## Introduction

Sage Lake is a 785-acre impoundment on the headwaters of the Au Gres River. Located 8.5 miles southwest of Hale, Sage Lake has two inlets and the one outlet. There are a variety of habitat types within Sage Lake including embayments, steep drop-offs, and islands. Sage Lake has a maximum depth of 80 feet and only a quarter of the lake is shallow (≤15 feet), littoral habitat. The bottom type in shallower water is sand, scattered gravel, and organic material. In the deeper parts of the lake, the bottom is pulpy peat and muck.

Most of the shoreline of Sage Lake is developed with seasonal or year-round houses. In addition, there is a Michigan Department of Natural Resources (DNR) public access boat launch in the southeast bay of Sage Lake. The boat launch has a gravel launch with one skid pier, parking for up to 26 vehicles with trailers, and a fishing pier. Conservation officers have noted that Sage Lake receives heavy fishing and recreational pressure year-round as there is ample public access; as well as, significant private property ownership around the lake.

## Historical Fisheries Surveys

The fishery communities in Sage Lake have been surveyed and managed for nearly a hundred years by the DNR. Initial management of Sage Lake began in the late 1930s with Walleye fry stockings. Walleye fry were stocked from 1937 to 1944 with little success at establishing a Walleye population in the lake. In 1949, the first biological inventory was conducted on Sage Lake. Subsequent fishery surveys were completed in 1955, 1958, 1965, 1979, 1986, 1988, 1993, 2001, and 2007.

Historically, Sage Lake has had a diverse fish assemblage, characterized by high abundances of Bullhead species and slow growth rates of panfish species. In 1988, manual removal of rough fish species was attempted in Sage Lake; however, it was unsuccessful at capturing substantial numbers of fish for removal. The slow growth rates for panfish was determined to be a result of overpopulation and lack of predators in Sage Lake. In an attempt to increase predator populations in the lake, Northern Pike fingerlings were stocked from 1987 to 1990 and Walleye fingerlings were stocked in 1985 and 1989. Initial surveys following these stocking events indicated that Walleye survival was poor and few fish were reported during the creel survey of the lake. Northern Pike survival was good, but similar to panfish they exhibited slow growth rates. In 1990, Northern Pike stocking was stopped in Sage Lake due to an imbalance in the predator and prey numbers. Since 1990, there have not been any fished stocked in Sage Lake by the DNR; however, the lake association stocked Walleye in Sage Lake under permit in 2005 and 2009.

## Materials and Methods

The 2019 fisheries status and trends community survey was conducted on Sage Lake in June 2019. The survey was conducted according to the Random Status and Trends protocol described by Wehrly et al. (in press). A variety of gears were used to sample the fish community in Sage Lake including boat electrofishing, trap nets, experimental gill nets, seines, large mesh (1.5") fyke nets, and small mesh fyke nets (0.1875"; Figure 1). By using a variety of gear, we targeted different fish species that utilize different habitats within Sage Lake. For example, seines target fish in shallow water habitats, whereas, trap nets and fyke nets target fish that are moving through the littoral zone of the lake. Limnological data was collected on August 28, 2019. The results from the 2019 status and trends survey will be compared to the 2007 Sage Lake status and trends survey.

## Results

A total of 1,939 fish representing 24 species were sampled in Sage Lake in 2019 (Table 1). Bluegill were the most abundant fish species sampled in 2019 with 428 captured representing 22 percent of the total catch. Bluegill varied from one to six inches long with an average length of 3.9 inches. All but four Bluegill sampled in 2019 were less than six inches. In 2007, Bluegill were also the most abundant species sampled with 1,319 individuals representing nearly 56 percent of the catch. Ten percent of the Bluegills sampled in 2007 (104 Bluegill) were six inches or larger. Five year-classes of Bluegill were present in the catch in 2019, but as previously described growth rates were slower than statewide averages. Bluegill growth rates in Sage Lake have increased since the 2007 survey. In 2007, Bluegill in Sage Lake were growing 2.1 inches slower compared to statewide averages; however, in 2019 Bluegill growth rate has slightly increased to only 1.0 inch slower than statewide averages.

