Bear Lake 2018 Aquatic Vegetation, Water Quality, and 2019 Management Recommendations Report

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Section 1

Bear Lake 2018 Aquatic Vegetation, Water Quality, and 2019 Management Recommendations Report

The following information is a summary of key lake findings collected in 2018.

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 2018 was excellent with an average of 19.5 feet. This is higher than in recent years and may explain the sudden increase in EWM in 2018. The nutrient concentrations in the lake are considered moderate and are adequate to support robust submersed aquatic plant growth. 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 had nearly 32.8 acres of EWM in 2018 which was very effectively treated with systemic herbicides such as triclopyr and 2, 4-D. 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. Trends for most water quality parameters are shown below. Overall, Bear Lake is a very stable aquatic ecosystem with excellent aquatic vegetation biodiversity and water clarity, and neutral pH and soft water alkalinity.

Section

2

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-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. 2018 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 18 and September 20 of 2018.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*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 18, 2018.

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	74.5	10.1	7.6	236	0.6	141.5	0.50	61	<0.010
10	71.9	9.2	7.7	238	0.9	123.9	0.50	61	0.010
21	68.6	9.3	7.4	233	1.2	112.4	0.50	63	0.025

Table 3. Bear Lake Water Quality Parameter Data Collected over Deep Basin 2 on June 18, 2018.

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	74.1	10.0	7.7	231	0.1	126.7	0.50	62	<0.010
10	71.4	10.0	7.5	236	0.3	119.4	0.50	62	<0.010
22	67.4	9.4	7.3	237	0.9	119.0	0.50	61	0.020

Table 4. Bear Lake Water Quality Parameter Data Collected over Deep Basin 3 on June 18, 2018.

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	74.0	10.4	7.6	235	0.6	122.5	0.50	62	0.010
10	71.6	10.1	7.4	236	0.8	116.7	0.50	62	0.010
21	68.1	9.0	7.4	236	1.1	102.0	0.50	60	0.030

Table 5. Bear Lake Water Quality Parameter Data Collected over Deep Basin 1 on September 20, 2018.

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	67.2	9.2	7.6	232	0.2	131.0	<0.50	63	<0.010
10	66.0	8.4	7.7	229	0.5	118.2	0.50	63	0.020
21	61.2	6.4	7.5	231	1.0	104.7	0.50	60	0.020

Table 6. Bear Lake Water Quality Parameter Data Collected over Deep Basin 2 on September 20, 2018.

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	67.9	9.6	7.7	227	0.4	136.1	0.50	62	0.010
10	66.5	8.0	7.7	230	0.4	120.8	<0.50	62	0.010
22	61.9	7.7	7.6	223	0.8	114.0	0.50	60	0.030

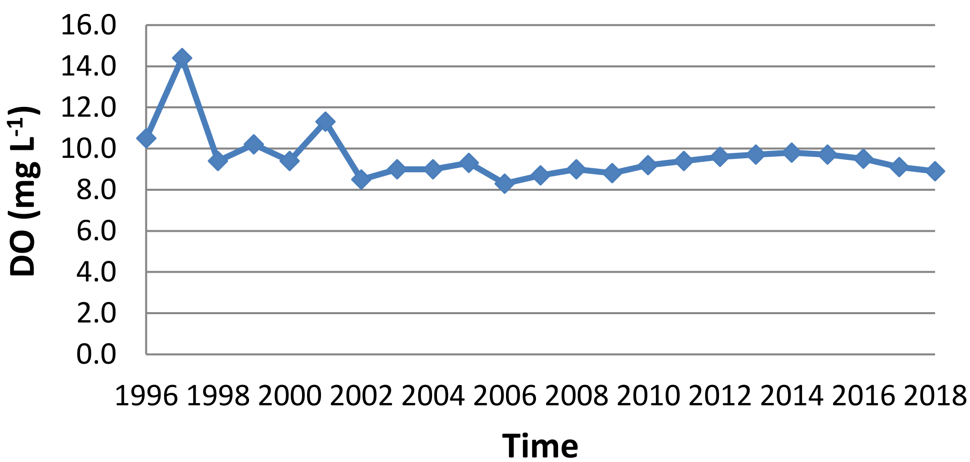
Table 7. Bear Lake Water Quality Parameter Data Collected over Deep Basin 3 on September 20, 2018.

