MI/DEQ/WB-10/003

COOPERATIVE LAKES MONITORING PROGRAM

Michigan's Citizen Volunteer Partnership for Lakes

"MI Lakes - Ours to Protect"

ANNUAL SUMMARY REPORT

2009

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 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

TABLE OF CONTENTS

DATA CORRECTIONS FROM PREVIOUS REPORTS

The Site ID Number for Clark Lake, Jackson Co. in the Total Phosphorus Results (Appendix 2) should be reported as 380173.

The Result Code "k" in the Total Phosphorus Results (Appendix 2) should be defined as: Sample collected outside sampling window.

The reported 2008 Secchi disk transparency results (Appendix 1) for Arbutus 1 and Arbutus 3 were switched. The corrected listing for the Arbutus Lake sites is as follows:

			Secchi Disk Transparency (feet)						**Carlson**
Lake	**County**	**Site ID**	Number of	Range				Standard	**TSI_{SD}**
		Number	Readings	Min	Max	Mean	Median	Deviation	(transparency)
Arbutus 1	Grand Traverse	280396	18	12	12.5	12.3	12.5	0.24	<41
Arbutus 2	Grand Traverse	280109	18	12	37	19.3	16.0	7.53	34
Arbutus 3	Grand Traverse	280108	18	12	28	17.8	15.5	5.29	36
Arbutus 4	Grand Traverse	280397	18	12	28	17.2	15.5	4.88	36
Arbutus 5	Grand Traverse	280398	18	10	20	13.6	13.0	2.64	39

The County, Site ID Number and Chlorophyll Results (Appendix 3) listed for Kimball and Klinger Lakes were switched. The corrected listing for Kimball and Klinger Lakes is as follows:

		Site ID	**Chlorophyll *a* (mg/L)**							**Std.**	**Carlson**
Lake	**County**	**Number**	**May**	**June**	**July**	**Aug**	**Sept**	**Mean**	**Median**	**Dev.**	**TSI_{CHL}**
Kimball	Newaygo	620107	3.5	8.2	8.2	5.3	8.8	6.8	7.5	1.9	50
Klinger	St. Joseph	750136	1.5	1.0	3.8	3.5	2.9	2.5	2.7	1.0	40

If you believe that the tabulated data for your lake in this Report are in error please contact Ralph Bednarz, CLMP program coordinator by telephone at 517-335-4211 or email at bednarzr@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

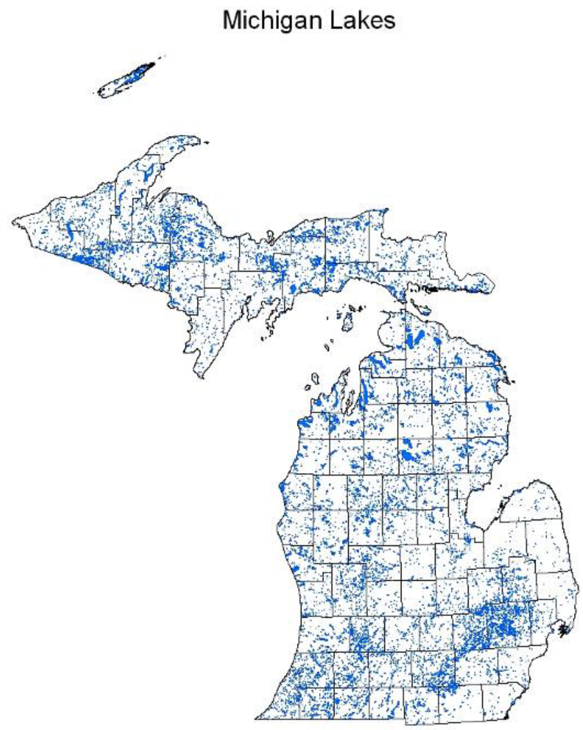
Michigan's unique geographical location provides its citizens with a wealth of freshwater resources including over 11,000 inland lakes. In addition to being valuable ecological resources, lakes provide aesthetic and recreational value for the people of Michigan and neighboring states. An ideal Michigan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

CLMP Contacts

Michigan Lake and Stream Associations, Inc.
306 E. Main St.
Stanton, MI 48888
989-831-5100
http://www.mlswa.org

Michigan Department of Natural Resources & Environment
P.O. Box 30273
Lansing, MI 48909-7773
Telephone: 517-335-4211
http://www.michigan.gov/dnre

Michigan Clean Water Corps c/o Great Lakes Commission
2805 South Industrial Hwy.
Suite 100
Ann Arbor, MI 48104-6791
Telephone: 734-971-9135
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.

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

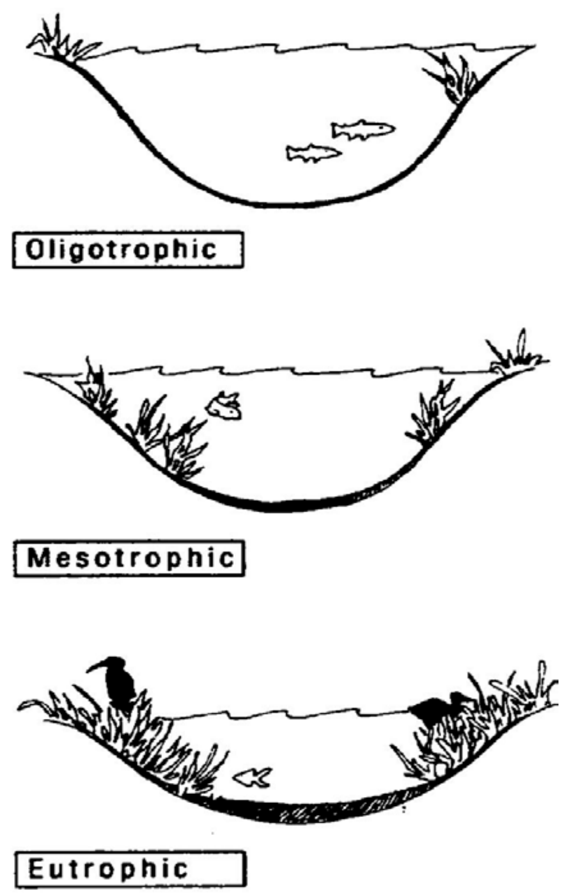
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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

The general lake classification scheme described is convenient, but somewhat misleading in that it places all lakes into a few distinct trophic categories. 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 which can be calculated directly from water quality data. A variety of indexes are available with Carlson's (1977) *Trophic State Index*, or TSI, being the most widely used.

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)

Carlson's TSI was developed to compare lake data on water clarity, as measured by a Secchi disk, chlorophyll *a,* and total phosphorus. These parameters are good indirect measures of a lake's productivity. 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).

Carlson developed mathematical relationships for calculating the TSI from measurements of Secchi depth transparency, chlorophyll *a*, and total phosphorus in lakes during the summer season. The computed TSI values for an individual lake can be used to compare with other lakes, to evaluate changes within the lake over time, and to estimate other

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)

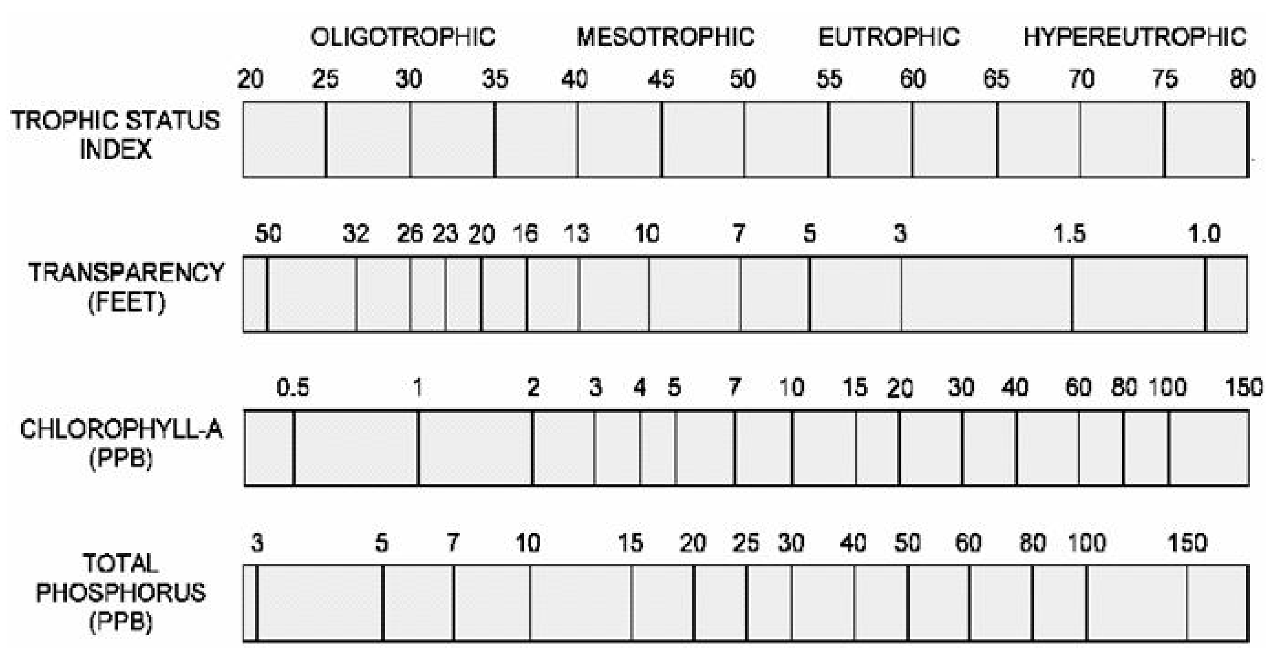
water quality parameters within the lake.

For those preferring to use the general lake classification scheme, the TSI values which correspond approximately with the trophic state terms are illustrated in the figure below. However, the dividing lines between these 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. For many lakes in Michigan, Carlson's TSI equations can be used to roughly predict values of one variable from measurements of another in the surface water of the lake during the summer season, as shown in the figure below.

Lake scientists have also developed relationships to predict summer productivity indicators from water quality variables measured during lake turnover in the spring. One such relationship was developed by Dillon and Rigler (1974) which predicts mean (average) summer chlorophyll *a* from spring phosphorus measurements.

These relationships must be used carefully when predicting water quality variables and productivity.

CARLSON'S TROPHIC STATE INDEX



Source: Minnesota Pollution Control Agency

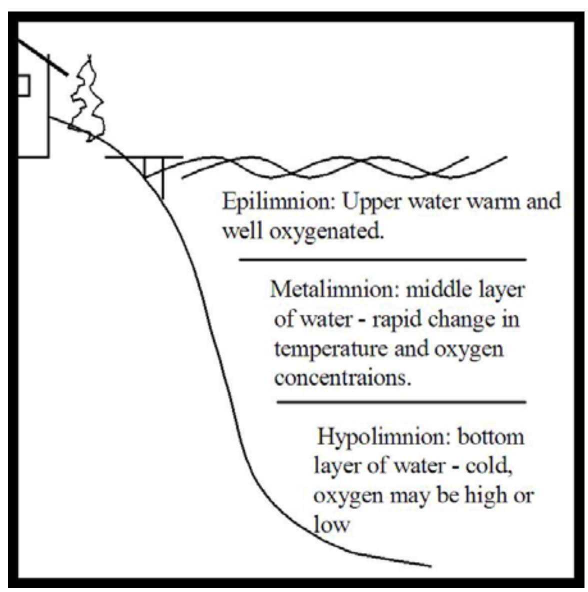
OTHER MEASURES OF LAKE PRODUCTIVITY

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

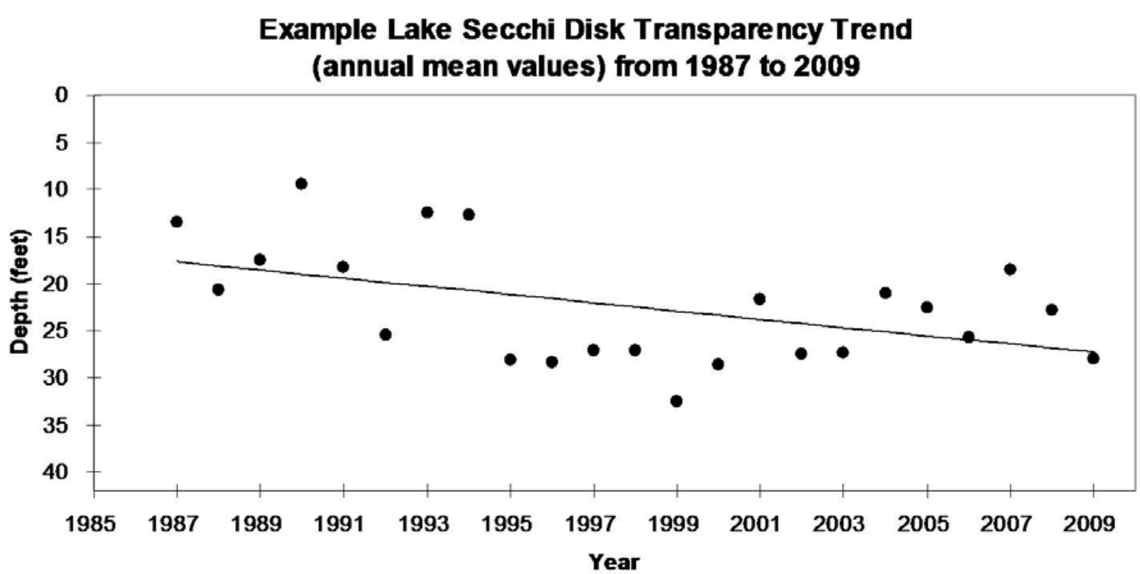
2009 is included in Appendix 1. The number of measurements, or readings, made between mid-May and mid-September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. For those lakes with eight or more evenly spaced readings over this 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 2009, Secchi disk transparency data were reported for 180 lakes (208



basins). Over 3280 transparency measurements were reported, ranging from 1.0 to 48.0 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 13.4 feet and the median value was 12.0 feet. The Carlson TSI_{SD} values ranged from 25 to 64 for these lakes with a mean value of 41. A Carlson TSI value of 41 is generally indicative of a mesotrophic lake (see page 8).

