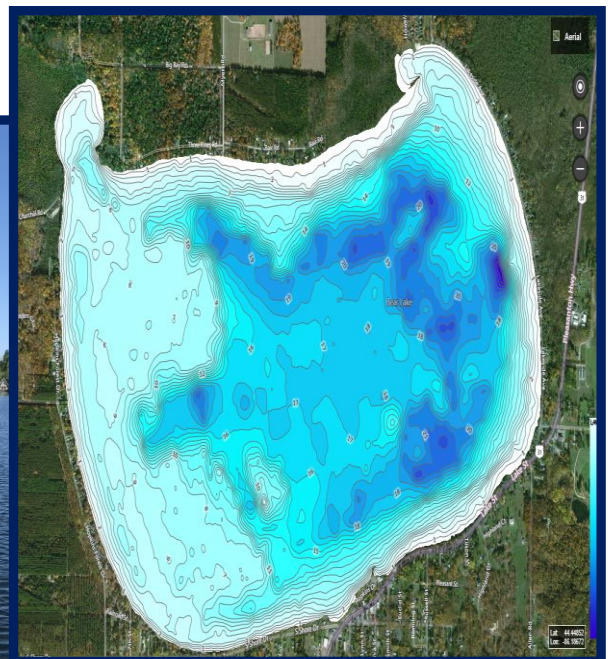
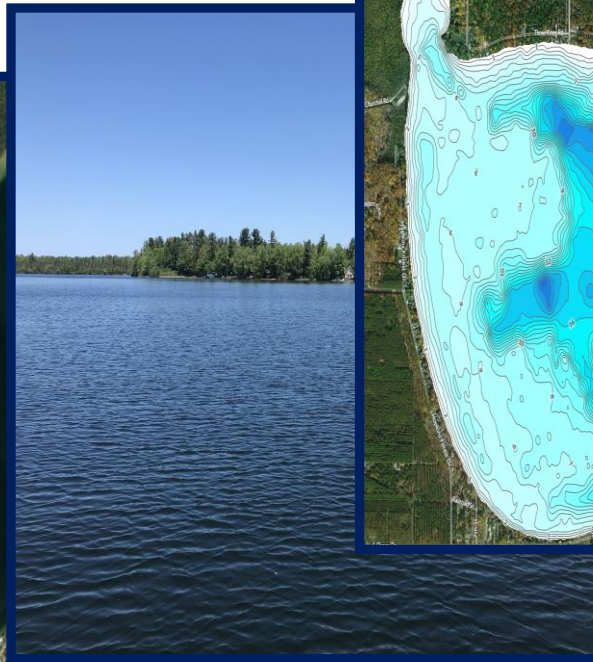
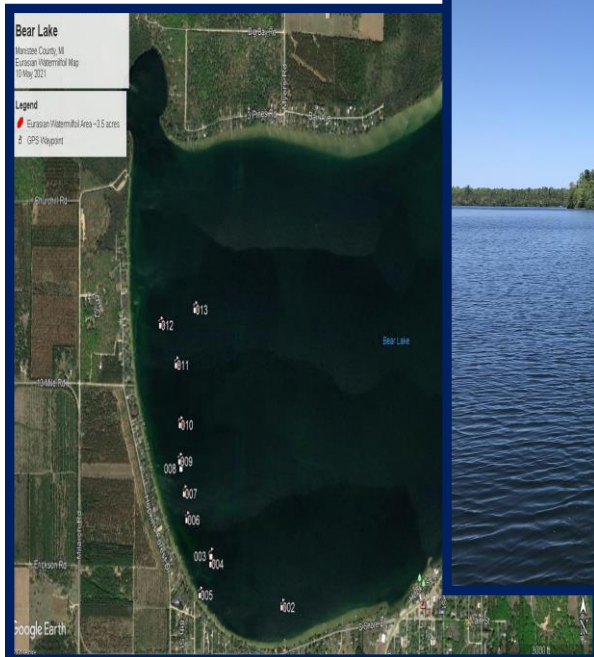


