MI/DEQ/WB-09/005

COOPERATIVE LAKES MONITORING PROGRAM

Michigan's Citizen Volunteer Partnership for Lakes

"MI Lakes - Ours to Protect"

ANNUAL SUMMARY REPORT

2008

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

Michigan Clean Water Corps

Michigan's Lakes and the Tragedy of the Commons

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

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

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

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

Cooperative Lakes Monitoring Program

TABLE OF CONTENTS

DATA CORRECTIONS FROM PREVIOUS REPORTS

The 2007 TSI_{SD} value for Cedar (Briarwood) Lake, Alcona/Iosco Co. should have been reported as <41.

The 2007 TSI_{SD} value for Cedar (Schmidt's) Lake, Alcona/Iosco Co. should have been reported as <46.

The following Secchi disk transparency results were not included in the 2007 CLMP annual report:

			Secchi Disk Transparency (feet)						Carlson
Lake	**County**	**Site ID Number**	Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	TSI_{SD} (transparency)
Coverdale	Cass	140175	9	16	32	19.2	18.0	4.95	34
Long 1	Cass	140174	9	10.6	30	17.8	17.0	7.18	36
Long 2	Cass	140176	9	9	27	15.6	16.0	6.49	37
Long	Gogebic	270179	13	14	19	16.6	17.0	1.26	37

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 Environmental Quality's (DEQ) Water Bureau and Michigan Lake and

Michigan's abundant water resources...

...include over 11,000 inland lakes.

Stream Associations, Inc. (ML&SA), recently joined by 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 DEQ (then the Department of Natural Resources) and the ML&SA entered into a cooperative agreement to expand the program. An advanced Self-Help program was initiated that included a monitoring component for the plant nutrient phosphorus. In 1994, a side-by-side sampling component was added to the program to assure the quality of the data being collected.

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

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

CLMP Contacts

- Michigan Lake and Stream Associations, Inc.
  P.O. Box 303
  Long Lake, MI 48743
  Telephone: 989-257-3583
  http://www.mlswa.org

- Michigan Department of Environmental Quality
  Water Bureau
  P.O. Box 30273
  Lansing, MI 48909-7773
  Telephone: 517-335-4211
  http://www.michigan.gov/deq

- 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. It was created through an executive order by Governor Granholm to assist the DEQ in collecting and sharing water quality data for use in management programs and to foster water resource stewardship. MiCorps provides volunteer monitoring programs with many services including:

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

The mission of MiCorps is to network with and to support and expand volunteer water quality monitoring organizations across the state. To learn more about MiCorps visit their web site (www.micorps.net).

Michigan Clean Water Corps

LAKE QUALITY

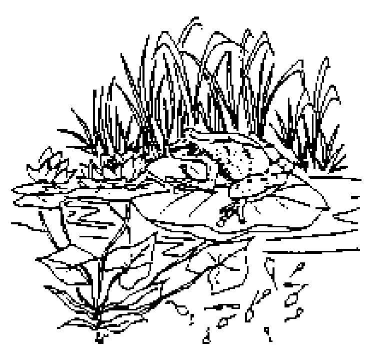
A lake's condition is influenced by many factors, such as the amount of recreational use it receives, shoreline development, and water quality. Lake *water quality* is a general term covering many aspects of chemistry and biology. The health of a lake is determined by its water quality.

CLMP Goals

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

CLMP Measurements

- Secchi disk transparency
- spring total phosphorus
- summer total phosphorus
- chlorophyll *a*
- dissolved oxygen and temperature
- aquatic plant identification and mapping



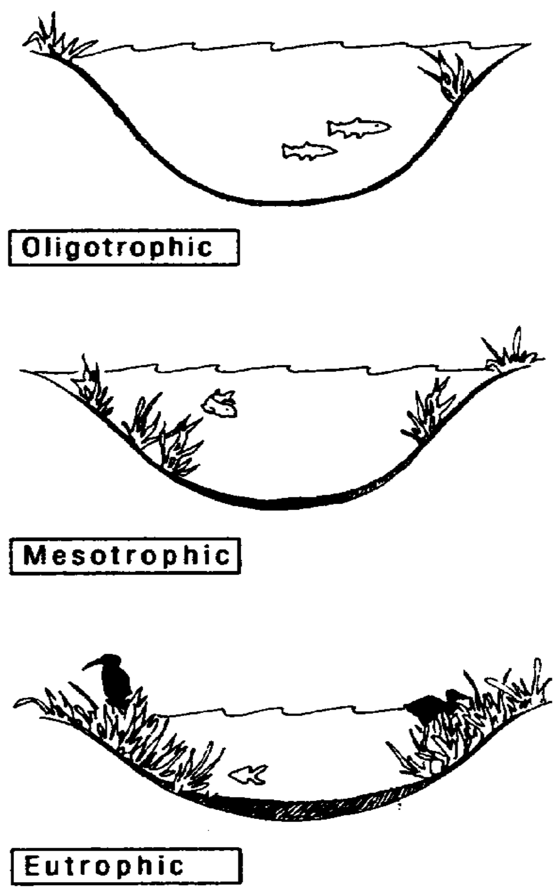
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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 is measured during the spring and late summer. These parameters are indicators of primary productivity and, if measured over many years, may document changes in the lake.

CLASSIFYING LAKES

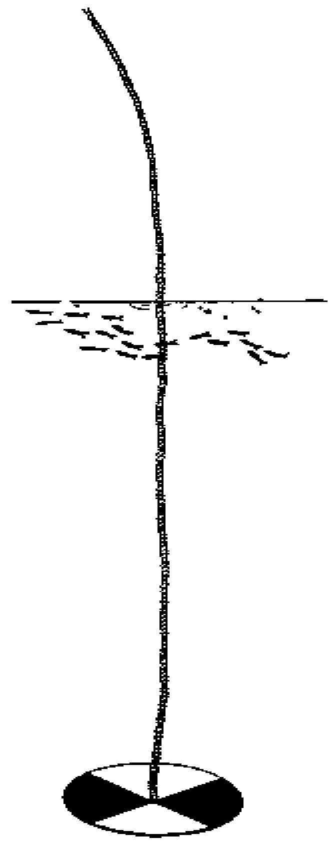
A lake's ability to support plant and animal life defines its level of productivity, or *trophic state*. Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved 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.



(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.



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 (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, 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.

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

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)

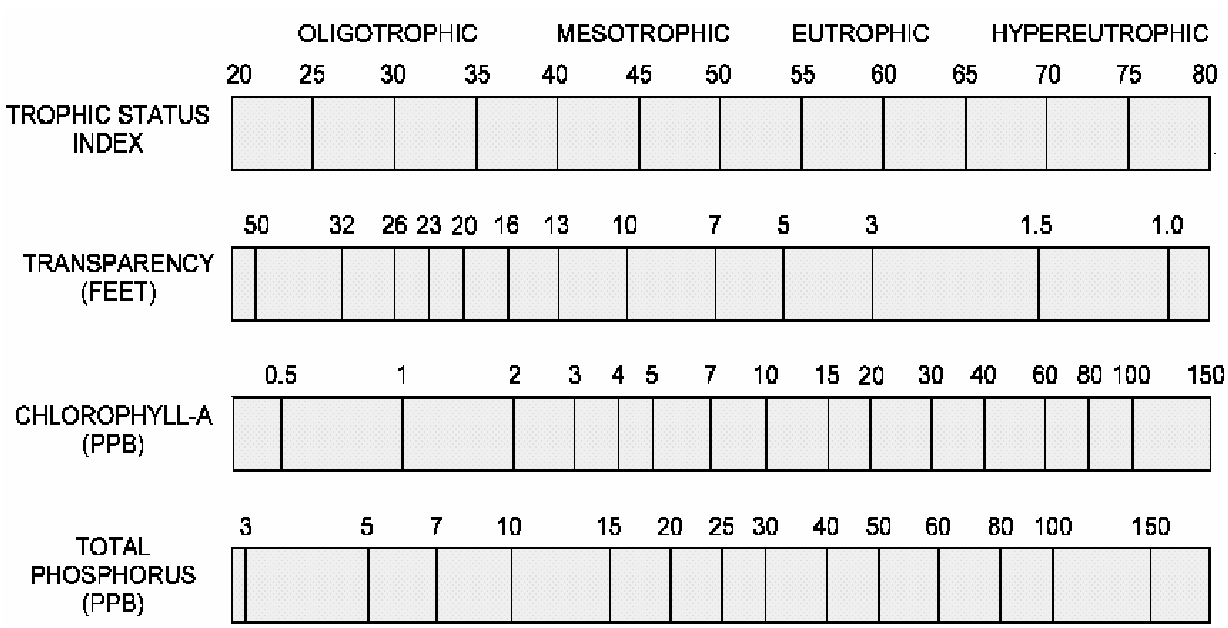
evaluate changes within the lake over time, and to estimate other water quality parameters within the lake.

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)

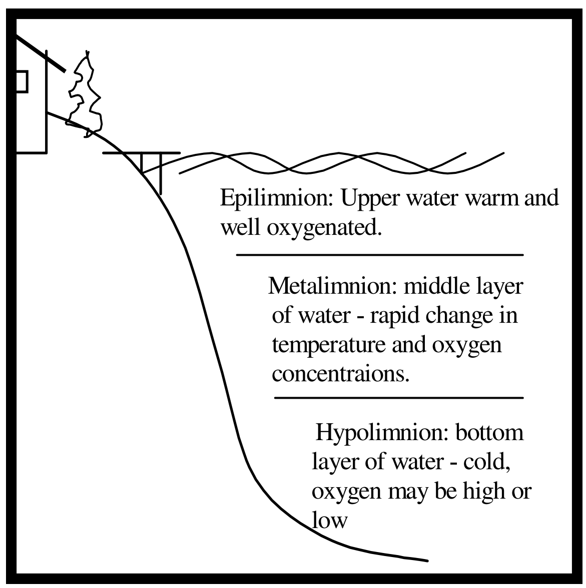
OTHER MEASURES OF LAKE PRODUCTIVITY

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, with all the water in the lake being 4 degrees Celsius. In the winter there is only a few degrees difference between the water under the ice (0 degrees Celsius) and the water on the bottom (4 degrees Celcius). 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 are 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. It is these macrophytes that some 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 (through 1993 at this time), 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.

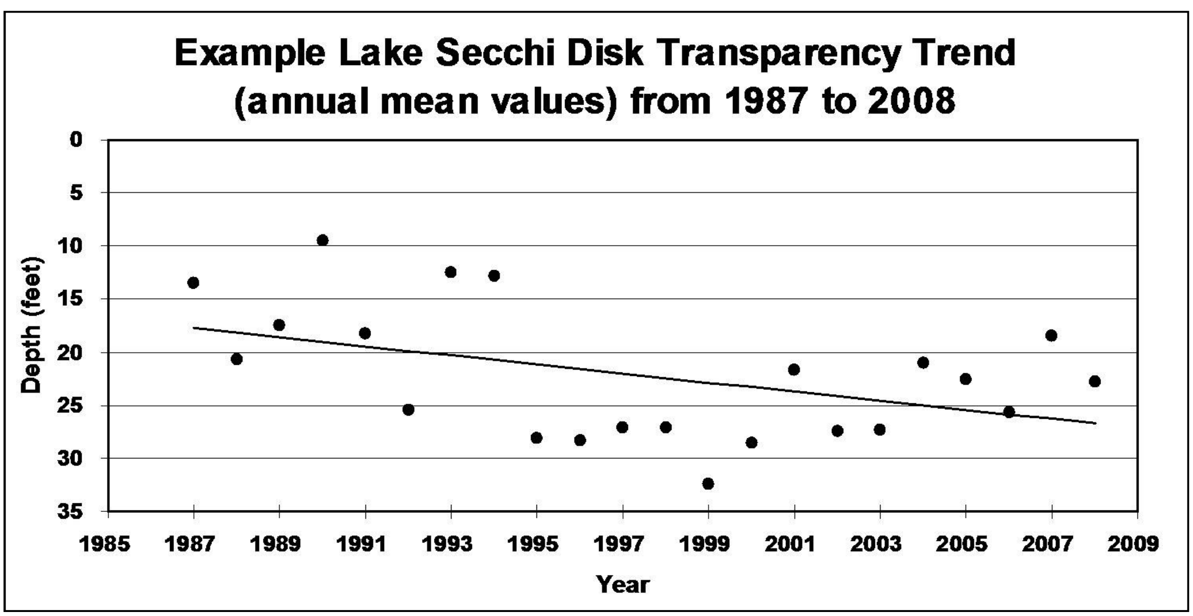
A summary of the transparency data collected by the lake volunteers during 2008 is included in Appendix 1. The number of measurements, or readings, made between mid-May and mid-September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. 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 2008, Secchi disk transparency data were reported for 170 lakes



(194 basins). Over 3140 transparency measurements were reported, ranging from 1.5 to 50.0 feet. For the lakes with eight or more equally spaced readings between mid-May and mid-September, the overall mean, or average, Secchi disk transparency was 12.7 feet and the median value was 11.5 feet. The Carlson TSI_{SD} values ranged from 27 to 68 for these lakes with a mean value of 42. A Carlson TSI value of 42 is generally indicative of a mesotrophic lake (see page 8).