Secchi disk transparency measurements were reported for 180 of the 220 enrolled lakes for a participation rate of 82%.

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 2009 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 10% of the lakes.

During 2009, samples for total phosphorus measurements were collected on 193 lakes. The spring overturn total phosphorus results ranged from <5 to 46 ug/l with a mean (average) of 10.5 ug/l and a median value of 9 ug/l. The late summer total phosphorus results ranged from <5 to 78 ug/l with 12.8 ug/l as the mean and 11 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 67 for these lakes with a mean value of 39.

A Carlson TSI value of 39 is generally indicative of a very good quality mesotrophic lake (see page 8).

For the spring overturn sampling, 143 total phosphorus samples were turned in from 163 enrolled lakes, for an 88% participation rate. For late summer sampling, 187 samples were received from 203 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 2009 volunteers collected a minimum of four samples on 117 lakes.

Results from the chlorophyll monitoring for 2009 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 20 percent of the lakes.

A total of 588 chlorophyll samples were collected and processed in 2009. The chlorophyll *a* levels ranged from <1 to 56 ug/l over the five-month sampling period. The overall mean (average) was 3.8 ug/l and the median was 2.4 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 61 with a mean value of 39. A Carlson TSI value of 39 is generally indicative of a very good quality mesotrophic lake (see page 8).

During 2009, a total of 127 lakes (130 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 94%. A total of 117 lakes turned in at least four samples for a complete participation rate of 92%. 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

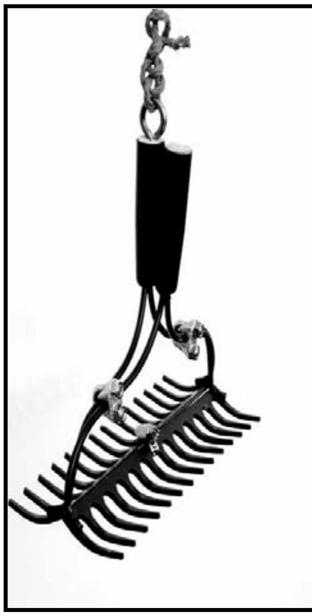
Temperature and dissolved oxygen are typically measured as surface-to-bottom profiles over the deep part of the lake. Temperature is usually measured with a thermometer or an electronic meter called a themistor. Dissolved oxygen is either measured with an electronic meter or by a chemical test. The CLMP 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 2009, CLMP participants in the dissolved oxygen/temperature project sampled 45 lakes (47 basins). A total of 302 dissolved oxygen/temperature profiles (approximately 4000 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 2009 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, 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 2009, CLMP participants in the aquatic plant project sampled one lake — Mud Lake in Jackson County. Volunteers on Mud Lake are completing a thorough report on their plant community, which is anticipated for inclusion in the 2010 CLMP Annual Report.

Exotic Aquatic Plant Watch – Pilot Project

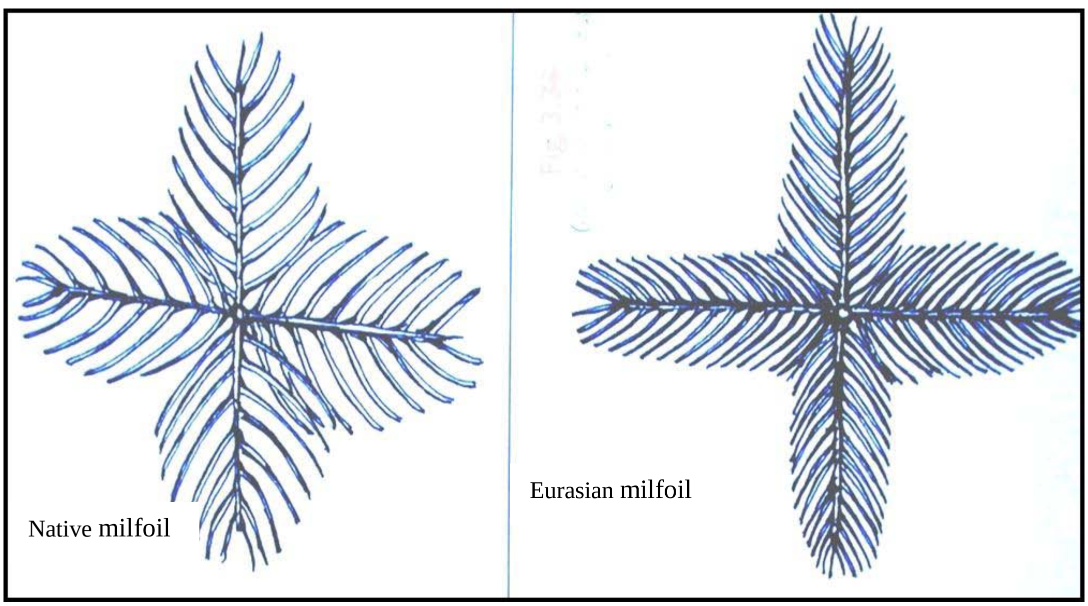
Beginning in 2007, the CLMP sponsored a pilot monitoring project to identify and map exotic aquatic plants in Michigan lakes, with the intent to add the Exotic Aquatic Plant Watch as a permanent component of the CLMP.

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

Participation in the Exotic Aquatic Plant Watch was too low in 2007 and 2008 to provide a good quality controlled estimate of the value of the monitoring project. Consequently, the Exotic Watch project was continued as a pilot project in 2009.

In 2009, twenty-one lakes enrolled in the Exotic Aquatic Plant Watch, and ten submitted reports, for a participation rate of 48%. 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 twelve leaflets on one side of the leaf's central axis, while native milfoils have fewer than twelve.

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.

REFERENCES

Carlson, R.E. 1977. A trophic state index for lakes. *Limnol. Oceanogr. 22(2):* 361-369

Carlson, R. and Simpson, J. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. February 1996.

Dillon, P.J. and Rigler, F.H. 1974. The phosphorus-chlorophyll relationship in lakes. *Limnol. Oceanogr. 19(5):* 767-773.

Hamlin Lake Improvement Board. 1994. Protecting Hamlin Lake - a homeowners guide. Prepared by: Progressive Architecture Engineering Planning, Grand Rapids, MI. July 1994.

Michigan DNR. 1990. Protecting Inland Lakes - a watershed management guidebook. Prepared by: Planning and Zoning Center, Inc., Lansing, MI. February 1990.

Minnesota PCA. 1991. Citizen Lake-Monitoring Program - 1990 report on the transparency of Minnesota lakes. Minnesota Pollution Control Agency, Division of Water Quality. St. Paul, MN. June 1991.

Wandell, H. and Wolfson, L. 2007. A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes. (2nd Edition) MSU Extension Water Quality Series WQ-55.

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

Submitted by Chip Kosloski, MSU Department of Fisheries and Wildlife, and Julie Stivers, Stony Lake CLMP Volunteer

Stony Lake is a 272-acre lake in Oceana County. It is located approximately a mile from Lake Michigan, 20-30 miles south of the popular summer destinations Ludington and Pentwater, and right on the western edge of the Manistee National Forest. The lake is distinctive because of its attractive location and proximity to Lake Michigan, and local residents are implementing environmental programs to try and keep the lake healthy and thriving.

Stony Lake has taken great advantage of the Cooperative Lakes Monitoring Program (CLMP), which has been very beneficial in helping local residents protect their lake. The Stony Lake Property Owners Association (SLPOA), concerned about excessive aquatic plant growth in the lake, worked with CLMP to establish their own monitoring program in 2004. The ultimate goal of their program is to develop a formal proposal for action to remediate the increasing problems with the lake ecosystem.

The program has tested for the following parameters: Secchi disk transparency, spring and summer total phosphorus, chlorophyll, and dissolved oxygen. Aquatic plant mapping and a study on fish age and growth were also conducted. The SLPOA funded the CLMP monitoring and Dr. Nancy Mathews, University of Wisconsin-Madison, a summer resident of Stony Lake, was the volunteer field coordinator. SLPOA funded students from UW-Madison to establish a web site to report the findings. The UW-Madison also funded a graduate student to create a GIS data base that tracks the survey work, which is reported there.

Dr. Mathews was the CLMP field coordinator for three years, after which John Stivers took on the volunteer role. However, due to their specific interests in aquatic plant growth, Stony Lake residents have really stepped up their efforts to monitor and control exotic and invasive plant species.

Julie Stivers joined the CLMP Exotic Plant Watch in 2009. She worked with Dr. Mathews to create a Google Map of Stony Lake exotic plant locations. One of the program's greatest successes was a workshop held to help people identify aquatic plants, understand the role of shoreline buffers, and understand the importance of underwater plants in maintaining water quality. The workshop, "The Water Plants of Stony Lake: The Good, The Bad, and The Slimy," took place in September at Camp Miniwanca, and was supported by the UW-Madison and many volunteers. Over 60 people attended. The group that organized the workshop hope it is the start of a longer term educational programming initiative for the lake's watershed.

Julie Stivers' reflection on her experience helps illustrate Stony Lake's successes with the CLMP: "This was definitely a learning year for me – not only learning to identify the plants, which I believe has been successful, but learning to use a GPS and Google Maps. The best part was realizing what a rich natural environment we have here at Stony Lake."

The efforts at Stony Lake are a great example of how a group of people can take the CLMP and mold it to their specific interests and concerns. The Stony Lake CLMP has fostered environmental awareness and given the local community the tools to take an active role in protecting their lake.

For more information on Stony Lake stewardship efforts, please visit: <u>www.stonylakemichigan.com</u>

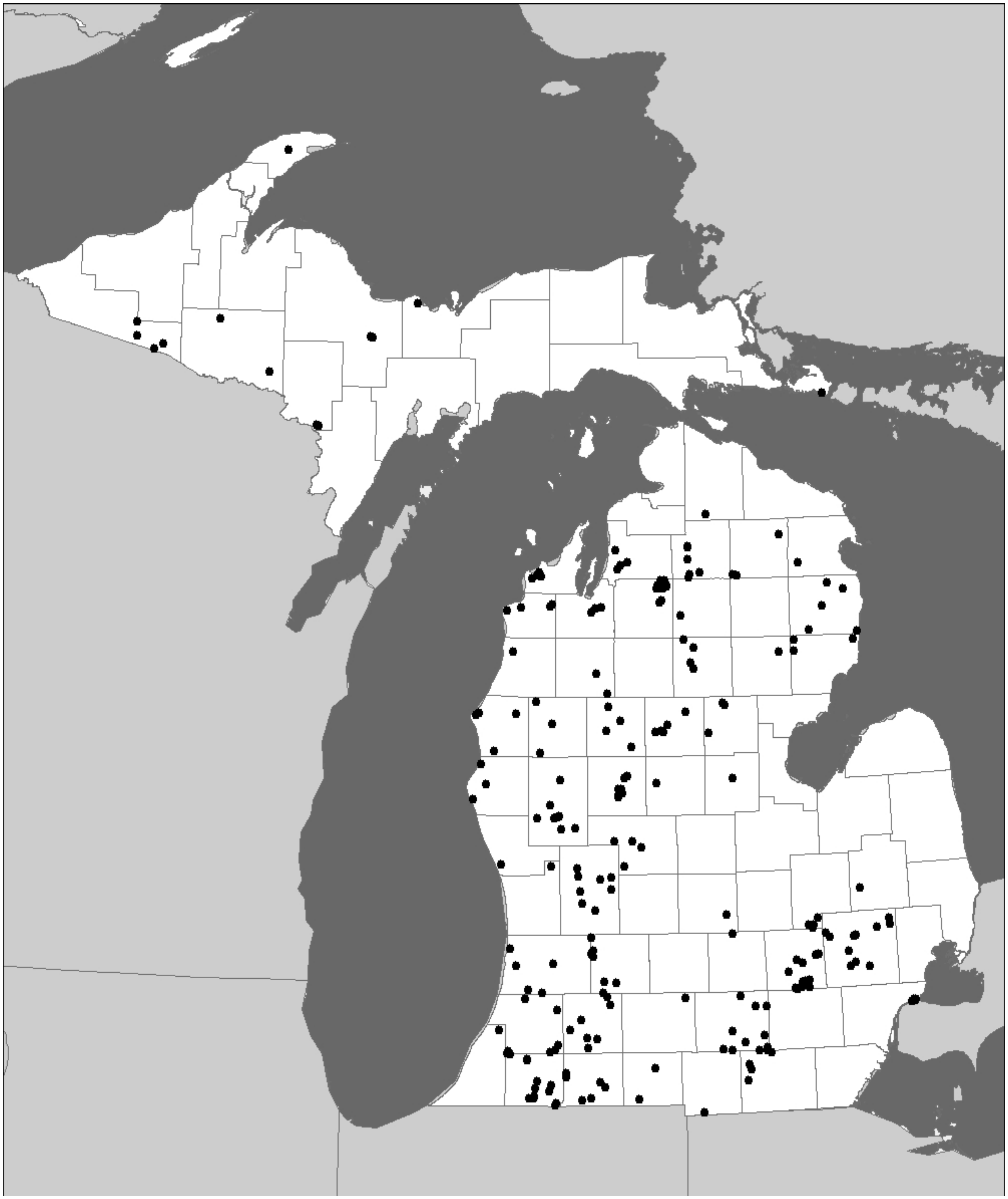
Do you have a success story of how your community has used CLMP data to implement a protection program for your lake? We would like to hear from you. Contact Ralph Bednarz at 517-335-4211 or bednarzr@michigan.gov.

