by nutrients from several human-caused sources (Brennan et al. 2015). The highest percentage of nutrients entering the lake was coming from riparian septic systems leaching nutrients into groundwater. The study ultimately recommended the installation of sanitary sewers to mitigate the septic pollution (Brennan et al. 2015). However, due to the high cost of sewer installation (estimated at more than $23 million), local residents were strongly opposed, and in May of 2019 the Golden Township Board voted to end the proposed sewer project.

The GVSU/USGS study also revealed other characteristics of Silver Lake. Steinman et al. (2015) found that the lake was polymictic- meaning it does not stratify due to its shallow nature. Hypoxia

(extremely low dissolved oxygen levels) was also found on several different occasions during the study. This condition can lead to mass kills of fish and other aquatic life. A total of 85 different species of phytoplankton were identified during the study (Steinman et al. 2015).

In 2004, due to poor growth rates and angler complaints regarding an overabundance of small Northern Pike, managers changed Northern Pike regulations on Silver Lake to no minimum size limit with only one greater than 24 inches and five per day.

Since 1994, a total of 48 exceptional fish caught from Silver Lake have been entered in the MDNR Fisheries Division Master Angler program. Master Angler species caught from Silver Lake have included Black Bullhead, Black Crappie, Bluegill, Bowfin, Brown Bullhead, Largemouth Bass, Pumpkinseed Sunfish, Rock Bass, Smallmouth Bass, and White Sucker (Table 2). Rock Bass was the most numerous species entered, with 21 entries.

Historical Fisheries Surveys

The first fisheries survey Silver Lake was conducted by the Michigan Department of Conservation (the precursor to the MDNR of today) in 1950 using gill nets (Taube 1951) and many species were caught and recorded (Table 3). Of note was the Walleye population, which was described as robust despite the fact that no stocking was occurring at that time. The Walleye were also growing exceptionally well, with growth rates that compared more closely with Great Lakes Walleye (which tend to grow faster than those from inland lakes). The author surmised that the Walleye were migrating back and forth from Lake Michigan through the Silver Lake Outlet stream (this was prior to the installation of the lake level control dam) and that some level of Walleye natural reproduction was occurring in Silver Lake.

In response to angler complaints regarding a lack of predators and an abundance of stunted Yellow Perch, another fisheries survey was conducted in 1972 (Table 3). The survey consisted of an electrofishing effort in late May and gill and trap net sets in July. The survey resulted in low catch rates of predator species, including Largemouth Bass, Northern Pike, Smallmouth Bass, and Walleye. The relative abundance of Bluegill in the survey was low, but they averaged over 8 inches in length. Yellow Perch were relatively abundant (over 700 caught in the gill and trap nets), but averaged only 6 inches in length, with very few individuals exceeding the average length. The 1972 survey recommended the fish toxicant treatment that was conducted in the spring of 1975. In the fall of 1975, an electrofishing effort was conducted after the toxicant treatment to confirm the survival of the Walleye fry that had been stocked the previous spring. The survey confirmed a proportion of the stocked Walleye had survived.

Additional electrofishing surveys were conducted in May of 1976, 1977, and 1978, and in April of 1980. These surveys confirmed a resurgence of predator fish, particularly Walleye and Northern Pike. In the 1978 and 1980 surveys, larger Walleye (over 15 inches) were collected. The Yellow Perch population remained at a lower level, exhibiting better growth rates and size structure than before the toxicant treatment (MDNR files, Cadillac).

A comprehensive netting survey of Silver Lake was conducted by MDNR in June of 1983. The survey consisted of small mesh fyke nets, large mesh fyke nets, and inland gill nets. The survey documented a robust Walleye population, however Fisheries Biologist Ralph Hay noted that the absence of younger Walleye may indicate a lack of Walleye reproduction (Walleye had last been stocked in 1980). The

Yellow Perch population was much improved from the early 1970s, as 38% of the 208 Yellow Perch caught in the gill nets were over 7 inches in length. Hay did note large numbers of small, slow growing Yellow Perch as present in the small mesh fyke net catch. Bluegill were also relatively abundant with good size structure, as 79% of the 86 Bluegill caught in the large mesh fyke nets were greater than 6 inches in length. Seven different Bluegill year classes were represented in the catch and growth rates were slightly slower than the State average. Northern Pike were present in decent numbers as well (14 in total; 12 from the gill nets and 2 from the large mesh fyke nets). Largemouth Bass were rare (only one caught in a large mesh fyke net), and no Smallmouth Bass were caught in the survey.

