Perch Lake

Marquette County, T46N, R29W, Section 08
Middle Branch of the Escanaba River, 2018

John M. Bauman, Fisheries Biologist

Environment

Location

Perch Lake is a deep and small 46-acre lake located in western Marquette County in Michigan's Upper Peninsula (Figure 1). In Marquette County, the city of Republic resides immediately west, while the cities of Champion and Humboldt reside to the north off M-28. Republic is noted as being "quietly world famous" for the four seasons of activities (e.g., fishing, hunting, ORVing, hiking, ice fishing, snowshoeing) which exist there. Republic, named after the Republic Iron Company, has supported an attractive mining industry for ore deposits which still exist beneath the soil.

Geology and Geography

Perch Lake is located within a region formed during the Precambrian period and consists of igneous and metamorphic rocks including iron-boring rock (MDNR, 2001). The surficial geology includes thin to discontinuous glacial till over bedrock. Surrounding shoreline soils consist mainly of Sundog silt loam with rocks and boulders, while adjoining areas with moisture contain Carbondale and Tawas soils. Both soil types are typical of glacial outwash regions of Michigan, however Sundog silt loam is more characteristic of sloping rocky surfaces, while Carbondale or Tawas soils are more characteristic of flat less permeable surfaces (USDA 2017).

Watershed Description

Perch Lake is a semi-disconnected waterbody located within the Middle Branch of the Escanaba River watershed. Bruce Creek, which is close to Perch Lake is likely only connected during periods of high water through intermittent outlets. Bruce Creek then flows into the Black River which flows easterly and serves as a tributary to the Middle Branch of the Escanaba River. The Middle Branch of the Escanaba River flows southeast to Gwinn, Michigan where it joins the East Branch of the Escanaba River and flows into the Main Branch of the Escanaba River (Escanaba River). The Escanaba River flows south towards the towns of Escanaba and Gladstone and serves as a tributary to Lake Michigan. Perch Lake is a deep, relatively long (0.7 miles) and narrow (0.2 miles) waterbody positioned on a northwest to southeast axis. Mapped in 1966, Perch Lake was calculated to be approximately 46.5 acres with a volume of 1009.5 acre-feet. Approximately 27 percent of the volume of Perch Lake is equal to or deeper than 20 feet in and the maximum depth is 55 feet. Bottom substrates consist of sand, gravel and rock near shore while deeper regions of Perch Lake consist of organic matter or pulpy peat. Aquatic vegetation consists of emergent (rare), submergent (common) and floating (rare) plants including Potamogetan, pickerel weed, pondweed, lily pads and leatherleaf.

Status of Lake Habitat

Habitat conditions within Michigan's inland lakes determine the rates of reproduction, mortality, and growth of fish that inhabit a waterbody. Consequently, the abundance as well as the type of fish that may inhabit a lake can also be determined by inland lake habitat. Habitat conditions influence water quality and general appearance of a lake, and as a result, can also determine the suitability of lake for

being a source for drinking water, swimming, fishing and boating. More generally, habitat indicators are used to assess the chemical, physical, and biological conditions in an inland lake.

Chemical Characteristics

Total Alkalinity - Total alkalinity is a measure of buffering capacity and plays an important role in determining a waterbody's pH (Wetzel 2001, Wehrly et al. 2015). Alkalinity values in Michigan inland lakes can be classified into low (< 49.5 mg/L CaCO3), medium (49.5 to 141.5) and high (>141.5) categories. On 22 August 2018, alkalinity in Perch Lake was less than 20 mg/L (low) which is similar to or lower than alkalinity samples taken during the 1960s. Therefore, Perch Lake has less capacity to buffer against significant changes in pH which fluctuate during spring run-off or snow melt periods. The average alkalinity value for small, deep inland lakes located within watersheds of northern Lake Michigan is 34 mg/L (Wehrly et al. 2015). Comparatively, Perch Lake has below average alkalinity when compared to other inland waterbodies similar in size. In addition to alkalinity, pH was measured on 22 August 2018 at multiple depths and the average pH was 6.63 (near neutral or normal).

Nutrients - Phosphorus and nitrogen are two important nutrients which influence production, biomass, and species composition of aquatic and nearby terrestrial plants in lake ecosystems. Concentrations of these two nutrients vary naturally depending on geology, watershed and the rate at which water cycles through a waterbody. Human-derived inputs of nutrients can lead to eutrophication which results in an increase in production of phytoplankton and aquatic macrophytes, which can often become noxious or a nuisance. As plants decompose, oxygen in the water is consumed by microorganisms and can be reduced to levels which compromise fish habitat and subsequently fish abundance. Alternatively, inland lakes which are characterized as having `too few' nutrients tend to have lower levels of primary production and thus much lower growth rates and less biomass per acre (e.g., standing crop). Total phosphorus occurs in relatively low concentrations in the aquatic environment and as a result tends to be the limiting nutrient for primary producers (phytoplankton, periphyton, and aquatic vegetation) in an aquatic ecosystem. Phosphorus values typically vary quite widely across Michigan inland lakes having low (<0.009 mg/L), medium (0.009 to 0.020 mg/L), and high (>0.020 mg/L) concentrations. Total phosphorus values in Perch Lake were measured 22 August 2018 and were reported to be 0.0048 mg/L (low). The average total phosphorus concentration for small deep lakes in the Perch Lake region is 0.0120 mg/L (Wehrly et al. 2015). In contrast to phosphorus, total nitrogen occurs in relatively high concentrations in aquatic environments and as a result, rarely limits primary production in lakes. Nitrogen values in Michigan inland lakes range from low (<0.403 mg/L), medium (0.403 to 0.750 mg/L), and high (>0.750 mg/L) concentrations. Total nitrogen values in Perch Lake were measured 22 August 2018 and were reported to be 0.391 mg/L (low). The average total phosphorus concentration for small deep lakes in the Perch Lake region is 0.550 mg/L. Values for phosphorus and nitrogen were at or just below average compared to similar sized waterbodies in the region. Also, based on the ratio of total nitrogen to total phosphorus (N:P), managers can classify lakes that may be limited by one nutrient versus the other. For example, plants typically require a specific ratio of N:P which tends to be 18:1, where total phosphorus is the limiting nutrient. In 2018, the N:P ratio for Perch Lake was 81:1 which suggests that total phosphorus is the nutrient which limits primary production in Perch Lake.

Dissolved Oxygen - Dissolved oxygen (DO) is a critical component to available habitat in aquatic ecosystems. Dissolved oxygen in lakes derives from the atmosphere as well as from aquatic

plants during photosynthesis. Concentration of DO in lakes can limit the distribution and growth of fish in lakes as well as the size composition and biomass of zooplankton. Concentrations of DO begin to limit cool- and warmwater fish populations at approximately 3.0 mg/L and are often lethal below 0.5 mg/L (Schneider 2002). As DO becomes limited, two regions which characterize low levels of DO exist. The hypoxic region, which is characterized by having low levels (e.g., less than 2 to 4 mg/L) of DO and the anoxic region which contains no DO. Results from DO profiles collected in winter and summer of 2018 (Figure 3) suggest that deep regions of Perch Lake had limited oxygen availability (Figure 3). During winter months, depths from 30- to 40-foot were measured as hypoxic (e.g., less than 2 to 4 mg/L), while depths greater than 40-foot were void of oxygen (anoxic). Approximately 9 percent of the lake bottom has limited to no oxygen available to aquatic organisms during the winter. During the summer, the depth of 24 foot was recorded as hypoxic while all deeper regions were recorded as anoxic. Therefore, approximately 18 percent of the lake bottom has limited to no oxygen available to aquatic organisms during the summer. Conversely, approximately 91 and 76 percent of the lake provides enough oxygen to support the aquatic community in Perch Lake during winter and summer, respectively. Compared to the regional average (63 percent, Wehrly et al. 2015) Perch Lake has a high percentage of the water column with suitable oxygen in the summer.

