Cooperative Lakes Monitoring Program

Michigan's Citizen Volunteer
Partnership for Lakes

"MI Lakes – Ours to Protect"

Annual Summary Report 2010

Michigan's Citizen Volunteers
Michigan Lake & Stream Associations, Inc.
Michigan Department of Natural Resources & Environment
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 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 Harding 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, hardy 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 partnership are often more 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 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

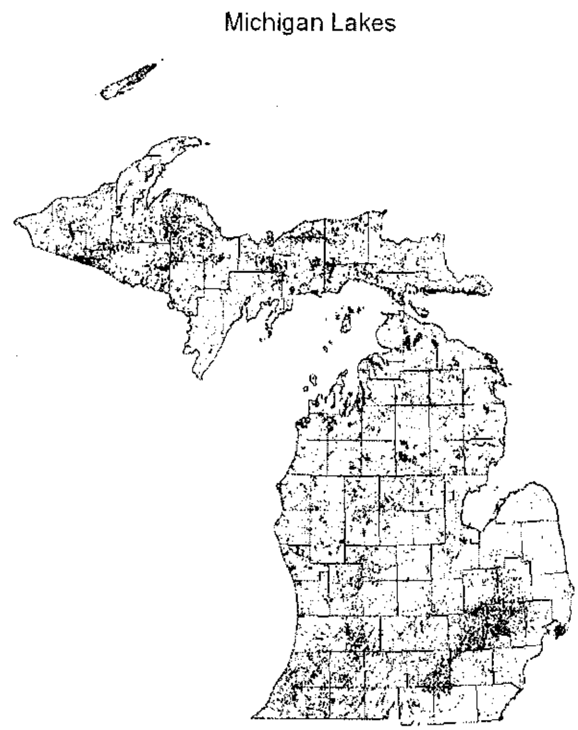
Michigan's unique geographical location provides its citizens with a wealth of freshwater resources including over 11,000 inland lakes. In addition to being valuable ecological resources, lakes provide aesthetic and recreational value for the people of Michigan and neighboring states. An ideal Michigan 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 Natural Resources & Environment (DNRE, formerly Department of Environmental Quality - DEQ), Michigan Lake & Stream Associations

Michigan's abundant water resources...



Source: Michigan Department of Natural Resources & Environment

...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 DNRE 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 DNRE/citizen volunteer partnership is critical to lake management in Michigan.

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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 Governor Jennifer Granholm to assist the DEQ (currently DNRE) 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,
A listserv,
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.

Michigan Clean
Water Corps

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 DNRE to increase baseline data for lakes statewide.

CLMP Measurements

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

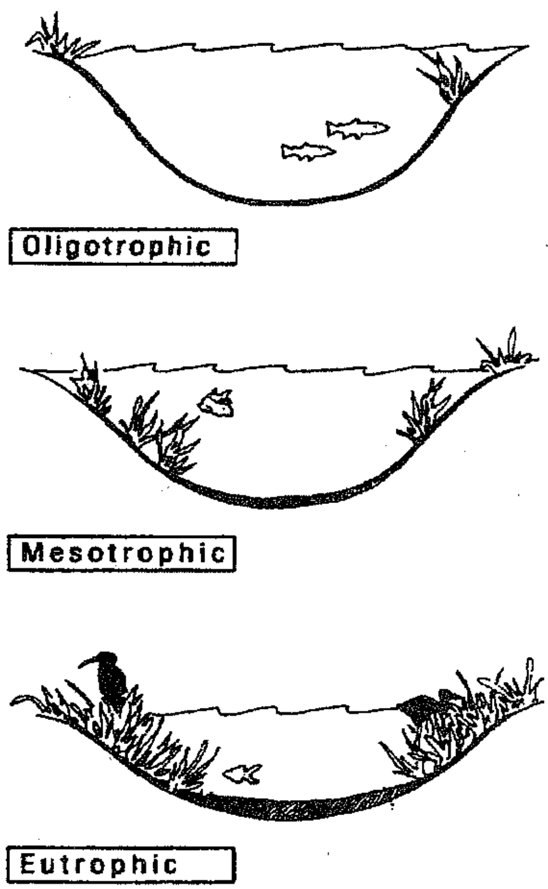
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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 ug/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 ug/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 (ug/l)
CHL = chlorophyll *a* concentration (ug/l)

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

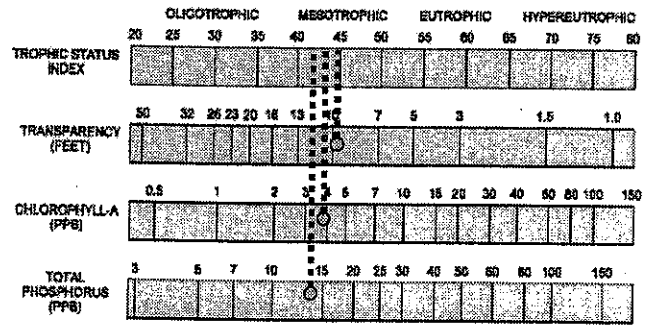
Example of how to use the chart below:

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.

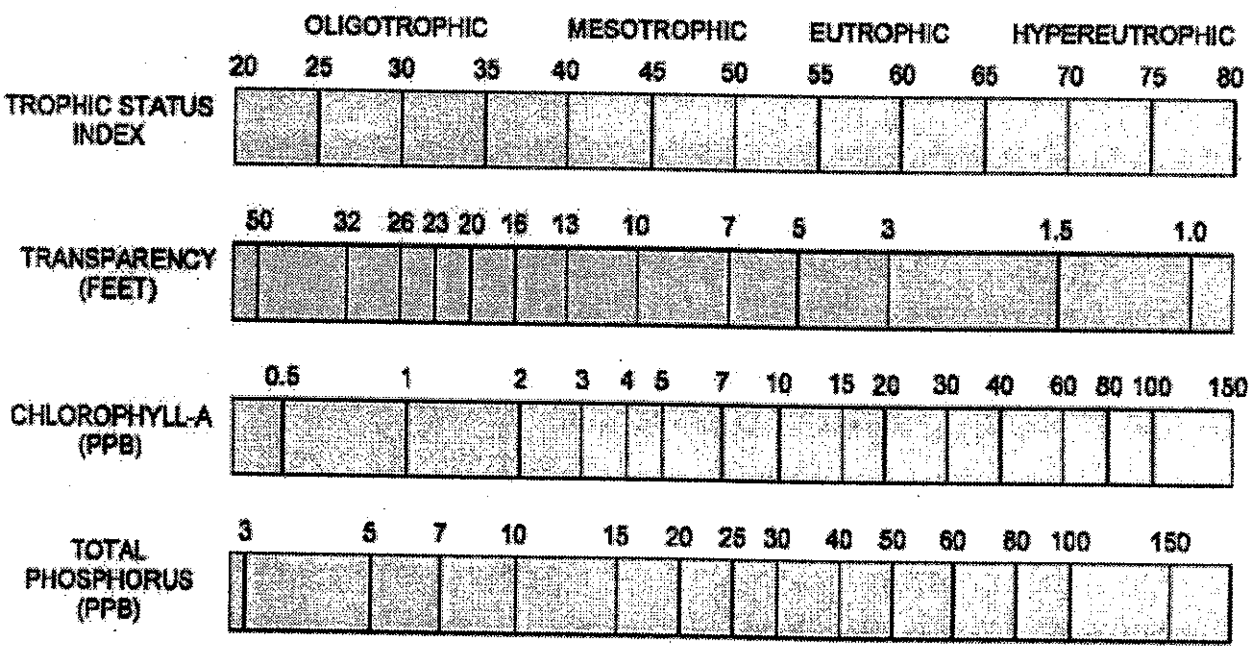
By drawing a straight line up from each of the points, the volunteer learns that the different TSI parameters for Horsehead Lake fall between 40 and 45, which places Horsehead Lake in the middle of the mesotrophic range. The lines from the different parameters do not exactly match up because of natural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

CARLSON'S TROPHIC STATE INDEX



Source: Minnesota Pollution Control Agency

CARLSON'S TROPHIC STATE INDEX



Source: Minnesota Pollution Control Agency

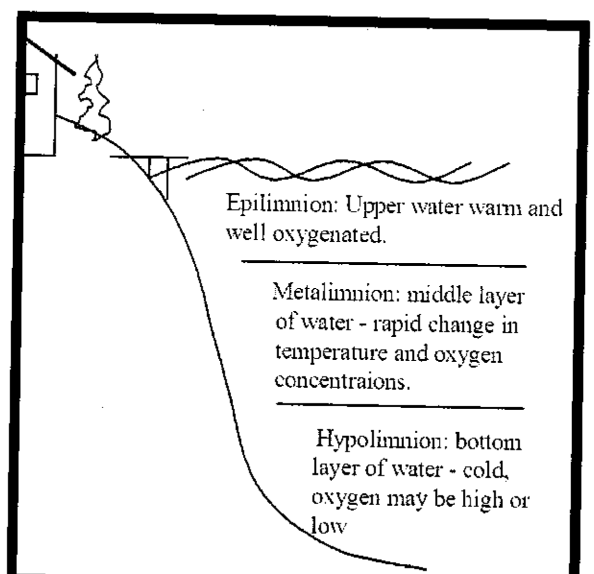
OTHER MEASURES OF LAKE PRODUCTIVITY

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

2010 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.

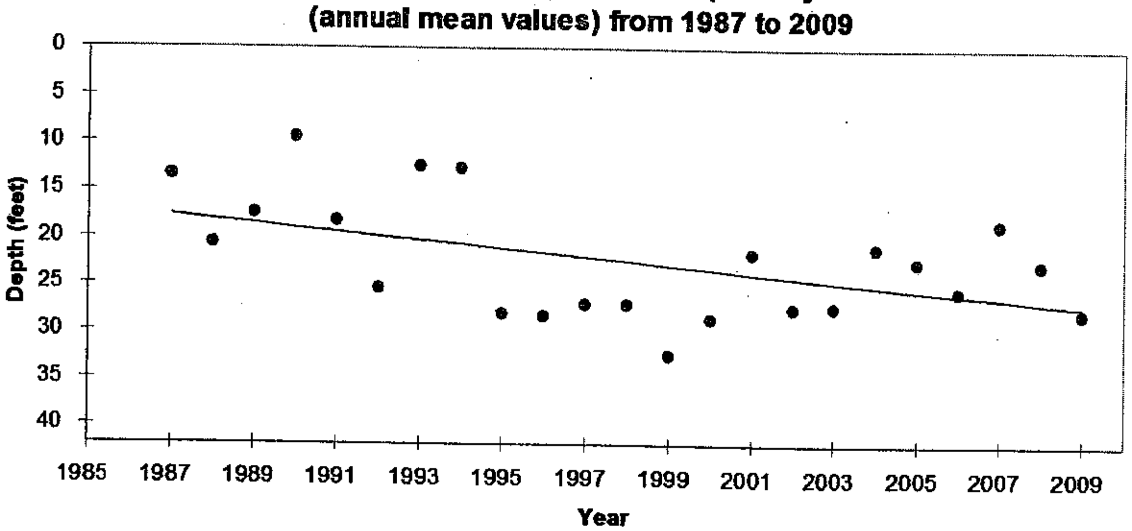
The mean, or average, is simply the sum of the measurements divided by the number of measurements. The median is the middle value when the set of measurements is ordered from lowest to highest value. The standard deviation is a common statistical determination of the dispersion, or variability, in a 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 2010, Secchi disk transparency data were reported for 193 lakes (215

Example Lake Secchi Disk Transparency Trend (annual mean values) from 1987 to 2009



basins). Approximately 3049 transparency measurements were reported, ranging from 1.0 to 46.0 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 12.8 feet and the median value was 11.0 feet. The Carlson TSI_{SD} values ranged from 27 to 65 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 193 of the 219 enrolled lakes for a participation rate of 88%.

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 2010 CLMP are included in Appendix 2. The spring total phosphorus data are listed first, followed by the late summer data. The TSI_{TP} values were calculated using Carlson's equations (see page 7) and the late summer total phosphorus data. Results from replicate and side-by-side sampling are also provided. Approximately 10% of the replicate samples collected by the volunteers were analyzed as part of the data quality control process for the CLMP. Also, the DEQ participated in side-by-side sampling on approximately 5% of the lakes.

During 2010, samples for total phosphorus measurements were collected on 193 lakes. The spring overturn total phosphorus results ranged from <5 to 125 ug/l with a mean (average) of 14.1 ug/l and a median value of 11 ug/l. The late summer total phosphorus results ranged from <5 to 90 ug/l with 14.5 ug/l as the mean and 11 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 69 for these lakes with a mean value of 39. A Carlson TSI value of 39 is generally indicative of a very good quality mesotrophic lake (see page 7).

For the spring overturn sampling, 152 total phosphorus samples were turned in from 163 enrolled lakes, for an 93% participation rate. For late summer sampling, 182 samples were received from 192 enrolled lakes/basins for a 95% 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 2010 volunteers collected a minimum of four samples on 113 lakes (116 basins).

Results from the chlorophyll monitoring for 2010 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 6 percent of the lakes.

A total of 609 chlorophyll samples were collected and processed in 2010. The chlorophyll *a* levels ranged from <1 to 160.0 ug/l over the five-month sampling period. The overall mean (average) was 4.8 ug/l and the median was 2.8 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 63 with a mean value of 43. A Carlson TSI value of 43 is generally indicative of a good quality mesotrophic lake (see page 7).

During 2010, a total of 124 lakes (127 basins) registered for chlorophyll sampling. A total of 121 lakes participated minimally by turning in at least one sample, for a minimum participation rate of 98%. A total of 113 lakes turned in at least four samples for a complete participation rate of 91%. Six samples were turned in, but not processed due to quality control issues for a 1% 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 2010, CLMP participants in the dissolved oxygen/temperature project sampled 44 lakes (46 basins). A total of 421 dissolved oxygen/temperature profiles (over 4500 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 2010 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

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

Submitted by Jim Novitski, Lake Management Chair, Perch Lake Owner Association

Perch Lake is located in north central Iron County in the Upper Peninsula of Michigan. The surface area of the lake is roughly 1,000 acres with an average depth of about 8 feet, with the deepest area around 15 feet, in the vicinity of the only island on the lake. The water is quite stained with two creeks emptying into it. A public boat landing and Forest Service campground are located on the west shore. The shoreline is about half privately owned and half Forest Service land. There is no electricity service available within ten miles.

