MI/DEQ/WB-08/008

COOPERATIVE LAKES MONITORING PROGRAM

Michigan's Citizen Volunteer Partnership for Lakes

"MI Lakes - Ours to Protect"

ANNUAL SUMMARY REPORT

2007

Michigan's Citizen Volunteers
Michigan Lake & Stream Associations, Inc.
Michigan Department of Environmental Quality
Fisheries and Wildlife Department – Michigan State University
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 sustainable commons not only in quantity but quality. The more each lake owner and user invests in this responsibility the more certain our children will be, that they will "inherit our water resources in the same quality that we the present generation borrowed it from them". Working together we can protect Michigan's lakes.

Cooperative Lakes Monitoring Program

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DATA CORRECTIONS FROM PREVIOUS REPORTS

There were no reported data or classification errors for the 2006 Annual Report.

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 abundant water resources...

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.

...include over 11,000 inland lakes.

To meet this need, the Department of Environmental Quality's (DEQ) Water Bureau and Michigan Lake and Stream Associations, Inc. (ML&SA) 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.

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- Michigan Clean Water Corps
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  http:// www.micorps.net

CLMP and MiCorps

The CLMP is also a principal program within the Michigan Clean Water Corps (MiCorps), a network of volunteer monitoring programs in Michigan. 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

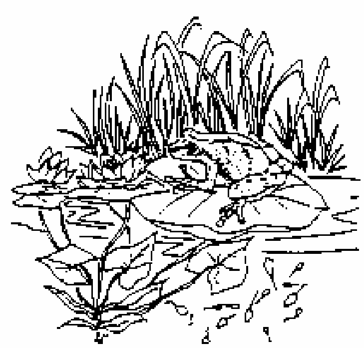
A lake's condition is influenced by many factors, such as the amount of recreational use it receives, shoreline development, and water quality. Lake *water quality* is a general term covering many aspects of chemistry and biology. The health of a lake is determined by its water quality.

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



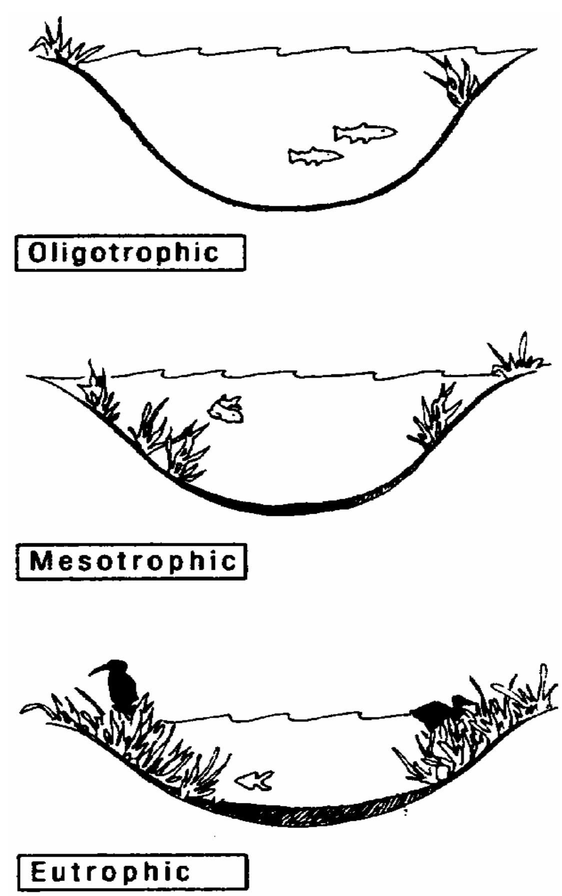
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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

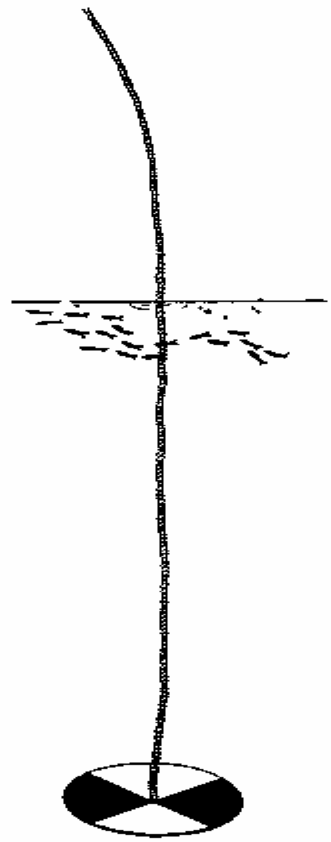
The gradual increase of lake productivity from oligotrophy to eutrophy is called lake aging or *eutrophication*. Lake eutrophication is a natural process resulting from the gradual accumulation of nutrients, increased productivity, and a slow filling in of the lake basin with accumulated sediments, silt, 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)

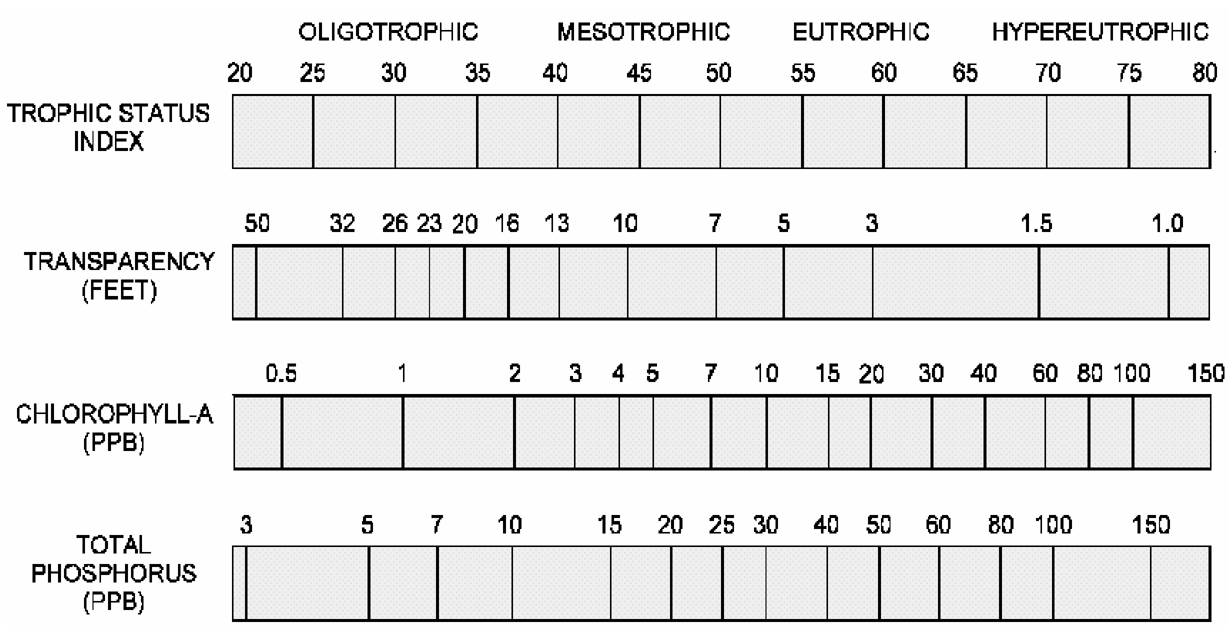
evaluate changes within the lake over time, and to estimate other water quality parameters within the lake.

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)

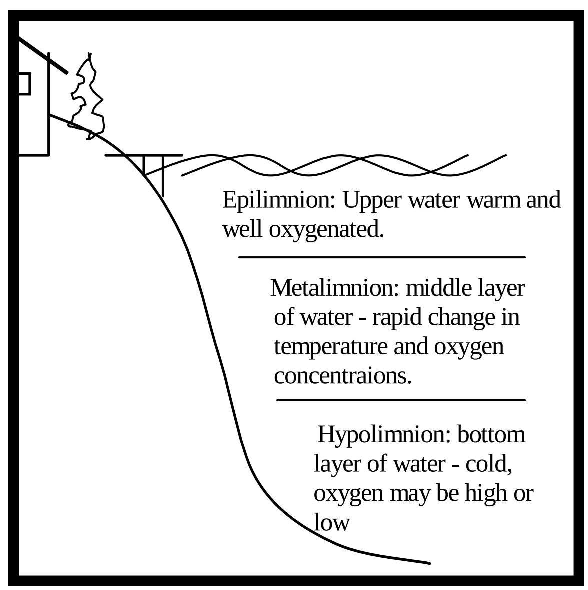
OTHER MEASURES OF LAKE PRODUCTIVITY

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 2003 at this time), please visit MiCorps' Data Exchange Network at www.micorps.net/data/view/search/ 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.