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	68.0	9.1	7.8	240	0.4	127.0	<0.50	61	<0.010
10	65.1	7.9	7.7	235	0.4	101.0	<0.50	60	0.020
21	62.3	6.9	7.7	231	0.6	103.8	0.50	60	0.030

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 9.1 mg L^{-1} in 2018. Figure 1 below shows the changes in mean dissolved oxygen with time in Bear Lake.

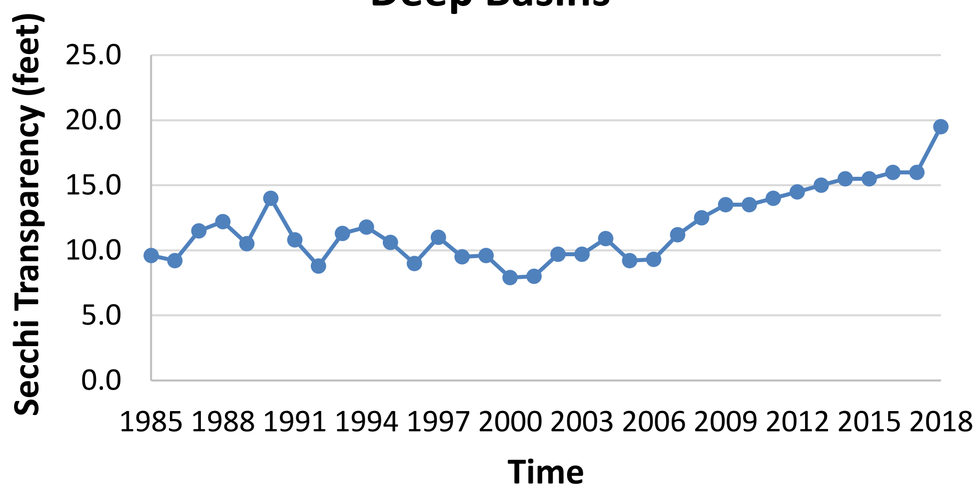
Figure 1. Temporal Trends in Mean DO among Bear Lake Deep Basins



Water Clarity (Transparency) Data & Turbidity

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Bear Lake is adequate (19.5 feet in 2018; 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 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 during the 2018 sampling events were also quite low at ≤1.2 NTU's and 46 mg/L, respectively.

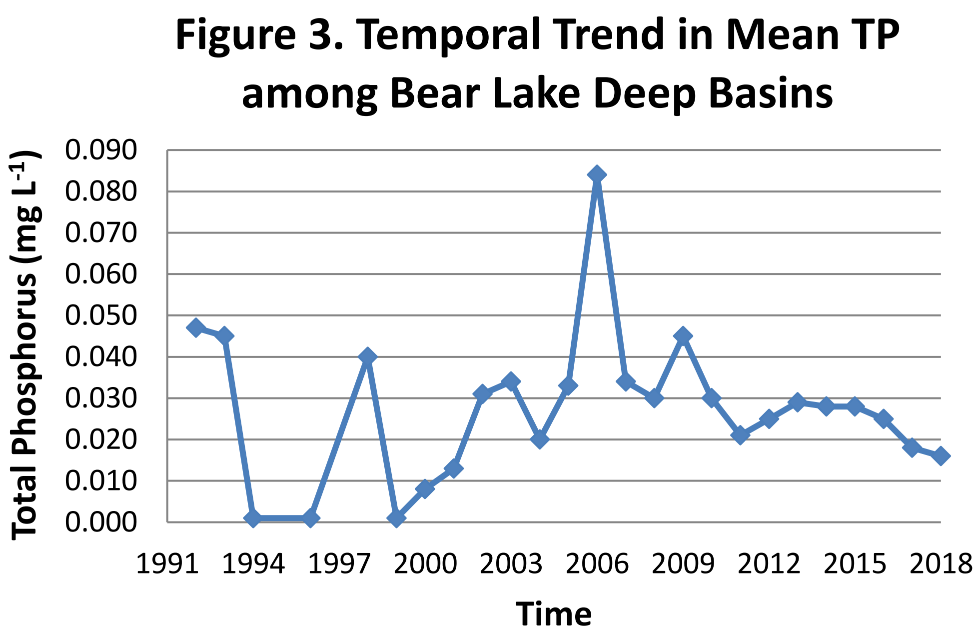
Figure 2. Temporal Trends in Mean Secchi Transparency among Bear Lake Deep Basins



