MI/DEQ/WRD-14/013

Cooperative Lakes Monitoring Program

Michigan's Citizen Volunteer
Partnership for Lakes

"MI Lakes - Ours to Protect"

ANNUAL SUMMARY REPORT

2013

Michigan's Citizen Volunteers
Michigan Lake & Stream Associations, Inc.
Michigan Department of Environmental Quality
Michigan State University Department of Fisheries and Wildlife
Great Lakes Commission
Huron River Watershed Council

Michigan Clean Water Corps
www.micorps.net

Michigan's Lakes and the Tragedy of the Commons

In 1968, Garrett Hardin published his classic environmental essay *The Tragedy of the Commons* in the journal *Science*. In it he succinctly depicted the degradation and exploitation of the environment to be expected whenever many individuals share a common resource, such as federal rangeland, state and national parks, the atmosphere, streams and lakes. Using a community pasture as an example, he explained how each herder added more and more animals to his herd until the pasture was destroyed by overgrazing. Each herder benefited monetarily by adding animals to his herd, but bore no responsibility for the pasture and its sustainability.

While Hardin popularized the tragedy of the commons, others before him identified the characteristic fate of common property. In fact, two thousand years ago, Aristotle in his book *Politics* stated, "what is common to the greatest number has the least care bestowed upon it. Everyone thinks chiefly of his own, hardly at all of the common interest". Lakes and streams are clearly a common property, shared by the riparian property owners and the community of citizens who use and enjoy the water, fish, wildlife and aesthetic appeal.

True to the tragedy of the commons, most lakes provide countless hours of recreational enjoyment for numerous users. Some receive waste discharges from municipal and industrial sources. Nearly all are impacted by urban and agricultural development and stormwater runoff, septic systems and lawn fertilizers, increasing weed growth, algae blooms and muck accumulation. Very few are managed to sustain their quality for future generations. With over 11,000 lakes in Michigan, limited state agency staff can provide only partial oversight and must concentrate on the most serious problems. Local governments, although possessing management tools like Lake Improvement Boards and Watershed Councils, address police and fire protection, schools, infrastructure development, and waste management as higher priorities. Riparian property owners who should be the leading advocates for lake protection and promoting collaborative management partnerships are more often interested in recreational activities such as swimming, fishing and boating.

Unfortunately, most lakes are fulfilling Hardin's principle of the tragedy of the commons. Only a few exceptional communities are proof that the principle is not an irrefutable law of human society. When communities accept ownership in their natural resources, lakes and streams can be high quality, sustainable commons. The more each lake owner and user invests in this responsibility, the more certain our children will be that they will “inherit our water resources in the same quality that we the present generation borrowed it from them”. **Working together we can protect Michigan’s lakes!**

Cooperative Lakes Monitoring Program

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DATA CORRECTIONS FROM PREVIOUS REPORTS

Indian Lake (Cass County) should have been included in the listing of lakes participating in Dissolved Oxygen and Temperature monitoring in 2012 (Appendix 4).

If you believe that the tabulated data for your lake in this Report are in error please contact Bill Dimond, CLMP program coordinator by telephone at 517-241-9565 or email at dimondw@michigan.gov. It is important for the credibility of the CLMP that all data be accurately reported. When tabulation and reporting errors are found they need to be identified and a correction statement issued. We appreciate your support in the review of CLMP data and maintaining a high level of quality for the program.

INTRODUCTION

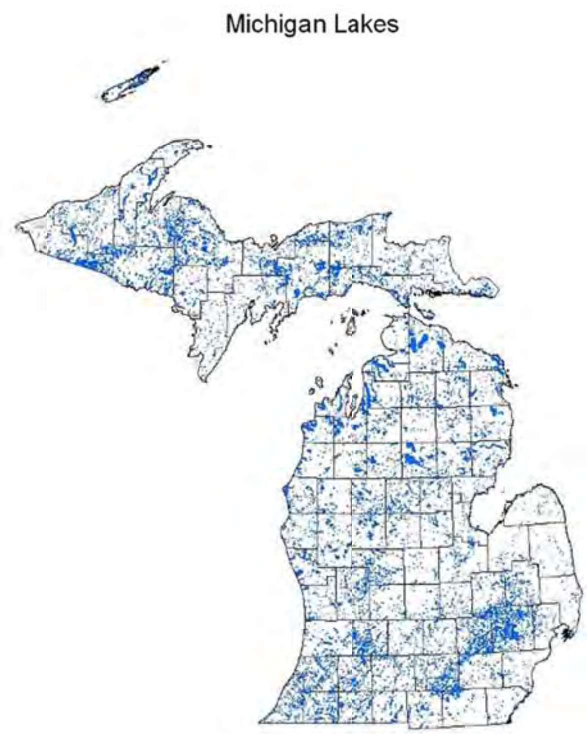
Michigan's unique geographical location provides its citizens with a wealth of freshwater resources including over 11,000 inland lakes. In addition to being valuable ecological resources, lakes provide aesthetic and recreational value for the people of Michigan and neighboring states. An ideal Michigan summer pastime is going to a cottage on an inland lake to fish, water-ski, swim, and relax.

As more and more people use the lakes and surrounding watersheds, the potential for pollution problems and use impairment increases dramatically. Although many of Michigan's inland lakes have a capacity to accommodate the burden of human activities in the short term, continuing stress on the lakes and lake watersheds over time will ultimately lead to adverse water quality and recreational impacts.

Reliable information including water quality data, levels of use, and use impairment are essential for determining the health of a lake and for developing a management plan to protect the lake. As the users and primary beneficiaries of Michigan's lake resources, citizens must take an active role in obtaining this information and managing their lakes.

To meet this need, the Department of Environmental Quality (DEQ), Michigan Lake & Stream Associations (MLSA), the Great Lakes Commission, the Huron River Watershed Council, and Michigan State University have partnered to implement the Cooperative Lakes Monitoring Program (CLMP). The purpose of this effort is to help citizen volunteers monitor indicators of water quality in their lake and document changes in lake quality. The CLMP

Michigan's abundant water resources...



Source: Michigan Department of Natural Resources, 1990.

...include over 11,000 inland lakes.

provides sampling methods, training, workshops, technical support, quality control, and laboratory assistance to the volunteer monitors. Michigan State University's Department of Fisheries and Wildlife supports the partnership with technical assistance.

THE SELF-HELP LEGACY

Originally known as the Self-Help Program, the CLMP continues a long tradition of citizen volunteer monitoring. Michigan has maintained a volunteer lake monitoring program since 1974, making it the second oldest volunteer lake monitoring program in the nation. The original program monitored water quality by measuring water clarity with a Secchi disk.

In 1992, the former Department of Natural Resources and MLSA entered into a cooperative agreement to expand the program. An advanced Self-Help program was initiated that included a monitoring component for the plant nutrient phosphorus. In 1994, a side-by-side sampling component was added to the program to assure the quality of the data being collected.

The CLMP continues the "self-help" legacy by providing citizens an opportunity to learn and participate in lake management. Currently, the CLMP supports monitoring components for Secchi disk transparency, total phosphorus, chlorophyll *a*, dissolved oxygen/temperature and aquatic plants.

The CLMP is a cost-effective process for the DEQ to increase the baseline data available for Michigan's lakes as well as establish a continuous data record for determining water quality trends. Therefore the DEQ/citizen volunteer partnership is critical to lake management in Michigan.

CLMP Contacts

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http://www.micorps.net

CLMP and MiCORPS

The CLMP is also a principal program within the Michigan Clean Water Corps (MiCorps), a network of volunteer monitoring programs in Michigan. MiCorps was created through an executive order by former Governor Jennifer Granholm to assist the DEQ in collecting and sharing water quality data for use in management programs and to foster water resource stewardship. MiCorps provides volunteer monitoring programs with many services including:

> Training programs,
> A web site-*www.micorps.net*,
> A data exchange network,
> An email list serve,
> An annual conference, and
> A monitor's newsletter.

The mission of MiCorps is to network, support, and expand volunteer water quality monitoring organizations across the state. To learn more about MiCorps visit www.micorps.net.

LAKE QUALITY

A lake's condition is influenced by many factors, such as the amount of recreational use it receives, shoreline development, and water quality. Lake *water quality* is a general term covering many aspects of chemistry and biology. The health of a lake is determined by its water quality.

CLMP Goals

- Provide baseline information and document trends in water quality for individual lakes.
- Educate lake residents, users, and interested citizens in the collection of water quality data, lake ecology, and lake management practices.
- Build a constituency of citizens to practice sound lake management at the local level and to build public support for lake quality protection.
- Provide a cost-effective process for the DEQ to increase baseline data for lakes state-wide.

CLMP Measurements

- Secchi disk transparency
- Spring total phosphorus
- Exotic aquatic plant watch
- Summer total phosphorus
- Chlorophyll *a*
- Dissolved oxygen and temperature
- Aquatic plant identification and mapping

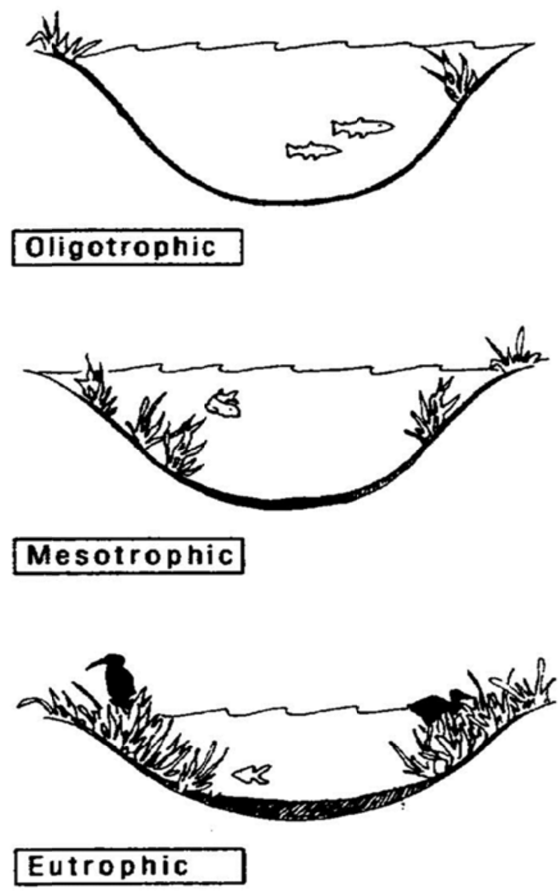
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

Plant *nutrients* are a major factor that cause increased productivity in lakes. In Michigan, *phosphorus* is the nutrient most responsible for increasing lake productivity.

The CLMP is designed to specifically monitor changes in lake productivity. The current program enlists citizen volunteers to monitor water clarity, the algal plant pigment chlorophyll *a* and dissolved oxygen throughout the summer months and total phosphorus during the spring and late summer. These parameters are indicators of primary (algal) productivity and, if measured over many years, may document changes in the lake.

CLASSIFYING LAKES

A lake's ability to support plant and animal life defines its level of productivity, or *trophic state*. Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved oxygen* in the cool, deep-bottom waters during late summer to support cold water fish, such as trout and whitefish. By contrast, high productive *eutrophic* lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish, such as bass and pike. Lakes that fall between these two classifications are called *mesotrophic* lakes. Lakes that exhibit extremely high productivity, such as nuisance algae and weed growth are called *hypereutrophic* lakes.



Possible trophic states of inland lakes.
(Source: Hamlin Lake Improvement Board, 1994)

EUTROPHICATION

The gradual increase of lake productivity from oligotrophy to eutrophy is called lake aging or *eutrophication*. Lake eutrophication is a natural process resulting from the gradual accumulation of nutrients, increased productivity, and a slow filling in of the lake basin with accumulated sediments, silt, and muck. Human activities can greatly speed up this process by dramatically increasing nutrient, soil, or organic matter input to the lake. This human influenced, accelerated lake aging process is known as *cultural eutrophication*. A primary objective of most lake management plans is to slow down cultural eutrophication by reducing the input of nutrients and sediments to the lake from the surrounding land.

MEASURING EUTROPHICATION

Measuring a lake's water quality and eutrophication is not an easy task. Lakes are a complex ecosystem made up of physical, chemical, and biological components in a constant state of action and interaction.

As on land, plant growth in lakes is not constant throughout the summer. Some species mature early in the season, die back, and are replaced by other species in a regular succession.

While overall population levels often reach a maximum in mid-summer, this pattern is influenced or altered by numerous factors, such as temperature, rainfall, and aquatic animals. For the same reasons lakes are different from week to week, lake water quality can fluctuate from year to year.

Given these factors, observers of lake water quality must train themselves to recognize the difference between short-term, normal fluctuations and long-term changes in lake productivity (e.g., eutrophication). Many years of reliable data collected on a consistent and regular basis are required to separate true long-term changes in lake productivity from seasonal and annual fluctuations.

(Above) A CLMP volunteer on White Lake (Oakland County) uses a Secchi disk to measure water transparency, a standard approach to assessing lake productivity. (Below) Dr. Jo Latimore of Michigan State University discusses aquatic plant mapping results with volunteers from Murray Lake in Kent County (MiCorps photos by Angela De Palma-Dow).

Important Measures of Eutrophication

Nutrients are the leading cause of eutrophication. Nitrogen and *phosphorus* both stimulate plant growth. Both are measured from samples of water and reported in units of µg/l (micrograms per liter), or ppb (parts per billion). *Phosphorus* is the most important nutrient affecting lake productivity, and is often used directly as a measure of eutrophication.

Plants are the primary users of nutrients. *Chlorophyll a* is a component of the cells of most plants, and can be used to measure the concentration of small plants in the water, such as algae. *Chlorophyll a* is measured from samples of water and reported in units of µg/l. Macrophytes are aquatic plants with stems and leaves. The location of different species of plants can be mapped, and the density can be measured in pounds of plants per acre of lake.

***Transparency*,** or the clarity of water, is measured using a device known as a *Secchi disk*. This is an eight inch diameter target painted black and white in alternate quadrants. The disk is attached to a marked line, or measuring tape, and lowered from a boat into the lake. The distance into the water column the disk can be seen is the transparency, measured in feet or meters. A short distance of visibility means that there are suspended particles or algae cells in the water, an indication of nutrient enrichment.

Dissolved Oxygen *(DO)* which is oxygen dissolved in the water, is necessary to sustain fish populations. Fish, such as trout, require more DO than warm water species. Eutrophic lakes occasionally have levels of DO below the minimum for fish to survive, and fish kills can result.

Sediments can be measured to determine how fast material is depositing on the bottom. This may indicate watershed erosion, or a large die-off of aquatic plants.

Fish can be sampled using nets. In an oligotrophic lake there are likely to be cold water species, such as trout. Warm water fish, such as sunfish, bass, bullheads, and carp are more typical of a eutrophic lake.

Temperature affects the growth of plants, the release of nutrients, and the mixing of layers of water in the lake. Temperature measurements can determine if mixing occurs, moving nutrients from the lake bottom up into the surface waters promoting algae blooms.

LAKE PRODUCTIVITY INDEX (Trophic Status Index, TSI)

The general lake classification scheme described on page 4 puts lakes into four categories depending on biological productivity level, or trophic state: oligotrophic, mesotrophic, eutrophic, hypereutrophic. While these categories are convenient, they are somewhat misleading because in reality, lake water quality is a continuum progressing from very good to very poor conditions. A more precise method of describing the productivity of a lake is to use a numerical index calculated directly from water quality data. The CLMP uses Carlson's (1977) *Trophic State Index* (TSI), to describe the productivity of the lakes enrolled in the program.

Carlson developed mathematical relationships for calculating the TSI from summer measurements of Secchi depth transparency, chlorophyll *a*, and total phosphorus in lakes. These parameters are good indirect measures of a lake's productivity, with chlorophyll *a* the most direct trophic state indicator . The TSI expresses lake productivity on a continuous numerical scale from 0 to 100, with increasing numbers indicating more eutrophic conditions. The zero point on the TSI scale was set to correlate with a Secchi transparency of 64 meters (210 feet).

The computed TSI values for an individual lake can be used for comparison with other lakes, to evaluate changes within the lake over time, and to estimate other water quality parameters within the lake. You can use the chart on the next page to convert measured parameter values to TSI values to determine the trophic status category. Michigan generally classifies a TSI <38 as oligotrophic, 38-48 as mesotrophic, 48-61 as eutrophic, and >61 as hypereutrophic. Please note that the dividing lines between the trophic status categories are somewhat arbitrary since lake water quality is a continuum and there is no broad agreement among lake scientists as to the precise point of change between each of these classifications.

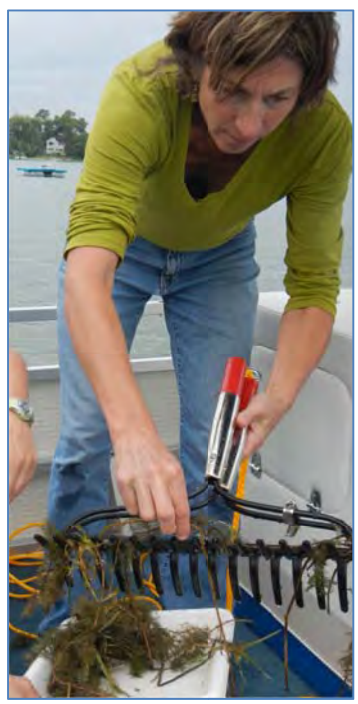
Carlson's TSI Equations

$$TSI_{SD} = 60 - 33.2 \log_{10} SD$$

$$TSI_{TP} = 4.2 + 33.2 \log_{10} TP$$

$$TSI_{CHL} = 30.6 + 22.6 \log_{10} CHL$$

where,
SD = Secchi depth transparency (m)
TP = total phosphorus concentration (µg/l)
CHL = chlorophyll *a* concentration (µg/l)



A volunteer on Murray Lake (Kent County) removes aquatic plants from a sampling rake while conducting the Exotic Aquatic Plant Watch. Volunteers learn to survey their lakes for invasive plants that can adversely impact lake health (MiCorps photo by Angela De Palma-Dow).

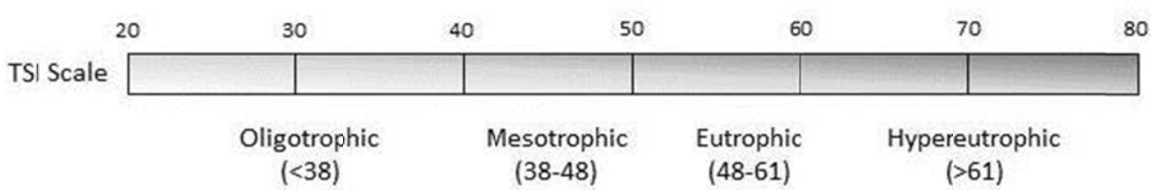
You may use the TSI chart below to record your lake's data and determine its Trophic Status Index category.