Secchi disk transparency measurements were reported for 170 of the 213 enrolled lakes for a participation rate of 80%.

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 2008 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 2008, samples for total phosphorus measurements were collected on 191 lakes. The spring overturn total phosphorus results ranged from <5 to 69 ug/l with a mean (average) of 14 ug/l and a median value of 10 ug/l. The late summer total phosphorus results ranged from <5 to 87 ug/l with 14 ug/l as the mean and 12 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 69 for these lakes with a mean value of 40. A Carlson TSI value of 40 is generally indicative of a good quality mesotrophic lake (see page 8).

For the spring overturn sampling, 140 total phosphorus samples were turned in from 158 enrolled lakes, for an 89% participation rate. For late summer sampling, 179 samples were received from 197 enrolled lakes/basins for a 91% 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 2008 volunteers collected a minimum of four samples on 111 lakes.

Results from the chlorophyll monitoring for 2008 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 562 chlorophyll samples were collected and processed in 2008. The chlorophyll *a* levels ranged from <1 to 46 ug/l over the five-month sampling period. The overall mean (average) was 4.0 ug/l and the median was 2.9 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 65 with a mean value of 40. A Carlson TSI value of 40 is generally indicative of a good quality mesotrophic lake (see page 8).

During 2008, a total of 131 lakes (132 basins) registered for chlorophyll sampling. A total of 121 lakes participated minimally by turning in at least one sample, for a minimum participation rate of 92%. A total of 111 lakes turned in at least four samples for a complete participation rate of 84 percent. Six samples were turned in, but not processed due to quality control issues for a 1.1% 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 2008, CLMP participants in the dissolved oxygen/temperature project sampled 37 lakes (39 basins). A total of 282 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 2008 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 patters are presented in Appendix 4. These five patterns include: an oligotrophic lake with a very large volume hypolimnion, a mesotrophic lake with a large volume hypolimnion, a mesotrophic lake with a small volume hypolimnion, a eutrophic lake with a moderate volume hypolimnion, and a oligo/mesotrophic lake basin which weakly stratifies but can't maintain stratification all summer. A sixth pattern not represented is the very shallow lake, with a maximum depth of less than 22 feet. These 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 the handles off of two garden rakes and bolt the rakes back to back with two "C" bolts. Use a small hose clamp between the rake tines to prevent side to side slipping. Drill a hole in the remaining wooden handle core and twist into the hole a moderately large eye bolt. The rope should be about 20 feet long. File off any sharp edges. Wear gloves when using the rake to protect the hands from cuts.

Aquatic Plant Mapping

To create 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 2008, CLMP participants in the aquatic plant project sampled one lake — Crystal Lake in Benzie County.

In 2008, Crystal Lake had low spring Total Phosphorus (6 ug/L). TSI values are not available for 2008 because summer Total Phosphorus and Chlorophyll samples were not submitted. However, in 2007, Crystal Lake had TSI values of <27 for Total Phosphorus and <31 for Chlorophyll. These values suggest that the lake is oligotrophic. Given this trophic state or productive level the lake should have a limited aquatic plant population. Indeed, all plant species had limited distribution and low densities in their plant survey. See the results of the Crystal Lake survey in Appendix 5.

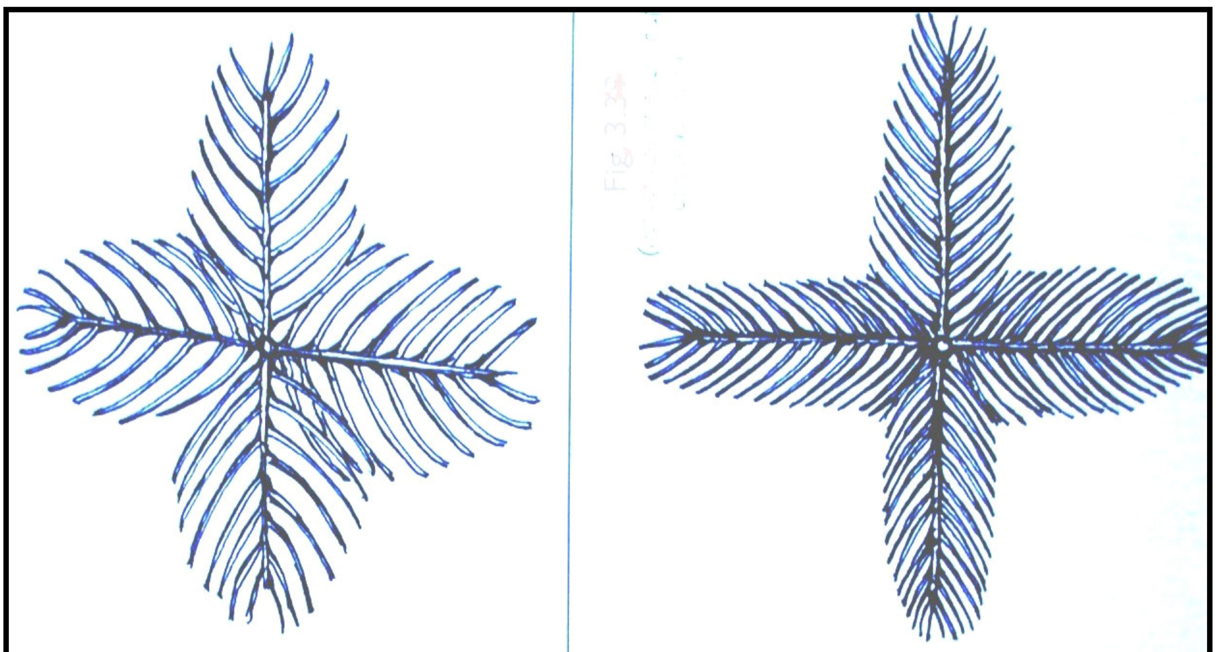
It is worth noting that the survey of Crystal Lake revealed Eurasian milfoil, an exotic species. This is not surprising, since Crystal Lake is a heavily used recreational lake. The lake community can use their data on the currently limited distribution of Eurasian milfoil in their lake to develop a maintenance control plan for their lake, and should continue to monitor for this and other exotic species.

(PILOT PROJECT) Exotic Aquatic Plant Watch

In 2007-08, the CLMP sponsored a pilot monitoring project to identify and map exotic aquatic plants in a lake. Participants were trained to identify the three exotic aquatic plants of concern in Michigan: curly-leaf pondweed, Eurasian milfoil, and Hydrilla.

Using a GPS unit the participants surveyed their lake and mapped the

The figures below represent stem cross sections at a leaf node for both native and Eurasian milfoils. 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 less than twelve.



Native milfoil Eurasian milfoil

location of any exotic plant beds with the GPS unit.

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.

One lake community participated in the Exotic Aquatic Plant Watch monitoring project in 2008. Participation in 2007-08 was not great enough to provide a good quality controlled estimate of the value of the monitoring project. Consequently, the Exotic Watch project will continue to be a pilot project in 2009.

CONCLUSION

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

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

CLMP Data in Research: Harmful Algae Study

In 2006, CLMP volunteers participated in a "Harmful Algae" survey of 77 lakes from 38 Michigan counties to assess concentrations of the cyanobacterial toxin, microcystin, in near-shore surface waters. This toxin is produced by cyanobacteria, also known as blue-green algae. Samples for the toxin microcystin, chlorophyll *a* and total phosphorus were collected by the volunteers, and Dr. Orlando Sarnelle and Howard Wandell (2008) of the Department of Fisheries and Wildlife at Michigan State University examined the data to determine how microcystin levels in these lakes related to total phosphorus, chlorophyll, latitude, maximum depth, and the presence or absence of zebra mussels.

The study was particularly focused on measuring toxin levels at the most likely point of human recreational contact, namely at the water's surface along the shoreline. Toxin-producing cyanobacteria can form surface scums. As a result, the potential exists for large concentrations of cyanobacteria (and accompanying toxins) to be blown toward the shoreline, where human recreational contact is most likely to occur.

Nearly all lakes sampled by CLMP volunteers during 2006 posed little or no public health risk to recreational users, based on World Health Organization standards for microcystin, at the time of sampling. However, it is important to note that very few lakes with high Total Phosphorus results (> 25 µg/L) were included in the survey, lakes were only sampled once, and it is not known whether 2006 was representative of typical climatic conditions that affect the development of toxin-producing cyanobacterial blooms in Michigan.

Interestingly, microcystin concentrations were substantially higher and more variable in lakes that have been invaded by zebra mussels. When a lake lacks zebra mussels, Total Phosphorus is a positive predictor of microcystin concentrations at the shoreline, because higher nutrient levels lead to higher production of cyanobacteria. However, the study showed that lakes with low nutrient concentrations that have been invaded by zebra mussels may have levels of microcystin that are higher than expected, suggesting that zebra mussels may promote the cyanobacteria that produce the toxin. The study also suggested that shoreline microcystin concentrations tend to be very low in lakes with Total Phosphorus < 15 µg/L that lack zebra mussels and in lakes with shoreline chlorophyll levels < 10 µg/L. Read the full report at www.micorps.net/pubs.html.

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.

Sarnelle, O. and Wandell, H. 2008. Monitoring and Predicting Concentrations of Cyanobacterial Toxins in Michigan Lakes. Final Report. Available at: www.micorps.net/documents/FinalReport_MSU.pdf.

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 David Boprie and Martha Kern-Boprie
Sweezey Lake Association, Norvell, Michigan

Sweezey Lake is a 105-acre spring fed lake in southeastern Jackson County. Across most of the lake, the average depth is five feet or less, with a few areas up to 23 feet.

The Cooperative Lakes Monitoring Program (CLMP) provided the necessary set of standardized water quality measurement tools the Sweezey Lake Association needed to monitor our lake. We began by monitoring Water Transparency (Secchi Depth), Chlorophyll and Total Phosphorus following the same easy-to-do procedures that other Michigan CLMP volunteers use. We found that the small investment in time and effort provides near-term and long-term benefits for managing and protecting our lake. Eventually, we added two more CLMP tests to our sampling program: Dissolved Oxygen/ Temperature and the Exotic Aquatic Plant Watch.

So far, we have observed a slight increase in water clarity as measured by the Secchi Disk and a slight decrease in Total Phosphorus when comparing 2007 results with 2006 results from the annual reports. The Secchi Disk Trophic State Index (TSI) went from 47 in 2006 to 45 in 2007. Total Phosphorus TSI went from 47 to 30. Chlorophyll TSI stayed the same at 37. We will continue to monitor in coming years to determine the long-term trends that are occurring in our lake.

Our participation in the Exotic Aquatic Plant Watch Program is new. The program is helping the Sweezey Lake community learn about the nonnative species that can negatively affect the lake. We have installed warning signs and hope to add more to inform lake users that it is important to make sure boating equipment is clean entering and leaving the lake in order to prevent the spread of nonnative species.

These data sets are very helpful tools to quantitatively communicate the conditions of the lake to our lake community. Most importantly, this has raised awareness of water quality issues for us in several ways. At the annual lake association meeting, results of the most recent CLMP data are presented and are trended with the previous year's data. After presenting the results, we review and discuss some of the simple behavior changes that we can do to slow the eutrophication, or aging, of the lake.

At the association meetings we emphasize the importance of minimizing excessive nutrients that can enter the lake, not emptying your bait bucket in the lake, and making sure boating equipment is clean entering and leaving the lake. These and other concepts are presented in a brief report with the CLMP data. Poster-sized story boards are left up during the meetings for those that want to learn more. Lakeshore residents often ask questions about "best practices" to enhance the health of lake water. Such questions afford an opportunity for education and advocacy, backed up by our CLMP data.