Physical Characteristics

Stratification - Thermal stratification (which is evaluated using a temperature profile) in lakes typically occurs in deep lakes during the summer months of the year where three water column `layers' form, which are called the epilimnion, metalimnion, and hypolimnion. The epilimnion consists of the upper layer of the water column which is characteristically warmer and has adequate levels of sunlight penetration to support photosynthesis. The metalimnion is the layer between the epilimnion and hypolimnion characterized by a quick transition in temperature change. The point at which temperature change is greatest within the metalimnion is referred to as the `thermocline'. On 13 August 1968, a summer temperature profile was recorded in Perch Lake (Figure 3). Additionally, on 19 March 2018 (winter) and 22 August 2018 (summer) temperature profiles (Figure 2) were recorded to capture information during periods of the year when these parameters may limit growth and survival of fish populations. Temperature profiles gathered from the summer of 1968 and 2018 are similar and show that Perch Lake thermally stratifies in the summer with a distinct thermocline located between the 15 to 20-foot depth range.

Transparency - Water transparency, which is measured using a Secchi Disk, provides an index of phytoplankton production and overall lake productivity. For example, lakes with greater transparency (i.e., greater Secchi depth) are often classified as Oligotrophic, meaning there are low levels of lake productivity (e.g., standing crop). Summer Secchi depths vary considerably across Michigan with lakes having low (<7.5 feet), medium (7.5 to 13.5 feet), and high (>13.5 feet) transparency. On 22 August 2018, the Perch Lake Secchi Disk reading was 15 feet (high). The average Secchi depth for small deep inland lakes in the Perch Lake region is 13.0 feet which suggests that Perch Lake is more transparent (less productive) than similar-sized waterbodies.

Residential Development - Residential development provides an index of the potential influence human activities have in areas adjacent to shoreline resources. Building structures (dwellings) in riparian areas, removing vegetation or woody debris, armoring shorelines, and building docks all have the potential to impact lake ecosystems and negatively affect fish populations and water quality. Dwelling density values along Michigan inland lake shorelines can be classified as low (<4.8

dwellings per mile), medium (4.8 to 30.4 dwellings per mile) and high (>30.4 dwellings per mile). The number of dwellings per mile along the shoreline of Perch Lake was measured 22 August 2018 and is reported to have 1.6 dwellings per mile (low). The average number of dwellings per mile for small deep inland lakes in the Perch Lake region is 7.3 which suggest that Perch Lake is relatively undeveloped.

The density of boat docks, measured as the number of docks per mile of shoreline, provides an index of the nearshore disturbance level as well as the potential boat activity level. Construction of docks is often accompanied by the removal large woody debris and aquatic vegetation which disrupts nearshore sediment and reduces available refugia habitat for aquatic organisms. Dock density values along Michigan's inland lake shorelines can be classified as low (<1.9 docks per mile), medium (1.9 to 21.9 dock per mile) and high (>19.1 docks per mile). The number of docks in Perch Lake was measured 22 August 2018 and is reported to be 2.1 docks per mile (medium). The number of docks per mile for small deep inland lakes in the Perch Lake region is 5.3 which suggests that Perch Lake is less impacted by the construction of docks compared to similar sized waterbodies.

The degree to which lake shorelines have been armored, to reduce impacts of wave action, provides an index of the extent to which shorelines may have been modified from their natural state. Shoreline armoring is measured as the percent of shoreline armored across all transects. The amount of shoreline armoring in Michigan's inland lakes can be classified as low (<0.6 percent), medium (0.6 to 30.1 percent) and high (>30.1 percent). The amount of shoreline armoring was measured in Perch Lake 22 August 2018 and is reported to be 0.0 percent. The average amount of shoreline armored in other nearby similar sized waterbodies is 5.1 percent, which suggests that the Perch Lake shoreline is largely intact.

Large woody debris is an important habitat component providing structure for aquatic organisms (e.g., fish, aquatic insects) during various life periods and providing stability of the lake bottom (e.g., sediments, vegetation). Trees growing adjacent to shoreland fall into the water and become a primary source for large woody debris habitat, however humans have greatly impacted the degree to which large woody debris exists in many lakes. Humans often remove woody debris from shoreline areas reducing critical habitat. Furthermore, humans reduce recruitment of new large woody debris by removing trees from shoreland areas during landscaping. The amount of large woody debris in Michigan's inland lakes can be classified as low (<1.1 trees per mile), medium (1.1 to 22.7 trees per mile) and high (>22.7 trees per mile). The amount of large woody debris in Perch Lake was measured 22 August 2018 and is reported to be 108.4 trees per mile (high). Approximately 50 percent of the large woody debris which existed in Perch Lake was located in the southeastern corner of the lake. The average amount of large woody debris in nearby similar sized waterbodies is 528 per mile which suggests that Perch Lake has less than average nearshore habitat.

Biological Characteristics

Additional biological parameters provide a picture of lakes level of productivity. The more productive a lake is, the more aquatic organisms (e.g., fish, insects) the lake can `grow' and support. Biological parameters often used to gauge a lake's level of productivity include; chlorophyll-a, trophic status and zooplankton size. Zooplankton size was not measured due to time and staff constraints and is not discussed further in this report.

Chlorophyll-a - Chlorophyll-a is a pigment used by plants for photosynthesis. Summer chlorophyll-a concentrations in the epilimnion provide a measure of lake primary production by phytoplankton. Chlorophyll-a can be used to estimate trophic state which provides an index of overall lake productivity. Lake which have `low' levels of chlorophyll-a tend to be limited by low nutrient availability or by high rates of grazing by zooplankton. Concentrations of chlorophyll-a in Michigan's inland lakes can be classified as low (<1.9 ug/L), medium (1.9 to 4.8 ug/L) and high (>4.8 ug/L). The concentration of chlorophyll-a in Perch Lake was measured 22 August 2018 and is reported to be 1.6 ug/L (low). The average chlorophyll-a concentration for nearby similar sized waterbodies is 3.2 ug/L which suggests that Perch Lake has half the average level of nutrients for phytoplankton to utilize in the epilimnion.

Trophic status - Trophic status provides an index of the amount of phytoplankton production can occur in a lake. This is determined by using a Carlson's Trophic Index (TSI) which uses phosphorus, Secchi depth, and chlorophyll-a values to provide a value which fits between a scale of 0 to 100 (Fuller and Jodoin 2016). Lakes with low TSI values tend to represent waterbodies with low phytoplankton production, while lakes with higher TSI values tend to represent lakes with high phytoplankton production. Values for TSI can be classified as oligotrophic (TSI<38), mesotrophic (TSI from 38 to 48), eutrophic (49 to 61), and hypereutrophic (TSI>61). On 22 August, the total phosphorus, Secchi depth, and chlorophyll-a values were reported to be 4.8 ug/L, 15.0 ft, and 1.6 ug/L, respectively (Average TSI = 33, oligotrophic).