CARLSON'S TROPHIC STATE INDEX

Total Phosphorus (ppb)	TSI Value
<5	<27
6	30
8	34
10	37
12	40
15	43
18	46
21	48
24	50
32	54
36	56
42	58
48	60
>50	>61

Secchi Depth (ft)	TSI Value
>30	<28
25	31
20	34
15	38
12	42
10	44
7.5	48
6	52
4	57
<3	>61

Chlorophyll-a (ppb)	TSI Value
<1	<31
2	37
3	41
4	44
6	48
8	51
12	55
16	58
22	61
>22	>61



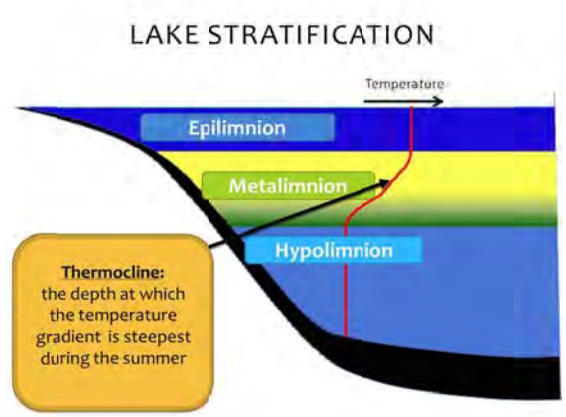
OTHER MEASURES OF LAKE PRODUCTIVITY

Dissolved Oxygen (DO) and Temperature

Dissolved oxygen and temperature are two fundamental measurements of lake productivity. The amount of dissolved oxygen in the water is an important indicator of overall lake health.

For approximately two weeks in the spring and fall, the typical lake is entirely mixed from top to bottom during a process called "overturn", when all water in the lake is 4 degrees Celsius. In the winter there is only a small difference between the temperature of the water under the ice (0°C) and the water on the bottom (4°C). However, in the summer most lakes with sufficient depth (greater than 30 feet) are stratified into three distinct layers of different temperatures. These layers are referred to as the epilimnion (warm surface waters) and hypolimnion (cold bottom waters) which are separated by the metalimnion, or thermocline layer, a stratum of rapidly changing temperature. The physical and chemical changes within these layers influence the cycling of nutrients and other elements within the lake.

During summer stratification the thermocline prevents dissolved oxygen produced by plant photosynthesis in the warm waters of the well-lit epilimnion from reaching the cold dark hypolimnion waters. The hypolimnion only has the dissolved oxygen it acquired during the short two-week spring overturn. This finite oxygen supply is gradually used by the bacteria in the water to decompose the dead plant and animal organic matter that rains down into the hypolimnion from the epilimnion, where it is produced. With no opportunity for re-supply the dissolved oxygen in the hypolimnion waters is gradually exhausted. The greater the supply of organic matter from the epilimnion and the smaller the volume of water in the hypolimnion the more rapid the oxygen depletion in the hypolimnion. Highly productive eutrophic lakes with small hypolimnetic volumes can lose their dissolved oxygen in a matter of a few weeks after spring overturn ends and summer stratification begins. Conversely, low productive oligotrophic lakes with large hypolimnetic volumes can retain high oxygen levels all summer.



Lakes over 25 feet in depth typically stratify into three layers during the summer. Water temperature will be warmest in the upper layer (epilimnion), decline through the metalimnion, and be coldest in the hypolimnion (Figure: Michigan State University Extension).

When a lake's hypolimnion dissolved oxygen supply is depleted, significant changes occur in the lake. Fish species like trout and whitefish that require cold water and high dissolved oxygen levels are not able to survive. With no dissolved oxygen in the water the chemistry of the bottom sediments are changed resulting in the release of the plant nutrient phosphorus into the water from the sediments. As a result the phosphorus concentrations in the hypolimnion of productive eutrophic and hypereutrophic lakes can reach extremely high levels. During major summer storms or at fall overturn, this phosphorus can be mixed into the surface waters to produce nuisance algae blooms.

Some eutrophic lakes of moderate depth (25 to 35 feet maximum deep) can stratify, lose their hypolimnion dissolved oxygen and then destratify with each summer storm. So much phosphorus can be brought to the surface water from these temporary stratifications and destratifications that the primary source of phosphorus for the lake is not the watershed but the lake itself in the form of internal loading or recycling.

Besides the typical lake stratification pattern just described, it is now known that some Michigan lakes may not follow this pattern. Small lakes with significant depth, and situated in hilly terrain or protected from strong wind forces, may not completely circulate during spring overturn every year. Additionally, some lakes deep enough to stratify will not, if they have a long fetch oriented to the prevailing wind or are influenced by major incoming river currents. Finally, lakes with significant groundwater inflow may have low dissolved oxygen concentrations due to the influence of the groundwater instead of the lake's productivity and biological decomposition.

The dissolved oxygen and temperature regime of a lake is important to know in order to develop appropriate management plans. A lake's oxygen and temperature patterns not only influence the physical and chemical qualities of a lake but the sources and quantities of phosphorus, as well as the types of fish and animal populations.

Aquatic Plant Mapping

A major component of the plant kingdom in lakes is the large, leafy, rooted plants. Compared to the microscopic algae the rooted plants are large. Sometimes they are collectively called the "macrophytes" ("macro" meaning large and "phyte" meaning plant). These macrophytes are the plants that people sometimes complain about and refer to as lake weeds.

Far from being weeds, macrophytes or rooted aquatic plants are a natural and essential part of the lake, just as grasses, shrubs and trees are a natural part of the land. Their roots are a fabric for holding sediments in place, reducing erosion and maintaining bottom stability. They provide habitat for fish, including structure for food organisms, nursery areas, foraging and predator avoidance. Waterfowl, shore birds and aquatic mammals use plants to forage on and within, and as nesting materials and cover.

Though plants are important to the lake, overabundant plants can negatively affect fish populations, fishing and the recreational activities of property owners. Rooted plant populations increase in abundance as nutrient concentrations increase in the lake. As lakes become more eutrophic rooted plant populations increase. They are rarely a problem in oligotrophic lakes, only occasionally a problem in mesotrophic lakes, sometimes a problem in eutrophic lakes and often a problem in hypereutrophic lakes.

In certain eutrophic and hypereutrophic lakes with abundant rooted plants it may be advantageous to manage the lake and its aquatic plants for the maximum benefit of all users. Plant management may also be necessary if invasive, non-native plants are introduced to the lake and threaten the native plant ecosystem. To be able to do this effectively it is necessary to know the plant species present in the lake and their relative abundance and location. A map of the lake showing the plant population locations and densities greatly aids management projects.

CLMP PROJECT RESULTS

—IMPORTANT—

CLMP monitoring results for participating lakes are available on the web in addition to being presented in summary form here in the annual report. To view current year and past results, please visit MiCorps' Data Exchange Network at www.micorps.net (select "Data Exchange") and follow the instructions to find data on your lake of interest. On the site, you may search the database for lakes by lake name, county or watershed. You can also limit the data delivered to you by date or monitoring parameter(s). Monitoring data will appear on the Data Exchange well in advance of publication of the annual report. CLMP volunteers may also find instructions on the website about how to enter their own data into the Data Exchange.

Secchi Disk Transparency

Citizen volunteers measure Secchi disk transparency from late spring to the end of the summer. Ideally, 18 weekly measurements are made from mid-May through mid-September. As a minimum, eight equally spaced measurements from the end of May to the beginning of September are accepted to provide a good summer transparency mean (average) for the lake. Frequent transparency measurements are necessary throughout the growing season since algal species composition in lakes can change significantly during the spring and summer months, which can dramatically affect overall water clarity.

A summary of the transparency data collected by the lake volunteers during 2013 is included in Appendix 1. The number of measurements, or readings, made between mid-May and mid-September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. For those lakes with eight or more evenly spaced readings over this time period, the mean, median, standard deviation, and Carlson TSI_{SD} values were calculated and listed.

The mean, or average, is simply the sum of the measurements divided by the number of measurements. The median is the middle value when the set of measurements is ordered from lowest to highest value. The standard deviation is a common statistical determination of the dispersion, or variability, in a set of data.

The data range and standard deviation gives an indication of seasonal variability in transparency in the lake. Lakes with highly variable Secchi disk readings need to be sampled frequently to provide a representative mean summer transparency value. Few measurements and inconsistent sampling periods for these lakes will result in unreliable data for annual comparisons.

The TSI_{SD} values were calculated using Carlson's equations (see page 7) and the mean summer transparency values. (Note: the mean transparency value is converted from feet to meters for the TSI_{SD} calculation) The TSI chart (see page 8) can be used to relate the TSI_{SD} value to the general trophic status classification for the lake (i.e., oligotrophic, mesotrophic, eutrophic) as well as to provide a rough estimate of summer chlorophyll *a* and total phosphorus levels in the lake. If the transparency measurements are made properly and consistently year after year, the Secchi disk transparency annual means or TSI_{SD} values can be compared to evaluate changes, or trends, in trophic status of the lake over time, see the figure below.

During 2013, Secchi disk transparency data were reported for 220 lakes (including sub-basins). Approximately 3098 transparency measurements were reported, ranging from 0.0 to 49.0 feet. For the lakes with eight or more equally spaced readings between mid-May and mid-September, the overall mean, or average, Secchi disk transparency was 12.7 feet. The Carlson TSI_{SD} values ranged from 29 to 59 for these lakes with a mean value of 41. A Carlson TSI value of 41 is generally indicative of a mesotrophic lake (see page 7).

Secchi disk transparency measurements were reported for 220 of the 239 enrolled lakes/basins for a participation rate of 92%.

Total Phosphorus

Phosphorus is one of several essential nutrients that algae need to grow and reproduce. For most lakes in Michigan, phosphorus is the most important nutrient, the limiting factor, for algae growth. The total amount of phosphorus in the water is typically used to predict the level of productivity in a lake. An increase in phosphorus over time is a measure of nutrient enrichment in a lake.

The CLMP volunteers monitor for total phosphorus during spring overturn, when the lake is generally well mixed from top to bottom, and during late summer, when the lake is at maximum temperature stratification from the surface to the bottom. Spring overturn is an opportune time of the year to sample just the surface of a lake to obtain a representative sample for estimating the total amount of phosphorus in the lake. A surface sample collected during late summer represents only the upper water layer of the lake, the epilimnion, where most algal productivity occurs. The late summer total phosphorus results, along with the Secchi disk transparency and chlorophyll measurements, are used to determine the trophic status of the lake. The spring overturn total phosphorus data, collected year after year, are useful for evaluating nutrient enrichment in the lake.

Total phosphorus results for the 2013 CLMP are included in Appendix 2. The spring total phosphorus data are listed first, followed by the late summer data. The TSI_{TP} values were calculated using Carlson's equations (see page 7) and the late summer total phosphorus data. Results from replicate and side-by-side sampling are also provided. Approximately 10% of the replicate samples collected by the volunteers were analyzed as part of the data quality control process for the CLMP. Also, the DEQ participated in side-by-side sampling on approximately 2% of the lakes.

During 2013, samples for total phosphorus measurements were collected on 201 lakes/basins. The spring overturn total phosphorus results ranged from <3 to 150 µg/l with a mean (average) of 16.9 µg/l and a median value of 11.0 µg/l. The late summer total phosphorus results ranged from <3 to 80 µg/l with 13.2 µg/l as the mean and 11 µg/l as the median. The Carlson TSI_{TP} values ranged from <27 to

67 for these lakes with a mean value of 39. A Carlson TSI value of 39 is generally indicative of a very good quality mesotrophic lake (see page 7).

For the spring overturn sampling, 152 total phosphorus samples were turned in from 170 enrolled lakes, for an 89% participation rate. For late summer sampling, 183 samples were received from 198 enrolled lakes/basins for a 92% participation rate.

Chlorophyll *a*

Chlorophyll is the green photosynthetic pigment in the cells of plants. The amount of algae in a lake can be estimated by measuring the chlorophyll *a* concentration in the water. As an algal productivity indicator, chlorophyll *a* is often used to determine the trophic status of a lake.

Chlorophyll monitoring was added to the CLMP in 1998. Volunteers were asked to collect and process five sets of chlorophyll *a* samples, one set per month from May through September. For purposes of calculating TSI values only those lakes that had data for at least four of the five sampling events were used. During 2013 volunteers collected a minimum of four samples on 144 lakes (including sub-basins).

Results from the 2013 chlorophyll monitoring are included in Appendix 3. Results for each monthly sampling event are listed as well as the mean, median, and standard deviation of the monthly data for each lake. The TSI_{CHL} values were calculated using Carlson's equations (page 7) and the median summer chlorophyll values. Volunteer-collected replicate samples were analyzed for quality assurance on about 13% of the lakes, and side-by-side sampling with MiCorps staff was conducted on 6% of the lakes. These data are included.

A total of 608 chlorophyll samples were collected and processed in 2013. The chlorophyll *a* levels ranged from <1 to 58 μg/l over the five-month sampling period. The overall mean (average) was 5.0 μg/l. The Carlson TSI_{CHL} values ranged from <31 to 60 with a mean value of 41. A Carlson TSI value of 41 is generally indicative of a mesotrophic lake (see page 7).

During 2013, a total of 144 lake sites were registered for chlorophyll sampling. A total of 138 sites were represented at least minimally through the submission of at least one sample, for a minimum participation rate of 96%. At least four samples were turned in for 118 lake sites, for a complete participation rate of 82%. Nineteen samples were turned in, but not processed due to quality control issues for a rejection rate of less than 3%.

TSI Comparisons

The TSI_{CHL}, TSI_{SD}, and TSI_{TP} values for the individual lakes can be compared to provide useful information about the factors controlling the overall trophic status in these lakes (Carlson and Simpson, 1996). For lakes where phosphorus is the limiting factor for algae growth, all three TSI values should be nearly equal. However, this may not always be the case. For example, the TSI_{SD} may be significantly larger than the TSI_{TP} and TSI_{CHL} values for lakes that precipitate calcium carbonate, or marl, during the summer. The marl particles in the water column would scatter light and reduce transparency in these lakes, which would increase the TSI_{SD}. Also, phosphorus may adsorb to the marl and become unavailable for algae growth, which would reduce the TSI_{CHL}. For lakes where zooplankton grazing or some factor other than phosphorus limits algal biomass, the

TSI_{TP} may be significantly larger than the TSI_{SD} and TSI_{CHL}.

Dissolved Oxygen and Temperature

Temperature and dissolved oxygen are typically measured as surface-to-bottom profiles over the deep part of the lake. Temperature is usually measured with a thermometer or an electronic meter called a themistor. Dissolved oxygen is either measured with an electronic meter or by a chemical test. The CLMP uses an electronic meter (YSI Models 95D, 550A, or Pro20) designed to measure both temperature, with a themistor, and dissolved oxygen. The meter is calibrated by the volunteer monitor before each sampling event.

Dissolved oxygen and temperature are measured from the surface to within 3 feet of the bottom, as a profile, in the deepest basin of the lake. Measurements are taken at 5-foot intervals in the upper part of the water column. Through the mid-depth region or thermocline (15 to 45 feet), measurements are taken at 2½ foot intervals. Below the thermocline, measurements are usually made every 5 feet. Measurements are made every two weeks from mid-May to mid-September in the same deep basin location.

During 2013, CLMP participants in the dissolved oxygen/temperature project sampled 54 lake sites. A total of 366 dissolved oxygen/temperature profiles (about 5,100 measurements) were recorded. The lakes involved in the project are identified in Appendix 4. The results of the sampling are highly varied depending upon the size, depth, volume and productivity of the lake sampled. Because of these highly varied results and the amount of individual data collected, each lake's results are not included in this report. Each participating lake community will receive individual data graphs for their lake. Instead of individual results, representative oxygen and temperature patterns are illustrated in Appendix 4. For the most part, data collected on lakes participating in the 2013 project are used to present these representative patterns. Volunteer monitors may compare the results from their lake with the patterns illustrated in Appendix 4.

While it is not possible to illustrate every conceivable temperature and dissolved oxygen scheme that may develop in a lake, five common summer patterns are presented in Appendix 4. These five patterns include: (1) an oligotrophic lake with a moderate hypolimnion volume, (2) a mesotrophic lake with a moderate hypolimnion volume, (3) a eutrophic lake with a small hypolimnion, (4) a mesotrophic lake that is too shallow to maintain stratification (such lakes usually have the same temperature and dissolved oxygen concentrations from surface to bottom as the result of frequent mixing), and (5) an oligotrophic lake with dissolved oxygen spikes in the thermocline (caused by algae producing oxygen via photosynthesis in this zone of high biological productivity).

Aquatic Plant Mapping

The Aquatic Plant Identification and Mapping parameter is the most labor-intensive volunteer activity within the CLMP. Typically, a team of volunteers from each enrolled lake is involved, with assistance from a MiCorps biologist.
Preparation begins with volunteers attending a half-day intensive training on aquatic plant identification and mapping techniques. Prior to heading to the lake,

the volunteers develop a sampling strategy for their lake, based on size and known areas of plant growth. Sampling transects (straight lines parallel to shore) are identified, along which plant samples are collected, generally at the one, four and eight foot depths with a constructed sampling rake. The rake is tossed out into the lake and retrieved from the four compass directions. The density of each plant species is determined by its presence on one, two, three or all four of the rake tosses. The sampling effort often requires several days. The data from all the transects then are used to create a plant distribution map and report. A complete description of procedures is provided in Wandell and Wolfson (2007).

2013 was a very active year for the CLMP Aquatic Plant Identification and Mapping program! Six lakes conducted surveys:

- Crockery Lake (Ottawa Co.)
- Gull Lake (Kalamazoo Co.)
- Kelsey Lake (Cass Co.)
- Park Lake (Ingham Co.)
- Pleasant Lake (Washtenaw Co.)
- White Lake (Muskegon Co.)

In addition, one lake continued their survey efforts from 2012:

- Spider Lake (Grand Traverse Co.)

Results of these surveys, including maps and full reports, can be found on the MiCorps Data Exchange online at www.micorps.net.

AQUATIC PLANT SAMPLING RAKE

Cut handles off two garden rakes and bolt rakes back to back with two "C" bolts. Use a small hose clamp between rake tines to prevent side to side slipping. Drill a hole in remaining wooden handle core and twist a moderately large eye bolt into hole. The rope should be about 20 feet long. File off any sharp edges. Wear gloves when using rake to protect hands from cuts.