Total Phosphorus and Total Nitrogen

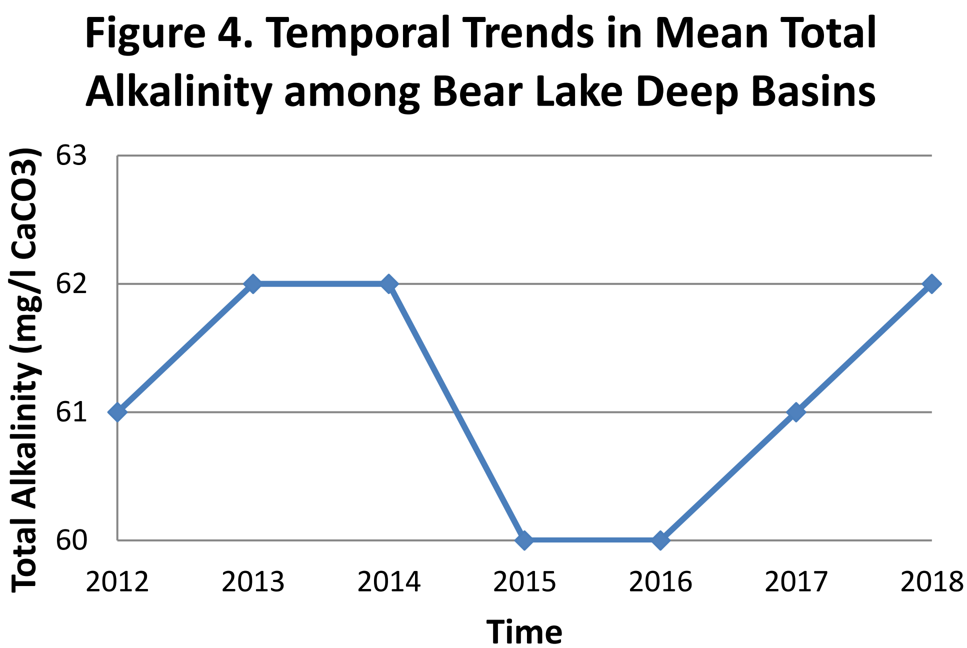
Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under 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 <0.010-0.030 mg L^{-1} during the 2018 season sampling events. The mean TP concentration was around 0.016 mg L^{-1} (Figure 3) in 2018 which is quite low and favorable and below the eutrophic threshold.

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 <0.50-0.50 mg L^{-1} during the 2018 sampling events which is considered oligo-mesotrophic and is desirable.



Total Alkalinity

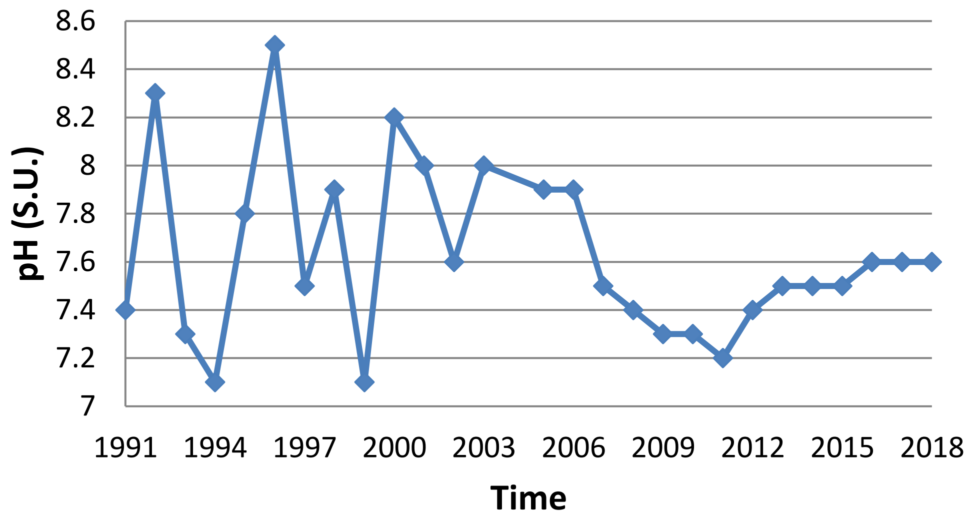
Lakes with high alkalinity (> 150 mg L^{-1} of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water. The alkalinity in Bear Lake averaged 62 mg L^{-1} of $CaCO_3$ (Figure 4) in 2018, which is soft and indicates a soft water lake.



