MI/DEQ/WRD-12/014

Cooperative Lakes Monitoring Program

Michigan's Citizen Volunteer Partnership for Lakes

"MI Lakes - Ours to Protect"

ANNUAL SUMMARY REPORT

2011

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

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

There are no known errors to report.

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

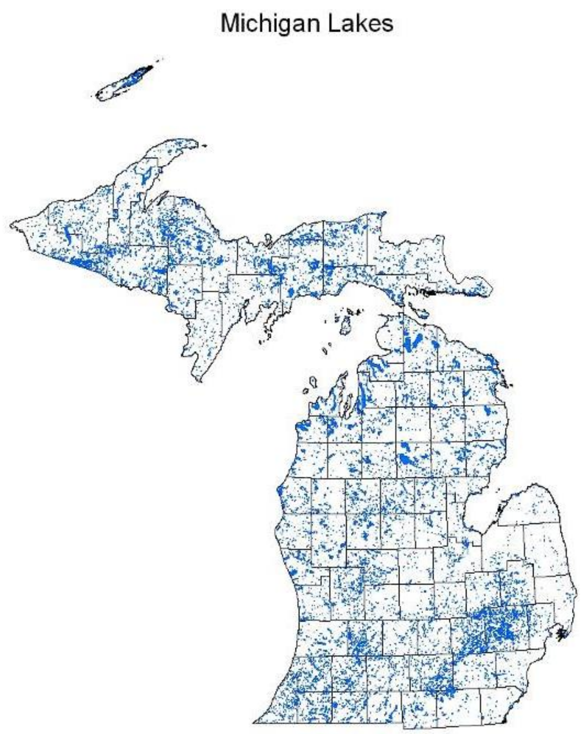
Michigan's unique geographical location provides its citizens with a wealth of freshwater resources including over 11,000 inland lakes. In addition to being valuable ecological resources, lakes provide aesthetic and recreational value for the people of Michigan and neighboring states. An ideal Michigan 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

Michigan's abundant water resources...



Source: Michigan Department of Natural Resources

...include over 11,000 inland lakes.

(MLSA), the Great Lakes Commission and the Huron River Watershed Council 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 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 monitoring program for lakes 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

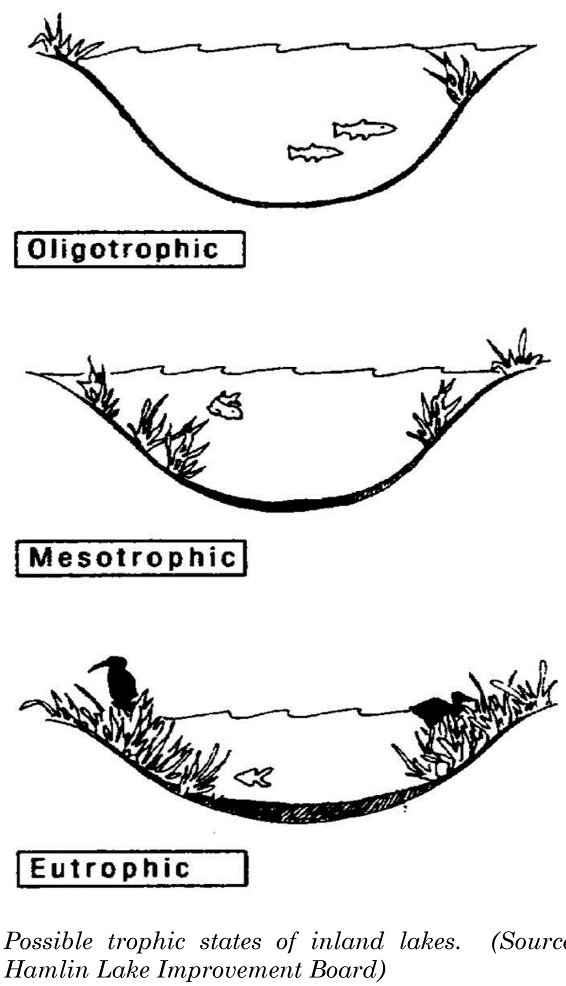
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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)

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.

CLMP Volunteer Nancy Beckwith demonstrates the use of a Secchi disk, a simple tool for measuring water transparency. Diminished water transparency is a possible indicator of eutrophication. (MiCorps photo by Jo Latimore)

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.

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 (TSI)

The general lake classification scheme described on page four 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. 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.

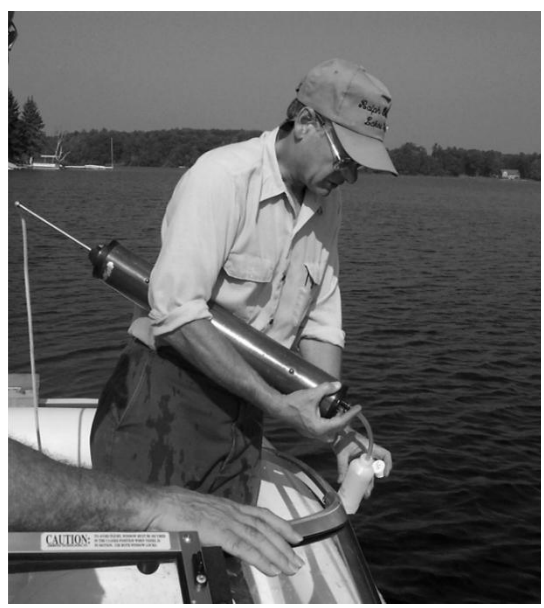
Carlson's TSI Equations

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

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

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

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



Ralph Bednarz (Michigan DEQ, now retired) joins CLMP volunteers for side-by-side lake sampling, part of the quality assurance program for CLMP data (MiCorps photo by Jo Latimore).

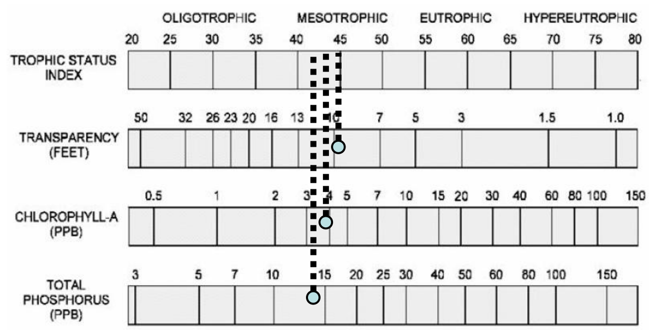
Example of how to use the chart below:

A volunteer from Horsehead Lake, Mecosta County, measured Secchi disk transparency, chlorophyll *a*, and summer total phosphorus. After receiving the results, the volunteer plots each of the parameters on the graph below. The volunteer uses the mean value of the Secchi disk data, the median value of the chlorophyll *a* data, and the summer phosphorus value, all available in the CLMP Annual Report.

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

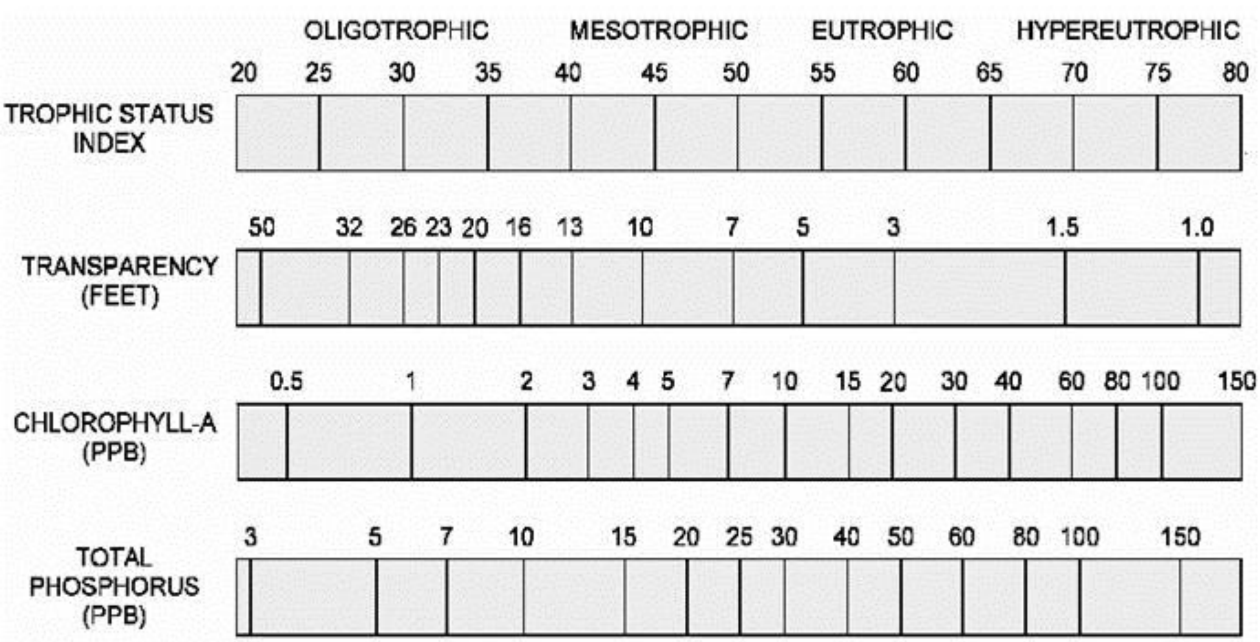
By drawing a straight line up from each of the points, the volunteer learns that the different TSI parameters for Horsehead Lake fall between 40 and 45, which places Horsehead Lake in the middle of the mesotrophic range. The lines from the different parameters do not exactly match up because of natural variability in the data.

CARLSON'S TROPHIC STATE INDEX



Source: Minnesota Pollution Control Agency

CARLSON'S TROPHIC STATE INDEX



Source: Minnesota Pollution Control Agency. Michigan values differ slightly.

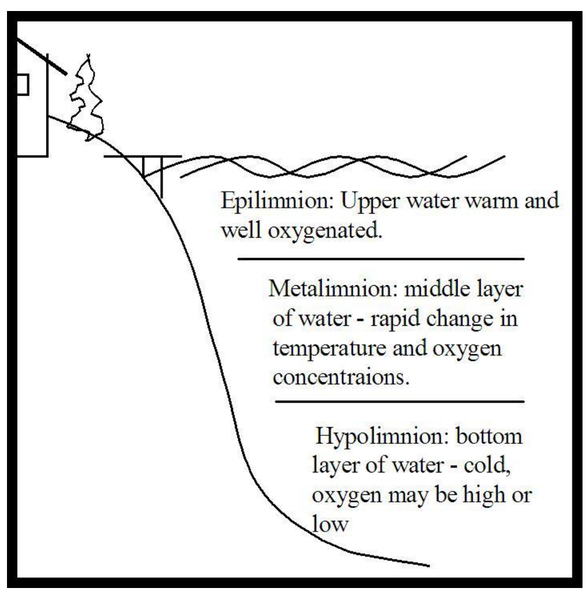
OTHER MEASURES OF LAKE PRODUCTIVITY

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.



This figure shows how lakes over 25 feet deep are divided into three layers during the summer.

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. 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 now 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). Additionally, 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

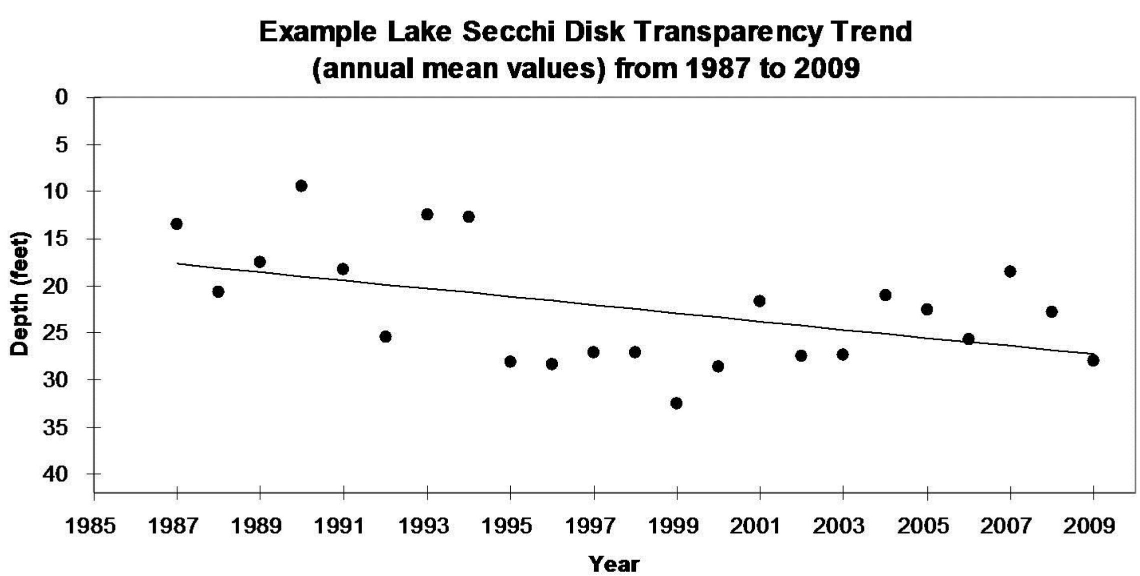
2011 is included in Appendix 1. The number of measurements, or readings, made between mid-May and mid-September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. For those lakes with eight or more evenly spaced readings over this 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 graphical relationship (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 2011, Secchi disk transparency data were reported for 198 lakes (219



basins). Approximately 3047 transparency measurements were reported, ranging from 1.0 to 57.0 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 12.2 feet and the median value was 11.0 feet. The Carlson TSI_{SD} values ranged from 27 to 66 for these lakes with a mean value of 42. A Carlson TSI value of 42 is generally indicative of a mesotrophic lake (see page 7).

Secchi disk transparency measurements were reported for 198 of the 221 enrolled lakes for a participation rate of 90%.

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 2011 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 12% 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 2011, samples for total phosphorus measurements were collected on 194 lakes/basins. The spring overturn total phosphorus results ranged from <5 to 113 µg/l with a mean (average) of 14.2 µg/l and a median value of 9 µg/l. The late summer total phosphorus results ranged from <5 to 74 µg/l with 12.7 µg/l as the mean and 10 µg/l as the median. The Carlson TSI_{TP} values ranged from <27 to 66 for these lakes with a mean value of 38. A Carlson TSI value of 38 is generally indicative of a very good quality mesotrophic lake (see page 7).

For the spring overturn sampling, 146 total phosphorus samples were turned in from 170 enrolled lakes, for an 86% participation rate. For late summer sampling, 187 samples were received from 204 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 2011 volunteers collected a minimum of four samples on 107 lakes (111 basins).

Results from the chlorophyll monitoring for 2011 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 (see page 7) and the median summer chlorophyll values. Results from the replicate and side-by-side sampling are also provided. Side-by-side and replicate samples were collected and analyzed for about 15 percent of the lakes.

A total of 570 chlorophyll samples were collected and processed in 2011. The chlorophyll *a* levels ranged from <1 to 37 µg/l over the five-month sampling period. The overall mean (average) was 3.6 µg/l and the median was 2.3 µg/l. The Carlson TSI_{CHL} values ranged from <31 to 60 with a mean value of 40. A Carlson TSI value of 40 is generally indicative of a very good quality mesotrophic lake (see page 7).

During 2011, a total of 125 lakes (128 basins) registered for chlorophyll sampling. A total of 120 lakes participated minimally by turning in at least one sample, for a minimum participation rate of 96%. A total of 107 lakes turned in at least four samples for a complete participation rate of 86%. Nine samples were turned in, but not processed due to quality control issues for a 2% rejection rate.