Exotic Aquatic Plant Watch

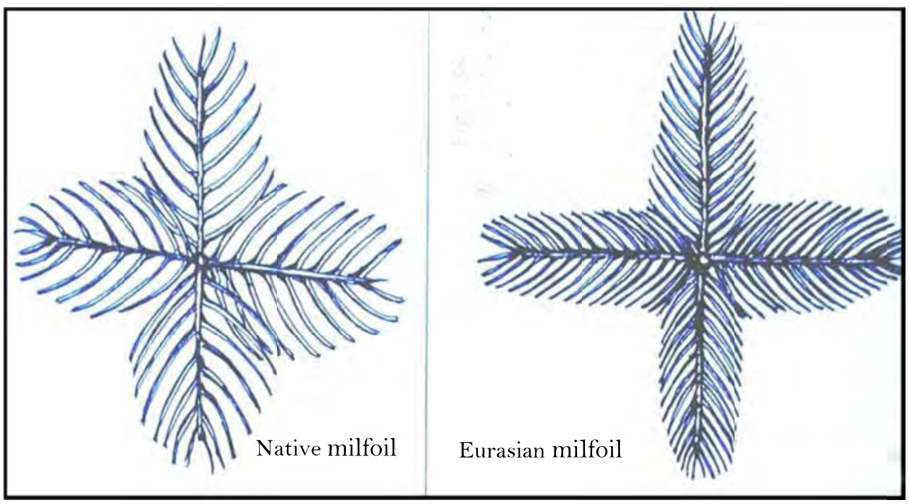
Beginning in 2007, the CLMP sponsored a pilot monitoring project to identify and map invasive aquatic plants in Michigan lakes, with the intent to add the Exotic Aquatic Plant Watch as a permanent component of the CLMP. This project is less time- and labor-intensive than Aquatic Plant Identification and Mapping, because only select invasive plants are surveyed.

The Exotic Aquatic Plant Watch project became a permanent component of the CLMP in 2011, due to steadily increasing interest and the high-quality data being generated by volunteers.

If exotic plant populations are found early before they become widespread around the lake, rapid response to the infestations will improve the options for management. The cost for treating small infestations will be considerably less than waiting until the exotic, invasive plants are covering large areas of the lake.

Volunteer participants are trained to identify select exotic aquatic plants of concern for Michigan lakes: currently, curly-leaf pondweed, Eurasian milfoil, starry stonewort and Hydrilla. Using a GPS unit, volunteers survey their lakes and map the location of any exotic plant beds with the GPS unit, or by hand.

In 2013, 26 lakes (including sub-basins) enrolled in the Exotic Aquatic Plant Watch. Two lakes requested to delay sampling until 2014. Of the remaining 24 lakes/basins, 17 submitted reports, for a participation rate of 71%. A summary of the results is presented in Appendix 5.



Stem cross sections at a leaf node of a typical native milfoil (left) and Eurasian milfoil, an invasive, non-native plant (right). Note that Eurasian milfoil has more leaflets on each leaf than native milfoils. Eurasian milfoil generally has more than 12 leaflets on one side of the leaf's central axis, while native milfoils have fewer than 12.

DATA USE

A voluntary survey on the MiCorps Data Exchange web page helps track interest in the data collected in the CLMP and the MiCorps stream monitoring program. One hundred fifty-nine data users responded to the survey in 2013. A summary of the results is below.

28% - Lake associations, CLMP volunteers
23% - Interested individuals
19% - Academia (students & professors from a variety of institutions, including 4 Michigan universities, and institutions in Indiana, Illinois, Wisconsin, and Oregon)
14% - Non-governmental organizations and Conservation Districts (groups typically associated with MiCorps stream monitoring, e.g., Gahagan Nature Preserve, Yellow Dog Watershed Preserve)
8% - State government (Michigan DNR, DEQ)
4% - Business (environmental consulting firms, landscapers)
3% - Other governmental agencies (US Army Corps of Engineers, US Geological Survey, other states' agencies)
1% - Media (newspapers)

CONCLUSION

Data from the CLMP provide citizens with basic information on their lakes that can be used as indicators of the lake's productivity. If measured over many years, these data may be useful in documenting changes and trends in water quality. More importantly these data will assist the local community with the management of their lake. Michigan's lakes are high quality resources that should be protected from nutrient and sediment inputs to keep them as the special places we use and enjoy. To do this, each lake should have its own management plan.

Although CLMP data provide very useful water quality information, for certain management programs it may be necessary to assemble more specific data or information on a lake's condition. The DEQ and MLSA may be able to help you obtain additional information on your lake.

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FROM MONITORING TO STEWARDSHIP: Putting the CLMP to Use on Duck and White Lakes, Muskegon County

Submitted by Thomas Tisue, Technical Committee Chair, Duck Creek Watershed Assembly, White Lake Association, and White River Watershed Assembly

Duck Lake

Duck Lake, all 271 acres of it, is a major recreational resource for visitors to Duck Lake State Park (more than 300,00 visits in 2012!), for the riparians along the lake's south shore, and for an extended community of local users. Much of the recreational use is focused on the Park's Lake Michigan beach, where the 23 sq.-mi. Duck Creek watershed debouches into Lake Michigan. But Duck Lake itself provides significant ecosystem services and contributes year-round to the local community's enjoyment and well-being. A detailed account of the lake's history, starting with the first days of European incursions into the area, is available in reference 1.

By 2005, Duck Lake exhibited large areas in the sub-littoral zone that were choked with impenetrable beds of Eurasian water milfoil (EWM). At the urging of a local activist, Tom Hamilton, the Duck Creek Watershed Assembly (DCWA) organized introduction of the Eurasian milfoil weevil, a native insect that feeds on EWM. The succeeding years saw a reduction in the prevalence of EWM that was obvious to regular lake users. To document these changes and to establish benchmarks for gauging future developments, the DCWA joined MiCorps and in 2012 surveyed the lake, using Cooperative Lake Monitoring Program (CLMP) protocols to conduct an Aquatic Plant Survey.

After being trained by MiCorps experts in sampling and plant identification procedures, ten volunteers sampled plants at 15 sites to characterize species abundance and diversity. The survey results showed unambiguously that introduction of the weevils had reduced EWM to a minor component of Duck Lake's aquatic plant community. The study supported the conclusion that no additional management actions---such as widespread herbicide application---were needed, given that the aquatic plant community exhibits desirable abundance and diversity.

Because continued vigilance is crucial to timely detection of new invasive species, the DCWA has embarked on annual surveys using the CLMP's Exotic Plant Watch protocols.

Temperature and dissolved oxygen profiles collected over several years as part of the CLMP strengthen the view that groundwater inputs are an important feature of the lake's physical-chemical dynamics. Groundwater inputs create and maintain a reservoir of cold water in the lake’s lower depths, leading to early and strong thermal stratification, and bottom waters in the deeper zones that remain around 12 C throughout the warm season.

Besides being of inherent interest, CLMP measurements also create context for other studies, which in Duck Lake have focused on 1) the recent near disappearance of formerly abundant zebra mussels and perhaps the decline of native mollusk populations as well, and 2) characterization of phytoplankton and cyanobacteria populations with an eye to early detection of harmful algal blooms (HABs).

White Lake

A few miles to the north of Duck Lake lies its big sister, the 2500+ acre White Lake, at the terminus of a 500 sq.-mi. watershed. Heavily impacted by various industries for over 150 years, White Lake is about to celebrate its “delisting” as an Area of Concern (AOC), meaning it is approaching freedom from major impairments to the ecological services it provides. This achievement culminates decades of effort by the local community, as well as considerable investment by county, state, and federal agencies. Reference 2 provides a synopsis of this compelling story, the final chapter of which emphasizes the importance of funding through the Great Lakes Restoration Initiative.

As concern begins to shift away from the legacy of past insults, decision-making by riparians and local units of government is coming to the fore. Recognizing the need for continuing assessments of water and habitat quality to guide management choices, the White Lake Association joined the CLMP in 2013. The lake has been the focus of several large studies by academic and governmental laboratories because of its AOC listing. Now that the biggest messes have been cleaned up, the CLMP will create a continuous picture of the trajectory the lake's trophic status follows in future.

High on the list of management concerns for White Lake is the presence of extensive aquatic plant beds, especially along the south shore where water depths are ideal for rooted plant growth. Eurasian water milfoil is one of the dominant species in these beds. Because of its growth characteristics, EWM helps make these areas unfit for navigation, and its mechanical fragility means nuisance quantities of EWM accumulate on shore, creating aesthetic problems (and a big removal chore for riparians).

To address this problem, the White Lake Association initiated a volunteer-based effort last year to better characterize White Lake's entire aquatic plant community in terms of its spatial distribution and species diversity through the CLMP Aquatic Plant Identification and Mapping program. This 2-year study will help create a factual basis for future management choices. The initial sampling took place over a weekend in September, 2013, and garnered significant community involvement: seven boats and more than two dozen volunteers took part despite less than ideal weather.

We have learned at both Duck and White Lake that the CLMP does more than provide crucial scientific information. It also puts flesh on the bones of our outreach and education efforts, while creating opportunities for active citizen involvement, perhaps the best way of fostering the community's sense of ownership of local water resources.

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2. Accessed at http://www.michigan.gov/deq/0,1607,7-135-3313_3677_15430_57456---,00.html

For more information on Duck and White Lake stewardship efforts, contact Dr. Thomas Tisue at thomastisue@comcast.net or 630-670-2237.

Do you have a success story of how your community has used CLMP data to implement a protection program for your lake? We would like to hear from you. Contact Bill Dimond at 517-241-9565 or dimondw@michigan.gov.

ACKNOWLEDGMENTS

Jo Latimore from the Michigan State University Department of Fisheries and Wildlife, Paul Steen of the Huron River Watershed Council, and Bill Dimond of the Michigan Department of Environmental Quality prepared this report. Additionally, those involved in coordinating the CLMP include Scott Brown and Jean Roth of Michigan Lake and Stream Associations, Inc. Support was provided by Laura Kaminski and Anne Sturm of the Great Lakes Commission.

We sincerely thank the dedicated volunteers who have made the CLMP one of the nation's most successful citizen volunteer lake monitoring programs. We are also indebted to Ralph Vogel for constructing the Secchi disks for the CLMP, and to those volunteers who entered their data into the MiCorps Data Exchange.

The Michigan Department of Environmental Quality will not discriminate against any individual or group on the basis of race, sex, religion, age, national origin, color, marital status, disability, or political beliefs. Questions or concerns should be directed to the Quality of Life Human Resources, PO Box 30473, Lansing, MI 48909.

2013 CLMP Volunteer Lake Monitors

In 2013, at least 383 Volunteer Lake Monitors participated in Michigan's Cooperative Lakes Monitoring Program. The CLMP staff welcomes all the new volunteers, and commends every volunteer's dedication and enthusiasm! Asterisks (*) indicate Certified Volunteer Mentors – experienced volunteers who have been specially trained to assist new volunteers in learning CLMP monitoring techniques.

Dave Adams
David Allen
Robert Alvey
Kimberly Andrews
Dick Bachelor
Dan Bailey
William Bainton
Rick Bakka
David Ball
Jody Ball
Susan Barnes
Neil Barr
Ronald Basso
Sara Basso
Mark Baynes
Jim Beaver
Dennis Becker
Nancy Beckwith*
Adam Beebe
Nancy Belton
Lawrence Bittner
Diane Blanchard
Emery Blanksma
Arthur Bombrys
David Boprie
John Bosker
Mike Boss
Sue Boss
Mark Bradburn
Dennis Bradley
Hope Bradley
Jim Bradley
Daryl Brandt
Dave Breaugh
Kyle Brown
Richard Brown
Gordon Buchanan
Carim Calkins
Keith Carman
Ursula Charaf
Jim Cherfoli
Karen Christensen
Rodney Chupp
Steve Clouse
Jim Collins
Phillip Collins
Doug Cooper
Craig Cotterman
Gerald Cox
Keith Crompton
Gary Cross
Paul Curell
Dennis Curtice
Toni Cusmano
Paul Dalpra
Linda Daniels
Stacy Daniels
Fred Daris
Emma Darling
Fred Darling
Jackie Dauw
Linda Davis
Harry Dawson
Mike Devarenne
John DiGiovanni
Wayne Disegna
Dave Dohring
Arnold Domanus, Jr.
Michael Dombrowski
Susan Donovan
Patricia Doran
Michael Dorys
Kevin Doyle
Duane Drake
Terry Dugan*
Andy DuPont
Janet Durbin
Wes Durbin
Gerry Durocher
Allen Dyer
Cheryl Dyer
Lorraine Eastham
Roy Eastham
Daniel Evert
Paul Fallon
Rose Fedewa
Donald Ferguson
Bill Ferris
James Feudi
John Fierens
Daniel Fleck
Shannon Fleck
Ernest Flinc
Chris Floyd
Bob Forche
Stephen Franklin
Dale French
Ursula Froehlich
William Fronk
Roger Gaede
Kathy Gallagher
Mike Gallagher
Greg Garrett
Ted Gatto
Laurence Gavin
Bill Gebo
Douglas Gembis
Gerald Gerou
Charles Gill
Ken Gill
Paul Gluski
Chuck Goll
Jim Gonzalez
Joe Goossens
Libby Greanya
Carla Gregory
Stan Grove
Connie Hales
Dave Hales
Cary Hamann
Thomas Hamilton
Tom Hamilton
George Hanley
Doug Hansen
Chuck Hartman
John Hartsig
Bob Hasse
John Hause
Dave Havercamp
Lynn Hawley
Bonnie Hay
Jim Hay
Daniel Hayes
Rita Heady
Ronald Heady
Ron Henning
William Henning
Nanette Hibler
Virginia Himich
Art Hoadley
Arthur Hoadley
John Hoek
Lynn Hoepfinger*
John Hoffman
Emmett Holmes
Karen Holmes
Susan Houseman
Ruth Hubbard
Jerry Huges
Sheryl Hugger
Ron Hughes
Sharon Hurlbert
Bob Hutchings
Harris John Iler
Joanne Iler
Bill Ingle
Bonnie Isaacs
Doug Jagen
Dorothy Jamison
Fred Jensen
Frederick Jensen
Dan Johnson
Gary Johnson
Joel Johnson
Ronald Johnson
Mike Jones
Gregg Kabacinski
Bonnie Kanitz
James Kasey
Martha Kern-Boprie
Emil Kezerle
Wayne Kiefer
Netty Kiekover
Calvin Killen
Bruce King
Marv Kingsley
Don Klobucar
Gretchen Klobucar
Ray Klomes
Lynn Knopf
John Kolleth
Steve Kosto
Gerry Kraft
John Kreag

Ronald Kreiger
Sheri Kurtyak
Carol LaGrasso
Daryl Lang
Jim Langerveld
Jane Lauber
Mitchell Le Claire
Tom Leister
Lori Leugers
Mark Leugers
Bruce Lichliter
John Lindahl
Ernest (Mike) Litch*
Lynda Little
Mark Little
David Long
Matthew Long
Doris Loomans
Julie Lovelace
Lonnie Loveland
John Lund
Joe Maguire
Ray Malcoun
John Mater
David Maxson
Eldonna May
Michael McDade
Char McDonnell
Jim McDowell
Alan McNamara
Rick Meeks*
Rich Meeuwenberg
Randy Mencarelli
Sandra Michalik
David Miller
Douglas Scott Miller
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Dick Morey*
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Matthew Naud
Reno Nave
Kenneth Nelson
Patricia Nelson
Don Nichols
Greg Nichols
Wilma Nichols
Cecil Niswonger
Lon Nordeen
Becky Norris
Ed Novak
James Novitski
Steve Ockaskis
Collin O'Dea
Jan Omo
Jim Osbourn
Melinda Otto
Michael Pardonoff
Ray Parker
Donald Parkey
Nola Parkey
Jane Patterson
James Penzott
Carole Petersen
Dale Petersen
Kathleen Anne Petersen
Dick Peterson
Kathleen Peterson
Donald Petree
Irene Petree
Chuck Pilar
Mike Pinson
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Mary Sue Pollitt
Joe Porter
Jerry Powley
June Powley
Joe Primozich
Chuck Pugh
Judith Pugh
George Purlee
Bill Rehling
Jack Reinhardt
Roy Retting
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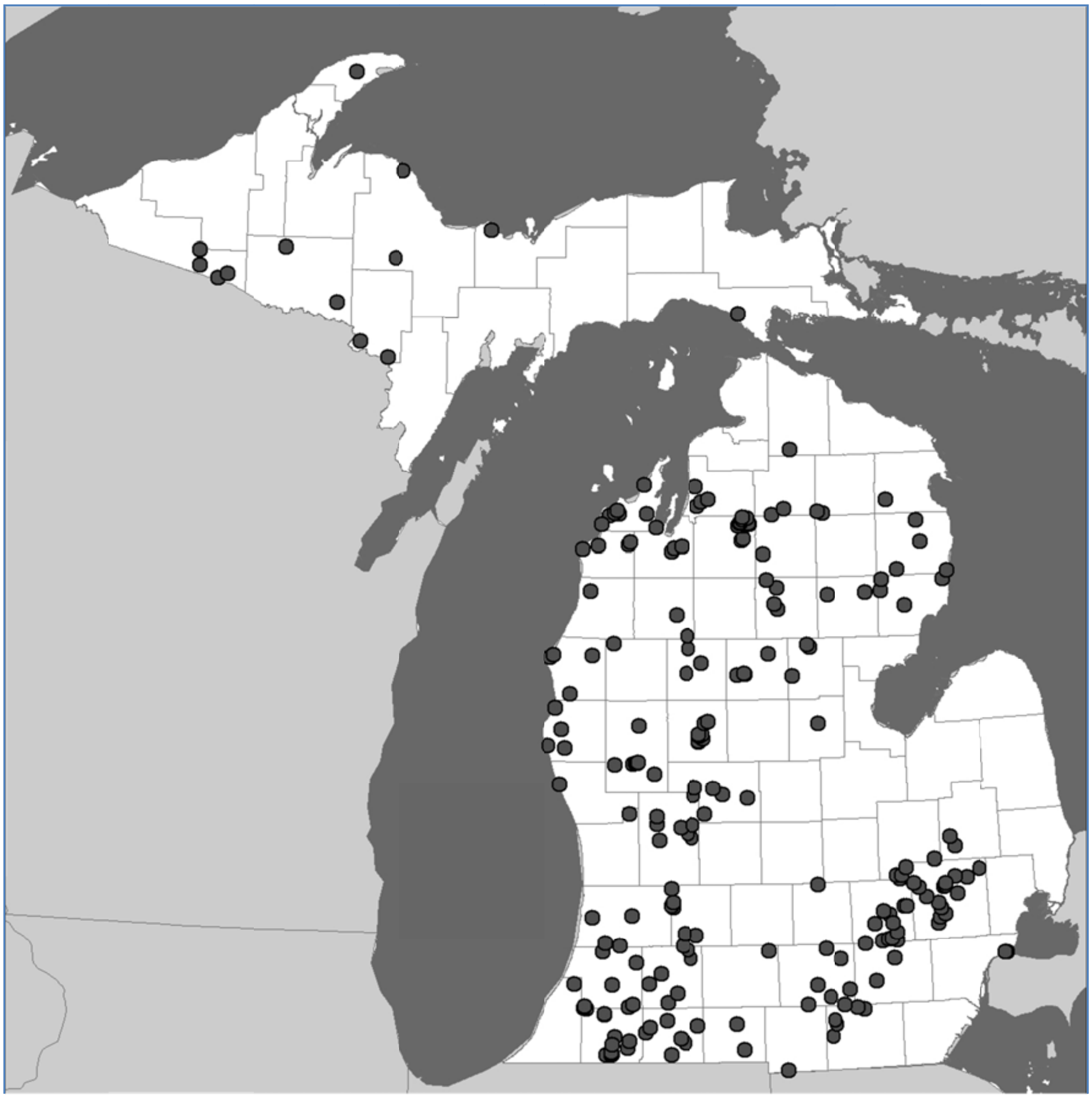
George Richey
Robert Robertson
Stan Roland
David Rose
Harold Rosengren
Jim Ross
Jean Roth
Jim Roth
Steve Roth
Nick Roupas
Rick Rumstead
Tom Rush
Michael Russell
Rick Russwurm
Bob Sacksteder
Dave Salela
Scott Scarpelli
Ronald Scheff
Michael Scherba
Jeff Schimp
Robert Schirado
Jeff Schlueter
Katie Schlueter
Jack Schoeppach
Roger Schweitzer
Al Schwennessen
Carl Seaver
Robert Seger
Connie Selles
Gordon Seyfarth
Eric Shafer
Harry Shaffer
Dale Sharpee
Judy Shatney
Mary Shaw
Gerald Shepard
John Sheppard
John Sick
Rich Sierrkowski
Mike Single
Michael Smith
Paul Smith
Paul Sniadecki*
Jim Soldan
David Stafford
Linda Stafford*
Tim Stegeman
John Stivers
Julie Stivers
Daniel Stock
Henry Storm
Roger Storm
Martin Straka
Dick Stub
Jan Stuhlmann
Wayne Swallow
Kent Taylor
Mark Teicher
Gertrude Temple
Robert Temple
Thomas Thering
Bill Tidey
Thomas Tisue
William Tomlin
Rusty Trapp
Robert Turnquist
Joan Uhley
James Van Herweg
Robert VanDenBrouck
John VanderMeer
Lesa VanderMeer
Stuart Vedder
Al Vichunas
Ralph Vogel
Ed Waits
Bill Waldeck
Jack Walls
Jim Walters
Howard Wandell*
John (Red) Warner
Darrin Wassom
Rhonda Wassom
Richard Weber
Susan Wedzel
Susan White
Ellen Whitehead
Blair Wickman
Jon Wilford
John Wilks
Frank Wolf
Don Wolstenholme
Gary Wolter*
Pat Wolters
Bernard Woltjer
Chuck Wolverton
Wayne Wunderlich
Alissa Yanochko
David Yanochko
Carolyn Zader
Maris Ziemelis
Dennis Zimmerman
Robb Zoellmer
Cheryl Zuelke
John Zuelke