pH

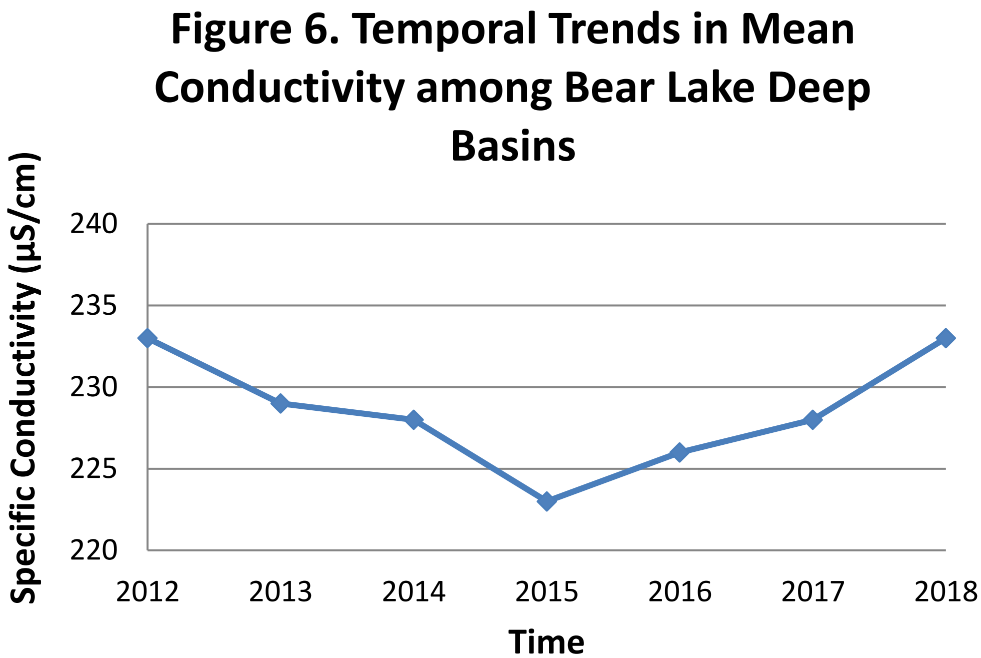
Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). Bear Lake is considered "slightly basic" on the pH scale. The mean pH of Bear Lake during the 2018 sampling events averaged 7.6 S.U. which is ideal for an inland soft water lake (Figure 5).

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



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 during the 2018 sampling events (Figure 6) were moderate and ranged from 227-240 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.