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 the 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.

Statewide Distribution of CLMP Lakes Sampled During 2009



APPENDICES

Appendix 1

2009 Secchi Disk Transparency Results

Appendix 2

2009 Total Phosphorus Results

Appendix 3

2009 Chlorophyll Results

Appendix 4

2009 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2009 Exotic Aquatic Plant Watch Participating Lakes and Example Results

APPENDIX 1
2009 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	18	12	27	18.1	16.5	4.4	35
Arbutus (1)	Grand Traverse	280396	17	6	>12	9.4	9.0	2.4	<45
Arbutus (2)	Grand Traverse	280109	17	13	31	19.9	17.0	6.1	34
Arbutus (3)	Grand Traverse	280108	17	13	28	19.0	18.0	4.7	35
Arbutus (4)	Grand Traverse	280397	17	14	28	18.5	18.0	3.8	35
Arbutus (5)	Grand Traverse	280398	17	12	21	15.4	15.0	2.6	38
Arnold	Clare	180107	18	8	24.5	15.0	16.0	4.8	38
Avalon	Montmorency	600022	7	33	48				
Badger	Alcona	010122	15	9.5	16.5	11.9	12.0	2.3	41
Baldwin	Montcalm	590171	13	8.5	16	11.2	10.5	2.3	42
Bankson	Van Buren	800159	*						
Barlow	Barry	080176	12	6	13	10.0	9.5	2.3	44
Barton	Kalamazoo	390215	12	5	9.5	7.0	6.5	1.5	49
Baseline	Liv/Washtenaw	470149	*						
Bear	Kalkaska	400026	15	23	27	24.0	24.0	0.9	31
Bear	Manistee	510122	18	8	14.5	10.8	10.0	2.6	43
Beatons	Gogebic	270105	15	14	30	21.1	21.0	3.7	33
Beaver	Alpena	040097	14	14	29	18.9	16.8	4.8	35
Bellaire	Antrim	050052	19	5	22	10.7	9.0	5.6	43
Big Blue	Kalkaska	400016	19	11	36	24.4	24.0	6.8	31
Big Bradford	Otsego	690036	12	16.5	33	23.5	23.0	5.6	32
Big Lake	Osceola	670056	*						
Big Pine Island	Kent	410437	19	6	11	8.0	8.0	1.7	47
Big Portage	Jackson	380245	10	7	16	10.7	10.0	3.4	43
Big Star	Lake	430611	13	12	14	12.9	13.0	0.8	40
Big Twin	Kalkaska	400025	14	17	31	22.0	20.5	4.1	33
Bills	Newaygo	620062	14	10	28	14.4	12.5	5.4	39
Bills (Waits)	Newaygo	620311	13	9	21	13.6	13.0	3.7	40
Birch (Russworm/Dugan)	Cass	140187	18	10	36	16.5	14.5	6.6	37

Lake	County	Site ID Number	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Birch (Temple)	Cass	140061	19	8	32	14.3	13.0	6.5	39
Blue	Mecosta	540092	18	11.5	23	15.8	15.5	3.8	37
Blue Heron	Wayne	821552	5	4	6.5				
Bostwick	Kent	410322	9	5.5	11	6.9	6.0	2.0	49
Bradford (Little)	Otsego	690151	10	15	17	15.9	16.0	0.6	37
Brooks	Leelanau	450222	17	9	15	11.6	11.5	2.1	42
Brown	Jackson	380477	19	7	12	9.9	9.5	1.3	44
Byram (1)	Genesee	250363	19	12	28	16.8	16.0	4.1	36
Byram (2)	Genesee	250364	19	12	28	16.6	15.0	4.1	37
Byram (3)	Genesee	250365	19	12	28	16.6	15.0	4.1	37
Canadian (Main)	Mecosta	540172	14	7	14	10.1	9.8	2.1	44
Canadian (West)	Mecosta	540171	14	7.5	14	10.1	10.0	1.9	44
Cascade (Impound)	Kent	410686	18	2	4	3.1	3.0	0.6	61
Cedar	Van Buren	800241	*						
Cedar (Briarwood)	Alcona/Iosco	350231	11	10	>13	12.4	13.0	0.9	<41
Cedar (Schmidt's)	Alcona/Iosco	010017	13	9	>10	9.3	9.0	0.5	<45
Center	Osceola	670238	10	14	20.5	17.3	17.8	2.5	36
Chain	Iosco	350146	12	11	12	11.5	11.5	0.5	42
Chancellor (Blue)	Mason	530287	15	21	35.5	28.0	28.5	4.5	29
Chemung	Livingston	470597	*						
Christiana	Cass	140055	13	7	12	8.7	8.5	1.5	46
Clam	Antrim	050240	14	9	23	15.9	14.5	4.6	37
Clark	Jackson	380173	16	13.5	17	15.0	15.0	1.0	38
Clear	Jackson	380453	15	9	15.5	12.2	12.0	1.7	41
Clear	St. Joseph	750166	*						
Clifford	Montcalm	590142	19	10	14.5	11.3	11.0	1.3	42
Cobb	Barry	080259	19	8	36	20.0	18.0	8.7	34
Corey	St. Joseph	750142	17	9.5	22	13.7	13.0	4.1	39
Coverdale	Cass	140175	*						

APPENDIX 1
2009 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)
Cranberry	Oakland	631196	9	12	16	14.6	15.0	1.3	38
Crockery	Ottawa	700422	*						
Crooked	Kalamazoo	390599	19	7.5	20	11.5	10.5	3.3	42
Crooked (Big)	Van Buren	800483	17	7.5	15.5	11.3	10.5	2.6	42
Crooked (Little)	Van Buren	800535	12	10	19.5	13.7	14.0	3.3	39
Crooked (North)	Kalkaska	400133	7	4.5	10.5				
Crystal	Benzie	100066	*						
Crystal	Oceana	640062	18	11	18	13.7	14.0	1.8	39
Cub	Kalkaska	400031	17	14	20	17.5	18.0	1.5	36
Deer	Alger	020127	11	7	9.5	8.2	8.0	1.0	47
Deer	Oakland	631128	14	9	23	14.5	13.5	5.1	39
Derby	Montcalm	590144	9	8	22.5	16.4	18.0	4.8	37
Devils	Lenawee	460179	6	10	21				
Diamond	Cass	140039	19	5	24	12.3	9.5	6.2	41
Diane	Hillsdale	300173	19	2	3.5	2.6	2.5	0.3	63
Dinner	Gogebic	270126	19	9	20	16.4	17.0	4.1	37
Duck	Calhoun	130172	13	9	25	14.3	11.5	5.3	39
Duncan	Barry	080096	17	3.5	12	6.3	4.0	3.3	51
Eagle	Allegan	030259	14	11.5	23.5	15.4	14.5	3.7	38
Eagle	Cass	140057	15	4	24	9.7	7.5	5.7	44
Eagle	Kalkaska	400130	13	10	20	15.7	16.5	3.6	37
Earl	Livingston	470554	19	3	11	5.9	5.0	2.5	51
East Twin	Montmorency	600013	*						
Emerald	Kent	410709	19	7.5	19	11.2	10.0	3.7	42
Emerald	Newaygo	620167	16	10	16	13.2	13.5	1.8	40
Evans	Lenawee	460309	15	9	20	13.3	12.5	3.2	40
Fair	Barry	080260	15	9.5	16	12.3	12.0	2.1	41

APPENDIX 1
2009 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)
Farwell	Jackson	380454	*						
Fenton	Genesee	250241	10	18.5	22	20.4	20.5	1.3	34
Fish	Van Buren	800461	15	6	10	7.7	8.0	1.0	48
Fremont	Newaygo	620029	19	6	23	12.0	11.0	4.8	41
Freska	Kent	410702	9	6	10.5	8.1	8.0	1.7	47
Gallagher	Livingston	470210	10	9	14	11.0	10.5	1.5	43
Gilead	Branch	120120	*						
Glen (Big)	Leelanau	450049	19	18	27	21.3	20.0	3.1	33
Glen (Little)	Leelanau	450050	19	5.5	12	9.4	10.0	2.1	45
Goshorn	Allegan	030650	19	4	7	5.1	5.0	0.8	54
Gourdneck	Kalamazoo	390541	18	7	17	11.5	11.0	2.7	42
Gratiot	Keweenaw	420030	10	12.5	20.5	17.0	17.3	2.8	36
Gravel	Van Buren	800461	*						
Gull	Kalamazoo	390210	18	6.5	32.5	16.8	15.5	7.6	36
Gut	Livingston	470567	7	10.5	13				
Hamburg	Livingston	470568	19	9.5	25	14.7	14.0	5.0	38
Hamlin (Lower)	Mason	530073	19	9	18	13.6	14.0	2.5	39
Hamlin (Upper)	Mason	530074	19	6.5	12.5	9.5	9.0	1.7	45
Harper	Lake	430030	15	13	20	17.0	17.5	1.8	36
Hawk	Oakland	631115	13	10	14	11.4	11.0	1.4	42
Hess	Newaygo	620032	14	1.5	4	2.5	2.5	0.6	64
Hicks	Osceola	670062	14	5	8	6.4	6.0	1.1	50
Higgins (North)	Roscommon	720026	8	34	44	37.5	37.5	3.4	25
Higgins (South)	Roscommon	720028	10	32	41	38.2	38.5	2.8	25
High	Kent	410703	*						
Horsehead	Mecosta	540085	16	8	17.5	11.6	10.8	3.0	42
Houghton (1)	Roscommon	720163	16	4	6	5.4	5.8	0.7	53

APPENDIX 1
2009 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)
Houghton (2)	Roscommon	720164	17	4	6	5.5	6.0	0.7	53
Hubbard (1)	Alcona	010101	14	13	28	20.0	20.0	4.8	34
Hubbard (2)	Alcona	010102	14	14	27	19.8	20.0	4.4	34
Hubbard (3)	Alcona	010103	10	14	33	20.0	18.0	5.9	34
Hubbard (4)	Alcona	010104	10	13	29	20.2	19.5	5.5	34
Hubbard (5)	Alcona	010105	11	14	29	19.1	18.0	4.9	35
Hubbard (6)	Alcona	010106	17	14	25	20.1	20.0	3.7	34
Hubbard (7)	Alcona	010107	14	13	26	20.6	21.0	4.2	34
Hunter	Gladwin	260119	17	7.5	16.5	10.6	10.5	2.4	43
Hutchins	Allegan	030203	17	6	14	9.1	8.5	2.4	45
Indian	Kalamazoo	390305	13	10.5	27	18.3	18.5	6.0	35
Indian	Kalkaska	400015	8	8.5	16.5	13.6	14.5	3.0	40
Indian	Osceola	670227	19	15	26	18.6	17.0	2.9	35
Isabella	Isabella	370135	13	6.5	9.5	8.2	8.5	0.9	47
Island	Grand Traverse	280164	14	15	36	23.7	22.0	7.5	31
Jewel	Alcona	010041	*						
Juno	Cass	140058	13	6	11	7.7	7.5	1.5	48
Kimball	Newaygo	620107	13	6	15	9.8	10.0	2.8	44
Kirkwood	Oakland	631116	14	3	9	6.6	6.5	1.9	50
Klinger	St. Joseph	750136	14	6.5	22	14.0	13.3	5.4	39
Lake George	Clare	180056	*						
Lakeville	Oakland	630670	18	9	19	13.9	14.5	2.9	39
Lancelot (1)	Gladwin	260104	10	9.5	13.5	11.6	11.8	1.2	42
Lancelot (2)	Gladwin	260112	10	6.5	12	9.4	10.0	1.7	45
Lancelot (3)	Gladwin	260113	10	6.5	10.5	9.1	9.5	1.4	45
Lancer (1)	Gladwin	260074	12	8	13.5	10.9	11.0	1.8	43
Lancer (2)	Gladwin	260114	5	8	10				
Lancer (3)	Gladwin	260115	12	2.5	8	4.2	3.8	1.5	57
Lancer (4)	Gladwin	260116	12	7.5	10	8.8	8.8	1.0	46