Statewide Distribution of CLMP Lakes Sampled During 2013



APPENDICES

Appendix 1

2013 Secchi Disk Transparency Results

Appendix 2

2013 Total Phosphorus Results

Appendix 3

2013 Chlorophyll Results

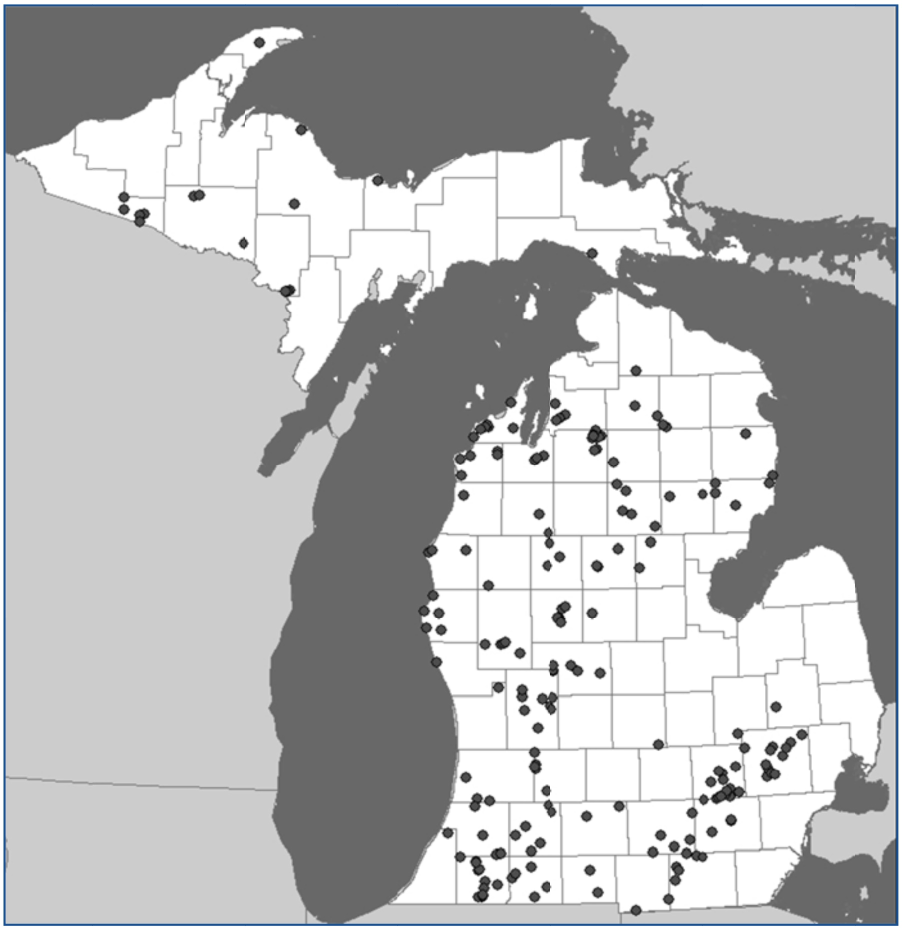
Appendix 4

2013 Dissolved Oxygen and Temperature:
Participating Lakes and Example Results

Appendix 5

2013 Exotic Aquatic Plant Watch Results

Appendix 1
2013 Cooperative Lakes Monitoring Program
Secchi Disk Transparency



Map above shows the distribution of the 239 lakes (including sub-basins) enrolled in Secchi Disk Transparency in the 2013 CLMP Program.

Recorded Secchi Disk Transparency Values:

Mean (average):	12.7 feet
Minimum:	0.0 feet
Maximum:	49.0 feet (Higgins Lake, Roscommon County)

Michigan Clean Water Corps
www.micorps.net

APPENDIX 1
2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet)						Carlson
			Number of	Range				Standard	TSI_{SD}
			Readings	Min	Max	Mean	Median	Deviation	(transparency)
Allen	Gogebic	270207	8	6.5	9.5	7.7	7.5	1.2	48
Angelus	Oakland	631227	12	11.5	25.0	17.2	16.8	3.6	36
Ann	Benzie	100082	18	13.0	24.0	19.0	18.5	3.0	35
Arbutus (1)	Grand Traverse	280396	19	12.0	>13	12.6	13.0	0.5	<41
Arbutus (2)	Grand Traverse	280109	19	13.0	26.0	19.4	18.0	4.0	34
Arbutus (3)	Grand Traverse	280108	19	13.0	26.0	18.1	16.0	4.5	35
Arbutus (4)	Grand Traverse	280397	19	13.0	29.0	18.4	18.0	4.4	35
Arbutus (5)	Grand Traverse	280398	19	12.0	21.0	16.0	15.0	2.8	37
Arnold	Clare	180107	18	12.5	25.5	18.4	18.3	3.7	35
Bar (South)	Leelanau	450237	18	7.0	9.5	8.3	8.5	0.8	47
Barlow	Barry	080176	16	5.5	16.5	10.6	10.5	2.7	43
Barton	Kalamazoo	390215	16	5.5	12.0	8.2	7.5	2.1	47
Baseline	Livingston	470149	12	9.0	16.0	12.0	11.5	2.3	41
Bear	Kalkaska	400026	9	26.0	32.0	28.7	28.5	1.6	29
Bear	Manistee	510257	17	8.5	13.0	10.5	11.0	1.3	43
Bear (Big)	Otsego	690041	*						
Beatons	Gogebic	270105	16	9.5	19.0	14.4	15.0	2.7	39
Beaver	Alpena	040097	10	9.5	23.5	16.1	16.0	4.0	37
Bellaire	Antrim	050052	18	9.0	23.5	16.0	16.5	4.8	37
Big	Osceola	670056	15	13.0	24.0	19.2	19.0	3.4	35
Big Pine Island	Kent	410437	16	5.5	15.0	8.2	7.5	2.8	47
Bills	Newaygo	620311	16	6.5	15.0	10.1	9.8	2.6	44
Bills (Reinhardt)	Newaygo	620062	13	6.0	14.0	9.0	9.0	2.4	45
Birch (Fallon)	Cass	140187	14	7.0	34.0	17.6	16.0	7.2	36
Birch (Temple)	Cass	140061	19	10.0	35.0	17.5	16.0	5.7	36

APPENDIX 1
2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Blue	Kalkaska	400017	16	20.0	34.0	25.8	24.8	4.2	30
Blue	Mecosta	540092	12	9.0	13.0	10.5	10.0	1.2	43
Blue (North)	Kalkaska	400131	9	20.0	27.0	22.2	22.0	2.6	32
Bostwick	Kent	410322	10	5.5	12.5	8.7	8.3	1.9	46
Bradford (Big)	Otsego	690036	10	21.0	35.0	24.9	23.0	4.5	31
Bradford (Little)	Otsego	690151	8	12.0	13.0	12.6	13.0	0.5	41
Brevoort	Mackinac	490036	10	8.5	15.5	11.7	12.0	1.9	42
Brooks	Leelanau	450222	15	8.5	12.0	10.6	10.0	1.1	43
Brown	Jackson	380477	19	5.0	21.5	10.5	8.0	5.6	43
Bruin	Washtenaw	810575	10	4.5	23.0	11.7	9.5	5.5	42
Byram	Genesee	250364	19	12.0	30.0	16.6	15.0	4.4	37
Cascade Impoundment	Kent	410686	17	0.0	5.5	3.5	3.5	1.4	59
Cedar	Alcona	010017	5	1.0	>10				
Cedar	Iosco	350231	5	14.0	>14				
Cedar	Leelanau	450234	15	7.5	18.5	10.9	10.0	3.2	43
Cedar	Van Buren	800241	11	8.0	16.0	11.9	12.0	2.4	41
Center	Osceola	670238	18	12.0	22.0	18.1	18.0	2.3	35
Chabenau	Marquette	520508	*						
Chain	Iosco	350146	12	9.0	13.0	11.7	12.5	1.5	42
Chancellor (Blue)	Mason	530287	11	21.0	35.0	26.0	25.0	4.1	30
Chemung	Livingston	470597	18	10.0	17.0	13.5	14.0	2.3	40
Christiana	Cass	140055	14	8.0	>19	11.9	12.0	2.8	<41
Clam	Antrim	050101	15	12.0	18.0	15.1	15.0	1.7	38
Clark	Jackson	380173	9	10.0	21.0	12.8	11.0	3.5	40

APPENDIX 1
2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	**County**	**Site ID Number**	Number of Readings	**Secchi Disk Transparency (feet)** Range Min	Max	Mean	Median	Standard Deviation	**Carlson TSI_{SD}** (transparency)
Clear	Jackson	380453	15	5.0	17.5	10.3	10.0	3.4	43
Clear	Ogemaw	650042	12	12.5	19.5	15.0	15.0	1.8	38
Clifford	Montcalm	590142	17	8.0	12.5	9.5	9.0	1.3	45
Cobb	Barry	080259	19	10.0	25.0	15.9	13.0	5.3	37
Coldwater	Branch	120077	11	9.0	16.0	13.4	14.0	2.2	40
Cora	Van Buren	800260	19	12.5	19.0	15.4	15.5	1.8	38
Corey	St. Joseph	750142	14	9.5	29.0	13.0	12.3	4.8	40
Cranberry	Oakland	631228	16	6.5	12.0	9.3	9.3	1.7	45
Crockery	Ottawa	700422	9	2.5	>6	4.1	3.5	1.5	<57
Crooked	Kalamazoo	390599	17	7.5	19.0	11.1	10.0	3.5	42
Crooked (Big)	Kent	410714	11	8.0	11.5	10.1	10.0	1.3	44
Crooked (East)	Livingston	470658	8	7.0	11.5	9.8	10.3	1.5	44
Crooked (Upper)	Barry	080071	19	10.5	16.0	12.7	12.0	1.8	40
Crooked (West)	Livingston	470571	8	6.5	11.5	8.4	7.0	2.4	46
Crystal	Benzie	100066	*						
Crystal	Montcalm	590105	15	8.0	16.0	10.6	10.0	2.1	43
Crystal	Oceana	640062	17	6.0	18.0	11.2	11.0	3.7	42
Cub	Kalkaska	400031	15	11.0	20.0	15.7	16.0	3.2	37
Deer	Alger	020127	14	7.0	11.0	8.8	8.0	1.4	46
Deer	Oakland	631128	19	8.0	18.0	12.1	11.0	3.3	41
Derby	Montcalm	590144	7	9.0	17.5				
Devils	Lenawee	460179	5	8.5	18.0				
Diamond	Cass	140039	19	7.0	26.0	16.1	14.0	5.4	37
Diane	Hillsdale	300173	17	2.0	3.0	2.7	3.0	0.4	61

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2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Number of Readings	Secchi Disk Transparency (feet) Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Dinner	Gogebic	270126	19	5.0	14.0	8.1	8.0	2.2	47
Duck	Calhoun	130172	14	9.0	14.0	11.6	12.0	1.4	42
Duck	Gogebic	270127	18	6.5	12.0	9.3	9.3	1.5	45
Duck	Muskegon	610778	15	8.0	10.0	9.0	9.0	0.8	45
Duncan	Barry	080096	16	2.0	10.5	5.5	5.3	2.6	53
Eagle	Allegan	030259	19	10.5	17.5	13.3	13.0	2.0	40
Eagle	Cass	140057	15	4.0	22.0	8.8	6.5	5.1	46
Eagle	Kalkaska	400130	10	14.0	20.0	17.3	17.5	2.5	36
Earl	Livingston	470554	19	4.0	10.0	6.9	6.5	1.8	49
Emerald	Kent	410709	19	6.5	20.0	11.8	10.0	4.2	42
Emerald	Newaygo	620167	15	12.0	30.0	17.8	15.5	5.5	36
Evans	Lenawee	460309	15	13.0	20.0	14.9	15.0	1.9	38
Farwell	Jackson	380454	17	10.0	35.0	16.9	16.0	6.2	36
Fawn	Hillsdale	300290	19	2.5	7.5	4.9	4.5	1.6	54
Fenton	Genesee	250241	11	14.0	24.0	19.2	19.0	3.5	35
Fish	Van Buren	800461	19	5.0	12.0	7.8	8.0	2.1	48
Fishers	St. Joseph	750139	19	7.0	30.0	14.4	11.0	7.3	39
Fremont	Newaygo	620029	15	6.0	25.0	13.7	11.5	6.2	39
Freska	Kent	410702	10	6.0	9.0	7.8	7.8	1.0	48
George	Clare	180056	*						
Glen (Big)	Leelanau	450049	18	15.5	27.5	20.9	20.8	3.5	33
Glen (Little)	Leelanau	450050	15	5.5	10.5	7.8	7.5	1.5	48
Gratiot	Keweenaw	420030	11	11.0	19.0	14.8	15.0	2.5	38
Gravel	Van Buren	800271	16	11.0	17.0	13.0	13.0	1.6	40

APPENDIX 1
2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Green Oak (Silver)	Livingston	470589	13	10.0	24.0	14.9	13.0	4.8	38
Gull	Kalamazoo	390210	19	7.5	21.0	14.2	16.0	4.7	39
Hamburg	Livingston	470568	19	11.0	24.0	15.5	15.0	2.9	38
Hamilton	Dickinson	220060	17	10.0	15.0	12.5	12.0	1.7	41
Hamlin (Lower)	Mason	530073	18	7.0	12.0	9.1	9.0	1.6	45
Hamlin (Upper)	Mason	530074	18	5.0	10.5	7.3	6.8	1.5	49
Hannah Webb	Iron	360165	2	10.0	12.5				
Hawk	Oakland	631115	16	5.0	13.0	8.7	9.0	2.5	46
Herring (Upper)	Benzie	100247	13	5.5	12.5	8.8	9.0	2.6	46
Hicks	Osceola	670062	5	3.5	6.5				
Higgins (N. Basin)	Roscommon	720026	6	32.0	42.0				
Higgins (S. Basin)	Roscommon	720028	6	30.0	49.0				
High	Kent	410703	*						
Horsehead	Mecosta	540085	17	8.0	12.5	9.7	9.5	1.4	44
Houghton (Cut River)	Roscommon	720163	*						
Houghton (Denton)	Roscommon	720164	*						
Hubbard (1)	Alcona	010101	11	12.0	28.0	19.0	18.0	4.7	35
Hubbard (2)	Alcona	010102	10	12.0	25.0	19.5	20.3	4.2	34
Hubbard (3)	Alcona	010103	8	15.0	25.0	19.1	18.0	4.0	35
Hubbard (4)	Alcona	010104	9	14.0	26.0	20.6	21.0	4.6	33
Hubbard (5)	Alcona	010105	8	16.0	27.0	21.5	21.0	4.5	33
Hubbard (6)	Alcona	010106	16	15.0	28.0	20.9	19.8	4.2	33
Hubbard (7)	Alcona	010107	10	15.0	28.5	20.8	19.8	4.9	33
Hunter	Gladwin	260119	16	8.0	15.0	11.6	10.8	2.0	42