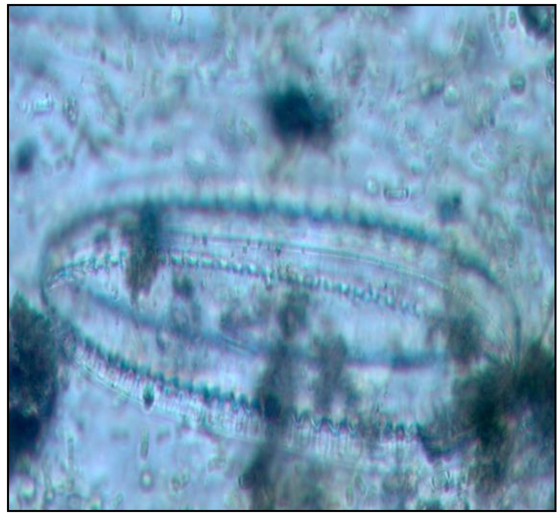


Chlorophyll-*a* and Algal Species Composition

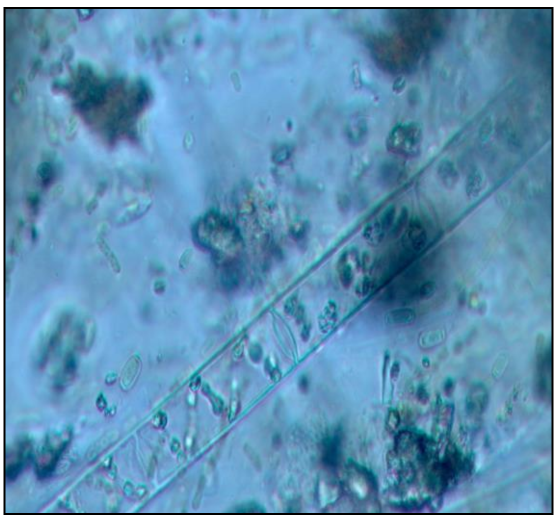
Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg L^{-1} are found in eutrophic or nutrient-enriched 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 during the 2018 sampling events in Bear Lake did not exceed 1.7 µg/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 2018 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae): *Scenedesmus* sp., *Chlorella* sp., *Mougeotia* sp., *Cosmarium* sp., *Haematococcus* sp., *Spirogyra* sp., *Cladophora* sp., *Pediastrum* sp., *Rhizoclonium* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): G*leocapsa* sp., the Bascillariophyta (diatoms): *Synedra* sp., *Cymbella* sp., *Navicula* sp., *Stephanodiscus* 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. Microscopic photos of some key algae in Bear Lake are shown below.

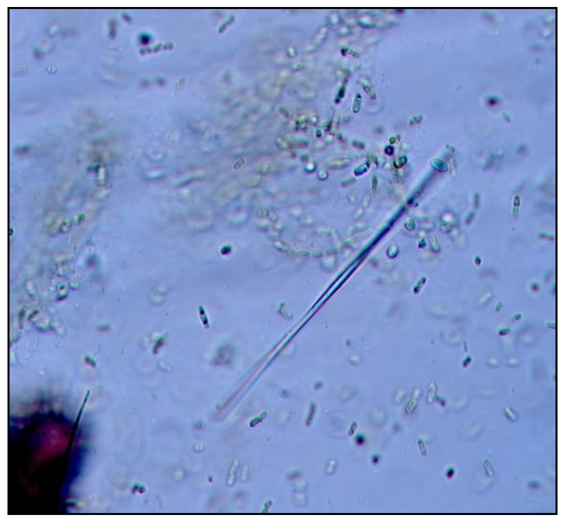
Scenedesmus- A green algae in Bear Lake



Navicula- A diatom algae in Bear Lake



Spirogyra- A green algae in Bear Lake



Synedra- A diatom algae in Bear Lake

Section 3

Aquatic Vegetation Data (2018)

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 2018 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) Leafless Watermilfoil (Figure 7) which lies close to the lake bottom and creates a “sod” appearance; 2) Fern-leaf Pondweed (Figure 8) which lies close to the lake bottom and has green fern-like leaves. 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 2018 is found in Table 8 below.

Figure 7. Leafless Watermilfoil

Figure 8. Fern-leaf Pondweed

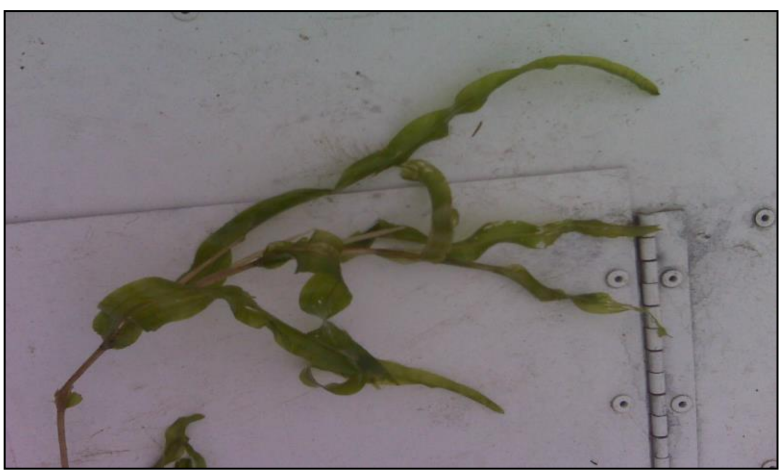


Figure 9. White-Stem Pondweed

Table 8. 2017 Bear Lake Native Aquatic Plant Species and Relative Abundance.