Based upon chemical, physical, and biological parameters measured, Perch Lake is characterized as being a deep, small, oligotrophic lake where primary production is limited by the low availability of nutrients and woody habitat. Given the temperature and dissolved oxygen profiles collected during the summer, some fish species (cold-water) may be limited in their abundance and distribution in Perch Lake. Additionally, while the Perch Lake shoreline is largely undeveloped the amount of in-lake habitat (i.e., large woody debris) is below average and likely limits the size and abundance of some fish species (e.g., panfish) available.

Development, Public Ownership, and Access

The Republic area is a recreational destination offering diverse outdoor activities (e.g., camping, hunting fishing, hunting, ORVing, hiking, ice fishing, snowshoeing). A large portion of the Perch Lake north shore is public land owned either by Republic Township or the State of Michigan (Figure 4). Historically, Perch Lake was utilized by the village of Republic as a water source until 1962 however, this ceased and later became a popular fishing location by residents of Republic. A public boat launch exists (GPS: 46.399084 -87.954133) in the south east corner of the lake which was installed by the Republic Sportsmen's Club. The public access site was later purchased by the Michigan Department of Natural Resources in 2004. In 1985, foot paths were developed along the shore of Perch Lake to provide additional shoreline fishing access. An electrical transfer station is located at the west end of the lake and electrical transmission lines cross the western portion of the lake from south to north.

History

Fisheries management began in 1936 when 1,200 adult Yellow Perch were stocked in Perch Lake. Perch Lake has had a long history of stocking and details of historical stocking records may be found in Table 1. Following that initial stocking of Yellow Perch, a more focused management effort began

in the 1960s to manage Perch Lake as a Rainbow Trout fishery. While there were undocumented attempts to establish Northern Pike and Walleye in Perch Lake led by local anglers, fishing was often reported a poor. Therefore, in 1966 the Michigan Department of Conservation (hereinafter referred to as MI DNR) conducted a preliminary survey to evaluate the current Perch Lake fish community and establish a direction towards trout management.

At the time of the survey, Smallmouth Bass, Walleye, Northern Pike, Pumpkinseed, Bluegill and Yellow Perch made up most of the catch. Soon after this survey, Perch Lake was chemically treated to remove all species and begin management for Rainbow Trout. By this time, the public had interest in the chemical reclamation and were noted to be in favor of trout management. From 1967 to 1980 Rainbow Trout (strain: Michigan steelhead) had been stocked routinely while providing a popular night fishery. In July of 1968, MI DNR staff responded to reports of "film" and "iron dust" which had originated at the local mine, been carried by a southwest wind, and later settled on the surface of Perch Lake. This was a concern for anglers given that trout management of Perch Lake had become popular after the recent chemical reclamation. A survey conducted soon after the reports of `pollution' captured a total of 63 Rainbow Trout, which were noted to be in excellent condition with sufficient fat deposits. Two Rainbow Trout captured were noted as having `ragged' caudal fins.

As trout management became more popular in the late 1960s, the Republic Sportsman's Club built and opened a public access site on the southeast side of the lake. In August of 1968 MI DNR staff conducted a limnological survey of Perch Lake to see if the lake thermally stratified and to quantify the amount of oxygen available in the water column (Figure 2). Results from this survey showed that little to no oxygen was available below 15 feet of water in Perch Lake.

From the 1960s through the 1970s Perch Lake had been stocked with a total of 86,636 Rainbow Trout with an average stocking rate of 134 per acre ranging from 51 to 218 fish per acre. In 1972 MI DNR staff conducted a survey to evaluate the trout management program. Several non-desirable species were captured (i.e., Pumpkinseed) which warranted an additional chemical reclamation. Additional species captured during this survey included Bluntnose Minnow, Pearl Dace, and Brook Stickleback. In 1974, Perch Lake was again chemically treated to remove non-desirable species. Similar to the treatment conducted the decade prior, this treatment used 185 gallons of rotenone to achieve a 0.5 mg/L concentration which cost approximately $1,326.00 dollars (equivalent to $7,213.44 today). Post-treatment, the following fish were captured as part of a follow-up survey: Rainbow Trout, Pumpkinseed, Rainbow Smelt, and Common White Sucker, assorted minnows, shiners, and sticklebacks. Following the treatment, Rainbow Trout management resumed, and stocking continued.

During the 1980s, management shifted in Perch Lake from providing a Rainbow Trout fishery to providing a Splake fishery. A survey conducted in 1980 found that non-desirable species had once again became established in Perch Lake, however it was noted in an agency report that numbers were not likely to negatively affect trout management. Results from this survey also concluded that Rainbow Trout were growing 2 to 5 inches above the state average (for one and two-year old fish). However, by October of 1980, MI DNR staff requested that the Michigan steelhead strain of Rainbow Trout no longer be stocked given that their growth was slow compared to alternatives available (i.e., Splake). Additionally, given that warmwater `non-desirable' species had again become established, agency staff recommend that Splake be considered for future stocking as this species was expected to

fare better in association with non-desirables. From 1981 to the late 1980s, Perch Lake was stocked with 23,490 Splake at an average stocking rate of 64 per acre ranging from 24 to 98 fish per acre.

By 1984 Perch Lake was sought by anglers for Rainbow Smelt, Pumpkinseed, Rainbow Trout and Splake. However, MI DNR staff had received reports from anglers that the banks of Perch Lake were difficult to access. Therefore, a permit was approved to create access paths and clear brush near the shoreline in hopes of improving angler access. No records exist pertaining to whether this project was completed. In addition to Splake; Rainbow Trout, and large hatchery Brook Trout were also stocked into Perch Lake. In 1988, MI DNR staff conducted a survey of Perch Lake to evaluate the Splake stocking program. A total of 104 Splake were captured and were noted as being in `excellent health', with stomachs gorged with small insects. Yellow Perch were also captured, however were not believed to be in high abundance and thus would not negatively affect trout management. Following the 1988 survey, MI DNR staff wrote an additional prescription requesting a continuation of stocking Splake noting that a popular winter sport fishery had developed.

During the 1990s Perch Lake continued to be stocked with Splake at an average rate of 59 fish per acre ranging from 38 to 98 fish per acre. In addition to Splake, Rainbow Trout were stocked annually from 1995 to 1999 with Arlee, Shasta, and Kamloops strains. Stocking prescriptions from the early 1990s stated that Rainbow Smelt were also noted as having been stocked by the Republic Sportsman's Club. However, it is unknown how many were planted in Perch Lake.
In 1993, a fishery survey was conducted by MI DNR in collaboration with the Republic Sportsman's Club to evaluate trout management in Perch Lake. Recent fishing reports for Perch Lake for Splake and Rainbow Smelt were noted as `poor'. By this time, non-desirable species (e.g., Rock Bass, Common White Sucker, and Yellow Perch) were thought to be in too high of abundance and might be negatively affecting trout management. During this survey, non-desirable species captured in nets were not returned to the water. A total of 8, 605, and 46 lbs of Yellow Perch, Common White Sucker and Rock Bass respectively, were removed from Perch Lake. Agency staff recommended that a chemical reclamation be conducted to remove additional non-target species in order to resume trout management and improve fishing quality. However, permits needed to conduct the chemical reclamation were not supported and so other alternatives were explored (i.e., manual removal). In 1994 a survey was conducted in Perch Lake to manually remove non-target species which were believed to be competing with trout and Rainbow Smelt, resulting in poor fishing. A total of 50, 725, and 150 lbs of Yellow Perch, Common White Sucker, and Rock Bass respectively, were captured and removed from Perch Lake. The cumulative weight of fish removed in 1993 and 1994 was 58, 1,330, and 190 lbs of Yellow Perch, Common White Sucker, and Rock Bass, respectively. Additional species captured during manual removal efforts include 48 Splake and one Rainbow Smelt. No follow-up surveys were conducted to evaluate the effectiveness of the manual removal.