In June of 1984, MDNR set five small mesh fyke nets in Silver Lake in an attempt to manually remove some of the small, slow-growing Yellow Perch. However, very few small Yellow Perch were caught, and the attempt was aborted. Other species caught in the survey included Rock Bass, Yellow Bullhead, Bluegill, Pumpkinseed Sunfish, Walleye, White Sucker, and Longnose Gar.

A brief, one-night netting survey was conducted by MDNR in 1994, with gear consisting of 4 trap nets and 2 inland gill nets. Decent numbers of both Walleye (71 in total from 9 to 21 inches) and Yellow Perch (72 in total from 5 to 9 inches) were caught. Yellow Perch size structure was improved over the 1983 survey, although growth rates remained about the same. MDNR Fisheries Biologist Rich O'Neal indicated that some natural reproduction for Walleye was occurring, as fish age- 4 to age- 8 were present, and no stocking had been conducted in that timeframe. He also noted slower growth rates on Walleye older than age- 4.

In 1997, MDNR (O'Neal 1997) conducted a population estimate of the Silver Lake Walleye population using the mark/recapture method. Walleye were caught by trap nets in April, marked with fin clips, and returned to the lake. In May, trap nets and inland gill nets were utilized in the recapture attempt. The total Walleye population was estimated at 1,627 (+/-682), while those 15 inches or larger were estimated at 1,574 (+/-681). This type of survey can underestimate smaller Walleye (< 12 inches) that are less susceptible to the survey gear. The Walleye caught in the survey ranged from 12 to 25 inches, with an average size of 18 inches. Nine different year classes were present (including some non-stocked year classes). Age- 6 (the 1991-year class) was the most represented Walleye age class. Walleye were heavily stocked in 1991, likely leading to the strong age-6 year class. A total of 17 different fish species were caught in the survey, with Rock Bass, Northern Pike, Walleye, and Black Crappie being the most numerous. A total of 1,611 Northern Pike were also caught. They ranged up to 38 inches in length and averaged 21.6 inches. Due to their relatively small average size and slow growth (age classes -3 through -7 were growing a full 2 inches slower than the State average), O'Neal (1997) recommended the consideration of smaller size limits for Northern Pike.

Creel surveys were conducted in 1996 and 1997 by MDNR (Lockwood 2000) to estimate fishing effort and numbers of fish caught, released, and kept by species. The surveys were a joint effort between Fisheries Division and Silver Lake State Park. The surveys were conducted from April through September and included both in-person interviews and voluntary interviews gathered via postcards left at the access site. In 1996, an estimated 6,218 angler trips were taken, resulting in an effort estimate of 21,537 angler-hours. In 1997, an estimated 3,244 angler trips were taken, resulting in an effort estimate of 14,772 angler-hours. In both years, the most frequently caught fish was Walleye, with harvest estimates exceeding 3,000 fish in both years. These are likely overestimates, as the 1997 mark/recapture study only showed a population estimate of 1,574 legal Walleye in Silver Lake, and

that estimate is more in line with other inland lake Walleye populations in Michigan. Regardless, the creel survey showed the popularity of Walleye with Silver Lake anglers. Other frequently caught fish in the creel surveys included Black Crappie, other panfish (Bluegill, Pumpkinseed Sunfish, and Rock Bass), Yellow Perch, and Northern Pike. Many comments were received from anglers during these surveys about how the lack of aquatic plants in the lake was negatively affecting fishing by eliminating the habitat of popular fish species.