Native Aquatic Plant Species	***Aquatic Plant Common Name***	***% cover in/around Bear Lake (June 2018)***	***% cover in/around Bear Lake (Sept. 2018)***
Chara vulgaris	**Muskgrass**	**6.0**	**9.5**
Potamogeton illinoensis	Illinois Pondweed	10.9	15.9
Potamogeton pusillus	Small-leaf Pondweed	6.0	8.8
Potamogeton robbinsii	Fern-leaf Pondweed	29.4	44.7
Stuckenia pectinatus	Sago Pondweed	6.0	22.0
Potamogeton amplifolius	Large-leaf Pondweed	7.1	9.5
Potamogeton praelongus	White-stem Pondweed	27.0	35.7
Potamogeton gramineus	Variable-leaf Pondweed	10.6	16.4
Potamogeton natans	Floating-leaf Pondweed	6.7	11.2
Potamogeton zosteriformis	Flat-stem Pondweed	11.2	15.8
Vallisneria americana	Wild Celery	7.0	9.0
Najas guadalupensis	Southern Naiad	14.7	19.1
Najas flexilis	Slender Naiad	0.5	1.0
Myriophyllum tenellum	Leafless Watermilfoil	39.8	46.3
Megalodonta beckii	Water Marigold	2.0	3.0
Ceratophyllum demersum	Coontail	1.9	4.7
Elodea canadensis	Common Elodea	8.0	9.1
Utricularia vulgaris	Common Bladderwort	10.4	18.1
Utricularia minor	Small Bladderwort	0.6	1.0
Nymphaea odorata	White Waterlily	0.9	2.0
Nuphar variegata	Yellow Waterlily	1.9	3.4
Brasenia schreberi	Watershield	1.2	4.5
Typha latifolia	Cattails	2.8	5.6
Schoenoplectus acutus	Bulrushes	0.9	3.3
Iris versicolor	Blueflag Iris	0.7	2.5
Decodon verticillatus	Swamp Loosestrife	3.5	6.8

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 2018, the EWM grew later in the season with only 5 acres of EWM found during the June 18, 2018 survey (Figure 11) and 15.75 acres found during the August 9, 2018 survey (Figure 12). This may have been attributed to seed bank growth since the distribution is one that has not been observed since the original EWM infestation in 2008-9.

The first treatment occurred on June 26, 2018 by PLM and included 1.8 acres of Renovate OTF® @ 200lbs/acre, 4.25 acres of Sculpin G® at 240 lbs. /acre, and 0.5 acres of Sculpin G® at 200 lbs. /acre. On August 20, 2018, the EWM was treated with Sculpin G® @250 lbs. /acre. The higher doses of aquatic herbicides have been necessary to effectively treat and kill the milfoil.

The treatments were successful overall with minimal regrowth of the milfoil. The 2018 surveys revealed that there was a total of two invasive species in and around the lake which included non-hybrid watermilfoil and the emergent, Purple Loosestrife which was found in a small area of the West Bay. Map showing the locations of all milfoil are shown on the next two pages (Figures 11-12).