During the 2000s, Splake stocking continued at an average rate of 64 fish per acre ranging from 9 to 87 fish per acre. In 2007 a survey was conducted to evaluate the Splake fishery. A total of 57 Splake were captured and were noted as `having very little body fat' and looking `very slender' which suggested a lack of forage. In addition to reports of poor body condition, angler reports for Splake had been poor for several years. These data, in addition to poor fishing reports resulted in a cessation in Splake stocking in 2007 given that there was limited forage available to support stocked Splake. Perch Lake had provided a sufficient Splake fishery for some time prior to reports of poor returns.

Therefore, trout management was not abandoned but shifted from stocking Splake to stocking Rainbow Trout, large Brook Trout and Lake Trout.

Following the 2007 survey, Rainbow Trout (strain: Eagle Lake) were stocked routinely at an average rate of 34 fish per acre ranging from 21 to 128 fish per acre. However, no surveys had been conducted to evaluate the Rainbow Trout fishery. Perch Lake has been managed as a trout fishery for nearly 50 years shifting from Rainbow Trout to Splake while conducting chemical reclamations and manual removals. Beginning in 2016, MI DNR staff began receiving reports of poor returns of Rainbow Trout in Perch Lake. These reports, in addition to Perch Lake being randomly selected for a Status and Trends Survey, prompted a substantial survey effort in 2018. Perch Lake was sampled in March, June, August, and October of 2018 in attempt to evaluate trout management. Results from these surveys will provide the information needed to update or create a new management recommendation for Perch Lake.

Current Status

Three surveys were used to determine the current status of the Perch Lake fishery. The first survey, conducted in June of 2018, was a Status and Trends Survey used to gather general information about the fish community with respect to available habitat. Three additional surveys were conducted to evaluate the current Rainbow Trout management program that has existed in Perch Lake for several decades. The first of these three Rainbow Trout management surveys included a late winter (March of 2018) limnological survey used to quantify available habitat when conditions may limit fish survival and growth. The second of these two surveys consisted of a netting survey conducted in October of 2019 targeting Rainbow Trout specifically. The third of these surveys included an additional limnological profile conducted during August of 2018. Information from general surveys conducted in 1988, 1993, 1999 and 2007 were also referenced in the Analysis and Discussion section to evaluate long-term trend capture information.

Status and Trends Survey 2018

A total of 2,877 fish totaling 226 pounds were captured during the June 2018 Status and Trends survey which included 10 species (Table 2). Piscivore or gamefish species such as Smallmouth Bass, Rock Bass, and Yellow Perch comprised 56 percent of the catch by number and 61 percent of the total biomass. Benthic species, such as bottom dwelling Common White Sucker and Brown Bullhead comprised less than 1 percent of the catch by number and approximately 1 percent of the total biomass. Lastly, pelagic species (Planktivore-Insectivores) such as shiners, Pumpkinseed and Rainbow Trout comprised 44 percent of the catch by number and 38 percent of the total biomass. A summary of species captured by gear type in comparison to regional and state averages may be found in Table 3. The estimated standing crop biomass of Perch Lake is approximately 49 pounds of fish per acre (Schneider 2000).

A total of 8 Smallmouth Bass averaging 10.6 inches comprised 0.3 percent of the catch by number and 2.4 percent of the catch by biomass. Smallmouth Bass sized ranged from 6.0 to 13.0 inches in length and zero percent of the catch met the minimum size for harvest (14.0 inches). Insufficient numbers of Smallmouth Bass were captured to assess age composition or make growth comparisons.

A total of 162 Yellow Perch averaging 6.6 inches comprised 5.6 percent of the catch by number and 6.6 percent of the catch by biomass. Yellow Perch sized ranged from 2.0 to 8.0 inches in length and 30 percent of the catch met the minimum preferred size for harvest (greater than 6.0 inches). Age

distribution indicated annual recruitment from 7 year-classes. Age analysis indicated that 6 year-old Yellow Perch were growing nearly 3.0 inches below state average.
A total of 1,428 Rock Bass averaging 4.8 inches comprised 49.6 percent of the catch by number and 51.7 percent of the catch by biomass. Rock Bass size ranged from 2.0 to 7.0 inches and 3.0 percent of the catch met the minimum preferred size for harvest (6.0 inches). Insufficient numbers of Rock Bass were captured to assess age composition or make growth comparisons.

A total of 1,195 Pumpkinseed averaging 4.2 inches comprised 41.5 percent of the catch by number and 36.8 percent of the catch by biomass. Pumpkinseed size ranged from 1.0 to 6.0 inches in length and zero percent of the catch met the minimum preferred size for harvest (greater than 6.0 inches). Age distribution indicated annual recruitment from 8 year-classes (ages 3 to 11, excluding 10). Age analysis indicated that 6 year-old Pumpkinseed were growing more than 2.0 inches below state average.

Rainbow Trout Management Evaluation
During March 2018, the Perch Lake water column was sampled from the surface to a depth of 55 feet. One-hundred percent of the Perch Lake water column recorded water temperatures less than 68°F. Additionally, the top 15 feet of the water column contained dissolved oxygen concentrations greater than 7.0 mg/L which equates to approximately 27 percent of the water column and 59 percent of the lake volume. Approximately 27 percent of the water column (15 feet) and 59 percent of the lake volume contains water temperatures below 68°F and dissolved oxygen concentrations above 7.0 mg/L.

During August of 2018, the Perch Lake water column was sampled from the surface to a depth of 51 feet. Water depths which ranged from 15 to 51 feet recorded water temperatures less than 68°F which equates to 71 percent of the water column and 41 percent of the lake volume. Additionally, the top 18 feet of the water column contained dissolved oxygen concentrations greater than 7.0 mg/L which equates to approximately 35 percent of the water column and 59 percent of the lake volume. However, only 5.9 percent of the water column (3 feet) and 8.7 percent of the lake volume contains water temperatures below 68°F and dissolved oxygen concentrations above 7.0 mg/L (i.e., trout habitat) (Figure 2).
During the October 2018 Rainbow Trout management evaluation survey, a total of 186 fish totaling 12.4 pounds were captured which included 6 species (Table 2). Piscivore or gamefish species such as Smallmouth Bass, Rock Bass, and Yellow Perch comprised 46 percent of the catch by number and 64 percent of the total biomass. Benthic species, such as bottom dwelling Common White Sucker and Brown Bullhead were not captured during this survey. Lastly, pelagic species (Planktivore-Insectivores) such as shiners, Pumpkinseed and Rainbow Trout comprised 54 percent of the catch by number and 36 percent of the total biomass.

A total of one (CPUE = 0.083) Rainbow Trout, 14.5 inches in length, was captured during the fall management evaluation survey which was greater than the minimum size for harvest (12 inches). Additional species captured during this survey include Golden Shiner, Pumpkinseed, Rock Bass, Smallmouth Bass and Yellow Perch.