APPENDIX 1
2009 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)
Lancer (5)	Gladwin	260117	12	3	5	3.9	4.0	0.5	57
Lansing	Ingham	330137	14	9.5	14.5	12.2	12.0	1.6	41
Lily	Clare	180066	*						
Little	Marquette	520210	*						
Little Long	Barry	080279	14	12	22	15.7	16.3	2.6	37
Little Paw Paw	Berrien	110765	19	4	6.5	5.2	5.0	0.7	53
Little Twin	Kalkaska	400013	10	13	23	16.0	15.8	2.8	37
Long	Cass	140174	*						
Long	Gogebic	270179	9	17	19	18.2	18.0	0.7	35
Long	Iosco	350076	19	15	18	15.8	16.0	0.9	37
Louise	Dickinson	220124	18	14.5	21.5	17.2	16.5	2.2	36
Magician	Cass	140065	18	6	25.5	14.3	12.3	6.0	39
Margrethe	Crawford	200157	9	9	24	14.7	12.0	6.0	38
Marl	Genesee	250480	*						
Mary	Dickinson	220039	18	15.5	23	19.1	18.5	1.9	35
Mary	Iron	360071	19	16	27	21.7	22.0	2.9	33
Mecosta	Mecosta	540057	15	8	18	10.8	9.0	2.9	43
Mehl	Marquette	520451	*						
Middle Straits	Oakland	630732	*						
Mirror	Jackson	380478	*						
Mona	Muskegon	610225	*						
Moon	Gogebic	270120	17	16	32	23.7	24.0	4.4	31
Mud	Jackson	380469	11	8.5	15	10.0	9.0	1.9	44
Murray	Kent	410268	15	5.5	12	8.6	9.0	1.9	46
Muskellunge	Montcalm	590154	19	5.5	10	7.8	8.0	1.5	48
Muskoday	Wayne	821553	*						
Nepessing	Lapeer	440220	9	11	15	13.3	14.0	1.3	40
North Blue	Kalkaska	400131	10	16	27	21.7	21.0	3.9	33
North Buckhorn	Oakland	631113	17	10.5	13.5	12.0	12.0	1.0	41

APPENDIX 1
2009 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)
North Oxbow	Mason	530289	*						
Okonoka	Wayne	821554	5	1	3.5				
Oneida	Livingston	470573	13	7.5	11.5	9.5	9.5	1.3	45
Ore	Livingston	470100	8	7.5	18.5	12.0	10.3	3.8	41
Orion	Oakland	630554	17	10.5	15	13.1	12.8	1.5	40
Osterhout	Allegan	030263	19	8	12	9.6	10.0	1.1	45
Oxbow	Oakland	630666	*						
Painter	Cass	140108	13	4	6	5.0	5.0	0.7	54
Papoose	Kalkaska	400135	*						
Parke	Oakland	631119	17	11	17	14.2	14.0	1.9	39
Payne	Barry	080103	10	6	15	9.2	8.0	2.6	45
Pentwater	Oceana	640089	8	5.5	9	7.0	7.3	1.2	49
Perch	Iron	360046	12	3.5	6.5	5.2	5.0	1.0	53
Perch	Otsego	690150	9	10	13	11.3	11.5	0.9	42
Perrin	St. Joseph	750314	17	8.5	13	11.0	11.0	1.3	43
Pickerel	Kalkaska	400035	19	20	26	24.7	25.0	1.6	31
Pickerel	Newaygo	620066	13	9	21	13.5	13.0	3.1	40
Platte (Big)	Benzie	100086	19	11	23	15.5	13.0	4.0	38
Pleasant	Jackson	380244	*						
Pleasant	Wexford	830183	16	6.5	9	7.6	7.8	0.7	48
Portage	Washtenaw	810248	19	10.5	21.5	13.9	13.0	2.8	39
Posey	Lenawee	460423	*						
Pretty	Mecosta	540079	15	7	14	10.1	9.5	2.0	44
Puterbaugh	Cass	140170	17	3.5	17.5	9.8	11.0	4.6	44
Randall	Branch	120078	15	4.5	10	7.3	7.5	1.5	49
Reeds	Kent	410270	15	3.5	12	5.9	5.0	2.7	52
Rifle	Ogemaw	650022	16	19.5	30	23.6	23.0	3.0	32
Robinson	Newaygo	620061	6	5	9				
Round	Clinton	190146	*						

APPENDIX 1
2009 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)
Round	Lenawee	460304	10	9	28	15.3	13.5	5.9	38
Round	Livingston	470546	11	5.5	15.5	11.3	11.0	2.8	42
Round	Mecosta	540073	14	6	11	8.6	8.3	1.5	46
Sanford	Benzie	100208	19	16	26	19.9	19.0	3.4	34
Sanford	Midland	560169	16	5.5	10.5	8.0	7.8	1.9	47
School Section (1)	Mecosta	540080	16	5.5	11.5	8.1	7.5	2.0	47
School Section (2)	Mecosta	540190	16	5.5	10	7.5	7.3	1.5	48
Shavehead	Cass	140071	18	5	12.5	7.3	6.8	2.3	48
Sherman	Kalamazoo	390382	12	13	22.5	15.2	14.0	2.7	38
Shingle	Clare	180108	*						
Silver	Van Buren	800534	19	9	11.5	9.9	9.5	0.8	44
Silver (1)	Genesee	250481	19	9	25	14.6	12.0	4.9	39
Silver (2)	Genesee	250503	19	9	25	13.9	12.0	4.9	39
Silver (3)	Genesee	250504	19	10	25	15.1	12.0	5.0	38
Silver (Green Oak)	Livingston	470589	10	13.5	24	16.5	14.5	3.9	37
Spider	Grand Traverse	280395	8	14	22	17.4	15.5	3.4	36
Squaw	Kalkaska	400135	18	6.5	9	7.4	7.0	0.6	48
Starvation	Kalkaska	400030	18	21	28	23.5	23.3	2.2	32
Stone Ledge	Wexford	830186	*						
Stony	Oceana	640049	18	1.5	13.5	8.7	8.8	2.9	46
Strawberry	Livingston	470213	18	8	12.5	9.1	8.8	1.1	45
Sweezey	Jackson	380470	17	7	16	10.7	10.0	2.9	43
Sylvan	Newaygo	620168	17	11.5	17	14.5	15.0	1.5	39
Takoma	Wayne	821555	*						
Taylor	Oakland	631114	19	15.5	23	19.3	20.0	2.0	34
Templene	St. Joseph	750322	14	9	12	10.2	10.0	0.8	44
Torch North	Antrim	050055	18	14.5	41.5	28.5	28.3	8.8	29
Torch South	Antrim	050240	16	17	45	28.6	29.0	8.1	29
Triangle	Livingston	470591	10	7	14	10.5	10.3	2.2	43

APPENDIX 1
2009 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)
Twin (Big)	Cass	140165	12	7	19.5	11.4	9.0	4.7	42
Twin (Little)	Cass	140166	18	5	19	11.4	11.0	3.5	42
Upper Crooked	Barry	080071	17	8	15	11.2	11.5	2.0	42
Van Etten	Iosco	350201	17	7	10	8.9	9.0	1.0	46
Vaughn	Alcona	010049	9	16	23	20.0	20.0	2.8	34
Viking	Otsego	690136	18	8	14	11.4	11.0	2.0	42
Vineyard	Jackson	380263	18	7.5	19	11.4	11.0	3.1	42
Wahbememe	St. Joseph	750313	7	12	25				
Wamplers	Jackson	380249	*						
Webinguaw	Newaygo	620283	10	2.5	4	3.4	3.5	0.5	60
West Twin	Montmorency	600072	11	8.5	14	11.6	12.0	1.5	42
Wetmore	Allegan	030664	10	3.5	5.5	4.3	4.3	0.7	56
Wildwood	Cheboygan	160230	9	8	9.5	8.9	9.0	0.5	46
Windover	Clare	180069	10	13.5	24	18.1	18.0	3.1	35
Woods	Kalamazoo	390542	18	4	15	10.0	10.8	3.7	44

* No measurements reported

> Maximum value includes measurements made on lake bottom

APPENDIX 2

2009 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOPHORUS 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)
Ann	Benzie	100082	6				5				27
Arbutus	Grand Travers	280109	3 W				7				32
Arnold	Clare	180107	*				7				32
Badger	Alcona	010122	18	20	25		14				42
Baldwin	Montcalm	590171	12				17 H				45
Bankson	Van Buren	800159	*				15				43
Barlow	Barry	080176	5				9				36
Barton	Kalamazoo	390215	16				17				45
Baseline	Liv/Washtenaw	470149	12				15				43
Bass	Chippeaw	170272					*				
Bear	Kalkaska	400026	4 T				5				27
Bear	Manistee	510122	6				7				32
Beatons	Gogebic	270105	3 W				4 T				<27
Beaver	Alpena	040097	7				9				36
Bellaire	Antrim	050052	3 W				3 W				<27
Big Blue	Kalkaska	400016	7				3 W				<27
Big Bradford	Otsego	690036	5				*				
Big Lake	Osceola	670056					11				39
Big Pine Island	Kent	410437	24				17				45
Big Portage	Jackson	380245	9				13				41
Big Star	Lake	430611	11				9				36
Big Twin	Kalkaska	400025	12				6				30
Bills (Waits)	Newaygo	620311	3 W				7	8	9	8	32
Birch (Russworm/Dugan)	Cass	140187	3 W	3 W	5		8				34
Birch (Temple)	Cass	140061	5	3 W			6				30
Blue	Mecosta	540092	2 W	2 W			8				34
Blue Heron	Wayne	821552					16				44
Bostwick	Kent	410322	35				21				48

APPENDIX 2
2009 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOPHORUS 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	16	12	12		8				34
Cascade (Impound)	Kent	410686	33				32				54
Cedar	Alcona/Iosco	010017	5				6				30
Cedar	Van Buren	800241	5				11				39
Center	Osceola	670238					7				32
Chain	Iosco	350146	8		9	9	9				36
Chancellor (Blue)	Mason	530287	13				8				34
Chemung	Livingston	470597	11	16			13				41
Christiana	Cass	140055	*				20				47
Clam	Antrim	050101	6				7				32
Clark	Jackson	380173	6				9				36
Clear	Jackson	380453					11				39
Clifford	Montcalm	590142	16				12				40
Cobb	Barry	080259	2 W				9				36
Corey	St.Joseph	750142	4 T				11				39
Cranberry	Oakland	631196	32	34			12				40
Crockery	Ottawa	700422					*				
Crooked	Kalamazoo	390599	8				10				37
Crooked	Kalkaska	400133	8				23				49
Crooked (Big)	Van Buren	800483	*				11				39
Crooked (Little)	Van Buren	800535	*				9				36
Crystal	Benzie	100066	4 T				4 T				<27
Crystal	Oceana	640062	11				12				40
Cub	Kalkaska	400031	5				10				37
Deer	Alger	020127	3 W				8	6			34
Deer	Oakland	631128	4 T				7				32
Derby	Montcalm	590144	2 W	4 T			8	8			34

APPENDIX 2

2009 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOPHORUS 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	6				10				37
Diamond	Cass	140039	2 W				9				36
Diane	Hillsdale	300173	38				58 a				63
Dinner	Gogebic	270126	5				13				41
Duck	Calhoun	130172	7				11				39
Duncan	Barry	080096					38	31			57
Eagle	Allegan	030259	16				9				36
Eagle	Cass	140057	2 W				16				44
Eagle	Kalkaska	400130	4 T	3 W			7	10			32
Earl	Livingston	470554	42				33				55
East Twin	Montmorency	600013	8				9				36
Emerald	Kent	410709	*				11				39
Emerald	Newaygo	620167	6				8				34
Evans	Lenawee	460309	11				7				32
Fair	Barry	080260	*				11				39
Farwell	Jackson	380454					*				
Fenton	Genesee	250241	12				10		9	12	37
Fish	Van Buren	800461					23				49
Fisher (Big)	Leelanau	450224	3 W				5				27
Fisher (Little)	Leelanau	450223	3 W				4 T	4 T			<27
Five Lakes (2)	Otsego	690157	12				17				45
Five Lakes (3)	Otsego	690152	10	8			8				34
Fremont	Newaygo	620029	*				11				39
Freska	Kent	410702	*				11				39
Gallagher	Livingston	470210	14				17				45
Gilead	Branch	120120					9	13	14		36
Glen (Big)	Leelanau	450049	4 T				4 T				<27
Glen (Little)	Leelanau	450050	4 T				7				32