Of the approximately forty private owners, about half formed a lake association about seven or eight years ago. The Perch Lake Owners Association (PLOA) was formed to protect and improve the lake and its surroundings. My name is Jim Novitski and I volunteered to chair the Lake Management Committee.

Two years ago Dave Crowe, one of our members, contacted Michigan Lake and Stream Associations (MLSA) about signing up for a few tests to do on the lake through the Cooperative Lakes Monitoring Program (CLMP).

The first year we signed up for Secchi disk and summer phosphorous. We sat down and decided to sign up for more tests the following year. We signed up for Secchi disk, spring and summer phosphorous, chlorophyll and aquatic plant mapping. We are concerned about an invasion of Eurasian Water Milfoil (EWM) to the lake. Surrounding lakes have it, but luckily we have not found it. We joined aquatic plant mapping program to help us keep a lookout for an EWM invasion. It has proven to be very helpful for monitoring the lake not only for EWM but a few other problem invasive plants as well. The spring training sessions at the MLSA Annual Meeting were very helpful, not only for learning the testing procedures, but also for providing ideas on how to recruit a volunteer base.

The summer training session provided by the CLMP at our lake for the aquatic plant mapping program, which was taught by Jo Latimore of MSU, was provided with lots of helpful information and enthusiasm. Fifteen volunteers got hands-on experience doing the plant sampling and mapping. We chose to split our large lake in half, and conduct the mapping over two years so it wasn't such a daunting task for our volunteers.

In 2011 we are going to sign up for the same programs as last year, plus finishing up our aquatic plant mapping. We have some very enthusiastic and helpful people involved in volunteering up at the lake. I would like to sincerely thank them for their time and effort and look forward to 2011.

For more information on Perch Lake stewardship efforts, contact Jim Novitski at jnovitski@bayland.net

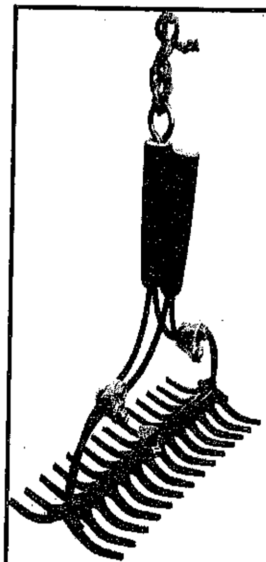
Do you have a success story of how your community has used CLMP data to implement a protection program for your lake? We would like to hear from you. Contact Bill Dimond at 517-241-9565 or dimondw@michigan.gov.

ACKNOWLEDGMENTS

Ralph Bednarz of the Michigan Department of Natural Resources & Environment (formerly Department of Environmental Quality), Jo Latimore from the Michigan State University Department of Fisheries and Wildlife, and Paul Steen of the Huron River Watershed Council prepared this report. Additionally, those involved in coordinating the CLMP include Scott Brown and Jean Roth of Michigan Lake and Stream Associations, Inc., and Ric Lawson of the Huron River Watershed Council. Support was provided by Anne Sturm of the Great Lakes Commission who maintained the MiCorps Data Exchange and Jack Wuycheck of the Michigan Department of Natural Resources & Environment who coordinated entry of historical CLMP data and clarified historic and current sampling site locations.

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.

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, an oligo/mesotrophic lake with a large volume hypolimnion, a mesotrophic lake with a moderate volume hypolimnion, a hypereutrophic lake with a small volume hypolimnion, and 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 a result of frequent mixing.



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.

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:

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 2010, CLMP participants in the aquatic plant project sampled one new lake — Perch Lake in Iron County.

In 2010, Perch Lake had TSI values of 48 for Secchi disk, 51 for Total Phosphorus, and 42 for chlorophyll.

These values suggest that the lake is mesotrophic. Communities of rooted plants were diverse but usually not dense around the lake, with no problematic invasive species found. For more information on the Perch Lake efforts, see page 19.

Exotic Aquatic Plant Watch – Pilot Project

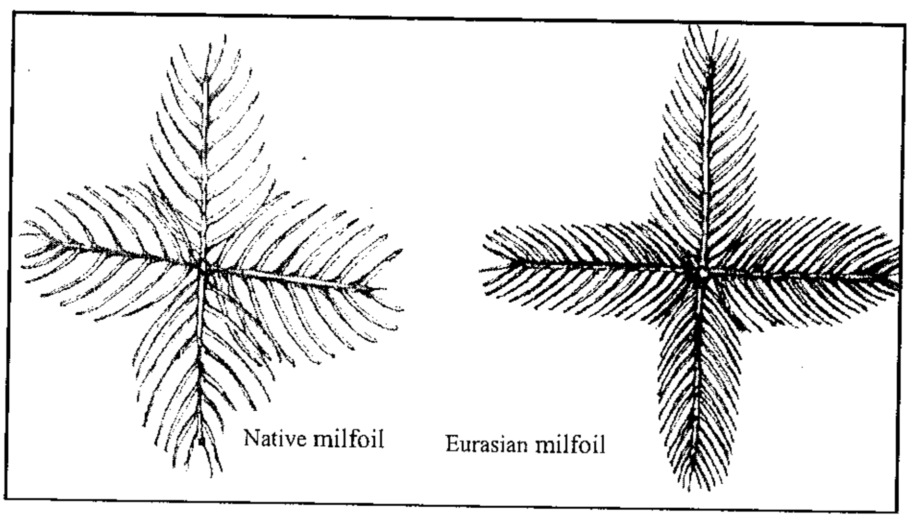
Beginning in 2007, the CLMP sponsored a pilot monitoring project to identify and map exotic aquatic plants in Michigan lakes, with the intent to add the Exotic Aquatic Plant Watch as a permanent component of the CLMP.

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 remained in pilot status through 2010. Steadily increasing enrollment and the high-quality data being generated by volunteers have shown the project to be of significant value to the CLMP. Consequently, the Exotic Watch will become a standard component of the CLMP in 2011.

In 2010, 20 lakes enrolled in the Exotic Aquatic Plant Watch, and 8 submitted reports, for a participation rate of 40%. Participants and example results are presented in Appendix 5.



Stem cross sections at a leaf node of a typical native milfoil (left) and 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

This year, a voluntary survey on the MiCorps Data Exchange web page helped track accessing and using the data collected in the CLMP. Eighty-seven data users responded to the survey. A summary of the results is below.

29% - Lake associations, CLMP volunteers
25% - Academia (students & professors from a variety of institutions, including Grand Valley State University, Eastern Michigan University, and the University of Wisconsin)
11% - State government (Michigan DNRE, and others including the Utah Division of Water Quality, using the CLMP as a guide to start their own program!)
10% - Business (realtors, environmental engineers)
10% - Interested individuals
10% - Non-governmental organizations (e.g., Huron River Watershed Council, Trout Unlimited, Sierra Club)
5% - Federal government

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 DNRE and MLSA may be able to help you obtain additional information on your lake.

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2010 CLMP Volunteer Lake Monitors

In 2010, more than 300 Volunteer Lake Monitors participated in Michigan's Cooperative Lakes Monitoring Program. The CLMP staff welcomes all the new volunteers, and commends all of the volunteers' dedication and enthusiasm!

David Allen
Russ Anton
Al Apsitis
Barbara Armstrong
Dan Bailey
Rick Bakka
David Ball
Susan Barnes
Neil Barr
Nancy Beckwith
Julie Bennett
Diane Blanchard
Emery Blanksma
Arthur Bombrys
David Boprie
Mike Bosela
John Bosker
Betty Bosowski
Richard Bosowski
Bob Boyd
Mark Bradburn
Dennis Bradley
Leonard Brockhahn
Dick Brown
Scott Brown
Clete Brummel
Carim Calkins
Dave Card
Paul Carmichael
Sally Casey
Gary Chisholm
Christopher Chupp
Justus Chupp
Rodney Chupp
Dave Clark
Steve Clouse
Gary Cogston
Jim Collins
Chuck Connelly
Craig Cotterman
Margaret Couturier
Gerald Cox
Paul Curell
Dennis Curtice
Phil Cushman
Paul Dalpra
Stacy Daniels
Linda Davis
Harry Dawson

Greg Dedes
Mike Devarenne
John DiGiovanni
Dave Dohring
Arnold Domanus Jr.
Gary Doyle
Kevin Doyle
Duane Drake
Terry Dugan
Andra DuPont
Janet Durbin
Wes Durbin
Allen Dyer
John Esch
Daniel Evert
Jeffery Falknor
Donald Ferguson
Deborah Ferry
William Finzel
Daniel Fleck
Chris Floyd
Bob Forche
Bruce Frappier
Dale French
William Fronk
Roger Gaede
John Gajar
Mike Gallagher
Ted Gatto
Laurence Gavin
William Gay
Douglas Gembis
Charles Gill
Ken Gill
Joe Goossens
Diane Graves
Andrea Grix
Stan Grove
Robert Hake
Connie Hales
Cary Hamann
George Hanley
Larry Harker
John Hartsig
John Hause
Bonnie Hay
Ron Herron
Nanette Hibler
Ed Highfield

Virginia Himich
Lynn Hoepfinger
John Hoffman
Emmett Holmes
Karen Holmes
Roger Hopkins
Susan Houseman
Richard Hubbard
Ruth Hubbard
Sheryl Hugger
Gary Hunt
Sharon Hurlbert
Bob Hutchings
Bill Ingle
Bonnie Isaacs
Jeff Jayne
Thomas Jenkins
Frederick Jensen
Dan Johnson
Gary Johnson
Bonnie Kanitz
William Kantor
Jeff Kempfer
Claudia Kerbawy
Martha Kern-Boprie
Bill Kestermeier
Emil Kezerle
Wayne Kiefer
Netty Kiekover
Calvin Killen
Marvin Kingsley
Phil Kinney
James Kollar
John Kolleth
Ronald Kreiger
Sheri Kurtyak
Brian Kusch
Jim Langerveld
Mary Lantz
Phil Laven
David Lawrence
Mitchell Le Claire
John Lewandowski
Bruce Lichliter
John Lindahl
Kenneth Lindstrom
Ernest (Mike) Litch
Mark Little
Timothy Locker

Doris Loomans
Lonnie Loveland
Steve Lucas
Joe Maguire
Erin Malloy
Mike Mankvitz
John Mater
Jack Matthews
David Maxson
Eldonna May
Timothy McCarthy
Rex McCormick
Char McDonnell
Jim McDowell
Alan McGowen
Alan McNamara
Robert McPertlin
Rick Meeks
Rich Meeuwenberg
Joan Melvin
Jeff Menz
Dale Miller
David Miller
Jim Miller
Bill Miner
Pete Minich
Terry Monson
Frank Montgomery
Thomas Moore
Chauncey Moran
Darlene Morey
Dick Morey
Pam Moseley
Thomas Murphy
Tim Murphy
Michael Mutschler
James Nadeau
Kenneth Nelson
Patricia Nelson
Ed Novak
James Novitski
Steve Ockaskis
Collin O'Dea
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Raymond Reinertson
Jack Reinhardt
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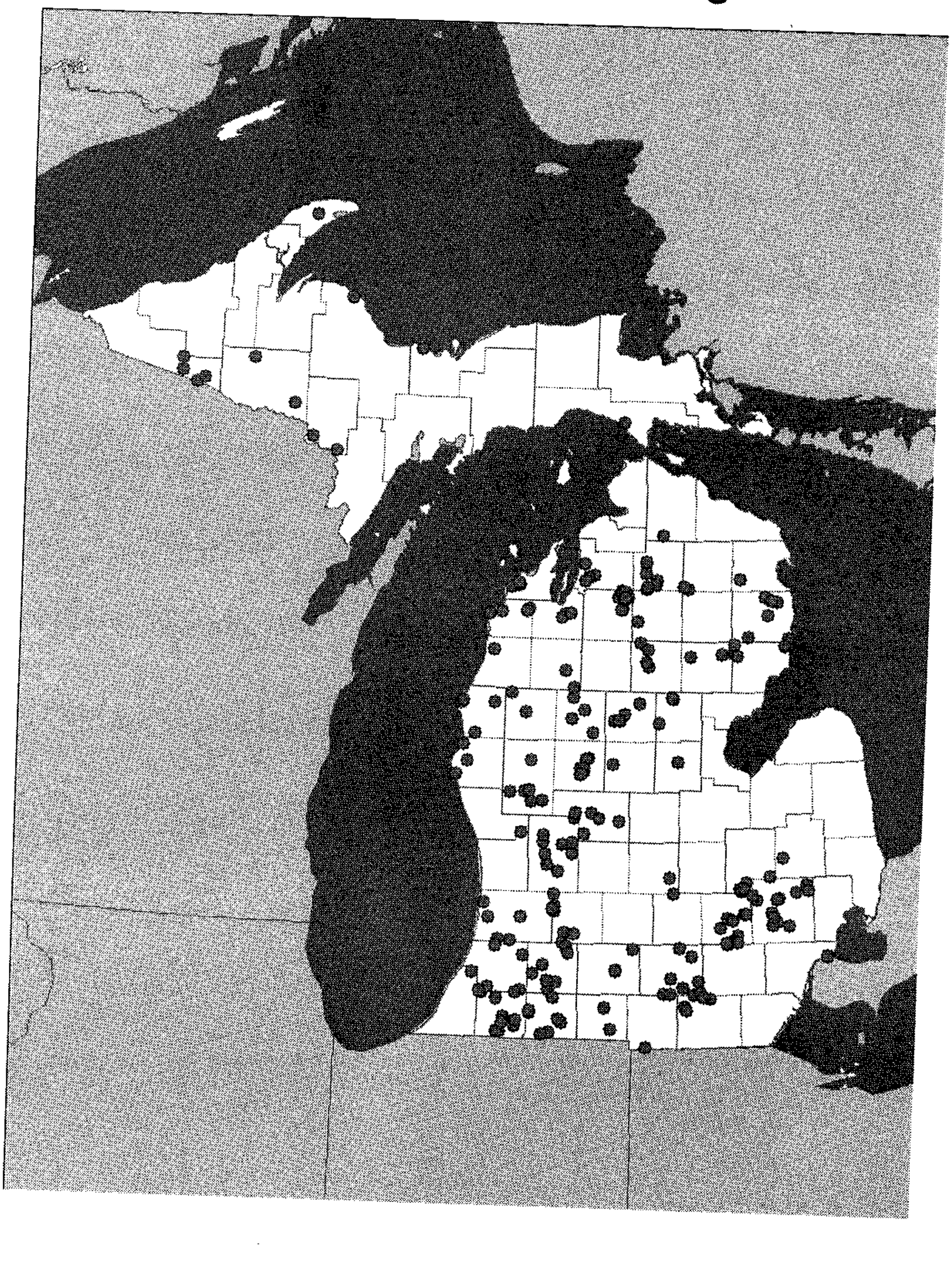
Emily Whittaker
Blair Wickman
Jon Wilford
James Wilkinson
John Wilks
Carol Wilson
Rick Winkley
Frank Wolf
Gary Wolter
Pat Wolters
Chuck Wolverton
Sam Wright
Frank Wrobel
Larry York
Leslie York
Carolyn Zader
Sue Zanotti
Dennis Zimmerman
Cheryl Zuelke

