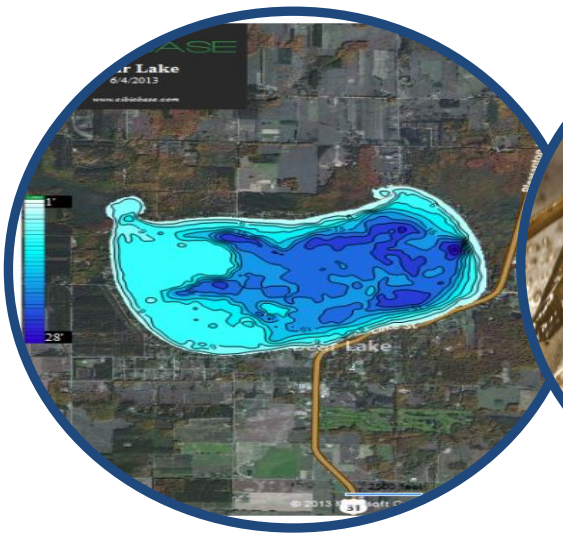
Bear Lake "State of the Lake" (2015) Report & 2016 Management Recommendations



December, 2015

Bear Lake "State of the Lake" Report

(2015)

© Restorative Lake Sciences
18406 West Spring Lake Road
Spring Lake, Michigan 49456
Email: info@restorativelakesciences.com
Website: http://www.restorativelakesciences.com

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1

Bear Lake "State of the Lake" Summary

The following information is a summary of key lake findings collected during the spring and summer of 2015.

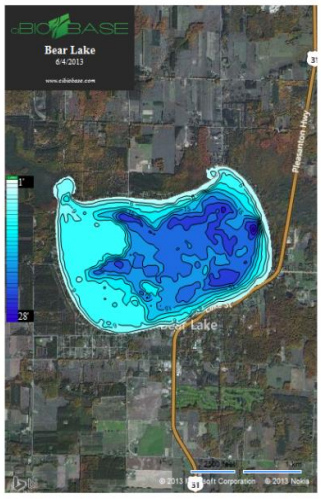
The overall condition of Bear Lake is ranked in the top 15% of developed lakes of similar size in the state of Michigan. The water clarity has been consistently over 14 feet during the past few years due to accelerated filtration by Zebra Mussels which extract green algae from the water for a food source and leave the water clearer. Bear Lake has enough nutrients (phosphorus and nitrogen) to support some algae and submersed aquatic plant growth, but the nutrient levels are considered moderate. Invasive species such as Eurasian Watermilfoil are able to grow in moderate nutrient waters and thus are a challenge to the Bear Lake ecosystem. Bear Lake was lucky to receive the news that the milfoil currently in the lake was genetically determined to not be hybridized which makes treatment more effective. 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 (i.e. lily pads in East Bay).

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. In the spring dissolved oxygen was high between 10.9-11.3 mg/L and the water temperature varied by 5°F. During late summer, the dissolved oxygen was 9.0 mg/L at the surface and 7.0 mg/L at the bottom. Water temperatures also ranged from 66.9-61.0°F. Conductivity remains relatively low and pH and alkalinity are indicative of a healthy soft water system. Nutrients such as phosphorus and nitrogen are also moderate and remain similar to in previous years.

Section

2

Bear Lake Water Quality Data



Did You Know? Bear Lake has a maximum depth of 28 feet

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-µS/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 µg/L), chlorophyll-*a* (in µg/L), and algal species composition. Graphs that show some critical trends for some parameters in spring and late summer of each year are displayed below. Trend data was calculated using mean values for each parameter for each season 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. 2015 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 10 and September 25 of 2015.

Lake Trophic Status	*Total Phosphorus (µg L^{-1})*	*Chlorophyll-a (µg 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 1. Lake trophic classification (MDNR).