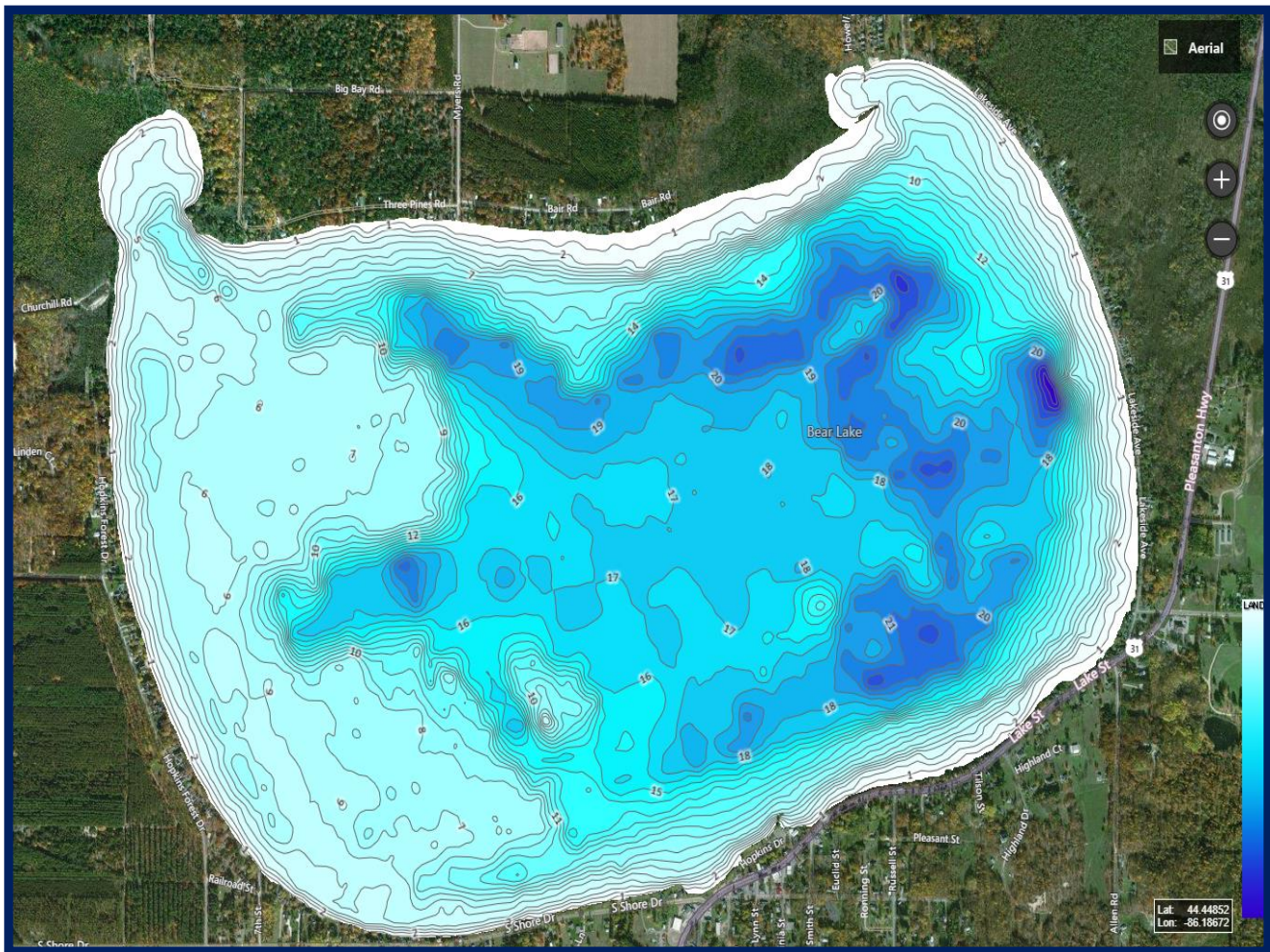


Bear Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report



November 2021

Bear Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report



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Bear Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report

***The following information is a summary of
key lake findings collected in 2021.***

The overall condition of Bear Lake is ranked in the top 15% of developed lakes of similar size in the state of Michigan. The water clarity in 2021 was excellent with an average of 19.0 feet. The nutrient concentrations in the lake are considered low to moderate and are adequate to support robust submersed aquatic plant growth due to the high water clarity. Invasive species such as Eurasian Watermilfoil (EWM) are able to grow in moderate nutrient waters and thus are a challenge to the Bear Lake ecosystem. Bear Lake had a total of 10.7 acres of EWM in 2021 (determined by whole-lake surveys conducted in May and August of 2021) which was very effectively treated with the new systemic herbicide ProcellaCOR® and the contact herbicide diquat on May 27 and August 18, 2021. Protection of the 26 native aquatic plant species is paramount for the health of the lake fishery and these plants should not be managed unless they are a nuisance to lakefront property owners and possess navigational and recreational hazards.

The lake did not experience depletion of dissolved oxygen with depth during spring or mid-summer sampling which is common for a large lake that minimally stratifies. Trends for most water quality parameters are shown below. Overall, Bear Lake is a very stable aquatic ecosystem with excellent aquatic vegetation biodiversity, relative abundance, and water clarity, and neutral pH and soft water alkalinity.

Bear Lake Water Quality Data

Water Quality Parameters Measured

There are hundreds of water quality parameters one can measure on an inland lake, but several are the most critical indicators of lake health. These parameters include water temperature (measured in °F), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter- $\mu\text{S}/\text{cm}$), total alkalinity or hardness (measured in mg of calcium carbonate per liter-mg CaCO_3/L), total dissolved solids (mg/L), Secchi transparency (feet), total phosphorus and total nitrogen (both in mg/L), chlorophyll-a (in $\mu\text{g}/\text{L}$), and algal community composition. Graphs that show critical trends for some parameters in spring and late summer of each year are displayed below. Trend data were calculated using mean values for each parameter for spring and summer over each sampling location. Table 1 below demonstrates how lakes are classified based on key parameters. Bear Lake would be considered mesotrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but has excellent water clarity and moderate algal growth. 2021 water quality data for Bear Lake is shown below in Tables 2-7. Three deep basins were measured, with DB#1 located at the NW corner of the lake, DB#2 located at the central portion of the lake, and DB#3 located at the northeastern portion of the lake. These parameters are discussed below along with water quality data specific to Bear Lake which were collected on June 7 and August 19 of 2021.



Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	Total Phosphorus ($\mu\text{g L}^{-1}$)	Chlorophyll-a ($\mu\text{g L}^{-1}$)	Secchi Transparency (feet)
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Table 2. Bear Lake Water Quality Parameter Data Collected over Deep Basin 1 on June 7, 2021.

<i>Depth ft.</i>	<i>Water Temp °F</i>	<i>DO mg L⁻¹</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TDS mg L⁻¹</i>	<i>Total Kjeldahl Nitrogen mg L⁻¹</i>	<i>Total Alk. mgL⁻¹ CaCO₃</i>	<i>Total Phos. mg L⁻¹</i>
0	72.8	9.6	7.8	222	0.4	142	<0.5	58	<0.010
10	70.4	9.6	7.8	222	0.6	142	<0.5	58	<0.010
21	68.6	9.4	7.6	223	1.3	143	1.0	57	0.020

Table 3. Bear Lake Water Quality Parameter Data Collected over Deep Basin 2 on June 7, 2021.

<i>Depth ft.</i>	<i>Water Temp °F</i>	<i>DO mg L⁻¹</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TDS mg L⁻¹</i>	<i>Total Kjeldahl Nitrogen mg L⁻¹</i>	<i>Total Alk. mgL⁻¹ CaCO₃</i>	<i>Total Phos. mg L⁻¹</i>
0	72.0	9.8	7.8	220	0.3	140	<0.50	59	<0.010
10	69.3	9.8	7.8	220	0.7	140	<0.50	58	<0.010
22	67.5	9.7	7.7	221	1.1	141	<0.50	58	0.020

Table 4. Bear Lake Water Quality Parameter Data Collected over Deep Basin 3 on June 7, 2021.