In the fall of 1997, MDNR conducted an electrofishing survey targeting juvenile Walleye using methods later described by Ziegler and Schneider (2000). Surveys of this nature are typically conducted in the fall following a spring Walleye stocking event. Similar surveys were conducted in 1998, 2000, 2002, 2006, and 2016. While catch rates varied (Table 4), all of these surveys documented survival of the stocked Walleye (O'Neal 2000, 2006, and 2017). In response to declining growth rates found in the 2000 survey, O'Neal (2000) recommended dropping the Walleye stocking rate from 100/acre to 25-50/acre. After the 2006 and 2016 surveys, O'Neal (2006, 2017) recommended staying with a stocking rate of 50/acre.

Current Status

The most recent comprehensive fisheries survey of Silver Lake was conducted in the spring/summer of 2019. In the survey, fish were sampled with trap nets, large-mesh fyke nets, small-mesh fyke nets, inland gill nets, beach seines, and electrofishing gear. The netting portion of the survey occurred from May 20 through May 24, and the electrofishing and seining portion was completed on June 17. Surface water temperatures ranged from 52.5F to 58.8F during the netting portion of the survey and was 71.9F during the electrofishing portion of the survey. Habitat evaluation and water chemistry data was collected on August 8, 2019.

In May 2019, during the netting portion of the survey, a total of 475 fish consisting of 14 species were caught (Table 5). White Sucker were the most frequently collected species in the survey, with 105 individuals caught that ranged in size from 9 to 19 inches. Black Crappie was the most abundant panfish species, with 83 individuals caught that ranged in size from 4 to 13 inches. Other panfish species were rare in the survey, with only 28 Rock Bass, 20 Yellow perch, and one Bluegill caught. No Pumpkinseed Sunfish were caught. Walleye were the most numerous predator species caught in the survey, with 33 individuals ranging from 10 to 24 inches. Only 9 Largemouth Bass were caught, along with one Smallmouth Bass and two Northern Pike. Common Carp were also relatively abundant, with 54 caught from 18 to 30 inches. In combination, White Sucker and Common Carp comprised over 68% of the fish biomass captured in the survey (Table 5). Other species caught in the netting portion of the survey included Bluntnose Minnow, Brown Bullhead, Longnose Gar, and Sand Shiner.

Statistical inferences regarding growth rates were only produced for Black Crappie, Walleye, and Yellow Perch (Table 6). Low sample sizes for other species in the survey made similar inferences impossible. Black Crappie and Walleye were growing substantially better than the state average length-at-age, while Yellow Perch were near the state average (Table 6).

During the June 17 electrofishing/seining effort an additional 160 fish representing 11 species were caught (Table 7). Walleye were the most numerous species represented in this portion of the survey, with 73 caught ranging from 7 to 18 inches in length. Spottail Shiners and White Suckers were also among the more abundant species in the electrofishing/seining effort. One Round Goby was also

caught, representing the first time Round Goby have been documented in Silver Lake. The only species with enough individuals caught to allow for statistical inferences regarding growth rates was Walleye, but only for those that were age 1. They were growing slightly slower than the state average length at age (Table 8).

Limnological and shoreline data were collected on August 8, 2019. The limnological profile showed a distinct lack of stratification, with temperatures nearly identical from top to the bottom at 18 feet (Table 9). Below 15 feet, oxygen readings dropped abruptly, going from 7.04 ppm at 15 feet to 2.6 ppm at 18 feet. Silver Lake had 21.7 docks/km, 26.8 dwellings/km, 41.3% shoreline armoring, and 0.3 submerged trees/km (Table 10). Silver Lake is heavily developed with cottages and residences along much of its shoreline. Compared to other shallow, medium-sized lakes in Michigan and in the Central Lake Michigan Management Unit (CLMMU; basically, the northwestern portion of the Lower Peninsula), Silver Lake has an above-average number of docks and dwellings, and a moderate percentage of armored shoreline (Wehrly et al. 2015; Table 10).