Statewide Distribution of CLMP Lakes Sampled During 2010



APPENDICES

Appendix 1

2010 Secchi Disk Transparency Results

Appendix 2

2010 Total Phosphorus Results

Appendix 3

2010 Chlorophyll Results

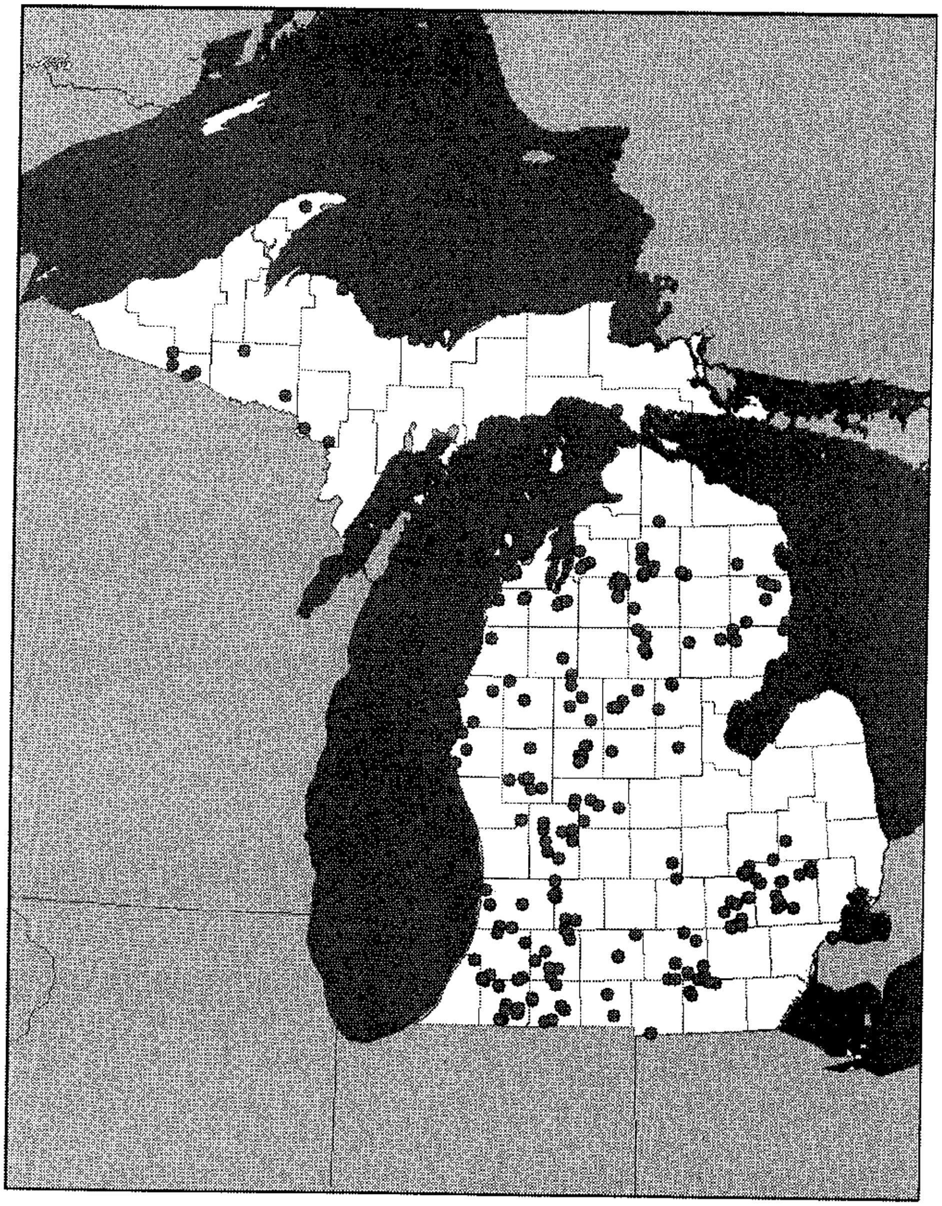
Appendix 4

2010 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2010 Exotic Aquatic Plant Watch Participating Lakes and Example Results

Appendix 1
2010 Cooperative Lakes Monitoring Program
Secchi Disk Transparency



Map above shows the distribution of the 219 lakes enrolled in Secchi Disk Transparency in the 2010 CLMP Program.

Recorded Secchi Disk Transparency Values:

- Mean (average): 12.8 feet
- Minimum: 1.0 feet
- Maximum: 46.0 feet [Higgins Lake (Roscommon Co.) and Torch Lake (Antrim Co.)]

APPENDIX 1
2010 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 (6)	Alcona	010106	16	10.5	27	17.0	16.5	4.6	36
Hubbard (7)	Alcona	010107	12	10	26	16.1	15.0	4.7	37
Hunter (Twenty)	Gladwin	260119	15	5.5	14.5	9.1	9.0	3.1	45
Hutchins	Allegan	030203	17	4	17	7.9	6.0	4.1	47
Independence	Marquette	520149	9	8	15	12.0	13.5	2.8	41
Indian	Kalamazoo	390305	14	5	23	12.9	10.3	6.1	40
Indian	Kalkaska	400015	10	9.5	16	12.9	12.5	2.1	40
Indian	Osceola	670227	19	15	26	19.9	20.0	3.0	34
Isabella	Isabella	370135	*						
Island	Grand Traverse	280164	16	12	29	19.3	16.0	6.1	34
Keeler	Van Buren	800482	*						
Kimball	Newaygo	620107	13	6	11.5	9.0	9.0	1.8	45
Kirkwood	Oakland	631116	*						
Klinger	St. Joseph	750136	18	4	21	10.6	8.0	5.3	43
Lakeville	Oakland	630670	14	8	20	13.2	12.5	4.3	40
Lancelot (1)	Gladwin	260104	10	4.5	10.5	7.3	6.8	1.9	48
Lancelot (2)	Gladwin	260112	10	5.5	10	8.2	8.0	1.3	47
Lancelot (3)	Gladwin	260113	10	6.5	9.5	7.9	7.8	1.0	47
Lancer (1)	Gladwin	260074	13	8	14	10.2	9.5	1.7	44
Lancer (2)	Gladwin	260114	13	8.5	10	9.1	9.0	0.5	45
Lancer (3)	Gladwin	260115	13	3	4.5	3.9	4.0	0.4	58
Lancer (4)	Gladwin	260116	13	4	9	7.3	8.0	1.6	48
Lancer (5)	Gladwin	260117	13	1	5	3.2	3.5	0.9	60
Lansing	Ingham	330137	14	8.5	14	10.0	9.3	1.8	44
Lily	Clare	180066	*						
Little Long	Barry/Kalamazoo	080279	14	9.5	23	13.4	13.0	3.1	40
Long	Gogebic	270179	7	14	26				
Long	Iosco	350076	19	11.5	15.5	13.4	13.0	1.4	40
Long	Oakland	631118	18	11	21	13.6	12.0	2.8	39
Loon	Iosco	350078	*						

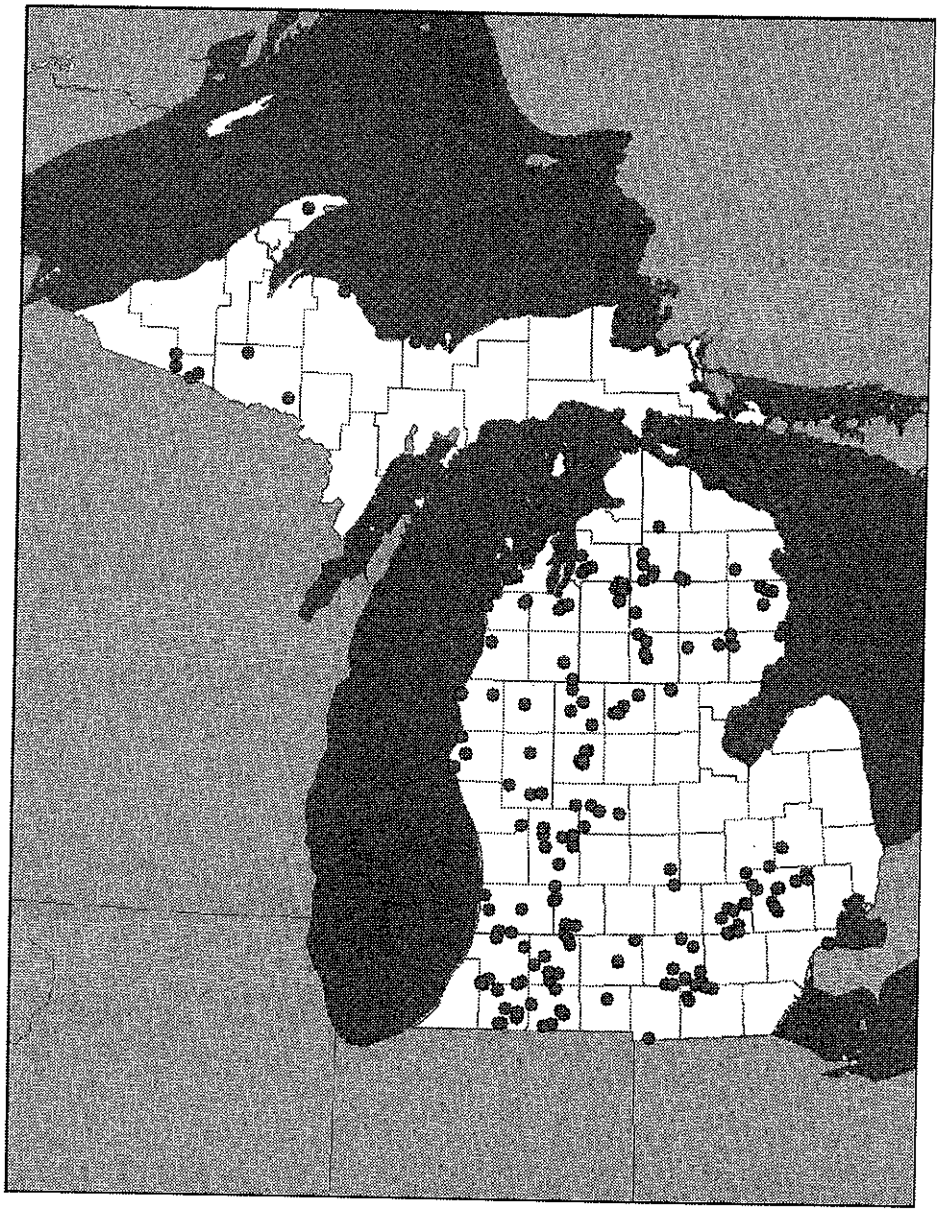
APPENDIX 1
2010 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID Number	Secchi Disk Transparency (feet)						Carlson
			Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	TSI_{SD} (transparency)

* No measurement reported

> Maximum value includes measurements made on lake bottom

Appendix 2
2010 Cooperative Lakes Monitoring Program
Total Phosphorus Results



Map above shows the distribution of the 192 lakes enrolled in late summer Total Phosphorus monitoring in the 2010 CLMP Program.

Recorded Total Phosphorus Values:

Spring Mean:	14.1 µg/l	Summer Mean:	14.5 µg/l
Minimum:	<5 µg/l	Minimum:	<5 µg/l
Maximum:	125 µg/l	Maximum:	90 µg/l
(L. Okonoka, Wayne Co.)		(Goshorn L., Allegan Co.)	