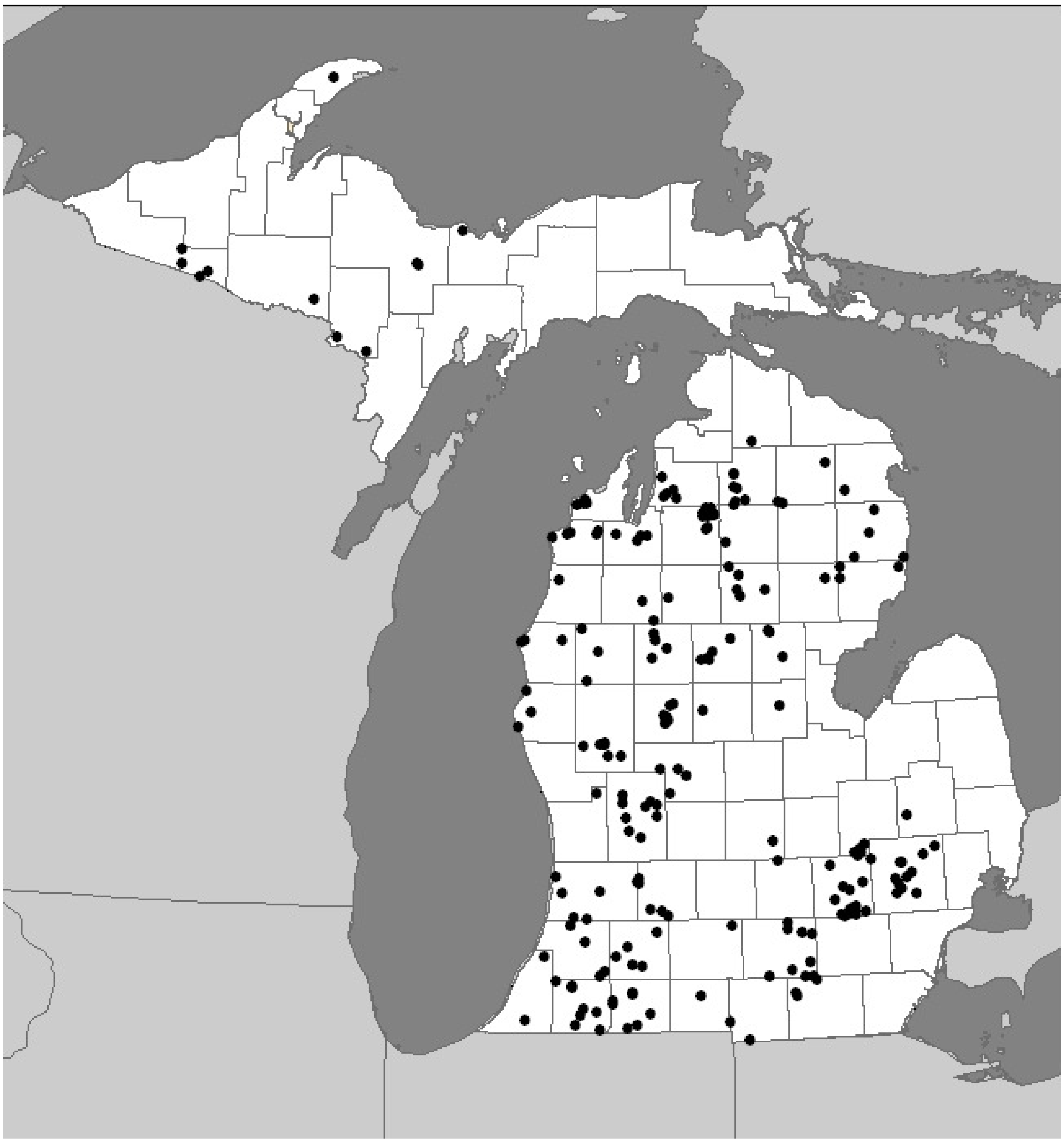
Do you have a success story of how your community has used the CLMP data to implement a protection program for your lake? We would like to hear from you. Contact Ralph Bednarz at 517-335-4211 or bednarzr@michigan.gov

ACKNOWLEDGMENTS

Ralph Bednarz of the Michigan Department of Environmental Quality, Water Bureau, 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 Pearl Bonnell, Scott Brown and Donald Winne of the Michigan Lake and Stream Associations, Inc., and Ric Lawson of the Huron River Watershed Council. Jean Roth supported the effort by entering data in to the online MiCorps Data Exchange and Bruce Bonnell compiled enrollment information.

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, to Jean Roth for handling numerous administrative tasks, and to those volunteers who entered their data into the MiCorps Data Exchange.

Statewide Distribution of CLMP Lakes Sampled During 2008



APPENDICES

Appendix 1

2008 Secchi Disk Transparency Results

Appendix 2

2008 Total Phosphorus Results

Appendix 3

2008 Chlorophyll Results

Appendix 4

2008 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2008 Aquatic Plant Mapping Participating Lakes and Example Results

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Ann	Benzie	100082	17	11.5	28	16.6	13.5	6.08	37
Antoine	Dickinson	220028	5	14	19				
Arbutus 1	Grand Traverse	280108	18	12	28	17.8	15.5	5.29	36
Arbutus 2	Grand Traverse	280109	18	12	37	19.3	16.0	7.53	34
Arbutus 3	Grand Traverse	280396	18	12	12.5	12.3	12.5	0.24	41
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
Arnold	Clare	180107	19	15	33	19.4	18.0	4.78	34
Baldwin	Cass	140105	*						
Baldwin	Montcalm	590171	14	11	14.5	12.9	13.0	1.06	40
Bankson	Van Buren	800159	6	9	13				
Barlow	Barry	080176	10	5	18.5	11.3	12.5	4.84	42
Barton	Kalamazoo	390215	16	3.5	10	7.6	8.5	2.22	48
Base Line	Livingston	470149	8	13.5	22	15.9	15.0	2.84	37
Bass	Kalkaska	400129	*						
Bear	Kalkaska	400026	*						
Bear	Manistee	510122	19	8	15	11.0	10.0	2.60	43
Beatons	Gogebic	270105	11	16	22.5	18.5	18.0	1.63	35
Beaver	Alpena	040097	15	16	34.5	21.5	21.0	4.68	33
Bellaire	Antrim	050052	17	9	20	13.0	12.0	2.92	40
Big Pine Island	Kent	410437	19	6	12	8.0	7.0	1.78	47
Big Star	Lake	430611	12	10	13	11.6	11.8	1.02	42
Bills	Newaygo	620062	16	10	36	19.6	18.0	7.52	34
Birch	Cass	140061	19	8	20	12.6	12.0	3.85	41
Blue	Mecosta	540092	19	9	21	13.1	11.5	3.78	40
Blue (Big Blue)	Kalkaska	400017	14	16	31	24.1	26.0	4.73	31
Blue (North)	Kalkaska	400131	*						

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Bostwick	Kent	410322	9	4.5	12	8.1	8.0	2.89	47
Bradford, Big	Otsego	690036	13	18	24	19.9	19.0	2.10	34
Bradford, Little	Otsego	690151							
Brooks	Leelanau	450222	18	7	14	11.1	11.3	2.17	42
Buckhorn	Oakland	631113	12	10	16	13.4	13.3	1.70	40
Byram 1	Genesee	250363	19	10	16	14.2	15.0	2.14	39
Byram 2	Genesee	250364	19	10	16	14.2	15.0	2.14	39
Byram 3	Genesee	250365	19	10	17	14.2	15.0	2.20	39
Canadian, Main	Mecosta	540172	15	8	14	10.7	10	2.28	43
Canadian,West	Mecosta	540171	15	9	13	10.3	10	1.33	44
Cedar	Alcona/Iosco	010017	*						
Cedar	Van Buren	800241	14	8	26	14.6	12.5	6.18	38
Center	Osceola	670238	10	14	21	16.3	16.0	2.30	37
Chain	Iosco	350146	15	10	12.5	11.5	12.0	0.67	42
Chancellor (Blue)	Mason	530287	10	16	30	22.8	21.3	5.15	32
Chemung	Livingston	470597	15	15	18.5	17.5	18.0	1.03	36
Clam	Antrim	050101	17	13	26	18.3	17.0	4.32	35
Clark	Jackson	380177	15	9	44	16.1	12.0	9.26	37
Clear	Berrien	110771	15	10.5	17.5	13.7	13.0	2.22	39
Clear	St. Joseph	750166	*						
Clear	Jackson	380453	18	10	16	13.1	12.8	1.54	40
Clifford	Montcalm	590142	19	10	17.5	12.9	11.5	2.79	40
Cobb	Barry	080259	19	8	32.5	16.0	14.0	7.41	37
Corey	St. Joseph	750142	17	6	25	12.4	11.0	5.44	41
Coverdale	Cass	140175	12	9	30	14.6	12.3	5.67	38
Cowan	Kent	410550	16	4	8	5.8	5.8	1.29	52
Crescent	Oakland	630563	*						

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

			Secchi Disk Transparency (feet)						Carlson
Lake	**County**	**Site ID**	Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	**TSI_{SD}** (transparency)
Crockery	Ottawa	700422	*						
Crooked	Kalamazoo	390599	16	9.5	19	13.0	12.8	2.62	40
Crooked, North	Kalkaska	400133	*						
Crooked, Upper 1	Barry	080071	17	8.5	22	13.1	10.0	4.96	40
Crooked, Upper 2	Barry	080081	16	8	20	11.3	10.0	3.73	42
Crystal	Benzie	100066	*						
Crystal	Oceana	640062	19	3	19	9.3	11.5	4.80	45
Cub	Kalkaska	400031	*						
Deer	Alger	020127	10	7	13.5	9.1	9.0	1.91	45
Deer	Oakland	631128	17	8	18.5	11.6	10.5	3.27	42
Derby	Montcalm	590144	18	10	22	15.7	15.0	3.64	37
Devils	Lenawee	460179	4	8	13				
Diamond	Cass	140039	19	5	18	11.0	10.0	3.90	43
Diane	Hillsdale	300174	19	1.5	2.5	1.8	2	0.29	68
Dinner	Gogebic	270126	17	8.5	17	11.2	10.0	2.47	42
Duck	Calhoun	130172	6	10.5	22.5				
Eagle	Allegan	030259	15	7.5	16	12.4	12.5	2.70	41
Eagle	Cass	140057	18	3	15.5	8.8	7.0	4.82	46
Eagle	Kalkaska	400130	9	13	20.5	15.9	14.5	2.91	37
Earl	Livingston	470554	19	5	9	6.5	6.0	1.31	50
Emerald	Newaygo	620167	18	10	18	12.0	11.5	2.05	41
Emerald (Button)	Kent	410709	19	6.5	21	13.2	15.0	5.29	40
Evans	Lenawee	460309	19	10.5	23.5	14.5	14.0	3.57	39
Fair	Barry	080260	16	9.5	14	11.5	11.0	1.47	42
Farewell	Jackson	380454	16	8	21	12.1	10.0	4.41	41
Fenton	Genesee	250241	*						
Fine	Barry	080097	*						

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet)						Carlson
			Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	TSI_{SD} (transparency)
Fish	Livingston	470602	7	4.5	17				
Fisher	St. Joseph	750139	*						
Fisher, Little	St. Joseph	750312	*						
Fisher, Big	Leelanau	450224	*						
Fisher, Little	Leelanau	450223	*						
Five (Lake 2)	Otsego	690157	*						
Fremont	Newaygo	620029	16	5	19	11.4	11.0	4.24	42
Freska	Kent	410702	6	7	10				
Gallagher	Livingston	470210	11	9	14.5	11.6	12.0	1.48	42
George	Clare	180156	*						
Glen (Big Glen)	Leelanau	450049	19	14	23.5	18.5	19.0	2.28	35
Glen, Little	Leelanau	450050	19	5	12	7.6	7.0	1.83	48
Goshorn	Allegan	030650	18	3.5	8.5	5.8	5.8	1.55	52
Gourdneck	Kalamazoo	390541	*						
Gratiot	Keweenaw	420030	13	9	17	12.8	12.5	2.43	40
Green Oak (Silver)	Livingston	470589	12	11	27	16.5	15.0	5.18	37
Gut	Livingston	470567	9	10.5	13	11.6	11.5	0.78	42
Hamburg	Livingston	470568	18	11.5	20	14.9	15.3	2.24	38
Hamilton	Dickinson	220061	16	11	17.5	13.9	14.8	1.99	39
Hamlin, Lower	Mason	530073	16	5	16	9.6	9.0	3.00	45
Hamlin, Upper	Mason	530074	17	3	12	6.8	5.5	2.92	50
Harper	Lake	430030	18	14	19	15.9	15.8	1.59	37
Hawk	Oakland	631115	16	6.5	11	9.6	10.0	1.17	45
Hess	Newaygo	620032	11	2	4.5	2.9	2.5	0.74	62
Hicks	Osceola	670062	11	4	6	4.5	4.0	0.71	55
Higgins (N. Basin)	Roscommon	720026	8	23.5	50	32.7	30.5	8.90	27
Higgins (S. Basin)	Roscommon	720028	8	20	46.5	31.3	31.5	8.77	27

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
High	Kent	410703	*						
Horsehead	Mecosta	540085	19	7.5	20	11.7	10.0	4.12	42
Houghton 1	Roscommon	720163	9	3	5.5	4.3	4.0	1.03	56
Houghton 2	Roscommon	720164	19	4	5.5	4.8	4.5	0.54	55
Hubbard 1	Alcona	010101	17	10	22	16.1	16.0	4.45	37
Hubbard 2	Alcona	010102	18	9	25	16.4	17.0	4.42	37
Hubbard 3	Alcona	010103	11	11	23.5	16.3	16.0	3.95	37
Hubbard 4	Alcona	010104	11	11	22.5	16.1	16.0	4.16	37
Hubbard 5	Alcona	010105	11	11	24.5	17.1	19.0	4.82	36
Hubbard 6	Alcona	010106	19	10	26	17.5	19.0	4.83	36
Hubbard 7	Alcona	010107	17	10	25	16.4	15.5	4.52	37
Hutchins	Allegan	030203	18	5.5	11.5	8.5	9.0	1.99	46
Indian	Kalkaska	400016	11	8.5	18	11.9	10	3.32	41
Indian	Kalamazoo	390307	14	7	21	12.6	10.8	4.72	41
Indian	Osceola	670227	*						
Isabella	Isabella	370135	15	5	9.5	7.7	8	1.16	48
Island	Grand Traverse	280164	15	16	36	23.1	20.0	6.48	32
Jewell	Alcona	010041	11	7	10.5	8.7	9.5	1.42	46
Kimball	Newaygo	620107	13	4	11	6.7	7.0	2.06	50
Kirkwood	Oakland	631116	*						
Klinger	St. Joseph	750136	19	4.5	21	10.6	9.0	4.56	43
Lake of the Woods	Antrim	050103	16	5	8	6.6	6.8	0.76	50
Lakeville	Oakland	630670	16	8	17	13.9	15.5	3.12	39
Lancelot 1	Gladwin	260104	10	2.5	10	5.5	4.8	2.81	53
Lancelot 2	Gladwin	260112	11	5.5	15	9.5	8.0	3.62	45
Lancelot 3	Gladwin	260113	10	3	8.5	5.9	6.0	2.37	52
Lancer 1	Gladwin	260074	12	8	15	11.7	12.0	2.49	42