Analysis and Discussion

The 2019 MDNR fisheries survey of Silver Lake reflected some significant changes from historical assessments of the fish community. Top predators such as Largemouth Bass, Smallmouth Bass, and Northern Pike were at very low population levels. Panfish species such as Bluegill and Pumpkinseed Sunfish were nearly or completely extirpated from Silver Lake, as no Pumpkinseed Sunfish and only one Bluegill were caught in the survey effort. The poor catch rates for panfish and bass in the 2019 survey correspond with recent angler reports of poor fishing for those species in Silver Lake. It is also important to note that in the 2019 survey nearly 70% of the fish biomass was comprised of species that are less desirable to anglers, including Common Carp and White Sucker.

One panfish species that was more abundant in the 2019 survey was Black Crappie. A total of 87 Black Crappie were caught in the survey, with most of them exceeding the minimum acceptable size of 7 inches. Nine different year classes of Black Crappie were represented in the survey, indicating consistent natural reproduction. Growth rates of Black Crappie were also substantially faster than the state of Michigan average.

Walleye were also relatively abundant in the 2019 MDNR fisheries survey, with a total of 106 Walleye caught. Seven different year classes were present. The 2018, 2016, and 2014- year classes were the most represented. This is not surprising, as Walleye were stocked by MDNR in each of those years. This indicates that the Walleye stocking program continues to be successful and is providing the desired result. The presence of Walleye from other year classes indicates that low-level natural reproduction of Walleye is also contributing to the fishery in Silver Lake. Spottail Shiners and Sand Shiners are likely the preferred prey of Walleye in Silver Lake. Both of those species were present in the 2019 survey.

Habitat limitations are likely hindering bass, Northern Pike, and panfish populations, which were all at low relative abundances in Silver Lake during the 2019 survey. MDNR Fisheries personnel noted that there was very little aquatic vegetation of any kind, anywhere in the lake. In addition to the scarcity of aquatic plants in Silver Lake, there was also virtually no woody cover, with less than one submerged tree per km (Table 10). Silver Lake is essentially a fishbowl, devoid of fish habitat. For that reason, aquatic nuisance weed treatments remain controversial on Silver Lake. If Silver Lake anglers and

riparian landowners wish to have healthy fish populations in Silver Lake, it is recommended to cease the aggressive chemical treatments. In addition to providing fish cover and habitat, aquatic plants would also help sequester the additional nutrient load entering the lake through failing septic systems that can also fuel harmful algae blooms. Without aquatic plants to utilize the existing nutrients in the lake, nuisance algae will continue to plague Silver Lake.

The low dissolved oxygen readings recorded in the 2019 survey are also alarming. Popular coolwater species like Walleye and Northern Pike could be negatively influenced by reduced habitat suitability based on oxygen availability. If the deeper parts of Silver Lake continue to have low oxygen levels, Walleye and Northern Pike will be pushed into marginal habitats and temperature zones and no longer have a deep-cool water refuge in the summer, which could ultimately influence growth and lead to poor survival rates. If further deterioration in the water quality of Silver Lake occurs, it could conceivably preclude the lake from further management for Walleye.

Management Direction

The Walleye fishery in Silver Lake is extremely popular with anglers. While a few fish from unstocked years were present in the 2019 survey catch, the bulk of the catch came from stocked years. Therefore, Walleye fingerlings should continue to be stocked into Silver Lake to maintain the Walleye fishery. The stocking rate should be 50/acre, or 34,500 spring fingerlings on an every-other-year basis. Silver Lake was most recently stocked with spring fingerlings in 2018, so the next stocking event (with spring fingerlings) should occur in 2020.

Due to the low population of Northern Pike documented in the 2019 survey, the Northern Pike fishing regulation on Silver Lake should be changed. Currently, Silver Lake has a "no minimum size limit" regulation on Northern Pike that allows anglers to harvest up to 5 Northern Pike per day (although only one over 24 inches can be harvested). The condition that caused this regulation to be enacted (O'Neal 1997) does not exist any longer. Therefore, the recommended regulation is two Northern Pike per day, with a minimum size limit of 24 inches. This regulation provides the best option for restoring the relative abundance of Northern Pike in Silver Lake to levels seen historically.