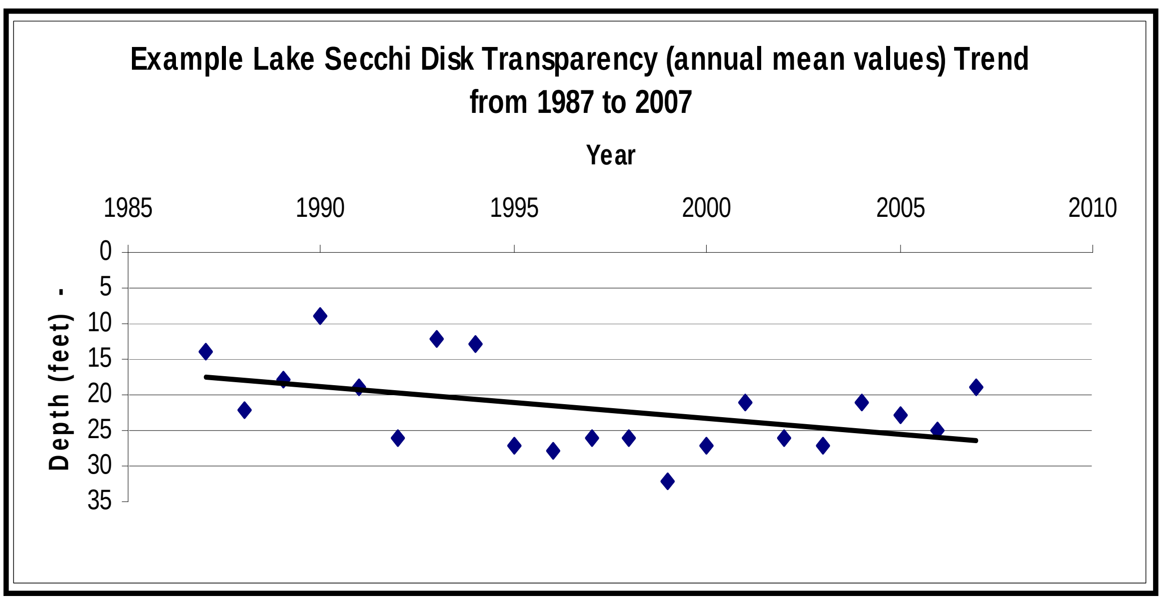
A summary of the transparency data collected by the lake volunteers during 2007 is included in Appendix 1. The number of measurements, or readings, made between mid-May and mid-September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. 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 2007, Secchi disk transparency data were reported for 200 lakes



(229 basins). Over 3515 transparency measurements were reported, ranging from 1.5 to 49.0 feet. For the lakes with eight or more equally spaced readings between mid-May and mid-September, the overall mean, or average, Secchi disk transparency was 12.3 feet and the median value was 11.0 feet. The Carlson TSI_{SD} values ranged from 28 to 67 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).

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 2007 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 percent 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 percent of the enrolled lakes.

During 2007, samples for total phosphorus measurements were collected on 197 lakes. The spring overturn total phosphorus results ranged from <5 to 71 ug/l with a mean (average) of 12 ug/l and a median value of 10 ug/l. The late summer total phosphorus results ranged from <5 to 52 ug/l with 12 ug/l as the mean and 10 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 61 for these lakes with a mean value of 37. A Carlson TSI value of 37 is generally indicative of a very good quality oligo/

mesotrophic lake (see page 8).

For the spring overturn sampling, 162 total phosphorus samples were turned in from 194 lakes registered in the program, for a participation rate of 83.5 percent. For the late summer sampling period 184 samples were received from 210 lakes for a participation rate of 87.6 percent.

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 2007 volunteers collected a minimum of four samples on 108 lakes.

Results from the chlorophyll monitoring for 2007 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 565 chlorophyll samples were collected and processed in 2007. The chlorophyll *a* levels ranged from <1 to 34 ug/l over the five-month sampling period. The overall mean (average) was 3.9 ug/l and the median was 2.8 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 59 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 2007, a total of 127 lakes (130 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 95 percent. A total of 108 lakes turned in at least four samples for a complete participation rate of 85 percent. Two samples were turned in, but not processed because of quality control issues for a 0.4 percent quality control 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 2007, CLMP participants in the dissolved oxygen/temperature project sampled 43 lakes. A total of 291 dissolved oxygen/temperature profiles 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 2007 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 meso/eutrophic 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, 2000.

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 2007, CLMP participants in the aquatic plant project sampled two lakes. They included Big Fisher Lake in Leelanau County and Viking Lake in Otsego County.

In 2007, Big Fisher Lake had TSI

values of <27 for Total Phosphorus and <31 for Chlorophyll. These values would suggest that the lake is oligotrophic. Given this trophic state or productive level the lake should have a limited aquatic plant population. Indeed, except for Stonewort, which is common to oligotrophic lakes, all plant species had limited distribution and low densities. (See the results of the Big Fisher Lake survey in Appendix 5)

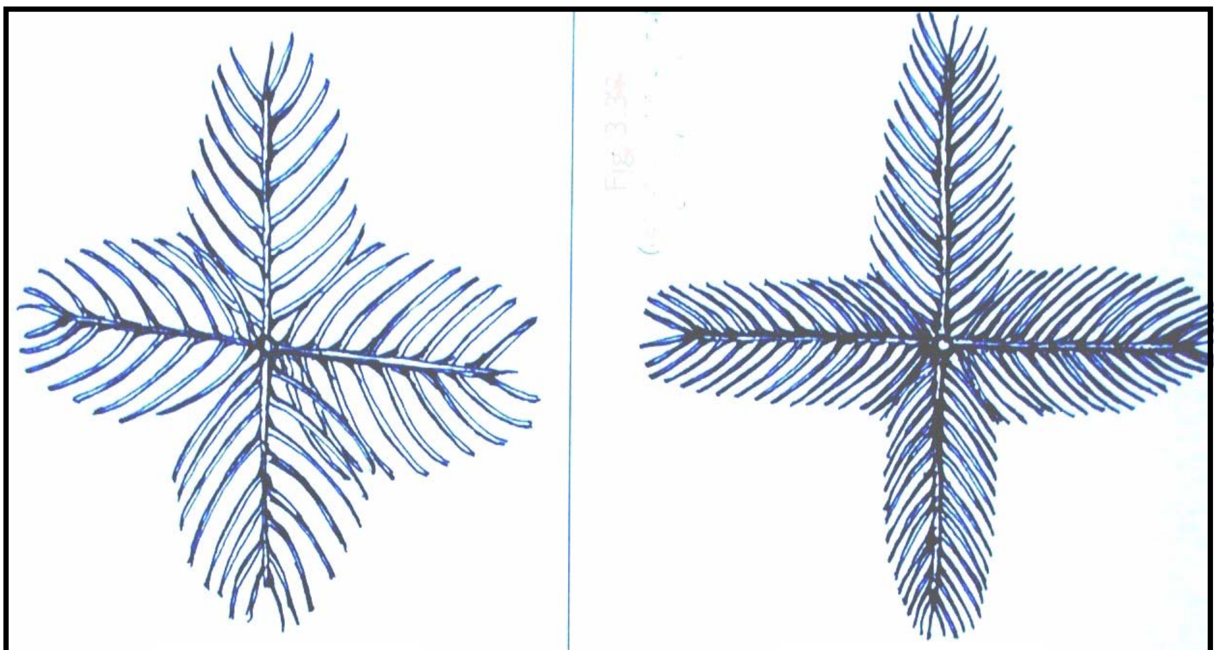
Viking Lake had TSI values of 52 for Secchi disk, 50 for Total Phosphorus and 44 for Chlorophyll. These values would suggest that the lake is eutrophic. Viking Lake often has high algal turbidity. Rooted plant populations were limited in the lake.

The surveys at both Big Fisher and Viking Lakes found no exotic plant species. The lakes are susceptible to infestation and nuisance populations of aggressive exotic species. The lake communities should continue to monitor for exotic species.

(PILOT PROJECT) Exotic Aquatic Plant Watch

In 2007, 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 location of any exotic plant beds with the GPS unit.

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

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.

Several lake communities participated in the Exotic Aquatic Plant Watch monitoring project in 2007. However, the number was not large 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 2008.

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 the ML&SA may be able to help you obtain additional information on your lake.

CLMP
Data in Research

The U.S. Geological Survey (USGS) in cooperation with the DEQ have been developing tools to predict water-quality trophic status characteristics by relating Secchi disk transparency and chlorophyll a measurements to Landsat satellite imagery for Michigan inland lakes that are at least 25 acres in surface area (Fuller and Minnerick, 2007) . The CLMP volunteers have been supporting this research since 2003 by measuring or sampling for these parameters within days of when the satellite passes overhead.

The CLMP data along with data collected directly by the USGS and DEQ are processed by the researchers to develop regression models that relate the sampled measurements to the satellite imagery. These predictive models are then used to estimate trophic state indicators specifically for unsampled lakes. Michigan has over 3500 inland lakes 25 acres or greater in size and more than two-thirds of these lakes have not been sampled.

Detailed information on the satellite remote sensing project is available on the USGS web-site at http://

mi.water.usgs.gov/splan1/sp00301/remotesensing.php. The modeling tool is accessible online from this web-site. Currently available are statewide layers with predicted Secchi disk transparency and corresponding trophic state index (TSI) values from years 2003-2006 (2005 layer) and predicted chlorophyll-*a* and corresponding trophic state index values from 2004 for Michigan inland lakes. This research is continuing and the regression models will be updated with current data as it is collected by the CLMP volunteers and others.

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.

Fuller, L.M. and and R.J. Minerick. 2007. Predicting Water Quality by Relating Secchi-Disk Transparency and Chlorophyll *a* Measurements to Landsat Satellite Imagery for Michigan Inland Lakes, 2001-2006. U.S. Geological Survey Fact Sheet 2007-3022, August 2007.

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

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

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

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

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

Houghton Lake Improvement Board (HLIB)
Houghton Lake, Roscommon County

Houghton Lake, Michigan's largest inland lake has a surface area of 20,044 acres. Although large, it is shallow with a mean depth of only 8.6 feet and a maximum depth of 19 feet. The shoreline is 30.5 miles in length and the water shed is 187 square miles, with over half being wetlands.

In the early 1970's, the community moved to protect the character of the lake by connecting all property in close proximity to the lake to a major sewer system. That system is currently undergoing a $9.2 million upgrade which should help protect the lake for the next twenty years.