Figure 10. Eurasian Watermilfoil

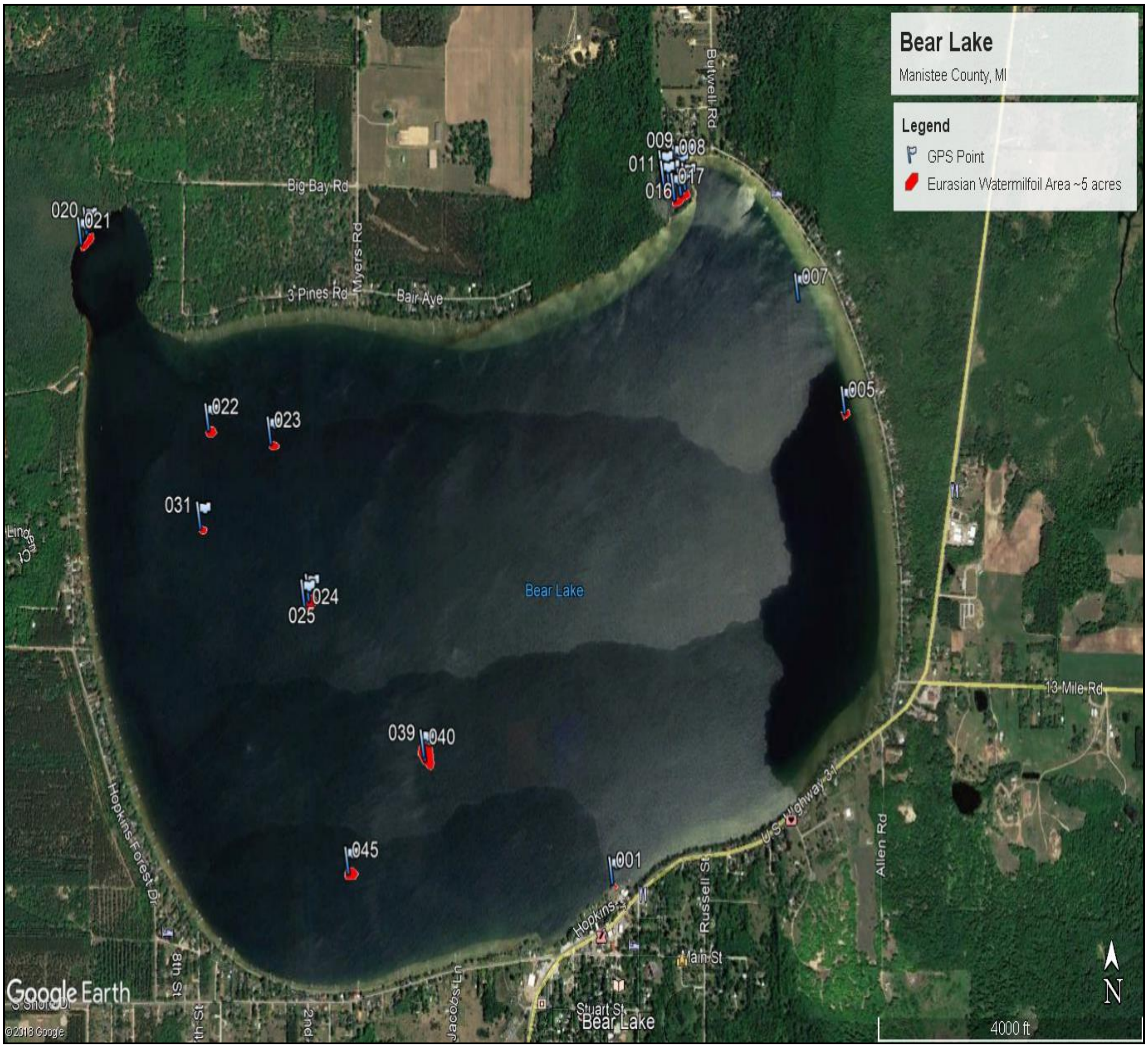


Figure 11. Distribution of EWM in Bear Lake (June 18, 2018).