The bowfishing potential of Silver Lake should be promoted. Bowfishing is a growing sport in Michigan, and the large populations of Common Carp and White Sucker in Silver Lake provide an excellent opportunity for bowfishers to target them. Common Carp can have a number of negative effects on inland lakes, including uprooted vegetation, increased turbidity levels, reduced water clarity, and increased algae blooms (Weber and Brown 2009). Common Carp have long been considered a nuisance species in Silver Lake, and bowfishing would one way to reduce their overall numbers and potentially their negative impacts on the lake.

The nutrient budget of Silver Lake has been closely examined (Brennan et al. 2015), and the septic systems of riparian landowners on the lake and in the watershed were determined to be the primary source of the nutrients to the lake. The Brennan et al. (2015) report recommended the installation of sewers around Silver Lake and the immediate upstream watershed to alleviate the ongoing pollution. Until such action is taken, Silver Lake likely remains resigned to a fate of continued nuisance algae blooms, high turbidity levels, low dissolved oxygen levels, reduced fish populations, and fish kills.

Proper management of aquatic plants is of utmost importance in Silver Lake. We recommend small-scale treatments of Eurasian milfoil, but only when absolutely necessary. If the Eurasian milfoil beds are not "topped out" and hampering recreation, then they should not be treated. Instead, they should be left as fisheries habitat. We also recommend that native plants not be treated, because a healthy aquatic plant community is critical to healthy fish communities. Many of the desired fish species in Silver Lake, including Northern Pike, Largemouth Bass, Smallmouth Bass, Bluegill, Pumpkinseed Sunfish, and Yellow Perch require healthy native aquatic plant communities. In addition, a healthy, robust native aquatic plant community will sequester excess nutrients in Silver Lake and help reduce nuisance algae blooms.

The few remaining riparian wetlands adjacent to Silver Lake should be protected and considered critical to the continued health of the lake's aquatic community. The Silver Lake shoreline is already more developed than most other lakes in Michigan of comparable size. Future unwise riparian development and wetland loss may result in further deterioration of the water quality and aquatic habitat. Healthy biological communities in inland lakes require suitable natural habitat. Human development within the lake watershed, along the shoreline, and in the lake basin tends to change and diminish natural habitat.

Improved shoreline management would benefit the fish populations of Silver Lake. Seawalls and developed shorelines do not provide the appropriate habitat for robust fish populations. The Michigan Natural Shoreline Partnership, an organization dedicated to promoting natural shoreline landscaping to protect Michigan's inland lakes (http://www.mishorelinepartnership.org/), can provide guidance and training on how best to manage the land/water interface for the benefit of Silver Lake. Also, downed trees in the shallows of the lake provide excellent habitat for panfish and bass. Any trees that fall into the lake should be left alone as fisheries habitat. In addition, trees could be intentionally placed in appropriate shallow water areas of Silver Lake to provide cover and habitat for desirable fish species.

Appropriate watershed management is necessary to sustain healthy biological communities, including fish, invertebrates, amphibians, reptiles, birds and aquatic mammals. Generally, for inland lakes this includes maintenance of good water quality, especially for nutrients; preservation of natural shorelines, especially shore contours and vegetation; and preservation of bottom contours, vegetation, and wood structure within a lake. Guidelines for protecting fisheries habitat in inland lakes can be found in Fisheries Division Special Report 38 (O'Neal and Soulliere 2006).

Another comprehensive fisheries survey should be conducted within the next ten years to monitor the fish populations of Silver Lake. In particular, the Walleye population should be targeted to assess the continued effectiveness of the Walleye stocking program. Other goals of future fisheries surveys should include monitoring of the panfish, Largemouth Bass, Smallmouth Bass, and Northern Pike populations. These species are important to anglers and their populations can also serve as indicators of the health of the Silver Lake ecosystem.

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Table 1. Fish stocked in Silver Lake, Oceana County, 1904-2019.