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 95D or 550A) 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.

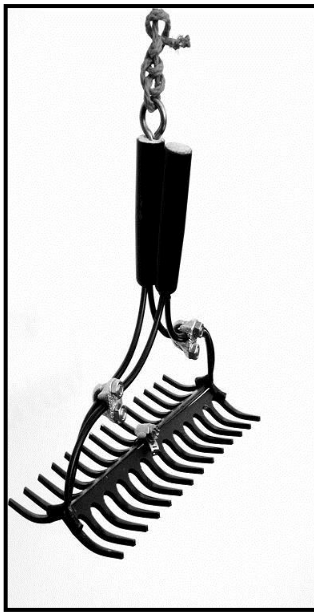
During 2011, CLMP participants in the dissolved oxygen/temperature project sampled 41 lakes (43 basins). A total of 306 dissolved oxygen/temperature profiles (nearly 5000 measurements) were recorded. The lakes involved in the project are identified in Appendix 4. The results of the sampling are highly 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 2011 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: an oligotrophic lake with a very large volume hypolimnion, a mesotrophic lake with a moderate volume hypolimnion, a meso/eutrophic lake with a small volume hypolimnion, a mesotrophic lake which 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 a mesotrophic 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

To complete the volunteer's aquatic plant map and data sheets, sampling transects are identified on each lake. Along each transect, plant samples are collected 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 data from all the transects are calculated to create the plant distribution map and data sheet. A complete description of sampling procedures is provided in Wandell and Wolfson (2007).

During 2003, an evaluation of the aquatic plant monitoring project was made and presented in the CLMP 2003 Report, Appendix 5. The results of this study of volunteer aquatic plant survey methods suggested that:



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.

Citizen volunteers are capable of conducting good qualitative aquatic plant surveys, if properly trained and provided limited professional assistance, and

Volunteer survey methods compare reasonably well with DEQ methods to qualify aquatic plant species, densities and distributions in a lake.

The results warranted continuing aquatic plant monitoring as a component of the CLMP.

During 2011, CLMP volunteers in the aquatic plant project sampled two lakes: Duck Lake in Muskegon County and Sweezey Lake in Jackson County.

In 2011, Duck Lake had a TSI value of 43 for Total Phosphorus, suggesting that the lake is mesotrophic. Volunteers on Duck Lake mapped a diverse aquatic plant community including at least 19 species, of which the most abundant were wild celery, coontail, muskgrass, and sago pondweed. The invasive plants Eurasian water milfoil and curly-leaf pondweed were both present, but in low abundance. Introduction of milfoil weevils in 2006-07 to combat Eurasian water milfoil appears to have been effective.

Sweezey Lake had a TSI value of 43 for Secchi Disk transparency, 34 for total phosphorus, and 36 for chlorophyll. These values indicate a very high quality mesotrophic lake. Communities of rooted plants were diverse but usually not dense around the lake, with at least 14 different species found. A variety of pondweeds, white water lily, and wild celery were the most frequently collected. The somewhat invasive curly-leaf pondweed was sparsely present at only one site.

Exotic Aquatic Plant Watch

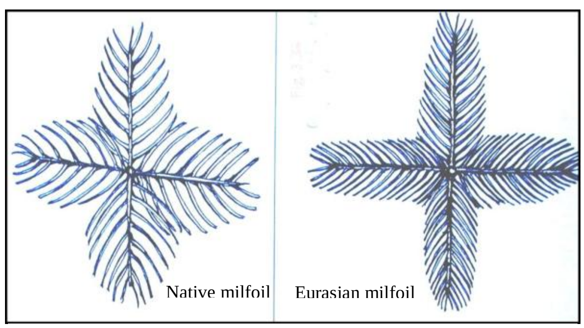
Beginning in 2007, the CLMP sponsored a pilot monitoring project to identify and map exotic aquatic plants in Michigan lakes, with the intent to add the Exotic Aquatic Plant Watch as a permanent component of the CLMP.

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 three exotic aquatic plants of concern in Michigan: curly-leaf pondweed, Eurasian milfoil, and Hydrilla. Using a GPS unit, the participants survey their lake and map the location of any exotic plant beds with the GPS unit.

The Exotic Aquatic Plant Watch project became a standard component of the CLMP in 2011, as a result of steadily increasing enrollment and the high-quality data being generated by volunteers.

In 2011, 26 lakes enrolled in the Exotic Aquatic Plant Watch, and ten submitted reports, for a participation rate of 38%. Participants and example results are presented in Appendix 5.



Stem cross sections at a leaf node of a typical native milfoil (left) and invasive Eurasian milfoil (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 access and use of data collected in the CLMP. One hundred thirty-six data users responded to the survey in 2011. A summary of the results is below.

26% - Lake associations, CLMP volunteers
15% - Academia (students & professors from a variety of institutions, including Michigan State University, University of Maryland, and New Lothrop Area Public Schools)
14% - State government (Michigan DNR, DEQ)
4% - Business (environmental consulting firms, realtors)
26% - Interested individuals
11% - Non-governmental organizations (e.g., Clinton River Watershed Council, Sierra Club, Southeast Michigan Land Conservancy)
4% - Other governmental agencies (e.g., federal, townships, conservation districts)

CLMP Data in Research: Predicting Lake Trophic State Using Satellite Imagery

Inland lake monitoring in Michigan is conducted both by CLMP volunteers and by professionals in the DEQ and the U.S. Geological Survey (USGS). CLMP volunteers sample approximately 250 lakes per year, while DEQ and USGS sampled over 700 lakes between 2001 and 2010. Despite these efforts, it is still impossible to physically collect measurements for Michigan's 11,000 lakes.

Understanding the trophic state of lakes across Michigan's landscape – even those that have not been physically sampled – is important for understanding of the quality of Michigan's lakes as a whole, and for identifying changes or trends occurring over time.

Recently, the USGS undertook a research project to predict the trophic state of unsampled inland lakes by analyzing imagery (pictures) taken by satellites overhead. A computer model was developed to quite accurately predict the trophic state of unsampled lakes, by comparing images of unsampled lakes to images of lakes for which sampling data exists (Fuller et al. 2011).

CLMP volunteers provided much of the field data used in this study, cooperating by intentionally collecting their Secchi Disk transparency measurements on days when the satellite was overhead.

The complete report, as well as a link to the USGS web site where you can try the computer model out for yourself, is available on the MiCorps website: www.micorps.net/pubs.html.

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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A PROFILE OF HOW
A COMMUNITY HAS USED CLMP DATA TO PROTECT THEIR LAKE

Submitted by Paul J. Sniadecki, President and Water Quality Chairperson, Eagle Lake Improvement Association, Inc.

Our **Eagle Lake** (one of eight such "eagles" in Michigan) is located in southern Cass County, in the extreme southwest part of lower Michigan. The surface area of the main body of the lake is 379 acres. There are seven channels which were created before an Anti-Funneling/Anti-Keyholing ordinance was enacted, and the channels add another 20+ acres to our surface area.

Eagle is a shallow lake, with 64% of the lake at a depth of less than 10 feet, and only 2% of the lake with depth of 30-35 feet. Our lake has no inlet, but is entirely spring fed. The 18 springs provide year-round active flows to the point that our lake basin water volume turns over in about 1.3 years. Our Eagle Lake was the first water body in Michigan to be infested with zebra mussels (1990-1991), and that infestation helps the water to be very clear from October through mid-June.

The Eagle Lake Improvement Association, Inc. (ELIA) was formed in 1961 to protect, promote, and preserve the quality of "lake life". ELIA recently celebrated 50 years of service to approximately 316 property owners with water access to Eagle Lake. ELIA first participated in the CLMP in the mid-1970s and 80s. The only parameter collected back then was Secchi Disk transparency. We recently used these historical data, preserved in the online MiCorps database, to assess water quality changes following the arrival of zebra mussels (1990) and sewer system installation (2001).

Subsequently, facing significant lake shore development challenges, ELIA resumed participation in the CLMP in 2007 with Secchi and Total Phosphorus. In 2009, we advanced to performing the full battery of tests available through CLMP. This includes Exotic Aquatic Plant Watch, which involves identifying and mapping infestations of aquatic invasive plants throughout our lake.

We have an ongoing concern about our invasion of Eurasian Water Milfoil (EWM), and the Exotic Plant Watch mapping helps us keep a lookout for the spread of EWM. Our lake is also only 60 miles away from Lake Manitou in Indiana, which was shut down due to an infestation of the dreaded HYDRILLA invasive plant. We believe our annual Exotic Aquatic Plant Watch effort ensures that we detect any invasions as soon as possible. We have eight property owners participate each year and have a grand time during our "day on the water" with special casting rakes and GPS equipment.

We have also been able to use our CLMP data to:

- Help achieve passage of a Special Assessment District for control of aquatic plants in 2012
- Influence the creation of a "Water Front" Overlay Zoning District in the newly revised Ontwa Township Master Plan for 2011-2016
- Influence Decisions reached by the Zoning Board of Appeals for variances that requested over-size structures in the lake watershed.
- Educate our members about the health of Eagle Lake at our Annual Membership Meetings.
- Share the data on our lake Web Site – www.eaglelakemichigan.org.

Another tangible benefit of our participation in CLMP and MLSA has been the development of some very enthusiastic and helpful volunteers involved with caring for the water quality of Eagle Lake. I would like to sincerely thank them for their time and effort and look forward to 2012 and beyond.

For more information on Eagle Lake stewardship efforts, contact Paul J. Sniadecki at psniadecki@yahoo.com.

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 Anne Sturm of the Great Lakes Commission who maintained the MiCorps Data Exchange.

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.

2011 CLMP Volunteer Lake Monitors

In 2011, nearly 400 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
Bob Alvey
Russ Anton
Barbara Armstrong
Richard Bachelor
Dan Bailey
William Bainton
John Bajema
Rick Bakka
David Ball
Susan Barnes
Neil Barr
Nancy Beckwith*
Julie Bennett
Bonnie Blackledge
Diane Blanchard
Emery Blanksma
Dick Blumenstein
Mike Bodenbach
Larry Bogart
Arthur Bombrys
David Boprie
Mike Bosela
John Bosker
Michael Boss
Susan Boss
Woody Boudeman
Bob Boyd
Mark Bradburn
Dennis Bradley
Hope Bradley
Jim Bradley
Leonard Brockhahn
Dick Brown
Wm. Scott Brown
Wayne Bryant
Carim Calkins
Keith Carman
Paul Carmichael
Sandra Carolan
Sally Casey
Gary Chisholm
Karen Christensen
Julie Christiansen
Christopher Chupp
Justus Chupp
Rodney Chupp
Dave Clark
Steve Clouse
Gregory Cole
Jim Collins
Craig Cotterman
Gerald Cox
Keith Crompton
David Crowe
Paul Curell
Dennis Curtice
Wes Daining
Paul Dalpra
Courtney Damkroger
Stacy Daniels
Linda Daniels
Fred Daris
Emma Darling
Fred Darling
Linda Davis
Harry Dawson
Paul Demerritt
Mike Devarenne
John DiGiovanni
Wayne Disegna
Dave Dohring
Arnold Domanus Jr.
Kevin Doyle
Duane Drake
Terry Dugan*
Andra DuPont
Janet Durbin
Wes Durbin
Allen Dyer
Cherly Dyer
Woody Ely
Daniel Evert
Paul Fallon
Donald Ferguson
Christine Fiedler
William Finzel
Lorie Fitzgerald
Daniel Fleck
Chris Floyd
Bob Forche
David Foster
Dale French
William Fronk
Roger Gaede
Mike Gallagher
Greg Garrett
Ted Gatto
Laurence Gavin
Susanne Gay
William Gay
Douglas Gembis
Gerald Gerou
Charles Gill
Ken Gill
James Gilliom
Joe Goossens
Andrea Grix
Stan Grove
Connie Hales
Glenn Hales
Michael Hales
Cary Hamann
George Hanley
Doug Hansen
Larry Harker
Chuck Hartman
Stevie Hartman
John Hartsig
John Hause
Bonnie Hay
Jim Hay
Rita Heady
Ronald Heady
Joan Hecht
Wayne Held
Ron Henning
Ron Herron
Jim Hibbard
Nanette Hibler
Ed Highfield
Virginia Himich
Arthur Hoadley
Lynn Hoepfinger*
John Hoffman
Emmett Holmes
Karen Holmes
Roger Hopkins
Susan Houseman
Ruth Hubbard
Sheryl Hugger
Gerald Hughes
Ron Hughes
Sharon Hurlbert
Bob Hutchings
Harris John Iler
Joanne Iler
Bill Ingle
Bonnie Isaacs
Lisa Izant
Laura Jacobson-Pentces
Dorothy Jamison
Virginia Jamison
Connie Jayne
Jeff Jayne
Marlo Jayne
Thomas Jenkins
Fred Jensen
Frederick Jensen
Dan Johnson
Gary Johnson
Joel Johnson
Bonnie Kanitz
William Kantor
Claudia Kerbawy
Martha Kern-Boprie
Bill Kestermeier
Emil Kezerle
Wayne Kiefer
Netty Kiekover
Calvin Killen
Bruce King
Marvin Kingsley
Phil Kinney
Ray Klomes
John Kolleth
Jim Kollar*
Gerry Kraft
John Kreag
Ronald Kreiger
Sheri Kurtyak
Brian Kusch
Tom Lange