APPENDIX 2

2009 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOPHORUS 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)
Goshorn	Allegan	030650	22				m				
Gourdneck	Kalamazoo	390541					13				41
Gratiot	Keweenaw	420030					14				42
Gravel	Van Buren	800271	3 W				12				40
Gull	Kalamazoo	390210					9				36
Gut	Livingston	470567					14				42
Hamburg	Livingston	470568	13				10				37
Hamlin (Lower)	Mason	530074	14				13				41
Hamlin (Upper)	Mason	530073	16				17				45
Harper	Lake	430030	10	12			8				34
Hess	Newaygo	620032	34				39				57
Hicks	Osceola	670062	22	22			17				45
Higgins (North)	Roscommon	720026	5				6				30
Higgins (South)	Roscommon	720028	5				6				30
High	Kent	410703					11	13			39
Horsehead	Mecosta	540085	7				13				41
Houghton (1)	Roscommon	720163					15				43
Hubbard	Alcona	010106	6				7				32
Hutchins	Allegan	030203	10	13			14				42
Indian	Kalamazoo	390305	4 T				18				46
Indian	Kalkaska	400015	9				7				32
Indian	Osceola	670227					10				37
Island	Grand Travers	280164	2 W				6				30
Jewel	Alcona	010041					*				
Juno	Cass	140058	*				28 H				52
Kimball	Newaygo	620107					15 e				43
Klinger	St. Joseph	750136	2 W				8				34
Lake George	Clare	180056	9				10		14	14	37

APPENDIX 2

2009 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOPHORUS 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)
Lakeville	Oakland	630670	17				13				41
Lancelot	Gladwin	260104	29				17	14			45
Lancer	Gladwin	260116	10				10				37
Lansing	Ingham	330137					17	14			45
Lily	Clare	180066	11	13			16				44
Little	Marquette	520210					*				
Little Long	Barry	080279					15				43
Little Twin	Kalkaska	400013	7				13				41
Long	Gogebic	270179	3 W	1 W			7	6			32
Long	Iosco	350076	10				9				36
Louise	Dickinson	220124	9				7				32
Magician	Cass	140065	*				11				39
Margrethe	Crawford	200157	5				7				32
Mary	Dickinson	220039	15				9				36
Mary	Iron	360071	<1 W				8				34
Mecosta	Mecosta	540057	4 T				10				37
Mehl	Marquette	520451					*				
Middle Straits	Oakland	630732					*				
Mirror	Jackson	380478					13	13	13		41
Mona	Muskegon	610225	29				78		86	84	67
Moon	Gogebic	270120	1 W				8				34
Mud	Jackson	380469	11		14	12	*				
Murray	Kent	410268	*				11				39
Muskellunge	Montcalm	590154					27				52
Muskoday	Wayne	821553					*				
Nepessing	Lapeer	440220	8	10			15	13	17	16	43
North Blue	Kalkaska	400131	3 W				8				34
North Buckhorn	Oakland	631113	20				10				37

APPENDIX 2
2009 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOPHORUS 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)
North Oxbow	Mason	530289					*				
Okonoka	Wayne	821554					31	31			54
Oneida	Livingston	470573	10				14				42
Ore	Livingston	470100	14				16				44
Orion	Oakland	630554	11				15				43
Osterhout	Allegan	030263	13				15	13			43
Oxbow	Oakland	630666					15				43
Painter	Cass	140108	*				36 H				56
Papoose	Kalkaska	400134	11				*				
Parke	Oakland	631119					12				40
Pentwater	Oceana	640313	19				28				52
Perch	Iron	360046					29				53
Perch	Otsego	690150	9				10	10			37
Perrin	St. Joseph	750314	10				14				42
Pickerel	Kalkaska	400035	*				6				30
Pickerel	Newaygo	620066					11 e				39
Pleasant	Jackson	380244					8				34
Pleasant	Wexford	830183	10				11				39
Portage	Washtenaw/Li\	810248	12				12				40
Posey	Lenawee	460423	46				*				
Pretty	Mecosta	540079	*		8		11	10			39
Randall	Branch	120078	18				31				54
Rifle	Ogemaw	650022					6	6			30
Robinson	Newaygo	620061	*				20				47
Round	Clinton	190146					21				48
Round	Lenawee	460304	12				9				36
Round	Livingston	470546					11				39
Round	Mecosta	540073	16				11				39

APPENDIX 2
2009 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOPHORUS 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)
Sanford	Benzie	100208	6				8				34
School Section	Mecosta	540080	6				8				34
Shavehead	Cass	140071	14	16	11		9				36
Sherman	Kalamazoo	390382	11				10				37
Shingle	Clare	180108	7				12		14	14	40
Silver	Van Buren	800534	8				9	12			36
Silver (Green Oak)	Livingston	470589	10				11				39
Spider	Grand Travers	280395	6				7				32
Squaw	Kalkaska	400135	6				14				42
Starvation	Kalkaska	400030	3 W				7				32
Stoneledge	Wexford	830186	*				15	15			43
Stony	Oceana	640049	9				13				41
Strawberry	Livingston	470213					14	13			42
Sweezey	Jackson	380470	5				9				36
Sylvan	Newaygo	620168	6				9				36
Takoma	Wayne	821555					*				
Taylor	Oakland	631114	19				13				41
Templene	St. Joseph	750322					16 N	8 N	17		44
Torch North	Antrim	050055	5				*				
Torch South	Antrim	050240	5				2 W	2 W			<27
Triangle	Livingston	470591	13				16				44
Twin (Big)	Cass	140165	9				10				37
Twin (Little)	Cass	140166	11				12	13			40
Upper Crooked	Barry	080071	*		16		15				43
Van Etten	Iosco	350201	17				18				46
Vaughn	Alcona	010049	22		17		12				40
Viking	Otsego	690136	24				17				45
Vineyard	Jackson	380263	5				7				32

APPENDIX 2

2009 COOPERATIVE LAKES MONITORING PROGRAM

TOTAL PHOPHORUS RESULTS

Lake	County	Site ID Number	Total Phosphorus (ug/l) Spring Overturn				Late Summer				Carlson TSI_{TP}
			Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Wahbememe	St. Joseph	750313	6				8				34
Webinguaw	Newaygo	620283	11	10			30				53
West Twin	Montmorency	600072	5				7				32
Wetmore	Allegan	030664	*				20				47
Wildwood	Cheboygan	160230	11		13		12				40
Windover	Clare	180069	*				9		7	10	36
Wolf	Lake	430026	9				10	11			37

Results Codes:

* No sample received or received too late to process.

H Recommended laboratory holding time was exceeded.

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

N Non-homogeneous sample made analysis of sample questionable.

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

a No field sheets received

e Used ink that ran on label

m Sample not collected at proper time - sample not processed

APPENDIX 3
2009 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	1.2	2.1	2.1	1.5	1.9	1.8	1.9	0.4	37
MDEQ						1.4					
MDEQ/Rep						1.5					
Arbutus	Grand Traverse	280109	1.0<	1.3	2.0	1.6	1.8	1.4	1.6	0.6	35
Arnold	Clare	180107	5.4	6.5	1.7	1.0<	2.0	3.2	2	2.6	37
Badger	Alcona	010122	1.0<	1.0<	7.8	17.0	10.0	7.2	7.8	7.0	51
Vol/Rep					7.9						
Baldwin	Montcalm	590171	1.0<	3.1	6.1	2.3	7.1	3.8	3.1	2.7	42
Bankson	Van Buren	800159	*	7.3	7.0	*	3.8				
Barlow	Barry	080176	1.0<	2.6	3.1	2.1	3.3	2.3	2.6	1.1	40
Barton	Kalamazoo	390215	*	*	2.7	3.3	6.1				
Bear	Manistee	510122	1.0<	2.5	3.6	3.6	2.5	2.5	2.5	1.3	40
Vol/Rep						3.5					
MDEQ						3.3					
MDEQ/Rep						3.6					
Beaver	Alpena	040097	1.0<	1.0<	1.0<	1.2	1.1	0.8	0.5	0.4	<31
Bellaire	Antrim	050052	1.5	2.2	2.7	3.1	2.8	2.5	2.7	0.6	40
Vol/Rep						1.8					
MDEQ						2.7					
MDEQ/Rep						2.5					
Big Blue	Kalkaska	400016	1.2	1.0<	1.0<	1.7	2.0	1.2	1.2	0.7	32
MDEQ					1.0<						
MDEQ/Rep					1.0<						
Big Pine Island	Kent	410437	1.1	6.0	4.2	4.1	5.7	4.2	4.2	1.9	45
Big Star	Lake	430611	*	1.5	1.9	2.6	1.2	1.8	1.7	0.6	36
Big Twin	Kalkaska	400025	2.7	1.1	1.6	1.5	1.5	1.7	1.5	0.6	35
MDEQ					1.5						

APPENDIX 3
2009 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}
MDEQ/Rep					1.7						
Bills (Waits)	Newaygo	620311	1.3	2.3	2.5	1.4	1.9	1.9	1.9	0.5	37
Vol/Rep							1.7				
MDEQ							1.7				
Birch (Russworm/D	Cass	140187	1.8	3.2	1.7	2.4	2.7	2.4	2.4	0.6	39
MDEQ				5.0							
MDEQ/Rep				5.2							
Birch (Temple)	Cass	140061	1.0<,a	1.9a	1.8a	1.7	2.3	1.6	1.8	0.7	36
Blue	Mecosta	540092	1.0<	1.0<	1.0<	1.0<	1.1	0.6	0.5	0.3	<31
Bostwick	Kent	410322	4.7	5.5	4.0	7.8	3.4	5.1	4.7	1.7	46
Brooks	Leelanau	450222	19.0	4.9	8.1	4.9	8.2	9.0	8.1	5.8	51
Cascade (Impound	Kent	410686	*	11.0	16.0	29.0	56.0	28.0	22.5	20.1	61
Cedar	Alcona/Iosco	010017	1.2	1.0<	2.4	1.9	1.9	1.6	1.9	0.7	37
Cedar	Van Buren	800241	1.3	2.4	4.6	4.0	3.4	3.1	3.4	1.3	43
Chancellor (Blue)	Mason	530287	*	*	*	*	*				
Chemung	Livingston	470597	1.1	1.0<	3.0	2.4	3.1	2.0	2.4	1.2	39
Christiana	Cass	140055	1.0<	3.3	3.6	6.1	4.1	4.3	3.9	1.3	44
MDEQ				4.9							
MDEQ/Rep				5.2							
Clam	Antrim	050101	1.0<	1.2	1.1	2.1	2.0	1.4	1.2	0.7	32
MDEQ						5.2					
MDEQ/Rep						4.3					
Clark	Jackson	380173	*	1.3	1.7	*	*				
Cobb	Barry	080259	1.0<	1.0<	2.2	1.6	2.0	1.4	1.6	0.8	35
Corey	St.Joseph	750142	3.3	1.7	2.6	1.3	2.1	2.2	2.1	0.8	38
Vol/Rep				1.9							
MDEQ				2.1							

APPENDIX 3
2009 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}
MDEQ/Rep				2.0							
Crockery	Ottawa	700422	*	*	*	*	*				
Crooked	Kalamazoo	390599	1.0<	2.9	5.1	3.6	2.9	3.0	2.9	1.7	41
Crooked (Big)	Van Buren	800483	7.5	5.0	2.6	3.1	2.7	4.2	3.1	2.1	42
Crooked (Little)	Van Buren	800535	2.1	2.7	2.5	4.4	3.9	3.1	2.7	1.0	40
Crystal	Benzie	100066	*	*	*	*	*				
Crystal	Oceana	640062	1.6	3.8	3.3	2.5	3.0	2.8	3	0.8	41
Deer	Alger	020127	1.8	1.7	2.9	2.1	1.8	2.1	1.8	0.5	36
Vol/Rep				2.8							
Deer	Oakland	631128	1.0<	1.1	1.5	1.0	1.6	1.1	1.1	0.4	32
Derby	Montcalm	590144	1.0	1.3	2.1	2.5	1.6	1.7	1.6	0.6	35
Devils	Lenawee	460179	1.3	1.0<	*	2.5	1.0<	1.2	0.9	0.9	<31
Diamond	Cass	140039	1.1	1.0<	4.9	4.1	2.8	2.7	2.8	1.9	41
Diane	Hillsdale	300173	9.8	*	5.1	35.0	19.0	17.2	14.4	13.2	57
Eagle	Allegan	030259	3.3	1.8	3.9	5.3	7.4	4.3	3.9	2.1	44
Eagle	Cass	140057	1.0	2.2	6.9	4.2	4.2	3.7	4.2	2.3	45
MDEQ				2.7							
MDEQ/Rep				3.2							
Eagle	Kalkaska	400130	1.0<	2.0	2.9	1.0<	1.9	1.6	1.9	1.0	37
Earl	Livingston	470554	3.6	3.3	33.0	9.7	12.0	12.3	9.7	12.2	53
East Twin	Montmorency	600013	4.3	3.7	6.1	4.0	3.0	4.2	4	1.2	44
Emerald	Kent	410709	8.9	6.1	6.1	7.8	19.0	9.6	7.8	5.4	51
Evans	Lenawee	460309	2.2	3.8	3.4	3.0	4.2	3.3	3.4	0.8	43
Fair	Barry	080260	2.8	3.4	5.8	9.4	4.1	5.1	4.1	2.7	44
Farwell	Jackson	380454	*	*	*	*	*				
Fenton	Genesee	250241	1.0<	1.0<	d	1.3	1.6	1.0	0.9	0.6	<31
MDEQ							1.6				