APPENDIX 2
2010 COOPERATIVE LAKES MONITORING PROGRAM
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)
Ann	Benzie	100082					11 c				39
Arbutus	Grand Traverse	280109	4 T				13				41
Arnold	Clare	180107	14				8				34
Badger	Alcona	010122	24				11 c				39
Baldwin	Montcalm	590171	20				17				45
Barlow	Barry	080176	10				14 c,d				42
Barton	Kalamazoo	390215	14				11 H				39
Base Line	Livingston/Wash	470149					10				37
Bass	Kalkaska	400129	*				5				27
Bear	Alcona	010125	11				12 c				40
Bear	Kalkaska	400026	5				6				30
Bear	Manistee	510257	9				12				40
Beatons	Geogebic	270105	5				11				39
Beaver	Alpena	040097	9				5				27
Bellaire	Antrim	050052	7				3 W				<27
Big	Osceola	670056					9	11	17		36
Big Pine Island	Kent	410437	19				23				49
Bills (Waits)	Newaygo	620311	7				6 H, c				30
Birch (Russwurm/Dugan)	Cass	140187	4 W,H				9				36
Birch (Temple)	Cass	140061	6				4 T, H				<27
Blue	Mecosta	540092	d				10				37
Blue (Big Blue)	Kalkaska	400016	9				5				27
Blue Heron	Wayne	821552	29				68				65
Blue, North	Kalkaska	400131	3 W				3 W	3 W			<27
Bostwick	Kent	410322	*				33				55
Brace, Upper	Calhoun	130206					12				40
Bradford, Big	Otsego/Crawford	690036					3 W				<27
Brevoort	Mackinau	490036	15	14			12	14			40

APPENDIX 2
2010 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
Brooks	Leelanau	450222	13				8				34
Brown	Jackson	380477	10				15	11			43
Buckhorn (North Buckhorn)	Oakland	631113	22				11				39
Cedar	Alcona/Iosco	010017	8				8				34
Cedar	Van Buren	800241					12 H				40
Center	Osceola	670238	8				12				40
Chain	Iosco	350146	10				7				32
Chancellor (Blue)	Mason	530287	8				*				
Chemung	Livingston	470597	13				11				39
Christiana	Cass	140055					15				43
Clam	Antrim	050101	5				3 W				<27
Clark	Jackson	380173	10				8				34
Clear	Jackson	380453					7				32
Clear	Ogemaw	650042	8				10	7			37
Clifford	Montcalm	590142	26				15				43
Cobb	Barry	080259	5				g				
Corey	St. Joseph	750142	6				8				34
Cranberry	Oakland	631196	32				20				47
Crockery	Ottawa	700422					*				
Crooked	Kalamazoo	390599	13				16 H				44
Crooked, Big (E. Basin)	Van Buren	800483	13				8	9	9		34
Crooked, Little	Van Buren	800535	8				7		15		32
Crooked, North	Kalkaska	400133	8				16				44
Crooked, Upper	Barry	080071	12				15				43
Crystal	Benzie	100066					4 T				<27
Crystal	Montcalm	590105					12				40
Crystal	Oceana	640062	7				11	12			39
Cub	Kalkaska	400031	6				6				30

APPENDIX 2
2010 COOPERATIVE LAKES MONITORING PROGRAM
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)
Deer	Alger	020127	10	9			11				39
Deer	Oakland	631128	5				12 H				40
Derby	Montcalm	590144					11	9			39
Devils	Lenawee	460179	9 a				8				34
Diamond	Cass	140039	6				7 H				32
Diane	Hillsdale	300173	46				82				68
Dinner	Gogebic	270126	16 c				15				43
Duck	Calhoun	130172					10				37
Duncan	Barry	080096	113				g				
Eagle	Allegan	030259	14				12 H				40
Eagle	Cass	140057	9				11 H				39
Eagle	Kalkaska	400130	4 w				11				39
Earl	Livingston	470554	50				31				54
Emerald (Button)	Kent	410709	*				22	17			49
Evans	Lenawee	460309	10				9				36
Fair	Barry	080260	13				10 H				37
Farwell	Jackson	380454	*				6				30
Fenton	Genesee	250241	11				12				40
Fish	Van Buren	800461	10				21				48
Fisher (Big Fisher)	Leelanau	450224	7				3 w				<27
Five Lakes (Lake #2)	Otsego	690157	30				16				44
Five Lakes (Lake #3)	Otsego	690152	16				6				30
Fremont	Newaygo	620029	38				11				39
Freska	Kent	410702	18				17 e				45
Gallagher	Livingston	470210	18				22				49
George	Clare	180056	10				13				41
Glen (Big Glen)	Leelanau	450049	5				6				30
Glen, Little	Leelanau	450050	5				9	10			36

APPENDIX 2
2010 COOPERATIVE LAKES MONITORING PROGRAM
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)
Goshorn	Allegan	030650	39				90				69
Gourdneck	Kalamazoo	390541	12				13	13			41
Gratiot	Keweenaw	420030					9				36
Gravel	Van Buren	800271	3 w				8				34
Gull	Kalamazoo	390210	7	7	9		8				34
Hamburg	Livingston	470568	13				4 T				<27
Hamilton	Dickinson	220060	16								
Hamlin, Lower	Mason	530073	13				22				49
Hamlin, Upper	Mason	530074	17				36				56
Hess	Newaygo	620032	30	36			45				59
Hicks	Osceola	670062	16				21 c				48
Higgins (N. Basin)	Roscommon	720026	10				3 w	3 w			<27
Higgins (S. Basin)	Roscommon	720028	6				5				27
High	Kent	410703	d				22				49
Horsehead	Mecosta	540085	8				14		14		42
Houghton (Station 1)	Roscommon	720163					19				47
Houghton (Station 2)	Roscommon	720164					21				48
Hubbard	Alcona	010106	6				3 w				<27
Hutchins	Allegan	030203	10				11				39
Independence	Marquette	520149					9 f	10			36
Indian	Kalamazoo	390305					7				32
Indian	Kalkaska	400015	*				8				34
Indian	Osceola	670227	18	12			*				
Island	Grand Traverse	280164	8				9				36
Keeler	Van Buren	800482					12				40
Kimball	Newaygo	620107	*								
Klinger	St. Joseph	750136	4 T				15 d				43
Lakeville	Oakland	630670	10				25 H,c				51

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2010 COOPERATIVE LAKES MONITORING PROGRAM
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)
Lancelot	Gladwin	260104	8	7			24				50
Lancer	Gladwin	260116	5				18				46
Lansing	Ingham	330137	12				11				39
Lily	Clare	180066	11				*				
Little Long	Barry/Kalamazoo	080279	6	6	11	8 T	a, g				
Long	Gogebic	270179	6 H,c				10				37
Long	Iosco	350076	5				11				39
Long	Oakland	631118					11				39
Loon	Iosco	350078					*				
Magician	Cass	140065	3 W				8				34
Margrethe	Crawford	200157	6				4 T				<27
Mary	Iron	360071	10				14				42
Maston	Kent	410764	12	16	14						
Maynard	Alcona	010126					20				47
Mecosta	Mecosta	540057	d				12				40
Middle Straits	Oakland	630732	15				21				48
Mirror	Jackson	380478	13	14			30				53
Moon	Gogebic	270120	7				8	8			34
Mud	Jackson	380469	15				*				
Murray	Kent	410268	14				13				41
Muskellunge	Kent	410765	11		13						
Muskellunge	Montcalm	590154	b				16				44
Nepessing	Lapeer	440220	13	15			25				51
Okonoka	Wayne	821554	125				89				69
Opal	Otsego	690129	9				9	6			36
Ore	Livingston	470100					17				45
Orion	Oakland	630554	11				15 H				43
Osterhout	Allegan	030263	14				g				

APPENDIX 2
2010 COOPERATIVE LAKES MONITORING PROGRAM
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)
Oxbow	Oakland	630666	12				N				
Papoose	Kalkaska	400134	11				17 H, c				45
Parke	Oakland	631119	18				15	17			43
Pentwater	Oceana	640313	14				22				49
Perch	Iron	360046	16	16			26 c				51
Perch	Otsego	690150					b				
Perrin	St. Joseph	750314	12				11				39
Pickerel	Kalkaska	400035	*				5				27
Pickerel	Newaygo	620066	*								
Pleasant	Jackson	380244					6				30
Pleasant	Wexford	830183	11	11			11				39
Portage	St. Joseph	750313					24				50
Portage	Liv/Wash	810248	12				7				32
Portage (Big Portage)	Jackson	380245	7				10				37
Pretty	Mecosta	540079	6				11				39
Randall	Branch	120078					32	30			54
Rifle	Ogemaw	650022	4 w				13				41
Round	Clinton	190146	35				19	14			47
Round	Lenawee	460304	9				6				30
Round	Livingston	470546	20				11	9			39
Round	Mecosta	540073	d				14	13			42
Sand	Lenawee	460264					9				36
Sanford	Benzie	100208	8	6			13				41
School Section	Mecosta	540080	6				*				
Shavehead	Cass	140071	15	15			4 T	7			<27
Sherman	Kalamazoo	390382	11				13				41
Shinagaug	Genesee	250519					32				54
Shingle	Clare	180108	21				16				44
Silver (Green Oak)	Livingston	470589	10	9			5				27

APPENDIX 2
2010 COOPERATIVE LAKES MONITORING PROGRAM
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)
Silver	Van Buren	800534	13				6				30
Spider	Grand Traverse	280395					10				37
Squaw	Kalkaska	400135	20				14				42
Starvation	Kalkaska	400030	6				5				27
Stone Ledge	Wexford	830186	15				19				47
Stony	Oceana	640049	27	21			22				49
Strawberry	Livingston	470213	16				15				43
Stuart (Lower Brace)	Calhoun	130388					10				37
Sweezey	Jackson	380470	27				12				40
Taylor	Oakland	631114	19	16			10				37
Templene	St. Joseph	750322	21				14	12			42
Thornapple R.-Cascade Imp.	Kent	410686	*				53 H, f				61
Torch (N. Basin)	Antrim	050055	3 w				*				
Torch (S. Basin)	Antrim	050240	2 w				8				34
Triangle	Livingston	470591	14				15				43
Twin (Big Twin)	Kalkaska	400025	13				10				37
Twin, Little	Kalkaska	400013	11				9 c				36
Twin (Big Twin, North Twin)	Cass	140165	8				8 H				34
Twin (Little Twin, South Twin)	Cass	140166	10				g				
Twin, East	Montmorency	600013	8	11			8				34
Twin, West	Montmorency	600014	8				4 T				<27
Van Etten	Iosco	350201	27				25 c				51
Vaughn	Alcona	010049	*								
Viking	Otsego	690136	19				*				
Vineyard	Jackson	380263	9				10				37
Wahbememe	St. Joseph	750313	*				9				36
Webinguaw	Newaygo	620283					19				47
Wetmore	Allegan	030664					16 H				44

2010 COOPERATIVE LAKES MONITORING PROGRAM

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)
Wildwood	Cheboygan	160230	18				21				48
Windover	Clare	180069	9				7				32
Wolf	Lake	430026					*				
Woods	Kalamazoo	390542	22				22 H				49

Results Codes:

* No sample received or received too late to process.

H Recommended laboratory holding time was exceeded.

N Non-homogeneous sample made analysis of sample questionable.

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)

a Used ink that ran on label

b Sample rejected - not frozen when received

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

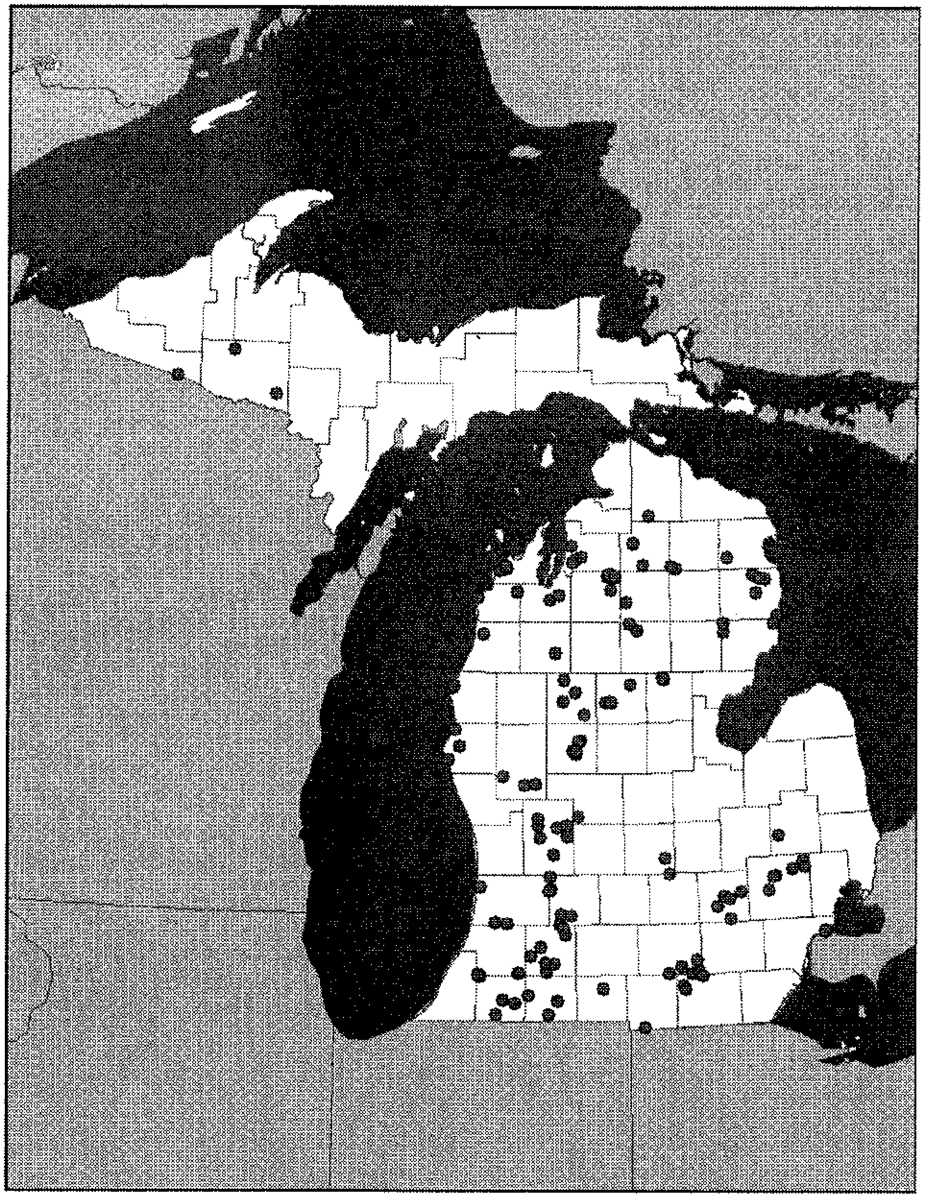
d Sample received late; greatly exceeding holding time limits

e Date on label did not match data form

f No data form submitted

g Sample destroyed after submission - lab handling error

Appendix 3
2010 Cooperative Lakes Monitoring Program
Chlorophyll Results



Map above shows the distribution of the 124 lakes enrolled in Chlorophyll monitoring in the 2010 CLMP Program.

Recorded Chlorophyll Values:

Spring Mean:	4.8 μg/l
Minimum:	<1 μg/l
Maximum:	160.0 μg/l (Goshorn Lake, Allegan Co.)