Year	Species	Number	Size	Strain
1904	Largemouth Bass	4,000	fry	
1909	Smallmouth Bass	2,000	fingerlings	
	Yellow Perch	160,000	fry	
1929	Bluegill	8,000	4-5 months	
	Largemouth Bass	490	4 months	
1930	Walleye	200,000	fry	
1934	Bluegill	280	adults	
	Bluegill	1,060	4 months	
1935	Bluegill	19,500	5 months	
1936	Bluegill	650	yearlings	
	Largemouth Bass	200	4 months	
1937	Bluegill	6,800	4 months	
	Largemouth Bass	1,000	4 months	
	Smallmouth Bass	1,500	4 months	
	Walleye	450,000	fry	
1938	Bluegill	18,000	3 months	
	Largemouth Bass	14,000	4 months	
	Walleye	440,000	fry	
1939	Bluegill	15,000	3 months	
	Walleye	440,000	fry	
1940	Bluegill	4,000	3 months	
	Largemouth Bass	300	3 months	
	Walleye	200,000	fry	
1941	Bluegill	10,000	3 months	
	Largemouth Bass	500	3 months	
	Rainbow Trout	500	yearlings	
	Smallmouth Bass	3,540	3-5 months	
1942	Bluegill	9,633	4 months	
	Largemouth Bass	500	4 months	
	Smallmouth Bass	500	3 months	
	Walleye	200,000	fry	
1943	Bluegill	454	yearlings	
	Largemouth Bass	470	4 months	
	Smallmouth Bass	1,092	4 months	
1944	Bluegill	6,948	3.5 months	
	Largemouth Bass	1,880	4 months	
	Smallmouth Bass	930	4 months	
1965	Brook Trout	6,000	sublegal	
1973	Northern Pike	352	fingerlings	
1974	Northern Pike	1,956	fingerlings	
1975	Walleye	4,689,740	fry	Muskegon
1977	Walleye	1,500,000	fry	Muskegon
1978	Walleye	1,000,000	fry	Muskegon
1979	Walleye	1,600,000	fry	Muskegon
1980	Walleye	1,598	fall fingerlings	Muskegon
1991	Walleye	65,209	spring fingerlings	Muskegon
1992	Walleye	114,648	spring fingerlings	Muskegon

Table 1, continued.

1993	Walleye	70,620	spring fingerlings	Muskegon
1995	Walleye	71,298	spring fingerlings	Muskegon
1997	Walleye	78,017	spring fingerlings	Muskegon
1998	Walleye	64,079	spring fingerlings	Muskegon
2000	Walleye	68,828	spring fingerlings	Muskegon
2002	Walleye	36,228	spring fingerlings	Muskegon
2004	Walleye	34,500	spring fingerlings	Muskegon
2006	Walleye	65,049	spring fingerlings	Muskegon
2008	Walleye	28,251	spring fingerlings	Muskegon
2010	Walleye	39,545	spring fingerlings	Muskegon
2012	Walleye	34,486	spring fingerlings	Muskegon
2014	Walleye	33,587	spring fingerlings	Muskegon
2016	Walleye	39,300	spring fingerlings	Muskegon
2018	Walleye	34,907	spring fingerlings	Muskegon

Table 2. Michigan DNR Master Angler awards issued for fish caught from Silver Lake, Oceana County, Michigan, 1994-2019.

Species	Number of Master Angler awards issued
Rock Bass	21
Brown Bullhead	9
White Sucker	5
Black Crappie	2
Largemouth Bass	2
Pumpkinseed Sunfish	2
Bullhead spp.	2
Smallmouth Bass	2
Bluegill	1
Black Bullhead	1
Bowfin	1
Total:	48

Table 3. Presence/absence of fish species in historical fisheries surveys of Silver Lake, Oceana County.