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	53.2	11.0	7.3	221	0.4	129.8	0.40	61	0.011
10	50.7	11.2	7.4	220	0.7	117.6	0.40	59	0.011
21	48.7	10.9	7.5	225	1.0	108.5	0.50	58	0.012

Table 2. Bear Lake Water Quality Parameter Data Collected over Deep Basin 1 on June 10, 2015.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	53.8	10.9	7.3	223	0.4	122.4	0.40	59	0.013
10	50.4	11.3	7.4	226	0.6	113.5	0.40	59	0.011
22	49.6	11.2	7.4	229	0.8	119.5	0.40	60	0.019

Table 3. Bear Lake Water Quality Parameter Data Collected over Deep Basin 2 on June 10, 2015.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	53.2	11.0	7.5	220	0.3	135.6	0.30	61	0.011
10	50.6	11.2	7.5	218	0.5	127.8	0.40	57	0.015
21	48.4	11.0	7.7	222	1.1	111.3	0.30	59	0.020

Table 4. Bear Lake Water Quality Parameter Data Collected over Deep Basin 3 on June 10, 2015.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	66.8	9.0	7.5	220	0.3	128.7	0.50	60	0.010
10	64.0	8.9	7.5	219	0.8	118.4	0.45	59	0.018
21	61.5	8.0	7.4	225	1.5	68.4	1.3	60	0.022

Table 5. Bear Lake Water Quality Parameter Data Collected over Deep Basin 1 on September 25, 2015.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	66.9	9.1	7.5	223	0.3	145.6	0.40	61	0.012
10	64.3	7.8	7.4	221	0.6	132.7	0.50	60	0.024
22	61.0	7.0	7.5	229	1.2	108.4	1.5	61	0.028

Table 6. Bear Lake Water Quality Parameter Data Collected over Deep Basin 2 on September 25, 2015.

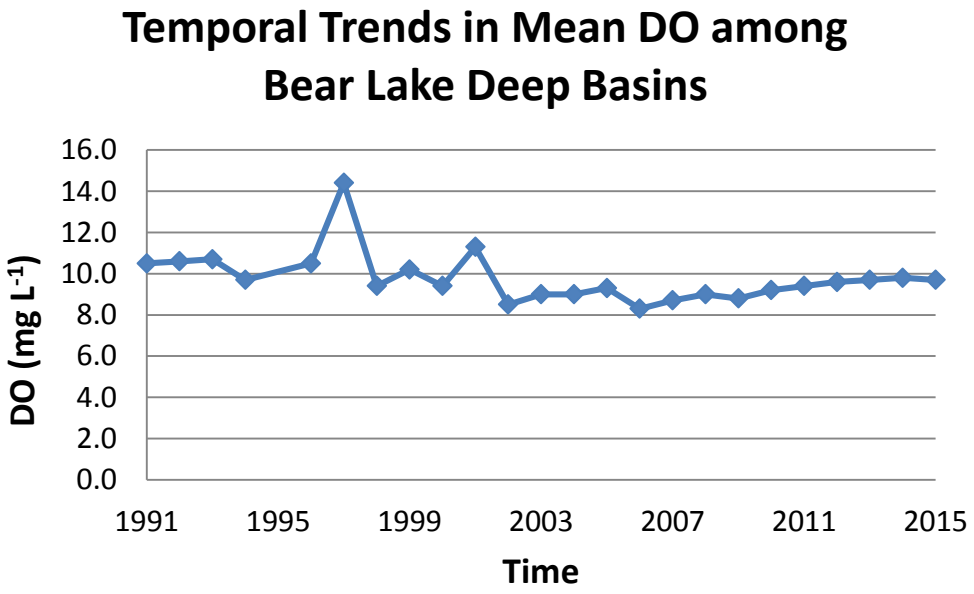
Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	66.4	9.0	7.5	226	0.5	136.9	0.40	59	0.011
10	64.7	8.4	7.4	222	0.6	126.5	0.50	60	0.026
21	62.0	7.2	7.4	217	1.9	88.6	0.55	61	0.030

Table 7. Bear Lake Water Quality Parameter Data Collected over Deep Basin 3 on September 25, 2015.