APPENDIX 3
2009 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}
MDEQ/Rep							1.7				
Fisher (Big)	Leelanau	450224	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Fisher (Little)	Leelanau	450223	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Five Lakes (2)	Otsego	690157	c	1.5	1.5	1.2	1.6	1.5	1.5	0.2	35
Five Lakes (3)	Otsego	690152	1.0<	3.7	1.0<	1.0	1.0<	1.2	0.5	1.4	<31
Fremont	Newaygo	620029	1.3	1.5	7.4	3.2	4.3	3.5	3.2	2.5	42
Freska	Kent	410702	6.1	6.5	5.7	4.7	15.0	7.6	6.1	4.2	48
Glen (Big)	Leelanau	450049	1.0	1.0<	1.0<	1.0<	1.0<	0.6	0.5	0.2	<31
Glen (Little)	Leelanau	450050	1.0<	1.0<	1.1	1.6	1.0<	0.8	0.5	0.5	<31
Goshorn	Allegan	030650	13.0	16.0	24.0	12.2	56.4	24.3	16	18.5	58
Gourdneck	Kalamazoo	390541	1.0<	7.8	5.8	5.4	5.5	5.0	5.5	2.7	47
Hamlin (Lower)	Mason	530073	1.9	1.0<	2.3	2.1	1.9	1.7	1.9	0.7	37
Hamlin (Upper)	Mason	530074	4.1	7.2	1.3	4.6	4.4	4.3	4.4	2.1	45
Hess	Newaygo	620032	8.9	2.6	9.6	3.8	3.8	5.7	3.8	3.3	44
Hicks	Osceola	670062	2.5	14.0	7.2	6.0	21.0	10.1	7.2	7.4	50
Vol/Rep			3.4								
MDEQ			3.5								
MDEQ/Rep			3.3								
Higgins (North)	Roscommon	720026	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Higgins (South)	Roscommon	720028	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
High	Kent	410703	3.3	4.2	3.8	3.6	4.4	3.9	3.8	0.4	44
Horsehead	Mecosta	540085	1.0<	4.8	4.2	4.1	3.7	3.5	4.1	1.7	44
Houghton (1)	Roscommon	720163	3.7	3.5	4.5	6.6	3.6	4.4	3.7	1.3	43
Houghton (2)	Roscommon	720164	5.2	3.6	4.9	4.6	4.0	4.5	4.6	0.7	46
Hubbard	Alcona	010106	1.0<	1.0<	1.1	1.0	1.3	0.9	1	0.4	31
Indian	Kalamazoo	390305	1.0<	1.0<	1.7	2.7	1.3	1.3	1.3	0.9	33
Indian	Kalkaska	400015	1.0<	1.4	2.1	2.0	1.8	1.6	1.8	0.7	36

APPENDIX 3
2009 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}
MDEQ					1.0<						
MDEQ/Rep					1.0<						
Indian	Osceola	670227	1.0<	1.7	3.8	2.2	5.3	2.7	2.2	1.9	38
Island	Grand Traverse	280164	1.0<	1.0<	1.0<	2.6	1.2	1.1	0.5	0.9	<31
Jewel	Alcona	010041	2.5	2.7	3.1	*	*				
Juno	Cass	140058	1.0	4.7	6.3	9.4	9.1	6.1	6.3	3.5	49
MDEQ				8.0							
MDEQ/Rep				8.7							
Klinger	St. Joseph	750136	1.0<	1.0	3.7	3.5	2.0	2.1	2	1.4	37
Lake George	Clare	180056	2.5	3.0	4.0	1.6	2.7	2.8	2.7	0.9	40
MDEQ							1.5				
MDEQ/Rep							2.5				
Lakeville	Oakland	630670	1.2	2.8	1.4	3.4	2.0	2.2	2	0.9	37
Lancelot	Gladwin	260104	2.6	1.0	2.5	1.1	3.2	2.1	2.5	1.0	40
Lancer	Gladwin	260116	c	1.3	1.9	2.1	1.3	1.7	1.6	0.4	35
Lansing	Ingham	330137	1.0<	1.9	*	2.1	2.0	1.6	1.95	0.8	37
Lily	Clare	180066	1.0<	1.1	1.7	2.0	1.6	1.4	1.6	0.6	35
Little	Marquette	520210	*	*	*	*	*				
Little Twin	Kalkaska	400013	1.2	1.7	1.7	18.0	1.8	4.9	1.7	7.3	36
Vol/Rep					1.6						
MDEQ					1.5						
MDEQ/Rep					1.3						
Long	Iosco	350076	*	*	1.8	1.8	2.9				
Magician	Cass	140065	1.6	1.0<	3.0	1.2	3.2	1.9	1.6	1.2	35
MDEQ				1.2							
MDEQ/Rep				1.1							
Margrethe	Crawford	200157	*	1.0	2.0	2.1	2.8	2.0	2.05	0.7	38

APPENDIX 3
2009 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}
Mary	Iron	360071	2.2	1.5	2.1	5.4	6.3	3.5	2.2	2.2	38
Vol/Rep				1.4							
Mecosta	Mecosta	540057	1.0<	4.4	3.6	3.6	2.6	2.9	3.6	1.5	43
Mehl	Marquette	520451	*	*	*	*	*				
Moon	Gogebic	270120	1.7	1.4	1.5	3.9	3.1	2.3	1.7	1.1	36
Mud	Jackson	380469	1.0<	4.3	6.5	12.0	2.7	5.2	4.3	4.4	45
Vol/Rep			1.0<								
Murray	Kent	410268	5.0	2.4	2.1	2.0	2.6	2.8	2.4	1.2	39
Nepessing	Lapeer	440220	2.4	4.3	2.7	2.7	1.9	2.8	2.7	0.9	40
Vol/Rep							2.3				
MDEQ							1.0<				
MDEQ/Rep							1.0<				
North Blue	Kalkaska	400131	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Ore	Livingston	470100	2.6	3.5	4.3	3.3	5.1	3.8	3.5	1.0	43
Orion	Oakland	630554	1.2	1.0	1.4	1.7	2.1	1.5	1.4	0.4	34
Vol/Rep						1.8					
Osterhout	Allegan	030263	1.8	6.6	3.1	*	2.2	3.4	2.65	2.2	40
Painter	Cass	140108	1.6	4.8	12.0	33.2	4.9	11.3	4.9	12.8	46
Vol/Rep							6.6				
MDEQ				18.0							
MDEQ/Rep				19.0							
Parke	Oakland	631119	1.0<	1.0<	2.4	4.3	5.9	2.7	2.4	2.4	39
Pentwater	Oceana	640313	19.0	18.0	18.0	14.0	16.0	17.0	18	2.0	59
Pleasant	Wexford	830183	*	1.0<	1.6	4.3	2.4	2.2	2	1.6	37
Pretty	Mecosta	540079	2.7	8.6	2.5	5.0	3.0	4.4	3	2.6	41
Vol/Rep			2.3								
MDEQ			3.6								

APPENDIX 3
2009 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}
MDEQ/Rep			3.8								
Randall	Branch	120078	5.5	7.2	11.0	20.0	15.0	11.7	11	5.9	54
Robinson	Newaygo	620061	*	*	*	*	*				
Round	Clinton	190146	2.3	11.0	6.9	4.1	4.5	5.8	4.5	3.4	45
Round	Lenawee	460304	1.0<	1.0<	2.4	1.5	1.8	1.3	1.5	0.8	35
Round	Livingston	470546	1.0<	8.4	18.0	12.0	12.0	10.2	12	6.4	55
Round	Mecosta	540073	1.6	7.0	1.9	6.3	9.1	5.2	6.3	3.3	49
School Section	Mecosta	540080	1.7	10.0	8.3	*	*				
Sherman	Kalamazoo	390382	2.1	*	5.9	13.9	5.4	6.8	5.65	5.0	48
Shingle	Clare	180108	2.0	2.5	2.8	1.9	4.7	2.8	2.5	1.1	40
MDEQ							5.6				
MDEQ/Rep							5.5				
Spider	Grand Traverse	280395	*	1.3	3.1	3.2	2.0	2.4	2.55	0.9	40
Stony	Oceana	640049	1.9	11.0	7.9	11.0	6.4	7.6	7.9	3.8	51
Strawberry	Livingston	470213	2.9	1.0<	2.1	4.1	1.8	2.3	2.1	1.3	38
Sweezey	Jackson	380470	1.0<	1.6	2.4	2.1	1.1	1.5	1.6	0.8	35
Torch North	Antrim	050055	*	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
MDEQ						1.0<					
MDEQ/Rep						1.0<					
Torch South	Antrim	050240	*	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Triangle	Livingston	470591	2.3	2.5	5.0	3.9	13.0	5.3	3.9	4.4	44
Vol/Rep			2.4								
Upper Crooked	Barry	080071	5.7	6.7	4.9	3.0	3.6	4.8	4.9	1.5	46
Van Etten	Iosco	350201	1.2	1.0	4.1	3.4	2.4	2.4	2.4	1.3	39
Viking	Otsego	690136	5.7	7.8	3.6	4.7	*	5.5	5.2	1.8	47
Vineyard	Jackson	380263	1.1	1.3	2.5	1.7	1.6	1.6	1.6	0.5	35
West Twin	Montmorency	600072	2.3	1.0	1.9	3.1e	1.9e	2.0	1.9	0.8	37

APPENDIX 3
2009 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}
Wildwood	Cheboygan	160230	d	d	d	6.0	3.9				
Windover	Clare	180069	1.0<	2.6	4.4	1.0<	1.2	1.8	1.2	1.7	32
MDEQ							1.6				
MDEQ/Rep							1.6				

Results Codes:

< Sample value is less than limit of quantification (1 ug/l)
* No sample received
a No data sheet submitted with sample
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

APPENDIX 4
2009 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Alcona	Badger Lake Hubbard Lake Jewell Lake
Alpena	Beaver Lake
Allegan	Eagle Lake
Barry	Cobb Lake Upper Crooked Lake
Benzie	Lake Ann
Cass	Birch Lake Eagle Lake Magician Lake
Cheboygan	Wildwood Lake
Clare	George Lake Shingle Lake
Grand Traverse	Arbutus Lake Silver Lake
Hillsdale	Lake Diane
Jackson	Sweezey Lake
Kalamazoo	Crooked Lake Indian Lake Sherman Lake
Kent	Bostwick Lake Freska Lake High Lake Murray Lake
Lenawee	Devils Lake Round Lake
Livingston	Earl Lake Strawberry Lake Triangle Lake
Manistee	Bear Lake

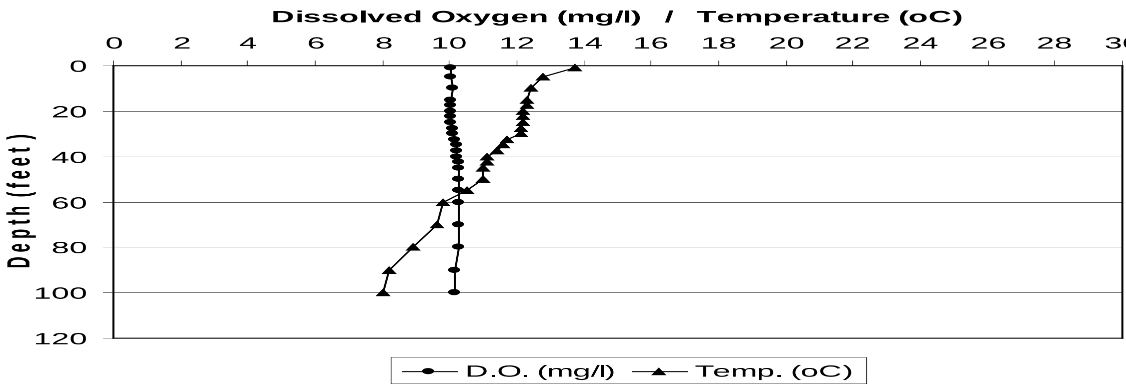
County	Participating Lakes
Mason	Hamlin (Upper) Lake Hamlin (Lower) Lake
Montcalm	Baldwin Lake Derby Lake
Newaygo	Fremont Lake Hess Lake Robinson Lake
Oakland	Deer Lake Parke Lake
Oceana	Pentwater Lake
Osceola	Hicks Lake
Roscommon	Higgins (North) Lake Higgins (South) Lake
St. Joseph	Corey Lake
Van Buren	Bankson Lake Cedar 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 oligo/mesotrophic lake with a large hypolimnion volume. It retains some oxygen in the hypolimnion through most of the summer, but the deepest parts of the lake do drop to zero dissolved 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 very productive hypereutrophic lake with a small 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 loses oxygen in the deeper water, but summer storms drive wave energy into the deepest parts of the lake renewing the oxygen supply to these waters.

