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PRELIMINARY
(NOT COMPLETE)

3/20/19

Status of Fishery Report Due April

Brevoort Lake

Mackinac County, Republic Township 42N / Range 05W / Section 34

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I. Environment

a. Location

Brevoort Lake is a large 4001-acre shallow lake located in central Mackinac County in Michigan's Upper Peninsula (Figure 1). In Mackinac County, St. Ignace resides south east while Brevoort Township resides just west of Brevoort Lake approximately 15 miles northwest of the Mackinac Bridge.

Commented [BJ(1)]: 32 feet maximum depth (Bassett 1987)

b. Geology and Geography

Brevoort Lake is located within the Point Aux Chenes bedrock formation consisting of sedimentary deposits such as shale, dolomite, chert and sandy shale formed during the Silurian age (Paleozoic Era) (Rosenau 1956). The surficial geology transitions from steep sand dunes near the south to a flat gently rolling mixture of glacial till and wetted sands to the north (Bassett 1987). Surrounding shoreline soils consist of a mix of various sand and silt loam types including Eastport, Carbondale, Wallace and Kalkaska. Erosion of dunes along the south shore of Brevoort Lake has produced extensive shallow, sand areas devoid of aquatic vegetation (Bassett 1987). The littoral zone of Brevoort Lake consists of unstable sand substrate with scattered beds of bulrush, while Boedne Bay (west) and Christiansen's Bay (east) provide more productive substrates consisting of loose organic and mixed sand-organic substrates (Bassett 1987).

Commented [BJ(2)]: Bassett 1987. Monitoring Report (1984 to 1986) Brevoort Lake Reef. United States Forest Service, St. Ignace, MI.

c. Watershed Description

Brevoort Lake is located within the Brevoort Lake watershed and was first mapped by the United States Forest Service (hereinafter referred to as "USFS") in 1939. Brevoort Lake is positioned on a west-northwest to east southeast axis with a total fetch length of approximately 5.5 miles with a maximum depth of approximately 32 feet. Little Brevoort Lake is connected to and flows into Boedne Bay of Brevoort Lake via the Little Brevoort River. Silver Creek also serves as tributary to Brevoort Lake located in the northeast of Boedne Bay. The Little Cut River flows into Brevoort Lake on the northeast shore near Walker road. Brevoort River is the sole outflow of Brevoort Lake and serves as a tributary to Lake Michigan 10.8 miles downstream of Brevoort Lake. A water level control structure, built in 1935, is located near the mouth of the Brevoort River and has been operated by USFS staff annually. While the legal water level has been topic for debate, it was first established in 1936 (625.97 feet above sea level) and then was later adjusted and reaffirmed in 1994 (625.00 feet above sea level).

d. Status of Lake Habitat (formerly physical and chemical parameters)

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.

i. 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 27 August 2018, alkalinity in Brevoort Lake was 86 mg/L (medium), which is similar to alkalinity samples taken during the 1940s. Therefore, Brevoort Lake has moderate capacity to buffer against significant changes in pH which fluctuate during spring run-off or snow melt periods. The average alkalinity value for large, shallow inland lakes located within watersheds of northern Lake Michigan is 78 mg/L (Wehrly et al. 2015). Comparatively, Brevoort Lake has above average alkalinity when compared to other inland waterbodies similar in size in the Northern Lake Michigan Management Unit (NLMMU). The average alkalinity value for large, shallow inland lakes in Michigan is 95 mg/L (Wehrly et al. 2015). Comparatively, Brevoort Lake has below average alkalinity when compared to other inland waterbodies across Michigan.

Commented [BJ(3)]: Good explain the good muskellunge population. Abundance of marl and calcium carbonate.???

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. On the other hand, 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 and Nitrogen – 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 Brevoort Lake were measured 27 August 2018 and were reported to be 0.0104 mg/L (medium).

Average total phosphorus concentrations for large shallow lakes in the NLMMU region and across the state of Michigan are 0.011 and 0.014 mg/L, respectively (Wehrly et al. 2015). Therefore, Brevoort Lake has phosphorus concentrations that are equal to below other inland lakes in the NLMMU region and across the state, respectively.

Commented [BJ(4)]: Phosphorus equal to or below levels compared to other waterbodies similar in size.