Dissolved Oxygen

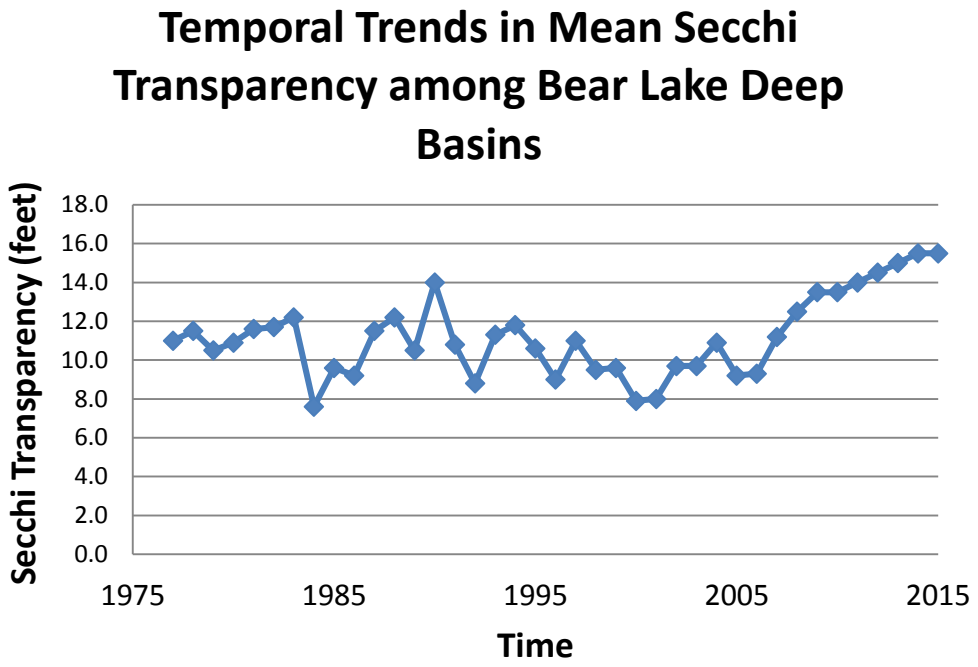
Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg L^{-1} to sustain a healthy warm-water fishery. Dissolved oxygen concentrations in Bear Lake may

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. The dissolved oxygen concentrations in Bear Lake support both a warm water and cool water fishery.



Water Clarity (Transparency) Data & Turbidity

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Bear Lake is adequate (~ 15 feet in 2015) 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 amount 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 were also quite low at less than 1.9 NTU's and 52 mg/L, respectively.

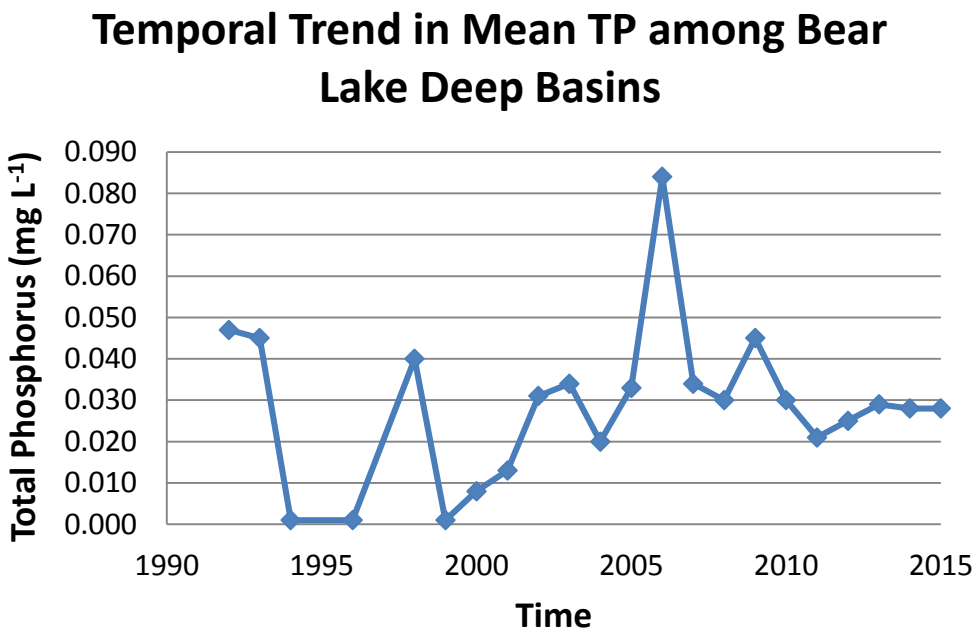


Total Phosphorus and Total Nitrogen

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 have fluctuated between 0.010-0.030 mg L^{-1} during the 2015 season.