APPENDIX 3
2010 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}
Ann	Benzie	100082	1.0	1.4	1.1	1.9	1.5	1.4	1.4	0.4	34
Arbutus	Grand Traverse	280109	1.0<	1.5	1.8	2.0	2.4	1.6	1.8	0.7	36
Arnold	Clare	180107	1.1	1.0<	3.1	*	*				
Vol/Rep					3.1						
MDNRE					2.8						
MDNRE/Rep					2.8						
Badger	Alcona	010122	18.0	20.0	11.0	14.0	9.8	14.6	14.0	4.4	57
Balwin	Montcalm	590171	5.0	5.9	19.0	8.0	16.0	10.8	8.0	6.3	51
Vol/Rep				6.8							
Barlow	Barry	080176	1.0<	2.7	2.5	2.7	3.0b	2.3	2.7	1.0	40
Barton	Kalamazoo	390215	*	5.9	3.2	4.8	5.8b	4.9	5.3	1.3	47
Bear	Alcona	010125	3.0	1.2	2.1	2.7	1.8	2.2	2.1	0.7	38
Bear	Kalkaska	400026	1.0<	1.0	1.3	1.4	2.3	1.3	1.3	0.7	33
Bear	Manistee	510122	1.0<	2.3	3.1	3.1	5.0	2.8	3.1	1.6	42
Beaver	Alpena	040097	1.7	1.3	1.3	1.5	*	1.5	1.4	0.2	34
Bellaire	Antrim	050052	1.0<	1.5	1.3	1.8	2.2	1.5	1.7	0.6	35
Big	Osceola	670056	*	1.4a	1.7a	2.6	3.9	2.4	2.2	1.1	38
MDNRE							3.7				
MDNRE/Rep							3.7				
Big Pine Island	Kent	410437	4.2a	7.8a	5.2a	15.0	12.0	8.8	7.8	4.6	51
Bills (Waits)	Newaygo	620311	1.7	1.1	2.3	2.1	2.3	1.9	2.1	0.5	38
Birch (Russwurm/Dugan)	Cass	140187	1.4b	2.2b	2.1	2.2	2.5	2.1	2.2	0.4	38
Birch (Temple)	Cass	140061	1.0	1.6	3.3	1.8	3.0	2.1	1.8	1.0	36
Blue	Mecosta	540092	2.5	2.7	2.9	2.8	1.0<	2.3	2.7	1.0	40
Blue (Big Blue)	Kalkaska	400016	2.1	1.5	1.0<	1.3	1.6	1.4	1.5	0.6	35
Blue, North	Kalkaska	400131	1.0<,a	1.0<,ab	1.0<,a	1.0<	1.0<	0.5	0.5	0.0	<31
Blue Heron	Wayne	821552	*	1.0<,b	*	1.0<,b	1.0<				

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2010 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}
Bostwick	Kent	410322	2.0	4.5	5.1	6.0	6.0	4.7	5.1	1.6	47
Brooks	Leelanau	450222	10.0	16.0	18b	11.0	9.8	13.0	11.0	3.8	54
Vol/Rep				15.0							
Cedar	Alcona/Iosco	010017	2.6	1.0<	5.3	3.4	4	3.1	3.6	1.8	43
Cedar	Van Buren	800241	1.0<	6.5	3.4	3.8	4.3	3.7	3.8	2.2	44
Chain	Iosco	350146	1.7	4.9	5.1	3.7	3.4	3.8	3.7	1.4	43
Chemung	Livingston	470597	1.0<,b	5.8b	5.3b	c	9.1	5.2	5.6	3.5	47
Clam	Antrim	050101	1.0<	1.0<	1.7	2.0	1.6	1.3	1.6	0.7	35
Clark	Jackson	380173	1.0	1.7	3.3	2.7	3.1	2.4	2.7	1.0	40
Vol/Rep					3.6						
Cobb	Barry	080259	1.0<	1.0<	2.3	2.6	7.0	2.6	2.3	2.7	39
Corey	St. Joseph	750142	1.4	3.2	2.2	3.3	1.3	2.3	2.2	1.0	38
Cranberry	Oakland	631196	1.8	2.0	*	2.1	7.8	3.4	2.1	2.9	38
Crooked	Kalamazoo	390599	1.5	1.7	4.8	12.0	3.9	4.8	3.9	4.3	44
Crooked, Big (E. Basin)	Van Buren	800483	4.0	3.8	2.9	3.2	2.8	3.3	3.2	0.5	42
MDNRE							2.6				
MDNRE/Rep							2.6				
Crooked, Little	Van Buren	800535	3.3	4.9	2.9	3.0	3.5	3.5	3.3	0.8	42
MDNRE							3.6				
MDNRE/Rep							3.6				
Crooked, Upper	Barry	080071	3.3	6.3	4.0	4.8	3.3b	4.3	4.0	1.3	44
Crystal	Oceana	640062	3.0	18.0	4.6	4.8	12.0	8.5	4.8	6.4	46
Crystal	Benzie	100066	*	*	*	*	*				
Deer	Alger	020127	2.6b	1.5	2.6	3.9	3.7	2.9	2.6	1.0	40
Deer	Oakland	631128	1.0<	1.0<	1.0<	1.4	1.8b	0.9	0.5	0.6	<31
Devils	Lenawee	460179	1.0<	4.7	3.5	1.0<	3.9	2.6	3.5	2.0	43
Diane	Hillsdale	300173	23.0	17b	36.0	26.0	23.0	25.0	23.0	7.0	61

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2010 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)								
Diamond	Cass	140039	1.0<	1.1	5.6	c	1.0<	1.9	0.8	2.5	<31
Vol/Rep							2.3				
Duncan	Barry	080096	2.8	1.5	31.0	23.0	27.0b	17.1	23.0	13.9	61
Vol/Rep						6.3					
Eagle	Cass	140057	1.0<	3.3	6.3	6.4	9.0	5.1	6.3	3.3	49
Eagle	Kalkaska	400130	1.2	1.6	1.0<	4.0	1.0<	1.6	1.2	1.4	32
Eagle	Allegan	030259	1.2	1.1	3.3	12.0	4.5	4.4	3.3	4.5	42
Earl	Livingston	470554	9.5	10.0	5.6	3.0	16.0	8.8	9.5	4.9	53
Emerald (Button)	Kent	410709	1.5	3.2	7.3	13.0	6.5	6.3	6.5	4.4	49
Evans	Lenawee	460309	1.0<	2.3	3.1	3.3	3.3	2.5	3.1	1.2	42
Fair	Barry	080260	1.6	4.1b	3.1	6.8	2.3	3.6	3.1	2.0	42
Fisher (Big Fisher)	Leelanau	450224	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Five Lakes (Lake #2)	Otsego	690157	4.8	2.0	2.4	1.0<	1.0<	2.0	2.0	1.8	37
Five Lakes (Lake #3)	Otsego	690152	1.0<	1.5	1.0	1.0<	f	0.9	0.8	0.5	<31
Fremont	Newaygo	620029	1.4	4.5	1.8	4.2	2.0	2.8	2.0	1.5	37
MDNRE				5.3							
MDNRE/Rep				5.6							
Freska	Kent	410702	4.1	4.0	9.8	3.0	3.4	4.9	4.0	2.8	44
Vol/Rep			3.5								
George	Clare	180056	2.2	2.8	3.5	4.7	3.3	3.3	3.3	0.9	42
Glen (Big Glen)	Leelanau	450049	1.3	*	1.0<	1.0<	1.0	0.8	0.8	0.4	<31
Glen, Little	Leelanau	450050	1.0<	*	1.3	1.7	1.3	1.2	1.3	0.5	33
Goshorn	Allegan	030650	25.0	15.0	28.0	60.0	160.0	57.6	28.0	59.7	63
Gourdneck	Kalamazoo	390541	1.0	1.4	5.9	5.7	7.4	4.3	5.7	2.9	48
Gull	Kalamazoo	390210	1.0<	1.0<	1.6	2.9	3.0	1.7	1.6	1.2	35
Hamlin, Lower	Mason	530073	2.7	1.7	2.0	2.6	1.0	2.0	2.0	0.7	37
Hamlin, Upper	Mason	530074	1.7	3.2	4.8	18.0	2.1	6.0	3.2	6.8	42

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CHLOROPHYLL RESULTS

Lake	County	Site ID Number	Chlorophyll *a* (µg/L) May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Hess	Newaygo	620032	9.9	14.0	4.9	4.7	6.1	7.9	6.1	4.0	48
Hicks	Osceola	670062	7.0	21.0	17.0	16.0	*	15.3	16.5	5.9	58
Higgins (N. Basin)	Roscommon	720026	*	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Higgins (S. Basin)	Roscommon	720028	*	1.0<	1.0<	1.0<	1.2	0.7	0.5	0.4	<31
High	Kent	410703	4.7	3.4	5.3	7.4	5.7	5.3	5.3	1.5	47
Horsehead	Mecosta	540085	1.1	1.8	5.4	5.3	3.8	3.5	3.8	2.0	44
MDNRE							3.1				
MDNRE/Rep							3.4				
Hubbard	Alcona	010106	1.0<	1.2	1.0<	1.8	1.6	1.1	1.6	0.6	32
Indian	Kalamazoo	390305	1.0<	*	3.6	2.3	1.5	2.0	1.9	1.3	37
Indian	Kalkaska	400015	*	2.9	2.6	2.5	2.4	2.6	2.6	0.2	40
Indian	Osceola	670227	2.2	1.9	3.1	4.7	4.1	3.2	3.1	1.2	42
Island	Grand Traverse	280164	1.0<	1.2	2.6	2.1	2.3	1.7	2.1	0.9	38
Klinger	St. Joseph	750136	1.2	1.0<	3.6	2.9	2.0	2.0	2.0	1.3	37
Lakeville	Oakland	630670	1.7	1.0<	2.5	3.5	6.0b	2.8	2.5	2.1	40
Lancelot	Gladwin	260104	2.1	5.3	2.2	7.8	11.0	5.7	5.3	3.8	47
Vol/Rep					1.6						
Lancer	Gladwin	260116	1.0<	1.3	3.1	3.4	1.3	1.9	1.3	1.3	33
Lansing	Ingham	330137	3.6	1.3	5.0	5.8	3.1	3.8	3.6	1.7	43
Little Long	Barry/Kalamazoo	080279	1.0<	2.2	2.4b	2.7	3.7b	2.3	2.4	1.2	39
Long	Iosco	350076	1.0<	1.0<	3.1	2.3	2.6	1.8	2.3	1.2	39
Magician	Cass	140065	7.1	1.0<	1.0<	4.1	2.3	2.9	2.3	2.8	39
Margrethe	Crawford	200157	1.0<	1.0<	2.9	2.9	2.9	1.9	2.9	1.3	41
Mary	Iron	360071	1.0	1.8	1.6	4.4	4.7	2.7	1.8	1.7	36
Vol/Rep						4.8					
Maynard	Alcona	010126	4.3	8.5b	13.0	16.0	9.9	10.3	9.9	4.4	53
Mecosta	Mecosta	540057	1.0<	1.0<	2.9	3.6	3.8	2.3	2.9	1.6	41

APPENDIX 3
2010 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)								
Mirror	Jackson	380478	*	*	*	*	*				
Moon	Gogebic	270120	1.4	2.2	2.7	3.3	7.1	3.3	2.7	2.2	40
Mud	Jackson	380469	a,c	1.6a	2.6a	5.4	*				
Murray	Kent	410268	1.2	1.2	4.9	2.3b	4.3	2.8	2.3	1.7	39
Nepessing	Lapeer	440220	1.7	3.4	3.7	11.0	6.9	5.3	3.7	3.7	43
Okanoka	Wayne	821554	1.0<	1.7b	*	5.3b	8.1	3.9	3.5	3.5	43
Orion	Oakland	630554	1.0<	1.5	3.5	1.2	1.3	1.6	1.3	1.1	33
Vol/Rep						1.0<					
Osterhout	Allegan	030263	2.7	5.6	5.1	3.5	2.2	3.8	3.5	1.5	43
Oxbow	Oakland	630666	*	*	*	*	*				
Parke	Oakland	631119	1.0<	1.0<	1.5	3.8	3.3	1.9	1.5	1.6	35
Pentwater	Oceana	640313	9.4	8.6	25.0	26.0	36.0	21.0	25.0	11.8	62
Perch	Iron	360046	1.2	2.9	3.1	9.0	6.5b	4.5	3.1	3.1	42
Pleasant	Wexford	830183	*	*	3.5	4.2	4.3				
Pretty	Mecosta	540079	1.1	1.5	2.9	2.5	3.4	2.3	2.5	1.0	40
Randall	Branch	120078	*	7.6	6.9	14.0	12.0	10.1	9.8	3.4	53
Round	Clinton	190146	2.9	11.0	6.0	4.7	9.2	6.8	6.0	3.3	48
Round	Lenawee	460304	1.0<	1.0<	2.7	2.8b	2.6	1.8	2.6	1.2	40
Round	Livingston	470546	4.3	5.9	11.0	12.0	11.0	8.8	11.0	3.5	54
Vol/Rep				7.1							
Round	Mecosta	540073	2.2	5.0	4.4	3.5	7.8	4.6	4.4	2.1	45
School Section	Mecosta	540080	d	d	d	*	*				
Sherman	Kalamazoo	390382	2.4	3.9	3.4	7.4	5.8	4.6	3.9	2.0	44
Shingle	Clare	180108	4.7	6.4	5.8	4.3	3.2	4.9	4.7	1.3	46
Stony	Oceana	640049	4.5	8.1	13.0	8.1	17.0	10.1	8.1	4.9	51
Strawberry	Livingston	470213	1.7	1.4	4.5	12.0	5.2	5.0	4.5	4.3	45
Sweezey	Jackson	380470	1.0<	1.0<	1.0	1.8	1.0	1.0	1.0	0.5	31