Analysis and Discussion

Status and Trends Survey
Status of lake habitat

Perch Lake remains a small, deep, oligotrophic (nutrient poor) lake with an undeveloped shoreline which contains fish species typical of inland lakes in northern Michigan. Chemical and biological parameters measured (e.g., alkalinity, phosphorus, nitrogen, oxygen, chlorophyll-a) suggest that Perch Lake's limited availability of nutrients has not changed and remains typical of oligotrophic lakes. Although Perch Lake is considered a `deep' lake (depth greater than 15 feet), summer dissolved oxygen values limit how much of the lake volume may be inhabited by cool- and cold-water fish species. This low level of oxygen in the summer may be due to the decomposition of organic material which exists in deeper regions of Perch Lake.

Physical parameters measured (e.g., temperature, transparency, development) indicate that Perch Lake continues to stratify with shallow warmer water and deeper cooler water. However, during the summer, temperature in conjunction with dissolved oxygen may limit the abundance, distribution, and survival of some cold-water species (i.e., Rainbow Trout). There are four characteristics used to evaluate the level of development on an inland lake: dwelling density, number of boat docks, shoreline armoring, and abundance of trees (e.g., large woody debris). Perch Lake had low to medium levels of development when number of dwellings, boat docks and percent shoreline armoring are considered. This would suggest that the natural shoreline is largely intact and near its natural state. However, the number of trees is low compared to other waterbodies of similar size. For example, Perch Lake has approximately 108 trees per shoreline mile which by majority (>50 percent) is in the southeast corner of the lake. However, average densities of trees in other similar-sized waterbodies exceeds 500 trees per mile. Therefore, the Perch Lake fisheries community would benefit from the installation of large woody habitat at a level four times its current level.

Status and Trends Survey

Status of lake fishes

The number of fish species captured (or species richness) in Perch Lake is typical of inland lakes in Northern Michigan which tend to support fewer species (average 10.4) compared to lakes in southern Michigan (15 to 16) (Wehrly et al, 2015). No fish captured in Perch Lake were listed as a Species of Great Conservation Need (SGCN). Comparatively, 61 percent of lakes of similar size in Michigan contain at least one SGCN. This may be due to the low level of development along the Perch Lake shoreline. There were no invasive species captured during these surveys.

Results from the Status and Trends netting survey suggest that the growth of panfish (planktivore-insectivores) in Perch Lake is well below average. Except Yellow Perch, growth of gamefish species (i.e., piscivores) is also below average providing few legal- or preferred size individuals for harvest. Growth and abundance of panfish and gamefish may suggest that the abundance of zooplankton and insect larvae is limited in Perch Lake. Aquatic insects tend to inhabit large woody debris, which as described earlier is limited in Perch Lake. Also, Perch Lake has been managed for various trout species during the past five decades and has been stocked more recently since 2008 with Rainbow Trout, an aggressive planktivore (Brynildson and Kempinger 1973, MDNR 2004). Limited shoreline habitat, in the form of woody debris, in conjunction with an overabundance of planktivore-insectivores in an already nutrient poor waterbody could explain the poor growth of game- and panfish species. Therefore, a habitat focused improvement project and a cessation of stocking additional planktivores (MDNR 2004) may improve the growth of panfish and gamefish in Perch Lake.

Rainbow Trout Evaluation

The MI DNR annually stocks approximately 200 inland lakes to provide diverse fishing opportunities to resident and non-resident trout anglers. East of the Ford River watershed, MI DNR Northern Lake Michigan Management Unit (NLMMU) manages approximately 39 inland lakes in Michigan's Upper Peninsula for trout species including brook trout (Salvelinus fontinalis, Strain: Assinica), brown trout (Salmo trutta, Strain: Gilchrest Creek), and rainbow trout (Oncorhynchus mykiss, Strain: Eagle Lake).

Lakes managed for trout species in this region are often small (less than 100 acres) compared to other inland lakes and are regulated (Type A through D) specifically to provide anglers with diverse fishing opportunities. Additionally, these small inland lakes are remote and provide a unique wilderness experience sought by many anglers. For example, Perch Lake has been managed as a rainbow trout fishery for more than 50 years with intermittent cessations in stocking. Despite the long history of trout management, a complete survey which included the collection of habitat, fish community, and limnological data had not been conducted. These surveys are used to provide data needed to develop criteria that are used to evaluate trout management in inland lakes.

Criteria used to evaluate Rainbow Trout management in Michigan's inland lakes includes biological, social, and economical components (Table 4). Biological criteria include capture efficiency of stocked Rainbow Trout in survey gear, plankton abundance, as well as the thermal and oxygen habitat availability. Social criteria include information pertaining to angler satisfaction and level of development on inland lakes stocked with trout. Lastly, economic criteria compare the estimated revenue generated from each angler trip (USFWS 2011) to the total cost of stocking. Of these criteria listed, the Perch Lake Rainbow Trout fishery has been evaluated using biological and social criteria.

Important biological criteria which would be needed to justify continued Rainbow Trout management in Perch Lake were not met. For example, captures of Rainbow Trout were low and limnological data suggest that thermal and oxygen habitat (i.e., biological criteria) limit the survival of stocked fish. Additionally, recent angler reports of poor returns (i.e., social criteria) confirm poor survival of stocked fish which has lowered angler satisfaction associated with the Perch Lake Rainbow Trout fishery.

Stocking guidelines for the State of Michigan explain that trout do well in the absence of predators (such as pike) and competitors (any type), and in lakes where large daphnia exceed 150 organisms per sample (Galbraith 1975; Galbraith and Schneider 2000). Perch Lake was not sampled for plankton abundance or growth, however the biological and social criteria considered warrant a cessation in stocking and discontinuation of trout management in Perch Lake.

Management Direction

1. Perch Lake has had a long history of trout management, however recent habitat and fish community evaluations suggest that trout management is not feasible in Perch Lake at this time.
-Cease stocking of Rainbow Trout and discontinue trout management in Perch Lake.
-Remove Type A regulation for Perch Lake.

2. For many decades Perch Lake has supported a community of some cool- but mostly warm-water species (e.g., Yellow Perch, Pumpkinseed, and Smallmouth Bass). Therefore, future management of Perch Lake should focus on improving habitat conditions within the lake to improve growth and size structure of panfish and gamefish species.

-Introduction of shoreline habitat is intended to increase surface area for macroinvertebrates to benefit planktivore-insectivore species (e.g., shiners, Pumpkinseed). Large woody debris, in the form of submerged trees and brush bundles should be installed on the northwest and southwest region of the lake.

3. Coordinate future management (habitat) efforts with Forest Resources Division and the Republic Sportsman's Club to obtain materials and facilitate deployment of habitat structures, respectively.

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Figure 1. Map of Perch Lake (Marquette County, Michigan).