Mary Lantz
Monica Larsen
Mitchell Le Claire
Lori Leugers
Bruce Lichliter
John Lindahl
Ernest (Mike) Litch*
Sarah Litch*
Mark Little
Gary Logston
Matthew Long
Doris Loomans
Lonnie Loveland
Steve Lucas
John Lund
Robert MacKenzie
Joe Maguire
Lois Maharg
Anne Mammel
Becca Mammel
Tim Mammel
Tom Mammel
John Mater
David Maxson
Eldonna May
Mac McCauley
Rex McCormick
Rosemary McCormick
Bob McDonald
Char McDonnell
Gary McDonnell
Jim McDowell
Alan McGowen
Jim McGurrin
Marilyn McLain
Alan McNamara
Robert McPertlin
Rick Meeks*
Rich Meeuwenberg
Gary Melvin
Joan Melvin
Aaron Miller
David Miller
Isaac Miller
Jim Miller
John Miller
Josef Miller
Scott Miller
Seth Miller
Stephen Miller
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Bill Miner
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Terry Monson
Thomas Moore
Chauncey Moran
Darlene Morey
Dick Morey*
Brian Morgan
Mike Moschetta
Pam Moseley
Thomas Murphy
Tim Murphy
Michael Mutschler
Rob Namowicz
Reno Nave
Kenneth Nelson
Patricia Nelson
Wayne Nesbitt
Don Nichols
Greg Nichols
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Gerry Powley
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Jeff Schlueter
Katie Schlueter
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Al Schwennessen
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Rich Sicrakowski
Carol Simon
Mike Single
Marie Smith
Michael Smith
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Darrol Spurgeon
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Linda Stafford*
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Gary Stelow
Kathleen Stelow
John Stivers
Julie Stivers
Daniel Stock
Beth Storm
Roger Storm
Chris Streeter
Jan Stuhlmann
Wayne Swallow
Gertrude Temple
Robert Temple
Greg Thebo
Thomas Thering
Bill Tidey
Tomas Tisue
William Tomlin
Robert Turnquist
Joan Uhley
James Van Herweg
Robert VanDenBrouck
Barbara VanDenEeden
Stuart Vedder
Robert Vermette
Al Vichunas
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Rhonda Wassom
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Milt Weeks
Milton Weeks
Kathie Weinmann
Judd Wellard
Mary Ann Wellard
Ken Wendt
Thomas Wheeler
Susan White
Ellen Whitehead
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John Wilks
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Chuck Wolverton
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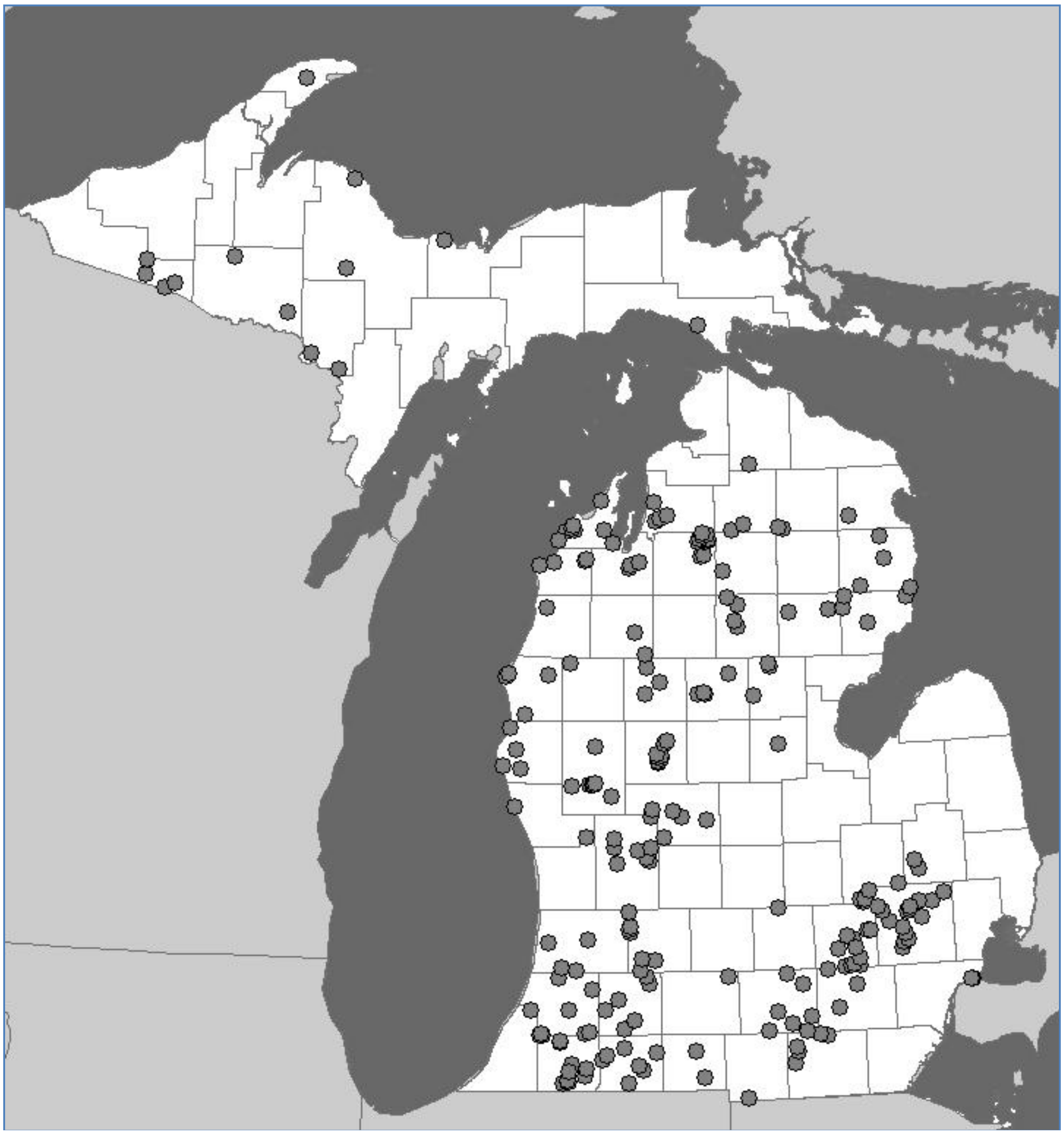
Cheryl Zuelke

Statewide Distribution of CLMP Lakes Sampled During 2011



APPENDICES

Appendix 1

2011 Secchi Disk Transparency Results

Appendix 2

2011 Total Phosphorus Results

Appendix 3

2011 Chlorophyll Results

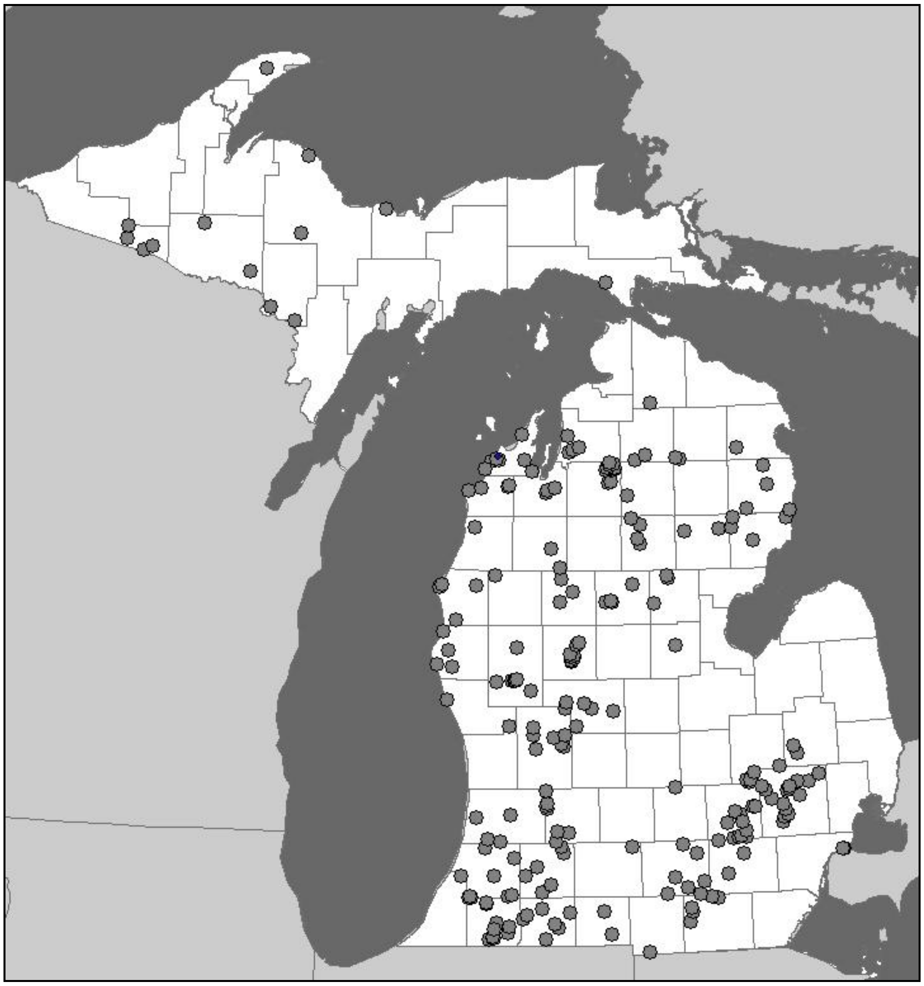
Appendix 4

2011 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2011 Exotic Aquatic Plant Watch Participating Lakes and Example Results

Appendix 1
2011 Cooperative Lakes Monitoring Program
Secchi Disk Transparency



Map above shows the distribution of the 221 lakes enrolled in Secchi Disk Transparency in the 2011 CLMP Program.

Recorded Secchi Disk Transparency Values:

Mean (average): 12.2 feet
Minimum: 1.0 feet
Maximum: 57.0 feet [Higgins Lake (Roscommon Co.)]

APPENDIX 1
2011 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)
Hubbard (1)	Alcona	010101	10	9.0	15.0	12.8	13.0	1.7	40
Hubbard (2)	Alcona	010102	10	12.0	16.0	13.4	13.0	1.5	40
Hubbard (3)	Alcona	010103	11	13.0	16.0	14.2	14.0	0.9	39
Hubbard (4)	Alcona	010104	10	12.5	17.0	14.2	14.0	1.4	39
Hubbard (5)	Alcona	010105	13	12.0	15.0	13.8	14.0	1.1	39
Hubbard (6)	Alcona	010106	14	12.0	16.0	13.7	13.3	1.1	39
Hubbard (7)	Alcona	010107	12	9.5	16.0	13.5	14.0	1.9	40
Maynard	Alcona	010126	12	6.0	8.0	7.3	7.5	0.5	49
Vaughn	Alcona	010049	8	13.0	18.0	16.0	16.0	2.0	37
Cedar	Alcona/Iosco	010017	14	6.0	>10.5	>8	>8	1.6	<47
Cedar	Alcona/Iosco	350231	12	6.0	12.5	8.9	8.3	2.0	46
Deer	Alger	020127	13	6.5	8.5	7.6	7.5	0.7	48
Eagle	Allegan	030259	17	9.5	22.5	15.2	14.5	3.8	38
Hutchins	Allegan	030203	17	8.0	22.5	11.3	10.0	3.7	42
Osterhout	Allegan	030263	18	6.0	12.0	8.2	8.0	2.0	47
Scott (Upper)	Allegan	030698	*						
Wetmore	Allegan	030664	10	3.5	6.0	5.1	5.5	1.0	54
Beaver	Alpena	040097	*						
Bellaire	Antrim	050052	17	7.5	18.5	12.1	10.5	3.9	41
Clam	Antrim	050101	15	11.0	22.0	16.1	15.0	3.2	37
Torch (North)	Antrim	050055	*						
Torch (South)	Antrim	050240	14	19.0	42.0	25.7	23.0	6.9	30
Barlow	Barry	080176	14	6.5	22.0	11.2	10.8	4.4	42
Cobb	Barry	080259	18	8.0	25.0	15.5	13.5	6.4	38
Crooked (Upper)	Barry	080071	14	8.0	17.0	10.7	10.0	2.4	43
Duncan	Barry	080096	17	2.0	14.0	4.1	3.5	2.9	57
Fair	Barry	080260	11	9.5	15.5	11.4	11.0	1.8	42
Payne	Barry	080103	8	5.0	15.0	8.8	8.0	3.9	46
Long (Little)	Barry/Kalamazoo	080279	11	6.5	19.0	13.1	13.5	4.0	40

APPENDIX 1
2011 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)
Ann	Benzie	100082	17	8.0	31.5	17.5	16.0	6.7	36
Crystal	Benzie	100066	*						
Platte (Big)	Benzie	100086	17	11.0	20.0	14.1	14.0	2.9	39
Sanford	Benzie	100208	18	14.0	27.0	18.3	17.0	4.0	35
Paw Paw (Little)	Berrien	110765	16	5.0	8.0	6.1	6.0	0.9	51
Coldwater	Branch	120077	*						
Randall	Branch	120078	*						
Duck	Calhoun	130172	11	7.0	18.0	11.1	10.0	3.7	42
Birch (Fallon)	Cass	140187	18	11.0	27.0	16.2	16.0	3.5	37
Birch (Temple)	Cass	140061	18	11.0	26.0	16.7	16.0	3.3	37
Christiana	Cass	140055	15	5.5	15.0	10.0	10.0	2.1	44
Diamond	Cass	140039	19	5.0	19.0	11.1	11.0	4.2	42
Eagle	Cass	140057	16	4.0	20.0	9.4	6.8	6.2	45
Juno	Cass	140058	15	6.0	12.5	8.2	8.0	1.8	47
Magician	Cass	140065	15	5.0	23.5	13.3	10.0	6.7	40
Painter	Cass	140108	15	4.5	13.0	7.1	6.0	2.4	49
Puterbaugh	Cass	140170	17	4.5	22.5	12.6	13.0	5.5	41
Shavehead	Cass	140071	*						
Twin (Big-North)	Cass	140165	*						
Twin (Little-South)	Cass	140166	*						
Wildwood	Cheboygan	160230	15	8.0	11.0	8.7	8.5	0.8	46
Arnold	Clare	180107	18	10.0	20.0	13.1	12.5	3.1	40
George	Clare	180056	*						
Shingle	Clare	180108	*						
Windover	Clare	180069	14	11.0	21.0	15.2	16.0	3.1	38
Margrethe	Crawford	200157	11	14.0	24.0	18.0	18.0	3.1	35
Antoine	Dickinson	220028	7	16.0	19.0				
Louise	Dickinson	220124	15	10.0	16.0	12.1	12.0	1.8	41
Byram	Genesee	250364	18	7.0	16.0	11.4	12.0	3.1	42

APPENDIX 1
2011 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)
Fenton	Genesee	250241	11	17.0	21.5	19.1	19.0	1.3	35
Marl	Genesee	250480	*						
Shinanguag	Genesee	250519	8	6.0	14.0	10.1	10.5	2.9	44
Silver	Genesee	250481	18	8.0	23.0	14.7	13.3	5.3	38
Hunter	Gladwin	260119	15	6.0	12.5	9.0	9.0	1.4	45
Lancelot (1)	Gladwin	260104	10	5.0	10.0	7.2	7.5	1.4	49
Lancelot (2)	Gladwin	260112	10	5.5	9.5	7.0	7.0	1.3	49
Lancelot (3)	Gladwin	260113	11	5.5	11.0	7.2	7.5	1.6	49
Lancer	Gladwin	260116	14	8.0	13.5	12.0	12.0	1.3	41
Bass	Gogebic	270206	17	3.5	7.0	4.6	4.5	0.9	55
Beatons	Gogebic	270105	10	15.0	18.5	16.9	16.8	1.2	36
Dinner	Gogebic	270126	18	8.0	18.0	12.5	11.0	3.9	41
Long	Gogebic	270179	13	10.0	17.0	13.8	14.0	2.7	39
Moon	Gogebic	270120	16	14.5	26.5	17.8	17.0	3.1	36
Arbutus 1	Grand Traverse	280396	15	7.0	>12.0	>10.1	>11.0	1.8	<44
Arbutus 2	Grand Traverse	280109	15	12.0	26.0	17.3	16.0	4.4	36
Arbutus 3	Grand Traverse	280108	14	13.0	22.0	16.3	15.0	2.7	37
Arbutus 4	Grand Traverse	280397	15	12.0	23.0	16.6	16.0	3.2	37
Arbutus 5	Grand Traverse	280398	15	12.0	18.0	14.9	15.0	1.7	38
Island	Grand Traverse	280164	13	12.5	32.0	19.4	15.0	7.0	34
Spider	Grand Traverse	280395	18	11.5	22.0	15.4	14.8	3.4	38
Diane	Hillsdale	300173	18	2.0	2.5	2.1	2.0	0.2	66
Chain	Iosco	350146	14	10.0	14.0	11.6	12.0	1.2	42
Island (Little)	Iosco	350245	11	6.0	7.5	6.6	6.5	0.5	50
Long	Iosco	350076	18	11.5	17.0	12.8	12.5	1.3	40
Van Etten	Iosco	350201	18	3.0	13.0	7.0	6.8	2.3	49
Mary	Iron	360071	18	16.5	27.0	21.2	21.5	2.7	33
Perch	Iron	360046	10	4.0	6.5	5.4	5.5	0.9	53
Gorr	Isabella	370141	5	3.0	6.0				