<i>Depth ft.</i>	<i>Water Temp °F</i>	<i>DO mg L⁻¹</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TDS mg L⁻¹</i>	<i>Total Kjeldahl Nitrogen mg L⁻¹</i>	<i>Total Alk. mgL⁻¹ CaCO₃</i>	<i>Total Phos. mg L⁻¹</i>
0	72.3	9.9	7.9	221	0.5	141	<0.50	59	<0.010
10	70.0	9.7	7.9	221	0.7	141	<0.50	58	<0.010
21	68.8	9.1	7.6	223	1.0	143	0.50	58	0.020

Table 5. Bear Lake Water Quality Parameter Data Collected over Deep Basin 1 on August 19, 2021.

<i>Depth ft.</i>	<i>Water Temp °F</i>	<i>DO mg L⁻¹</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TDS mg L⁻¹</i>	<i>Total Kjeldahl Nitrogen mg L⁻¹</i>	<i>Total Alk. mgL⁻¹ CaCO₃</i>	<i>Total Phos. mg L⁻¹</i>
0	78.8	8.6	8.6	220	0.3	141	0.7	62	<0.010
10	76.5	9.2	8.6	220	0.9	141	0.6	62	<0.010
21	75.7	8.5	8.3	223	1.6	143	1.0	60	0.020

Table 6. Bear Lake Water Quality Parameter Data Collected over Deep Basin 2 on August 19, 2021.

<i>Depth ft.</i>	<i>Water Temp °F</i>	<i>DO mg L⁻¹</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TDS mg L⁻¹</i>	<i>Total Kjeldahl Nitrogen mg L⁻¹</i>	<i>Total Alk. mgL⁻¹ CaCO₃</i>	<i>Total Phos. mg L⁻¹</i>
0	78.8	8.8	8.5	221	0.4	141	0.8	61	<0.010
10	77.0	9.1	8.5	219	0.8	140	<0.5	61	<0.010
22	75.7	9.1	8.5	218	0.8	139	1.0	60	0.020

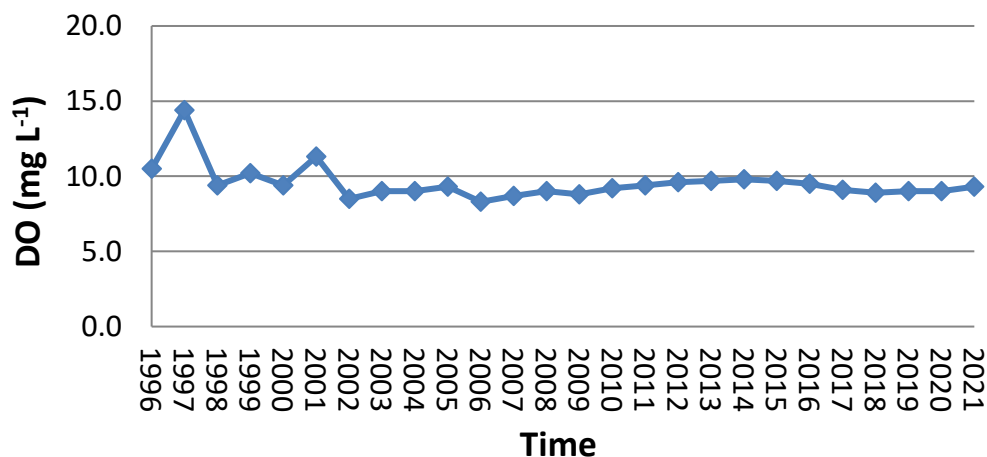
Table 7. Bear Lake Water Quality Parameter Data Collected over Deep Basin 3 on August 19, 2021.

<i>Depth ft.</i>	<i>Water Temp °F</i>	<i>DO mg L⁻¹</i>	<i>pH S.U.</i>	<i>Cond. μS cm⁻¹</i>	<i>Turb. NTU</i>	<i>TDS mg L⁻¹</i>	<i>Total Kjeldahl Nitrogen mg L⁻¹</i>	<i>Total Alk. mgL⁻¹ CaCO₃</i>	<i>Total Phos. mg L⁻¹</i>
0	78.3	8.6	8.6	219	0.6	140	<0.5	60	<0.010
10	76.8	9.3	8.6	219	0.9	140	0.6	59	<0.010
21	76.1	9.3	8.6	219	0.9	140	1.0	59	<0.050

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg L⁻¹ to sustain a healthy warm-water fishery. Dissolved oxygen concentrations in Bear Lake may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen is measured in milligrams per liter (mg L⁻¹) with the use of a dissolved oxygen meter and/or through the use of Winkler titration methods. The dissolved oxygen concentrations in Bear Lake were healthy and declined minimally with depth. This may be due to near isothermic conditions during the spring sampling and due to reduced stratification of the lake during summer months due to constant mixing of the lake water. The dissolved oxygen concentrations in Bear Lake support both a warm water and cool water fishery with an average concentration of around 9.3 mg L⁻¹ in 2021. Figure 1 below shows the changes in mean dissolved oxygen with time in Bear Lake.

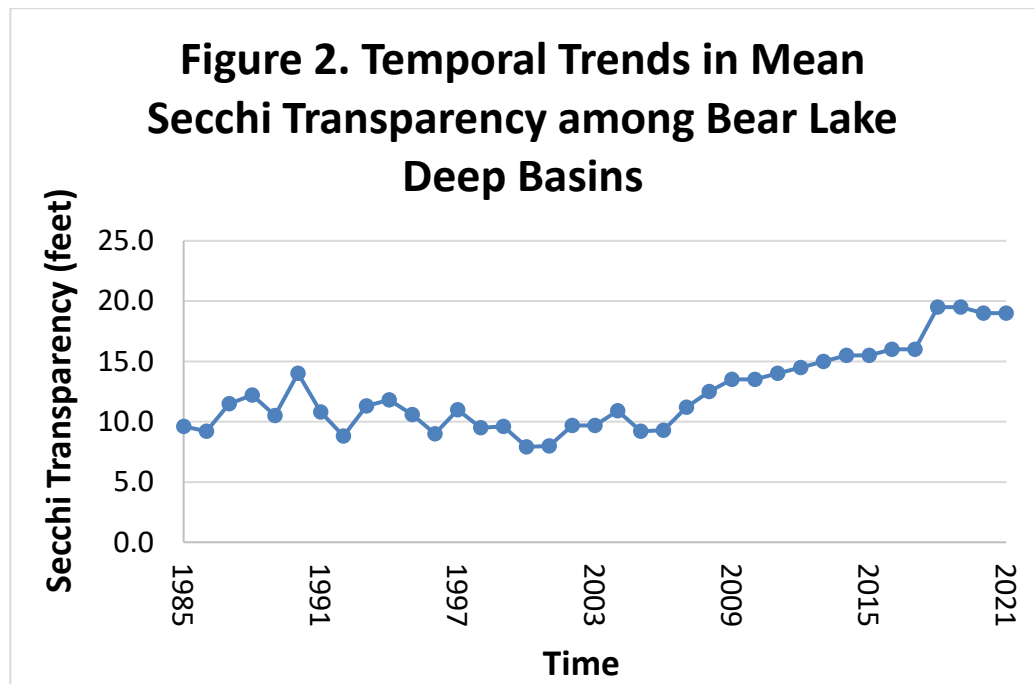
Figure 1. Temporal Trends in Mean DO among Bear Lake Deep Basins