Total Kjeldahl Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+), and organic nitrogen 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 0.30-1.5 mg L^{-1} which is considered oligo-mesotrophic and is desirable.

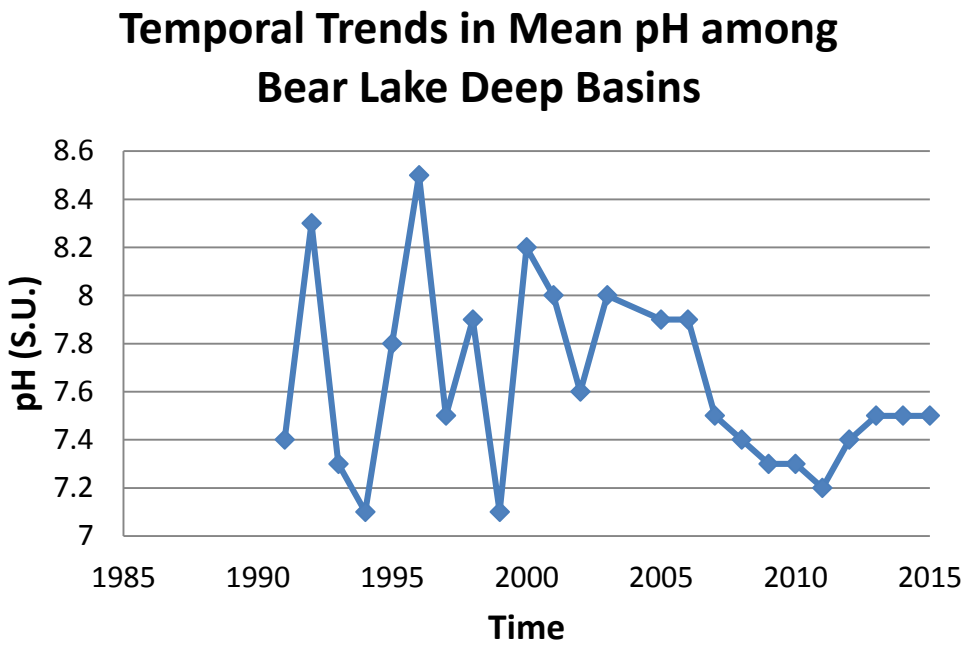


Total Alkalinity

Lakes with high alkalinity (> 150 mg L^{-1} of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ 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 of Bear Lake is soft and indicates a soft water lake.

pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (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 pH of Bear Lake has stabilized over the past few years to 7.5 S.U. which is ideal for an inland soft water lake.



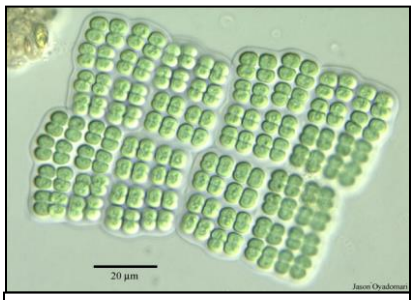
Conductivity

Conductivity is a measure of the amount 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 were moderate and ranged from 217-229 µS/cm. Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm.

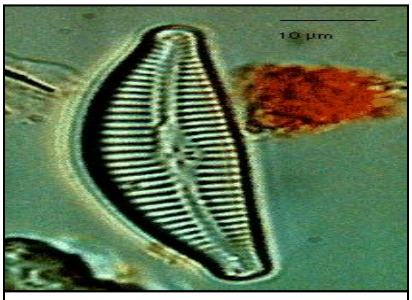
Chlorophyll-*a* and Algal Species Composition

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 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes. The mean chlorophyll-*a* concentrations in spring and late summer in Bear Lake do not exceed 3.2 µg/L which is moderate for an inland Michigan lake.