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 27 August 2018 and were reported to be 1.573 mg/L (high). Average total phosphorus concentrations for large shallow lakes in the NLMMU region and across the state of Michigan are 0.583 and 0.500 mg/L, respectively (Wehrly et al. 2015). Therefore, Brevoort Lake has total nitrogen concentrations that are well above what is to be considered normal for the region or compared to waterbodies across the state of Michigan. In 1977, Brevoort Lake was sampled at six locations for concentration of total nitrogen. The average concentration of total nitrogen across six sites was 0.468 mg/L and ranged from 0.430 to 0.550 mg/L. 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 Brevoort Lake was 151:1 which suggests that total phosphorus is the nutrient which limits primary production in Perch Lake.

NITROGEN
Commented [BJ(5)]: This is high, we should have this looked at.....

Commented [BJ(6)]: This is a difference which warrants additional looking into. Could this be from Zebras?

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. DO was measured in Brevoort Lake on 27 August 2018 and ranged from 4.99 to 8.64 mg/L which suggests that sufficient oxygen exists to support aquatic organisms.

ii. 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 27 August 2018, a summer temperature profile was recorded in

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Brevoort Lake which showed that no stratification had occurred. The lack of thermal stratification is normal for large shallow waterbodies in the NLMMU (Wehrly et al. 2015).

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 27 August 2018, the Brevoort Lake Secchi Disk reading was 8 feet (high). The average Secchi depths for large shallow inland lakes in the NLMMU region and across the state of Michigan are 8.2 and 9.8 feet, respectively. Therefore, Brevoort Lake has a transparency depth equal to or slightly less than similar-sized waterbodies in the NLMMU region and across the state, respectively.

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 Brevoort Lake was measured 18 July 2018 and is reported to have 11.7 dwellings per mile (medium). Average dwellings per mile for large shallow inland lakes in the NLMMU region and across the state of Michigan is 14.3 and 18.5 dwellings per mile, respectively. Therefore, Brevoort Lake has a residential development level that is below average compared to other waterbodies in the NLMMU region and across the state of Michigan.

40% PRIVATE
60% NATURAL

Commented [BJ(7): These data suggest that Brevoort Lake is largely undeveloped. However, much of the development is concentrated along the north shore, which is where the preferable habitat exists. As opposed to the south shore which is full of sand.....

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 Brevoort Lake was measured 17 July 2018 and is reported to have 9.6 docks per mile (medium). The number of docks per mile for large shallow inland lakes in the NLMMU region and across the state of Michigan is 8.5 and 14.3 boat docks per mile, respectively. Therefore, Brevoort Lake has more docks per mile compared to large shallow waterbodies in the NLMMU region, yet less compared to similar sized waterbodies across the state of Michigan.

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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 Brevoort Lake 17 July 2018 and was reported to be 44.3 percent (high). Average percent of shoreline armored in other large shallow inland lakes in the NLMMU region and across the state of Michigan is 26.5 and 28.4 percent armored, respectively. Therefore, Brevoort Lake has highly modified shoreline compared to similar sized waterbodies in the NLMMU region and across the state of Michigan.

Commented [BJ(8): This too is largely concentrated on the North shore, which suggests that this lake is highly altered despite having USFS ownership on the South Shore. The North shore is likely the more productive shoreline and that which is most heavily altered or differs from its more natural state.

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 Brevoort Lake was measured 17 July 2018 and is reported to be 44.3 trees per mile (high). Average densities of large woody debris in other large shallow inland lakes in the NLMMU region and across the state of Michigan are 15.3 and 27.8 trees per mile, respectively. Therefore, Brevoort Lake has a greater density of large woody debris compared to similar sized waterbodies in the NLMMU region and across the state of Michigan.

Commented [BJ(9): Again, these trees existed in reaches which were not armored (south shore and undeveloped bays).

iii. 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 (e.g., algal biomass) 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 Brevoort Lake was measured 17 July 2018 and is reported to be 0.22 ug/L (low). Average chlorophyll-a concentrations for large shallow inland lakes in the NLMMU region and

Commented [BJ(10): This is the lowest I think I've seen....Less than 10% of what is considered 'low'.

across the state of Michigan are 2.9 and 2.8 ug/L, respectively. Therefore, chlorophyll-a likely limits primary production in Brevoort Lake given the low values compared to similar sized waterbodies in the NLMMU region and across the state of Michigan.

Commented [BJ(11)]: This is likely due to zebra mussels.

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 27 August 2018, the total phosphorus, Secchi depth, and chlorophyll-a values were reported to be 0.22 ug/L, 8.0 ft, and 10.4 ug/L, respectively (Average TSI = 33.4, oligotrophic). *LOW*

Chlorophyll-a can be used as a measure of photosynthetic activity and algal biomass in lakes. Algae are the base of a lake food web. Without Algae, organisms higher up the food chain (zooplankton, benthos, mysis, and fish) would not survive). Too much algae can also be bad.... but we don't have that problem here.