Water Clarity (Transparency) Data & Turbidity

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Bear Lake is adequate (mean of 19.0 feet in 2021; Figure 2) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake.

Secchi transparency is variable and depends on the number of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. Other parameters such as turbidity (measured in NTU's) and Total Dissolved Solids (measured in mg/L) are correlated with water clarity and show an increase as clarity decreases. The turbidity and total dissolved solids in Bear Lake during the 2021 sampling events were also quite low at ≤ 1.6 NTU's and 143 mg/L, respectively.

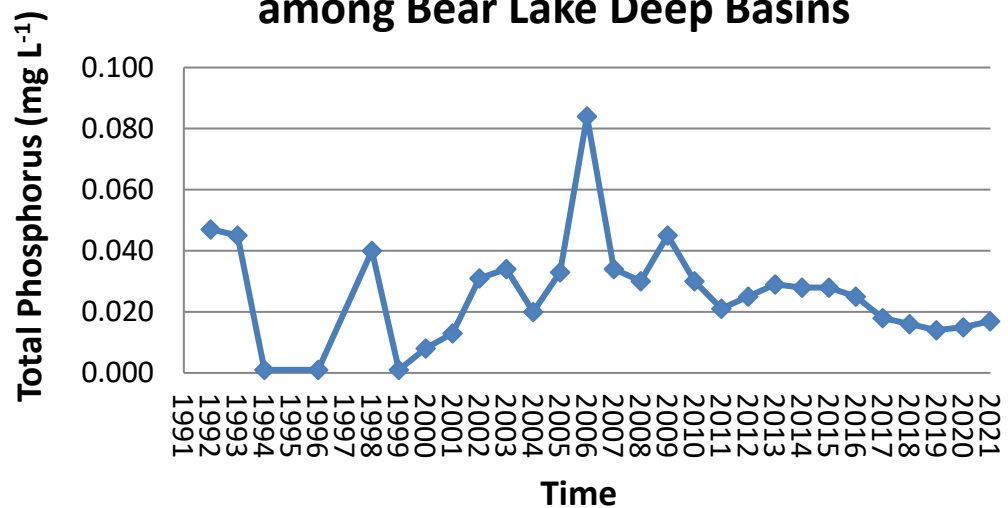


Total Phosphorus and Total Nitrogen

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Fortunately, even though the TP levels in Bear Lake are moderate, the dissolved oxygen levels are good enough at the bottom to not cause release of phosphorus from the bottom. TP concentrations fluctuated between <0.010 - <0.050 mg L⁻¹ during the 2021 season sampling events. The mean TP concentration was around 0.017 mg L⁻¹ (Figure 3) in 2021 which is quite low and favorable and below the eutrophic threshold. Most of the TP is being tied up by aquatic plants.

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen plus ammonia (NH₃) forms in freshwater systems. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e., burning of fossil fuels), wastewater sources from developed areas (i.e., runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through groundwater or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations may increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg L⁻¹ may be classified as oligotrophic, those with a mean TKN value of 0.75 mg L⁻¹ may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg L⁻¹ may be classified as eutrophic. Bear Lake possessed TKN concentrations between <0.50-1.0 mg L⁻¹ during the 2021 sampling events which is considered oligo-mesotrophic and is desirable.

Figure 3. Temporal Trend in Mean TP among Bear Lake Deep Basins

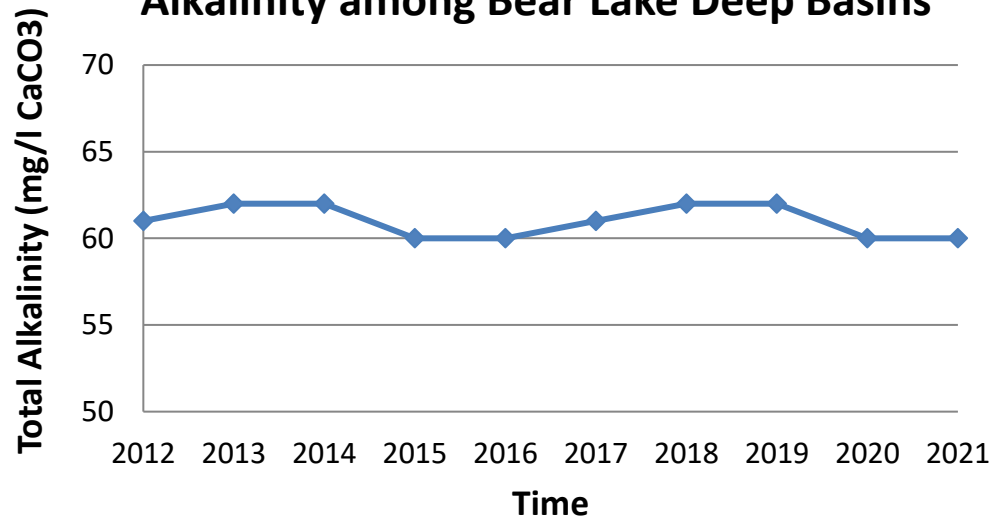


Total Alkalinity

Lakes with high alkalinity (> 150 mg L⁻¹ of CaCO₃) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of CaCO₃ and are categorized as having “hard” water.

Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water. The alkalinity in Bear Lake averaged 60 mg L^{-1} of CaCO_3 (Figure 4) in 2021, which is soft and indicates a soft water lake.

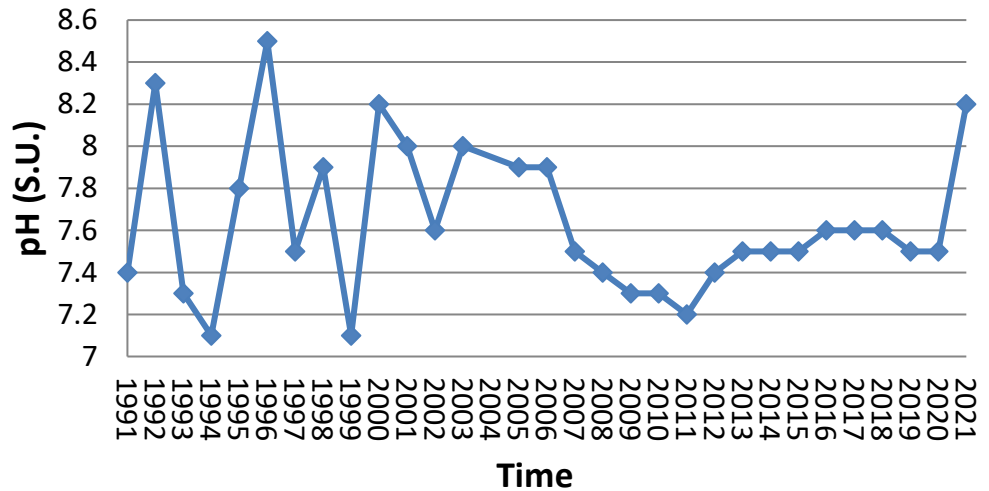
Figure 4. Temporal Trends in Mean Total Alkalinity among Bear Lake Deep Basins



pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes ($\text{pH} < 7$) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). Bear Lake is considered “slightly basic” on the pH scale. The mean pH of Bear Lake during the 2021 sampling events averaged 8.2 S.U. which is ideal for an inland soft water lake (Figure 5). pH values may change over time due to photosynthesis of submersed aquatic vegetation and algae.

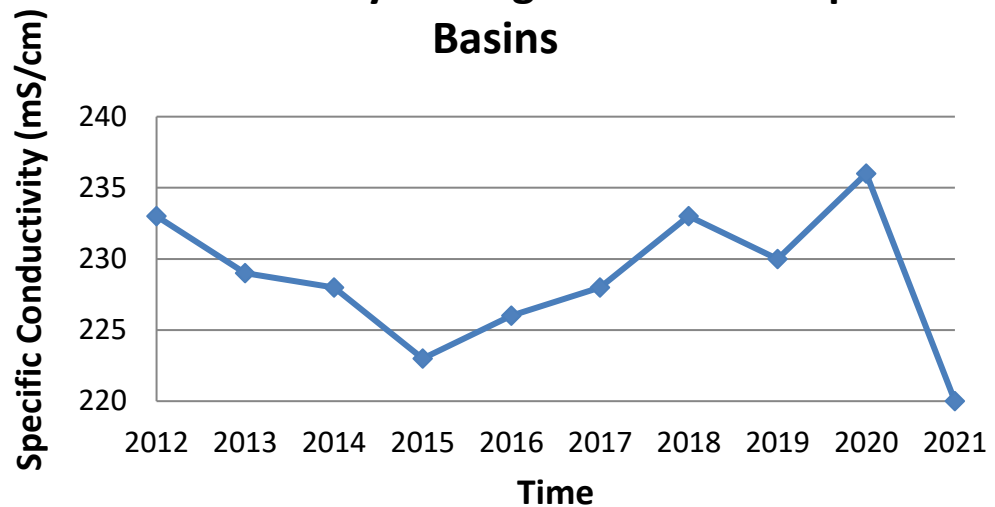
Figure 5. Temporal Trends in Mean pH among Bear Lake Deep Basins



Conductivity

Conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. The conductivity values for Bear Lake during the 2021 sampling events (Figure 6) were moderate and ranged from 218-223 $\mu\text{S}/\text{cm}$, which is lower than in 2020. Severe water quality impairments do not occur until values exceed 800 $\mu\text{S}/\text{cm}$ and are toxic to aquatic life around 1,000 $\mu\text{S}/\text{cm}$.

Figure 6. Temporal Trends in Mean Conductivity among Bear Lake Deep Basins



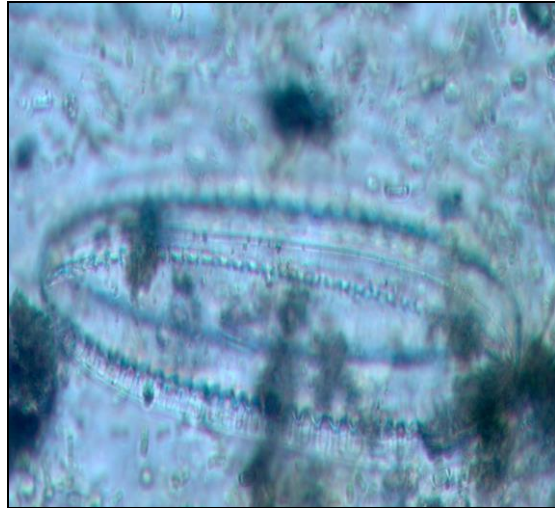
Chlorophyll-*a* and Algal Species Composition

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than $6 \mu\text{g L}^{-1}$ are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than $2.2 \mu\text{g/L}$ are found in nutrient-poor or oligotrophic lakes. The mean chlorophyll-*a* concentrations during the 2021 sampling events in Bear Lake did not exceed $1.6 \mu\text{g/L}$ which is moderately low for an inland Michigan lake and surprising given the increased runoff from intense rainfall events.

The algal genera were determined from composite water samples collected over the deep basins of Bear Lake in 2021 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae): *Chlorella* sp., *Chroococcus* sp., *Mougeotia* sp., *Cosmarium* sp., *Scenedesmus* sp., *Spirogyra* sp., *Pediastrum* sp., *Rhizoclonium* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): *Gleocapsa* sp., the Bascillariophyta (diatoms): *Navicula* sp., *Synedra* sp., *Stephanodiscus* sp., and *Diatoma* sp. The aforementioned species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of great water quality. Microscopic photos of some key algae in Bear Lake are shown below.