APPENDIX 1
2011 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)
Brown	Jackson	380477	19	5.0	14.0	8.7	8.0	3.1	46
Clark	Jackson	380173	10	8.0	19.0	14.2	14.8	4.1	39
Clear	Jackson	380453	17	7.0	15.5	10.9	11.0	2.6	43
Farwell	Jackson	380454	13	10.0	>20.0	>15.8	>16.0	2.6	<37
Pleasant	Jackson	380244	16	6.0	10.0	7.6	7.0	1.6	48
Portage (Big)	Jackson	380245	*						
Sweezey	Jackson	380470	15	7.0	14.0	10.4	10.0	2.1	43
Vineyard	Jackson	380263	17	4.5	18.0	10.0	9.5	4.1	44
Barton	Kalamazoo	390215	12	5.5	12.5	8.4	8.0	2.5	46
Crooked	Kalamazoo	390599	17	11.0	28.0	15.8	14.0	4.6	37
Gull	Kalamazoo	390210	13	7.0	23.0	13.2	11.0	5.9	40
Indian	Kalamazoo	390305	16	5.0	22.0	12.3	11.8	5.2	41
Sherman	Kalamazoo	390382	9	11.5	20.0	13.4	12.5	2.6	40
Woods	Kalamazoo	390542	18	3.0	14.5	7.8	7.0	2.8	48
Bear	Kalkaska	400026	17	21.0	42.0	32.6	31.0	5.7	27
Blue	Kalkaska	400016	17	17.0	>27.0	>22.4	>23.0	3.2	<32
Blue (Big)	Kalkaska	400017	*						
Blue (North)	Kalkaska	400131	11	18.0	26.0	22.0	22.0	3.1	33
Crooked	Kalkaska	400133	*						
Cub	Kalkaska	400031	19	12.0	24.0	19.5	20.0	3.2	34
Eagle	Kalkaska	400130	10	8.5	20.0	14.0	13.3	4.1	39
Indian	Kalkaska	400015	*						
Papoose	Kalkaska	400134	3	29.0	29.0				
Pickerel	Kalkaska	400035	19	20.0	27.0	23.4	23.0	1.9	32
Squaw	Kalkaska	400135	8	9.0	12.0	10.3	10.3	1.0	44
Starvation	Kalkaska	400030	17	14.0	26.0	19.5	20.0	3.9	34
Twin (Big)	Kalkaska	400012	16	16.0	23.0	19.9	21.0	2.1	34
Twin (Little)	Kalkaska	400013	19	8.0	25.0	16.6	17.0	5.2	37
Bostwick	Kent	410322	10	4.5	>8.0	>6.8	>7	1.3	<50

APPENDIX 1
2011 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)
Crooked (Big)	Kent	410714	9	7.5	10.5	8.6	8.5	0.9	46
Emerald	Kent	410709	18	6.0	19.0	10.7	10.0	4.0	43
Freska	Kent	410702	9	7.0	9.5	7.8	7.0	1.1	47
High	Kent	410703	*						
Maston	Kent	410764	18	11.0	31.0	17.4	17.3	5.0	36
Murray	Kent	410268	13	5.0	12.0	7.2	7.0	1.9	49
Muskellunge	Kent	410765	18	8.5	18.5	12.5	11.5	2.4	41
Pine Island (Big)	Kent	410437	17	5.0	10.0	7.5	7.0	1.8	48
Gratiot	Keweenaw	420030	11	14.0	19.0	15.7	15.0	1.6	37
Harper	Lake	430030	16	11.5	24.0	17.6	17.3	3.7	36
Metamora	Lapeer	440234	16	7.0	10.0	8.0	8.0	0.8	47
Nepessing	Lapeer	440220	9	8.0	15.0	10.8	10.0	2.9	43
Brooks	Leelanau	450222	16	6.0	15.0	11.0	12.0	2.6	43
Cedar	Leelanau	450234	17	7.5	25.0	14.4	14.5	4.8	39
Fisher (Big)	Leelanau	450224	*						
Glen (Big)	Leelanau	450049	15	16.0	27.0	19.7	19.0	3.6	34
Glen (Little)	Leelanau	450050	15	7.5	11.0	8.6	8.5	1.0	46
Leelanau (North)	Leelanau	450236	14	10.0	27.5	18.2	17.8	5.8	35
Leelanau (South)	Leelanau	450235	15	8.0	23.0	15.4	16.0	4.8	38
South Bar	Leelanau	450237	15	6.0	9.0	7.6	7.5	0.8	48
Devils	Lenawee	460179	8	8.5	>16	>11.2	>10.5	2.7	<42
Evans	Lenawee	460309	14	9.5	23.0	12.9	10.5	4.5	40
Posey	Lenawee	460423	7	4.0	6.0				
Round	Lenawee	460304	9	8.5	19.0	11.4	11.0	3.6	42
Sand	Lenawee	460264	8	12.0	22.0	14.6	13.5	3.2	38
Baetcke	Livingston	470649	9	8.5	11.5	9.9	9.5	1.2	44
Baetcke	Livingston	470650	9	7.5	15.5	10.0	9.5	2.3	44
Baetcke	Livingston	470651	9	8.5	11.5	9.9	10.0	0.9	44
Chemung	Livingston	470597	5	10.5	16.0				

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2011 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)
Earl	Livingston	470554	17	2.0	6.0	3.7	3.0	1.2	58
Gallagher	Livingston	470210	8	7.5	15.5	12.1	13.3	3.7	41
Green Oak (Silver)	Livingston	470589	13	9.0	25.0	14.4	10.0	6.6	39
Hamburg	Livingston	470568	18	11.0	22.0	16.0	15.5	3.4	37
Ore	Livingston	470100	15	5.0	17.0	10.8	11.0	4.5	43
Round	Livingston	470546	10	7.0	13.0	9.8	9.8	2.0	44
Strawberry	Livingston	470213	17	7.5	12.5	9.0	8.5	1.3	45
Triangle	Livingston	470591	16	6.5	>11	>8.7	>8.5	1.2	<46
Portage	Livingston/Wash.	810248	10	6.5	11.0	8.9	8.8	1.5	46
Brevoort	Mackinac	490036	11	7.0	11.0	8.7	9.0	1.3	46
Bear	Manistee	510257	17	7.5	14.0	10.1	10.0	2.0	44
Chabenau	Marquette	520508	18	11.5	>22.5	>16.6	>14.8	4.5	<37
Independence	Marquette	520149	9	6.0	12.0	8.7	7.5	2.3	46
Chancellor (Blue)	Mason	530287	13	16.0	27.5	22.0	23.5	3.6	33
Hamlin (Lower)	Mason	530073	19	6.0	17.5	11.3	11.5	3.1	42
Hamlin (Upper)	Mason	530074	18	3.5	12.0	7.5	8.0	2.6	48
Oxbow (North)	Mason	530289	10	12.0	17.0	14.0	14.0	1.5	39
Blue	Mecosta	540092	15	11.0	22.0	15.1	15.0	3.3	38
Canadian (Main)	Mecosta	540172	15	8.0	13.0	9.6	9.0	1.6	44
Canadian (West)	Mecosta	540171	15	8.5	12.0	10.7	11.0	1.1	43
Horsehead	Mecosta	540085	17	8.0	17.5	11.1	10.5	2.8	42
Mecosta	Mecosta	540057	14	9.0	12.0	10.5	10.5	1.1	43
Pretty	Mecosta	540079	16	9.0	15.5	12.1	11.8	2.2	41
Round	Mecosta	540073	14	5.0	11.0	8.1	8.0	1.6	47
School Section	Mecosta	540080	*						
Sanford	Midland	560169	12	3.5	8.0	5.6	5.5	1.5	52
Baldwin	Montcalm	590171	10	8.0	11.5	9.3	9.0	0.9	45
Clifford	Montcalm	590142	18	8.0	12.0	9.5	9.5	1.3	45
Crystal	Montcalm	590105	15	6.5	17.5	10.0	9.0	3.8	44

APPENDIX 1
2011 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)
Derby	Montcalm	590144	8	12.0	27.0	18.5	18.5	5.8		35
Muskellunge	Montcalm	590154	16	6.0	14.0	9.3	8.5	3.0		45
Twin (East)	Montmorency	600013	16	7.0	13.0	10.0	10.0	1.9		44
Twin (West)	Montmorency	600014	9	8.0	14.5	11.4	12.0	2.1		42
Duck	Muskegon	610778	6	6.0	14.0					
Bills (Reinhardt)	Newaygo	620062	15	7.0	21.0	13.5	14.0	4.3		40
Bills (Waits)	Newaygo	620311	12	6.0	20.5	12.8	11.3	4.8		40
Emerald	Newaygo	620167	17	9.0	15.0	12.1	12.0	2.0		41
Fremont	Newaygo	620029	16	6.5	20.0	11.5	11.5	3.5		42
Kimball	Newaygo	620107	13	3.5	8.0	5.6	5.0	1.4		52
Pickerel	Newaygo	620066	13	6.5	24.0	10.0	9.0	4.5		44
Sylvan	Newaygo	620168	17	9.0	29.0	18.9	18.0	5.4		35
Webinguaw	Newaygo	620283	10	3.0	4.5	3.5	3.5	0.5		59
Angelus	Oakland	631227	15	11.5	19.5	14.8	14.0	2.9		38
Buckhorn (North)	Oakland	631113	*							
Cranberry	Oakland	631228	17	5.5	>15.5	>10.1	>10.5	3.1		<44
Deer	Oakland	631128	17	5.0	16.0	10.2	9.0	4.1		44
Hawk	Oakland	631115	15	7.0	>13.0	>9.8	>10.0	2.0		<44
Lakeville	Oakland	630670	14	6.0	18.0	12.4	13.5	4.0		41
Long	Oakland	631118	16	11.0	20.0	13.3	12.0	2.5		40
Middle Straits	Oakland	630732	10	7.0	13.0	9.4	9.0	1.9		45
Orion	Oakland	630554	16	10.0	13.0	11.7	12.0	0.8		42
Ottawa	Oakland	631220	3	10.0	16.0					
Oxbow	Oakland	630666	*							
Parke	Oakland	631119	15	10.5	19.5	14.2	14.0	2.6		39
Taylor	Oakland	631114	18	15.0	23.5	18.5	18.5	2.1		35
Walled	Oakland	630550	16	6.5	24.0	12.6	10.8	5.8		41
White	Oakland	630684	11	5.0	15.0	10.5	13.0	3.9		43
Crystal	Oceana	640062	17	4.0	14.5	9.7	10.0	2.6		44

APPENDIX 1
2011 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

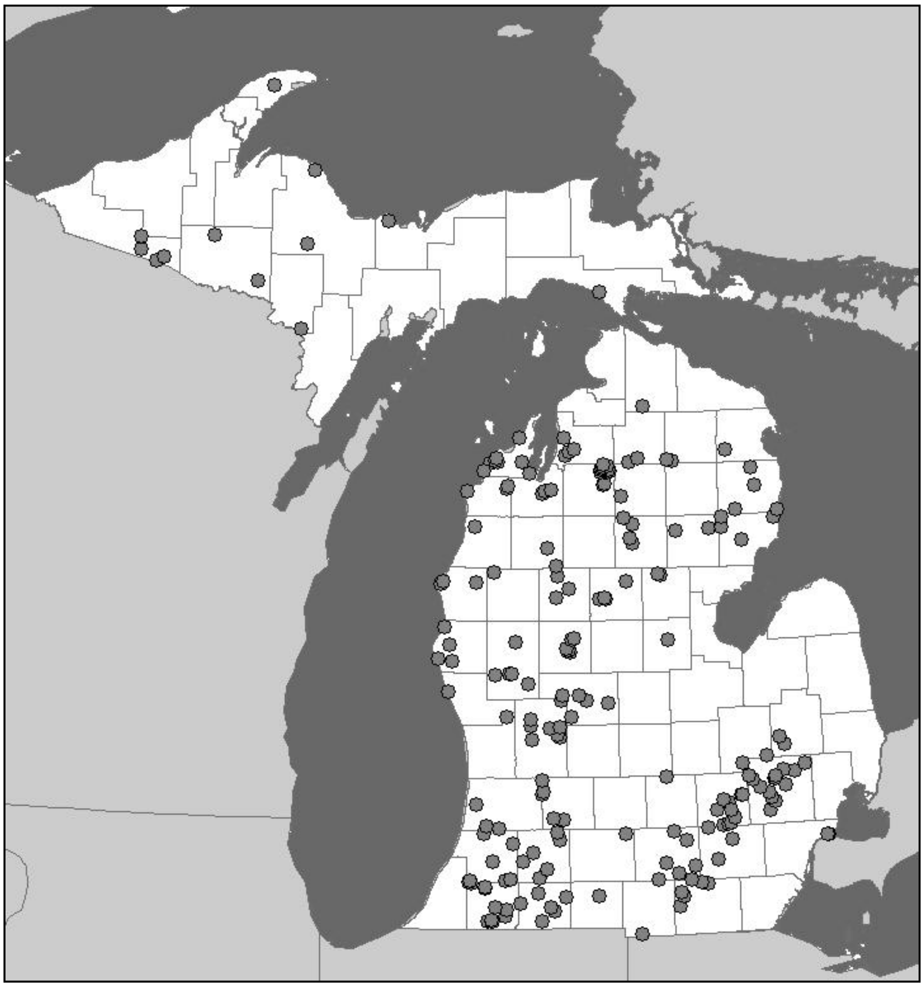
Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Pentwater	Oceana	640089	7	5.5	10.5				
Stony	Oceana	640049	19	4.0	14.0	7.3	6.8	2.7	48
Tahoe	Oceana	640332	14	6.0	12.5	9.1	8.8	2.3	45
Clear	Ogemaw	650042	11	13.0	15.5	14.3	14.5	0.8	39
Rifle	Ogemaw	650022	11	17.0	24.0	20.1	20.0	1.8	34
Center (Kettunen)	Osceola	670238	17	14.0	20.5	16.6	17.0	2.1	37
Hicks	Osceola	670062	13	2.0	6.0	4.2	4.5	1.4	56
Indian	Osceola	670227	17	16.0	24.0	17.9	17.0	2.3	36
Bradford (Big)	Otsego	690036	12	16.0	29.0	22.2	22.5	4.0	32
Bradford (Little)	Otsego	690151	9	13.0	15.0	14.1	14.0	0.8	39
Viking	Otsego	690136	16	3.5	7.5	5.8	6.0	1.1	52
Crockery	Ottawa	700422	*						
Higgins (N. Basin)	Roscommon	720026	7	31.0	57.0				
Higgins (S. Basin)	Roscommon	720028	7	31.0	47.0				
Houghton (1)	Roscommon	720163	16	5.0	9.0	6.8	6.5	1.3	50
Houghton (2)	Roscommon	720164	16	5.5	10.0	7.4	7.5	1.5	48
Corey	St. Joseph	750142	16	8.5	28.0	12.7	11.0	5.1	40
Fishers	St. Joseph	750139	18	6.0	31.5	12.9	8.3	8.5	40
Klinger	St. Joseph	750136	17	6.5	24.0	11.1	9.5	5.1	42
Perrin	St. Joseph	750314	15	10.0	13.5	11.9	12.0	1.0	41
Pleasant	St. Joseph	750144	9	7.5	9.5	8.7	9.0	0.7	46
Sturgeon	St. Joseph	750333	2	2.5	3.5				
Templene	St. Joseph	750322	10	10.5	12.5	11.6	11.5	0.7	42
Cedar	Van Buren	800241	11	9.0	18.0	12.7	13.5	2.7	40
Cora	Van Buren	800260	19	15.0	35.0	20.6	17.5	6.2	33
Crooked (Big)	Van Buren	800483	18	10.5	17.0	13.0	13.0	1.5	40
Crooked (Little)	Van Buren	800535	16	10.5	19.0	14.3	14.0	1.8	39
Fish	Van Buren	800461	17	6.0	9.0	7.5	7.5	1.2	48
Gravel	Van Buren	800271	9	8.0	21.0	12.4	12.0	4.1	41

APPENDIX 1
2011 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)
Silver	Van Buren	800534	18	7.0	12.0	9.0	9.0	1.3	45
Bridgeway	Washtenaw	810576	18	1.0	8.0	4.7	4.5	2.0	55
Bruin	Washtenaw	810575	18	6.5	23.5	13.0	11.0	4.8	40
Greenook	Washtenaw	810577	19	2.0	7.0	4.8	4.5	1.5	55
Pleasant (Central Basin)	Washtenaw	810265	18	8.0	10.0	8.9	8.8	0.8	46
Pleasant (East Basin)	Washtenaw	810264	18	8.0	10.0	8.9	8.8	0.8	46
Pleasant (Northwest Basin)	Washtenaw	810266	18	8.0	10.0	9.0	9.0	0.8	45
Blue Heron Lagoon	Wayne	821552	*						
Muskoday	Wayne	821553	*						
Pleasant	Wexford	830183	17	5.0	10.5	7.9	8.0	1.4	47
Stone Ledge	Wexford	830186	16	7.0	10.5	9.5	9.5	0.9	45

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

Appendix 2
2011 Cooperative Lakes Monitoring Program
Total Phosphorus Results



Map above shows the distribution of the 194 lakes/basins enrolled in late summer Total Phosphorus monitoring in the 2011 CLMP Program.