Since that time and prior to 2000, the community focused on planting walleye to supplement the natural reproduction, summer fishing contests and the annual winter Tip-Up-Town festival. Unfortunately, little attention was given to the health of the lake.

The arrival of Eurasian water milfoil in the late 90's was the wake up call that mobilized the community into forming a "lake improvement board" that was charged by the four townships surrounding the lake with the responsibility to "protect and improve" the lake.

In 2000, in addition to seeking professional help, the Houghton Lake Improvement Board (HLIB) embraced the CLMP and have been testing for chlorophyll and phosphorus in addition to taking weekly Secchi disk readings at two locations. The CLMP data has helped the community identify phosphorus as a problem that needs to be addressed. To that end, the HLIB is working with other lake groups in the county to get both the county and townships to enact a ban on the use of lawn fertilization with phosphorus. Our goal is to have the ban in effect by the end of 2008.

The improvement board had identified 48 major drains into the lake. They are one river, 6 creeks and 41 drains & culvert pipes raging in diameter from 6 to 48 inches. The impact of this flow and the non point pollution associated with the flow will begin to be tracked in 2008 and the resulting data provided to the CLMP and the community.

The CLMP data has become an integral part of the HLIB annual Report to the Community and is a part of a continuing education program. Since 2002, over 5.200 property owners are mailed a report on the lake which is tracking the (short) history we have on water quality and aquatic plant presence and providing information on how property owners and the general public can help maintain the quality of the lake.

By: Mr. Dick Pastula, Secretary HLIB
Houghton Lake Improvement Board
P.O. Box 843
Houghton Lake, MI 48629
Phone: 989-329-9937
Email: lakeboard@mail.com
Web site: Houghton-lake.com

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. Mr. Ralph Bednarz Telephone: 517-335-4211 or bednarzr@michigan.gov

ACKNOWLEDGMENTS

Ralph Bednarz of the Michigan Department of Environmental Quality, Water Bureau, Howard Wandell from Michigan State University Department of Fisheries and Wildlife and Jo Latimore of the Huron River Watershed Council prepared this report. Additionally, those involved in coordinating the CLMP include Donald Winne and Pearl Bonnell of the Michigan Lake and Stream Associations, Inc., and MiCorps staff member Ric Lawson of the Huron River Watershed Council. Jean Roth supported the effort by entering data in to the MiCorps/CLMP data exchange and Bruce Bonnell compiled enrollment information.

Thank you to the dedicated volunteers who have made the CLMP one of the nations most successful citizen volunteer lakes monitoring programs. Also a special thank you to Ralph Vogel for constructing the Secchi disks for the CLMP, to Jean Roth for handling numerous administrative tasks, and to Bruce Bonnell and volunteer samplers who compiled data.

APPENDIXES

Appendix 1

2007 Secchi Disk Transparency Results

Appendix 2

2007 Total Phosphorus Results

Appendix 3

2007 Chlorophyll Results

Appendix 4

2007 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2007 Aquatic Plant Mapping Participating Lakes and Example Results

APPENDIX 1
2007 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSI_{SD}
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
Angela	Oakland	9	4	6	4.6	4.5	0.68	55
Ann	Benzie	16	11	29	17.4	14	6.66	36
Antoine	Dickinson	8	10	18	15.4	16	2.41	38
Arbutus 1	Gr. Traverse	18	11	13	12.3	12.25	0.54	41
Arbutus 2	Gr. Traverse	18	14	33	19.8	17	6.61	34
Arbutus 3	Gr. Traverse	18	12	29	18.0	16	5.25	35
Arbutus 4	Gr. Traverse	18	13	27	17.4	16	3.96	36
Arbutus 5	Gr. Traverse	18	10	20	15.0	15	2.66	38
Arnold	Clare	18	12	25	16.1	15.5	3.45	37
Avalon	Montmorency	7	25	48				
Baldwin 1	Cass	7	11	20				
Baldwin 2	Cass	7	13	23.5				
Baldwin 3	Cass	7	11	24.5				
Baldwin 4	Cass	6	11	20				
Baldwin	Montcalm	13	8.5	17.5	12.1	12.5	2.52	41
Bankson	Van Buren	7	7	11.5				
Barlow	Barry	15	4.5	19	9.1	8.5	4.14	45
Base Line	Livingston	8	10.5	18	14.6	15.25	2.47	38
Bass	Kalkaska	4	14	24				
Bear	Manistee	18	7.5	17.5	10.8	10	3.33	43
Beatons	Gogebic	7	16.5	21.5				
Beaver	Alpena	10	13.5	23	18.0	17	3.72	35
Bellaire	Antrim	16	11	22	14.8	14	3.40	38
Big	Osceola	12	19	27	23.3	24	3.31	32
Big Star	Lake	17	8	12.5	9.6	9	1.61	45
Bills (EW)	Newaygo	17	3.5	15.5	8.8	8.5	3.98	46
Bills (JR)	Newaygo	14	6	21	12.0	12.5	4.57	41
Birch	Cass	18	13	39	20.4	19.5	7.39	34
Blue	Mecosta	18	8	20	11.3	10.5	2.97	42
Blue (Big)	Kalkaska	14	22	27	24.9	24.5	1.56	31
Blue, North	Kalkaska	13	17	21	19.8	20	1.46	34
Bostwick	Kent	8	5.5	10.5	8.3	8.5	1.75	47
Brace, Lower	Calhoun	16	6	12	8.3	8	1.66	47
Brace, Upper	Calhoun	16	5	16	9.2	9.5	3.30	45

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2007 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Bradford, Big	Otsego	11	15	19	17.6	18	1.03	36
Bradford, Little	Otsego	8	14	17	15.0	15	0.93	38
Brooks	Leelanau	18	7	13	10.2	10.5	1.72	44
Buck	Livingston	14	8.5	12.5	9.5	9.5	1.10	45
Buckhorn	Oakland	18	10.5	13.5	12.0	12	1.06	41
Byram 1	Genesee	18	13	23	16.4	17	2.62	37
Byram 2	Genesee	18	12	23	15.9	16.5	2.94	37
Byram 3	Genesee	18	12	23	15.9	16.5	2.94	37
Canadian	Mecosta	14	8	12	9.7	9.25	1.33	44
Canadian, West	Mecosta	14	8	12	9.8	9.25	1.16	44
Cedar	Van Buren	10	8	17	12.6	12.25	3.25	41
Cedar (Briarwood)	Alcona/Iosco	15	11	13	12.0	12	0.52	41
Cedar (Schmidt's)	Alcona/Iosco	15	6.5	10	8.7	9	1.10	46
Center	Osceola	9	12	18.5	14.9	15	2.76	38
Chain	Iosco	14	11	15	12.6	12.75	1.06	41
Chancellor (Blue)	Mason	11	14.5	22	18.5	19	2.54	35
Chemung	Livingston	16	11	18.5	14.7	14.5	1.90	38
Clam	Antrim	17	13	25.5	18.8	19	3.80	35
Clark	Jackson	15	8	46	15.8	13.5	9.34	37
Clear	Jackson	13	8	12.5	11.0	11	1.26	43
Clear	St. Joseph	2	18	18.5				
Clifford	Montcalm	15	8	16	10.4	9.5	2.70	43
Cobb	Barry	18	7	28	13.4	11	5.99	40
Corey	St. Joseph	16	10.5	19	12.8	12	2.28	40
Cowan	Kent	17	3	8	4.7	5	1.45	55
Crockery	Ottawa	18	4	7	5.2	5.25	1.20	53
Crooked	Kalamazoo	15	10	21.5	13.4	11.5	4.13	40
Crooked (North)	Kalkaska	8	4.5	7.5	6.5	7	0.96	50
Crooked, Big	Van Buren	18	10.5	22	13.7	13	2.91	39
Crooked, Little	Van Buren	12	10	16	12.3	12	1.84	41
Crooked, Upper 1	Barry	16	6.5	19	11.4	8.75	4.69	42
Crooked, Upper 2	Barry	16	6.5	19	11.5	9.75	4.51	42
Crystal	Benzie	10	20	44	25.2	23	7.44	31
Crystal	Newaygo	7	11	17				

APPENDIX 1
2007 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSISD
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
Crystal	Oceana	16	3.5	24	11.7	13	5.19	42
Cub	Kalkaska	15	13	20	16.1	15.5	2.01	37
Deer	Alger	10	7	10.5	8.9	9	1.17	46
Deer	Oakland	13	8	26	12.0	11	4.78	41
Derby	Montcalm	17	9	24	16.1	16	3.80	37
Devils	Lenawee	2	9	14.5				
Diamond	Cass	18	7	25	10.7	10	4.24	43
Diamond	Newaygo	7	9	15.5				
Diane	Hillsdale	18	2	2.5	2.1	2	0.23	66
Dinner	Gogebic	18	8.5	17	12.1	11.5	2.74	41
Eagle	Allegan	17	5	17	9.9	9	3.69	44
Eagle	Cass	14	3	18	8.9	7.5	4.94	46
Eagle	Kalkaska	10	11	21	16.8	16	3.65	36
Earl	Livingston	16	4.5	10	6.9	6.25	1.45	49
Emerald	Kent	18	5.5	22	13.7	11	6.08	39
Evans	Lenawee	17	10.5	20	14.1	13.5	3.16	39
Fair	Barry	16	9	15.5	11.3	11	1.72	42
Farwell	Jackson	14	7	22	10.9	9.5	4.38	43
Fenton	Genesee	7	16	22				
Fish	Van Buren	18	6	12	9.2	9.25	1.85	45
Fisher, Big	Leelanau	5	14.5	16.5				
Fisher, Little	Leelanau	5	13	14.5				
Fisher	St. Joseph	19	6	32	13.1	9.5	7.09	40
Fisher, Little	St. Joseph	19	7.5	15	11.2	11	2.51	42
Ford	Mason	17	15.5	22	17.4	17	1.61	36
Fremont	Newaygo	17	6	21	10.2	8	4.76	44
Freska	Kent	11	8	12	9.6	10	1.03	44
Gallagher	Livingston	10	9	13.5	11.0	10.75	1.50	43
George	Clare	15	7	14	8.9	8	2.13	46
Glen (Big)	Leelanau	18	13.5	24.5	18.4	17.5	3.16	35
Glen, Little	Leelanau	18	5.5	12	8.8	8.5	1.91	46
Goshorn	Allegan	18	4	9.5	7.2	8	1.52	49
Gourdneck	Kalamazoo	5	7	24				
Gratiot	Keweenaw	12	11.5	21.5	17.1	17	3.27	36