Species	1950	1972	1975**	1976	1977	1978	1980	1983	1984	1994	1997	2019
Banded Killifish	x											
Black Crappie		x		x		x	x	x		x	x	x
Bluegill	x	x		x	x	x		x	x	x	x	x
Bluntnose Minnow												x
Bowfin		x			x			x			x	
Brook Silverside	x											
Brook Trout											x	
Brown Bullhead		x			x			x		x	x	x
Bullhead spp.		x									x	
Common Carp		x	x								x	x
Golden Shiner			x	x								
Hybrid Sunfish	x											
Iowa Darter*	x											
Johnny Darter	x											
Largemouth Bass	x	x	x	x	x	x		x		x	x	x
Longnose Gar		x							x			x
Northern Pike	x	x	x		x			x		x	x	x
Pumpkinseed	x	x		x	x				x	x	x	
Rainbow Trout											x	
Rock Bass	x	x		x	x	x	x	x	x	x	x	x
Round Goby												x
Sand Shiner	x											x
Smallmouth Bass		x			x	x					x	x
Spottail Shiner			x									x
Walleye	x	x	x	x	x	x	x	x	x	x	x	x
White Crappie					x							
White Sucker		x	x		x	x		x	x	x	x	x
Yellow Bullhead	x							x	x	x	x	
Yellow Perch	x	x	x	x	x	x	x	x	x	x	x	x

*Was listed as "Rainbow Darter" on the survey card, but in the writeup (Taube 1951), it is listed as an Iowa Darter.

**Was not a true fisheries survey; instead was a fish toxicant treatment.

Table 4. The number of age-0 and age-1 Walleye caught in MDNR fall electrofishing surveys of Silver Lake, Oceana County, MI from 1997-2016. Catch rates are expressed as the number of Walleye captured per mile of sampling.

		# Walleye captured	Catch Rate
1997	Age-0	390	185.7
	Age-1	0	0
1998	Age-0	145	69.0
	Age-1	20	9.5
2000	Age-0	85	40.5
	Age-1	0	0
2002	Age-0	149	70.9
	Age-1	0	0
2006	Age-0	51	21.8
	Age-1	0	0
2016	Age-0	272	123.1
	Age-1	1	0.5

Table 5. Number, weight, and length of fish collected from Silver Lake, Oceana County, with trap nets, large mesh fyke nets, small mesh fyke nets, and inland gillnets, May 20-24, 2019.

Species	Number	Percent by number	Weight (pounds)	Percent by weight	Length range (inches)[1]	Average length	Percent legal size[2]
Black Crappie	83	17.5	61.7	9.1	4-13	10.6	98 (7")
Bluegill	1	0.2	0.3	0.0	7-7	7.5	100 (6")
Bluntnose Minnow	100	21.1	0.8	0.1	1-3	2.7	
Brown Bullhead	30	6.3	28.6	4.2	10-14	12.7	100 (7")
Common Carp	54	11.4	273.6	40.3	18-30	28.3	21.9
Largemouth Bass	9	1.9	15.1	2.2	13-18	14.6	67 (14")
Longnose Gar	7	1.5	16.5	2.4	20-34	28.9	
Northern Pike	2	0.4	5.1	0.8	20-24	22.5	50 (24")
Rock Bass	28	5.9	16.4	2.4	5-11	9.0	93 (6")
Sand Shiner	2	0.4	0.0	0.0	2-3	3.0	
Smallmouth Bass	1	0.2	3.8	0.6	19-19	19.5	100 (14")
Walleye	33	6.9	64.3	9.5	10-24	17.9	94 (15")
White Sucker	105	22.1	189.8	28.0	9-19	15.7	
Yellow Perch	20	4.2	2.4	0.4	5-10	6.4	5 (7")
Total	475	100	678.4	100			

[1]Note some fish were measured to 0.1 inch, others to inch group: e.g., "5" = 5.0 to 5.9 inch, “12” = 12.0 to 12.9 inches; etc.

[2]Percent legal size or acceptable size for angling. Legal size or acceptable size for angling is given in parentheses.

Table 6. Average total weighted length (inches) at age, and growth relative to the state average, for fish sampled from Silver Lake, Oceana County, with trap nets, large mesh fyke nets, small mesh fyke nets, and inland gill nets, May 20-24, 2019. Number of fish aged is given in parenthesis. A minimum of five fish per age group is statistically necessary for calculating a Mean Growth Index, which is a comparison to the State of Michigan average.