Other panfish species sampled in Sage Lake in 2019 include Black Crappie (10 fish), Green Sunfish (19 fish), Pumpkinseed (123 fish), Rock Bass (105 fish), and Yellow Perch (117 fish). Although few Black Crappie were sampled, the average length was 10.7 and 90 percent of fish sampled would be considered desirable to anglers. All the Green Sunfish sampled were five inches in length or less and do not present an additional opportunity for anglers currently based on low size. Pumpkinseed were the second most abundant panfish sampled in 2019. Pumpkinseed varied in size from two inches to eight inches with an average length of 5.0 inches. Unlike Bluegill, Pumpkinseed are growing near statewide averages and 14 percent of the Pumpkinseed (17 individuals) sampled were six inches in length or greater. In 2007, similar trends were noted of Pumpkinseed having larger overall sizes and providing more desirable sized fish for anglers. Rock Bass provide an additional opportunity for panfish anglers in Sage Lake. Rock Bass varied in size from two inches to eleven inches with an average length of 6.6 inches. Yellow Perch were the third most abundant panfish species sampled in Sage Lake in 2019. Yellow Perch varied from two inches to eight inches with an average length of 4.6 inches. Nearly all Yellow Perch sampled would not be desirable for anglers.

The predator fish community in Sage Lake was represented by Bowfin, Grass Pickerel, Largemouth Bass, Longnose Gar, Northern Pike, Smallmouth Bass, and Walleye. The total abundance of predators combined represented only four percent of the entire fish assemblage sampled. Bowfin were the most abundant predator fish sampled with 31 fish sampled varying in size from 16 inches to 24 inches with an average length of 19.9 inches. Although not typically thought of as a gamefish, Bowfin provide an excellent angling opportunity, as they are known for putting up a good tug. Only one Grass Pickerel and one Walleye were sampled in 2019. Longnose Gar were the second most abundant predator fish with 29 fish sampled.

Northern Pike were the most abundant gamefish predator species that was sampled with 22 fish varying in size from 17 inches to 32 inches with an average length of 22.9 inches. Eight year-classes of Northern Pike were sampled in 2019 and growth rates averaged 3.5 inches less than statewide growth rates for Northern Pike. Similar results were documented in the 2007 survey, where 27 Northern Pike were sampled with an average length of 21.1 inches and on average Northern Pike were growing 3.3 inches below the statewide average. Thirteen Largemouth Bass varying in size from 6 inches to 17 inches with an average length of 13.2 inches were sampled. Seven-year classes of Largemouth Bass were present; however, there were not adequate samples to make comparisons about growth rates to statewide averages. In the 2007 survey, 47 Largemouth Bass were sampled, and the average length was 12.4 inches, with six-year classes of Largemouth Bass present in Sage Lake. Finally, five Smallmouth Bass were sampled with an average length of 7.5 inches.

Rough fish are still abundant in Sage Lake and represent approximately 21 percent of the overall catch in 2019. Yellow Bullhead were the most abundant rough fish sampled with 253 fish sampled varying in size from 5 inches to 14 inches with an average length of 10.1 inches. One hundred sixty-three Brown Bullhead were also sampled in 2019 varying in size from 4 inches to 14 inches with an average length of 10.6 inches. The number of both Bullhead species was similar to catch rates in 2007. As noted in previous surveys, both Bullhead species are reaching large sizes in Sage Lake.

Other species sampled in 2019 include Banned Killifish, Blackchin Shiner, Bluntnose Minnow, Blacknose Shiner, Golden Shiner, Iowa Darter, Johnny Darter, Lake Chubsucker, and Tadpole Madtom. These fish are forage fish in Sage Lake and do not provide additional opportunities for anglers.

The 2019 limnological survey on Sage Lake indicated that the thermocline was around 20.5 feet, which was nearly identical to the limnological survey conducted in 2007 (20 feet). From 20 feet to the bottom, both temperature and oxygen decline to levels that cannot support fish (Table 2). The clarity of Sage Lake is similar from 2007 to 2019 with a secchi disk reading of 16 feet and 14 feet respectively. The main difference in the limnological features of the lake is the pH. In 2007, pH values varied from 6.5-7.6; whereas, in 2019 pH values varied from 6.74-8.25. Total alkalinity was 128 mg/L in 2019, but not measured in 2007.

During the limnological portion of the survey, information was also collected about shoreline features on lakes including number of small docks, large docks, dwellings, submerged trees, and percent of armored shorelines in each segment. In total, Sage Lake had 449 small docks, 33 large docks, 547 dwellings, and 32 submerged trees around the lake. The average amount of shoreline that has been armored was 46 percent. There has been a cumulative increase of 24 docks from 2007 to 2019 when combining the small and large docks numbers. In addition, the average amount of armoring has also increased from 43.2 percent in 2007.

## Discussion

The Bluegill population in Sage Lake appears to be declining in terms of overall abundance of fish and size of fish. Bluegill growth rates were slightly better compared to the 2007 status and trends survey on Sage Lake. Although growth rates are improving, we did not sample any desirable sized Bluegills that anglers would enjoy catching in Sage Lake. In addition to the Bluegill population, the other panfish species besides Pumpkinseed do not provide an angling opportunity currently due to low size. The low size distribution and angling opportunities for panfish species in Sage Lake is troubling. Initial conclusions may point to the lack of predators present in the 2019 survey. It should be noted though that more predators, especially Northern Pike, may be present in Sage Lake, but were not accurately assessed with this survey. In order to fully understand the Northern Pike population in the lake, an ice-out survey would be necessary. This type of survey is rather challenging given variability in weather conditions, ice out timing, and other scheduling conflicts.