APPENDIX 1
2007 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSISD (transparency)
Gravel	Van Buren	18	7.0	14.0	10.1	10.0	2.01	44
Green Oak (Silver)	Livingston	12	13	23	16.7	14	4.13	37
Gut	Livingston	9	8.5	13.5	11.8	12	1.44	42
Hamburg	Livingston	18	10	31	16.4	15	5.62	37
Hamlin, Lower	Mason	18	10.5	17	13.3	13	1.77	40
Hamlin, Upper	Mason	18	6	14	9.6	9.5	1.84	44
Harper	Lake	18	16	24	19.0	18	2.34	35
Hess	Newaygo	15	1.5	2.5	2.0	2	0.44	67
Hicks	Osceola	14	3	7.5	5.3	5.5	1.30	53
Higgins 1	Roscommon	7	22	46				
Higgins 2	Roscommon	7	26	43.5				
Horsehead	Mecosta	18	8	18.5	11.6	10	3.27	42
Houghton	Roscommon	11	4	6	4.7	5	0.61	55
Hubbard 1	Alcona	15	10	21	15.7	15.5	3.14	37
Hubbard 2	Alcona	15	11	22.5	16.6	16	3.61	37
Hubbard 3	Alcona	9	11	22	15.9	16	3.82	37
Hubbard 4	Alcona	9	11	25	16.1	17	4.43	37
Hubbard 5	Alcona	9	12	22	17.0	16	3.35	36
Hubbard 6	Alcona	16	10	23.5	16.0	17	3.82	37
Hubbard 7	Alcona	15	9	23	16.3	16	3.94	37
Hunter	Gladwin	18	7.5	15.5	11.2	10.75	2.40	42
Hutchins	Allegan	11	6	14	9.1	8	3.03	45
Indian	Kalamazoo	14	6	20.5	12.5	12.75	4.69	41
Indian	Kalkaska	12	9	17	12.2	11.5	2.73	41
Indian	Osceola	18	15	22	18.4	19	2.35	35
Island	Grand Traverse	13	18	23	20.4	21	1.56	34
Kimball	Newaygo	9	3	17	7.9	7	3.92	47
Klinger	St. Joseph	19	6	14.5	9.6	9	2.84	45
Lake of the Woods	Antrim	12	5	9	6.9	7	1.10	49
Lakeville	Oakland	17	12	19	14.6	15	2.03	38
Lancelot 1	Gladwin	9	4	8	6.9	7.5	1.31	49
Lancelot 2	Gladwin	9	6	9	7.7	7	1.12	48
Lancelot 3	Gladwin	9	7	11	8.8	9	1.12	46

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Lancer 1	Gladwin	15	7	10.5	8.2	8	1.10	47
Lancer 2	Gladwin	15	8	13	10.3	10	1.79	43
Lancer 3	Gladwin	15	6	10	8.6	8.5	0.96	46
Lancer 4	Gladwin	15	3	4.5	3.8	4	0.41	58
Lancer 5	Gladwin	15	3	5.5	4.7	5	0.70	55
Lansing	Ingham	15	5	8	6.1	6	0.79	51
Lily	Clare	10	7.5	11	9.2	9	1.36	45
Little	Marquette	6	12	22				
Long	Iosco	15	9	16	11.7	12	2.02	42
Long	Oakland	19	12	24.5	14.9	14	2.70	38
Louise	Dickinson	16	12	17	14.7	14.75	1.48	38
Magician	Cass	18	6	18	10.6	9.5	3.96	43
Maple	Van Buren	16	2.5	7.0	4.3	4.0	1.38	56
Margrethe	Crawford	10	11	16	13.2	12.5	1.69	40
Mary	Dickinson	16	14	18.5	16.1	16.25	1.52	37
Mary	Iron	18	12	37	23.8	22.75	6.34	31
Mecosta	Mecosta	12	7	13	9.0	8.75	1.59	45
Mehl	Marquette	6	12	16				
Middle Straits	Oakland	16	10.5	22.5	15.1	14.5	3.88	38
Moon	Gogebic	16	15.5	28	21.5	21	3.10	33
Mullett	Cheboygan	7	13	23				
Muskellunge	Montcalm	18	3	11	6.9	8	2.48	49
Nepessing	Lapeer	15	11	20	15.7	16	2.91	37
North Oxbow	Mason	12	5	10	7.1	6.75	1.48	49
Oneida	Livingston	12	7	12.5	9.0	8.75	1.40	45
Ore	Livingston	18	6	14	10.1	11	2.75	44
Osterhout	Allegan	14	5	12	7.4	7	2.34	48
Otsego	Otsego	17	8	12	10.1	10	1.36	44
Papoose	Kalkaska	8	29	30	29.6	30	0.52	28
Parke	Oakland	13	9.5	24	16.1	16.5	4.14	37
Paw Paw, Little	Berrien	13	4	7	5.3	5.5	1.03	53
Payne	Barry	8	7	12	8.8	8.25	1.79	46
Pentwater	Oceana	8	4	8	5.8	5.75	1.62	52
Perch	Otsego	9	8	11	9.9	10	0.96	44

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Perrin	St. Joseph	16	8	12	10.1	10.25	1.02	44
Pickerel	Kalkaska	17	22	28.5	26.4	27	1.65	30
Pickerel	Newaygo	9	10	19	12.3	11	2.92	41
Platte	Benzie	18	10	25	15.1	13.5	4.69	38
Pleasant	Jackson	17	5.5	10.5	7.9	7.5	1.68	47
Pleasant	Wexford	14	5.5	8.5	7.1	6.5	1.00	49
Ponemah	Genesee	18	8	15	10.8	10.25	1.96	43
Portage	Livingston	17	8.5	18.5	12.5	12	3.15	41
Portage, Big	Jackson	9	5	16	10.0	9	4.30	44
Pretty	Mecosta	7	8.5	12				
Puterbaugh	Cass	16	6	15	9.5	8.75	2.90	45
Randall	Branch	18	4.5	17.5	8.3	6.75	3.66	47
Reeds	Kent	13	2.5	12.5	6.3	5.5	3.73	51
Robinson	Newaygo	16	5.5	11.5	8.5	8	1.98	46
Round	Clinton	17	7	10.5	8.6	8.5	1.16	46
Round	Lenawee	7	10	27				
Round	Livingston	11	5.5	10	8.1	8	1.09	47
Round	Mecosta	12	6	13	10.1	10	2.25	44
Saint Helen	Roscommon	16	7	10	9.0	9.5	1.02	45
Sanford	Benzie	18	10	27	15.4	13	5.57	38
Sapphire	Missaukee	8	7	9	8.0	7.75	0.76	47
School Section	Van Buren	17	9.0	16.0	11.3	11.0	1.70	42
School Section 1	Mecosta	18	6.5	15	9.3	7.75	2.84	45
School Section 3	Mecosta	18	5.5	12.5	8.6	8.25	2.25	46
Sherman	Kalamazoo	13	8	20	13.8	13.5	3.71	39
Sherwood	Oakland	13	6.5	13.5	10.5	10.5	1.99	43
Shingle	Clare	16	9	16	12.4	12.25	2.38	41
Silver	Gr. Traverse	14	14	49	25.3	22.25	10.36	31
Silver	Oakland	8	19	22	20.4	20.5	1.12	34
Silver	Van Buren	18	8.0	11.0	9.5	9.8	0.97	45
Smallwood	Gladwin	8	4.5	8.5	6.7	7	1.41	50
Spider 1	Gr. Traverse	10	11	21	14.3	14	2.89	39
Spider 2	Gr. Traverse	10	11.5	19	14.2	13.25	2.50	39
Spider 3	Gr. Traverse	10	9	19.5	13.6	12.75	3.20	39