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Lancer 2	Gladwin	260114	12	6	10	8.8	9.3	1.42	46
Lancer 3	Gladwin	260115	12	2	5	3.7	4.0	0.72	58
Lancer 4	Gladwin	260116	12	6	10	8.8	9.0	1.18	46
Lancer 5	Gladwin	260117	12	4	5	4.7	4.8	0.39	55
Lansing	Ingham	330137	17	4	8	6.2	6.5	1.08	51
Lily	Clare	180066	*						
Little	Marquette	520210	5	13	28				
Long	Gogebic	270179	11	13	22	18.5	19.0	2.62	35
Long	Iosco	350076	9	12	16	14.1	14.0	1.33	39
Long	Oakland	631118	13	10	13	11.2	11.0	1.07	42
Long 1	Cass	140174	12	9	28	15.0	10.5	7.03	38
Long 2	Cass	140176	12	8.5	26	13.7	10.3	5.75	39
Magician	Cass	140065	18	6	27	13.2	9.8	7.44	40
Margrethe	Crawford	200036	10	8	22	13.0	10.5	5.36	40
Mary	Iron	360071	16	8	22	16.8	18.0	4.11	36
Marl	Genesee	250480	*						
Mecosta	Mecosta	540057	14	6	13	10.5	10.5	2.04	43
Mehl	Marquette	520451	5	11	17				
Middle Straits	Oakland	630732	10	12	19	15.1	15.0	2.56	38
Moon	Gogebic	270120	14	14	21	16.5	15.5	2.28	37
Murray	Kent	410268	17	4	10	7.3	8.0	1.72	49
Muskellunge	Montcalm	590154	19	4	11.5	7.5	7.0	2.30	48
Nepessing	Lapeer	440220	9	10	18	15.2	15.0	2.49	38
Oneida	Livingston	470573	14	7.5	13	9.5	8.8	1.83	45
Ore	Livingston	470100	17	5	23.5	13.8	14.5	5.94	39
Orion	Oakland	630554	10	13	17.5	14.7	14.5	1.55	38
Osterhout	Allegan	030263	19	5	10	7.9	8.0	1.31	47

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Otsego	Otsego	690018	10	9	12	10.9	11.3	0.91	43
Oxbow	Oakland	630666	*						
Papoose	Kalkaska	400134	6	26	28				
Parke	Oakland	631119	16	12.5	22	16.8	16.8	2.71	36
Paw Paw, Little	Berrien	110765	16	4	8	5.4	5.0	1.37	53
Payne	Barry	080103	9	6	14	8.7	8.0	2.44	46
Pentwater	Oceana	640089	8	4	7	5.8	5.8	1.00	52
Perch	Otsego	690150	9	8	13	11.3	12	1.87	42
Perrin	St. Joseph	750314	15	9	10.5	9.6	9.5	0.47	45
Pickerel	Kalkaska	400035	19	21	28	25.8	26.0	1.74	30
Pickerel	Newaygo	620066	13	7	17	11.7	11.5	2.57	42
Platte	Benzie	100086	19	7	29	15.8	15.0	5.92	37
Platte, Little	Benzie	100122	*						
Pleasant	Jackson	380244	16	5.5	12	8.7	8.5	2.52	46
Pleasant	Wexford	830183	13	5	9	6.1	6.0	1.06	51
Ponemah	Genesee	250243	*						
Portage	Washtenaw	810248	19	10	21	14.2	13.0	3.09	39
Portage, Big	Jackson	380245	12	6	19	9.8	8.8	3.52	44
Pretty	Mecosta	540079	*						
Puterbaugh	Cass	140170	17	6.5	16.5	9.6	7.5	3.52	44
Randall	Branch	120078	18	4.5	15.5	8.5	8.5	3.17	46
Rebeck	Hillsdale	300273	*						
Reeds	Kent	410270	14	3.5	14	7	5.8	3.44	49
Rifle	Ogemaw	650022	14	18.5	32.5	22.3	22.3	3.50	32
Rose	Osceola	670058	*						
Round	Clinton	190146	15	7	10	7.9	8.0	0.82	47
Round	Lenawee	460304	9	10	17	13.3	13.0	2.55	40

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Round	Livingston	470546	12	7.5	10	8.8	8.5	0.84	46
Round	Mecosta	540073	14	6	9	8.2	8.5	1.05	47
Sanford	Benzie	100208	19	12	22	16.3	16.0	3.19	37
Sanford	Midland	560169	16	6	11.5	7.8	8.0	1.44	47
Sapphite	Missaukee	570015	*						
School Section	Van Buren	800276	16	10	13	11.4	11.0	1.12	42
School Section 1	Mecosta	540080	19	4.5	14	8.9	8.5	2.30	46
School Section 2	Mecosta	540190	19	5	13	8.7	8.5	2.18	46
Sherman	Kalamazoo	390382	16	12	18.5	14.4	14.0	2.02	39
Shingle	Clare	180108	18	10	21	12.0	11.0	2.54	41
Silver	Grand Traverse	280116	15	17.5	40	24.0	22.0	7.47	31
Silver	Van Buren	800534	19	7.5	13.5	10.4	10.0	1.64	43
Smallwood	Gladwin	260107	7	5	10				
Spider	Grand Traverse	280395	*						
Squaw	Kalkaska	400135	7	6.5	10				
St. Helen	Roscommon	720056	*						
Starvation	Kalkaska	400030	17	15.5	22.5	18.6	19.5	2.18	35
Stone Ledge	Wexford	830186	19	8	12	9.4	9.0	1.01	45
Stony	Oceana	640049	11	5	10	7.0	6.5	1.36	49
Strawberry	Livingston	470213	16	6.5	11	8.4	8.3	1.20	46
Sweezey	Jackson	380470	17	5	12	9.4	9.5	2.21	45
Sylvan	Newaygo	620168	18	11	21	14.6	14.0	3.24	39
Taylor	Oakland	631114	19	17	23.5	19.7	19.0	1.74	34
Thornapple/Cascade Imp.	Kent	410716	8	2	5.5	3.8	3.5	1.34	58
Torch (N.Basin)	Antrim	050055	17	16	42	27.9	24.5	8.34	29
Torch (S. Basin)	Antrim	050240	14	13	42	27.1	22.8	8.90	30
Triangle	Livingston	470591	8	6	12	8.8	8.8	2.00	46

APPENDIX 1
2008 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Site ID	Secchi Disk Transparency (feet)						Carlson
			Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	TSI_{SD} (transparency)
Twin, Big	Kalkaska	400025	16	16	31	24.6	25.0	3.61	31
Twin, Big	Cass	140165	17	6	18.5	10.9	9.5	4.56	43
Twin, East	Montmorency	600013	9	7	10.5	9.1	9.5	1.45	45
Twin, Little	Cass	140166	19	5.5	17	10.2	10.0	3.01	44
Twin, Little	Kalkaska	400013	10	11	17.5	15.1	15.5	1.98	38
Twin, West	Montmorency	600014	9	6.5	11.5	8.4	8.5	1.40	46
Van Etten	Iosco	350201	17	5	14	9.4	10.0	2.32	45
Vaughn	Alcona	010049	4	9	14				
Viking	Otsego	690136	19	5	15	8.1	7.0	3.19	47
Vineyard	Jackson	380263	19	6.5	23	12.3	11.0	5.01	41
Wahbememe	St. Joseph	750313	11	11	28.5	16.5	17.0	5.28	37
Wamplers	Jackson/Lenawee	380249	*						
Wetmore	Allegan	030664	*						
White	Jackson	380473	*						
Wildwood	Cheboygan	160230	*						
Windover	Clare	180149	10	9	28	16.4	13.8	6.75	37
Woods	Kalamazoo	390542	18	6	16	12.2	12.5	2.60	41

* No measurements reported

APPENDIX 2
2008 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	7				4 T				<27
Arbutus	Gr. Traverse	280109	2 W				9				36
Arnold	Clare	180107	6				9				36
Avalon	Montmorency	600022	*				*				
Baldwin	Montcalm	590171	*				13				41
Bankson	Van Buren	800159	*				16				44
Barlow	Barry	080176	*				12				40
Barton	Kalamazoo	390215	18	19			14	14	19		42
Base Line	Livingston	470149	12				12	12			40
Bass	Kalkaska	400129	17	28			*				
Bear	Kalkaska	400026	*				4 T				<27
Bear	Manistee	510122	7	5			9				36
Beatons	Gogebic	270105					4 T	4 T			<27
Beaver	Alpena	040097	8				8				34
Bellaire	Antrim	050052					4 T	5			<27
Big Pine Island	Kent	410437	24				16				44
Big Star	Lake	430611	8				8				34
Bills	Newaygo	620062	5 k				*				
Birch	Cass	140061	*				7				32
Blue	Mecosta	540092	*				6				30
Blue (Big)	Kalkaska	400016	19				3 W,a	2 W			<27
Blue, North	Kalkaska	400131	5				4 T				<27
Bostwick	Kent	410322	16				39				57
Bradford, Big	Otsego	690036					8 j				34

APPENDIX 2

2008 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)
Brooks	Leelanau	450222	29				10		11		37
Buckhorn	Oakland	631113	14				*				
Cedar	Alcona/Iosco	010017	6				13				41
Cedar	Van Buren	800241	10 k				15				43
Center	Osceola	670238	6				5				27
Chain	Iosco	350146	10				11				39
Chancellor (Blue)	Mason	530287	7	9			9	7			36
Chemung	Livingston	470597	14				10				37
Clam	Antrim	050101					8				34
Clark	Jackson	380453	5				8				34
Clear	Berrien	110771					8	7			34
Clear	Jackson	380453					6				30
Clifford	Montcalm	590142	21				18				46
Cobb	Barry	080259	8		7	9	9				36
Corey	St. Joseph	750142	8				8				34
Cowan	Kent	410550	39				23	25			49
Crescent	Oakland	630563	30				*				
Crockery	Ottawa	700422	69				*				
Crooked	Kalamazoo	390599	11				12				40
Crooked (North)	Kalkaska	400133	11				13				41
Crooked (Upper)	Barry	080071					18				46
Crystal	Benzie	100066	6				*				
Crystal	Oceana	640062	12				20				47
Cub	Kalkaska	400031	*				6				30

APPENDIX 2

2008 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)
Deer	Alger	020127	9	5			2 w				<27
Deer	Oakland	631128	6				7				32
Derby	Montcalm	590144	3 w	3 w			10	5			37
Devils	Lenawee	460179	11				10				37
Diamond	Cass	140039	6				12				40
Diane	Hillsdale	300173	43				87	76			69
Dinner	Gogebic	270126	13	17			15				43
Duck	Calhoun	130172					13	12	12		41
Eagle	Allegan	030259	17				19		15		47
Eagle	Cass	140057					14				42
Eagle	Kalkaska	400130	8				11				39
Earl	Livingston	470554	45				38				57
Emerald	Kent	410709	8	9			13				41
Emerald	Newaygo	620167	9	9			9				36
Evans	Lenawee	460309	9				11				39
Fair	Barry	080260	9		12		15				43
Farwell	Jackson	380454	*				5				27
Fenton	Genesee	250241	8	10			10				37
Fine	Barry	080097					24				50
Fish	Livingston	470602	*				9				36
Fisher	St. Joseph	750139	5				k				
Fisher, Little	St. Joseph	750312	10				k				
Fisher, Big	Leelanau	450224	5				7				32
Fisher, Little	Leelanau	450223	5				8				34

APPENDIX 2

2008 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)
Five Lakes (2)	Otsego	690157	17				*				
Five Lakes (3)	Otsego	690152	11				*				
Fremont	Newaygo	620029	*				12 a				40
Freska	Kent	410702	16				12				40
Gallagher	Livingston	470210	10				16				44
George	Clare	180056	8				9	10			36
Glen (Big)	Leelanau	450049	4 T				6		7		30
Glen, Little	Leelanau	450050	5				10		10		37
Goshorn	Allegan	030650	28				46				59
Gourdneck	Kalamazoo	390541					11				39
Gratiot	Keweenau	420030					14				42
Green Oak (Silver)	Livingston	470589	8				11				39
Gut	Livingston	470567	14				18				46
Hamburg	Livingston	470568	16	14			6				30
Hamilton	Dickinson	220060	15				7				32
Hamlin, Lower	Mason	530073	14				35				55
Hamlin, Upper	Mason	530074	23				28				52
Harper	Lake	430030	12	7			12	9			40
Hess	Newaygo	620032					43				58
Hicks	Osceola	670062	23				25				51
Higgins (N)	Roscommon	720026	5				5				27
Higgins (S)	Roscommon	720028	5				2 W				<27
High	Kent	410703					*				
Horsehead	Mecosta	540085	10				19				47