Recorded Total Phosphorus Values:

Spring Mean:	14.2 µg/l	Summer Mean:	12.7 µg/l
Minimum:	<5 µg/l	Minimum:	<5 µg/l
Maximum:	113 µg/l	Maximum:	74 µg/l
(Gorr Lake, Isabella Co.)		(Upper Hamlin Lake, Mason Co.)	

2011 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol	Spring Overturn Rep.	Spring Overturn DEQ	Spring Overturn Rep.	Late Summer Vol	Late Summer Rep	Late Summer DEQ	Late Summer Rep	Carlson TSITP (summer TP)
Hubbard	Alcona	010106	*				<5 T				<27
Maynard	Alcona	010126	14				*				
Vaughn	Alcona	010049	32				11				39
Cedar	Alcona/Iosco	010017	6				<5 T				<27
Deer	Alger	020127	10				5				27
Eagle	Allegan	030259	10	12			9	12			36
Hutchins	Allegan	030203	9				26				51
Osterhout	Allegan	030263	12				13				41
Upper Scott	Allegan	030698	*				*				
Beaver	Alpena	040097	*				*				
Bellaire	Antrim	050052	8				≤ 3 W				<27
Clam	Antrim	050101	11		<5 T	<5 T	5				27
Torch (N. Basin)	Antrim	050055	10	11	≤ 3 W	≤ 3 W	≤ 3 W				<27
Torch (S. Basin)	Antrim	050240	7		≤ 3 W	≤ 3 W	≤ 3 W				<27
Barlow	Barry	080176	5				≤ 3 W				<27
Cobb	Barry	080259	≤ 3 W				≤ 3 W				<27
Crooked, Upper	Barry	080071	14				14				42
Duncan	Barry	080096	77				29 c		31		53
Fair	Barry	080260	7				9				36
Long (Little)	Barry/Kalamazoo	080279					<5 T				<27
Ann	Benzie	100082	8				8				34
Crystal	Benzie	100066	<5 T	<5 T			≤ 3 W				<27
Sanford	Benzie	100208					8	7			34
Randall	Branch	120078					*				
Duck	Calhoun	130172					9				36
Birch (Fallon)	Cass	140187	8				18				46
Birch (Temple)	Cass	140061	<5 T				<5 T	<5 T			<27
Diamond	Cass	140039	<5 T				21				48

2011 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)
Eagle	Cass	140057	≤ 3	W				23					49
Magician	Cass	140065	*					5					27
Shavehead	Cass	140071						*					
Twin (Big Twin)	Cass	140165	9					14		17			42
Twin (Little Twin)	Cass	140166	10					8					34
Christiana	Cass	140055						10					37
Juno	Cass	140058						15					43
Painter	Cass	140108						35					55
Wildwood	Cheboygan	160230	25		25			10			15		37
Arnold	Clare	180107	6					9		7			36
George	Clare	180056	≤ 3	W				10					37
Shingle	Clare	180108	13					10					37
Windover	Clare	180069	*					5					27
Margrethe	Crawford	200157	8					<5	T				<27
Louise	Dickinson	220124	5					12	H	17			40
Fenton	Genesee	250241	*					18					46
Shinangaug	Genesee	250519						32					54
Lancelot	Gladwin	260104		a				12					40
Lancer	Gladwin	260116	8					23					49
Beatons	Gogebic	270105	5					*					
Dinner	Gogebic	270126	15					10					37
Long	Gogebic	270179	≤ 3	W				5					27
Moon	Gogebic	270120	≤ 3	W				≤ 3	W	≤ 3 W			<27
Arbutus	Grand Traverse	280109	<5	T				5					27
Island	Grand Traverse	280164	≤ 3	W,b				≤ 3	W				<27
Spider	Grand Traverse	280395						9	H				36
Diane	Hillsdale	300173	41					65					64
Lansing	Ingham	330137						*					

2011 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)
Chain	Iosco	350146	16				7	6			32
Island (Little)	Iosco	350245					10				37
Long	Iosco	350076	9				7				32
Van Etten	Iosco	350201	31				32				54
Mary	Iron	360071	≤ 3 W				7				32
Perch	Iron	360046	26				27				52
Gorr	Isabella	370141	113				54				62
Brown	Jackson	380477	14				12				40
Clark	Jackson	380173	7	<5 T			6				30
Clear	Jackson	380453					9				36
Farwell	Jackson	380454	5				≤ 3 W				<27
Pleasant	Jackson	380244					<5 T				<27
Portage (Big Portage)	Jackson	380245	9				10				37
Sweezey	Jackson	380470	6				8				34
Vineyard	Jackson	380263	8				6				30
Barton	Kalamazoo	390215	19				11				39
Crooked	Kalamazoo	390599	*				21				48
Gull	Kalamazoo	390210	≤ 3 W				8	6			34
Indian	Kalamazoo	390305	7				17 b				45
Sherman	Kalamazoo	390382	5				9	9			36
Woods	Kalamazoo	390542	47				18				46
Bear	Kalkaska	400026	≤ 3 W				≤ 3 W				<27
Blue (Big Blue)	Kalkaska	400016	≤ 3 W	≤ 3 W			*				
Blue (Big)	Kalkaska	400017					≤ 3 W				<27
Blue, North	Kalkaska	400131	≤ 3 W				≤ 3 W				<27
Crooked, North	Kalkaska	400133	*				14				42
Cub	Kalkaska	400031	≤ 3 W	≤ 3 W			6				30
Eagle	Kalkaska	400130	≤ 3 W				9				36

2011 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	Kalkaska	400015	*					8	H				34
Papoose	Kalkaska	400134	*					*					
Pickerel	Kalkaska	400035	*					≤ 3	W				<27
Squaw	Kalkaska	400135	36					10					37
Starvation	Kalkaska	400030	*					5					27
Twin (Big Twin)	Kalkaska	400012	11					≤ 3	W				<27
Twin, Little	Kalkaska	400013	*					9					36
Big Pine Island	Kent	410437	19					23		20			49
Bostwick	Kent	410322	19					32					54
Crooked (Big)	Kent	410714	9					16					44
Emerald	Kent	410709						11					39
Freska	Kent	410702	22					10					37
High	Kent	410703	9					12					40
Maston	Kent	410764	8					11					39
Murray	Kent	410268	23		24			13					41
Muskellunge	Kent	410765	42					11		13			39
Gratiot	Keweenaw	420030						11	e				39
Harper	Lake	430030	*					≤ 3	W				<27
Metamora	Lapeer	440234						14					42
Nepessing	Lapeer	440220	10					20					47
Brooks	Leelanau	450222	6					8					34
Cedar	Leelanau	450234	≤ 3	W				≤ 3	W				<27
Fisher (Big Fisher)	Leelanau	450224	≤ 3	W				≤ 3	W				<27
Glen (Big Glen)	Leelanau	450049	<5	T				5					27
Glen (Little)	Leelanau	450050	<5	T				6					30
Leelanau (North)	Leelanau	450236	*					≤ 3	H				<27
Leelanau (South)	Leelanau	450235	<5	T				≤ 3	W,e				<27
South Bar	Leelanau	450237	10					12					40

2011 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)
Devils	Lenawee	460179	9					10						37
Evans	Lenawee	460309	*					9						36
Posey	Lenawee	460423	30					14						42
Round	Lenawee	460304	7					18						46
Sand	Lenawee	460264						6						30
Baetcke	Livingston	470646						5	c					27
Chemung	Livingston	470597	37					13		14				41
Earl	Livingston	470554	44					46	c					59
Gallagher	Livingston	470210	14					*						
Greenoak (Silver)	Livingston	470589	6	c				25						51
Ore	Livingston	470100	9					26						51
Round	Livingston	470546	13					17	H	17	H			45
Strawberry	Livingston	470213	11					30	H	29	H			53
Triangle	Livingston	470591	11		10			30						53
Brevoort	Mackinac	490036	6					18						46
Bear	Manistee	510122	6					8						34
Chabenau	Marquette	520508	10		10			10						37
Independence	Marquette	520149	*					*						
Chancellor (Blue)	Mason	530287	8					7						32
Hamlin, Lower	Mason	530073	9					44						59
Hamlin, Upper	Mason	530074	15					74						66
Blue	Mecosta	540092	*					8	f					34
Horsehead	Mecosta	540085	11					13						41
Mecosta	Mecosta	540057	*					7	f					32
Pretty	Mecosta	540079	6					13						41
Round	Mecosta	540073	*					12	f					40
School Section	Mecosta	540080	≤ 3	W				9						36
Sanford	Midland	560169	*					53						61

2011 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)
Baldwin	Montcalm	590171		d					13					41
Clifford	Montcalm	590142	16						13					41
Crystal	Montcalm	590105	9						7					32
Derby	Montcalm	590144	<5	T	<5	T			10					37
Muskellunge	Montcalm	590154	18						19					47
Twin, East	Montmorency	600013	14	c					13					41
Twin, West	Montmorency	600014	11						≤ 3	W				<27
Duck	Muskegon	610778	20						15		16			43
Bills (Waits)	Newaygo	620311	6						7					32
Fremont	Newaygo	620029	51						13					41
Kimball	Newaygo	620107							15					43
Pickerel	Newaygo	620066							13					41
Webinguaw	Newaygo	620283	14						28					52
Angelus	Oakland	631227	8						*					
Buckhorn (North)	Oakland	631113							*					
Cranberry	Oakland	631228							19					47
Deer	Oakland	631128	6		7				6					30
Lakeville	Oakland	630670	15						<5	T				<27
Long	Oakland	631118							11					39
Middle Straits	Oakland	630732	10						5					27
Orion	Oakland	630554	11						8					34
Ottawa	Oakland	631220	*						*					
Oxbow	Oakland	630666							9					36
Parke	Oakland	631119	15						7					32
Taylor	Oakland	631114	40						7					32
Walled	Oakland	630550							14					42
White	Oakland	630684							13					41
Crystal	Oceana	640062	14						15					43

2011 COOPERATIVE LAKES MONITORING PROGRAM
SPRING AND SUMMER TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol	Spring Overturn Rep.	Spring Overturn DEQ	Spring Overturn Rep.	Late Summer Vol	Late Summer Rep	Late Summer DEQ	Late Summer Rep	Carlson TSITP (summer TP)
Pentwater	Oceana	640089	26				31				54
Stony	Oceana	640049	25	7			19				47
Tahoe	Oceana	640332	9				16	14			44
Clear	Ogemaw	650042					6				30
Rifle	Ogemaw	650022	≤ 3 W				≤ 3 W				<27
Center	Osceola	670238	9				6				30
Hicks	Osceola	670062	28				25				51
Indian	Osceola	670227	*				7				32
Viking	Otsego	690136					21				48
Bradford, Big	Otsego/Crawford	690036	*				*				
Crockery	Ottawa	700422	71				8	10			34
Higgins (N. Basin)	Roscommon	720026	<5 T				≤ 3 W				<27
Higgins (S. Basin)	Roscommon	720028	5				≤ 3 W				<27
Houghton (Station 1)	Roscommon	720163	15				13				41
Houghton (Station 2)	Roscommon	720164	16	17			19	17			47
Corey	St. Joseph	750142	<5 T				≤ 3 W,c				<27
Fishers	St. Joseph	750139					7	5			32
Klinger	St. Joseph	750136	≤ 3 W				≤ 3 W	<5 T			<27
Perrin	St. Joseph	750314	8				8				34
Sturgeon	St. Joseph	750333	20								
Templene	St. Joseph	750322	18	19			11	10			39
Cedar	Van Buren	800241	8				5				27
Cora	Van Buren	800260	11				<5 T				<27
Crooked, Big	Van Buren	800483	9				5				27
Crooked, Little	Van Buren	800535	20	18			7				32
Fish	Van Buren	800461	9				35				55
Gravel	Van Buren	800271	7				10				37
Silver	Van Buren	800534	9				10				37

2011 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)
Bruin	Washtenaw	810575					10				37
Greenook	Washtenaw	810577	40	40			19				47
Pleasant	Washtenaw	810264					17				45
Bridgeway	Washtenaw	810576	70				17				45
Portage	Washtenaw/Livingston	810248	20				16				44
Blue Heron Lagoon	Wayne	821552					*				
Muskoday	Wayne	821553					*				
Pleasant	Wexford	830183	5				8				34
Stone Ledge	Wexford	830186	10	12			13				41

* No sample received or received too late to process.