APPENDIX 1
2007 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Squaw	Kalkaska	17	6	8.5	7.6	8	0.62	48
Starvation	Kalkaska	17	13	27	19.3	18.5	4.44	34
Stone Ledge	Wexford	18	8.5	13.0	10.2	10.0	1.14	44
Stony	Oceana	6	5.5	8				
Strawberry	Livingston	12	7.5	11	9.2	9.25	1.01	45
Sweezey	Jackson	17	6	14.5	9.0	9	2.39	45
Taylor	Oakland	18	18	21	18.9	18.5	1.01	35
Torch (N. Basin)	Antrim	18	16.5	44.5	28.4	23.75	9.58	29
Torch (S.Basin)	Antrim	2	21	25				
Triangle	Livingston	8	9.5	14	11.6	11.25	1.64	42
Twin, Big	Cass	16	7	24	11.0	8.75	5.03	43
Twin, Little	Cass	18	7.5	17	10.3	9.25	2.61	44
Twin, Big	Kalkaska	17	21	28	24.1	24	1.89	31
Twin, Little	Kalkaska	9	14	22	16.5	16	2.42	37
Twin, East	Montmorency	9	6.5	17.5	10.4	10	3.56	43
Twin, West	Montmorency	9	4.5	16.5	10.1	9.5	4.64	44
Van Etten	Iosco	17	5	11	7.9	8	1.81	47
Vaughn	Alcona	5	11	18				
Viking	Otsego	16	4	8	5.6	5	1.45	52
Vineyard	Jackson	17	3.5	32	13.3	11	9.62	40
Wahbememe	St. Joseph	9	17	26	21.3	22	3.10	33
Wamplers	Jackson	15	7	16	9.9	10	2.55	44
Webinguaw	Newaygo	8	3	4.5	3.8	4	0.59	58
Wetmore	Allegan	11	2.5	7	4.1	3.5	1.42	57
Windover	Clare	11	11	25	15.2	13	4.59	38
Woods	Kalamazoo	17	5.5	16	10.8	11.5	3.29	43

Lake	County	Total Phosphorus (ug/l)								Carlson
		Spring Overturn				Late Summer				TSITP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Angela	Oakland	*				21				48
Ann	Benzie	4 T		6		*				
Arbutus	Grand Traverse	3 W				5				27
Arnold	Clare	3 W				9				36
Avalon	Montmorency					7 b				32
Baldwin	Montcalm	17				15	16			43
Bankson	Van Buren	16		20		*				
Barlow	Barry	7				5				27
Baseline	Liv./Wash.	15				13				41
Bass	Kalkaska	7				6				30
Bass	Livingston	*				*				
Bear	Kalkaska	8				2 W	1 W			<27
Beatons	Gogebic/Onton.	9				6	4 T			30
Beaver	Alpena	5				7				32
Bellaire	Antrim	2 W				5				27
Big	Osceola	*				6				30
Big Pine Island	Kent					18				46
Big Star	Lake	*				8				34
Bills	Newaygo	8				7				32
Birch	Cass	6				7				32
Blue	Mecosta	*				11				39
Blue, Big	Kalkaska	4 T				1 W				<27
Blue, North	Kalkaska	5				1 W				<27
Bostwick	Kent			13		29				53
Brace, Lower	Calhoun	13				10				37
Brace, Upper	Calhoun	11	13			8				34
Bradford, Big	Otsego	13				8				34
Brooks	Leelanau	11	14			8				34
Buckhorn, North	Oakland	*				10				37
Cedar	Alcona/Iosco	8				10				37
Cedar	Van Buren	8				7				32
Center	Osceola	14				9				36
Chain	Iosco	12				13				41
Chancellor (Blue)	Mason	15				8				34

		Total Phosphorus (ug/l)								Carlson
Lake	**County**	**Spring Overturn**				**Late Summer**				**TSITP**
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Chemung	Livingston	*				18	18	19		46
Clam	Antrim	5				3 W				<27
Clark	Jackson	6				7	9	11		32
Clear	Jackson	10				8				34
Clifford	Montcalm	21				14	14			42
Cobb	Barry	8				6				30
Corey	St. Joseph	10				6				30
Coverdale	Cass					*				
Cowan	Kent	35				31				54
Crescent	Oakland	26				*				
Crockery	Ottawa	71	69			24		23	21	50
Crooked	Kalamazoo	18		22		6				30
Crooked, Big	Van Buren	*				8				34
Crooked, Little	Van Buren	*				8				34
Crooked, North (S)	Kalkaska	13				14				42
Crooked, Upper	Barry	*				12				40
Crystal	Benzie					3 W				<27
Crystal	Newaygo	18		18		20				47
Crystal	Oceana	12				16		14		44
Cub	Kalkaska	5				6				30
Deer	Alger	10	10			2 W				<27
Deer	Oakland	5 j		4 T		7				32
Derby	Montcalm	6	8			10	9			37
Devils	Lenawee	9				8				34
Diamond	Cass	12				9	9			36
Diamond	Newaygo					12				40
Diane	Hillsdale	32	34			52				61
Dinner	Gogebic	14				12				40
Eagle	Allegan	16				11				39
Eagle	Cass	10		15		*				
Eagle	Kalkaska	16				9				36
Earl	Livingston	39		29		36				56
Emerald	Kent	11				17				45
Emerald	Newaygo	10				10				37

APPENDIX 2
2007 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l)								Carlson
		Spring Overturn				Late Summer				TSITP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Evans	Lenawee	9				9		15		36
Fair	Barry	12				9				36
Farwell	Jackson	8				5		7		27
Fenton	Genesee	8				11	13			39
Fish	Van Buren	13		17		16				44
Fisher	St. Joseph	6				8				34
Fisher, Big	Leelanau	5				4 T				<27
Fisher, Little	Leelanau	7				7				32
Fisher, Little	St. Joseph	7				8				34
Five Lakes	Otsego	6				9				36
Fremont	Newaygo	49	50	51		16				44
Freska	Kent	18				13	13			41
Gallagher	Livingston	15				20				47
George	Clare	12				10				37
Glen (Big Glen)	Leelanau	4 T				2 W				<27
Glen (Little Glen)	Leelanau	5				9				36
Goshorn	Allegan	*				29				53
Gourdneck	Kalamazoo	10				10				37
Gratiot	Keweenaw					12				40
Gravel	Van Buren	9				9				36
Gut	Livingston	13				16				44
Hamburg	Livingston	14				11				39
Hamlin, Lower	Mason	15				20				47
Hamlin, Upper	Mason	20				23				49
Harper	Lake	10				4 T	5			<27
Hess	Newaygo	45				48				60
Hicks	Osceola	19				19				47
Higgins (N Basin)	Roscommon	4 T				6				30
Higgins (S Basin)	Roscommon	4 T				2 W				<27
High	Kent	20				*				
Horsehead	Mecosta	8				13				41
Houghton (Site 1)	Roscommon	16	16			20				47
Houghton (Site 2)	Roscommon	13				*				
Hubbard	Alcona	5				6	9	8		30

APPENDIX 2
2007 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

		Total Phosphorus (ug/l)								Carlson
Lake	County	Spring Overturn				Late Summer				TSITP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
Hutchins	Allegan	13				13				41
Indian	Kalamazoo	12	9			11				39
Indian	Kalkaska	5				9				36
Indian	Osceola	9				8				34
Island	Grand Traverse	5				7				32
Jewell	Alcona	9				9				36
Kimball	Newaygo					28				52
Klinger	St. Joseph	8				8				34
Lake of the Woods	Antrim	6	7			*				
Lakeville	Oakland	9	7			14				42
Lancelot	Gladwin	15				12				40
Lancer	Gladwin	*				11				39
Lansing	Ingham	12				22				49
Lily	Clare					*				
Little	Marquette	7				10				37
Long	Cass					*				
Long	Gogebic	7				2 w				<27
Long	Iosco	7				8		12		34
Long	Oakland	11 h				12				40
Louise	Dickinson	12				7				32
Magician	Cass	*				*				
Maple	Van Buren	30		32	29	16	16			44
Margrethe	Crawford	3 w				7				32
Mary	Dickinson	11				8				34
Mary	Iron	8				7				32
Mecosta	Mecosta	*				13				41
Mehl	Marquette	7				6	7			30
Middle Straits	Oakland	*				8	10			34
Moon	Gogebic	5				2 w				<27
Mullett	Cheboygan	*				*				
Murray	Kent	*				16				44
Muskellunge	Montcalm	19				20				47
Nepessing	Lapeer	*				17	18			45
Oneida	Livingston	10				14				42

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
Ore	Livingston	*				13				41
Orion	Oakland	*				*				
Osterhout	Allegan	18				16	17			44
Otsego	Otsego	8				8	11			34
Oxbow	Oakland	*				9				36
Oxbow, North	Mason					13	12			41
Papoose	Kalkaska	f				17				45
Parke	Oakland	9				11				39
Payne	Barry	11				11				39
Pentwater (Site 4)	Oceana	18 c				32	32			54
Perch	Otsego					10				37
Perrin	St. Joseph	14	15	21		12				40
Pickerel	Kalkaska	f				6				30
Pickerel	Newaygo					14				42
Platte, Little	Benzie	9		15		*				
Pleasant	Jackson	9				7				32
Pleasant	Wexford	9	10			10				37
Portage	Washtenaw	12		16		11				39
Portage, Big	Jackson	11				10				37
Pretty	Mecosta	9	8			*				
Randall	Branch	23				26				51
Rebeck	Hillsdale	29				19	19			47
Robinson	Newaygo	22				18				46
Round	Clinton	20				20				47
Round	Lenawee	8				6				30
Round	Livingston	21	19	20	22	18				46
Round	Mecosta	*				13				41
Sanford	Benzie	10				7	8			32
Sanford	Midland					*				
Sapphire	Missaukee	7				11				39
School Section	Mecosta	6				9				36
School Section	Van Buren	23	21	31		15				43
Shan-gri-la	Livingston	*				*				
Sherman	Kalamazoo	13				*				