APPENDIX 2

2008 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)
Houghton (1)	Roscommon	720163					21				48
Houghton (2)	Roscommon	720164					*				
Hubbard	Alcona	010106	11				6				30
Hutchins	Allegan	030203					19				47
Indian	Kalamazoo	390305	7				10				37
Indian	Kalkaska	400015	8				10				37
Indian	Osceola	670227					9				36
Isabella	Isabella	370135					12	12			40
Island	Gr. Traverse	280164	3 W				8				34
Jewell	Alcona	010041					10				37
Kimball	Newaygo	620107	60				17	17			45
Klinger	St. Joseph	750136	8				16				44
Lake of the Woods	Antrim	050103					10 j				37
Lakeville	Oakland	630670	12				12				40
Lancelot	Gladwin	260104	19				25				51
Lancer	Gladwin	260116	16				12				40
Lily	Clare	180066					10				37
Little	Marquette	520210	9				10				37
Long	Gogebic	270179	11				5				27
Long	Iosco	350076	15				9				36
Long	Oakland	631118	7				14				42
Magician	Cass	140065	*				9				36
Margrethe	Crawford	200157					5		11	11	27
Mary	Iron	360071	9				*				

APPENDIX 2
2008 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)
Mecosta	Mecosta	540057	*				13				41
Mehl	Marquette	520451	8				8	7			34
Middle Straits	Oakland	630732	7	7			9				36
Moon	Gogebic	270120	7				7				32
Murray	Kent	410268	33				18 g				46
Muskellunge	Montcalm	590154	18				22				49
Nepressing	Lapeer	440220					19				47
Oneida	Livingston	470573	12				11				39
Ore	Livingston	470100					17				45
Orion	Oakland	630554					12	9			40
Osterhout	Allegan	030263	14	13			21				48
Otsego	Ostego	690018	*				14 b,j				42
Oxbow	Oakland	630666					11				39
Papoose	Kalkaska	400134	6				19				47
Parke	Oakland	631119	21				15				43
Payne	Barry	080103	11				9 h	9 h			
Pentwater	Oceana	640313	25				25				51
Perch	Otsego	690150	10	10			9 d				36
Perrin	St. Joseph	750314					21				48
Pickerel	Kalkaska	400035	4 T				7				32
Pickerel	Newaygo	620066	43				16				44
Platte, Little	Benzie	100122	10				17				45
Pleasant	Jackson	380244	9		12		12				40
Pleasant	Wexford	830183	16				12				40

APPENDIX 2
2008 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)
Portage	Washtenaw	810248	13				12				40
Portage, Big	Jackson	380245	9		13		13				41
Pretty	Mecosta	540079	*				14				42
Randall	Branch	120078					36				56
Rebeck	Hillsdale	300273	32 a				20 c				47
Reeds	Kent	410270					33	32	59		55
Rifle	Ogemaw	650022	6	6			7	8			32
Rose	Osceola	670058					*				
Round	Clinton	190146	27				17				45
Round	Lenawee	460304	10 j				8				34
Round	Livingston	470546	24				13		12		41
Round	Mecosta	540073	*				20				47
Saint Helen	Roscommon	720056	*				*				
Sanford	Benzie	100208	7				9 a		10		36
Sapphire	Missaukee	570015	6				12				40
School Section	Mecosta	540080	8	8			11				39
School Section	Van Buren	800276	34				23				49
Sherman	Kalamazoo	390382	8	8			12				40
Shingle	Clare	180108	7				9				36
Silver	Gr. Traverse	280116	11				6				30
Silver	Van Buren	800534	*				16				44
Smallwood	Gladwin	260107	31				29	29			53
Spider	Gr. Traverse	280395	3 W				7				32
Squaw	Kalkaska	400135	5				9				36

APPENDIX 2

2008 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)
Starvation	Kalkaska	400030	4 T				8				34
Stone Ledge	Wexford	830186	19				14	14			42
Stony	Oceana	640049	17				17				45
Strawberry	Livingston	470213	24				27	22			52
Sweezey	Jackson	380470	7				7				32
Sylvan	Newaygo	620168	13				11				39
Taylor	Oakland	631114	14				24				50
Thornapple River- Cascade	Kent	410686					64 c		42		64
Torch (N. Basin)	Antrim	050055					3 W,j	5			<27
Torch (S. Basin)	Antrim	050240					3 W				<27
Triangle	Livingston	470591	18				21	19			48
Twin, Big (North)	Cass	140165	11 d				13				41
Twin, Little (South)	Cass	140166	9				15				43
Twin, Big	Kalkaska	400025	13				8				34
Twin, Little	Kalkaska	400013	6				8				34
Twin, East	Montmorency	600013					13				41
Twin, West	Montmorency	600072					11				39
Van Etten	Iosco	350201	24				25				51
Vaughn	Alcona	010049	31				16				44
Viking	Otsego	690136	24				22 j				49
Vineyard	Jackson	380263	7				7				32
Wahbememe	St. Joseph	750313	7				6				30
Wetmore	Allegan	030664					23	28	28		49
White	Jackson	380473	18	18	22		*				

APPENDIX 2

2008 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)
Wildwood	Cheboygan	160230	19				16 j				44
Windover	Clare	180069	4 T				9				36
Wolf	Lake	430026					13				41
Woods	Kalamazoo	390542	50				28				52

Results Codes:

* No sample received or received too late to process.
T Value reported is less than the reporting limit (5 ug/l). Result is estimated.
W Value is less than the method detection limit (3 ug/l)
a No field sheets received
b Sampling date on field sheet does not correspond with date on sample bottle label
c Improper sample collection - no replicate
d Sample bottle overfilled
e Used ink that ran on label
f Sample not collected at proper sampling site
g No labels on bottles
h Laboratory holding time exceeded
i Sample bottle not rinsed
j Sample received not frozen - thawed in mail
k Sample lost in transit

APPENDIX 3
2008 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

		Site ID	Chlorophyll *a* ($\mu g/L$)							Std.	Carlson
Lake	**County**	**Number**	**May**	**June**	**July**	**Aug**	**Sept**	**Mean**	**Median**	**Dev.**	**TSI_{CHL}**
Ann	Benzie	100082	1.8	2.2	2.5	1.8	2.1	2.1	2.1	0.3	38
Arbutus	Gr. Traverse	280109	1.0<	2.1	2.3	2.0	2.6	1.9	2.1	0.8	38
Arnold	Clare	180107	1.0<	1.8	2.0	1.9	1.9	1.6	1.9	0.6	37
Baldwin	Montcalm	590171	3.3	7.0	4.1	4.8	10.0	5.8	4.8	2.7	46
Bankson	Van Buren	800159	*	*	6.6	d	d				
Barlow	Barry	080176	1.5	1.3	4.4	1.8	2.2	2.2	1.8	1.3	36
Bass	Kalkaska	400129	*	*	*	*	*				
Bear	Manistee	510122	1.0<	3.0	3.3	3.5	4.4	2.9	3.3	1.5	42
Vol/Rep					3.2						
MDEQ				3.2							
MDEQ/Rep				2.9							
Beaver	Alpena	040097	1.0<	1.0<	1.0<	1.2	1.2	0.8	0.5	0.4	<31
Bellaire	Antrim	050052	1.2	1.4	1.7	1.9	1.4	1.5	1.4	0.3	34
Big Pine Island	Kent	410437	2.1	5.5	3.7	2.8	4.2	3.7	3.7	1.3	43
Big Star	Lake	430611	2.8	2.7	3.1	1.7	2.4	2.5	2.7	0.5	40
Bills	Newaygo	620062	1.0<	*	1.1	*	*				
Birch	Cass	140061	2.0	1.0<	2.3	2.6	2.5	2.0	2.3	0.9	39
Blue	Mecosta	540092	1.0<	2.3	2.8	2.9	2.7	2.2	2.7	1.0	40
Blue (Big)	Kalkaska	400016	*	1.7	1.0<	2.0	1.3	1.4	1.5	0.7	35
Blue, North	Kalkaska	400131	1.2	1.0<	1.0<	1.0<	1.0<	0.7	0.5	0.4	<31
Bostwick	Kent	410322	2.9	5.1	7.8	9.7	10.0	7.1	7.8	3.1	51
Brooks	Leelanau	450222	45.0	36.0	16.0	5.7	8.8	22.3	16	17.3	58
Vol/Rep						5.3					
MDEQ							12.0				
MDEQ/Rep							11.0				
Cedar	Alcona/Iosco	010017	*	1.6	3.9	2.8	2.2	2.6	2.5	1.0	40
Cedar	Van Buren	800241	1.3	1.9	2.9	3.0	3.7	2.6	2.9	1.0	41
Chancellor (Blue)	Mason	530287	1.8	1.5	2.5	3.4	1.9	2.2	1.9	0.8	37
Chemung	Livingston	470597	1.2	1.0<	2.9	2.0	2.2	1.8	2.0	0.9	37
Clam	Antrim	050101	1.0<	1.0<	1.8	2.2	1.5	1.3	1.5	0.8	35
Clark	Jackson	380173	*	1.0<	1.7	1.1	2.7	1.5	1.4	0.9	34
Cobb	Barry	080259	1.0<	1.0<	4.1	1.6	4.1	2.2	1.6	1.8	35
Vol/Rep			1.0								
MDEQ					1.0						
MDEQ/Rep					1.0						
Corey	St. Joseph	750142	1.0	3.4	1.7	2.0	3.0	2.2	2	1.0	37
Cowan	Kent	410550	8.8	6.0	9.6	6.6	1.5	6.5	6.6	3.2	49

APPENDIX 3
2008 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	Chlorophyll *a* ($\mu g/L$) May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
Crescent	Oakland	630563	*	*	*	*	*				
Crockery	Ottawa	700422	*	*	*	*	*				
Crooked	Kalamazoo	390599	3.5	*	1.2	3.5	4.0	3.1	3.5	1.3	43
Crooked, Upper	Barry	080071	3.6	1.5	9.8	4.5	4.7	4.8	4.5	3.1	45
Crystal	Benzie	100066	*	*	*	*	*				
Crystal	Oceana	640062	1.0<	3.2	9.0	9.9	17.0	7.9	9	6.4	52
Deer	Alger	020127	1.1	3.1	3.1	2.9	3.7	2.8	3.1	1.0	42
Deer	Oakland	631128	1.0<	1.0<	1.6	1.0<	1.0<	0.7	0.5	0.5	<31
Vol/Rep							1.1				
Derby	Montcalm	590144	1.8	3.0	2.5	1.2	1.0	1.9	1.8	0.8	36
Devils	Lenawee	460179	2.2	3.3	3.9	2.9	3.5	3.2	3.3	0.6	42
Diamond	Cass	140039	1.0<	1.2	3.5	3.5	2.3	2.2	2.3	1.3	39
Diane	Hillsdale	300173	27.0	31.0	41.0	46.0	33.0	35.6	33	7.7	65
Vol/Rep							35.0				
MDEQ						48.0					
MDEQ/Rep						50.0					
Eagle	Allegan	030259	5.7	5.5	3.7	5.3	6.9	5.4	5.5	1.1	47
MDEQ							5.8				
MDEQ/Rep							5.7				
Eagle	Kalkaska	400130	1.0<	1.0<	1.4	1.7	1.0<	1.0	0.95	0.6	<31
Earl	Livingston	470554	3.4	34.0	16.0	9.8	9.8	14.6	9.8	11.7	53
Emerald	Kent	410709	1.0<	3.8	*	3.9	3.3	2.9	3.55	1.6	43
Evans	Lenawee	460309	2.2	1.7	3.4	3.3	8.3	3.8	3.3	2.6	42
Fair	Barry	080260	1.6	7.3	5.3	12.0	2.3	5.7	5.3	4.2	47
Farwell	Jackson	380454	*	*	*	1.1	1.0<				
Fishers	St. Joseph	750139	*	1.0<	2.5	3.7	3.5	2.6	3	1.5	41
Fishers, Little	St. Joseph	750312	*	1.0<	1.0<	4.3	6.8	3.0	2.4	3.1	39
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 (3)	Otsego	690152	1.0<	1.0<	1.4	1.0<	*	0.7	0.5	0.5	<31
Vol/Rep			1.0<								
MDEQ			1.0<								
MDEQ/Rep			1.0<								
Fremont	Newaygo	620029	7.5	1.2	4.5	1.0<	3.0	3.3	3	2.8	41
Vol/Rep					7.6						
Freska	Kent	410702	*	7.9	4.3	6.5	7.7	6.6	7.1	1.7	50
George	Clare	180056	3.1	5.0	3.6	3.1	2.3	3.4	3.1	1.0	42