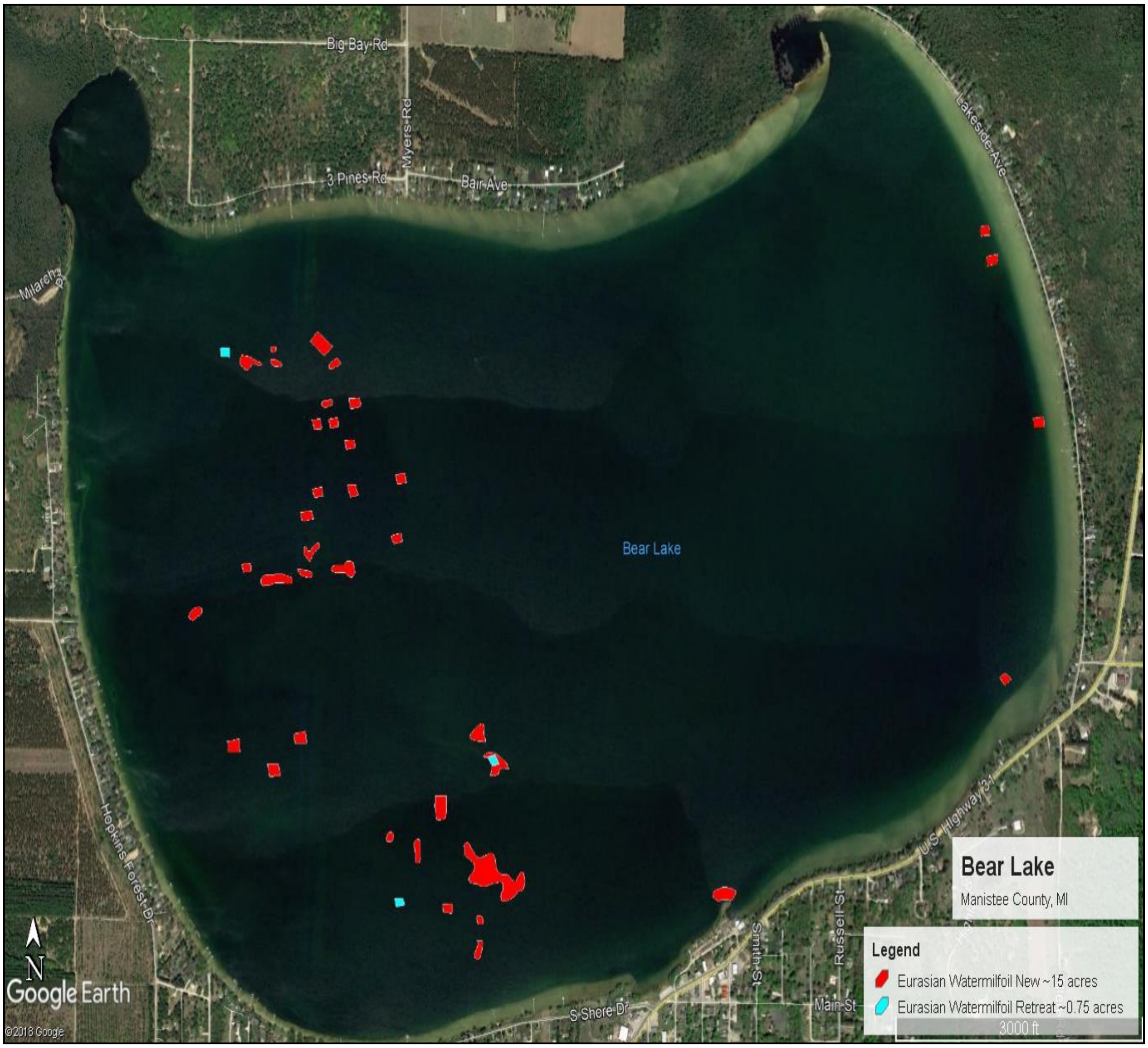


Figure 12. Distribution of EWM in Bear Lake (August 9, 2018).

Section

4

Bear Lake Sediment Macroinvertebrate Data (2018)

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 (hydro-logical, 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 9, 2018 (Table 9). The sampling found five key taxa which included mayflies (*Hexagenia limbata*, Ephemeridae), midges (Chironomindae), damselfly larvae, caddisfly larvae, freshwater shrimp, and zebra mussels (Dreisseniidae). 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 and of lakes. Schreiber et *al*. (2003) stated that disturbance and anthropogenic land use changes are usually considered to be key factors facilitating biological invasions.

These samples were similar those collected in 2017 but with higher counts of all taxa, including zebra mussels.

Table 9. 2018 Bear Lake Macroinvertebrates (August 9, 2018).

Sample 1 Bear Lake Marina	**Sample type – Dip Net/Sediment Grab**				
		Odonata	Coregonidae	1	Damselfly larvae
		Ephemeroptera	Isonychidae	4	Mayfly larvae
		Amphipoda	Gammaridae	6	Freshwater shrimp
		Trichoptera	Limnephilidae	4	Caddis larvae
		Diptera	Chironomidae	11	Midge larvae
		Veneroida	Dreissenidae	9	Zebra Mussels
			Total	**35**	
Sample 2 Northwest Cove	**Sample type – Dip Net/Sediment Grab**	Ephemeroptera	Isonychidae	5	Mayfly larvae
		Diptera	Chironomidae	7	Midge larvae
		Gastropoda	Physidae	8	Pond snails
			Total	**20**	
Sample 3 Mid-lake sample milfoil bed	**Sample type – Sediment Grab**				
		Diptera	Chironomidae	9	Midge larvae
		Veneroida	Dreissenidae	6	Zebra Mussels
		Amphipoda	Gammaridae	2	Freshwater shrimp
			Total	**17**	

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Section

5

Management Recommendations for 2018

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 2019. 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 (one exception is the overgrowth of lily pads in the East Bay. The plan for 2019 includes the use of high dose systemic aquatic herbicides as used in recent years. Products such as Sculpin G® at a dose of 200-250 lbs. /acre would be recommended offshore and a dose of 200-250 lbs. /acre of 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. This has been important since the nutrient concentrations and other parameters have demonstrated that Bear Lake is a stable and healthy aquatic ecosystem.

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) $CaCO_3$- 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.