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSI_{TP} (summer TP)
Shingle	Clare	12				12				40
Silver	Grand Traverse	6				5				27
Silver	Livingston	8				11				39
Silver	Oakland	9				7				32
Silver	Van Buren	12		16		12	10			40
Smallwood	Gladwin					16				44
Smoky	Iron	8	9			*				
Spider	Grand Traverse	8				7				32
Squaw	Kalkaska	15				7				32
Starvation	Kalkaska	3 w				6	5			30
Stone Ledge	Wexford	*				16				44
Stony	Oceana					17				45
Strawberry	Livingston	16				17		18		45
Sweezey	Jackson	6				6		9		30
Sylvan	Newaygo	9				10				37
Taylor	Oakland	8				*				
Torch (N Basin)	Antrim	1 w				3 w				<27
Torch (S Basin)	Antrim	2 w				5				27
Triangle	Livingston	11		15	13	16				44
Twin, Big	Cass	8				10				37
Twin, Big	Kalkaska	5				6				30
Twin, East	Montmorency	7				13				41
Twin, Little	Cass	8				9				36
Twin, Little	Kalkaska	6				8				34
Twin, West	Montmorency	3 w				12				40
Van Etten	Iosco	35	35			21				48
Vaughn	Alcona	28				14				42
Viking	Otsego	23	21			24				50
Vineyard	Jackson	7				7				32
Wahbememe	St. Joseph	7		12		*				
Webinguaw	Newaygo	13				21				48
Wells	Osceola	*				*				
Wetmore	Allegan					20	18			47
Wildwood	Cheboygan	*				13	13			41

APPENDIX 2
2007 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSI$_{TP}$ (summer TP)
Windover	Clare	5	5			9				36
Wolf	Lake	10				7				32
Woods	Kalamazoo	37				13				41
Zukey	Livingston	*				*				

* 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)

b Sampling date on field sheet and sample bottle label are not correct

c Improper sample collection - no replicate

f Sample not collected at proper sampling site - sample not processed

h Laboratory holding time exceeded

i Sample received not frozen - thawed in mail

APPENDIX 3
2007 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
Ann	Benzie	1.2	1.8	1.9	*	*				
Arbutus	Gr. Traverse	1.0<	1.5	2.1	2.8	2.7	1.9	2.1	0.9	38
Arnold	Clare	1.8	1.2	1.0<	2.5	1.6	1.5	1.6	0.7	35
Baldwin	Montcalm	1.4	2.8	2.8	4.5	7.2	3.7	2.8	2.2	41
Vol/Rep			2.5							
MDEQ				4.2						
MDEQ/Rep				4.2						
Bankson	Van Buren	2.6	5.6	7.0	*	*				
Vol/Rep		2.3								
Barlow	Barry	1.2	2.5	3.4	2.4	2.8	2.5	2.5	0.8	40
Bear	Kalkaska	*	1.0<	1.8	1.0<	1.2	1.0	0.9	0.6	<31
MDEQ					1.0<					
MDEQ/Rep					1.0<					
Beaver	Alpena	1.0<	1.0<	1.8	1.4	1.9	1.2	1.4	0.7	34
Bellaire	Antrim	1.5	1.0	1.5	1.5	1.9	1.5	1.5	0.3	35
Big	Osceola	1.0<	*	*	2.2	1.8				
Big Star	Lake	3.2	4.6	4.1	3.0	2.9	3.6	3.2	0.8	42
Bills	Newaygo	1.4	1.2	2.5	2.1	1.8	1.8	1.8	0.5	36
Vol/Rep					2.2					
Birch	Cass	3.2	1.7	3.8	3.0	3.4	3.0	3.2	0.8	42
Blue	Mecosta	1.2	1.7	4.3	2.9p	2.6p	2.5	2.6	1.2	40
Blue, Big	Kalkaska	1.0	1.0<	1.0	1.4	1.4	1.1	1.0	0.4	31
MDEQ					1.0<					
MDEQ/Rep					1.0<					
Blue, North	Kalkaska	*	*	*	*	*				
Bostwick	Kent	2.6	3.3	4.8	4.8p	7.5p	4.6	4.8	1.9	46
MDEQ		1.8								
MDEQ/Rep		1.9								
Brooks	Leelanau	7.4	12.0b	8.3	14.0	3.8	9.1	8.3	4.0	51
Cedar	Alcona/Iosco	1.0<	1.8	2.2	2.7	2.4	1.9	2.2	0.9	38
Cedar	Van Buren	c	3.9	3.1	3.6	3.0	3.4	3.4	0.4	42
Chemung	Livingston	1.4	*	1.9	1.2	3.1	1.9	1.7	0.9	35
MDEQ						3.2				
MDEQ-Rep						3.4				

APPENDIX 3
2007 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Deviation	Carlson TSI_{CHL}
Clam	Antrim	1.9	1.5	1.9	2.2	1.5	1.8	1.9	0.3	37
Vol/Rep		1.3								
Clark	Jackson	1.0<	1.6	2.8	*	1.0<	1.4	1.1	1.1	31
MDEQ						1.4				
MDEQ/Rep						1.7				
Cobb	Barry	1.0<	1.0<	1.3	1.0<	1.3	0.8	0.5	0.4	<31
Corey	St. Joseph	1.3	2.4	2.0	2.6	3.2	2.3	2.4	0.7	39
Cowan	Kent	2.9	8.3b	10.0	14.0p	18.0p	10.6	10.0	5.7	53
Crockery	Ottawa	*	*	*	*	5.7				
MDEQ						5.5				
MDEQ/Rep						6.2				
Crooked	Barry	2.4	5.3	4.9	*	2.9	3.9	3.9	1.4	44
Crooked	Kalamazoo	2.0	3.6	4.5	3.9	1.4	3.1	3.6	1.3	43
MDEQ		1.7								
MDEQ/Rep		1.5								
Crooked	Kalkaska	*	*	*	*	*				
Crooked, Big	Van Buren	3.1	3.8	2.5	3.1	3.1	3.1	3.1	0.5	42
Crooked, Little	Van Buren	2.6	4.0	4.3	4.9	3.0	3.8	4.0	0.9	44
Crystal	Benzie	1.0<,b	1.0<,b	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Crystal	Newaygo	2.2	4.1	6.1	5.7p	23.0p	8.2	5.7	8.4	48
Crystal	Oceana	1.0<	4.6	5.9	6.2	16.0	6.6	5.9	5.7	48
MDEQ						13.0				
MDEQ/Rep						13.0				
Cub	Kalkaska	*	*	*	2.9	3.5				
MDEQ					3.6					
MDEQ/Rep					3.6					
Deer	Alger	4.1b	2.3	3.6	2.7	1.0<	2.6	2.7	1.4	40
Deer	Oakland	1.0<	1.8	1.0<	1.0b	1.2	1.0	1.0	0.5	31
MDEQ		1.0<								
MDEQ/Rep		1.0<								
Derby	Montcalm	1.0<	2.8	2.0	2.4	1.0<	1.6	2.0	1.1	37
MDEQ				2.1						
MDEQ/Rep				2.3						
Devils	Lenawee	*	2.9b	2.4	*	*				

APPENDIX 3
2007 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
Diamond	Cass	1.6	1.0<	4.1	3.8	3.1	2.6	3.1	1.5	42
Eagle	Allegan	1.4	2.7	4.6	4.5	6.9	4.0	4.5	2.1	45
Earl	Livingston	3.2	2.5	25.0	18.0	9.6	11.7	9.6	9.7	53
Vol/Rep				22.0						
MDEQ		6.3								
MDEQ/Rep		7.0								
Emerald	Kent	1.0<	1.5	8.6	8.2p	4.8p	4.7	4.8	3.7	46
Evans	Lenawee	*	*	*	3.4	5.9				
MDEQ						4.9				
MDEQ/Rep						4.3				
Farwell	Jackson	1.0<	1.0<	1.0<	1.9	1.3	0.9	0.5	0.6	<31
MDEQ						1.0				
MDEQ/Rep						1.1				
Fish	Van Buren	7.4	16.0	9.4	11.0	24.0	13.6	11.0	6.6	54
Fisher	St. Joseph	1.0<	1.0<	2.6	2.3	2.5	1.7	2.3	1.1	39
Fisher, Big	Leelanau	1.0<,b	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Fisher, Little	Leelanau	1.0<,b	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Fisher, Little	St. Joseph	1.0<	1.0	3.0	1.6	1.3	1.5	1.3	0.9	33
Freska	Kent	4.7	5.0	6.1	4.4p	5.4p	5.1	5.0	0.7	46
George	Clare	2.1	2.7	3.5	4.8	2.9	3.2	2.9	1.0	41
Glen (Big Glen)	Leelanau	1.0	1.0<	1.0<	1.0<	1.0<	0.6	0.5	0.2	<31
Glen (Little Glen)	Leelanau	1.0<	1.0<	1.0	2.5	1.6	1.2	1.0	0.8	31
Goshorn	Allegan	15.0	19.0	11.0	25.0	34.0	20.8	19.0	9.0	59
Gourdneck	Kalamazoo	1.3	4.1	4.7	*	4.4	3.6	4.3	1.6	45
Hamlin, Lower	Mason	1.3	5.1	3.6	3.3p	4.3	3.5	3.6	1.4	43
Hamlin, Upper	Mason	2.2	3.9	8.3	3.5p	6.6	4.9	3.9	2.5	44
Hess	Newaygo	31.0	9.2	25.0	14.0p	19.0p	19.6	19.0	8.6	59
Hicks	Osceola	4.1b	7.3	24.0	16.0	2.7	10.8	7.3	9.0	50
Higgins (N Basin)	Roscommon	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Higgins (S Basin)	Roscommon	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
High	Kent	3.0	3.6	2.9	*	*				
Horsehead	Mecosta	1.0<	6.2	4.1	4.1p	3.7p	3.7	4.1	2.0	44
Houghton (Site 1)	Roscommon	6.4	4.0	8.8	11.0	10.0	8.0	8.8	2.8	52
Houghton (Site 2)	Roscommon	1.6	2.4	4.1	11.0	8.1	5.4	4.1	4.0	44