APPENDIX 3
2008 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

		Site ID	Chlorophyll *a* (µg/L)							Std.	Carlson
Lake	**County**	**Number**	**May**	**June**	**July**	**Aug**	**Sept**	**Mean**	**Median**	**Dev.**	**TSI_{CHL}**
Glen (Big)	Leelanau	450049	1.3	1.0<	1.0<	1.0<	1.0<	0.7	0.5	0.4	<31
MDEQ							1.0<				
MDEQ/Rep							1.0<				
Glen, Little	Leelanau	450050	2.7	1.7	1.1	2.5	2.0	2.0	2	0.6	37
MDEQ							2.0				
MDEQ/Rep							2.0				
Goshorn	Allegan	030650	17.0	13.0	38.0	*	*				
Gourdneck	Kalamazoo	390541	1.3	7.2	4.9	5.5	4.7	4.7	4.9	2.1	46
Hamlin, Lower	Mason	530073	2.0	1.6	20.0	4.9	2.7	6.2	2.7	7.8	40
Hamlin, Upper	Mason	530074	3.0	2.6	11.0	16.0	5.0	7.5	5	5.8	46
Hess	Newaygo	620032	5.9	35.0	20.0	12.0	6.9	16.0	12	12.0	55
Hicks	Osceola	670062	*	*	16.0	14.0	*				
Higgins (North)	Roscommon	720026	1.0	1.0<	1.0<	1.0<	1.0<	0.6	0.5	0.3	<31
Higgins (South)	Roscommon	720028	1.0<	1.0<	1.0<	*	1.0<	0.5	0.5	0.0	<31
High	Kent	410703	*	*	*	*	*				
Horsehead	Mecosta	540085	1.3	1.0<	5.7	4.0	5.2	3.3	4	2.3	44
Houghton (1)	Roscommon	720163	4.4	5.2	5.9	3.6	6.2	5.1	5.2	1.1	47
Houghton (2)	Roscommon	720164	6.7	11.0	6.0	9.0	*	8.2	7.85	2.3	51
Hubbard	Alcona	010106	1.0<	1.0<	2.6	1.8	1.1	1.3	1.1	0.9	32
Indian	Kalamazoo	390305	1.0<	1.6	1.3	1.0<	1.9	1.2	1.3	0.6	33
Indian	Kalkaska	400015	1.8	3.4	2.8	2.8	2.8	2.7	2.8	0.6	41
Indian	Osceola	670227	*	*	*	*	*				
Island	Gr. Traverse	280164	1.0<	1.5	2.8	2.9	1.5	1.8	1.5	1.0	35
Jewell	Alcona	010041	3.0	2.5	4.7	3.9	3.7	3.6	3.7	0.8	43
Kimball	St. Joseph	750136	1.5	1.0	3.8	3.5	2.9	2.5	2.7	1.0	40
Klinger	Newaygo	620107	3.5	8.2	8.2	5.3	8.8	6.8	7.5	1.9	50
Lakeville	Oakland	630670	5.7	1.9	1.1	1.6	3.5	2.8	1.9	1.9	37
Lancelot	Gladwin	260104	1.9	2.7	3.8	3.7	8.9	4.2	3.7	2.7	43
Lancer	Gladwin	260116	1.0<	1.0<	1.0	1.0<	1.0	0.7	0.5	0.3	<31
Little	Marquette	520210	2.6	2.0	4.7	4.3	3.1	3.3	3.1	1.1	42
Vol/Rep						4.3					
Long	Iosco	350076	1.0<	1.9	2.1	2.5	6.2	2.6	2.1	2.1	38
Magician	Cass	140065	1.0<	1.7	2.4	3.3	2.2	2.0	2.2	1.0	38
Margrethe	Crawford	200157	*	*	*	2.4	2.5				
Vol/Rep						2.5					
MDEQ							2.3				
MDEQ/Rep							2.4				

APPENDIX 3
2008 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	220039	6.4	7.2	7.0	2.1	2.5	5.0	6.4	2.5	49
Vol/Rep							3.0				
Mecosta	Mecosta	540057	2.1	2.9	3.1	3.5	2.9	2.9	2.9	0.5	41
Mehl	Marquette	520451	3.4	2.8	4.5	19.0	4.8	6.9	4.5	6.8	45
Vol/Rep											
Moon	Gogebic	270120	*	3.3	3.1	1.2	3.1	2.7	3.1	1.0	42
Murray	Kent	410268	3.4	4.3	3.9	1.8	4.9	3.7	3.9	1.2	44
Nepessing	Lapeer	440220	1.4	2.4	1.0	2.6	4.6	2.4	2.4	1.4	39
Vol/Rep			1.6								
Ore	Livingston	470100	1.0<	1.2	1.8	4.8	3.6	2.4	1.8	1.8	36
Orion	Oakland	630554	*	*	1.7	1.1	1.7				
Osterhout	Allegan	030263	9.5	4.1	4.9	4.4	2.8	5.1	4.4	2.6	45
Otsego	Otsego	690018	*	1.0<	4.7	3.9	4.6	3.4	4.25	2.0	45
Oxbow	Oakland	630666	*	3.1	3.0	2.0	1.5	2.4	2.5	0.8	40
Parke	Oakland	631119	1.0<	1.5	1.2	2.7	1.9	1.6	1.5	0.8	35
Payne	Barry	080103		*	*	*	*	*			
Pentwater	Oceana	640313	6.2	6.3	11.0	9.5	7.1	8.0	7.1	2.1	50
Pickerel	Kalkaska	400035	*	*	*	*	*				
Pickerel	Newaygo	620066	1.7	5.2	3.4	2.4	4.2	3.4	3.4	1.4	43
Platte, Little	Benzie	100122	d	d	d	2.0	2.5				
Pleasant	Wexford	830183	3.4	5.2	4.5	5.6	*	4.7	4.85	1.0	46
Randall	Branch	120078	1.9	2.6	7.6	18.0	8.8	7.8	7.6	6.5	51
Round	Clinton	190146	1.7	4.7	12.0	2.7	5.0	5.2	4.7	4.0	46
Round	Lenawee	460304	1.0<	1.7	2.8	2.9a	2.1a	2.0	2.1	1.0	38
Round	Livingston	470546	3.1	3.4	7.4	23.0	6.0	8.6	6	8.3	48
MDEQ							4.7				
MDEQ/Rep							5.2				
Round	Mecosta	540073	12.0	3.3	4.5	11.0	3.9	6.9	4.5	4.2	45
Sapphire	Missaukee	570015	1.5	3.3	3.3	2.1a	3.5a	2.7	3.3	0.9	42
School Section	Mecosta	540080	1.0<	3.7	1.6	*	*				
Vol/Rep				3.0							
Sherman	Kalamazoo	390382	1.0<	1.6	6.0	13.0	4.2	5.1	4.2	4.9	45
Vol/Rep				1.0<							
MDEQ					4.1						
MDEQ/Rep					4.0						
Shingle	Clare	180108	2.5	3.2	2.4	4.5	4.4	3.4	3.2	1.0	42
Silver	Gr. Traverse	280116	1.0<	2.3	1.7	1.9	2.3	1.7	1.9	0.7	37

APPENDIX 3
2008 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Site ID Number	May	June	July	Aug	Sept	Mean	Median	Std. Dev.	Carlson TSI_{CHL}
			Chlorophyll *a* (µg/L)								
Smallwood	Gladwin	260107	2.2	6.1	2.8	3.8	2.9	3.6	2.9	1.5	41
Spider	Gr. Traverse	280395	1.0<	1.4	3.9	2.9	2.5	2.2	2.5	1.3	40
Stony	Oceana	640049	6.1	8.7	12.0	12.0	11	10.0	10.5	2.1	54
Strawberry	Livingston	470213	1.0<	3.0	6.0	9.0	3.1	4.3	3.7	2.7	43
Starvation	Kalkaska	400030	*	*	*	*	*				
Sweezey	Jackson	380470	1.0<	1.0<	1.6	1.1	2.6	1.3	1.1	0.9	32
Torch (N. Basin)	Antrim	050055	*	x	1.0<	1.0<	1.0<				
Torch (S. Basin)	Antrim	050240	*	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Triangle	Livingston	470591	2.0	1.0<	6.0	2.9	5.1	4.0	4.0	1.9	41
Vol/Rep					6.7						
Twin, Big	Kalkaska	400025	4.1	2.1	1.5	1.9	1.7	2.3	1.9	1.1	37
Vol/Rep				2.1							
Twin, East	Montmorency	600013	3.5	3.5	6.3	6.1	7.8	5.4	6.1	1.9	48
Twin, Little	Kalkaska	400013	1.0<	2.4	1.3	1.9	2.0	1.6	1.9	0.7	37
Twin, West	Montmorency	600072	1.0<	2.8	4.2	2.4	3.4	2.7	2.8	1.4	41
Van Etten	Iosco	350201	6.8	6.9	2.4	2.8	1.4	4.1	2.8	2.6	41
Viking	Otsego	690136	4.8	3.6	2.7	2.1	4.8	3.6	3.6	1.2	43
Vineyard	Jackson	380263	1.0	1.3	2.9	2.2	1.9	1.9	1.9	0.8	37
Wildwood	Cheboygan	160230	*	*	*	*	*				
Windover	Clare	180069	1.4	1.4	3.2	2.7	2.3	2.2	2.3	0.8	39
Woods	Kalamazoo	390542	3.8	11.0	13.0	18.0	12.0	11.6	12	5.1	55

Results Codes:

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

APPENDIX 4
2008 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Alcona	Hubbard Lake
	Jewell Lake
Alpena	Beaver Lake
Allegan	Eagle Lake
Barry	Cobb Lake
Benzie	Lake Ann
Cass	Magician Lake
Gladwin	Smallwood Lake
Grand Traverse	Arbutus Lake
	Silver Lake
Jackson	Sweezey Lake
Kalamazoo	Crooked Lake
	Indian Lake
	Sherman Lake
Kent	Bostwick Lake
	Cowan Lake
	Freska Lake
	Murray Lake
Lenawee	Devils Lake
	Round Lake
Livingston	Strawberry Lake
	Earl Lake
Marquette	Little Lake
	Mehl Lake
Mason	Hamlin (Upper) Lake
	Hamlin (Lower) Lake

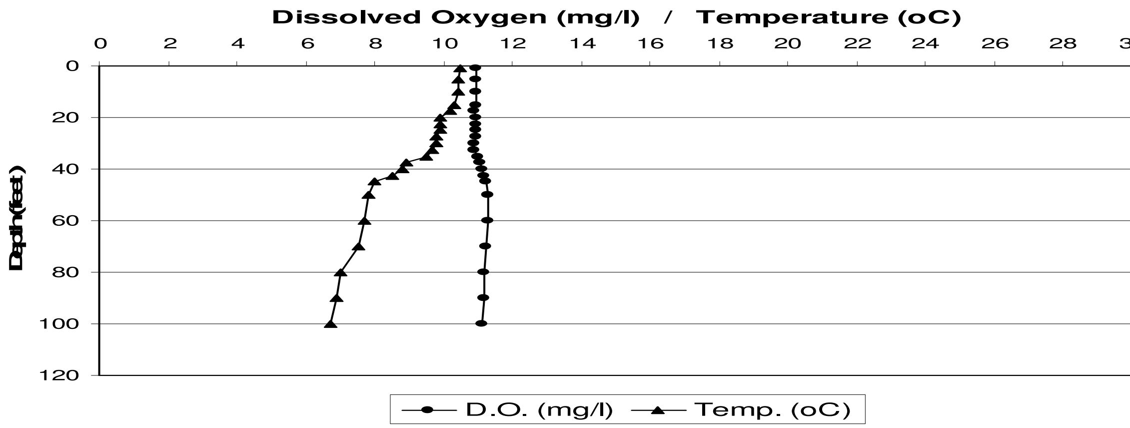
County	Participating Lakes
Montcalm	Baldwin Lake Derby Lake
Newaygo	Pickerel Lake Kimball Lake
Oakland	Deer Lake Parke Lake
Oceana	Pentwater Lake
Osceola	Hicks Lake
Roscommon	Higgins (North) Lake Higgins (South) Lake
St. Joseph	Corey Lake
Van Buren	Bankson Lake Cedar Lake

On the following pages five representative dissolved oxygen/temperature patterns are illustrated. The first is of a high quality oligotrophic lake, which has a very large hypolimnion volume. The lake maintains high oxygen levels in the hypolimnion all summer. The second pattern represents a good quality mesotrophic lake with a 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 small 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 productive eutrophic lake with a moderate size hypolimnion. Within a few weeks of spring overturn the hypolimnion has lost all oxygen. This anaerobic condition persists all summer. The final pattern is an oligo/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.