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2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Hutchins	Allegan	030203	19	5.5	17.5	9.7	9.0	3.4	44
Independence	Marquette	520149	15	5.5	>11	9.3	9.5	1.6	<45
Indian	Kalamazoo	390305	15	9.0	29.0	16.2	14.0	5.8	37
Indian	Kalkaska	400015	*						
Indian	Osceola	670227	17	10.0	23.0	18.7	19.0	3.0	35
Isabella	Isabella	370135	19	4.5	10.5	7.1	7.5	1.8	49
Island	Grand Traverse	280164	15	11.0	33.0	20.1	16.0	8.7	34
Island (Little)	Iosco	350245	13	5.5	>7.5	6.3	6.5	0.5	<50
James	Roscommon	720171	*						
Juno	Cass	140058	14	6.0	>10	8.4	9.0	1.3	<46
Kelsey (Big)	Cass	140195	5	8.0	10.5				
Kelsey (Little)	Cass	140196	5	6.0	13.0				
Kimball	Newaygo	620107	16	3.0	8.0	4.9	5.0	1.4	54
Klinger	St. Joseph	750136	19	6.0	13.0	9.3	9.0	2.0	45
Lakeville	Oakland	630670	16	6.0	19.0	10.9	10.5	3.2	43
Lancelot (1)	Gladwin	260104	10	6.0	13.0	9.2	9.8	2.5	45
Lancelot (2)	Gladwin	260112	10	5.5	12.0	9.6	10.0	1.8	45
Lancelot (3)	Gladwin	260113	10	6.5	12.0	9.9	10.0	1.8	44
Lancer	Gladwin	260116	12	8.5	13.0	10.1	9.8	1.3	44
Leelanau (North)	Leelanau	450236	17	10.0	24.0	16.9	16.5	4.5	36
Leelanau (South)	Leelanau	450235	16	11.0	25.0	16.8	17.8	4.2	36
Leninger	Cass	140197	17	7.5	13.0	8.9	8.5	1.5	46
Long	Gogebic	270179	*						
Long	Iosco	350076	19	12.0	14.0	13.2	13.0	0.6	40

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2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Long	Oakland	631118	16	11.0	19.0	14.1	14.0	2.1	39
Long (Little)	Barry	080279	8	11.0	27.5	15.9	14.0	5.6	37
Louise	Dickinson	220124	17	11.5	21.0	15.7	16.0	2.6	37
Magician	Cass	140065	17	8.0	>22	11.4	10.0	3.6	<42
Margrethe	Crawford	200157	12	12.0	19.0	16.3	16.5	2.2	37
Marl	Genesee	250480	14	7.0	10.0	8.8	8.8	1.0	46
Mary	Dickinson	220039	17	12.5	23.0	16.7	16.0	3.2	37
Mary	Iron	360071	19	16.0	32.5	22.6	21.5	5.0	32
Maston	Kent	410764	19	6.5	15.0	10.2	10.0	2.7	44
Mecosta	Mecosta	540057	11	7.5	10.0	8.7	9.0	1.0	46
Moon	Gogebic	270120	16	14.5	24.0	18.7	18.0	3.2	35
Murray	Kent	410268	16	6.5	15.0	10.7	11.3	3.0	43
Muskellunge	Kent	410765	19	10.0	18.0	13.5	13.0	2.7	40
Muskellunge	Montcalm	590154	17	4.0	10.0	7.4	7.5	1.8	48
Nepessing	Lapeer	440220	9	8.0	14.0	10.0	10.0	1.8	44
Ore	Livingston	470100	18	5.0	17.0	8.8	9.0	3.4	46
Orion	Oakland	630554	14	10.5	15.5	12.8	13.0	1.3	40
Osterhout	Allegan	030263	18	5.0	12.0	8.2	7.5	2.7	47
Oxbow	Oakland	630666	*						
Painter	Cass	140108	14	4.0	>10	6.6	6.0	1.8	<50
Papoose	Kalkaska	400134	4	34.0	34.0				
Park	Clinton	190099	16	6.5	14.0	9.7	9.3	2.5	44
Paw Paw (Little)	Berrien	110765	19	3.5	7.0	4.8	4.5	0.9	54
Payne	Barry	080103	11	6.5	9.0	8.3	8.5	0.9	47

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2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Pentwater	Oceana	640089	18	3.0	10.5	6.1	5.8	1.8	51
Perch	Iron	360046	13	4.5	7.0	5.9	6.0	0.7	51
Perrin	St. Joseph	750314	18	10.0	17.0	12.4	12.0	1.9	41
Pickerel	Kalkaska	400035	17	18.5	28.0	23.4	24.0	2.9	32
Pickerel	Newaygo	620066	16	6.5	17.0	13.7	14.3	2.8	39
Platte	Benzie	100086	19	10.0	20.0	15.1	14.5	2.7	38
Pleasant	St. Joseph	750144	16	8.5	15.0	10.8	10.0	2.2	43
Pleasant	Wexford	830183	19	7.0	10.0	8.6	8.5	0.9	46
Pleasant (Central Basin)	Washtenaw	810265	19	8.5	10.0	9.3	9.0	0.5	45
Pleasant (East Basin)	Washtenaw	810264	19	7.0	10.0	9.1	9.5	1.0	45
Pleasant (Northwest Basin)	Washtenaw	810266	19	8.5	10.5	9.3	9.0	0.5	45
Portage	Wash/Livingston	810248	16	8.5	18.0	12.7	13.5	2.6	41
Posey	Lenawee	460423	10	3.0	6.5	4.9	4.8	1.2	54
Pretty	Mecosta	540079	14	8.5	14.0	11.7	11.5	1.6	42
Puterbaugh	Cass	140170	17	5.0	16.0	8.0	6.0	3.7	47
Randall	Branch	120078	18	4.0	12.0	6.4	5.0	3.0	50
Rifle	Ogemaw	650022	10	11.5	20.0	15.3	14.8	2.8	38
Round	Lenawee	460304	9	9.0	24.0	13.6	11.0	5.1	40
Round	Livingston	470546	9	9.5	14.5	11.9	12.0	1.7	41
Round	Mecosta	540073	12	5.5	10.0	7.8	8.0	1.1	48
Sand	Lenawee	460264	7	11.0	23.0				
Sanford	Benzie	100208	19	13.0	29.0	20.3	21.0	5.3	34
Sanford	Midland	560169	19	1.5	5.0	3.5	3.0	1.1	59
School Section	Mecosta	540080	14	8.5	13.5	10.5	10.0	1.7	43

APPENDIX 1
2013 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
School Section (2)	Mecosta	540190	14	8.5	13.5	10.5	9.5	1.8	43
Sherman	Kalamazoo	390382	9	5.5	24.0	11.1	9.5	6.0	42
Shingle	Clare	180108	*						
Silver	Genesee	250481	*						
Silver	Oceana	640341	*						
Silver	Van Buren	800534	19	8.0	10.5	9.2	9.5	0.8	45
Sister (First)	Washtenaw	810588	10	3.5	6.5	5.0	4.8	1.0	54
Sister (Second)	Washtenaw	810589	10	1.5	10.0	5.7	6.0	2.2	52
Spider	Grand Traverse	280395	19	11.0	25.0	16.7	14.5	4.6	37
Squaw	Kalkaska	400135	9	10.0	15.0	11.3	10.5	1.5	42
Star (Big)	Lake	430022	4	10.0	12.5				
Starvation	Kalkaska	400030	17	20.0	42.0	28.9	26.0	6.6	29
Stoneledge	Wexford	830186	18	7.0	13.5	10.1	10.0	2.1	44
Stony (1)	Oceana	640345	17	5.5	12.0	7.7	7.5	2.0	48
Stony (2)	Oceana	640049	17	5.5	12.0	9.0	9.0	2.0	45
Straits (Middle)	Oakland	630732	9	7.0	12.5	9.8	10.0	1.9	44
Straits (Upper)	Oakland	631172	9	9.5	22.0	15.4	16.5	4.4	38
Strawberry	Livingston	470213	*						
Sweezey	Jackson	380470	10	6.0	15.0	10.6	10.0	3.6	43
Sylvan	Newaygo	620168	15	10.0	34.0	21.2	18.5	8.0	33
Tahoe	Oceana	640332	13	6.5	>13	9.8	10.0	2.7	<44
Tamarack	Livingston	470610	4	9.5	14.5				
Taylor	Oakland	631114	19	14.5	21.0	17.2	17.0	1.7	36
Torch (North)	Antrim	050055	19	14.0	38.0	28.6	29.0	8.1	29

APPENDIX 1
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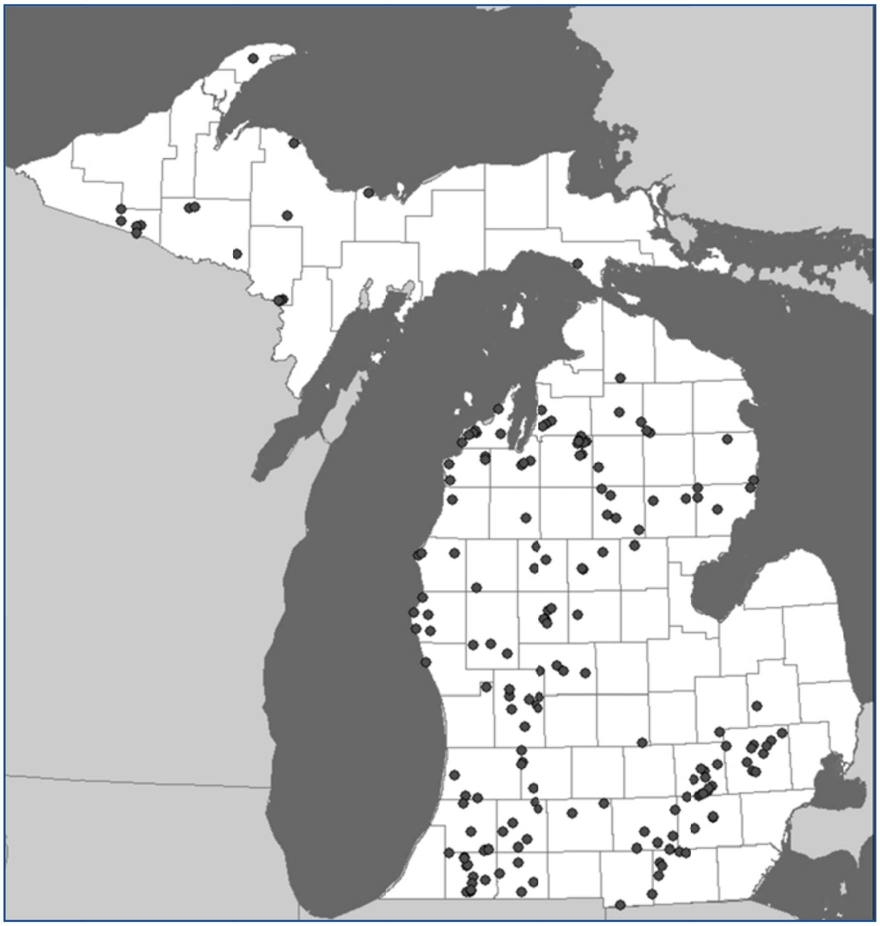
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Number of Readings	Secchi Disk Transparency (feet) Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Torch (South)	Antrim	050240	13	18.0	40.0	25.8	25.0	6.0	30
Triangle	Livingston	470591	9	6.0	14.5	9.3	8.5	3.1	45
Twin (Big)	Kalkaska	400025	16	14.0	27.0	21.5	22.0	4.3	33
Twin (Big) (North)	Cass	140165	*						
Twin (East)	Montmorency	600013	6	5.5	9.0				
Twin (Little)	Cass	140166	19	9.0	17.5	12.9	13.0	2.9	40
Twin (Little)	Kalkaska	400013	17	13.0	>27.5	20.6	20.0	4.1	<33
Twin (West)	Montmorency	600014	4	8.5	10.0				
Van Etten	Iosco	350201	18	3.5	11.5	6.4	6.3	2.1	50
Viking	Otsego	690136	19	7.0	13.5	9.8	9.0	2.3	44
Vineyard	Jackson	380263	3	6.5	12.5				
Voorheis	Oakland	631146	9	10.0	21.5	13.8	13.0	3.3	39
White	Oakland	630684	8	14.0	18.0	15.9	15.5	1.5	37
White (East)	Muskegon	610330	14	5.0	11.0	7.3	7.3	1.6	48
White (West)	Muskegon	610349	14	5.0	9.0	7.0	6.8	1.3	49
Whitewood	Livingston	470592	18	7.0	16.0	9.1	8.3	2.1	45
Wildwood	Cheboygan	160230	15	7.0	10.5	8.8	9.0	0.9	46
Winans	Livingston	470611	*						
Wolf	Lake	430026	1	11.5	11.5				
Woods	Kalamazoo	390542	19	5.0	20.0	11.7	11.5	4.0	42

* No measurement reported
> and < : At least one measurement was made on lake bottom, so TSI calculation is artifically inflated.

Appendix 2
2013 Cooperative Lakes Monitoring Program
Total Phosphorus Results



Map above shows the distribution of the 201 lakes (including sub-basins) enrolled in late summer Total Phosphorus monitoring in the 2013 CLMP Program.

Recorded Total Phosphorus Values:

Spring Mean:	16.9 µg/l	Summer Mean:	13.2 µg/l
Minimum:	<3 µg/l	Minimum:	<3 µg/l
Maximum:	150 µg/l	Maximum:	80 µg/l
(Crockery Lake, Ottawa Co.)		(Sanford Lake, Midland Co.)	

Michigan Clean Water Corps
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APPENDIX 2

2013 COOPERATIVE LAKES MONITORING PROGRAM

SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l)								Carlson TSITP
			Spring Overturn				Late Summer				
			Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Allen	Gogebic	270207	11				6				30
Angelus	Oakland	631227	5				5				27
Ann	Benzie	100082	6				5				27
Arbutus	Grand Traverse	280109	≤ 3 W				5				27
Arnold	Clare	180107	5				7				32
Bar (South)	Leelanau	450237					18				46
Barlow	Barry	080176	8				≤ 3 W				< 27
Barton	Kalamazoo	390215					12				40
Baseline	Washtenaw/Liv.	470149	*				12				40
Bear	Kalkaska	400026	*				6				30
Bear	Manistee	510122	7				8				34
Bear (Big)	Otsego	690041	*				*				
Beatons	Gogebic	270105	9				≤ 3 W	≤ 3 W			< 27
Beaver	Alpena	040097	6				5				27
Bellaire	Antrim	050052	6				≤ 3 W				< 27
Big	Osceola	670056	8				12				40
Big Pine Island	Kent	410437	17				18				46
Bills	Newaygo	620311					7				32
Birch (Fallon)	Cass	140187					≤ 3 W				< 27
Birch (Temple)	Cass	140061					*				
Blue	Kalkaska	400017					< 5 T				< 27
Blue	Mecosta	540092	*				8				34
Blue (North)	Kalkaska	400131	5				≤ 3 W				< 27
Bostwick	Kent	410322	*				26				51
Bradford (Big)	Otsego	690036					< 5 T				< 27
Brevoort	Mackinaw	490036	14				12				40

APPENDIX 2
2013 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	**County**	**Site ID Number**	**Total Phosphorus (ug/l)** Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	**Carlson TSITP** (summer TP)
Brooks	Leelanau	450222	20				12				40
Browns	Jackson	380477	8				5				27
Bruin	Washtenaw	810575					6				30
Cascade Impoundment	Kent	410686	*				*				
Cedar	Alcona	010017	8				9				36
Cedar	Leelanau	450234					6				30
Cedar	Van Buren	800241	10				≤ 3 W				< 27
Center	Osceola	670238					7				32
Chabenau	Marquette	520508	*				*				
Chain	Iosco	350146	12				14				42
Chancellor (Blue)	Mason	530287	13				7				32
Chemung	Livingston	470597	18				9				36
Christiana	Cass	140055	15				13				41
Clam	Antrim	050101	< 5 T				11				39
Clark	Jackson	380173	≤ 3 W				6				30
Clear	Jackson	380453					8				34
Clear	Ogemaw	650042	≤ 3 W				7				32
Clifford	Montcalm	590142	16				14				42
Cobb	Barry	080259	5				≤ 3 W	< 5 T			< 27
Cora	Van Buren	800260	9				5				27
Corey	St. Joseph	750142	10				9				36
Cranberry	Oakland	631228	27				16				44
Crockery	Ottawa	700422	150				20				47
Crooked	Kalamazoo	390599	10				8				34
Crooked (Big)	Kent	410714	24				17				45
Crooked (East)	Livingston	470658					10				37

APPENDIX 2
2013 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
Crooked (Upper)	Barry	080071	15				12				40
Crooked (West)	Livingston	470571					12	11			40
Crystal	Benzie	100066	5				5				27
Crystal	Montcalm	590105	8				8	9			34
Crystal	Oceana	640062	8				13				41
Cub	Kalkaska	400031	*				10				37
Deer	Alger	020127	9	9			8				34
Deer	Oakland	631128	≤ 3 W				5				27
Derby	Montcalm	590144	8				6	6			30
Devils	Lenawee	460179	≤ 3 W				8				34
Diamond	Cass	140039	7				5				27
Diane	Hillsdale	300173	38				*				
Dinner	Gogebic	270126					16				44
Duck	Calhoun	130172					7				32
Duck	Gogebic	270127	11				10				37
Duck	Muskegon	610778	12				17	17			45
Duncan	Barry	080096	93				51				61
Eagle	Cass	140057	17				11				39
Eagle	Allegan	030259	18				9	9			36
Eagle	Kalkaska	400130	< 5 T				7				32
Earl	Livingston	470554	45				26				51
Emerald	Kent	410709	*				*				
Evans	Lenawee	460309					7				32
Farwell	Jackson	380454	≤ 3 W				≤ 3 W				< 27
Fawn	Hillsdale	300290	14				52				61
Fenton	Genesee	250241	10	8			7				32

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2013 COOPERATIVE LAKES MONITORING PROGRAM

SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

		Site ID	Total Phosphorus (ug/l)								Carlson
Lake	**County**	**Number**	**Spring Overturn**				**Late Summer**				**TSI TP**
			Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Fish	Van Buren	800461	11				16				44
Fisher (Big)	Leelanau	450224	≤ 3 W				≤ 3 W				< 27
Fishers	St. Joseph	750139					≤ 3 W				< 27
Fremont	Newaygo	620029	37				13				41
Freska	Kent	410702	25				10				37
George	Clare	180056	7 c	7			10 g				37
Glen (Big)	Leelanau	450049	7	6			≤ 3 W				< 27
Glen (Little)	Leelanau	450050	5				8				34
Gratiot	Keewenaw	420030					8				34
Gravel	Van Buren	800271	7				6	6			30
Gull	Kalamazoo	390210	< 5 T				< 5 T				< 27
Hamilton	Dickinson	022060	10	7			*				
Hamlin (Lower)	Mason	530073	18	20			33				55
Hamlin (Upper)	Mason	530074	27				34	34			55
Hannah Webb	Iron	360165	6	8			8				34
Herring (Upper)	Benzie	100247	7				14				42
Hicks	Osceola	670062	29				*				
Higgins (North)	Roscommon	720026	5				5				27
Higgins (South)	Roscommon	720028	6				< 5 T				< 27
High	Kent	410703	10				14				42
Horsehead	Mecosta	540085	12				j				
Houghton (Cut River)	Roscommon	720163	11				15				43
Houghton (Denton)	Roscommon	720164	12				14				42
Hubbard	Alcona	010106	5				8				34
Hutchins	Allegan	030203	f				10				37
Independence	Marquette	520149	14	10			15	11			43