APPENDIX 3
2007 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
Hubbard	Alcona	1.0<	1.6	1.5	1.0<	1.4	1.1	1.4	0.6	34
MDEQ						1.7				
MDEQ/Rep						1.8				
Indian	Kalamazoo	2.9	1.0<	2.7	1.0<	2.5	1.8	2.5	1.2	40
Indian	Kalkaska	3.6	1.7	3.3	1.0<	2.3	2.3	2.3	1.3	39
Indian	Osceola	2.0	2.1	2.8	9.4	5.5	4.4	2.8	3.2	41
Island	Gr. Traverse	2.4	1.0<	1.8	4.4	1.5	2.1	1.8	1.4	36
Vol/Rep			1.0<							
Jewell	Alcona	2.4	2.8	3.4	4.4	4.6	3.5	3.4	1.0	43
Kimball	Newaygo	2.4	15.0	5.4	4.9p	12.0p	7.9	5.4	5.3	47
Klinger	St. Joseph	1.3	1.1	2.0	3.5	2.9	2.2	2.0	1.0	37
Lakeville	Oakland	1.5	1.9	1.9	1.9	3.6	2.2	1.9	0.8	37
Lancelot	Gladwin	2.7	5.9	5.4	5.5	3.2	4.5	5.4	1.5	47
Lancer	Gladwin	1.3	2.2	1.6	1.2	1.9	1.6	1.6	0.4	35
Lansing	Ingham	*	5.2	4.8	d	5.0				
Lily	Clare	*	1.0<	1.2	*	*				
Little	Marquette	1.0b	3.8b	3.6	4.8	5.2	3.7	3.8	1.6	44
Long	Iosco	2.8	2.7	3.4	2.4	1.0<	2.4	2.7	1.1	40
MDEQ						2.5				
MDEQ/Rep						2.2				
Magician	Cass	1.0<	2.2	4.7	*	*				
Vol/Rep			2.8							
Margrethe	Crawford	1.0<	1.0	2.0	3.1	2.5	1.8	2.0	1.1	37
Mary	Iron	1.0<	1.2	2.7	5.8	9.5	3.9	2.7	3.7	40
Vol/Rep						11.0				
Mecosta	Mecosta	1.0<	1.0<	2.8	2.8p	2.3p	1.8	2.3	1.2	39
Mehl	Marquette	1.4b	2.4b	3.7	4.5	4.2	3.2	3.7	1.3	43
Moon	Gogebic	1.8	2.0	2.0	2.3	4.0	2.4	2.0	0.9	37
Mullett	Cheboygan	*	1.0<	1.3	*	*				
Murray	Kent	3.5	2.0	1.9	3.2	3.3	2.7	2.7	0.8	40
Nepessing	Lapeer	1.0<	1.1	1.9	1.0<	2.5	1.3	1.1	0.9	32
Vol/Rep		1.0<								
Ore	Livingston	*	2.8a	*	3.6	4.8				
Orion	Oakland	*	*	*	*	*				

APPENDIX 3
2007 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l)					Mean	Median	Std. Deviation	Carlson TSI_{CHL}
		May	June	July	Aug	Sept				
Osterhout	Allegan	3.6	5.1	5.7	*	3.1	4.4	4.4	1.2	45
Otsego	Otsego	2.3p	1.8p	3.8p	4.2	3.9	3.2	3.8	1.1	44
Oxbow	Oakland	2.3	5.0	3.6	*	2.1	3.3	3.0	1.3	41
Papoose	Kalkaska	*	*	*	*	*				
Parke	Oakland	1.0<	1.3	1.8	5.4	3.4	2.5	1.8	1.9	36
Vol/Rep						4.1				
Pentwater	Oceana	8.5	5.8	7.9	7.4	6.1	7.1	7.4	1.2	50
Pickerel	Newaygo	1.2	5.0	6.2	4.3p	6.1p	4.6	5.0	2.0	46
Platte, Little	Benzie	*	3.0	2.6	*	*				
Vol/Rep				2.5						
Pleasant	Wexford	2.4	3.1	8.6	4.1	2.5	4.1	3.1	2.6	42
Pretty	Mecosta	3.1	4.5	2.7	3.1	14.0	5.5	3.1	4.8	42
Randall	Branch	6.4	6.0	17.0b	11.0	12.0	10.5	11.0	4.5	54
Vol/Rep						14.0				
Robinson	Newaygo	8.8	9.7	5.0	14.0p	7.1p	8.9	8.8	3.4	52
Round	Clinton	9.2	4.5	5.7	7.8	7.1	6.9	7.1	1.8	50
Round	Lenawee	1.0<	1.1	3.1	1.5	2.4	1.7	1.5	1.0	35
Round	Mecosta	1.6	2.3	5.0	5.9p	14.0p	5.8	5.0	4.9	46
Sapphire	Missaukee	*	3.8	10.0	4.3	3.8	5.5	4.1	3.0	44
School Section	Mecosta	1.8	3.2	4.8	4.9	4.0	3.7	4.0	1.3	44
Shingle	Clare	2.9	3.5	4.0	4.7	2.9	3.6	3.5	0.8	43
Vol/Rep					4.7					
Silver	Gr. Traverse	1.0<	1.0<	2.0	1.8	1.6	1.3	1.6	0.7	35
MDEQ			1.0<							
MDEQ/Rep			1.0<							
Smallwood	Gladwin	7.0	3.2b	5.1	2.2b	2.2	3.9	3.2	2.1	42
Spider	Gr. Traverse	3.6	5.5	3.8	3.3	3.4	3.9	3.6	0.9	43
Starvation	Kalkaska	*	*	*	*	1.0<,e				
MDEQ					2.1					
MDEQ/Rep					2.1					
Strawberry	Livingston	2.9	3.5	5.3	13.0f	4.1	5.8	4.1	4.1	44
MDEQ						4.9				
MDEQ/Rep						5.1				

APPENDIX 3
2007 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
Sweezey	Jackson	1.9	1.0	1.9	2.0	1.0<	1.5	1.9	0.7	37
MDEQ						1.0<				
MDEQ/Rep						1.0<				
Torch (N Basin)	Antrim	1.0<	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Torch (S Basin)	Antrim	1.0<,b	1.0<	1.0<	1.0<	1.0<	0.5	0.5	0.0	<31
Twin, East	Montmorency	*	4.1	5.2	4.4	4.5	4.6	4.5	0.5	45
Twin, Little	Kalkaska	*	*	*	*	*				
Twin, West	Montmorency	2.4	2.3	3.6	4.2	2.9	3.1	2.9	0.8	41
Van Etten	Iosco	11.0	1.6	4.3	3.8	18.0	7.7	4.3	6.7	45
Vol/Rep					5.3					
Viking	Otsego	8.8	3.9	4.6	2.2	1.8	4.3	3.9	2.8	44
Vineyard	Jackson	1.0<	3.7	3.1	1.8	2.2	2.3	2.2	1.2	38
Webinguaw	Newaygo	4.5	11.0	4.7	9.2	5.3	6.9	5.3	3.0	47
Wells	Osceola	*	*	*	*	*				
Windover	Clare	1.7	1.6	3.2	3.0	2.9	2.5	2.9	0.8	41
Woods	Kalamazoo	1.0	4.4	11.0	22.0	16.0	10.9	11.0	8.5	54

< 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. No date on sample or field sheet.

f. No magnesium carbonate in sample.

p. Sample thawed on shipment - laboratory results may be an underestimate of true value.

APPENDIX 4
2007 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Alcona	Hubbard Lake
	Jewell
Alpena	Beaver Lake
Barry	Upper Crooked (Delton) Lake
Benzie	Ann
Cass	Magician Lake
Clare	Lake George
Gladwin	Smallwood Lake
Grand Traverse	Arbutus
	Silver
Jackson	Sweezey Lake
Kalamazoo	Gourdneck Lake
	Crooked Lake
	Indian Lake
Kalkaska	Bear Lake
Kent	Bostwick Lake
	Cowan Lake
	Freska Lake
Lenawee	Devils Lake
	Round Lake
Livingston	Strawberry Lake
	Earl Lake
Marquette	Little Lake
	Mehl Lake
Mason	Hamlin (Upper) Lake
	Hamlin (Lower) Lake
Montcalm	Baldwin Lake
	Derby Lake

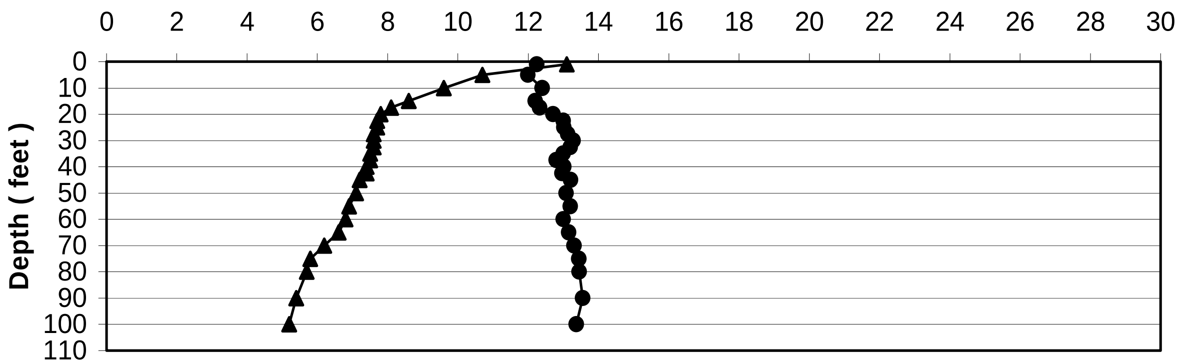
County	Participating Lakes
Newaygo	Crystal Lake Hess Lake Pickerel Lake Kimball Lake Robinson Lake
Oakland	Deer Lake Parke Lake
Montcalm	Baldwin Lake Derby Lake
Newaygo	Crystal Lake Hess Lake Pickerel Lake Kimball Lake
Oakland	Deer Lake Oxbow Lake Parke Lake
Osceola	Big Lake Hicks Lake
Roscommon	Higgins (North) Lake Higgins (South) Lake
St. Joseph	Fisher Lake Little Fisher 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 oligotrophic/mesotrophic lake with a large hypolimnion volume. It retains some oxygen in the hypolimnion all summer, but the deepest parts of the lake do drop to zero dissolved oxygen. The third pattern is of a good quality oligotrophic/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 small hypolimnion. Within a few weeks of spring overturn the hypolimnion has lost all oxygen. This anaerobic condition persists all summer. The final pattern is a eutrophic 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.