Scenedesmus- A green algae in Bear Lake



Navicula- A diatom algae in Bear Lake



Spirogyra- A green algae in Bear Lake



Synedra- A diatom algae in Bear Lake

Aquatic Vegetation Data (2021)

Status of Native Aquatic Vegetation in Bear Lake

The native aquatic vegetation present in Bear Lake is essential for the overall health of the lake and the support of the lake fishery. The 2021 surveys in June, August, and September of 2021 determined that there were a total of 26 native aquatic plant species in Bear Lake. These include 19 submersed species, 3 floating-leaved species, and 4 emergent species. This indicates a high biodiversity of aquatic vegetation in Bear Lake. The overall % cover of the lake by native aquatic plants is low relative to the lake size and thus these plants should be protected unless growing near swim areas at nuisance levels.

The most common native aquatic plants included: 1) Fern-leaf Pondweed (Figure 7) which lies close to the lake bottom and has green fern-like leaves. Leafless Watermilfoil (Figure 8) which lies close to the lake bottom and creates a “sod” appearance; The plant is largely responsible for carpeting the lake bottom and lowering the probability for milfoil fragments to re-root, and 3) White-stem Pondweed (Figure 9) which is a bright green, lance-leaved pondweed with slightly curled leaf margins that tends to grow in offshore deeper waters. A list of all native aquatic plants (scientific and common names) and their relative abundance in 2021 is found in Table 8 below.



Figure 7. Fern-leaf Pondweed



Figure 8. Leafless Watermilfoil



Figure 9. White-Stem Pondweed

Table 8. 2021 Bear Lake Native Aquatic Plant Species and Relative Abundance.

<i>Native Aquatic Plant Species</i>	<i>Aquatic Plant Common Name</i>	<i>% cover in/around Bear Lake (June 2021)</i>	<i>% cover in/around Bear Lake (August 2021)</i>
<i>Chara vulgaris</i>	Muskgrass	7.0	14.0
<i>Potamogeton illinoensis</i>	Illinois Pondweed	10.1	15.5
<i>Potamogeton pusillus</i>	Small-leaf Pondweed	4.2	4.2
<i>Potamogeton robbinsii</i>	Fern-leaf Pondweed	22.0	49.6
<i>Stuckenia pectinatus</i>	Sago Pondweed	4.0	10.1
<i>Potamogeton amplifolius</i>	Large-leaf Pondweed	9.0	12.7
<i>Potamogeton praelongus</i>	White-stem Pondweed	20.2	38.9
<i>Potamogeton gramineus</i>	Variable-leaf Pondweed	7.0	25.5
<i>Potamogeton natans</i>	Floating-leaf Pondweed	4.0	15.6
<i>Potamogeton zosteriformis</i>	Flat-stem Pondweed	2.1	2.8
<i>Vallisneria americana</i>	Wild Celery	2.0	9.4
<i>Najas guadalupensis</i>	Southern Naiad	2.5	8.8
<i>Najas flexilis</i>	Slender Naiad	0.1	2.3
<i>Myriophyllum tenellum</i>	Leafless Watermilfoil	32.5	48.4
<i>Megalodonta beckii</i>	Water Marigold	0.7	0.7
<i>Ceratophyllum demersum</i>	Coontail	0.1	0.3
<i>Elodea canadensis</i>	Common Elodea	4.3	9.4
<i>Utricularia vulgaris</i>	Common Bladderwort	9.6	17.1
<i>Utricularia minor</i>	Small Bladderwort	0.5	0.2
<i>Nymphaea odorata</i>	White Waterlily	1.2	1.2
<i>Nuphar variegata</i>	Yellow Waterlily	1.5	1.5
<i>Brasenia schreberi</i>	Watershield	1.0	2.1
<i>Typha latifolia</i>	Cattails	2.6	2.8
<i>Schoenoplectus acutus</i>	Bulrushes	1.0	1.3
<i>Iris versicolor</i>	Blueflag Iris	0.2	0.6
<i>Decodon verticillatus</i>	Swamp Loosestrife	3.0	3.5

Status of Invasive (Exotic) Aquatic Plant Species in Bear Lake

The amount of Eurasian Watermilfoil (Figure 10) present in Bear Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. In 2021, the EWM was scarce in summer with 3.5 acres of EWM found during the May 12, 2021 survey (Figure 11).

The initial treatment occurred in late May, 2021 by PLM and included a combination of ProcellaCOR® and diquat. An additional 5.8 acres of EWM was found on an August 12, 2021 survey (Figure 12) which was also treated shortly after with ProcellaCOR® and diquat. This new combination was necessary to prevent the accumulated tolerance of the EWM to both triclopyr and 2,4-D products. Increased tolerance reduces the efficacy of the systemic herbicides on the sustained control of EWM.