APPENDIX 2
2013 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
Indian	Kalamazoo	390305	6		11		< 5 T				< 27
Indian	Kalkaska	400015	*				*				
Indian	Osceola	670227					8				34
Isabella	Isabella	370135	27				16				44
Island	Grand Traverse	280164	≤ 3 W				9				36
Island (Little)	Iosco	350245	7				15				43
James	Roscommon	720171	16				13				41
Juno	Cass	140058	19				20	20			47
Kelsey (Big)	Cass	140195	7 c				12				40
Kelsey (Little)	Cass	140196	17 c				27	28			52
Kimball	Newaygo	620107	110	110							
Klinger	St.Joseph	750136	7				< 5 T				< 27
Lakeville	Oakland	630670	15				13				41
Lancelot	Gladwin	260104	16				14				42
Lancer	Gladwin	260116	19 e				23				49
Leelanau (North)	Leelanau	450236	≤ 3 W				≤ 3 W				< 27
Leelanau (South)	Leelanau	450235	9	8			6				30
Leninger	Cass	140197					25				51
Long	Gogebic	270179	8				6				30
Long	Iosco	350076	13				8				34
Long (Little)	Barry	080279					7				32
Louise	Dickinson	220124	7	7			*				
Magician	Cass	140065	*				8				34
Margrethe	Crawford	200157	5				8				34
Mary	Dickinson	220039	8	10			*				
Mary	Iron	360071	≤ 3 W	< 5 T			7				32

APPENDIX 2
2013 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn				Late Summer				Carlson TSI_{TP}
			Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Maston	Kent	410764	8				5		8		27
Mecosta	Mecosta	540057	*				9				36
Middle Straits	Oakland	630732	7				6				30
Moon	Gogebic	270120	7	8			11				39
Murray	Kent	410268	18				14				42
Muskellunge	Kent	410765	18				6		8		30
Nepessing	Lapeer	440220	23				20				47
Ore	Livingston	470100					15				43
Orion	Oakland	630554	13				8				34
Osterhout	Allegan	030263	7				11				39
Oxbow	Oakland	630666	14				*				
Painter	Cass	140108	23				50				61
Papoose	Kalkaska	400134	20				12				40
Park	Clinton	190099	18				15				43
Pentwater	Oceana	640089	38				39				57
Perch	Iron	360046	20	20			23	24			49
Perrin	St. Joseph	750314	9				6				30
Pickerel	Kalkaska	400035	*				5 g				27
Pickerel	Newaygo	620066	53								
Pleasant	Washtenaw	810266	*				17				45
Pleasant	Wexford	830183	8				12				40
Portage	Washtenaw	810248	10				12				40
Posey	Lenawee	460423	35 e				14				42
Pretty	Mecosta	540079	7	6			13				41
Puterbaugh	Cass	140170					10				37
Rifle	Ogemaw	650022					10				37

APPENDIX 2
2013 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol		Rep.		DEQ	Rep.	Late Summer Vol		Rep	DEQ	Rep	Carlson TSI TP (summer TP)
Round	Lenawee	460304	11						8					34
Round	Livingston	470546	14						12		11			40
Round	Mecosta	540073	*						15					43
Sand	Lenawee	460264							6					30
Sanford	Benzie	100208	7						7					32
Sanford	Midland	560169							80	b				67
School Section	Mecosta	540080	6						8					34
Sherman	Kalamazoo	390382	8	c					19					47
Shingle	Clare	180108	15	c					19					47
Silver	Oceana	640341	22						*					
Silver	Van Buren	800534	8		8				≤ 3	W				< 27
Sister (First)	Washtenaw	810588	70						45					59
Sister (Second)	Washtenaw	810589	59						30					53
Spider	Grand Traverse	280395	*						6					30
Squaw	Kalkaska	400135	*						12					40
Star (Big)	Lake	430022							8	c				34
Starvation	Kalkaska	400030	< 5	T	< 5	T			< 5	T				< 27
Stony	Oceana	640049	37		40				15					43
Straits (Upper)	Oakland	631172	15		12				5					27
Strawberry	Livingston	470213							16					44
Sweezey	Jackson	380470	≤ 3	W,c					7	c				32
Tahoe	Oceana	640332	7						15					43
Tamarack	Livingston	470610	13						15					43
Taylor	Oakland	631114	12		12				8					34
Torch (North)	Antrim	050055	≤ 3	W					≤ 3	W				< 27
Torch (South)	Antrim	050240	≤ 3	W	≤ 3	W			≤ 3	W				< 27

APPENDIX 2
2013 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l)								Carlson TSI
			Spring Overturn				Late Summer				TSI TP
			Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Triangle	Livingston	470591	13				15				43
Twin (Big)	Cass	140165	9				9				36
Twin (Big)	Kalkaska	400025	8				7				32
Twin (East)	Montmorency	600013	10				12				40
Twin (Little)	Kalkaska	400013	< 5 T	< 5 T			11				39
Twin (Little-South)	Cass	140166	11				6				30
Twin (West)	Montmorency	600014	≤ 3 W				10				37
Van Etten	Iosco	350201	23				35				55
Viking	Otsego	690136					12				40
Vineyard	Jackson	380263	5				*				
Voorheis	Oakland	631146	7				11				39
White	Oakland	630684					9	11			36
White (East)	Muskegon	610330	25				26				51
White (West)	Muskegon	610349	28				25				51
Whitewood	Washtenaw/Liv.	470592	*				*				
Wildwood	Cheboygan	160230	13				15				43
Winans	Livingston	470611	38				*				
Wolf	Lake	430026					12				40
Woods	Kalamazoo	390542	22				15				43

APPENDIX 2

2013 COOPERATIVE LAKES MONITORING PROGRAM

SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSI_{TP} (summer TP)

Results Codes:

*   No sample received or received too late to process.

T   Value reported is less than the reporting limit (5 µg/l). Result is estimated.

W Value is less than the method detection limit (3 µg/l).

b   Used non-waterproof ink that ran on label, rendering it illegible.

c   Sample not collected at proper time - may not be comparable to other data

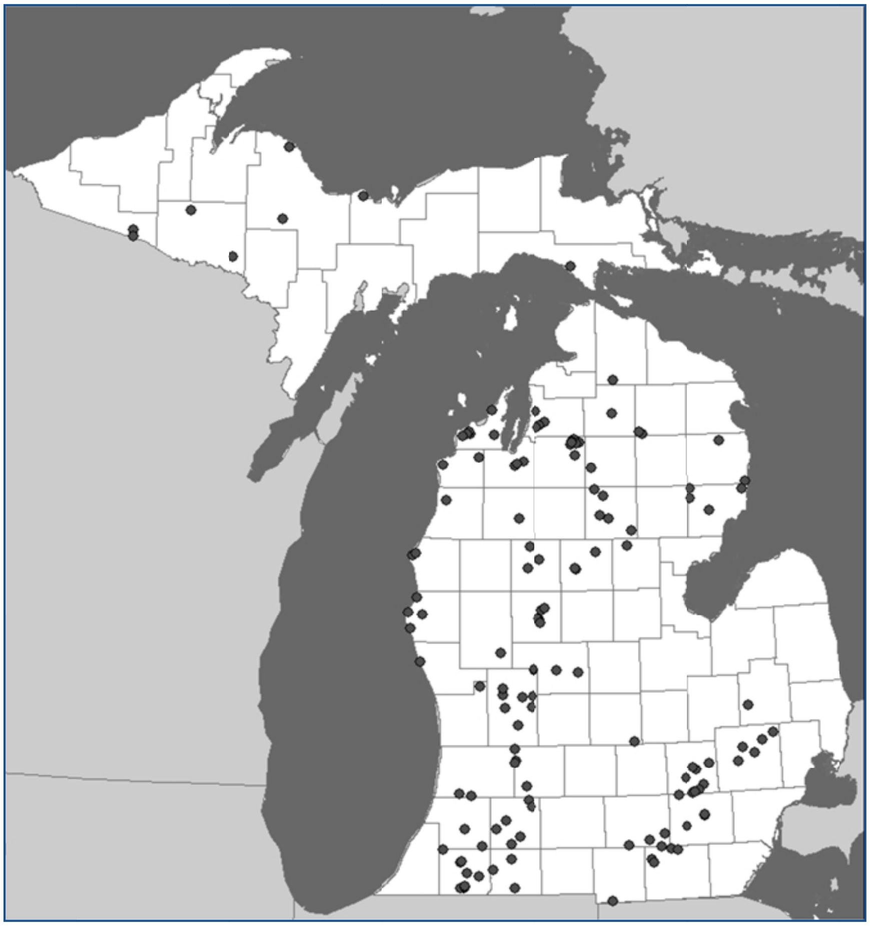
e   Dates on sample bottle and data form did not match.

f   Sample collected from improper location; rejected.

g   Data form not submitted with samples.

j   Sample collected in non-standard sample bottles; rejected.

Appendix 3
2013 Cooperative Lakes Monitoring Program
Chlorophyll Results



Map above shows the distribution of the 144 lakes (including sub-basins) enrolled in Chlorophyll monitoring in the 2013 CLMP Program.

Recorded Chlorophyll Values:

Mean: 5.0 µg/l
Minimum: <1 µg/l
Maximum: 58.0 µg/l (First Sister Lake, Washtenaw County)

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APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	Chlorophyll *a* (µg/L) May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Angelus	Oakland	631227	1.2	2.2	1.8	1.6	1.8	1.7	1.8	0.4	36
Ann	Benzie	100082	1.6	1.6	2.5	1.3	1.3	1.7	1.6	0.5	35
Arbutus (2)	Grand Traverse	280109	5.1	<1.0	2.2	1.8	2.0	2.3	2.0	1.7	37
Arnold	Clare	180107	<1.0	<1.0	<1.0	<1.0	1.4	0.7	0.5	0.4	<31
Barlow	Barry	080176	1.2	3.5	1.9	1.9	2.3	2.2	1.9	0.8	37
Volunteer Replicate							1.6				
Barton	Kalamazoo	390215	2.4	6.6	6.7	4.8	<1.0	4.2	4.8	2.7	46
Baseline	Washtenaw	470149	*	2.0	2.0	<1.0	2.9	1.9	2.0	1.0	37
Bear	Kalkaska	400026	(c)	(c)	(c)	1.7	1.0				
Bear	Manistee	510122	2.1	3.8	2.8	1.9	2.6	2.6	2.6	0.7	40
Beaver	Alpena	040097	<1.0	2.0	<1.0	1.3	<1.0	1.0	0.5	0.7	<31
Bellaire	Antrim	050052	<1.0	1.2	2.0	1.7	1.3	1.3	1.3	0.6	33
Big	Osceola	670056	<1.0	<1.0	1.3(b)	2.2	1.8	1.3	1.3	0.8	33
Big Pine Island	Kent	410437	1.8	7.2	5.9	10.0	6.6	6.3	6.6	3.0	49
Bills	Newaygo	620311	2.4	1.0	2.2	1.9	2.0	1.9	2.0	0.5	37
Volunteer Replicate					2.6						
MDEQ					1.4						
Birch (Fallon)	Cass	140187	<1.0	1.3	1.7	1.7	2.3	1.5	1.7	0.7	36
Birch (Temple)	Cass	140061	1.9	<1.0	*	*	*				
Blue	Kalkaska	400017	1.5	1.5	1.4	2.2	2.4	1.8	1.5	0.5	35

APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	Chlorophyll *a* (μg/L) May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Blue	Mecosta	540092	2.2	3.3	3.0	2.2	2.4	2.6	2.4	0.5	39
Blue (North)	Kalkaska	400131	*	1.1	1.1(b)	*	<1.0	0.9	1.1	0.3	32
Bostwick	Kent	410322	7.8	2.7	2.7	2.1	5.4	4.1	2.7	2.4	40
Brevoort	Mackinac	490036	*	*	*	2.1(b)	<1.0				
Brooks	Leelanau	450222	9.1	14.0	7.0	4.8	2.6	7.5	7.0	4.4	50
Bruin	Washtenaw	810575	1.0	<1.0	2.1	2.4	3.0	1.8	2.1	1.0	38
Volunteer Replicate					2.4						
Cascade Impoundment	Kent	410686	16.0	3.1	10.0	10.0	8.3	9.5	10.0	4.6	53
Cedar (Alcona site)	Alcona/Iosco	010017	*	*	*	3.9	3.0				
Cedar (Iosco site)	Alcona/Iosco	350231	<1.0	1.5	4.0	*	*	2.0	1.5	1.8	35
Cedar	Van Buren	800241	1.6	4.1	4.1	(d)	(d)	3.3	4.1	1.4	44
Center	Osceola	670238	1.1	1.9	1.5	1.7	2.0	1.6	1.7	0.4	36
Chabenau	Marquette	520508	*	*	*	*	*				
Chain	Iosco	350146	2.2	2.4	4.0	2.4	2.0	2.6	2.4	0.8	39
Chemung	Livingston	470597	2.5	8.1	3.8	*	*	4.8	3.8	2.9	44
Christiana	Cass	140055	<1.0	2.7	7.6	7.1	7.7	5.1	7.1	3.3	50
Volunteer Replicate					4.5						
Clam	Antrim	050101	<1.0	<1.0	1.7	<1.0	1.2	0.9	0.5	0.5	<31
Clark	Jackson	380173	<1.0	1.5	1.9	2.1	2.2	1.6	1.9	0.7	37

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2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
			Chlorophyll *a* (µg/L)								
Cobb	Barry	080259	<1.0	<1.0	1.5	1.1	1.9	1.1	1.1	0.6	32
Volunteer Replicate				<1.0							
Cora	Van Buren	800260	<1.0	<1.0	1.5	1.6	1.7	1.2	1.5	0.6	35
Corey	St. Joseph	750142	<1.0	3.6	<1.0	(d)	(d)	1.5	0.5	1.8	<31
Crockery	Ottawa	700422	*	*	*	*	4.8				
Crooked	Kalamazoo	390599	1.1	2.7	5.2	2.8	2.9	2.9	2.8	1.5	41
Crooked (Upper)	Barry	080071	(d)	(d)	(d)	3.3	3.7				
Crystal	Benzie	100066	*	<1.0	<1.0	*	<1.0	0.5	0.5	0.0	<31
Crystal	Montcalm	590105	<1.0	5.6	2.3	<1.0	<1.0	1.9	0.5	2.2	<31
Crystal	Oceana	640062	<1.0	2.2	4.2	3.6	5.4	3.2	3.6	1.9	43
Volunteer Replicate						<1.0					
Deer	Alger	020127	<1.0	2.4	2.5	2.2	2.0	1.9	2.2	0.8	38
Deer	Oakland	631128	<1.0	<1.0	3.3	2.2	<1.0	1.4	0.5	1.3	<31
Volunteer Replicate					2.9						
Derby	Montcalm	590144	1.3	*	3.6	1.8	2.8	2.4	2.3	1.0	39
Devils	Lenawee	460179	<1.0	<1.0	4.2	2.7	2.3 (b)	2.0	2.3	1.6	39
Volunteer Replicate							1.1 (b)				
Diamond	Cass	140039	1.0	<1.0	<1.0	1.8	(c)	1.0	0.8	0.6	28
Diane	Hillsdale	300173	21.0	14.0	20.0	50.0	27.0	26.4	21.0	14.0	60
Volunteer Replicate			20.0								

APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	Chlorophyll *a* (µg/L) June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Duck	Gogebic	270127	2.3	2.7 (b)	6.2	8.9	4.2	4.9	4.2	2.7	45
Duck	Muskegon	610778	1.8	2.8	4.3	*	7.0	4.0	3.6	2.3	43
MDEQ					4.8						
Duncan	Barry	080096	9.5	5.0	9.3	15.0	52.0	18.2	9.5	19.2	53
Volunteer Replicate				8.4							
MDEQ				13.0							
Eagle	Allegan	030259	3.6	4.7	3.6	3.9	5.0	4.2	3.9	0.7	44
Eagle	Cass	140057	<1.0	1.8	5.0	<1.0	6.2	2.8	1.8	2.6	36
Eagle	Kalkaska	400130	<1.0	2.1	2.4	1.7	2.0	1.7	2.0	0.7	37
Earl	Livingston	470554	2.7	1.0	11.0	14.0	4.8	6.7	4.8	5.6	46
Volunteer Replicate						8.7					
Emerald	Kent	410709	8.5	1.6	4.9	*	*	5.0	4.9	3.5	46
MDEQ						5.4					
Evans	Lenawee	460309	3.0	1.9	2.6	3.0	4.6	3.0	3.0	1.0	41
Farwell	Jackson	380454	<1.0	<1.0	1.4 (b)	1.2	1.7	1.1	1.2	0.5	32
Fisher (Big)	Leelanau	450224	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	0.5	0.0	<31
Fishers	St. Joseph	750139	<1.0	2.4	1.7	2.9	3.7	2.2	2.4	1.2	39
Freska	Kent	410702	4.0	5.7	6.7	4.2	4.5	5.0	4.5	1.1	45
George	Clare	180056	2.2	2.6	3.1	4.4	2.5	3.0	2.6	0.9	40
Volunteer Replicate					3.6						

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2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	Chlorophyll *a* (µg/L) June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Glen (Big)	Leelanau	450049	1.0	<1.0	<1.0	<1.0	<1.0	0.6	0.5	0.2	<31
Glen (Little)	Leelanau	450050	3.3	1.9	1.9	1.6	1.2	2.0	1.9	0.8	37
Gull	Kalamazoo	390210	1.7	*	2.6	1.3	2.8	2.1	2.2	0.7	38
Hamlin (Lower)	Mason	530073	2.9	2.2	4.4	3.1	3.9	3.3	3.1	0.9	42
Hamlin (Upper)	Mason	530074	11.0	2.9	5.1	7.9	6.3	6.6	6.3	3.0	49
Hicks	Osceola	670062	*	20.0	15.0	24.0	*	19.7	20.0	4.5	60
Volunteer Replicate						12.0					
Higgins (N. Basin)	Roscommon	720026	<1.0	<1.0	<1.0	<1.0(b)	<1.0	0.5	0.5	0.0	<31
Higgins (S. Basin)	Roscommon	720028	<1.0	<1.0	<1.0	<1.0(b)	<1.0	0.5	0.5	0.0	<31
Volunteer Replicate				<1.0							
High	Kent	410703	10.0	1.7	2.9(b)	3.1	3.5	4.2	3.1	3.3	42
MDEQ						5.9					
Horsehead	Mecosta	540085	1.6	3.2	4.8	4.1	<1.0	2.8	3.2	1.8	42
Houghton (Cut River)	Roscommon	720163	2.5	3.4	6.4(b)	4.2	6.6	4.6	4.2	1.8	45
Houghton (Denton)	Roscommon	720164	3.4	3.3	5.1(b)	3.2	4.7	3.9	3.4	0.9	43
Hubbard (6)	Alcona	010106	<1.0	<1.0	1.6	<1.0	1.3	0.9	0.5	0.5	<31
Independence	Marquette	520149	*	2.1	3.4	2.6	1.9	2.5	2.4	0.7	39
Indian	Kalamazoo	390305	<1.0	<1.0	*	3.1	<1.0	1.2	0.5	1.3	<31
Indian	Kalkaska	400015	*	*	*	*	*				

APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	Chlorophyll *a* (µg/L) June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Indian	Osceola	670227	4.2	1.3	2.6	2.6	2.5	2.6	2.6	1.0	40
Volunteer Replicate			4.3								
Island	Grand Traverse	280164	<1.0	<1.0	3.1	5.1	9.5	3.7	3.1	3.8	42
Island (Little)	Iosco	350245	*	4.1	5.1	4.3	3.3	4.2	4.2	0.7	45
James	Roscommon	720171	*	*	*	*	*				
Juno	Cass	140058	4.0	5.4	11.0	8.7	5.6	6.9	5.6	2.8	48
Kelsey (Big)	Cass	140195	*	*	*	2.4	5.2				
Kelsey (Little)	Cass	140196	*	*	*	2.4	8.7				
Klinger	St. Joseph	750136	4.0	5.0	4.1	*	1.8	3.7	4.1	1.4	44
Lakeville	Oakland	630670	3.0	3.6	1.5	3.5	3.7	3.1	3.5	0.9	43
Lancelot (1)	Gladwin	260104	3.1	2.0	3.3	2.7	4.1	3.0	3.1	0.8	42
Lancer	Gladwin	260116	3.1	3.3	1.8	4.7	7.1	4.0	3.3	2.0	42
Leelanau (North)	Leelanau	450236	<1.0	<1.0	<1.0	<1.0	1.4	0.7	0.5	0.4	<31
Leelanau (South)	Leelanau	450235	<1.0	<1.0	3.6	2.0	1.8	1.7	1.8	1.3	36
Long	Iosco	350076	<1.0	1.3	2.3	2.4	5.6	2.4	2.3	1.9	39
Volunteer Replicate			1.5								
Long (Little)	Barry	080279	<1.0	1.1	3.0	2.9	2.6	2.0	2.6	1.1	40
MDEQ				1.3							
Magician	Cass	140065	1.2	1.6	3.7	1.6	2.4	2.1	1.6	1.0	35

APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	Chlorophyll *a* (μg/L) June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Margrethe	Crawford	200157	1.5	1.5	2.1	1.8	2.1	1.8	1.8	0.3	36
Volunteer Replicate				1.7							
Mary	Iron	360071	5.4	2.2	3.3	2.5	4.3	3.5	3.3	1.3	42
Maston	Kent	410764	2.8	3.0	4.1	2.7	3.2	3.2	3.0	0.6	41
MDEQ							4.1				
Mecosta	Mecosta	540057	2.5	2.3	3.7	2.7	2.6	2.8	2.6	0.5	40
Moon	Gogebic	270120	1.7	6.0	3.2	2.8	1.9	3.1	2.8	1.7	41
Murray	Kent	410268	1.4	3.0	<1.0	<1.0	<1.0	1.2	0.5	1.1	<31
Muskellunge	Kent	410765	<1.0	2.9	3.3	3.5	8.9	3.8	3.3	3.1	42
MDEQ							11.0				
Nepessing	Lapeer	440220	8.5	3.9	8.2	6.0	6.9	6.7	6.9	1.9	50
Volunteer Replicate				<1.0							
Ore	Livingston	470100	2.8	*	7.5	5.4	6.9	5.7	6.2	2.1	48
Orion	Oakland	630554	3.9	2.4	2.8	2.0	2.5	2.7	2.5	0.7	40
Osterhout	Allegan	030263	*	*	4.4	4.4	2.9	3.9	4.4	0.9	45
Oxbow	Oakland	630666	*	*	*	*	*				
Painter	Cass	140108	7.1	12.0	23.0	16.0	35.0	18.6	16.0	10.8	58
Park	Clinton	190099	<1.0	3.9	4.3	3.5	2.8	3.0	3.5	1.5	43
Pentwater	Oceana	640089	4.8	17.0	7.4	12.0	19.0	12.0	12.0	6.1	55
Perch	Iron	360046	3.0	1.4	7.4	4.1	4.0	4.0	4.0	2.2	44

APPENDIX 3

2013 COOPERATIVE LAKES MONITORING PROGRAM

CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
			Chlorophyll *a* (µg/L)								
Pickerel	Kalkaska	400035	*	*	*	*	*				
Pleasant	Wexford	830183	3.1	3.1	2.7	3.4	2.8	3.0	3.0	0.3	41
Pleasant (Northwest Basin)	Washtenaw	810266	2.5	6.5	14.0	(d)	(d)	7.7	6.5	5.8	49
Pretty	Mecosta	540079	4.0	<1.0	3.0	1.5	1.5	2.1	1.5	1.4	35
Volunteer Replicate							1.6				
Round	Lenawee	460304	(d)	(d)	(d)	1.5	2.6				
Round	Livingston	470546	1.4	4.1	27.0	13.0	10.0	11.1	10.0	10.0	53
Round	Mecosta	540073	2.0	3.2	4.5	4.0	2.9	3.3	3.2	1.0	42
Sand	Lenawee	460264	*	*	2.5	(d)	(d)				
School Section	Mecosta	540080	3.1	2.9	6.7	17.0	2.2	6.4	3.1	6.2	42
Sherman	Kalamazoo	390382	1.5	2.5	4.4	8.2	19.0	7.1	4.4	7.1	45
Shingle	Clare	180108	2.3	3.0	4.4	4.5	4.2	3.7	4.2	1.0	45
Silver	Oceana	640341	*	*	*	*	*				
Sister (First)	Washtenaw	810588	9.5	16.0	21.0	58(b)	22.0	25.3	21.0	18.9	60
Sister (Second)	Washtenaw	810589	10.0	18.0	15.0	10.0(b)	17.0	14.0	15.0	3.8	57
Spider	Grand Traverse	280395	*	*	1.4	2.1	2.6	2.0	2.1	0.6	38
Stony	Oceana	640049	7.2	7.0	7.3	8.6	16.0	9.2	7.3	3.8	50

APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
			Chlorophyll *a* (µg/L)								
Strawberry	Livingston	470213	2.4	5.3	1.7	<1.0	3.9	2.8	2.4	1.9	39
Sweezey	Jackson	380470	<1.0	<1.0(b)	1.9	1.3(b)	*	1.1	0.9	0.7	<31
Tamarack	Livingston	470610	*	(c)	3.4(b)	1.8	*				
Torch (North)	Antrim	050055	<1.0	<1.0	<1.0	<1.0	<1.0	0.5	0.5	0.0	<31
Torch (South)	Antrim	050240	*	<1.0	<1.0	<1.0	<1.0	0.5	0.5	0.0	<31
Triangle	Livingston	470591	*	3.0	<1.0	4.1	6.2	3.5	3.6	2.4	43
Twin (Big)	Kalkaska	400025	4.9	2.3	1.9	<1.0	1.7	2.3	1.9	1.6	37
Twin (East)	Montmorency	600013	*	*	*	3.1	4.2				
Twin (Little)	Kalkaska	400013	1.8	<1.0	2.2	2.7	3.2	2.1	2.2	1.0	38
Twin (West)	Montmorency	600014	*	*	*	3.0	3.6				
Van Etten	Iosco	350201	9.7	5.2	8.2	14.0	6.7	8.8	8.2	3.4	51
Viking	Otsego	690136	10.0	19.0	28.0	13.0	28.0	19.6	19.0	8.3	59
Vineyard	Jackson	380263	*	*	2.0	2.0	*				
White (East)	Muskegon	610330	3.3	21.0	6.8(b)	12.0	5.1	9.6	6.8	7.1	49
White (West)	Muskegon	610349	8.7	21.0	4.2(b)	8.9	6.0	9.8	8.7	6.6	52
Whitewood	Livingston	470592	3.2	3.7	3.9	2.3	3.6	3.3	3.6	0.6	43
Wildwood	Cheboygan	160230	3.6	5.6	2.2	2.8	3.9	3.6	3.6	1.3	43
Woods	Kalamazoo	390542	*	*	*	6.4	12.0				

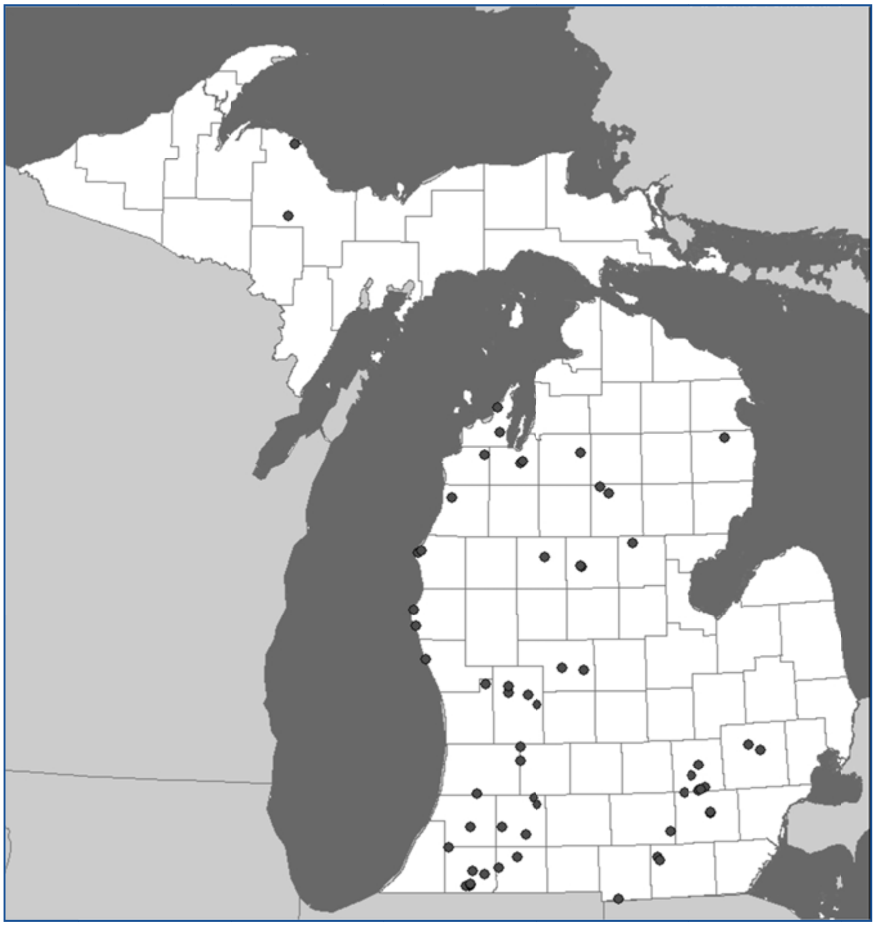
APPENDIX 3
2013 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

		Site ID		Chlorophyll *a* (µg/L)						Std.	Carlson
Lake	County	Number	May	June	July	Aug	Sept	Mean	Median	Dev.	TSI_{CHL}

Results Codes:

< Sample value is less than limit of quantification (1 ug/l)
* No sample received
b Sample not collected at proper time - may not be comparable to other data
c Sample not collected at proper time; rejected.
d Sample poorly or not covered by aluminum foil; rejected.

Appendix 4
2013 Cooperative Lakes Monitoring Program Dissolved Oxygen and Temperature Results



Map above shows the distribution of the 64 lakes enrolled in Dissolved Oxygen and Temperature monitoring in the 2013 CLMP Program.

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APPENDIX 4
2013 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes	Site ID
Alcona	Hubbard	010106
Allegan	Eagle	030259
Barry	Cobb	080259
	Duncan	080096
	Little Long	080299
Benzie	Ann*	100082
Cass	Birch	140187
	Christiana	140055
	Eagle	140057
	Juno	140058
	Magician	140065
	Painter	140108
Gladwin	Lancelot	260104
	Lancer	260116
Grand Traverse	Arbutus	280109
Hillsdale	Diane	300173
Jackson	Sweezey	380470
Kalamazoo	Crooked	390599
	Gull	390210
	Indian	390305
	Sherman	390382
Kalkaska	Bear	400026
Kent	Bostwick	410322
	Freska	410702
	Murray	410268
Leelanau	Leelanau (North)	450236
	Leelanau (South)	450235
Lenawee	Devils	460179
	Round	460304

APPENDIX 4
2013 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes	Site ID
Livingston	Baseline	470149
	Earl	470554
	Tamarack	470610
	Triangle	470591
	Whitewood	470592
Manistee	Bear	510257
Marquette	Independence*	520149
Mason	Hamlin (Lower)	530073
	Hamlin (Upper)	530074
Montcalm	Crystal	590105
	Derby	590144
Muskegon	Duck	610778
	White (East)	610330
	White (West)	610349
Oakland	Angelus*	631227
	Deer	631128
Oceana	Stony*	640049
Osceola	Hicks	670062
Ottawa	Crockery	700422
St. Joseph	Corey	750142
	Fishers	750139
Van Buren	Cora	800260
Washtenaw	Bruin	810575
	First Sister*	810588
	Second Sister	810589

**Profile featured below.*

APPENDIX 4
2013 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

On the following pages five representative dissolved oxygen/temperature patterns are illustrated.

The first is of a high quality oligotrophic lake, which has a moderate hypolimnion volume. The lake maintains high oxygen levels in the hypolimnion all summer.

The second pattern represents a good quality mesotrophic lake with a moderate hypolimnion volume. This lake keeps some dissolved oxygen in the hypolimnion through early summer, but by late summer the entire hypolimnion is devoid of oxygen.

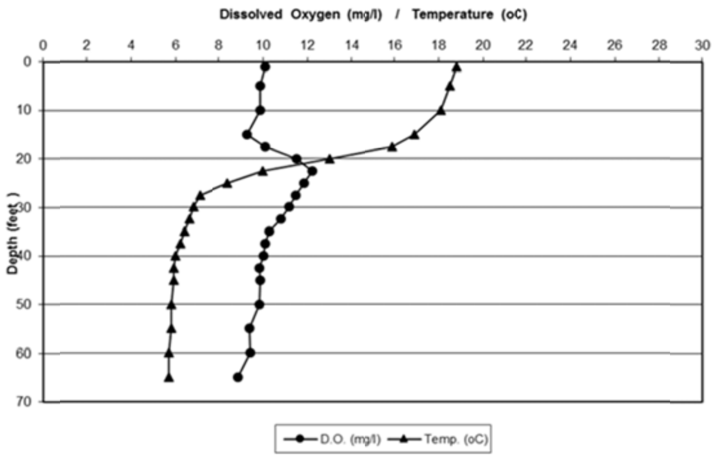
The third pattern is a eutrophic lake with a small sized hypolimnion. Within a few weeks of spring overturn the hypolimnion has lost all oxygen. This anaerobic condition persists all summer.

The fourth pattern is a mesotrophic lake, which is too shallow to maintain stratification. It could lose oxygen in the deeper water, but summer storms cause mixing though the deepest parts of the lake, renewing the oxygen supply to these waters.

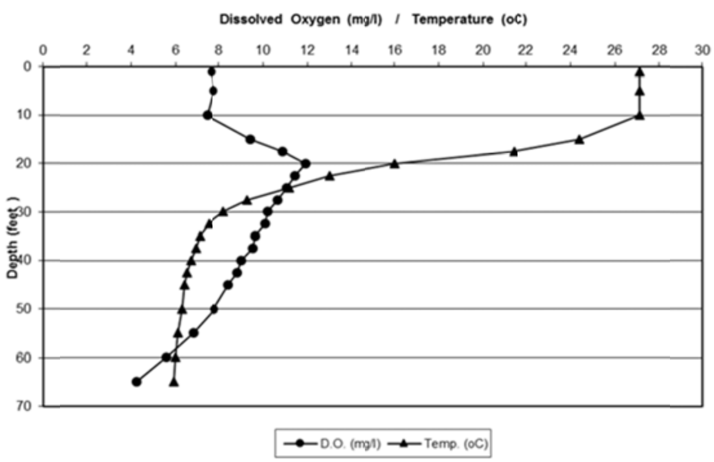
The fifth example is a mesotrophic lake that has dissolved oxygen spikes in the thermocline. This graph is included because many people will see this in the data from their lake.

Oligotrophic Lake with a Moderate Volume Hypolimnion

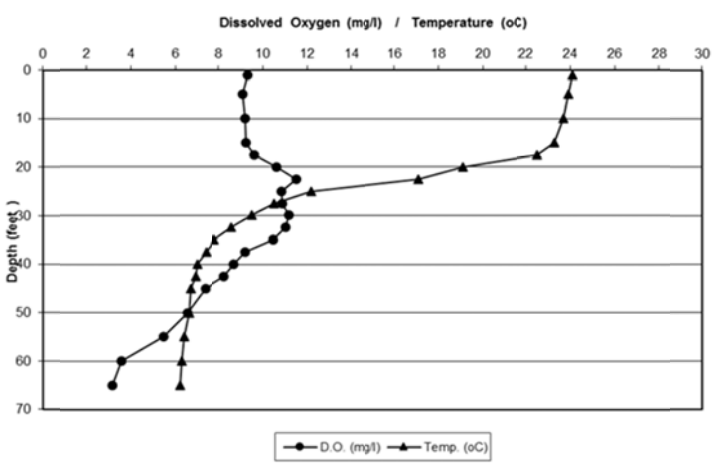
Ann Lake in Benzie County is an oligotrophic lake with a moderate volume hypolimnion. As an oligotrophic lake, it produces less organic material that must be decomposed as compared to a mesotrophic or eutrophic lake. Its moderate volume hypolimnion has a substantial oxygen supply that is not reduced significantly by the decomposition of the limited organic material, which falls into the hypolimnion during the summer. Consequently, dissolved oxygen levels remain high in the hypolimnion all summer long. In fact, dissolved oxygen levels are actually higher in the upper hypolimnion than at the water surface. The colder hypolimnion water is able to hold more oxygen than the warmer epilimnion (surface) waters.