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

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

H Recommended laboratory holding time was exceeded.

a Sample rejected - caps cracked when received.

b Used ink that ran on label

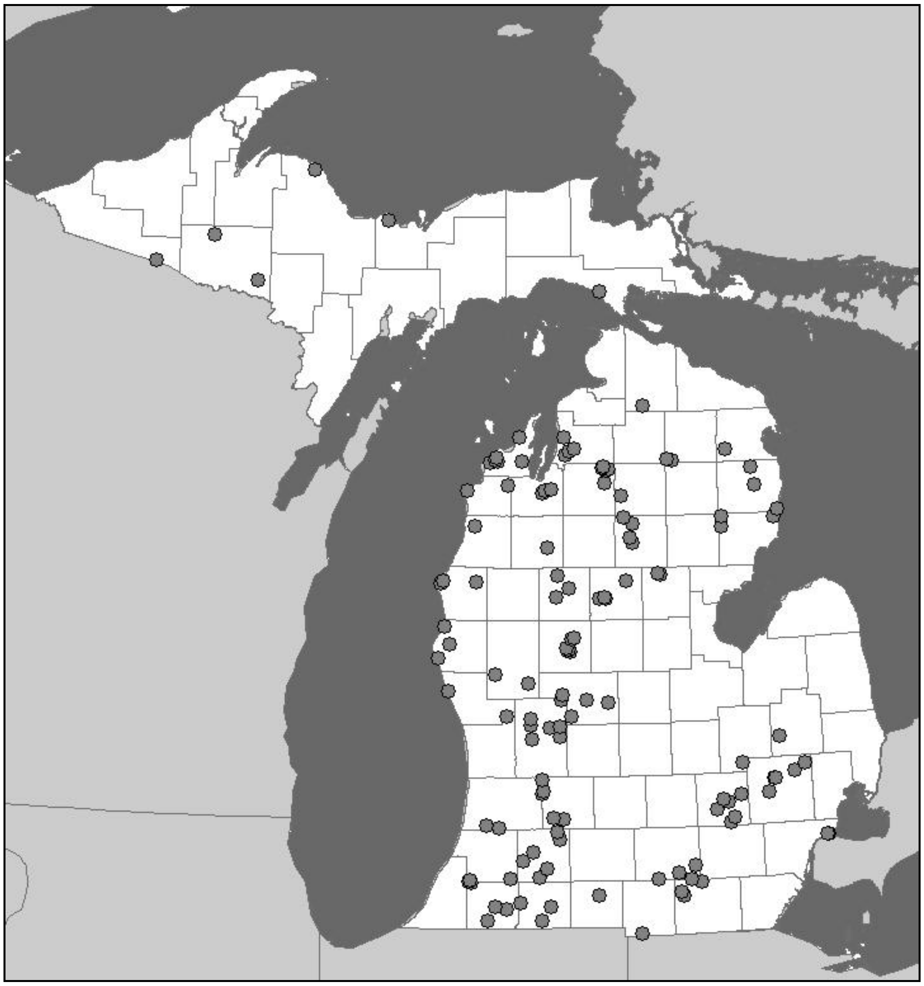
c Sample not collected at proper time - may not be comparable to other data

d Sample rejected - collected from dock, rather than deep basin of lake.

e Sample dates on bottle label and data sheet did not match.

f No replicate sample submitted.

Appendix 3
2011 Cooperative Lakes Monitoring Program
Chlorophyll Results



Map above shows the distribution of the 107 lakes enrolled in Chlorophyll monitoring in the 2011 CLMP Program.

Recorded Chlorophyll Values:

Mean:	3.6 µg/l
Minimum:	<1 µg/l
Maximum:	37.0 µg/l (Crockery Lake, Ottawa Co.)

APPENDIX 3
2011 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}
Cedar	Alcona	010017	1.5	1.6	4.9	2.9	1.9	2.6	1.9	1.4	37
Hubbard	Alcona	010106	1.5	1.8	<1	1.3	1.2	1.3	1.3	0.5	33
Maynard	Alcona	010126	4.9	4	8.9	*	*				
Deer	Alger	020127	2.4	2.7	4.4	2.3	1.8	2.7	2.4	1.0	39
Eagle	Allegan	030259	<1	3	2.5	5.8	6.8	3.7	3.0	2.6	41
Osterhout	Allegan	030263	4.2	3.5a	7.2	4.5	3.1	4.5	4.2	1.6	45
Beaver	Alpena	040097	*	*	*	*	*				
Bellaire	Antrim	050052	1	<1	1.2	2.5	2.3	1.5	1.2	0.9	32
Clam	Antrim	050101	<1	<1	1.4	1.3	1.4	1.0	1.3	0.5	33
Torch (North)	Antrim	050055	*	*	<1	<1	<1				
Torch (South)	Antrim	050240	*	<1	<1	<1	<1	0.5	0.5	0.0	<31
Barlow	Barry	080176	d	2	1.9	1.4	1.5	1.7	1.7	0.3	36
Cobb	Barry	080259	<1	<1	3.3	<1	1.8a	1.3	0.5	1.2	<31
Crooked, Upper	Barry	080071	<1	4.5	5.2	6.2	3.9	4.1	4.5	2.2	45
Duncan	Barry	080096	8.9	19	11	36f	22	19.4	19.0	10.8	59
Vol/Rep							14				
MDEQ							32				
Fair	Barry	080260	3	5.1	5.8	4.8	1.7	4.1	4.8	1.7	46
Ann	Benzie	100082	1.3	2.2	2.3	1.4	1.4	1.7	1.4	0.5	34
Crystal	Benzie	100066	*	*	*	*	<1				
Randall	Branch	120078	*	4.8	9.2	<1b	13b	6.9	7.0	5.4	50
Birch (Fallon)	Cass	140187	2.5	3.1	1.8	1.5	2.2	2.2	2.2	0.6	38
Birch (Temple)	Cass	140061	1.8	3.5	2.2	1.6	2.5	2.3	2.2	0.7	38
Vol/Rep					2.9						
Diamond	Cass	140039	1.6	1.4	<1	<1	<1a	0.9	0.5	0.6	<31
Eagle	Cass	140057	<1	<1	9.9	4	2.7	3.5	2.7	3.9	40

APPENDIX 3
2011 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)								
Magician	Cass	140065	<1	<1	3.2	<1	<1	1.0	0.5	1.2	<31
Wildwood	Cheboygan	160230	*	4.7	4.7	6.1	3.9	4.9	4.7	0.9	46
Arnold	Clare	180107	<1	<1	<1	1.4	1.2	0.8	0.5	0.4	<31
George	Clare	180056	1.9	2.9	3.9	4	3	3.1	3.0	0.9	41
Shingle	Clare	180108	1.8	2.4	2.8	1.7	1.2	2.0	1.8	0.6	36
Windover	Clare	180069	1.3	1.9	4.2	2.1a	1.6	2.2	1.9	1.1	37
Margrethe	Crawford	200157	<1	<1	2.1	1.6	2.2	1.4	1.6	0.8	35
Vol/Rep				<1							
Fenton	Genesee	250241	<1	1.5	1.9	2.2	1.5	1.5	1.5	0.6	35
Lancelot	Gladwin	260104	4.1	*	3.2	4.8	2	3.5	3.7	1.2	43
Lancer	Gladwin	260116	<1	<1	1.4	1.4	3.7	1.5	1.4	1.3	34
MDEQ					1.5						
Moon	Gogebic	270120	2.8	1	2.5	2.9	3.9	2.6	2.8	1.0	41
Arbutus	Grand Traverse	280109	<1	1	1.6	1.7	1.7	1.3	1.6	0.5	35
Island	Grand Traverse	280164	<1	<1	1.3	<1	1.5	0.9	0.5	0.5	<31
Spider	Grand Traverse	280395	1.9	1.3	3.9	2.1	2.3	2.3	2.1	1.0	38
Diane	Hillsdale	300173	22	16	24	c	c				
Chain	Iosco	350146	<1	1.9	5.3	3	2.9	2.7	2.9	1.8	41
Vol/Rep						3.5					
Long	Iosco	350076	4.8	<1	2.3	2.5	2.2	2.5	2.3	1.5	39
Van Etten	Iosco	350201	8.1	2.9	6.6	4	9.8	6.3	6.6	2.8	49
Mary	Iron	360071	<1	<1	3.6	4.3	8.5	3.5	3.6	3.3	43
Vol/Rep				1.1							
Perch	Iron	360046	1.6	2.9	3.4	7.5	4	3.9	3.4	2.2	43
Clark	Jackson	380173	<1	2	1.8	2.3	1.6	1.6	1.8	0.7	36
Vol/Rep			<1								

APPENDIX 3
2011 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)								
Farwell	Jackson	380454	1.3	<1	<1	1.5	1	1.0	1.0	0.5	<31
Sweezey	Jackson	380470	<1	2.1	1.8	3.1	<1	1.6	1.8	1.1	36
Vineyard	Jackson	380263	1.4	1.2a	2.5	2.4a	2.5	2.0	2.4	0.6	39
Barton	Kalamazoo	390215	*	5.6	3.8	3.7	6.5	4.9	4.7	1.4	46
Crooked	Kalamazoo	390599	2.4	1.7	4.9	6.2	6.7	4.4	4.9	2.2	46
Vol/Rep					5.6						
Gull	Kalamazoo	390210	*	1.5	2	1.5	3	2.0	1.8	0.7	36
Indian	Kalamazoo	390305	1.2	3.1	1.3	1.8	<1	1.6	1.3	1.0	33
Sherman	Kalamazoo	390382	2a	5	4.6	3.2	4.3	3.8	4.3	1.2	45
Woods	Kalamazoo	390542	9.6	12	6.3	5.9	8.1	8.4	8.1	2.5	51
Bear	Kalkaska	400026	<1	1.2	1.1	1.4	1.3	1.1	1.2	0.4	32
Blue (Big)	Kalkaska	400017	4.6	2.7	1.7	1.8	1.4	2.4	1.8	1.3	36
Blue (North)	Kalkaska	400131	<1	<1	<1	<1	<1	0.5	0.5	0.0	<31
Eagle	Kalkaska	400130	<1	<1	1	<1	2.5	1.0	0.5	0.9	<31
Indian	Kalkaska	400015	*	*	2.8	1.5	1.2				
Twin (Big)	Kalkaska	400012	3	1.6	1.5	1.6	1.2	1.8	1.6	0.7	35
Bostwick	Kent	410322	3.2b	4.4b	2.6b	4	7.6	4.4	4.0	1.9	44
Emerald	Kent	410709	*	*	*	3.9	<1				
Freska	Kent	410702	3.4	6.9	5	*	6.1	5.4	5.6	1.5	47
High	Kent	410703	*	*	*	4.7	3.6				
Maston	Kent	410764	<1	<1	1.7	1.7	2.2	1.3	1.7	0.8	36
Murray	Kent	410268	5.8	3.2	3.5	<1	1	2.8	3.2	2.1	42
Muskellunge	Kent	410765	4.5	7	11	5.3	5.3	6.6	5.3	2.6	47
Pine Island (Big)	Kent	410437	1.9	7.2	9.5	7.6	7.5	6.7	7.5	2.9	50
Nepessing	Lapeer	440220	5.3	1.3	6.2	5.9	4.1	4.6	5.3	2.0	47
MDEQ				3							

APPENDIX 3
2011 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}
Brooks	Leelanau	450222	16	14	14	2.9	4.6	10.3	14.0	6.1	57
Fisher (Big)	Leelanau	450224	<1	<1	<1	<1	<1	0.5	0.5	0.0	<31
Vol/Rep						<1					
MDEQ						<1					
Glen (Big)	Leelanau	450049	1.4	<1	<1	<1	<1	0.7	0.5	0.4	<31
Glen (Little)	Leelanau	450050	<1	1.5	1.6	1.7	1.5	1.4	1.5	0.5	35
Vol/Rep				1.6							
Leelanau (North)	Leelanau	450236	<1	<1	<1	<1	<1	0.5	0.5	0.0	<31
Leelanau(South)	Leelanau	450235	<1	<1	3	<1	<1	1.0	0.5	1.1	<31
Devils	Lenawee	460179	<1a	<1	<1	b,e	b,d	0.5	0.5	0.0	<31
Evans	Lenawee	460309	<1	<1	3.6	2.4	2.9	2.0	2.4	1.4	39
Vol/Rep					4.1						
Round	Lenawee	460304	1.3b	1.4b	2.2b	b,d	<1b	1.4	1.4	0.7	34
Chemung	Livingston	470597	<1	9	7.1	*	*				
Earl	Livingston	470554	9.5	16	13	30f	7.7	15.2	13.0	8.8	56
Vol/Rep							14				
Ore	Livingston	470100	1.8a	1.7a	2.8	11a	8.6	5.2	2.8	4.3	41
Round	Livingston	470546	<1	<1	6.9	6.6	2.9	3.5	2.9	3.1	41
Strawberry	Livingston	470213	6.5	2.2	7.2	5.7	<1	4.4	5.7	2.9	48
Triangle	Livingston	470591	2	6	3.3	3.8	7.8	4.6	3.8	2.3	44
Brevoort	Mackinaw	490036	2.5	2	2.7	2.8	3	2.6	2.7	0.4	40
Bear	Manistee	510122	1.4	4.8	3.5	3.8	3.5	3.4	3.5	1.2	43
Independence	Marquette	520149	c	c	c	*	*				
Chancellor(Blue)	Mason	530287	*	*	*	*	*				
Hamlin (Lower)	Mason	530073	<1	<1	1.8	5.9	6	2.9	1.8	2.8	36
Hamlin (Upper)	Mason	530074	3.6	1.9	6.2	19	23	10.7	6.2	9.6	49

APPENDIX 3
2011 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}**
Blue	Mecosta	540092	<1	1.3	<1	2.1	1.8	1.2	1.3	0.7	33
Horsehead	Mecosta	540085	5	4	3.9	3.4	3.3	3.9	3.9	0.7	44
Mecosta	Mecosta	540057	2.4	2.6	4.6	1.4	1.7	2.5	2.4	1.3	39
Pretty	Mecosta	540079	1.3a	1.5	3.7	2.5	2.7	2.3	2.5	1.0	40
Round	Mecosta	540073	3.3	3.7	5.6	1.3	2.1	3.2	3.3	1.6	42
School Section	Mecosta	540080	1.5	2.9	2.9	*	*				
Baldwin	Montcalm	590171	1	7.1	6.4	3.5	7.3	5.1	6.4	2.7	49
Crystal	Montcalm	590105	<1	1.3	1	2.9	2.6	1.7	1.3	1.0	33
Derby	Montmorency	590144	<1	<1	1.8	1.6	1.3	1.1	1.3	0.6	33
Twin (East)	Montmorency	600013	11	6.3	9.5	3.3	8.5	7.7	8.5	3.0	52
Twin (West)	Montmorency	600014	1.3	3	2.6	3.9	2.1	2.6	2.6	1.0	40
Duck	Muskegon	610778	*	*	5.6	*	6.1				
Bills (Waits)	Newaygo	620311	2.2	1.8	2.1	2	2.3	2.1	2.1	0.2	38
Fremont	Newaygo	620029	<1	3.5	3.4	2.4	1.6	2.3	2.4	1.3	39
Deer	Oakland	631128	d	1.8	1.1	2.5	<1a	1.5	1.5	0.9	34
Lakeville	Oakland	630670	2.2	1.7	2.7	4.1	2.3	2.6	2.3	0.9	39
Orion	Oakland	630554	1.5	1.8	4.7	4	1.8	2.8	1.8	1.5	36
Oxbow	Oakland	630666	*	*	*	*	*				
Parke	Oakland	631119	<1	<1	1.6	2.1	3.2	1.6	1.6	1.1	35
Crystal	Oceana	640062	8.4	4	2.8	2.5	8	5.1	4.0	2.9	44
Pentwater	Oceana	640089	8.2	2.4	2.9	8.7	13	7.0	8.2	4.4	51
Stony	Oceana	640049	10	2.7	5.8	9.4	8.2	7.2	8.2	3.0	51
Center (Kettunen)	Osceola	670238	1	3.8	2.2	2.6	2.7	2.5	2.6	1.0	40
Hicks	Osceola	670062	*	8.8	17	17	*				
Indian	Osceola	670227	2.2	2.7	2.6	2.1	3	2.5	2.6	0.4	40
Crockery	Ottawa	700422	14a	*	37	4.9	6.9	15.7	10.5	14.7	54