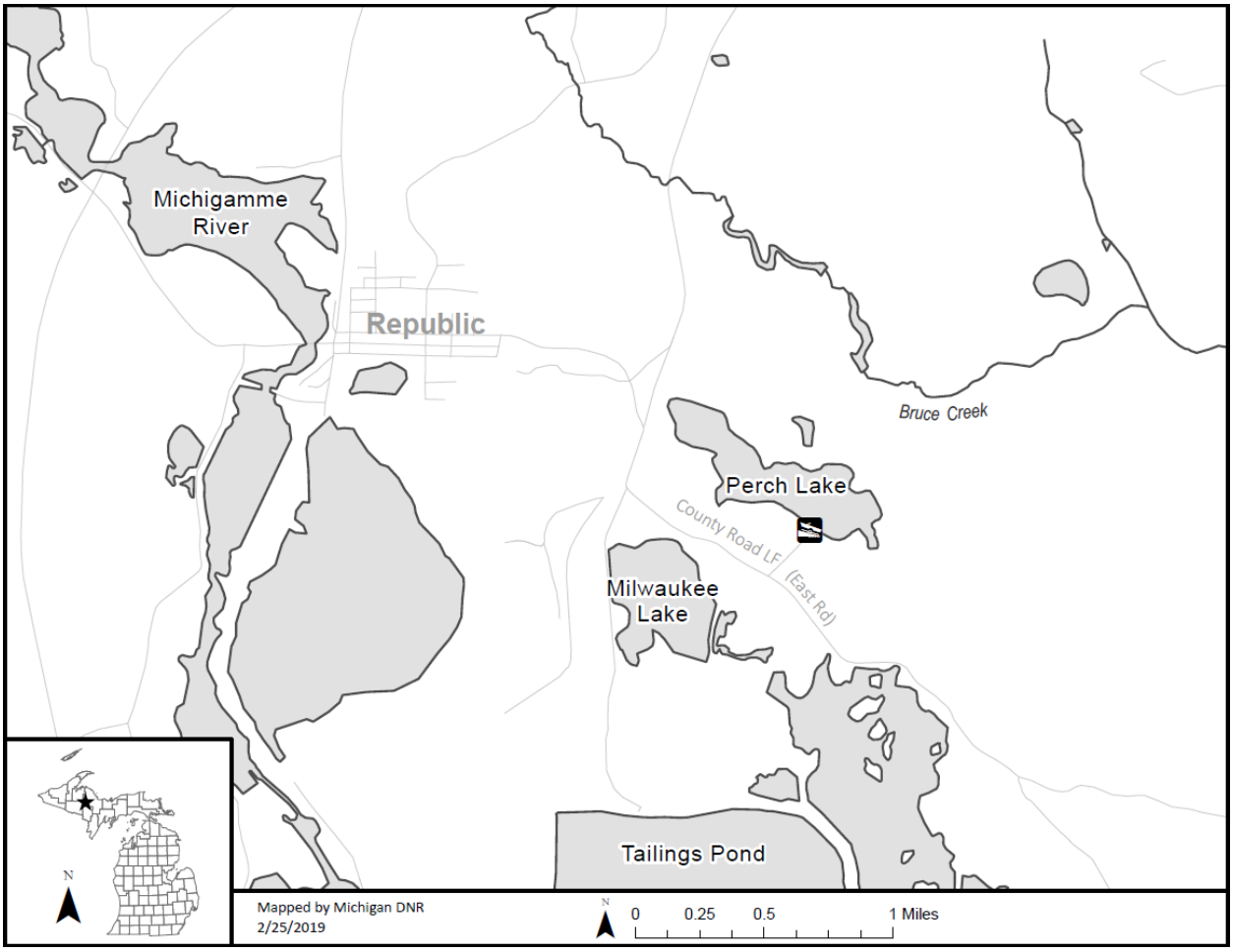

Figure 2. Temperature (°F) and dissolved oxygen (mg/L) of water in Perch Lake (Marquette County, Michigan) recorded 19 March 2018 (Left) and 22 August 2018 (Right). Data points depicted as triangle represent temperature, while data points depicted as circles represent dissolved oxygen.

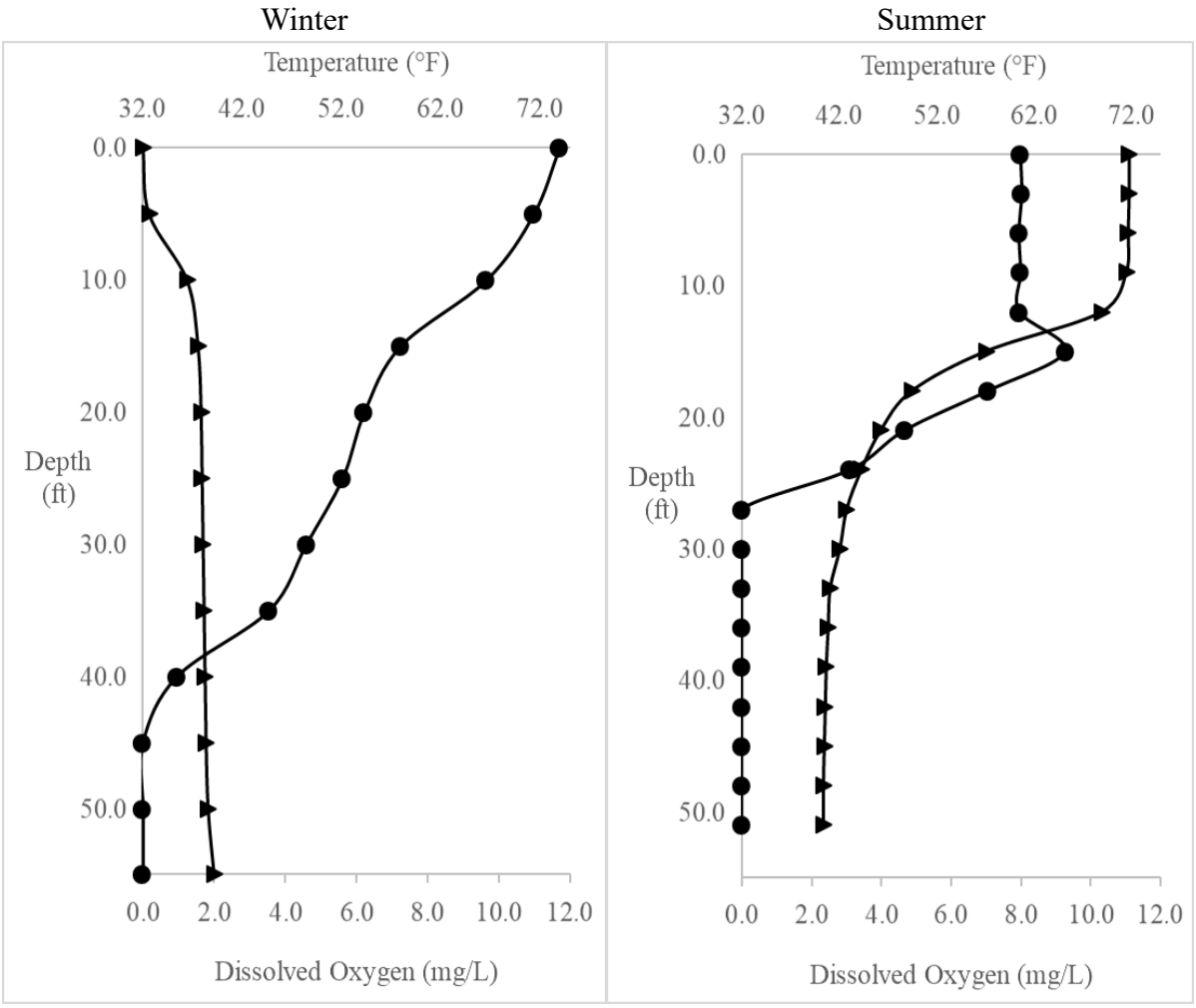

Figure 3. Temperature and dissolved oxygen of water in Perch Lake (Marquette County, Michigan) recorded 13 August 1968. Data points depicted as triangle represent temperature, while data points depicted as circles represent dissolved oxygen.