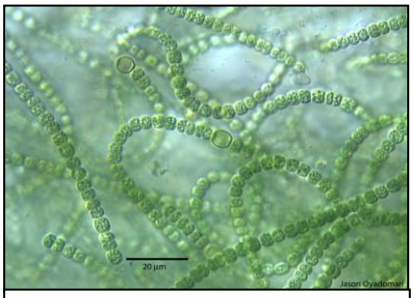
The algal genera were determined from composite water samples collected over the deep basins of Bear Lake in 2015 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae): *Scenedesmus* sp., *Haematococcus* sp., *Chlorella* sp., *Euglena* sp., *Radiococcus* sp., Cladophora sp., *Pediastrum* sp., *Gleocystis* sp., *Pandorina* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): G*leocapsa* sp., the Bascillariophyta (diatoms*): Stephanodiscus sp., Synedra* sp., *Fragilaria* sp., *Navicula* sp., *Cymbella* sp., *Nitzschia* sp., and *Tabellaria* 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.



A Green Alga (Good)



A Diatom (Good)



A Blue-Green Alga (Bad)

Section

3

Aquatic Vegetation Data (2015)

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 most recent survey in September of 2015 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 include Leafless Watermilfoil which lies close to the lake bottom and creates a "sod" appearance. Another common aquatic plant includes Variable-leaf Pondweed which grows close to the shore and has small, curled, green leaves. Also common was the Fern-leaf Pondweed which carpets the lake bottom with individual stems that resemble small ferns.

A list of all native aquatic plants and their relative abundance is found in Table 8 below.

Native Aquatic Plant Species	***Aquatic Plant Common Name***	***% cover in/around Bear Lake (June 2015)***	***% cover in/around Bear Lake (Sept. 2015)***
Chara vulgaris	Muskgrass	3.0	3.0
Potamogeton illinoensis	Illinois Pondweed	2.1	7.0
Potamogeton pusillus	Small-leaf Pondweed	4.0	5.7
Potamogeton robbinsii	Fern-leaf Pondweed	6.0	14.5
Stuckenia pectinatus	Sago Pondweed	0.5	2.6
Potamogeton amplifolius	Large-leaf Pondweed	1.1	4.0
Potamogeton praelongus	White-stem Pondweed	2.5	5.7
Potamogeton gramineus	Variable-leaf Pondweed	6.0	10.5
Potamogeton natans	Floating-leaf Pondweed	3.5	4.8
Potamogeton zosteriformis	Flat-stem Pondweed	0.9	3.5
Vallisneria americana	Wild Celery	2.5	2.9
Najas guadalupensis	Southern Naiad	6.2	7.0
Najas flexilis	Slender Naiad	0.7	2.7
Myriophyllum tenellum	Leafless Watermilfoil	12.4	15.6
Megalodonta beckii	Water Marigold	4.6	5.7
Ceratophyllum demersum	Coontail	2.9	2.9
Elodea canadensis	Common Elodea	7.1	7.8
Utricularia vulgaris	Common Bladderwort	4.1	5.2
Utricularia minor	Small Bladderwort	0.2	0.3
Nymphaea odorata	White Waterlily	0.2	0.2
Nuphar variegata	Yellow Waterlily	0.4	0.5
Brasenia schreberi	Watershield	0.7	1.4
Typha latifolia	Cattails	0.7	0.7
Scirpus acutus	Bulrushes	0.8	1.0
Iris versicolor	Blueflag Iris	0.2	0.2
Decodon verticillatus	Swamp Loosestrife	0.7	0.9

Table 8. 2015 Bear Lake Native Aquatic Plant Species and Relative Abundance.