Figure 10. Eurasian Watermilfoil

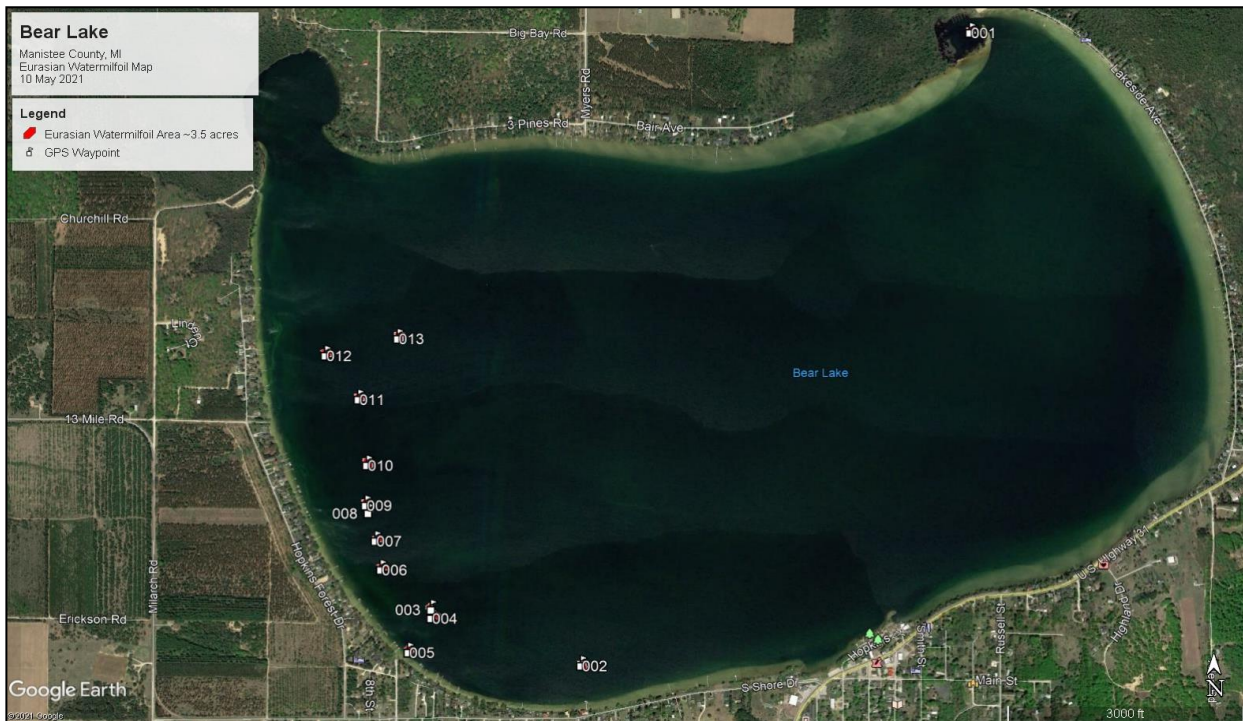


Figure 11. Distribution of EWM in Bear Lake (May 11, 2021).

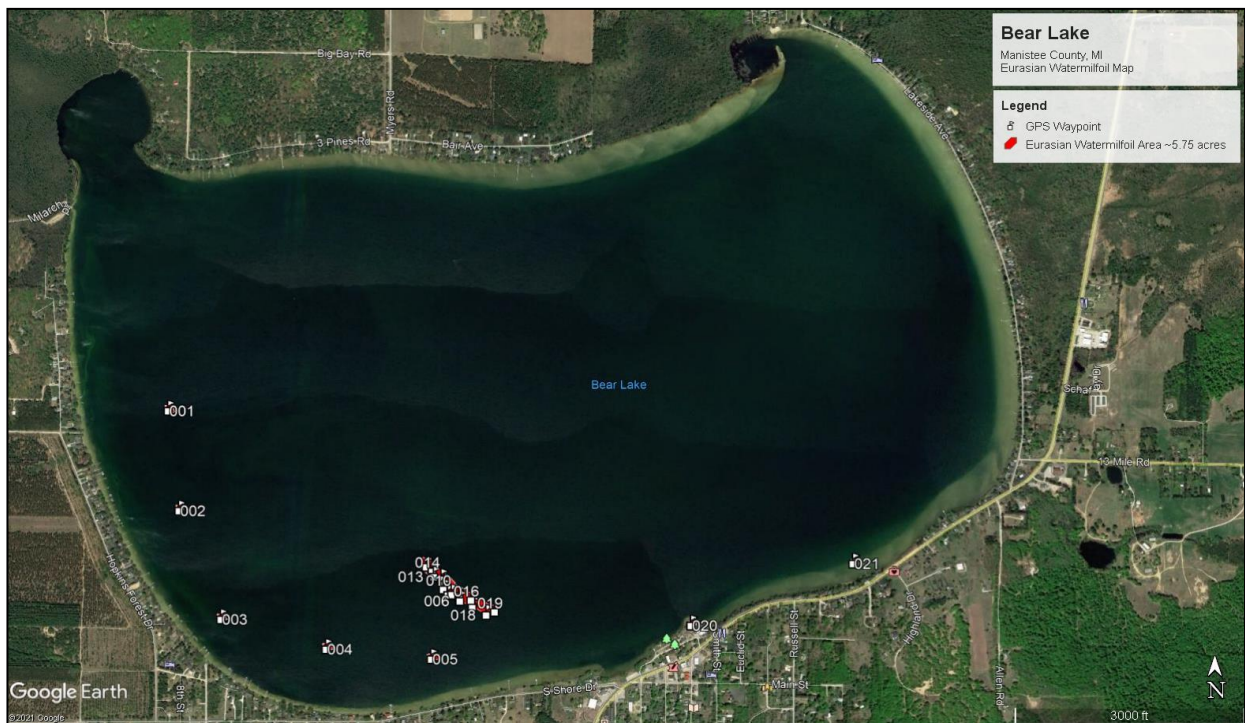


Figure 12. Distribution of EWM in Bear Lake (August 12, 2021).

Bear Lake Sediment Macroinvertebrate Data (2021)

Freshwater macroinvertebrates are ubiquitous, as even the most impacted lake contains some representatives of this diverse and ecologically important group of organisms. Benthic macroinvertebrates are key components of lake food webs both in terms of total biomass and in the important ecological role that they play in processing of energy. Others are important predators, graze algae on rocks and logs, and are important food sources (biomass) for fish. The removal of macroinvertebrates has been shown to impact fish populations and total species richness of an entire lake or stream food web (Lenat and Barbour 1994). In the food webs of lakes, benthic macroinvertebrates have an intermediate position between primary producers and higher trophic levels (as fish) on the other side. Hence, they play an essential role in key ecosystem processes (food chain dynamics, productivity, nutrient cycling, and decomposition). These may also include many rare species.

Several characteristics of benthic macroinvertebrates make them useful bio-indicators of lake water quality including that many are sensitive to changes in physical, chemical, and biological conditions of a lake, many complete their life cycle in a single year, their life cycles and ecological requirements are generally well known, they are sessile organisms and cannot readily escape pollution or other negative aspect, and they are easily collected. As benthic macroinvertebrates respond sensitively not only to pollution, but also to a number of other human impacts (hydrological, climatological, morphological, navigational, recreational, and others), they could potentially be used for a holistic indication system for lake ecosystem health (Solimini *et al.* 2006).