In addition to the gamefish, Sage Lake has a substantial population of Yellow Bullhead and Brown Bullhead. Actual number of Bullhead species sampled has remained similar overtime, but the relative amount of Bullhead compared to all other fish in Sage Lake has increased with time. This trend is worth noting as it may lend some insight into the panfish populations declining.

## Management
1. Continue to manage Sage Lake as a warm-water fishery with focus on panfish, Largemouth Bass, and Northern Pike. This lake does not appear to be suited for Walleye.
2. Consider an additional survey to gather further information on the Northern Pike fishery to better understand the predator prey relationships in Sage Lake.
3. Explore other options for weed treatments in terms of timing, areas of the lake, and any potential alternatives.
4. Institute an angler diary program with Lake Association members to try and understand the changing dynamics of Sage Lake, while learning more about how to bolster the poor panfish fishery in the lake.
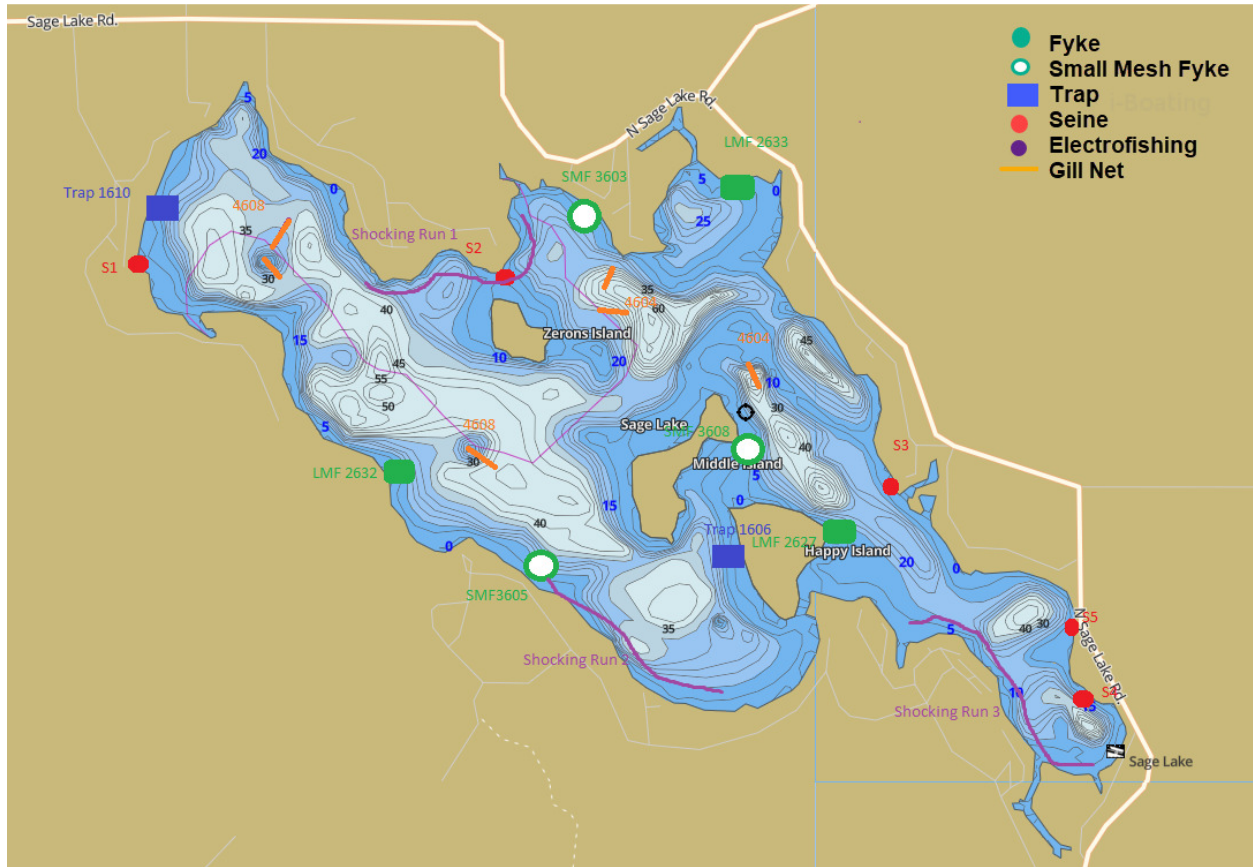
## Tables and Figures



Figure 1. Contour map of Sage Lake with locations of all gear used during the 2019 status and trends survey, conducted in June 2019.