APPENDIX 3
2011 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)								
Higgins (N. Basin)	Roscommon	720026	<1	<1	<1	<1	<1	0.5	0.5	0.0	<31
Vol/Rep			<1								
Higgins (S. Basin)	Roscommon	720028	<1	<1	<1	<1	<1	0.5	0.5	0.0	<31
Houghton (Site 1)	Roscommon	720163	1.2	4.2	4	4.1	4.1	3.5	4.1	1.3	44
Houghton (Site 2)	Roscommon	720164	1.2	3.3	3.8	3.6	3.3	3.0	3.3	1.1	42
Corey	St.Joseph	750142	<1b	4.2b	2.5a,b	2.9	2.5a	2.5	2.5	1.3	40
Klinger	St.Joseph	750136	<1	1.6	2.2	1.9	1.9	1.6	1.9	0.7	37
Templene	St.Joseph	750322	d	1	8.2	1.7	3.2	3.5	2.5	3.2	39
Cedar	Van Buren	800241	1.5	5	3.3	3.6	3.1	3.3	3.3	1.3	42
Vol/Rep		800241	2.5								
Crooked (Big)	Van Buren	800483	3.1a	4.9	2.6	1.8	2.6	3.0	2.6	1.2	40
Vol/Rep							2.5				
Crooked (Little)	Van Buren	800535	1.7a	4.9	4.3	2.3	2.6	3.2	2.6	1.4	40
Pleasant	Wexford	830183	12	4.3	3.6	2.6	2.1	4.9	3.6	4.0	43
Blue Heron Lagoon	Wayne	821552	*	*	*	*	*				
Muskoday	Wayne	821553	*	*	*	*	*				

Results Codes:

< Sample value is less than limit of quantification (1 ug/l)

* No sample received

a Sample not collected within the designated sampling period; result may not be comparable with other data for month

b No data sheet submitted with sample

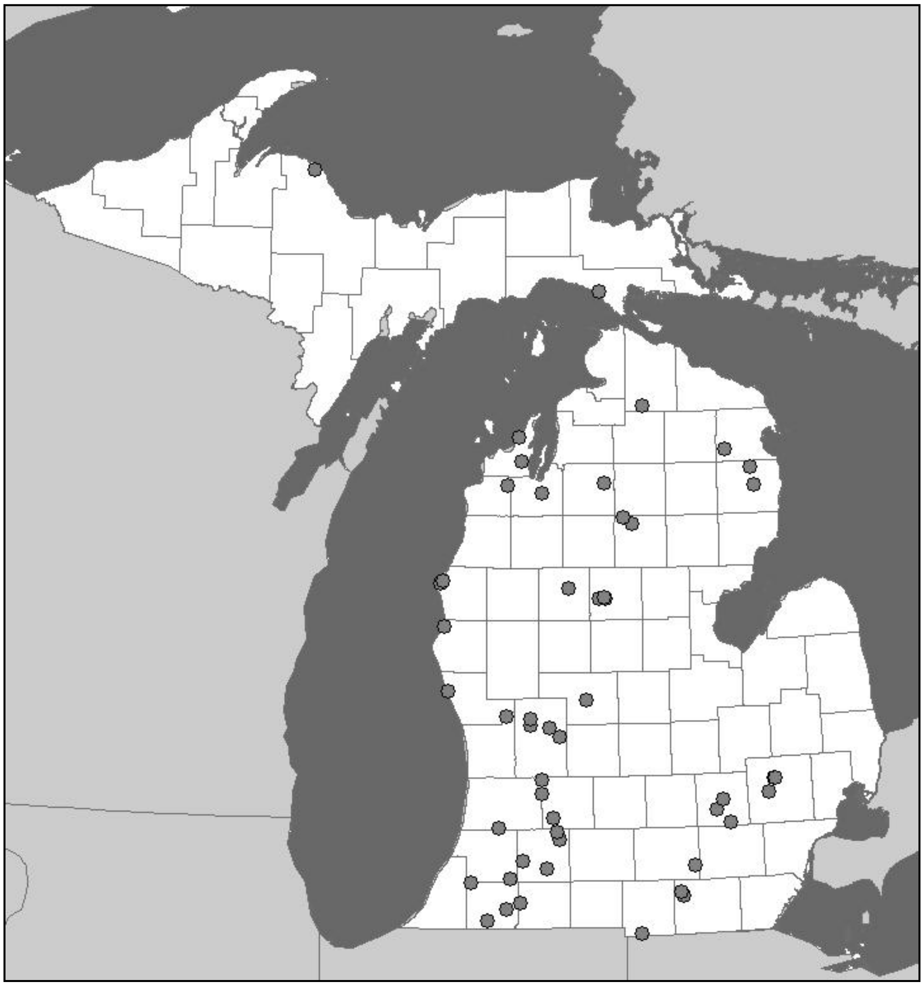
c Sample not covered by aluminum foil when received - sample not processed

d Sample collected far outside the designated sampling period - sample not processed

e Blue separator sheet used instead of filter - sample not processed

f Results determined from a dilution of sample

Appendix 4
2011 Cooperative Lakes Monitoring Program
Dissolved Oxygen and Temperature Results



Map above shows the distribution of the 50 lakes enrolled in Dissolved Oxygen and Temperature monitoring in the 2011 CLMP Program.

APPENDIX 4
2011 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Alcona	Hubbard Lake Maynard Lake
Allegan	Eagle Lake
Barry	Cobb Lake Duncan Lake
Benzie	Lake Ann
Cass	Birch Lake Eagle Lake Magician Lake
Clare	Windover Lake
Grand Traverse	Arbutus Lake
Hillsdale	Lake Diane
Jackson	Sweezey Lake
Kalamazoo	Crooked Lake Gull Lake Indian Lake Sherman Lake
Kalkaska	Bear Lake
Kent	Bostwick Lake Freska Lake Murray Lake
Leelanau	North Lake Leelanau South Lake Leelanau
Lenawee	Devils Lake Round Lake
Livingston	Earl Lake Strawberry Lake Triangle Lake
Mackinac	Brevoort Lake

County	Participating Lakes
Marquette	Lake Independence
Mason	Lower Hamlin Lake Upper Hamlin Lake
Montcalm	Baldwin Lake Crystal Lake Derby Lake
Muskegon	Duck Lake
Oakland	Deer Lake Parke Lake
Osceola	Hicks Lake
Ottawa	Crockery Lake
Roscommon	Higgins Lake (North basin) Higgins Lake (South basin)
St. Joseph	Corey Lake

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

The first is of a very high quality oligotrophic lake, which has a very large 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.

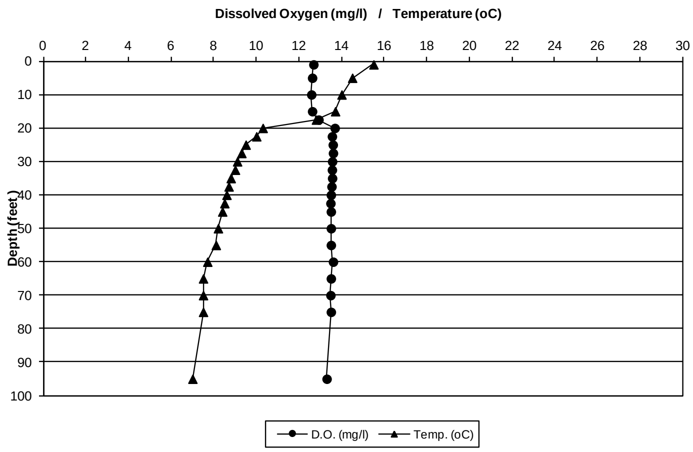
The third pattern is a mesotrophic/eutrophic lake with a small sized hypolimnion. Within a few weeks of spring overturn the hypolimnion has lost all oxygen. This anaerobic condition persists all summer.

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.

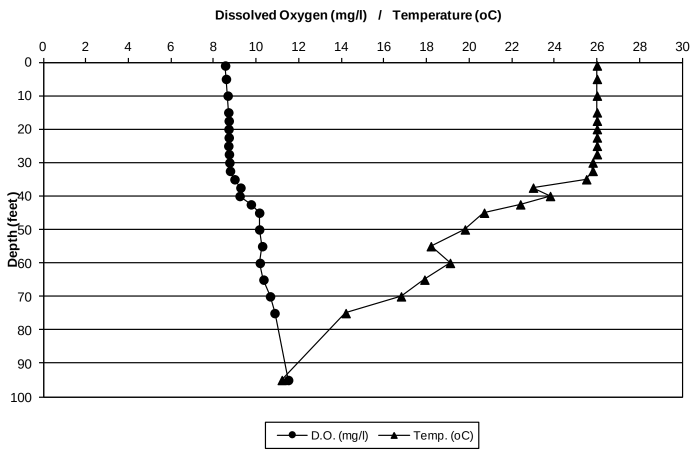
The fifth example is a mesotrophic lake that has dissolved oxygen spikes in the thermocline. This graph is included because many people will see this in the data from their lake.

Oligotrophic Lake with a Very Large Volume Hypolimnion

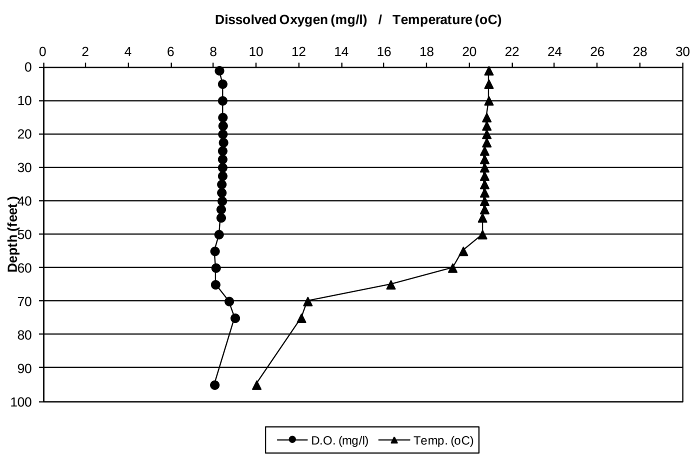
North Lake Leelanau in Leelanau County is an oligotrophic lake with a large volume hypolimnion. As an oligotrophic lake, it produces less organic material that must be decomposed (as compared to a mesotrophic or eutrophic lake). Its large volume hypolimnion has a substantial oxygen supply that is not 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.



May 22, 2011



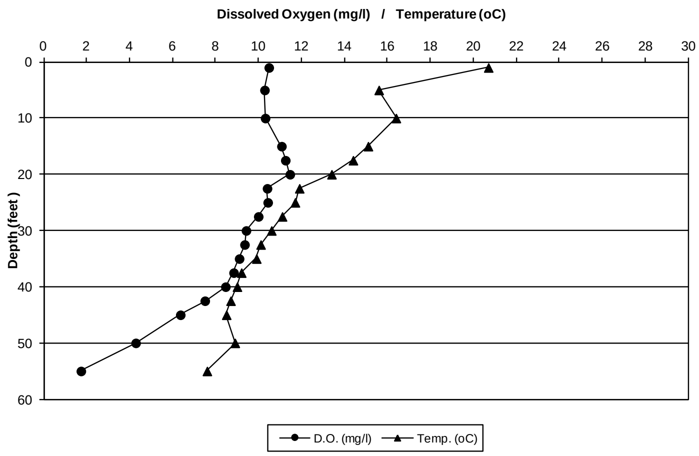
July 25, 2011



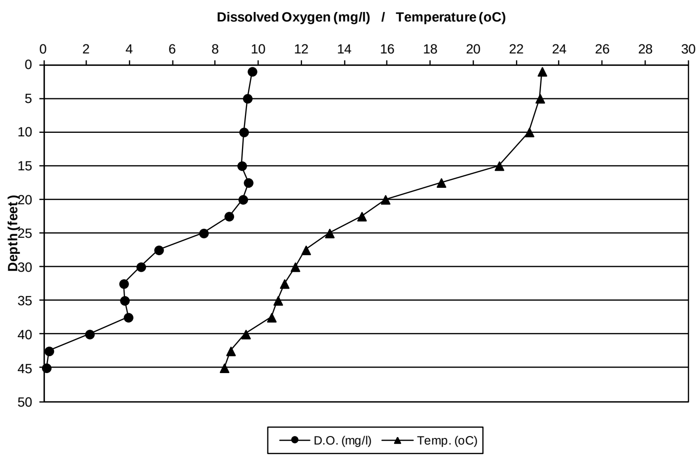
September 16, 2011

Mesotrophic Lake with a Medium Volume Hypolimnion

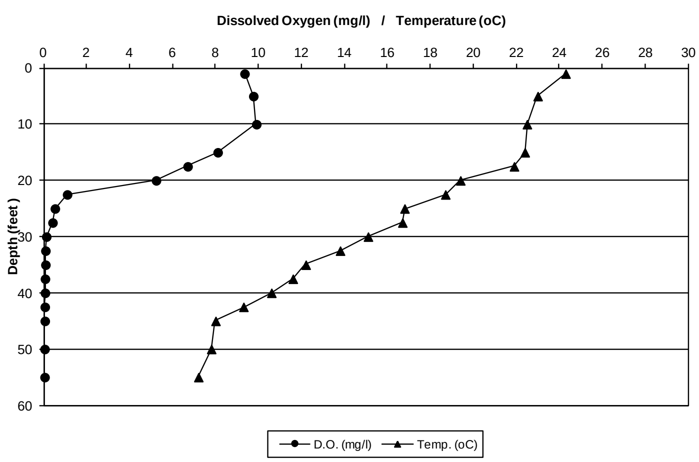
Magician Lake in Cass County is a mesotrophic lake with a medium volume hypolimnion. As a mesotrophic lake it produces moderate amounts of organic material that must be decomposed. Its hypolimnion has a limited oxygen supply that is gradually depleted by the decomposition of the organic material, which 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 by late-summer (September) the entire hypolimnion is without oxygen.



May 12, 2011



June 13, 2011



September 3, 2011

Mesotrophic/Eutrophic Lake with a Small Volume Hypolimnion

Earl Lake in Livingston County is a borderline mesotrophic/eutrophic 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 drop to near zero within a few weeks of spring overturn. With no oxygen re-supply from the upper waters and atmosphere, the hypolimnion is devoid of oxygen all summer.