Some of the common lake macroinvertebrates include the Diptera (true flies), Coleoptera (beetles), Odonata (damselflies and dragonflies), Ephemeroptera (mayflies), Hemiptera (true bugs), Megaloptera (hellgrammites), Trichoptera (caddisflies), Plecoptera (stoneflies),

Crustacea (freshwater shrimp, crayfish, isopods), Gastropoda (snails), Bivalvia (clams and mussels), Oligochaeta (earthworms), Hirudinea (leeches), Turbellaria (planarians). While the majority of these are native species, numerous invasive species have been impacting lakes in the Great Lakes Region.

Restorative Lake Sciences, LLC, collected aquatic macroinvertebrate samples from three separate locations within Bear Lake, Manistee County, Michigan on August 12, 2021 (Table 9). The sampling found five key taxa which included mayflies (*Hexagenia limbata*, Ephemeroidea), midges (Chironomidae), damselfly larvae, caddisfly larvae, freshwater shrimp, and zebra mussels (Dreissenidae). Of all the species found, all were native except for the zebra mussels. While the majority of the species were native, some are located universally in low quality and high-quality water. The midge larvae family Chironomidae can be found in both high- and low-quality water (Lenat and Barbour 1994). The mayfly, *Hexagenia limbata*, found within this lake, has been shown to be linked with good water quality.

Native lake macroinvertebrate communities can and have been impacted by exotic and invasive species. A study by Stewart and Haynes (1994) examined changes in benthic macroinvertebrate community in southwestern Lake Ontario following the invasion of zebra and quagga mussels (*Dreissena spp.*). They found that *Dreissena* had replaced a species of freshwater shrimp as the dominant species. However, they also found that additional macroinvertebrates actually increased in the 10-year study, although some species were considered more pollution-tolerant than others. This increase was thought to have been due to an increase in *Dreissena* colonies increasing additional habitat for other macroinvertebrates.

Eurasian watermilfoil (*Myriophyllum spicatum*) has been shown to negatively influence both fish and macroinvertebrate communities (Lillie and Budd 1992). In addition to exotic and invasive macroinvertebrate species, macroinvertebrate assemblages can be affected by land-use. Stewart et al. (2000) showed that macroinvertebrates were negatively affected by surrounding land-use. They also indicated that noted these land-use practices are important to restoration and management of lakes. Schreiber et al. (2003) stated that disturbance and anthropogenic land use changes are usually considered to be key factors facilitating biological invasions.

Table 9. 2021 Bear Lake Macroinvertebrates (August 12, 2021).

Sample 1 Bear Lake Marina	Sample type – Dip Net/Sediment Grab				
		Odonata	Coregonidae	1	Damselfly larvae
		Trichoptera	Limnephilidae	2	Caddis larvae
		Diptera	Chironomidae	9	Midge larvae
		Gastropoda	Physidae	4	Pond snails
		Veneroida	Dreissenidae	8	Zebra Mussels
			Total	24	
Sample 2 Northwest Cove	Sample type – Dip Net/Sediment Grab	Ephemeroptera	Isonychidae	2	Mayfly larvae
		Odonata	Coregonidae	2	Damselfly larvae
		Diptera	Chironomidae	9	Midge larvae
		Veneroida	Dreissenidae	6	Zebra Mussels
		Gastropoda	Physidae	3	Pond snails
			Total	22	
Sample 3 Mid-lake sample milfoil bed	Sample type – Sediment Grab				
		Diptera	Chironomidae	11	Midge larvae
		Veneroida	Dreissenidae	6	Zebra Mussels
			Total	17	

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Management Recommendations for 2022

Continuous whole-lake geo-referenced aquatic vegetation surveys are needed to determine the precise locations of EWM or other problematic invasives in and around Bear Lake. These surveys should occur in late May, early June, and again post-treatment in 2022 and in-between as needed if more treatments become necessary. As in previous years, scientists from RLS will be present to oversee all aquatic herbicide applications.

Due to the relative scarcity of native aquatic vegetation in Bear Lake, the treatment of these species with aquatic herbicides is not recommended. The plan for 2022 includes the use of high dose systemic aquatic herbicides as used in 2021, which includes ProcellaCOR® with the contact herbicide diquat. This was used to reduce the tolerance of EWM to commonly used triclopyr and 2,4-D.

Water quality parameters in the main lake will also be monitored and graphed with historical data to observe long-term trends. This has been important since the nutrient concentrations and other parameters have demonstrated that Bear Lake is a stable and healthy aquatic ecosystem and that nutrients appear to be in balance.

Bear Lake was initially treated for over 330 acres of EWM in 2008. Since then, the lake has been treated for anywhere from 7 to 75 acres on an annual basis. What causes this variation and what can we expect in the future?

Little is known about the variation in acres of EWM found in Michigan Lakes from year to year. It is common to have new growth in the general area that we have found it and treated it in the past. It is generally thought that is due to roots spreading, propagation from segments of the plant drifting and re-rooting, or a dormant seed bed that comes from mature plants. Little is known about dormant seed beds.

Observation demonstrates that seed beds can remain dormant for several years, but there is no specific research in the literature that substantiates this. Bear Lake has had wide variation in treatment areas over the years, but ultimately could experience EWM re-grow in excess of 300 acres without careful management. Overall Bear Lake treatment has been highly successful resulting in very low assessments for a lake this large.

The scientists at RLS think that lake management which maintains EWM levels below 5% of the lakes surface areas are being managed successfully. Though EWM is an invasive plant that we want to minimize, it is a plant that is excellent fish cover in limited amounts. RLS surveys are intensive and site-specific, but it is impossible to find every hidden stem of EWM. RLS uses the latest technologies including GPS location of EWM and BioBase to help quantify the bio-volume of all aquatic vegetation. Below is a history of the annual acres treated to date.

<u>Year</u>	<u>Acres treated (rounded)</u>
2008	330
2009	11
2010	7
2011	11
2012	70
2013	10
2014	10
2015	29
2016	11
2017	17
2018	32
2019	75
2020	10
2021	11

In conclusion, Bear Lake is a very healthy lake with excellent aquatic plant biodiversity, very good water clarity, moderate nutrients, and a healthy lake fishery. Management of the EWM and protection of the water quality are paramount for the long-term health of the lake.