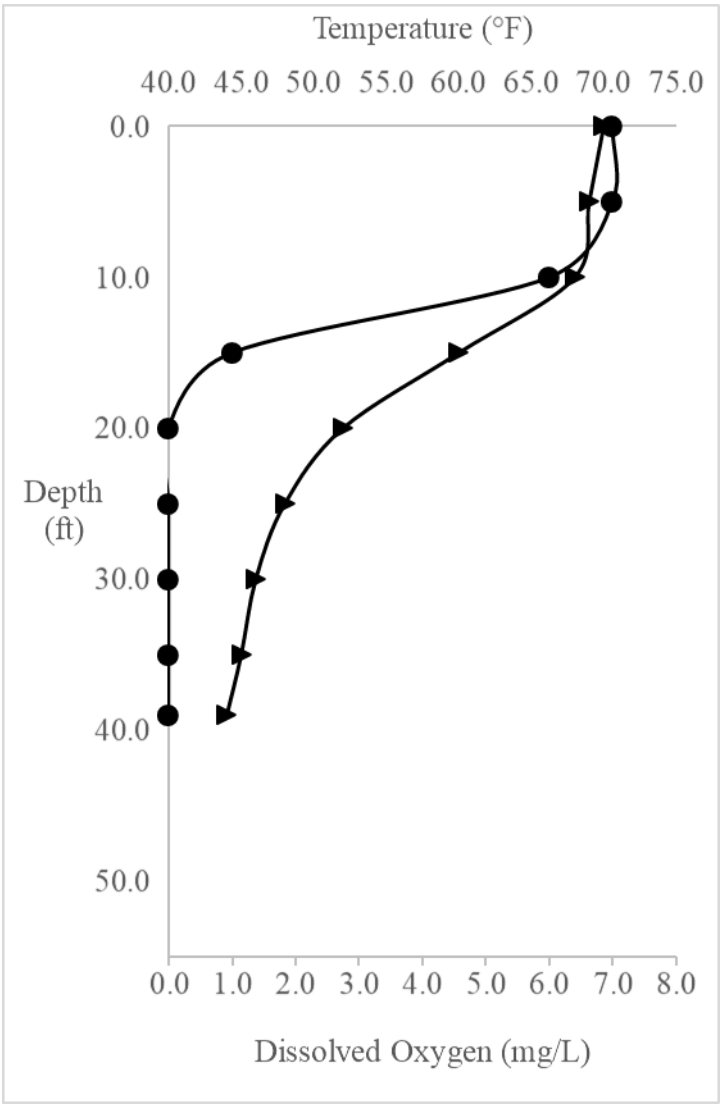

Figure 4. Plat map (Rockford Publishing) of Perch Lake located T 46N R29W section 08, Marquette County, MI.

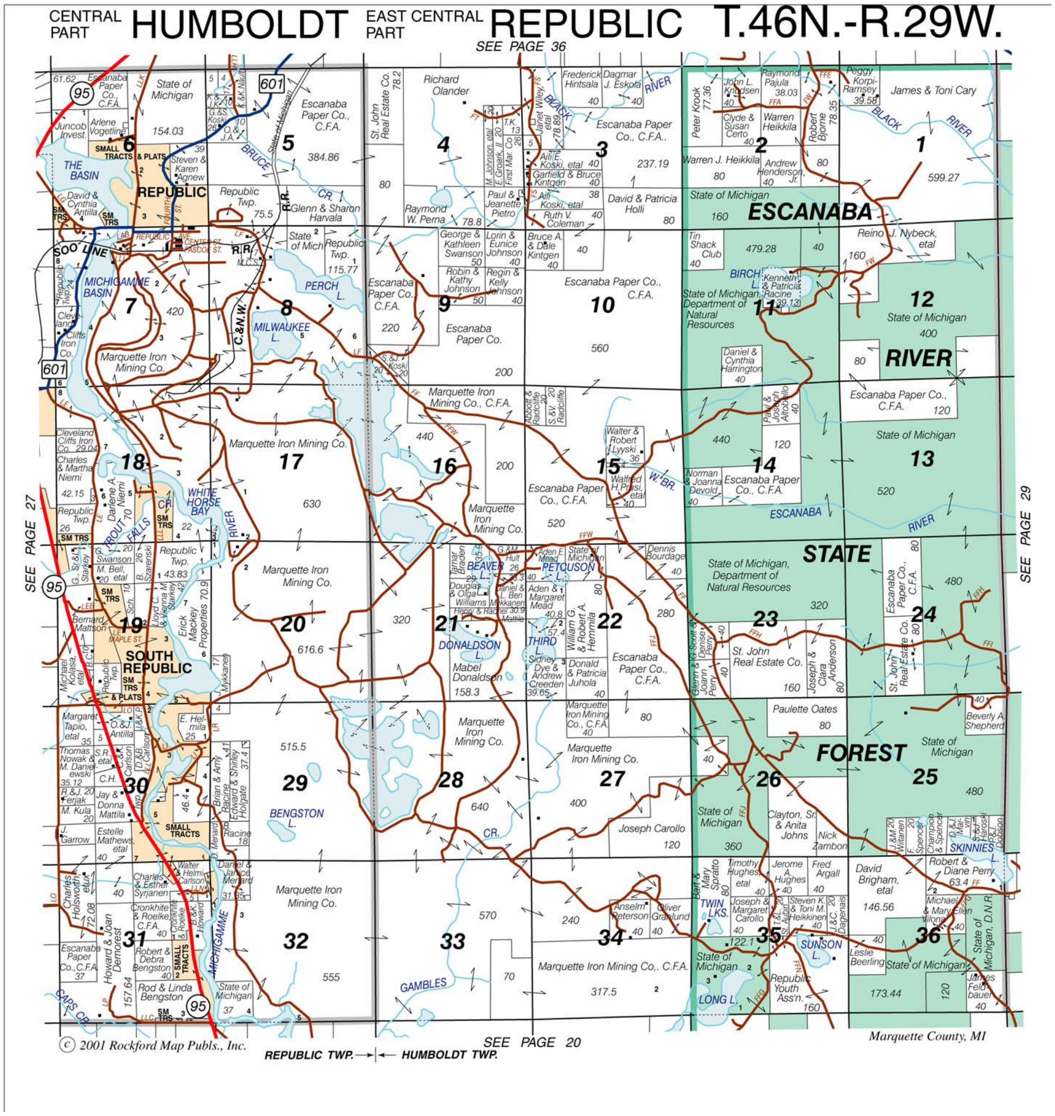

Table 1. Species, strain, year stocked, number (N) stocked, number stocked per acre and average (AVG) total length (TL) of fish stocked in Perch Lake, Marquette County.