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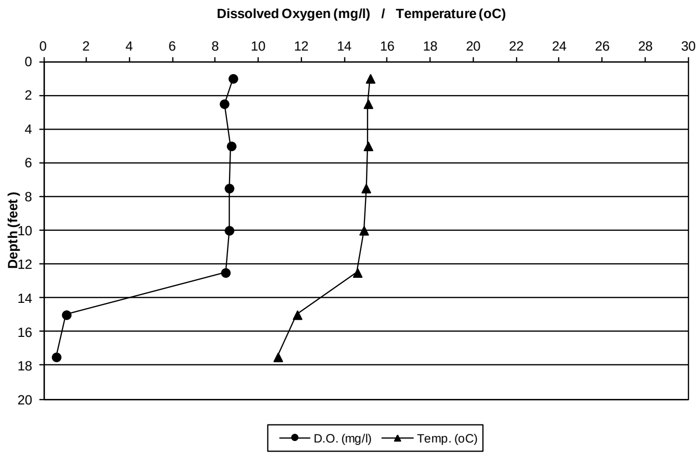
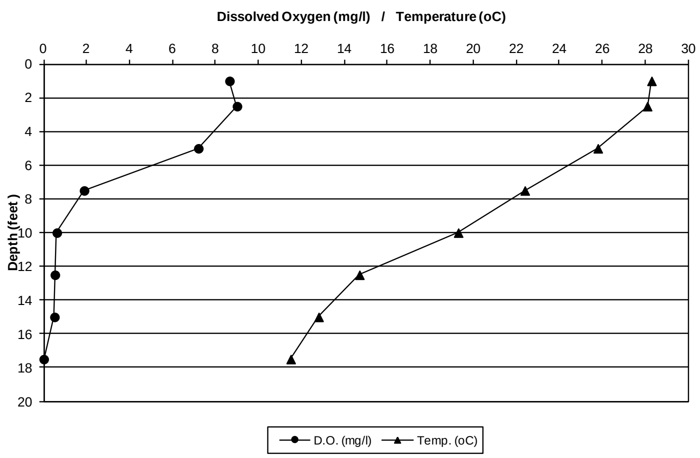
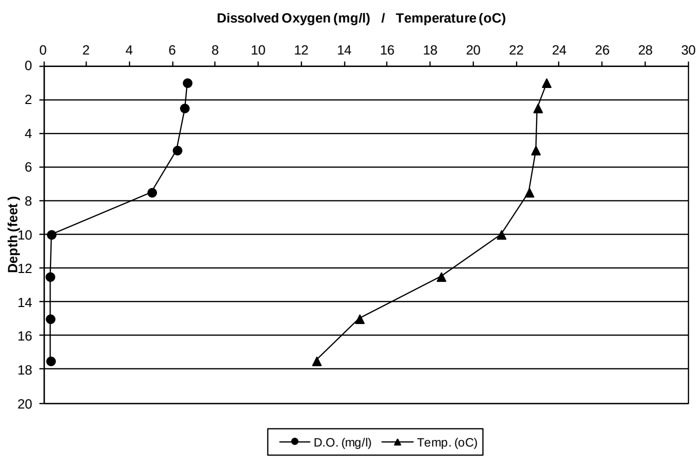


May 16, 2011



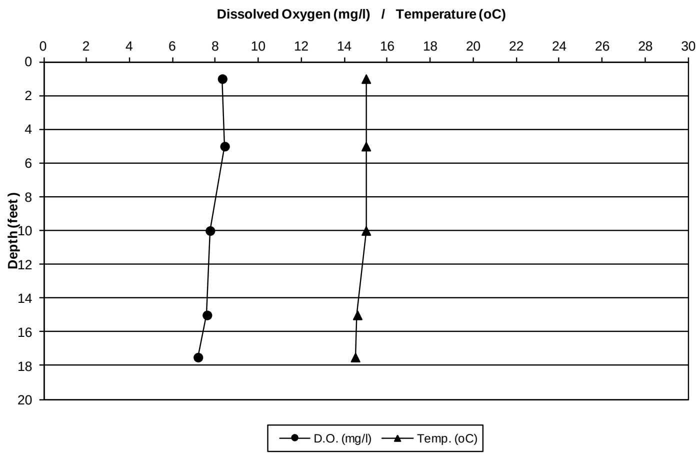
July 18, 2011



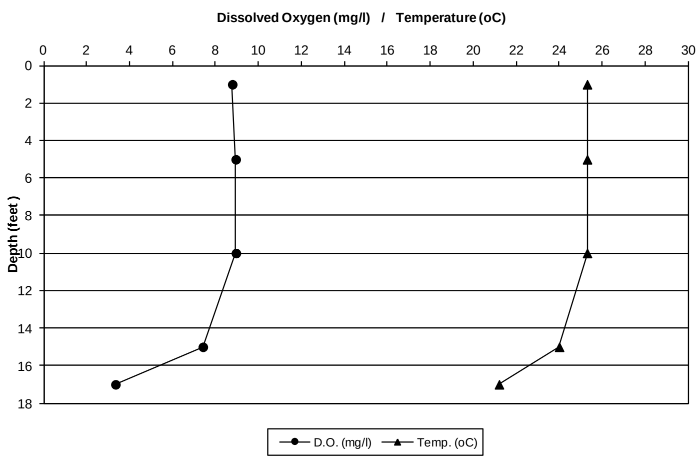
August 29, 2011

Shallow Mesotrophic Lake That Does Not Maintain Summer Stratification

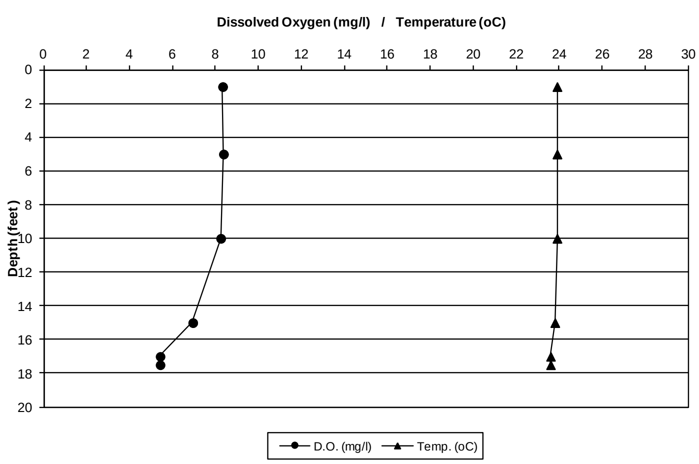
Bostwick Lake in Kent County is a shallow mesotrophic lake basin with insufficient depth to maintain stratification all summer. As a mesotrophic lake it produces moderate amounts of organic material that must be decomposed. Its hypolimnion, if present, has a small oxygen supply that is depleted by the decomposition of the organic material, which falls into the deeper parts of the lake during the summer. It is possible that dissolved oxygen levels in the deeper water can drop to zero by midsummer. However, 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. In the calm periods between storms, dissolved oxygen is again lost.



May 19, 2011



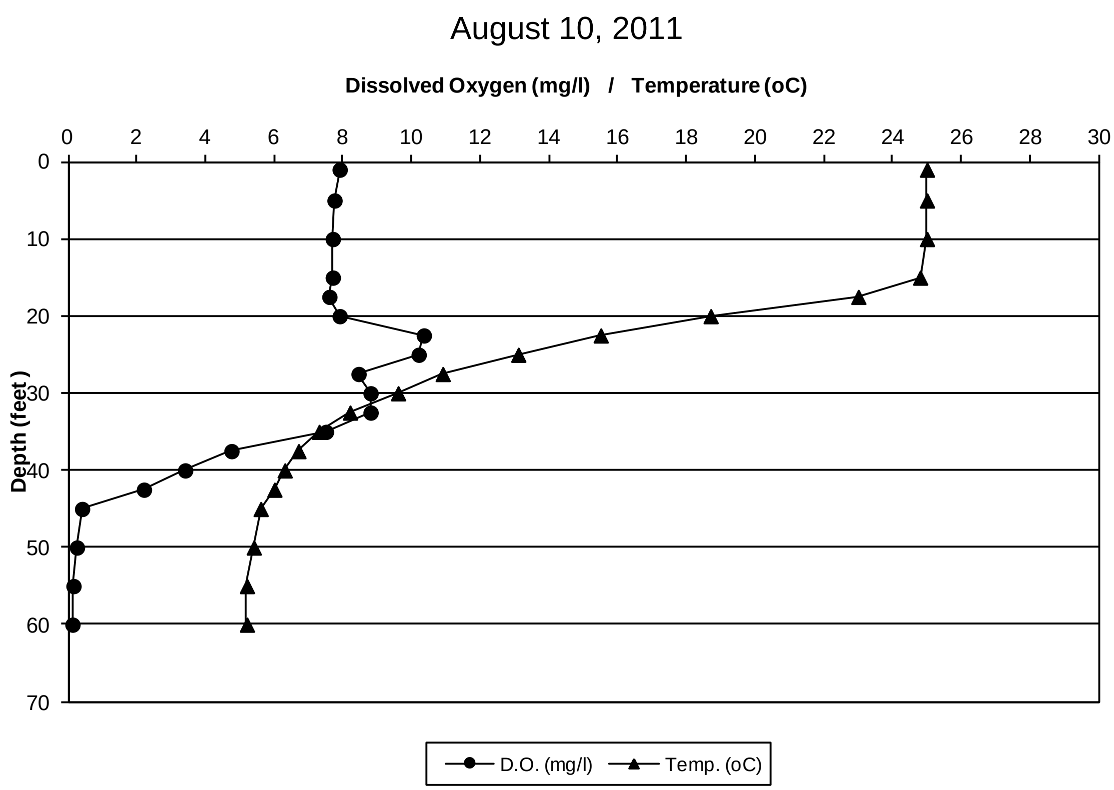
July 15, 2011



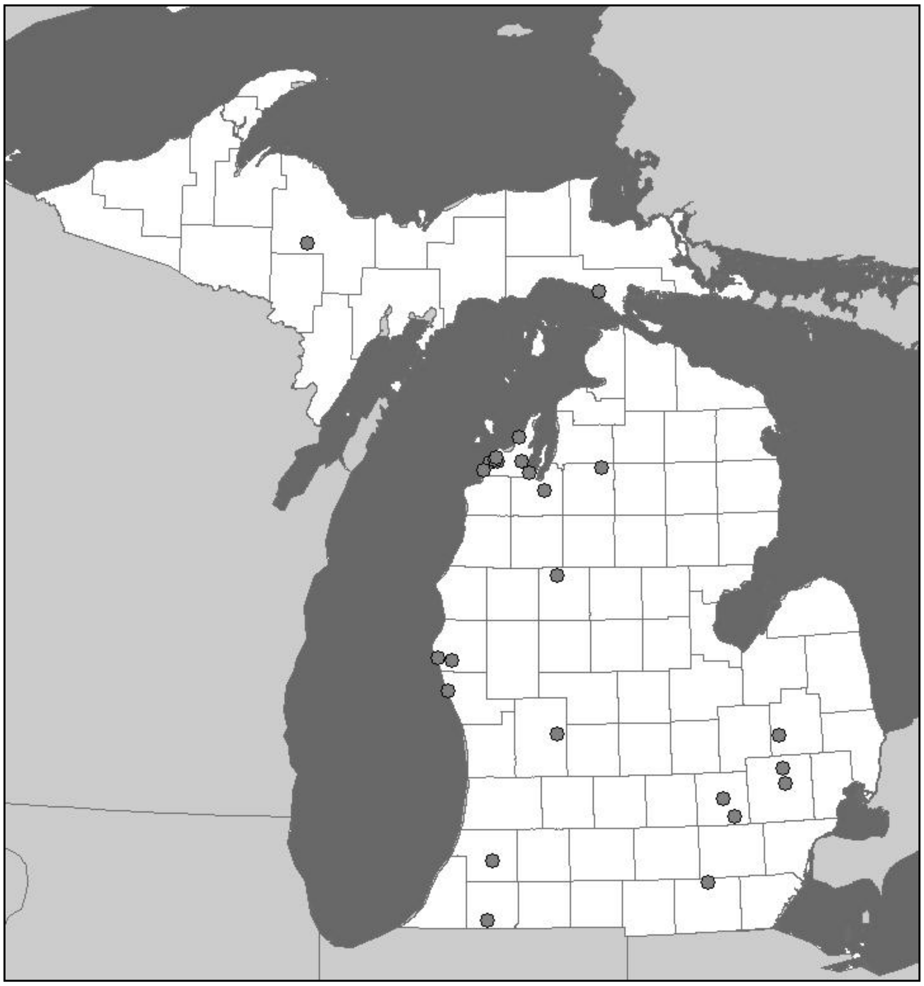
August 22, 2011

Mesotrophic Lake with Dissolved Oxygen Spikes in the Thermocline

Windover Lake in Clare County is a mesotrophic 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.



Appendix 5
2011 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 2011 CLMP Program.

APPENDIX 5
2011 COOPERATIVE LAKES MONITORING PROGRAM
EXOTIC AQUATIC PLANT WATCH RESULTS

County	Participating Lakes
Cass	Eagle Lake
Kent	Big Crooked Lake
Leelanau	Brooks Lake Fisher Lake Glen Lake Little Glen Lake Little Fisher Lake
Oceana	Stony Lake
Osceola	Center Lake
Van Buren	Lake Cora

Twenty-six lakes enrolled in the 2011 CLMP Exotic Aquatic Plant Watch. Of those enrolled, ten lakes submitted a report of their results. As an example of the data collected in the Exotic Aquatic Plant Watch project, the data for Stony Lake, Oceana County, are presented below. CLMP volunteers on Stony Lake took note of the locations of any of the three species included in the Exotic Watch – Eurasian milfoil, curly-leaf pondweed, and Hydrilla – and also took note of other species of interest. They also created a Google Earth map of the locations of these species for easy reference.

Map of Stony Lake (Oceana County) Exotic Aquatic Plant Watch sites, created by CLMP volunteers using Google Maps (maps.google.com).

APPENDIX 5
2011 COOPERATIVE LAKES MONITORING PROGRAM
EXOTIC AQUATIC PLANT WATCH – EXAMPLE RESULTS

Some site-description details removed from original report to protect privacy.

Stony Lake Exotic Plant Watch 2011

Exotic Plants found in Stony Lake, Oceana County, Benona & Claybanks Townships, Michigan summer 2011. Volunteer Monitor Julie Stivers; Field ID# 640049

NOTE: Herbicide spraying at selected sites June 15 Harvesting on entire lake July 14-25.
Standard Aquatic Vegetation Survey conducted by Progressive AE on July 20, 2010.

CLPW = Curly Leaf Pondweed
EWMF = Eurasian Watermilfoil
DNRE Aquatic Vegetation Survey terminology: Found = one or two plants; Sparse = scattered distribution; Common = easily found; Dense = 60%-70% of plant mass.

Site 1: 43.56321 / 86.47826
June 8 EWMF sparse; CLMP sparse
Oct. 5 EWMF common in NW corner

Site 2: 43.56196 / 86.47723
June 8 and all summer EWMF dense on east side of dock.

Site 3: 43.56205 / 86.47300
Just east of launch. June 8 EWMF found.

Site 4: 43.56190 / 86.46814
June 15 EWMF spot-treated before Lake Board harvesting. June 17 common, July 7 sparse.

Site 5: 43.33761 / 86.28069
July 7 CLPW sparse; EWMF sparse

Site 6: 43.56105 / 86.40251
June 30 EWMF found; CLPW sparse. Sept. 8 & 14 EWMF found; CLPW gone.

Site 7: 43.56125 / 86.48435
June 30, Sept. 8 & 14 EWMF found

Site 8: 43.56107 / 86.40287
Sept. 8 & 14 EWMF found

Site 9: 43.56111 / 86.48972
July 5 & August 13 EWMF sparse.

Site 10: 43.55999 / 86.49514
July 25 & August 13 EWMF common around and under dock.

Site 11: 43.56055 / 86.49303
August 13 EWMF found
Sept. 14 could not locate

Site 12: 43.55950 / 86.49637 (east side)
43.55910 / 86.49641 (west side)
June 25 Clean-up organized by Eagle Scout, Dense EWMF hand-pulled from south side of dock, some on east side. West side by outlet channel protected with nets, but dense EWMF not pulled there.
Sept. 14 EWMF common on east side, dense on west side. Common in area hand-pulled.

Site 13: 43.55699 / 86.48543
July 25 EWMF found

Site 14: 43.55724 / 86.47819
July 25 EWMF common along west side of dock; CLPW sparse

Site 15: 45.55913 / 86.49027
Sept. 14 & Oct. 6 EWMF found; just upstream, 45.55956 / 86.49754, EWMF common, CLPW sparse.
Oct. 6 Surveyed creek downstream of dam to Lake Michigan, no exotics found.

Site 16: 43.56103 / 86.48701
Sept. 28 After dock removal. EWMF found on west side of dock area, dense on east side; CLPW sparse.