APPENDIX 3
2010 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}
Templene	St. Joseph	750322	1.0<	1.0<	1.4	1.3	1.0<	0.8	0.5	0.5	<31
Vol/Rep			1.0<								
Thornapple R.-Cascade Imp.	Kent	410686	4.9a	7.3a	18.0a	44.0a	14.0a	17.6	14.0	15.6	57
Torch (N. Basin)	Antrim	050055	*	*	1.0<	*	*				
Torch (S. Basin)	Antrim	050240	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Triangle	Livingston	470591	1.0<	5.3	2.6	27.0	3.7	7.8	3.7	10.9	43
Twin (Big Twin, North Twin)	Kalkaska	400012	1.0<	1.0<	1.5	1.7	2.1	1.3	1.5	0.7	35
Twin (Little Twin, South Twin)	Kalkaska	400013	c	*	1.0	1.6	1.0<,b				
Twin, East	Montmorency	600013	9.6	5.1	f	3.9	5.5	6.0	5.3	2.5	47
Twin, West	Montmorency	600072	2.6	2.5	3.9	2.6	3.5	3.0	2.6	0.6	40
Van Etten	Iosco	350201	2.6	1.8	3.8	11.0	2.3	4.3	2.6	3.8	40
Viking	Otsego	690136	11.0	7.2	*	9.8	f				
Vineyard	Jackson	380263	1.0<	1.7	3.6	2.3	1.9	2.0	1.9	1.1	37
Windover	Clare	180069	1.0<	4.6b	7.7	4.0	1.9	3.7	4.0	2.8	44
Wildwood	Cheboygan	160230	2.3	1.7	1.0	4.7b	4.9	2.9	2.3	1.8	39
Vol/Rep							3.0				
Woods	Kalamazoo	390542	1.0<	1.0<	2.9	18.0	11.0b	6.6	2.9	7.7	41
MDNRE						18					
MDNRE/Rep						17					

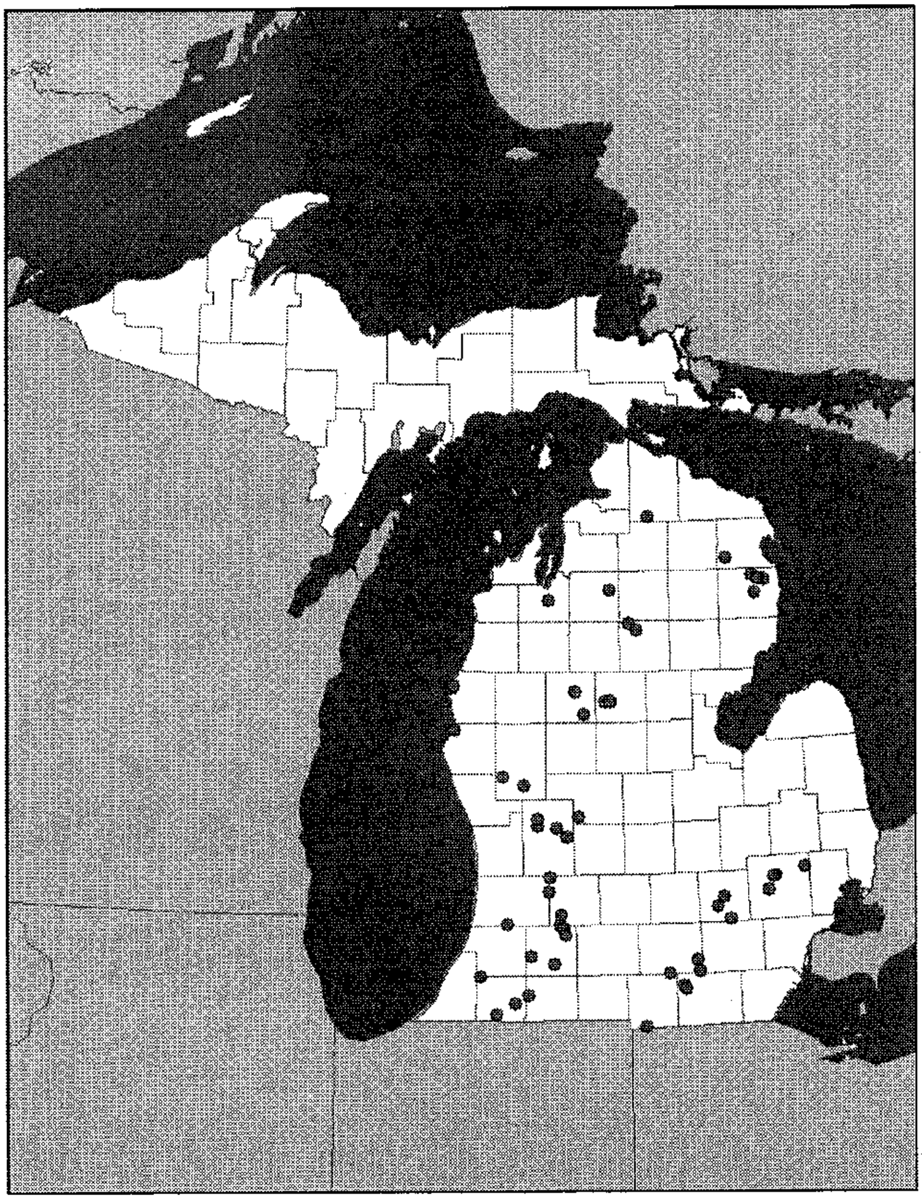
APPENDIX 3
2010 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

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

Results Codes:

< Sample value is less than limit of quantification (1 ug/l)
* No sample received
a No data sheet submitted with sample
b Sample not collected within the designated sampling window
c Sample not collected at proper time - sample not processed
d Sample poorly or not covered by aluminum foil - sample not processed
e Dates on field sheet and vial labels do not match
f Separator sheets used instead of filter - sample not processed
g No MgCO3 used to preserve the sample
x No filter; received vial filled with water

Appendix 4
2010 Cooperative Lakes Monitoring Program
Dissolved Oxygen and Temperature Results



Map above shows the distribution of the 44 lakes enrolled in Dissolved Oxygen and Temperature monitoring in the 2010 CLMP Program.

APPENDIX 4
2010 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Alcona	Badger Lake Bear Lake Hubbard Lake Maynard Lake
Allegan	Eagle Lake
Alpena	Beaver Lake
Barry	Cobb Lake Duncan Lake Little Long Lake
Cass	Birch Lake Eagle Lake Magician Lake
Cheboygan	Wildwood Lake
Clare	Windover Lake
Grand Traverse	Arbutus Lake
Jackson	Mirror Lake Mud Lake Sweezey Lake
Kalamazoo	Crooked Lake Gull Lake Indian Lake Sherman Lake
Kalkaska	Bear Lake
Kent	Bostwick Lake Freska Lake Murray Lake
Lenawee	Devils Lake Round Lake
Livingston	Earl Lake Strawberry Lake Triangle Lake

County	Participating Lakes
Mason	Lower Hamlin Lake Upper Hamlin Lake
Newaygo	Fremont Lake Hess Lake
Oakland	Cranberry Lake Deer Lake Oxbow Lake Parke Lake
Oceana	Pentwater Lake
Osceola	Big Lake Hicks 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 high quality oligotrophic lake with a moderate hypolimnion volume. The lake retains some oxygen in the hypolimnion through the entire summer. By late summer, the dissolved oxygen levels drop, but the hypolimnion never becomes devoid of oxygen.

The third pattern is of a good quality mesotrophic lake with a moderate hypolimnion volume. This lake keeps some dissolved oxygen in the hypolimnion into mid-summer, but by late summer the entire hypolimnion is devoid of oxygen.

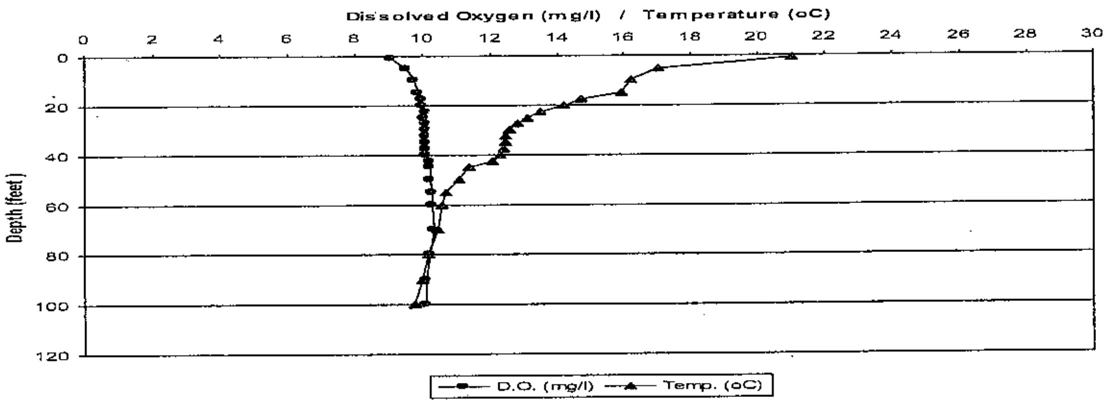
The fourth pattern is a meso/eutrophic lake with a moderate size hypolimnion. Within a few weeks of spring overturn the hypolimnion has lost all oxygen. This anaerobic condition persists all summer.

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

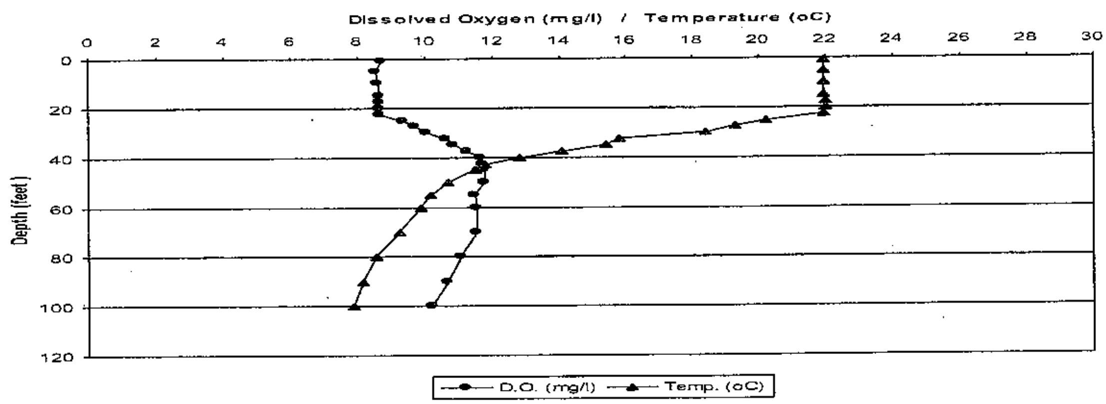
Oligotrophic Lake with a Very Large Volume Hypolimnion

Higgins Lake in Roscommon 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.

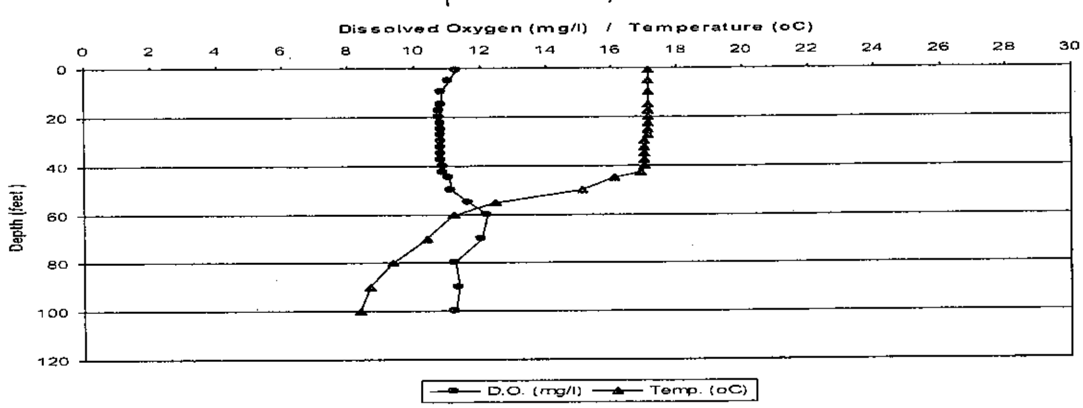
May 28, 2010



July 19, 2010



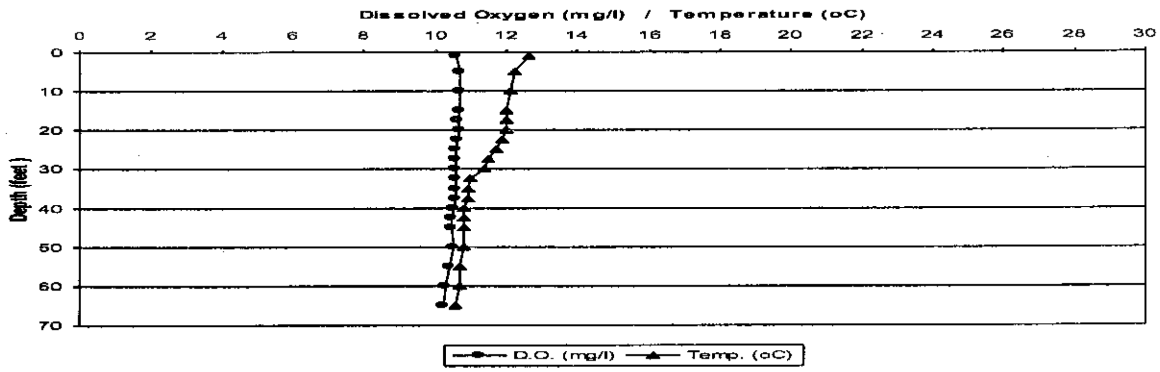
September 19, 2010



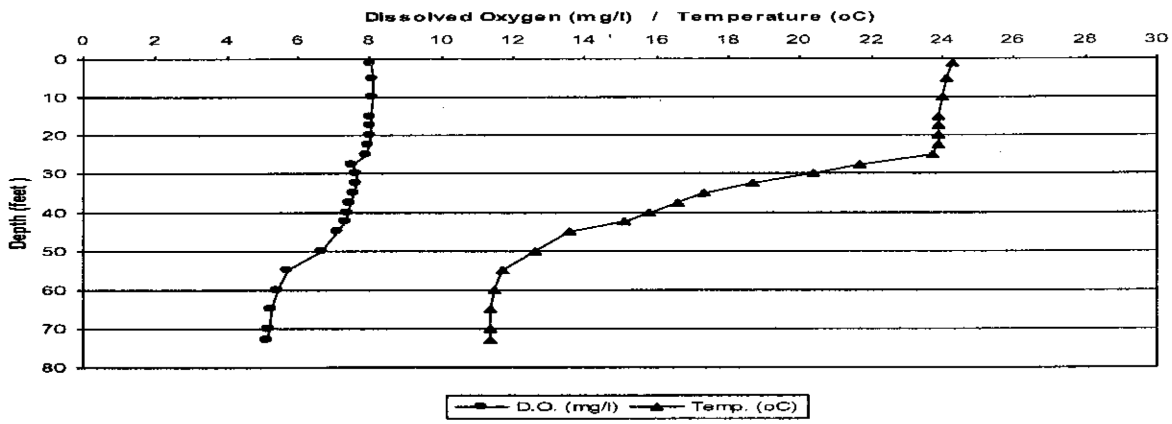
Oligotrophic Lake with a Moderate Volume Hypolimnion

Hubbard Lake in Alcona County is an oligotrophic lake with a moderate hypolimnion. As an oligotrophic lake, it produces less organic material that must be decomposed (as compared to a mesotrophic or eutrophic lake). Its 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 most of the summer. By late summer (September) there is enough organic matter decomposing to reduce oxygen in the hypolimnion, but the hypolimnion is never completely anaerobic.