Invasive (Exotic) Aquatic Plant Species

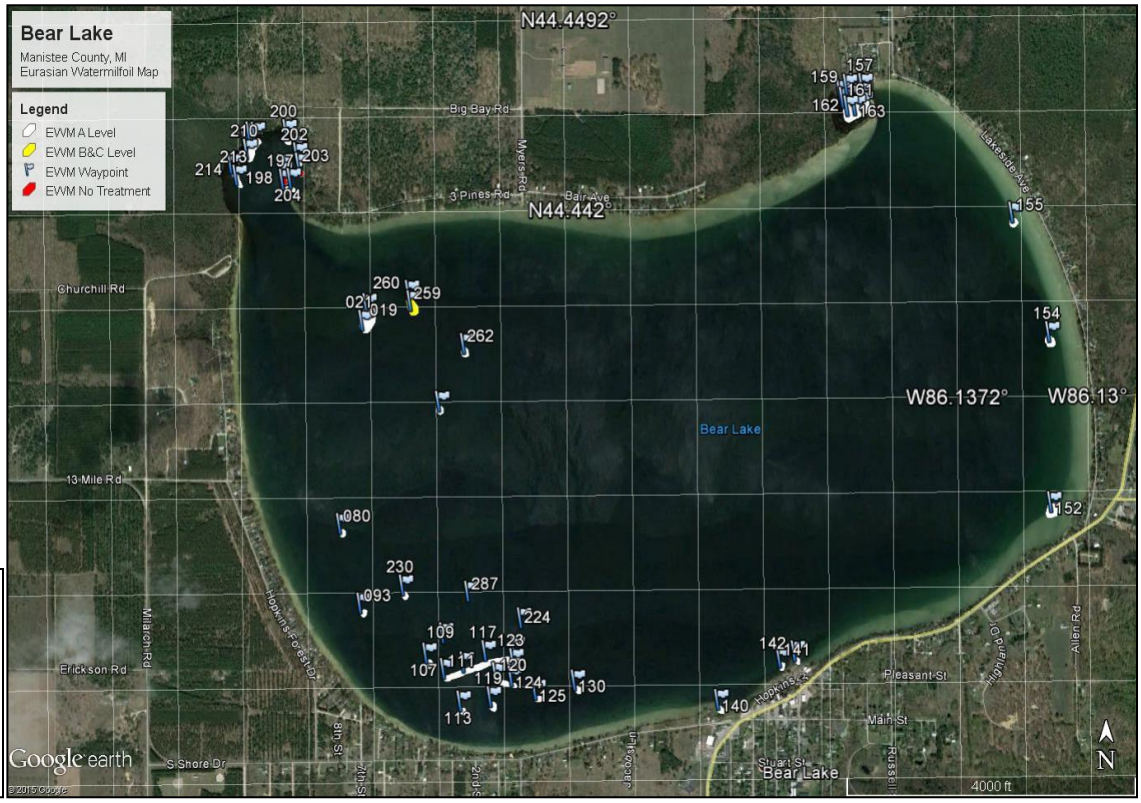
Eurasian Watermilfoil

The amount of Eurasian Watermilfoil present in Bear Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. 2015 was the wettest year on record and many lakes experienced nuisance milfoil and algal outbreaks even given the two consecutive harsh winters.