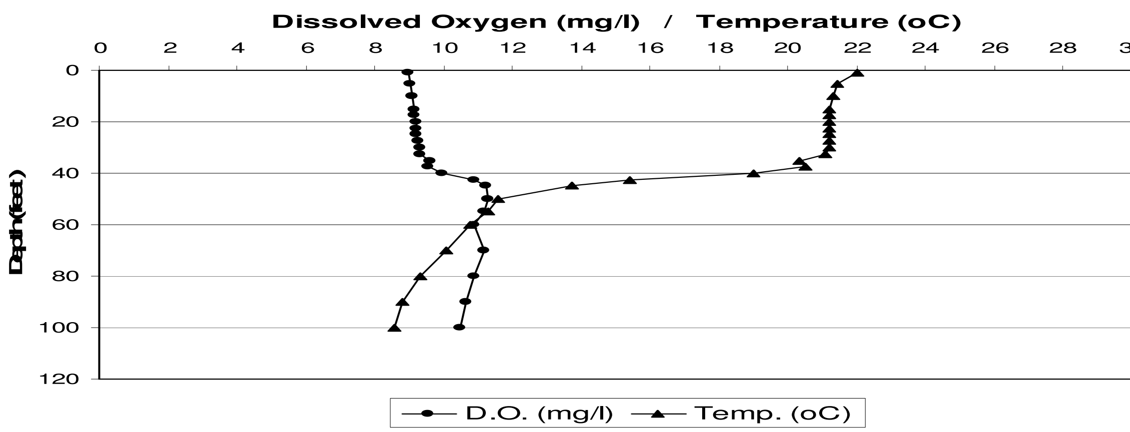
Oligotrophic Lake with a Very Large Volume Hypolimnion

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.

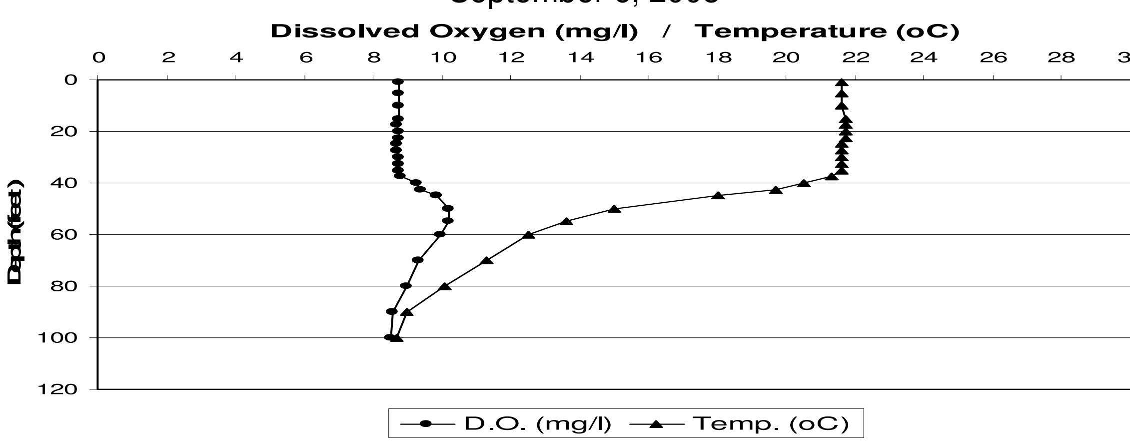
May 16, 2008



July 16, 2008

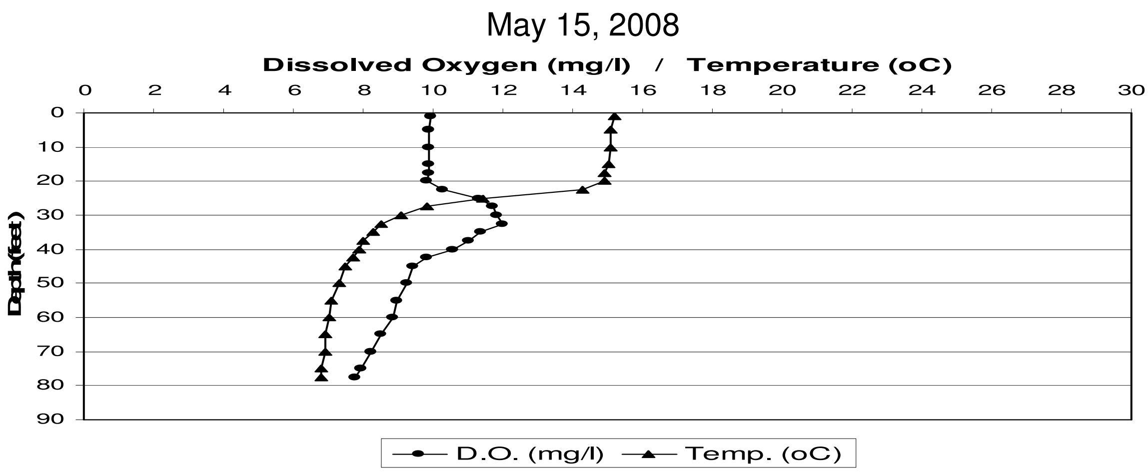


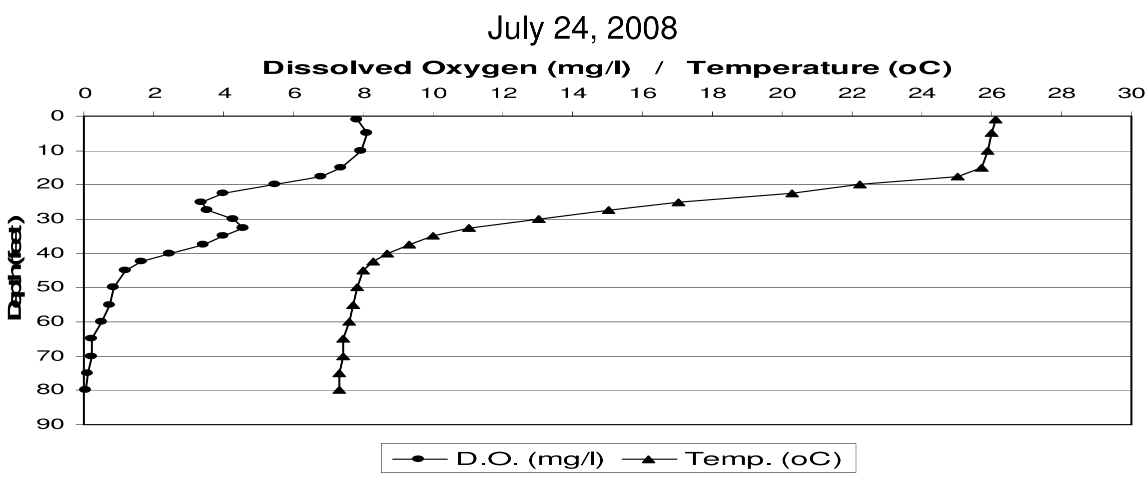
September 6, 2008

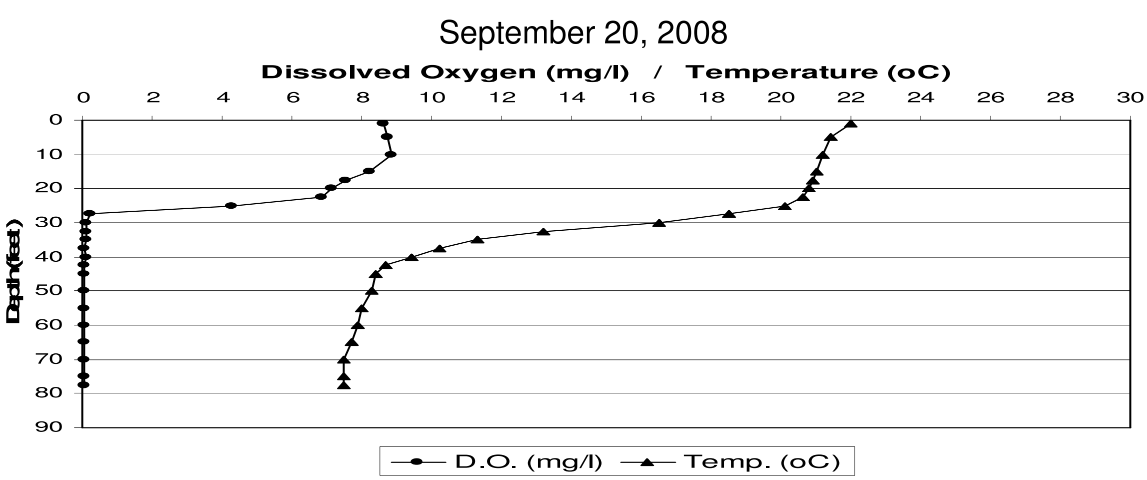


Mesotrophic Lake with a Large Volume Hypolimnion

Cedar Lake in Van Buren County is a 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

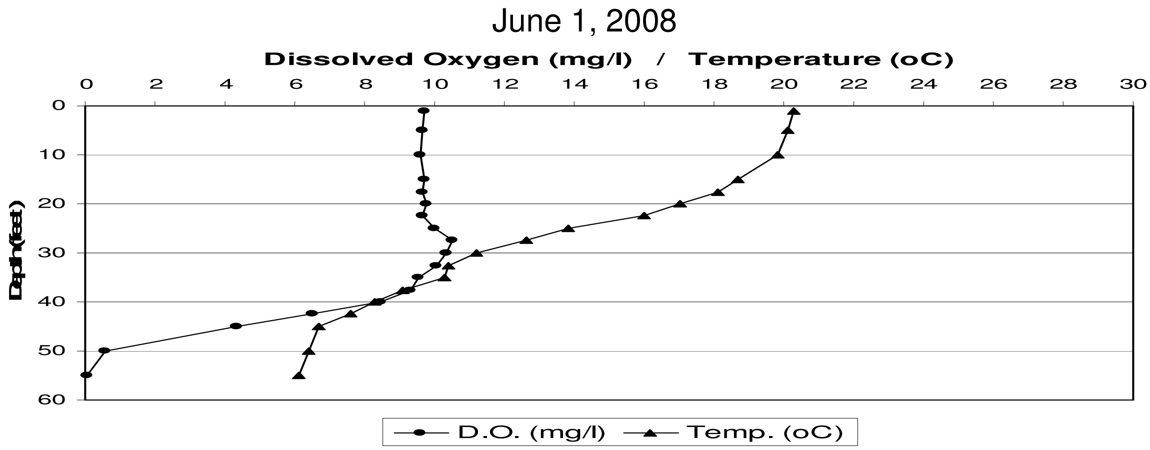


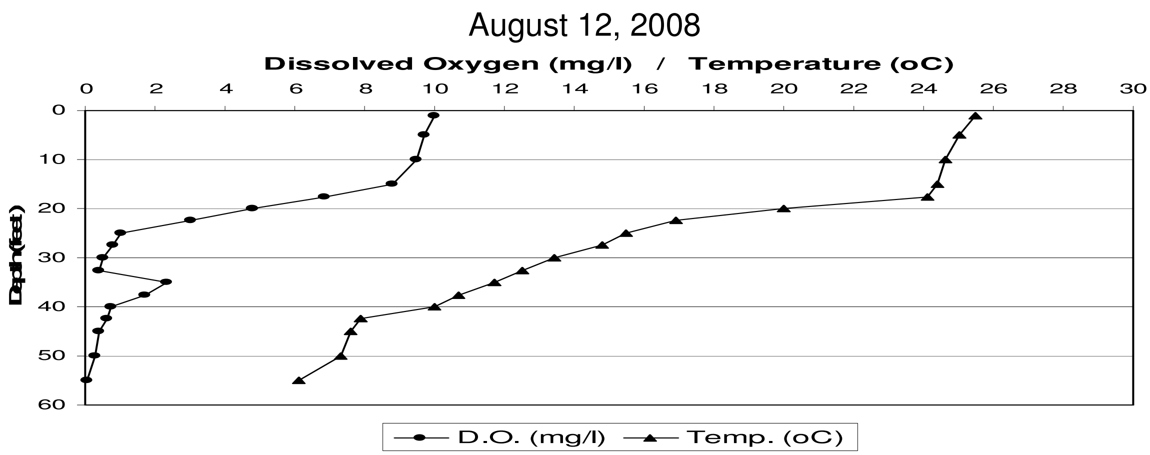


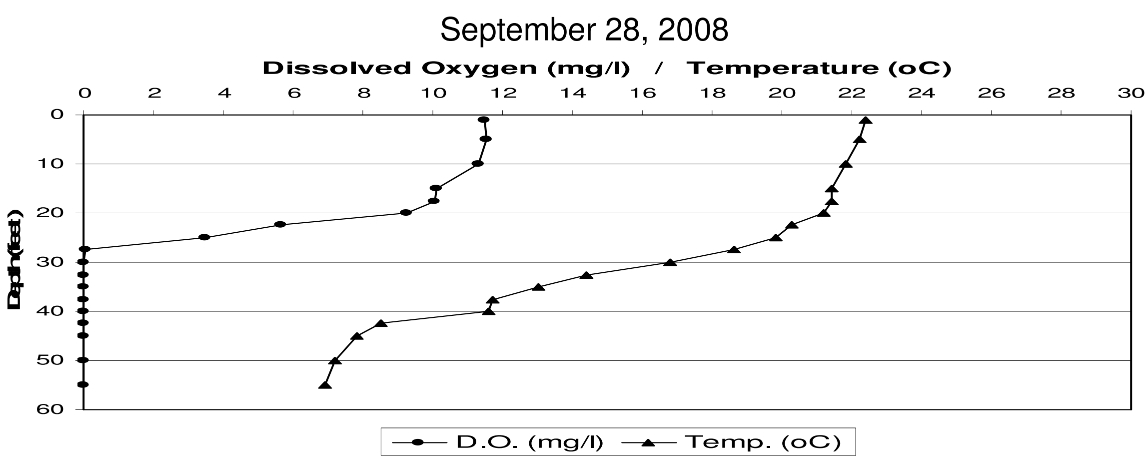


Mesotrophic Lake with a Small Volume Hypolimnion

Magician Lake in Cass County is a mesotrophic lake with a small volume hypolimnion. As a mesotrophic lake it produces moderate amounts of organic material that must be decomposed. Its hypolimnion has a limited oxygen supply that is gradually depleted by the decomposition of the organic material, which falls into the hypolimnion during the summer. Dissolved oxygen levels remain in the hypolimnion into mid-summer, but by August oxygen is gone in the deepest waters, and by late-summer (September) the entire hypolimnion is without oxygen.