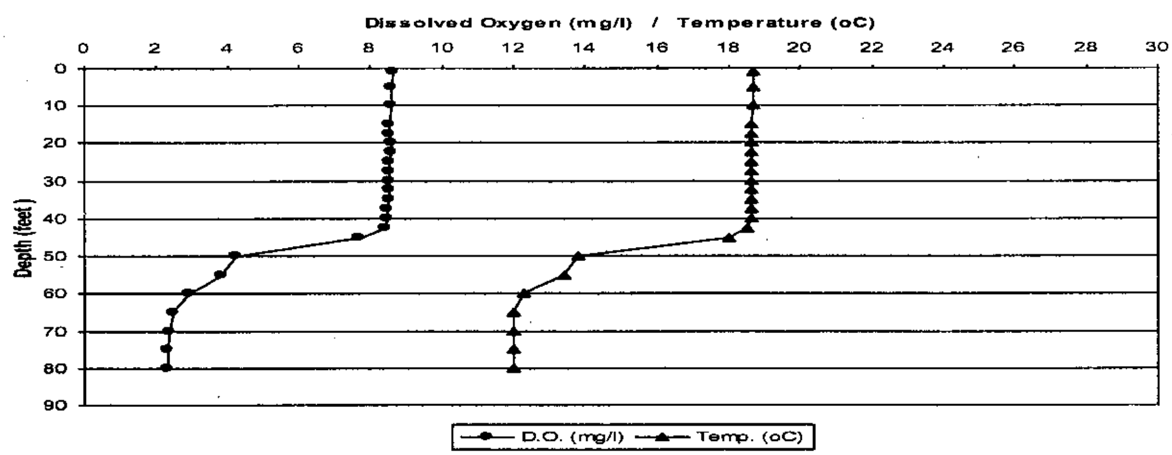
May 17, 2010



July 29, 2010

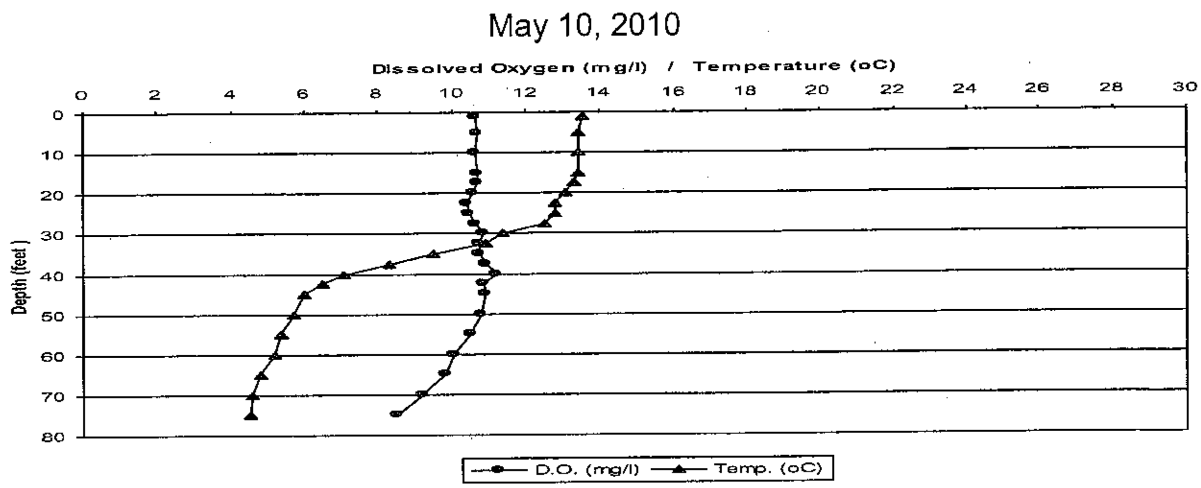


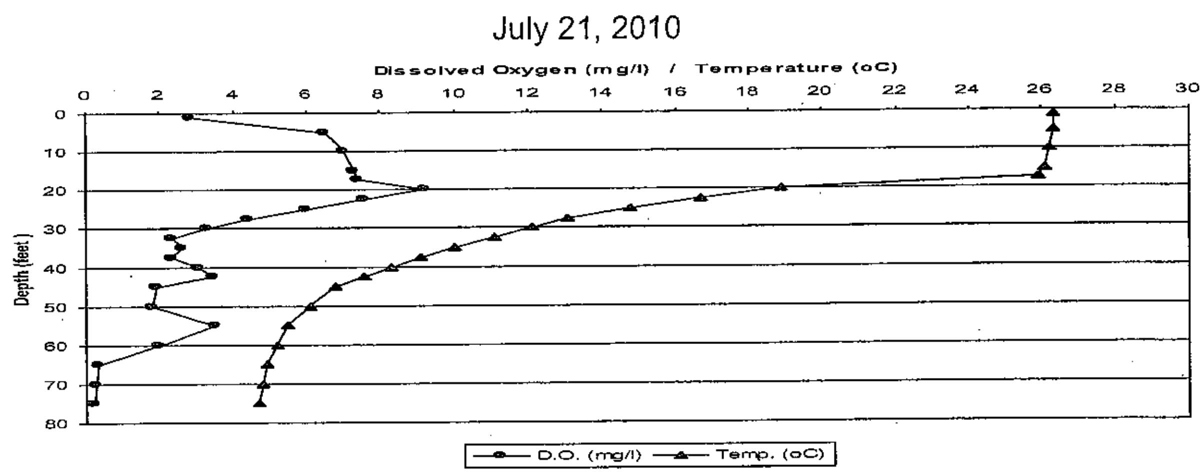
September 10, 2010

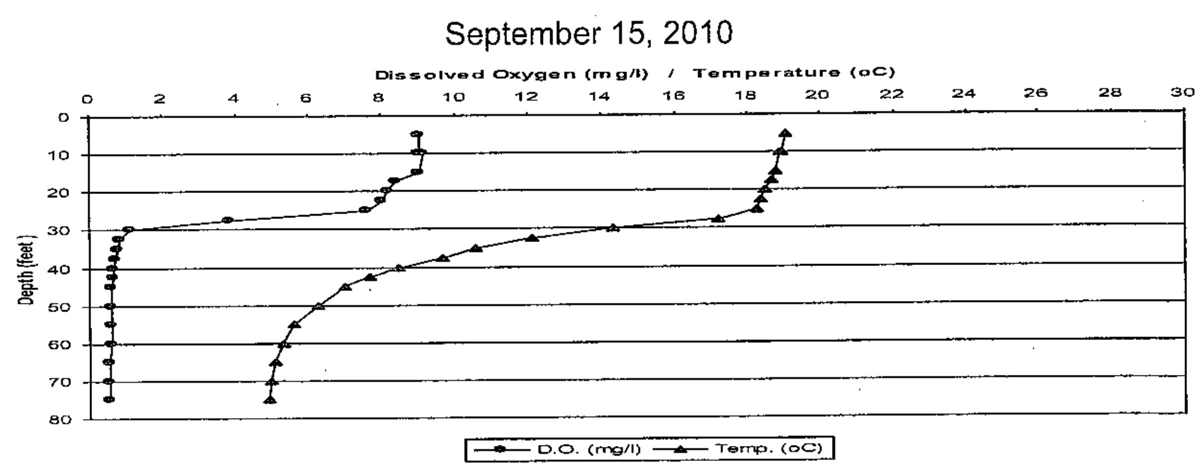


Mesotrophic Lake with a Moderate Volume Hypolimnion

Corey Lake in St. Joseph County is a mesotrophic lake with a moderate volume hypolimnion. As a mesotrophic lake, it produces moderate amounts of organic material that must be decomposed. Its hypolimnion has a moderate 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 into mid-summer, but by August oxygen is gone in the deepest waters, and by late-summer (September) the entire hypolimnion is without oxygen.



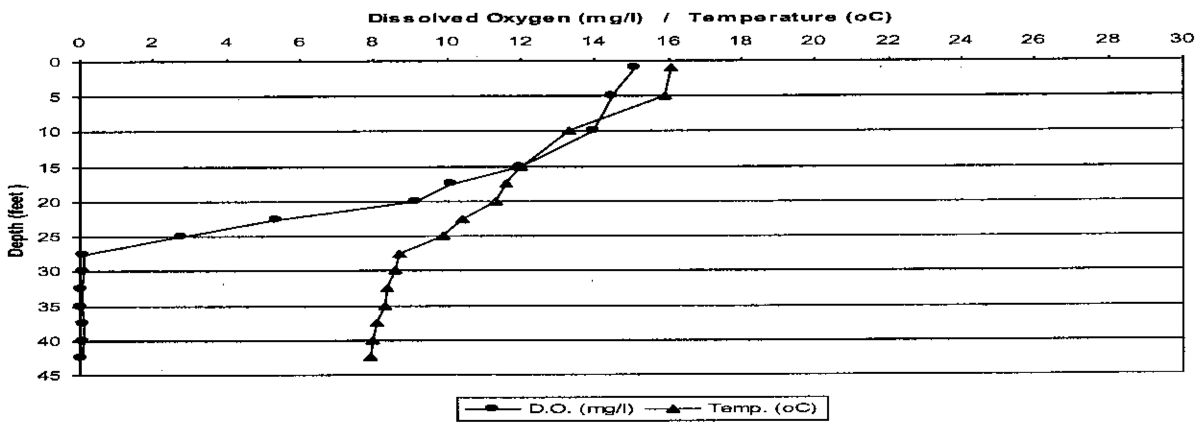




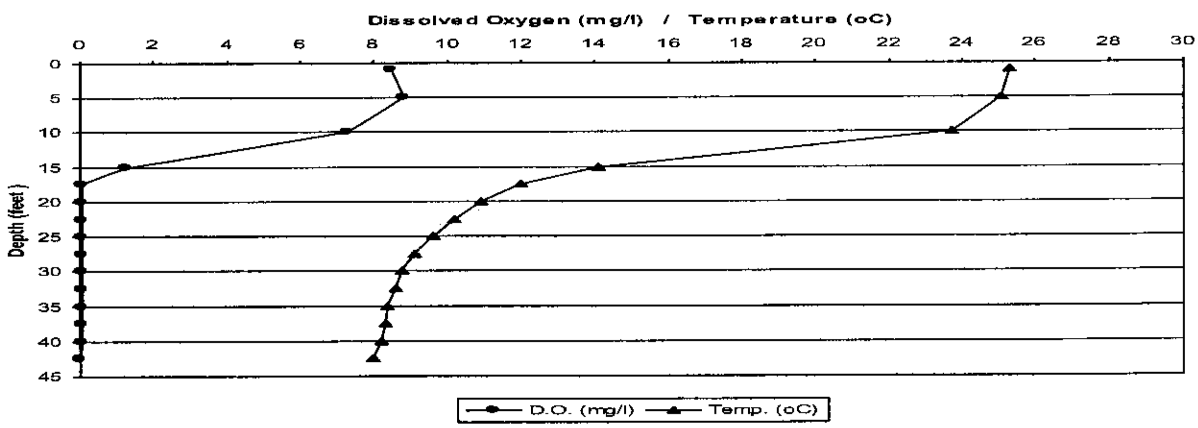
Mesotrophic/Eutrophic Lake with a Moderate Volume Hypolimnion

Badger Lake in Alcona County is a borderline mesotrophic/eutrophic lake with a moderate 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.