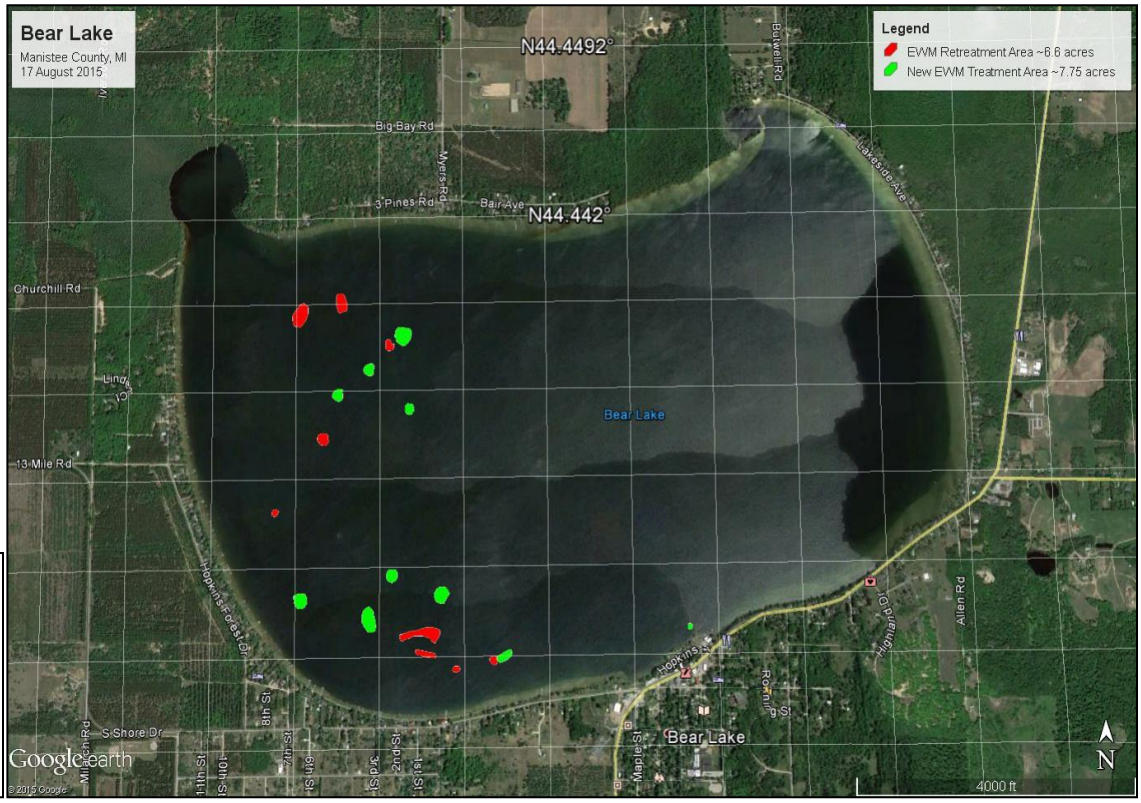
The spring 2015 survey revealed that approximately 8 acres of milfoil was found throughout the lake and it treated with granular 2,4-D (Sculpin®) at a dose of 200 lbs. per acre on June 15th. On August 27, 2015 an additional 7 acres of milfoil was treated based on the early August post-treatment survey. The treatments were successful overall with minimal regrowth of the milfoil. Maps showing the locations of all milfoil are shown on the next page. The milfoil in the West Bay was not treated in front of one residence due to request for non-treatment. The 2015 surveys revealed that there was a total of 2 invasive species in and around the lake which included non-hybrid watermilfoil and the emergent, Purple Loosestrife (see photo below).

Purple Loosestrife as found in the West Bay of Bear Lake. This plant should be hand-removed if possible.

Bear Lake 2015 Milfoil Distribution Map



Bear Lake 2015 Additional EWM Distribution Map



Section

4

Management Recommendations for 2016

Continuous 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 June and again post-treatment in 2016.

Due to the relative scarcity of native aquatic vegetation in Bear Lake, the treatment of these species with aquatic herbicides is not recommended (one exception is the overgrowth of lily pads in the East Bay). The plan for 2016 includes the use of high dose systemic aquatic herbicides as used in recent years. Products such as Sculpin G® at a dose of 200 lbs. per acre would be recommended offshore and a dose of 200 lbs. per acre for Renovate OTF® nearshore for effective control of the milfoil.

Water quality parameters in the main lake will also be monitored and graphed with historical data to observe long-term trends.

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.

Glossary of Scientific Terms used in this Report

1) Biodiversity- The relative abundance or amount of unique and different biological life forms found in a given aquatic ecosystem. A more diverse ecosystem will have many different life forms such as species.

2) CaCO3- The molecular acronym for calcium carbonate; also referred to as "marl" or mineral sediment content.

3) Eutrophic- Meaning "nutrient-rich" refers to a lake condition that consists of high nutrients in the water column, low water clarity, and an over-abundance of algae and aquatic plants.

4) Mesotrophic- Meaning "moderate nutrients" refers to a lake with a moderate quantity of nutrients that allows the lake to have some eutrophic qualities while still having some nutrient-poor characteristics

5) Oligotrophic- Meaning "low in nutrients or nutrient-poor" refers to a lake with minimal nutrients to allow for only scarce growth of aquatic plant and algae life. Also associated with very clear waters.

6) Sedimentary Deposits- refers to the type of lake bottom sediments that are present. In some lakes, gravel and sand are prevalent. In others, organic muck, peat, and silt are more common.