Species	Strain	Year	N Stocked	N Stocked/acre	AVG Size (TL)
Yellow Perch	Michigan	1936	1200	26.1	
Rainbow trout		1967	8000	173.9	
Rainbow trout		1968	5000	108.7	
Rainbow trout		1969	10000	217.4	
Rainbow trout		1970	5000	108.7	
Rainbow trout		1971	10005	217.5	
Rainbow trout		1972	10000	217.4	
Rainbow trout		1975	4400	95.7	
Rainbow trout		1975	4800	104.3	
Rainbow trout		1975	4600	100.0	
Rainbow trout	Michigan	1976	9331	202.8	
Rainbow trout	Michigan	1977	6150	133.7	
Rainbow trout		1978	3500	76.1	
Rainbow trout		1979	3,500	76.1	6.97
Rainbow trout	Michigan	1980	2,350	51.1	3.9
Splake	Hybrid	1981	3,450	75.0	7.01
Splake	Hybrid	1982	1,100	23.9	7.05
Splake	Hybrid	1983	2,310	50.2	6.65
Splake	Hybrid	1984	2,300	50.0	5.63
Splake	Hybrid	1985	2,330	50.7	8.5
Splake	Hybrid	1986	4,500	97.8	8.7
Splake	Hybrid	1987	4,500	97.8	7.4
Splake	Hybrid	1988	3,000	65.2	6.42
Brook trout	Assinica	1989	150	3.3	17.56
Brook trout	Maine	1989	50	1.1	11.34
Rainbow trout	Wytheville	1989	3,450	75.0	8.23
Splake	Hybrid	1990	2,300	50.0	5.98
Splake	Hybrid	1991	3,610	78.5	6.06
Splake	Hybrid	1992	3,450	75.0	6.38
Splake	Hybrid	1993	2,850	62.0	6.93
Splake	Hybrid	1994	4,500	97.8	6.3
Splake	Hybrid	1995	1,885	41.0	6.69
Rainbow trout	Arlee	1995	2,015	43.8	7.95
Splake	Hybrid	1996	2,055	44.7	7.48
Rainbow trout	Shasta	1996	2,250	48.9	7.56
Splake	Hybrid	1997	1,755	38.2	6.5
Rainbow trout	Shasta	1997	1,915	41.6	6.97
Splake	Hybrid	1998	1,905	41.4	6.18
Rainbow trout	Shasta	1998	1,500	32.6	7.52
Rainbow trout	Gerrard Kamloops	1999	1,700	37.0	8.07

Splake	Hybrid	1999	2,015	43.8	7.13
Splake	Hybrid	2000	3,500	76.1	7.68
Splake	Hybrid	2001	4,000	87.0	7.91
Splake	Hybrid	2002	3,650	79.3	7.99
Splake	Hybrid	2003	3,600	78.3	7.52
Splake	Hybrid	2003	400	8.7	7.28
Splake	Hybrid	2004	3,240	70.4	6.38
Splake	Hybrid	2004	720	15.7	6.57
Splake	Hybrid	2005	4,000	87.0	7.05
Splake	Hybrid	2006	4,000	87.0	7.56
Splake	Hybrid	2007	3,300	71.7	7.52
Rainbow trout	Eagle Lake	2008	1,100	23.9	7.01
Lake trout	Marquette	2008	50	1.1	39.76
Rainbow trout	Eagle Lake	2009	5,900	128.3	7.24
Lake trout	Seneca Lake	2009	50	1.1	15.54
Rainbow trout	Eagle Lake	2010	1,100	23.9	6.42
Rainbow trout	Eagle Lake	2011	1,100	23.9	6.5
Lake trout	Big (Parry) Sound	2011	50	1.1	19.17
Rainbow trout	Eagle Lake	2012	1,080	23.5	7.32
Rainbow trout	Eagle Lake	2013	1,100	23.9	6.97
Rainbow trout	Eagle Lake	2014	950	20.7	7.32
Rainbow trout	Eagle Lake	2015	1,100	23.9	6.54
Rainbow trout	Eagle Lake	2016	1,000	21.7	6.69
Rainbow trout	Eagle Lake	2017	1,100	23.9	7.01

Table 2. Species, forage category, and number captured by year in Perch Lake, Marquette County. Numbers captured in column titled "2018S" refers to those fish captured during the spring 2018 assessment. Numbers captured in column titled "2018F" refers to those fish captured during the fall 2018 assessment.

		Number Captured					
Species	**Category**	**1988**	**1993**	**1999**	**2007**	**2018S**	**2018F**
Bluegill	Pelagic Planktivore-Insectivore	0	0	0	0	0	0
Bluntnose Minnow	Pelagic Planktivore-Insectivore	0	0	0	0	46	0
Brown Bullhead	Benthivore	0	0	0	0	1	0
Common White Sucker	Benthivore	0	150	97	0	1	0
Creek Chub	Pelagic Planktivore-Insectivore	0	1	0	0	0	0
Golden Shiner	Pelagic Planktivore-Insectivore	0	12	5	26	28	18
Hybrid Sunfish	Pelagic Planktivore-Insectivore	0	0	0	0	7	0
Northern Pike	Piscivore	0	0	0	0	0	0
Pumpkinseed Fish	Pelagic Planktivore-Insectivore	6	34	280	58	1195	82
Rainbow Trout	Pelagic Planktivore-Insectivore	0	0	2	0	1	1
Rock Bass	Piscivore	11	336	1385	275	1428	72
Smallmouth Bass	Piscivore	0	1	13	3	8	1
Splake	Piscivore	104	16	0	64	0	0
Yellow Perch	Piscivore	12	76	38	5	162	12

Table 3. Summary of species captured during 2018 Status and Trends survey by gear type, number (N) captured, catch per unit effort (CPUE), regional CPUE in small deep lakes (Region), and state CPUE in small deep lakes (State) in Perch Lake, Marquette County.

	Boomshocking				Experimental Gill Net				Large Mesh Fyke		
Species	**N**	**CPUE**	**Region**	**State**	**N**	**CPUE**	**Region**	**State**	**N**	**CPUE**	**Region**
Bluntnose Minnow	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Brown Bullhead	0	0.00	0.00	0.02	0	0.00	0.00	0.07	1	0.08	0.06
Common White Sucker	0	0.00	0.00	0.04	0	0.00	0.89	0.60	1	0.08	1.12
Golden Shiner	12	0.40	0.06	0.04	0	0.00	0.24	0.08	14	1.17	0.03
Hybrid Sunfish	0	0.00			0	0.00			3	0.25	
Pumpkinseed Fish	53	1.77	0.63	0.46	0	0.00	0.08	0.04	983	81.92	10.38
Rainbow Trout	0	0.00			0	0.00			1	0.08	
Rock Bass	14	0.47	0.10	0.11	0	0.00	0.06	0.20	1266	105.50	1.08
Smallmouth Bass	5	0.17	0.06	0.01	0	0.00	0.00	0.00	3	0.25	0.05
Yellow Perch	35	1.17	3.30	1.20	0	0.00	4.55	4.06	59	4.92	7.15

Table 4. Criteria used to evaluate trout management in Michigan's inland lakes.

Biological Criteria	Social Criteria	Economic Criteria
Survey CPUE[1]	Angler satisfaction[6]	Cost:Benefit[8]
Percent legal sized fish captured[2]	Dwelling density[7]	
Lake thermally stratifies[3]		
Temperature and dissolved oxygen[4]		
Number of large daphnids[5]		

[1] Catch per unit effort (CPUE) is greater than 5 fish per net night.

[2] Percent legal-size trout captured is greater than or equal to 20 percent.

[3] Limnological profiles show summer stratification.

[4] A minimum of 5 feet of the water column contains temperatures less than 68 °F, with dissolved oxygen concentrations greater than 7.0 mg/L.

[5] Rainbow Trout lakes: number of large daphnids exceeds 100 organisms per tow, calculated from an average of three tows.

[6] Angler satisfaction with the fishery is greater than or equal to 49%.

[7] Number of dwellings per mile is below 1.86 dwellings per mile.

[8]Estimated revenue generated by the fishery equals or exceeds the cost of stocking (e.g., cost per angler trip equal to or greater than total cost of stocking).