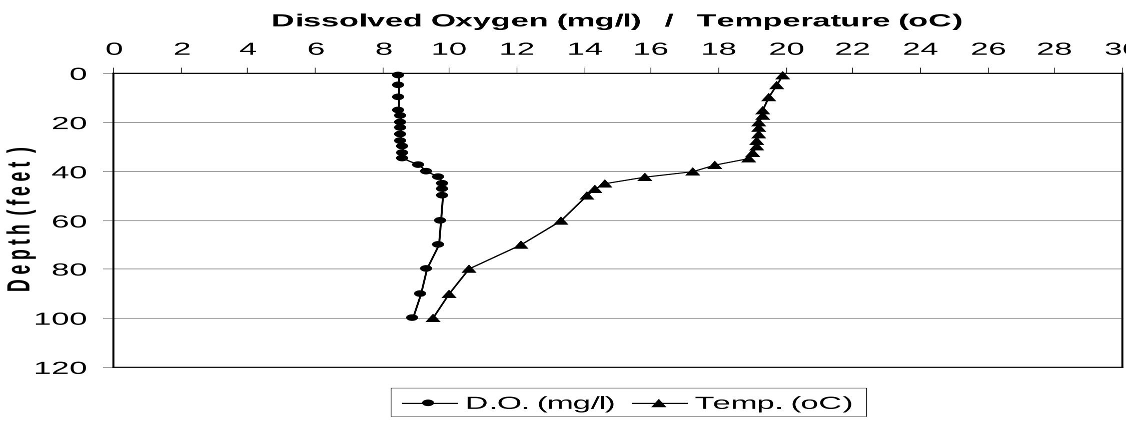
Oligotrophic Lake with a Very Large Volume Hypolimnion

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. 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.

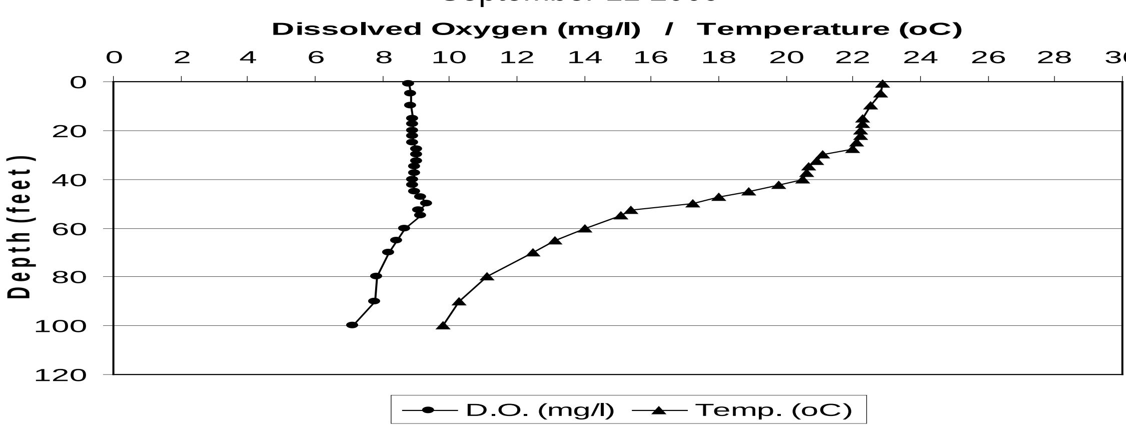
May 22, 2009



July 14, 2009

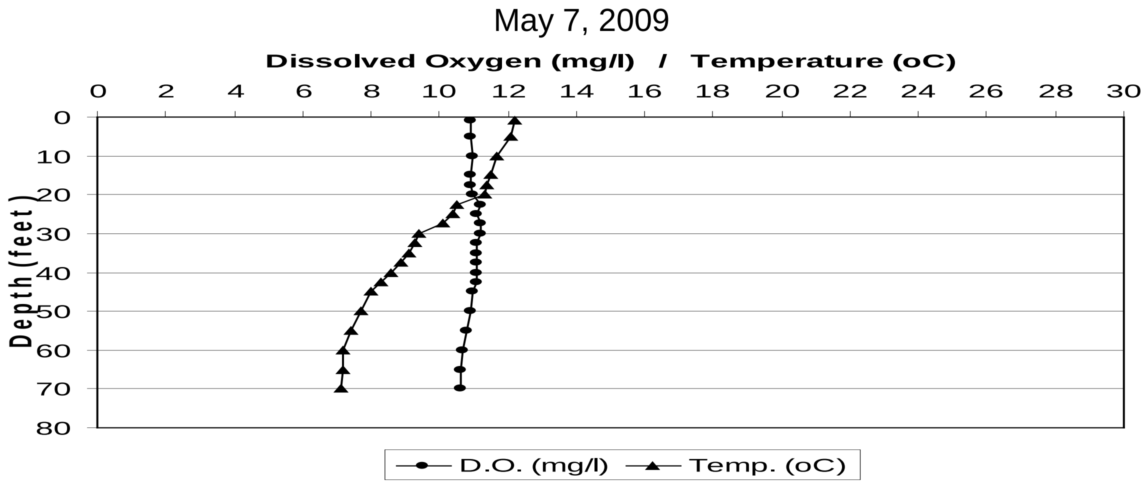


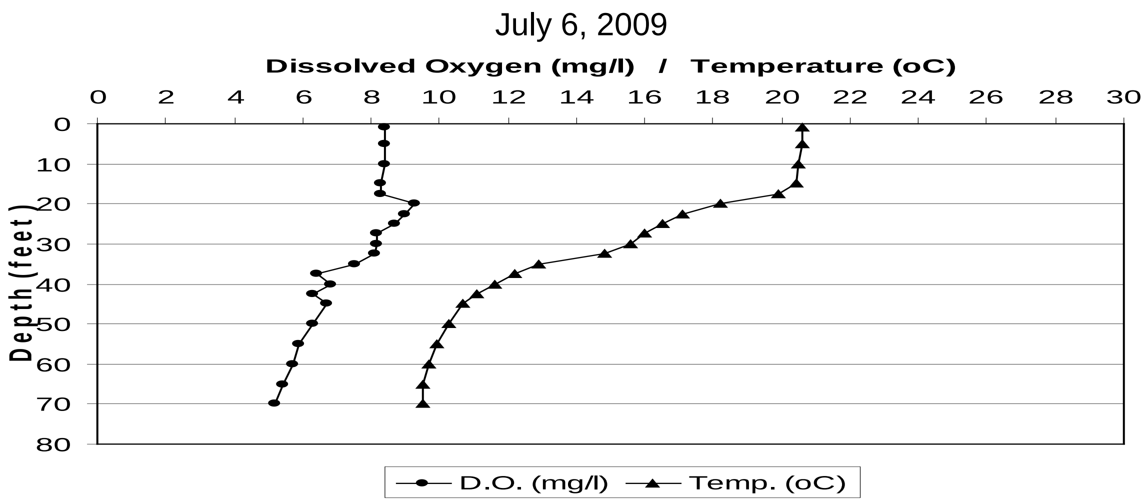
September 11 2009

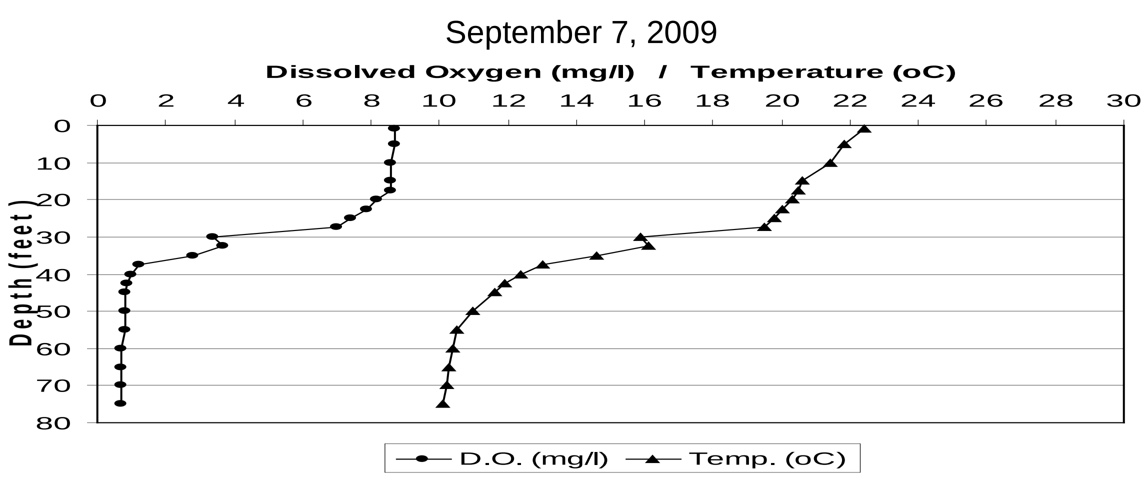


Oligo/Mesotrophic Lake with a Large Volume Hypolimnion

Beaver Lake in Alpena County is an oligo/mesotrophic lake with a large hypolimnion. It produces moderate amounts of organic material that must be decomposed. Its hypolimnion has a substantial oxygen supply that is gradually depleted by the decomposition of the organic material. Dissolved oxygen levels remain high in the hypolimnion into mid-summer. By late July oxygen is gone in the deepest waters, but the upper hypolimnion retains some oxygen. By late summer (September) oxygen is depleted in the hypolimnion



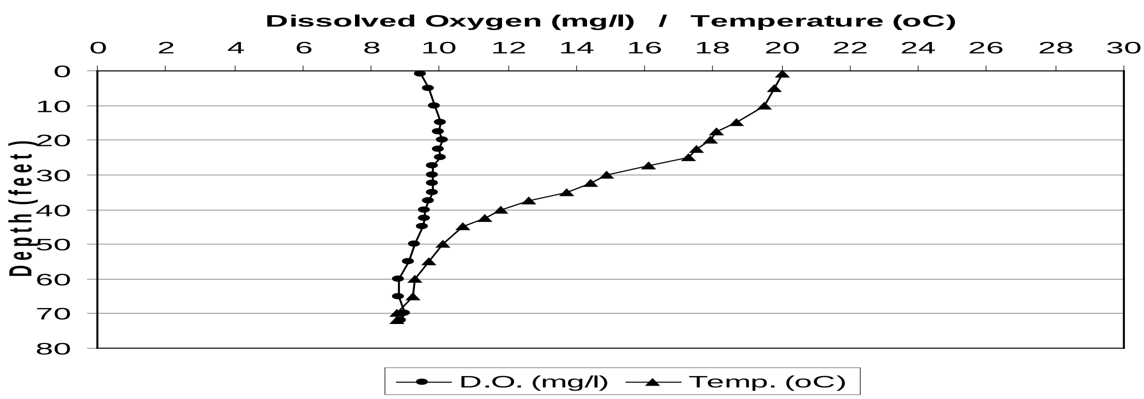




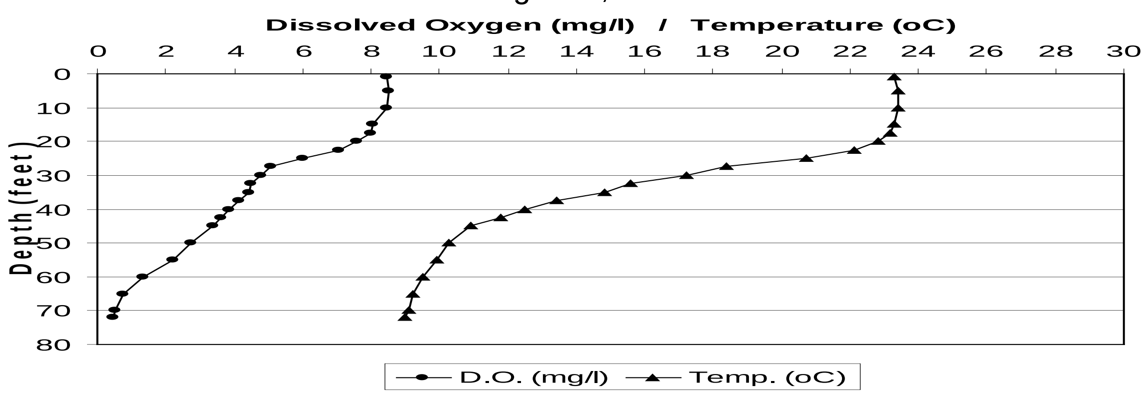
Mesotrophic Lake with a Moderate Volume Hypolimnion

Indian Lake in Kalamazoo 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.