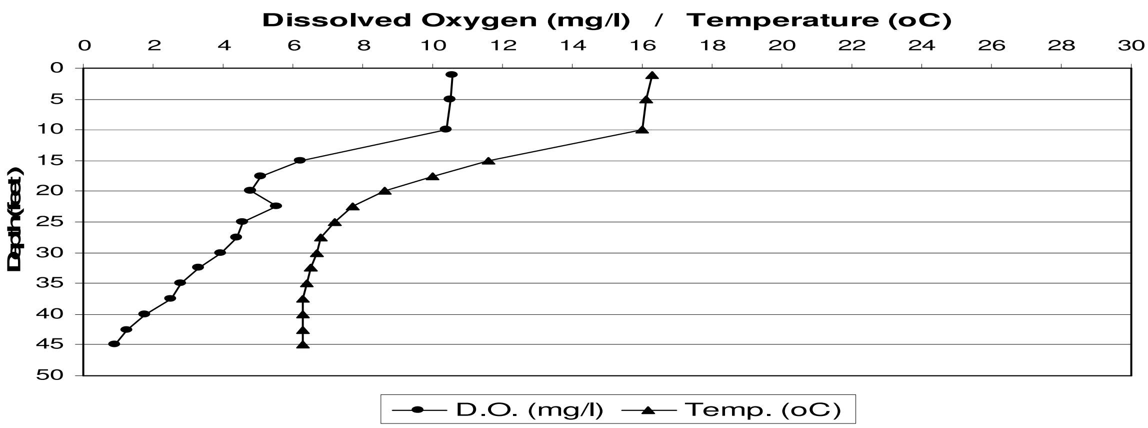




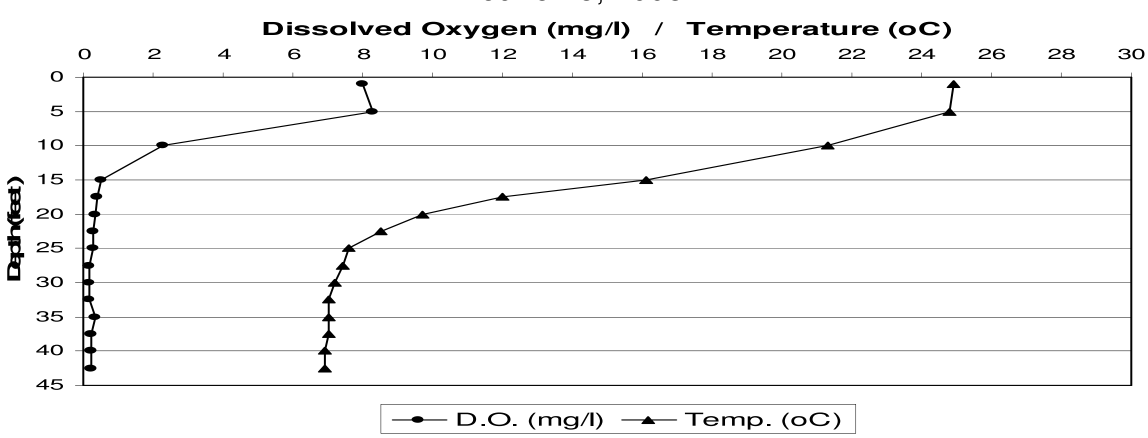
Eutrophic Lake with a Moderate Volume Hypolimnion

Kimball Lake in Newaygo County is a highly eutrophic lake with a moderate volume hypolimnion. As a productive lake it produces abundant amounts of organic material that must be decomposed. Its hypolimnion has a moderate oxygen supply that is rapidly depleted by the decomposition of the organic material, which falls into the hypolimnion during the summer. Dissolved oxygen levels in the hypolimnion drop to near zero within a few weeks of spring overturn. With no oxygen re-supply from the upper waters and atmosphere, the hypolimnion is devoid of oxygen all summer.

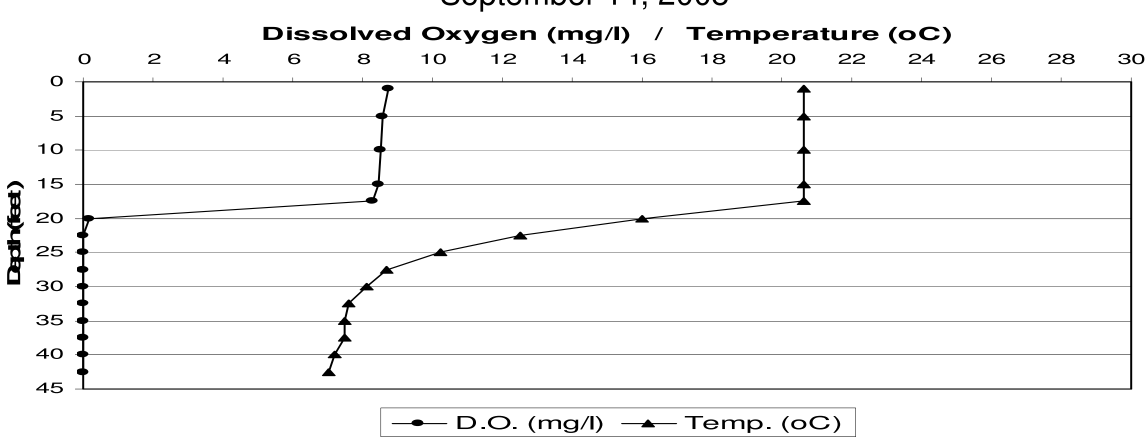
May 17, 2008



June 28, 2008



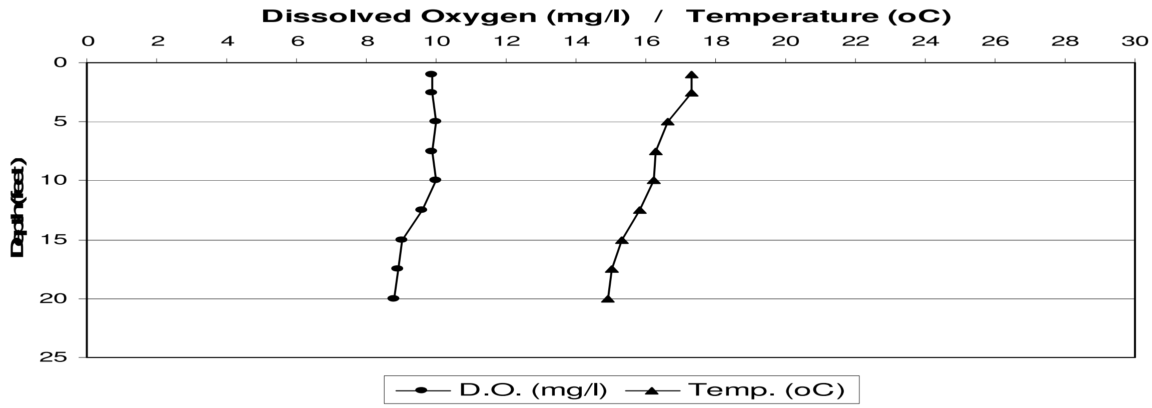
September 14, 2008



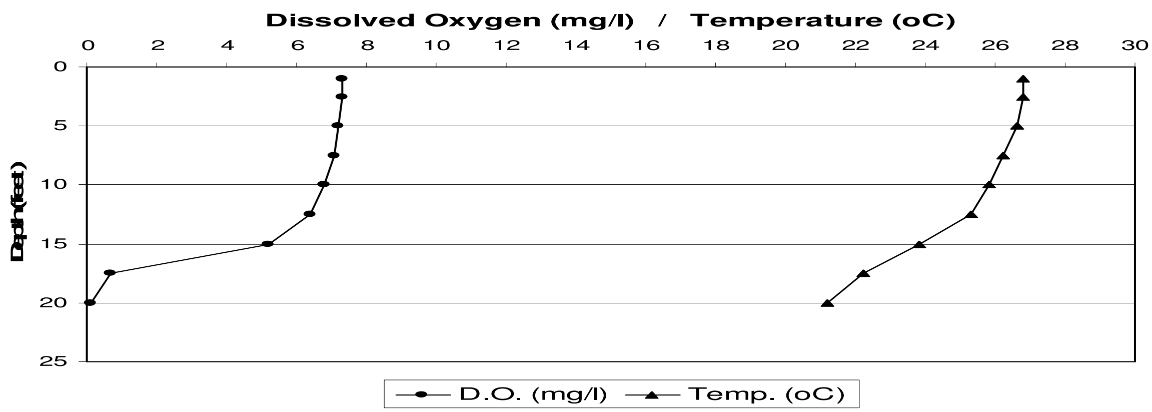
Shallow Oligo/Mesotrophic Lake that does not maintain Summer Stratification

Sweezey Lake in Jackson County is a shallow oligo/mesotrophic lake basin with insufficient depth to maintain stratification all summer. As a oligo/mesotrophic lake it produces small 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.

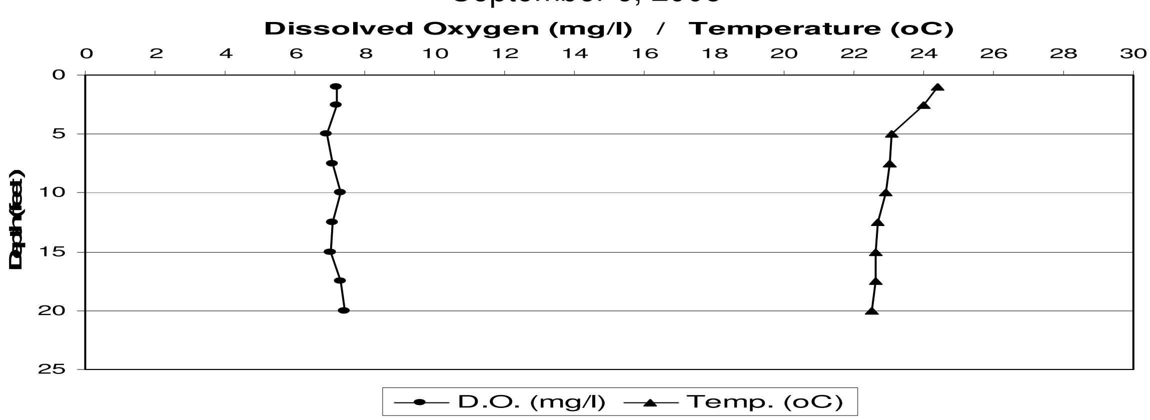
May 10, 2008



July 27, 2008



September 6, 2008



APPENDIX 5
2008 COOPERATIVE LAKES MONITORING PROGRAM
AQUATIC PLANT MAPPING RESULTS

One lake participated in the 2008 CLMP aquatic plant mapping project — Crystal Lake in Benzie County. Crystal Lake has low productivity, with TSI values generally below 30. Transparency tends to range from 20 to more than 40 feet, and summer Total Phosphorus and Chlorophyll are often below levels detectable by the laboratory. The CLMP plant mapping project revealed that Crystal Lake has limited plant populations consisting of a good diversity of species, located in discrete patches around the lake. One exotic species, Eurasian watermilfoil, was found.

As an example of the data collected in the CLMP aquatic plant mapping project, the data for Crystal Lake are presented below. In addition to the species list, each lake monitoring team that participates in the project produces aquatic plant maps for their lake.

Plant Name	**Scientific name**
Celery, Wild	*Vallisneria americana*
Coontail	*Certophyllum demersum*
Elodea (American)	*Elodea canadensis*
Horsetail	*Equisetum sp.*
Muskgrass (Stonewort)	*Chara frailis; Chara spp.*
Pondweed	*Potamogeton sp.*
Pondweed, floating-leaf	*Potamogeton natans*
Pondweed, sago	*Potomogeton pectinatus*
Pondweed, thin leaved	*Potamogeton sp.*
Pondweed, variable-leaf	*Potamogeton gramineus (perfoliatus)*
Rush	*Juncus sp.*
Sedge	*Carex spp.*
Watermilfoil, Eurasian	*Myriophyllum spicatum*
Watermilfoil, Northern	*Myriophyllum sibericum*