June 8, 2013



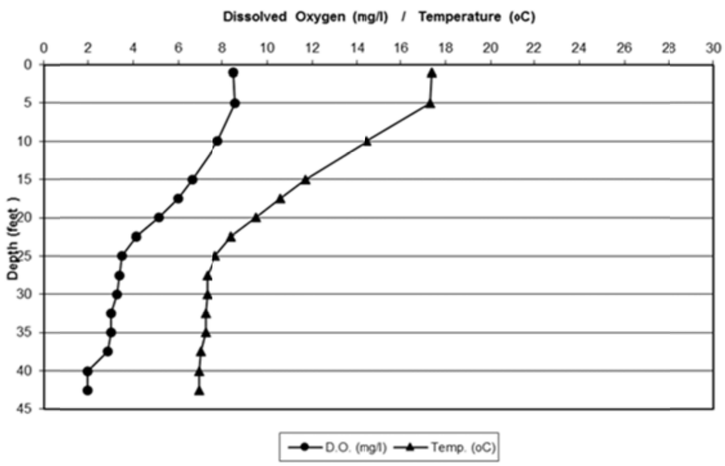
July 20, 2013



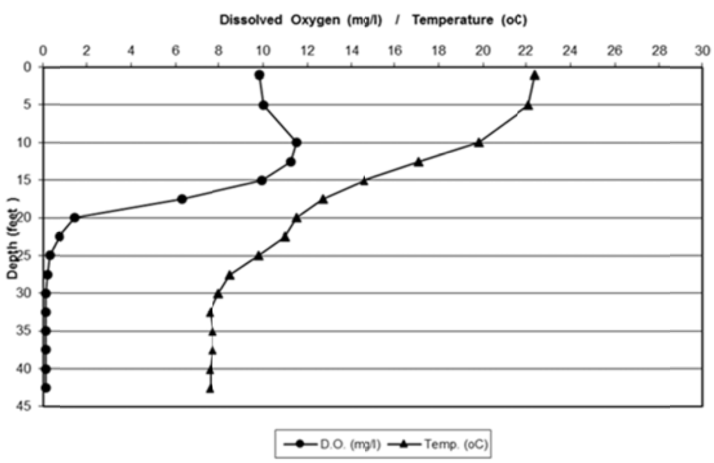
August 31, 2013

Mesotrophic Lake with a Medium Volume Hypolimnion

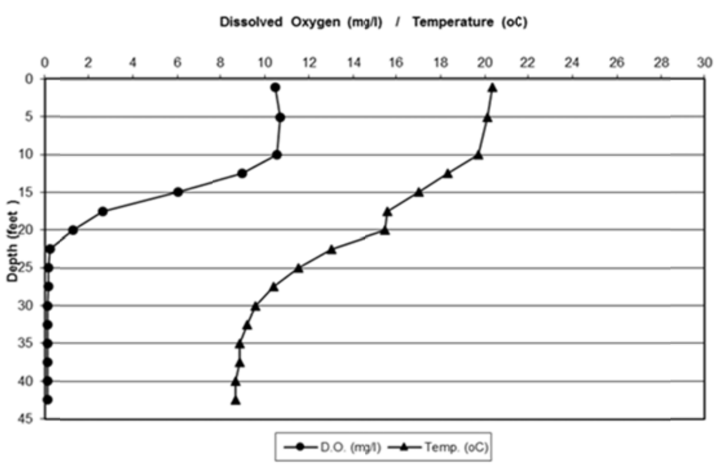
Stony Lake in Oceana County is a mesotrophic lake with a medium volume hypolimnion. As a mesotrophic lake it produces moderate amounts of organic material that must be decomposed. Its hypolimnion has a limited oxygen supply that is gradually depleted by the decomposition of the organic material, which falls into the hypolimnion during the summer. Dissolved oxygen levels remain in the hypolimnion through the early summer, but by mid-July oxygen is gone in the deepest waters, and the hypolimnion does not regain oxygen until fall turn-over.



May 26, 2013



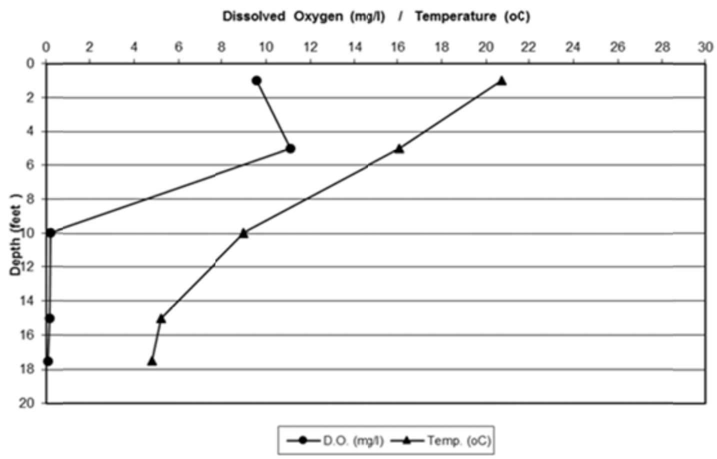
July 4, 2013



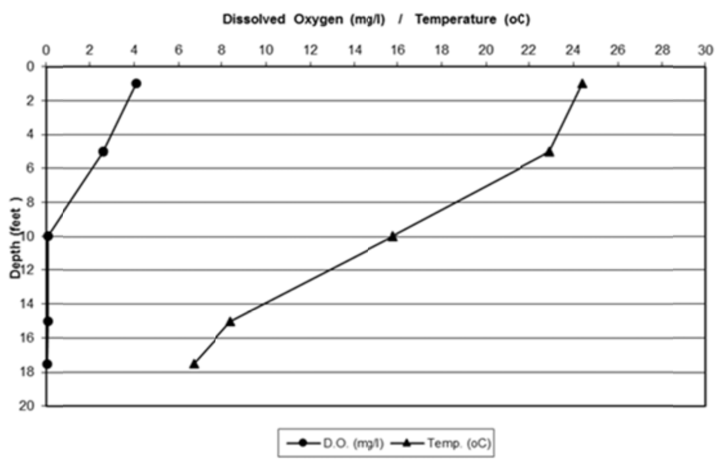
September 14, 2013

Eutrophic Lake with a Small Volume Hypolimnion

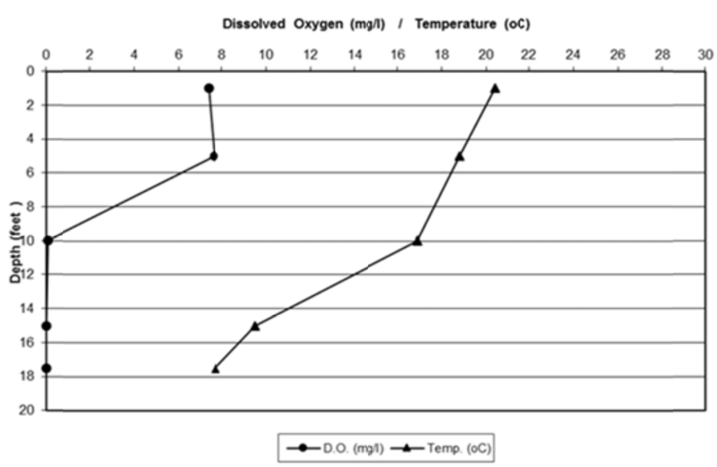
First Sister Lake in Washtenaw County is a borderline eutrophic/hypereutrophic lake with a small volume hypolimnion. As a productive lake it produces abundant amounts of organic material that must be decomposed. Its hypolimnion has a moderate oxygen supply that is rapidly depleted by the decomposition of the organic material, which falls into the hypolimnion during the summer. Dissolved oxygen levels in the hypolimnion often drop to zero even before summer starts. With no oxygen re-supply from the upper waters and atmosphere, the hypolimnion is devoid of oxygen through the whole summer until fall turn-over. It is possible that oxygen levels even at the surface can become very low, and this lake has a high chance of experiencing fish kills.



May 16, 2013



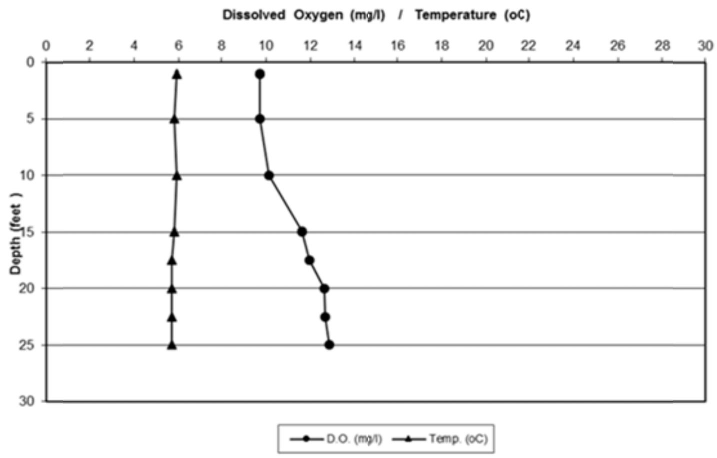
August 8, 2013



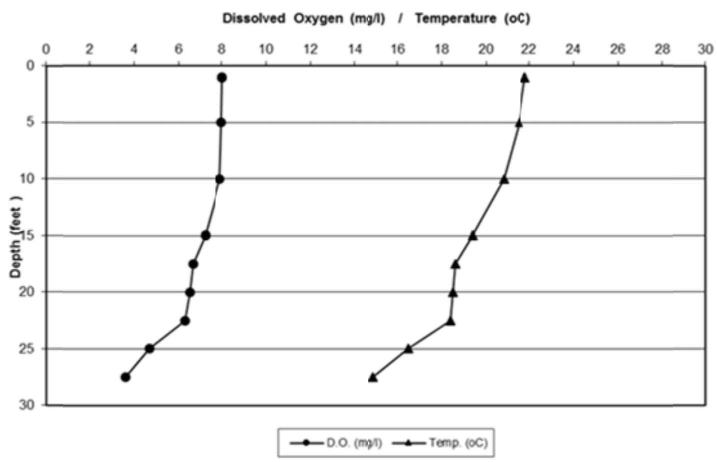
September 21, 2013

Shallow Mesotrophic Lake that Does Not Maintain Summer Stratification

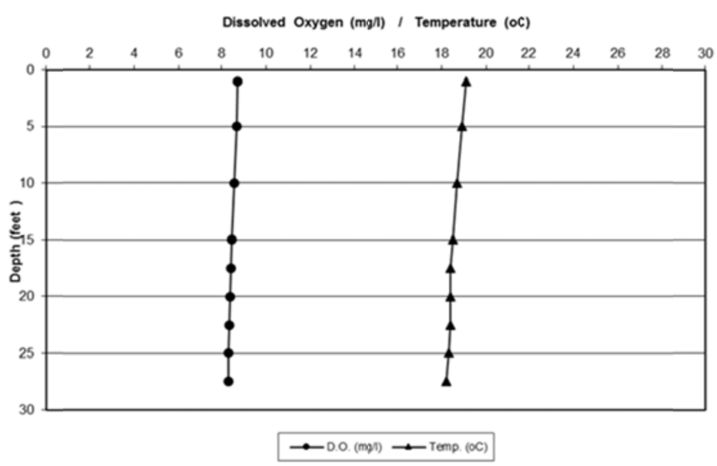
Independence Lake in Marquette County is a shallow mesotrophic lake basin with insufficient depth to maintain stratification all summer. Because the lake is shallow, summer storms can drive wave energy into the deepest parts of the lake breaking up any stratification present and re-supplying the deep water with oxygen.



May 13, 2013



July 3, 2013

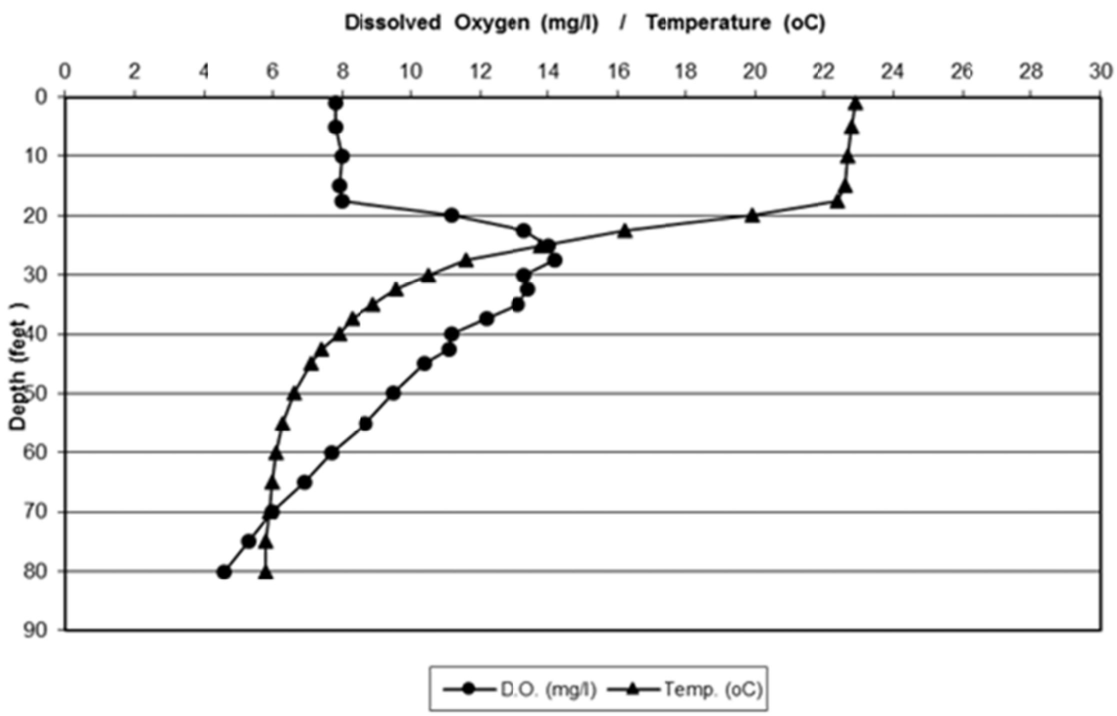


August 14, 2013

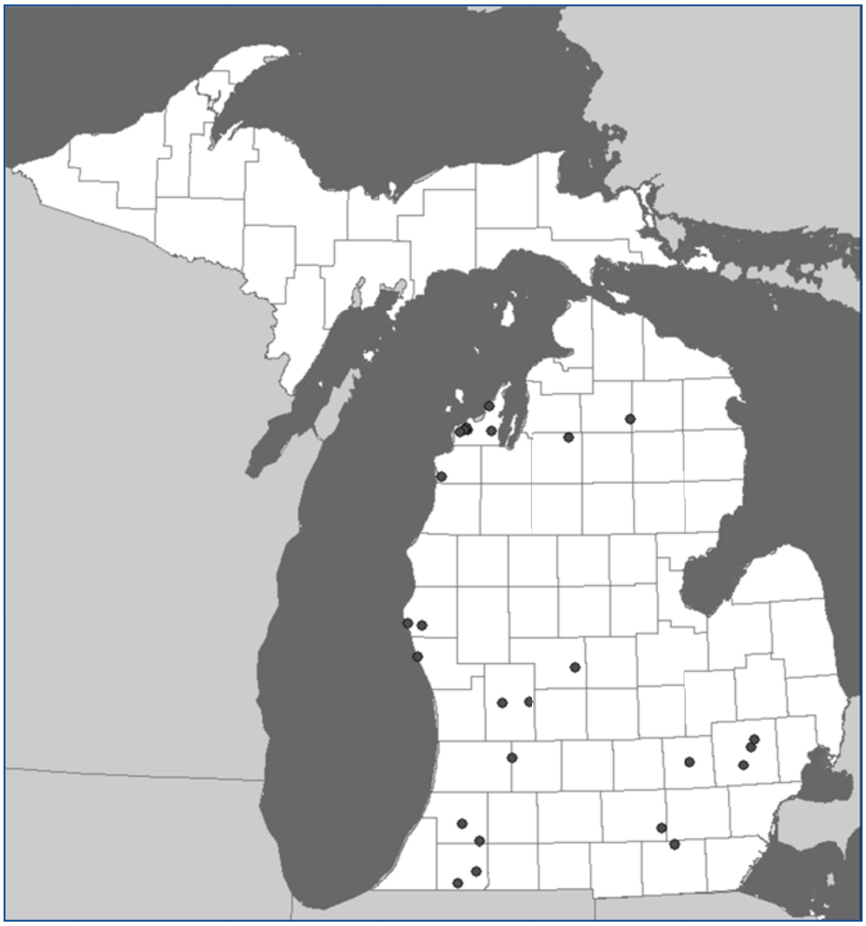
Lake with Dissolved Oxygen Spike in the Thermocline

Lake Angelus in Oakland County is an oligotrophic lake with a medium volume hypolimnion. It is not unusual to see dissolved oxygen levels spike in the area of the thermocline (the depth where the water temperature declines rapidly). The thermocline can be an area of high biological productivity and algal oxygen production can cause these spikes. It is not unusual to see the oxygen reach supersaturated levels, either, as seen below.

July 30, 2013



Appendix 5
2013 Cooperative Lakes Monitoring Program
Exotic Aquatic Plant Watch



Map above shows the distribution of the 26 lakes enrolled in Exotic Aquatic Plant Watch in the 2013 CLMP Program.

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APPENDIX 5

2013 COOPERATIVE LAKES MONITORING PROGRAM

EXOTIC AQUATIC PLANT WATCH RESULTS

Lake	County	Site ID Number	Species Found[1]
Angelus	Oakland	631227	*
Birch	Cass	140187	*
Brooks	Leelanau	450222	None
Cedar	Van Buren	800241	*
Cora	VanBuren	800260	Eurasian watermilfoil
Crystal	Montcalm	590105	*
Duck	Muskegon	610778	Eurasian watermilfoil
Eagle	Cass	140057	Eurasian watermilfoil
Earl	Livingston	470554	*
Emerald	Kent	410709	Curly-leaf pondweed
Fisher (Big)	Leelanau	450224	None
Glen (Big)	Leelanau	450049	None
Glen (Little)	Leelanau	450050	None
Herring, Upper	Benzie	100247	None
Leelanau (North)	Leelanau	450236	*
Leelanau (South)	Leelanau	450235	None
Long (Little)	Barry/Kalamazoo	080279	None
Murray	Kent	410268	Eurasian watermilfoil, Curly-leaf pondweed
Stony	Oceana	640049	Eurasian watermilfoil, Curly-leaf pondweed
Sweezey	Jackson	380470	None
Tahoe	Oceana	640332	Eurasian watermilfoil, Curly-leaf pondweed
Twin (Big)	Kalkaska	400024	None
Straits (Upper)	Oakland	631172	*
White	Oakland	630684	Starry stonewort

* No survey results reported

[1]For species location information, including maps, see the MiCorps Data Exchange at www.micorps.net.