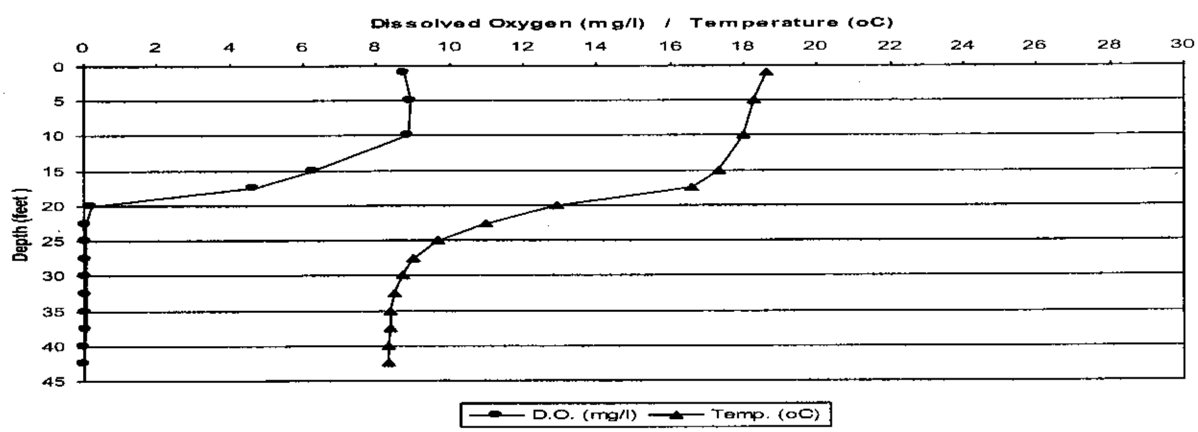
May 15, 2010



July 21, 2010



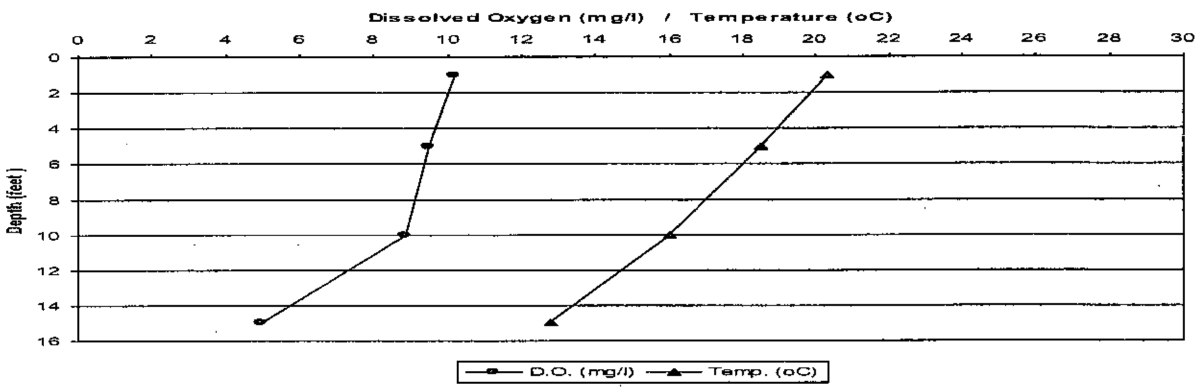
September 15, 2010



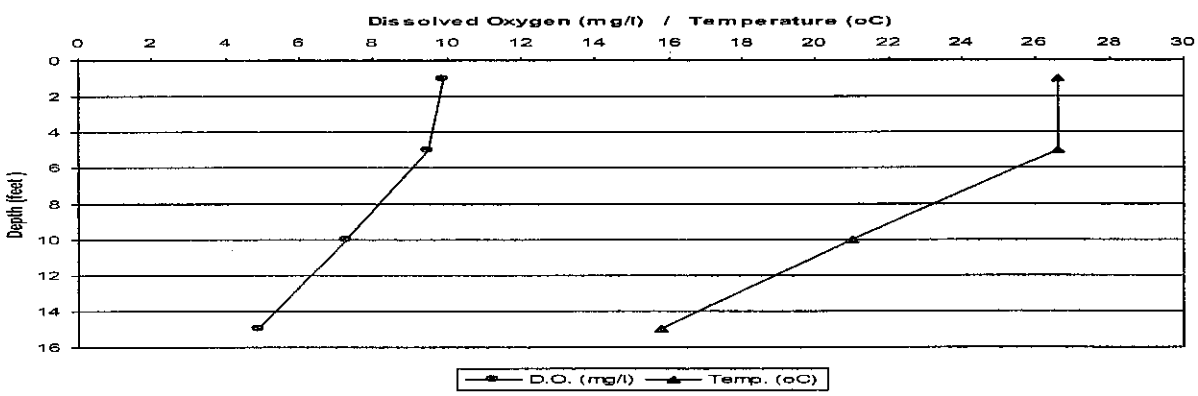
Shallow Mesotrophic Lake that does not maintain Summer Stratification

Cranberry Lake in Oakland 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.

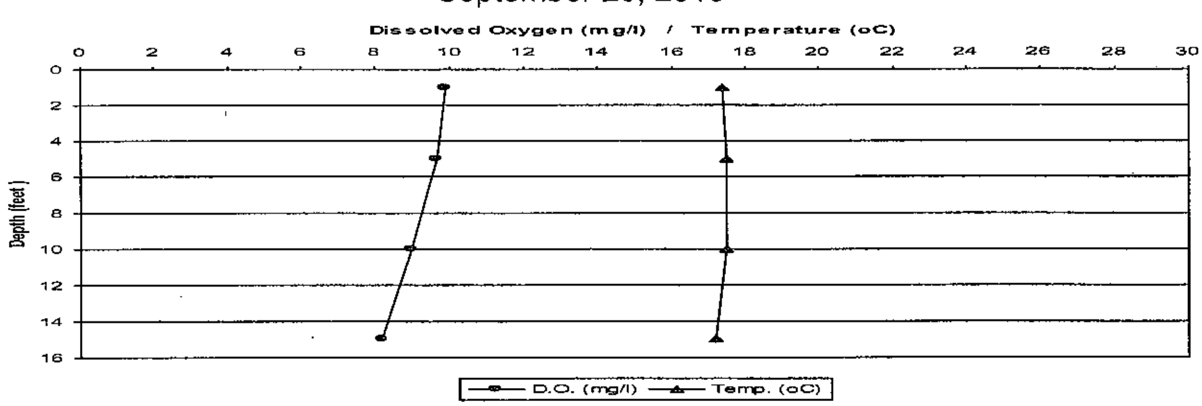
May 20, 2010



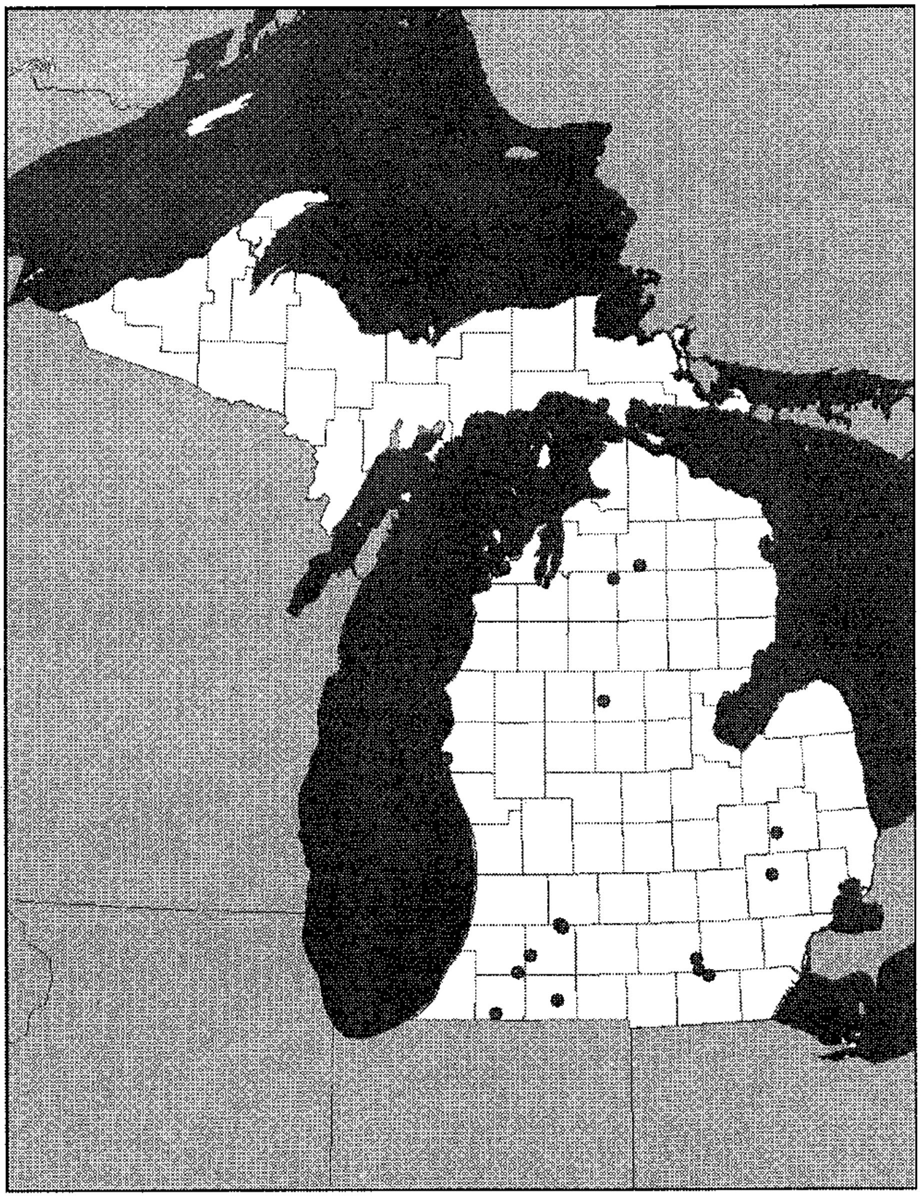
June 20, 2010



September 20, 2010



Appendix 5
2010 Cooperative Lakes Monitoring Program
Exotic Aquatic Plant Watch – Pilot Program

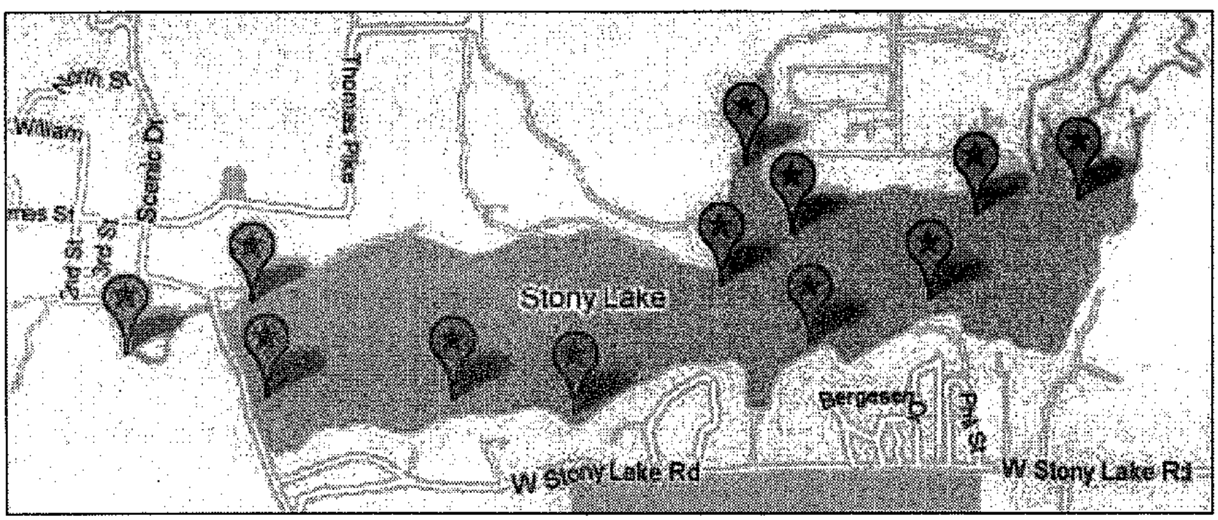


Map above shows the distribution of the 20 lakes enrolled in Exotic Aquatic Plant Watch pilot program in the 2010 CLMP Program.

APPENDIX 5
2010 COOPERATIVE LAKES MONITORING PROGRAM
EXOTIC AQUATIC PLANT WATCH RESULTS

County	Participating Lakes
Barry/Kalamazoo	Little Long Lake
Cass	Eagle Lake
Jackson	Sweezey Lake
Leelanau	Brooks Lake Fisher Lake Glen Lake Little Glen Lake
Oceana	Stony Lake

Twenty lakes enrolled in the 2010 CLMP Exotic Aquatic Plant Watch, a pilot program for the CLMP. Of those enrolled, eight 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 using Google Maps.

Stony Lake Exotic Plant Watch 2010

Exotic Plants found in Stony Lake, Oceana County, Benona & Claybanks Townships, Michigan (Field ID# 640049)

NOTE: Herbicide spraying at selected sites June 21 and August 19. Harvesting at selected sites July 10-11. Standard Aquatic Vegetation Survey conducted by Progressive AE on July 20.

- 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.

East End Marsh

- 43.33761 / 86.28069
- June 7 CLPW dense; June 30, brown and dying; July 28 gone. August 3-4 coming back--common.

Bootleggers Cottage

- 43.56230 / 86.47173
- August 3-4 EWMF in two spots, sparse, scattered among dense water stargrass and wild celery. September 28 found.

Stony Acres Point

- 43.56190 / 86.47730
- June 7 EWMF common; July 1 mostly dying; July 28 return sparse among stargrass, elodea, wild celery. September 28 EWMF common in small patch east of dock.

Green Point Bayou

- 43.56321 / 86.47826
- June 27 CLPW common throughout bay, gone by mid-July. EWMF found. September 28 EWMF sparse among diverse mix of native milfoil, elodea, coontail and water crowfoot (buttercup).

Green Point

- 43.56059 / 86.47951
- July 6 CLPW sparse

Public Swimming Dock

- 43.55950 / 86.49637 (east side) 43.55910 / 86.49641 (west side)
- July 7 EWMF dense on west side, sparse on east. Harvested on July 10-11 without first knocking back with herbicide. Also sparse CLPW on both. October 11 EWMF dense around SW corner of dock; CLPW found.

West End

- From Robinwood 43.55893 / 86.49658 to just north of public fishing dock: 43.55803 / 86.49623
- July 7 EWMF sparse all along shore; CLPW found; August 13 EWMF sparse.

Yurt Cottage to Chandler Cottages

- 43.55691 / 86.49144 to 43.55710 / 86.48559
- August 13 EWMF found, scattered through stargrass and pondweed.

Larmore Bay

- 43.55662 / 86.48473
- July 14 EWMF found; August 13 gone.

Lutheran Camp

- 43.55850 / 86.47612
- September 9 EWMF found.

SE shore

- From the Lutheran Beach to the SE corner, 43.55891 / 86.47077 (boat launch).
- September 9 EWMF sparse. September 28 EWMF sparse among dense native milfoil, others.

Stony Creek Dam

- 43.55934 / 86.49841
- August 6 EWMF just upstream of dam at shoreline.