(A) Based upon chemical, physical, and biological parameters measured, Brevoort Lake is characterized as being a large, shallow, oligotrophic lake where primary production is limited by the low availability of nutrients (i.e., chlorophyll-a, total phosphorus). Brevoort Lake habitat values (i.e., trees per mile, percent armoring, dwellings per mile) suggest that the lake has not been greatly impacted by human development. However, much of the armoring, construction of dwellings and docks, as well as the removal of submerged trees has occurred along the northern shore which was historically noted as being the more productive shore containing a mix of rock and sand substrate with intermittent growth of bulrush rush (Bassett 1987). The south shore is largely comprised of sand substrates which tends to offer less habitat for macroinvertebrates and fish despite a greater abundance of large woody debris. Since the 1940s Brevoort Lake has been characterized as being a large shallow water body capable providing management opportunities for warmwater fish species (MI DNR, internal report 1943). This classification of being a 'warmwater' fishery is best supported by the lack of thermal stratification (e.g., less habitat for cool- or cold-water fishes) during the summer months. Temperature and DO in Brevoort Lake in 2018 was similar to that recorded in the 1940s which showed 70°F (+/- 1°F) water temperatures from the surface of the water to the bottom with sufficient oxygen at all depths to support aquatic organisms.

e. Development, Public Ownership, and Access

i. Development

The Brevoort Lake area is a recreational destination located in the eastern region of the Hiawatha National Forest offering diverse opportunities for outdoor activities (e.g., camping, hunting fishing, hunting, ORVing, hiking, ice fishing, snowshoeing). Nearly the entire south shore of Brevoort Lake is public land (USFS ownership). Two public boat launches exist in Brevoort Lake: 1) located in Boedne Bay (GPS: 46.009612 -84.972115) as part of a USFS campground and 2) located in Christiansen's Bay (GPS: 45.991098 -84.878275) in the south east corner of the lake of Dukes Road.

(6)

II. Fishery Resource

a. Describe the fish stocks and the fishery in earlier years along with problems and management history.

b. Current Status of the Fishery

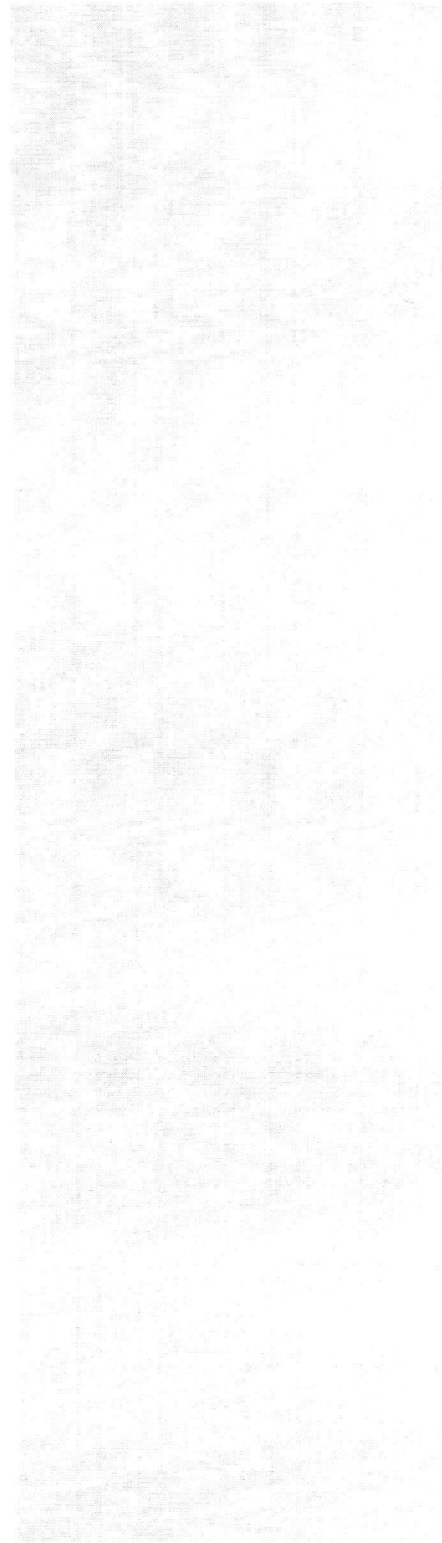
Status and Trends Survey 2018

c. Analysis and Discussion

Status and Trends Survey - Status of lake habitat

Status and Trends Survey - Status of lake fishes

d. Management Direction



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