Species	Age I	II	III	IV	V	VI	VII	VIII	IX	X	Mean Growth Index
Black Crappie	5.3 (2)	7.3 (1)	9.2 (6)	10.0 (14)		12.6 (1)	12.5 (2)	13.1 (5)	13.3 (7)	13.6 (2)	+1.6
Bluegill				7.5 (1)							--
Largemouth Bass			13.2 (2)	14.3 (4)	14.1 (2)			18.5 (1)			--
Northern Pike		20.6 (1)			24.4 (1)						--
Smallmouth Bass					19.0 (1)						--
Walleye	10.7 (1)	15.1 (2)	17.3 (17)	19.7 (2)	19.9 (8)		23.8 (2)		19.1 (1)		+2.9
Yellow Perch	5.0 (1)	5.8 (7)	6.1 (7)	8.6 (4)	6.1 (1)						+0.1

Table 7. Number, weight, and length of fish collected from Silver Lake, Oceana County, with seining and electrofishing, June 17, 2019.

Species	Number	Percent by number	Weight (pounds)	Percent by weight	Length range (inches)[1]	Average length	Percent legal size[2]
Black Crappie	4	2.5	2.6	6.1	5-12	9.8	75 (7")
Bluntnose Minnow	1	0.6	0.0	0.0	1-1	1.5	
Brown Bullhead	1	0.6	0.9	2.1	12-12	12.5	100 (7")
Common Carp	4	2.5	18.2	42.9	20-22	21.3	
Longnose Gar	1	0.6	0.5	1.2	19-19	19.5	
Round Goby	1	0.6	0.0	0.0	2-2	2.5	
Sand Shiner	11	6.9	0.1	0.2	2-3	2.6	
Spottail Shiner	38	23.8	0.8	1.9	3-5	4.0	
Walleye	73	45.6	16.4	38.7	7-18	8.3	4 (15")
White Sucker	24	15.0	2.8	6.6	1-17	10.0	
Yellow Perch	2	1.3	0.1	0.2	4-6	5.5	0 (7")
Total	160	100	42.4	94			

[1]Note some fish were measured to 0.1 inch, others to inch group: e.g., "5"=5.0 to 5.9 inch, 12=12.0 to 12.9 inches; etc.

[2]Percent legal size or acceptable size for angling. Legal size or acceptable size for angling is given in parentheses.

Table 8. Average total weighted length (inches) at age, and growth relative to the state average, for fish sampled from Silver Lake, Oceana County, with electrofishing and seining, June 17, 2019. Number of fish aged is given in parenthesis. A minimum of five fish per age group is statistically necessary for calculating a Mean Growth Index, which is a comparison to the State of Michigan average.

	Age									
Species	I	II	III	IV	V	VI	VII	VIII	IX	Mean Growth Index
Black Crappie	5.9 (1)			9.8 (1)		11.7 (1)			12.5 (1)	--
Walleye	7.9 (24)		14.7 (4)							-0.3

Table 9. Temperature, dissolved oxygen, pH, and specific conductance profile for Silver Lake, Oceana County, on 8/8/2019.

Depth (feet)	Temperature (F)	O2 (ppm)	pH	Specific conductance (mS/cm)
0	76.5	7.24	7.94	0.2960
3	76.7	7.22	7.94	0.2961
6	76.7	7.19	7.93	0.2962
9	76.6	7.20	7.90	0.2964
12	76.6	7.16	7.89	0.2965
15	76.5	7.04	7.88	0.2966
18	75.5	2.62	7.3	0.3046

Table 10. Shoreline data for Silver Lake, Oceana County, compared with that for other medium, shallow depth lakes in Michigan (from Wehrly et al. 2015). Sampling was conducted by MDNR Fisheries personnel in August 2019.

	Total docks per km	Dwellings per km	Percent shoreline armoring	Submerged trees per km
Silver Lake	21.7	26.8	41.3	0.3
Michigan statewide average for medium, shallow depth inland lakes	15.3	17.5	53.5	12.0