Table 1. Fish species captured during the 2019 status and trends survey on Sage Lake. All gears used are combined and columns represent number of fish, percent by number, and average length of each species captured.

| Species | Number | % by Number | Average Length (inches) |
| --- | --- | --- | --- |
| Black Crappie | 10 | 0.5 | 10.7 |
| Blackchin Shiner | 52 | 2.7 | 1.9 |
| Banded Killifish | 251 | 12.9 | 2.4 |
| Bluegill | 428 | 22.1 | 3.9 |
| Bluntnose Minnow | 209 | 10.8 | 2.4 |
| Blacknose Shiner | 60 | 3.1 | 1.9 |
| Bowfin | 31 | 1.6 | 19.9 |
| Brown Bullhead | 163 | 8.4 | 10.6 |
| Golden Shiner | 5 | 0.3 | 4.5 |
| Grass Pickerel | 1 | 0.1 | 13.5 |
| Green Sunfish | 19 | 1.0 | 3.7 |
| Iowa Darter | 22 | 1.1 | 1.6 |
| Johnny Darter | 2 | 0.1 | 1.5 |
| Lake Chubsucker | 1 | 0.1 | 7.5 |
| Largemouth Bass | 13 | 0.7 | 13.2 |
| Longnose Gar | 29 | 1.5 | 25.0 |
| Northern Pike | 22 | 1.1 | 22.9 |
| Pumpkinseed | 123 | 6.3 | 5.0 |
| Rock Bass | 105 | 5.4 | 6.6 |
| Smallmouth Bass | 5 | 0.3 | 7.5 |
| Tadpole Madtom | 16 | 0.8 | 3.3 |
| Walleye | 1 | 0.1 | 21.5 |
| Yellow Perch | 117 | 6.0 | 4.6 |
| Yellow Bullhead | 254 | 13.0 | 10.1 |

Table 2. Limnological readings by two-foot increments including water temperature in Fahrenheit (F), Oxygen in parts per million (ppm), and pH.

| Depth (ft) | Temperature (F) | Oxygen (ppm) | pH |
|---|---|---|---|
| 0 | 71.4 | 8.32 | 8.25 |
| 2 | 71.9 | 8.03 | 8.31 |
| 4 | 71.9 | 8.14 | 8.32 |
| 6 | 71.9 | 8.2 | 8.33 |
| 8 | 71.9 | 8.22 | 8.32 |
| 10 | 71.9 | 8.02 | 8.32 |
| 12 | 71.8 | 8.17 | 8.32 |
| 14 | 71.8 | 8.23 | 8.32 |
| 16 | 71.8 | 8.08 | 8.32 |
| 18 | 71.1 | 7.75 | 8.22 |
| 20 | 62.8 | 0.59 | 7.44 |
| 22 | 60.0 | 0.25 | 7.27 |
| 24 | 57.2 | 0.22 | 7.19 |
| 26 | 54.6 | 0.23 | 7.05 |
| 28 | 53.1 | 0.23 | 7.00 |
| 30 | 52.8 | 0.23 | 6.97 |
| 32 | 52.1 | 0.23 | 6.94 |
| 34 | 50.8 | 0.26 | 6.89 |
| 36 | 49.5 | 0.25 | 6.86 |
| 38 | 48.7 | 0.26 | 6.84 |
| 40 | 48.1 | 0.33 | 6.80 |
| 42 | 47.9 | 0.30 | 6.77 |
| 44 | 47.6 | 0.27 | 6.76 |
| 46 | 47.0 | 0.28 | 6.86 |
| 48 | 47.0 | 0.27 | 6.84 |
| 50 | 46.9 | 0.28 | 6.82 |
| 52 | 46.7 | 0.29 | 6.80 |
| 54 | 46.8 | 0.28 | 6.79 |
| 56 | 46.7 | 0.30 | 6.77 |
| 58 | 46.6 | 0.30 | 6.76 |
| 60 | 46.5 | 0.29 | 6.76 |
| 62 | 46.1 | 0.28 | 6.74 |
| 64 | 46.1 | 0.29 | 6.76 |
| 66 | 46.3 | 0.30 | 6.76 |
| 68 | 46.3 | 0.30 | 6.76 |
| 70 | 46.3 | 0.29 | 6.76 |
| 72 | 46.3 | 0.30 | 6.75 |
| 74 | 46.2 | 0.29 | 6.76 |
| 76 | 46.2 | 0.30 | 6.76 |
| 78 | 46.2 | 0.30 | 6.78 |