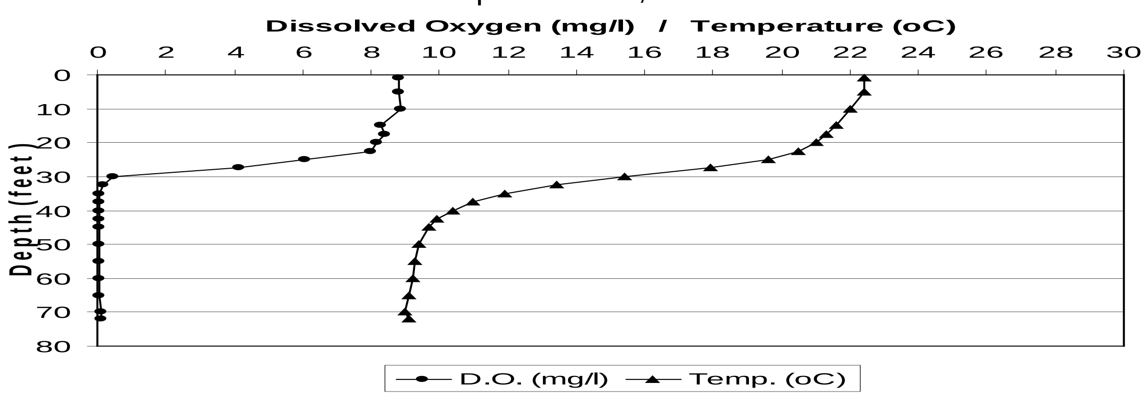
May 24, 2009



August 2, 2009



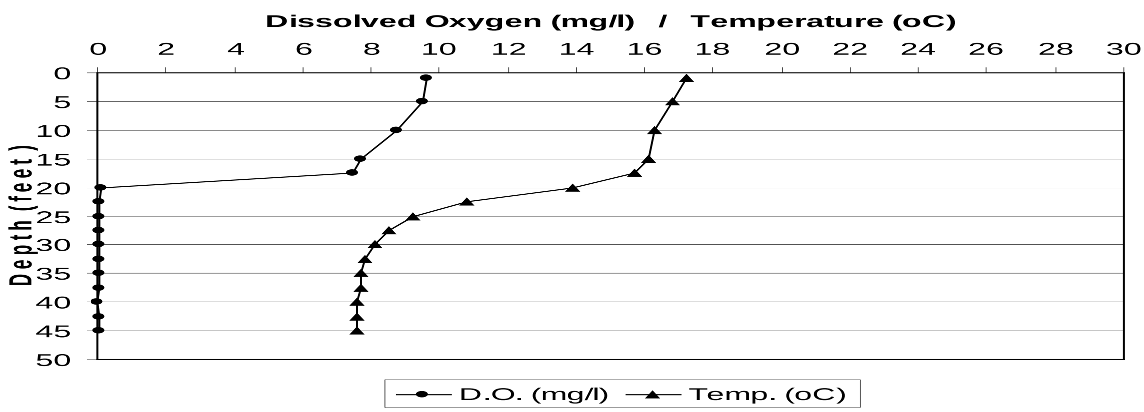
September 12, 2009



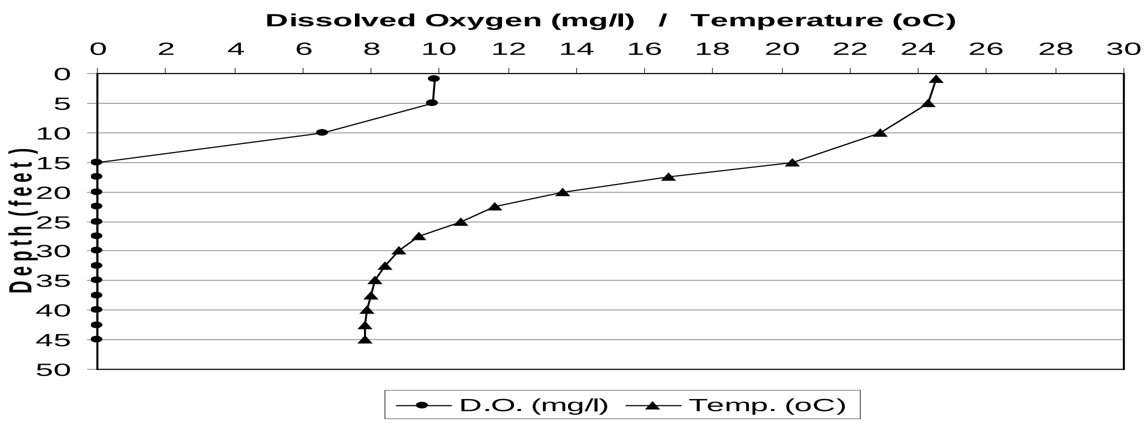
Hypereutrophic Lake with a Small Volume Hypolimnion

Lake Diane in Hillsdale County is a hypereutrophic lake with a small volume hypolimnion. As a highly productive lake it produces abundant amounts of organic material that must be decomposed. Its hypolimnion has a limited 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.

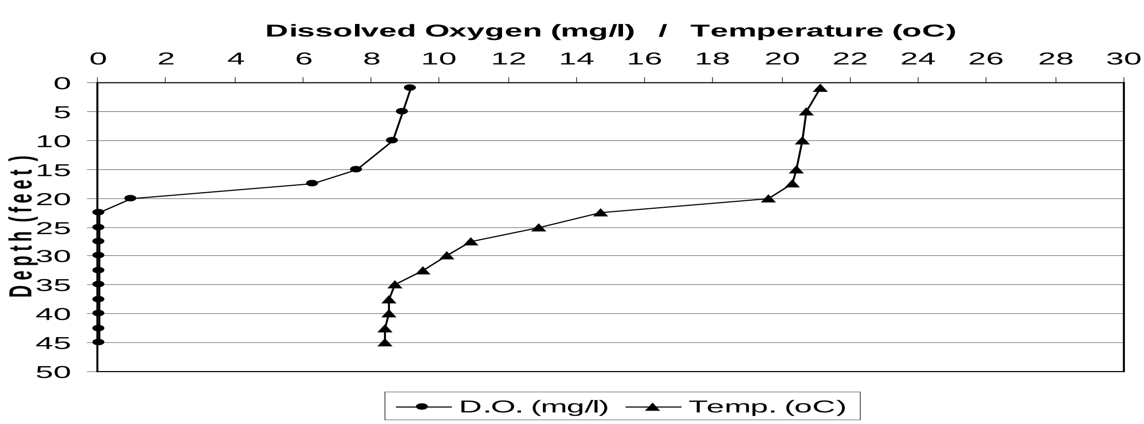
May 15, 2009



July 7, 2009

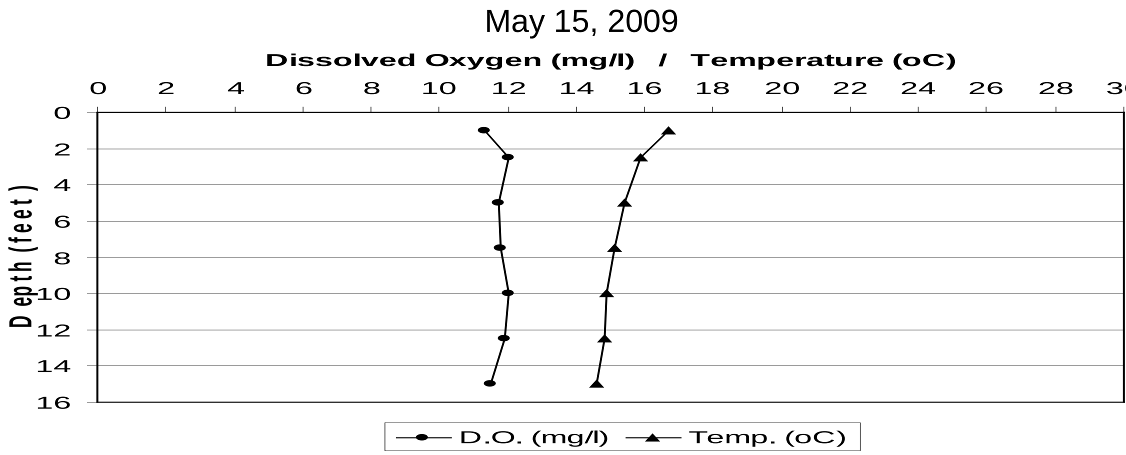


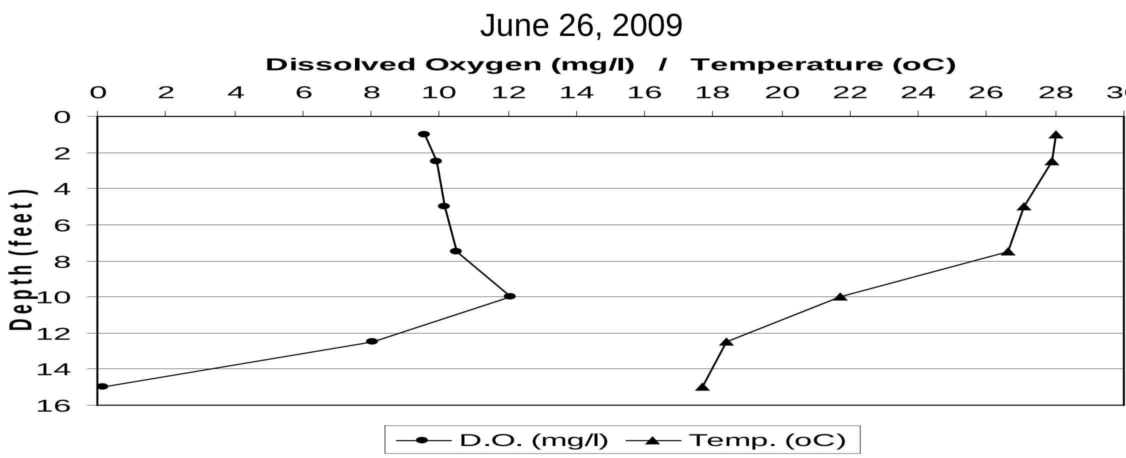
September 27, 2009

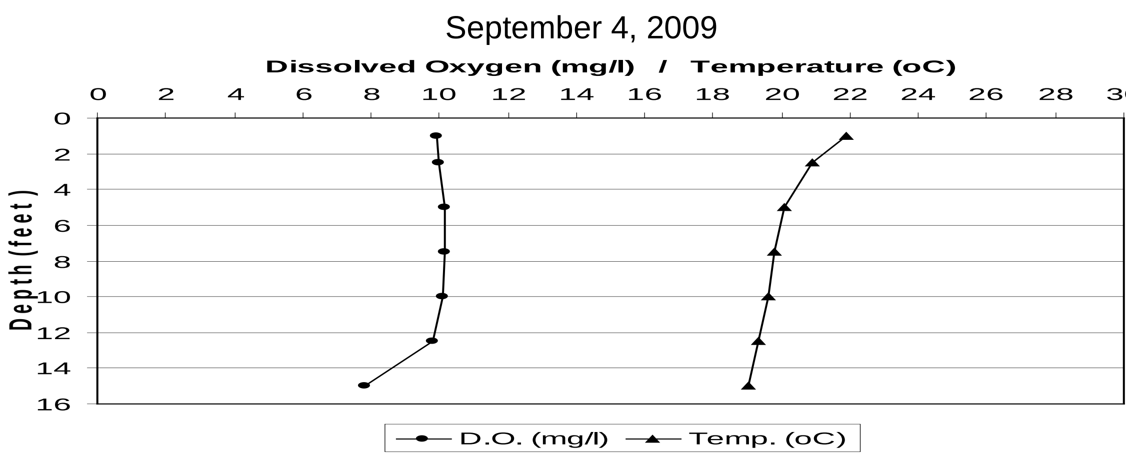


Shallow Mesotrophic Lake that does not maintain Summer Stratification

Wildwood Lake in Cheboygan 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. Dissolved oxygen levels in the deeper water can drop to zero by mid summer. Because the lake is shallow, summer storms can drive wave energy into the deepest parts of the lake breaking up any stratification present and re-supplying the deep water with oxygen. In the calm periods between storms, dissolved oxygen is again lost.







APPENDIX 5
2009 COOPERATIVE LAKES MONITORING PROGRAM
EXOTIC AQUATIC PLANT WATCH RESULTS

County	Participating Lakes
Cass	Eagle Lake
Jackson	Big Portage Lake Sweezey Lake
Leelanau	Big Fisher Lake Little Fisher Lake Glen Lake Little Glen Lake
Oakland	Deer Lake
Oceana	Stony Lake
Osceola	Center Lake

Twenty-one lakes enrolled in the 2009 CLMP Exotic Aquatic Plant Watch, a pilot program for the CLMP. Of those enrolled, ten lakes submitted a report of their results. As an example of the data collected in the Exotic Watch project, the data for Big Portage Lake, Jackson County, are presented below. CLMP volunteers on Big Portage 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.

Big Portage Lake (Jackson County, Waterloo & Henrietta Townships)
MiCorps CLMP Field ID # 380245

Exotic Plant Watch Program
GPS Coordinates Worksheet

Site 1: EWM1: Eurasian Water Milfoil:	42	20	112N	84	13	502W
Site 2: EWM2: Eurasian Water Milfoil:	42	20	168N	84	13	444W
Site 3: EWM3: Eurasian Water Milfoil:	42	20	629N	84	14	128W
Site 4: EWM4:Eurasian Water Milfoil:	42	20	441N	84	14	809W
Site 5: EWM5:Eurasian Water Milfoil:	42	20	393N	84	14	547W
Site 6: Cabomba1:Fanwort:	42	20	424N	84	14	971W

APPENDIX 5
2009 COOPERATIVE LAKES MONITORING PROGRAM
EXOTIC AQUATIC PLANT WATCH RESULTS

Big Portage Lake (Jackson County, Waterloo & Henrietta Townships)
MiCorps CLMP Field ID # 380245

EXOTIC AQUATIC PLANT WATCH MAP, 2009