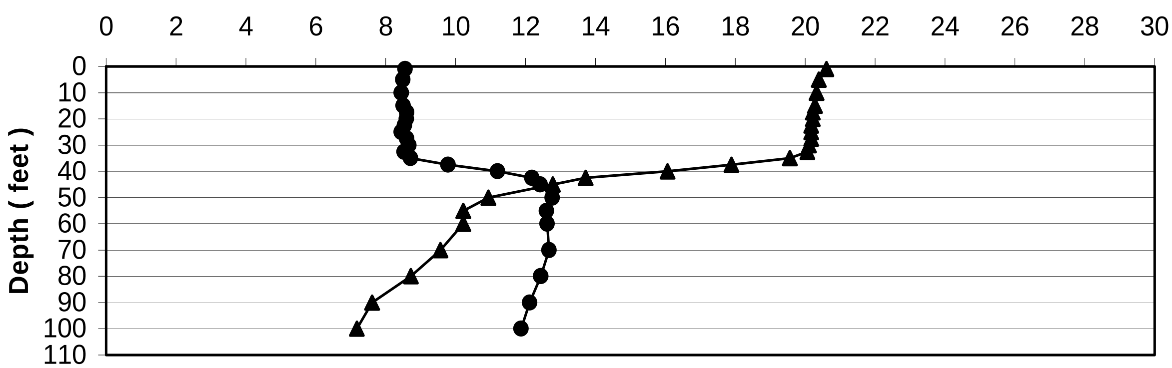
Oligotrophic Lake with a Very Large Volume Hypolimnion

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.

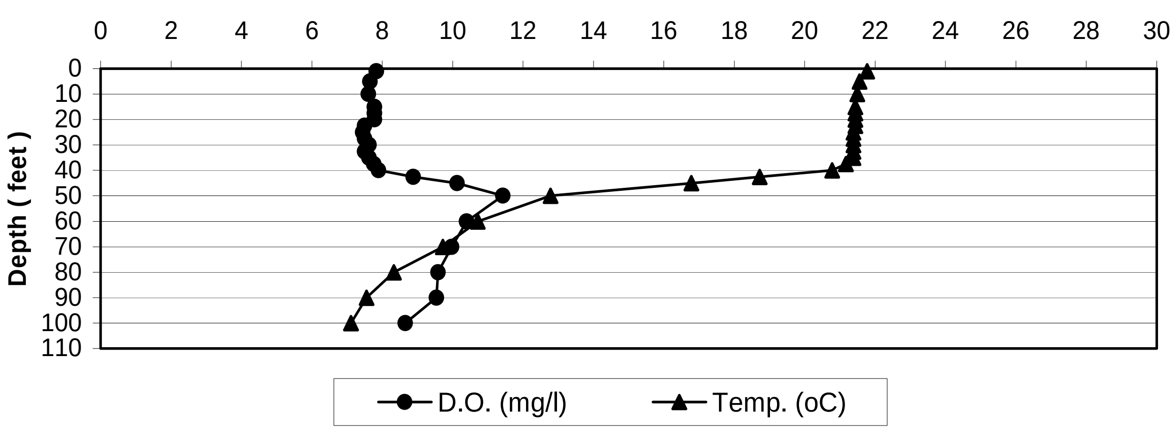
May 10, 2007



July 17, 2007



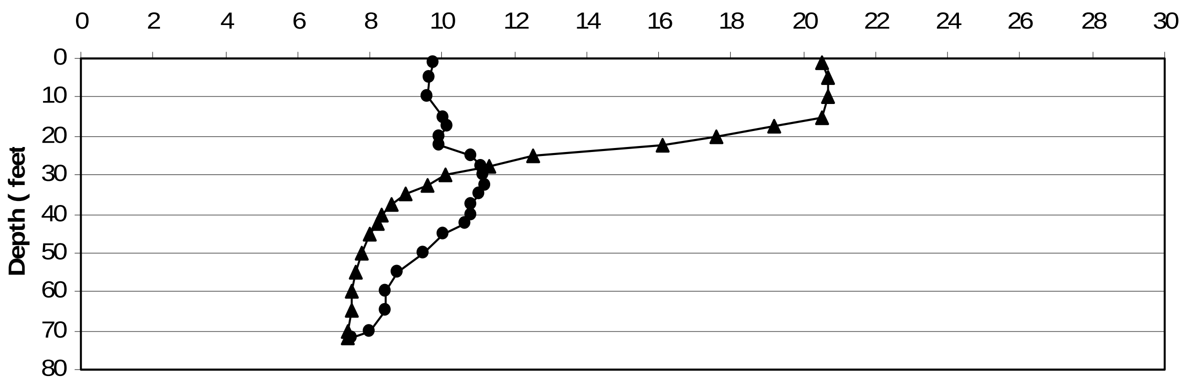
September 9, 2007



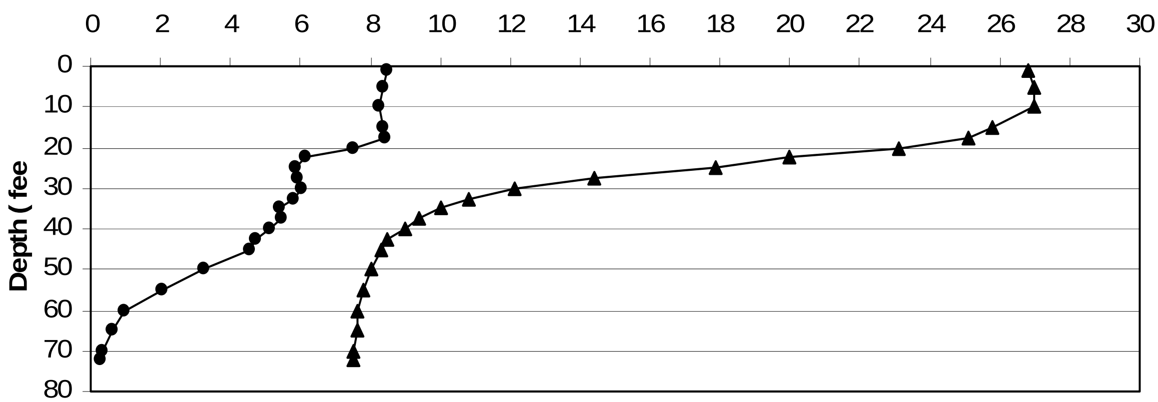
Mesotrophic Lake with a Large Volume Hypolimnion

Indian Lake in Kalamzaoo 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 August oxygen is gone in the deepest waters, but the upper hypolimnion retains some oxygen. By late summer (September) oxygen is depleted in the hypolimnion

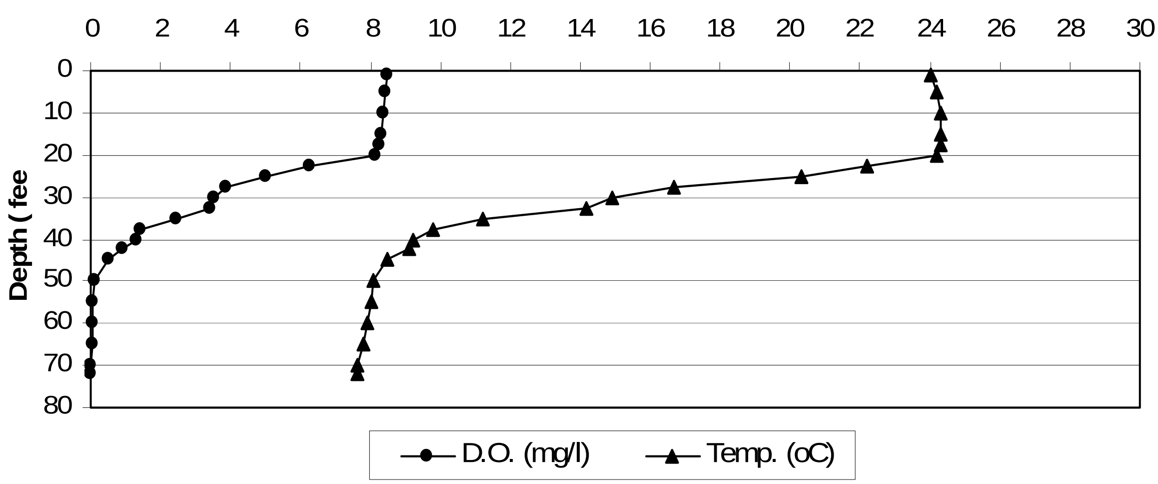
June 6, 2007



August 10, 2007

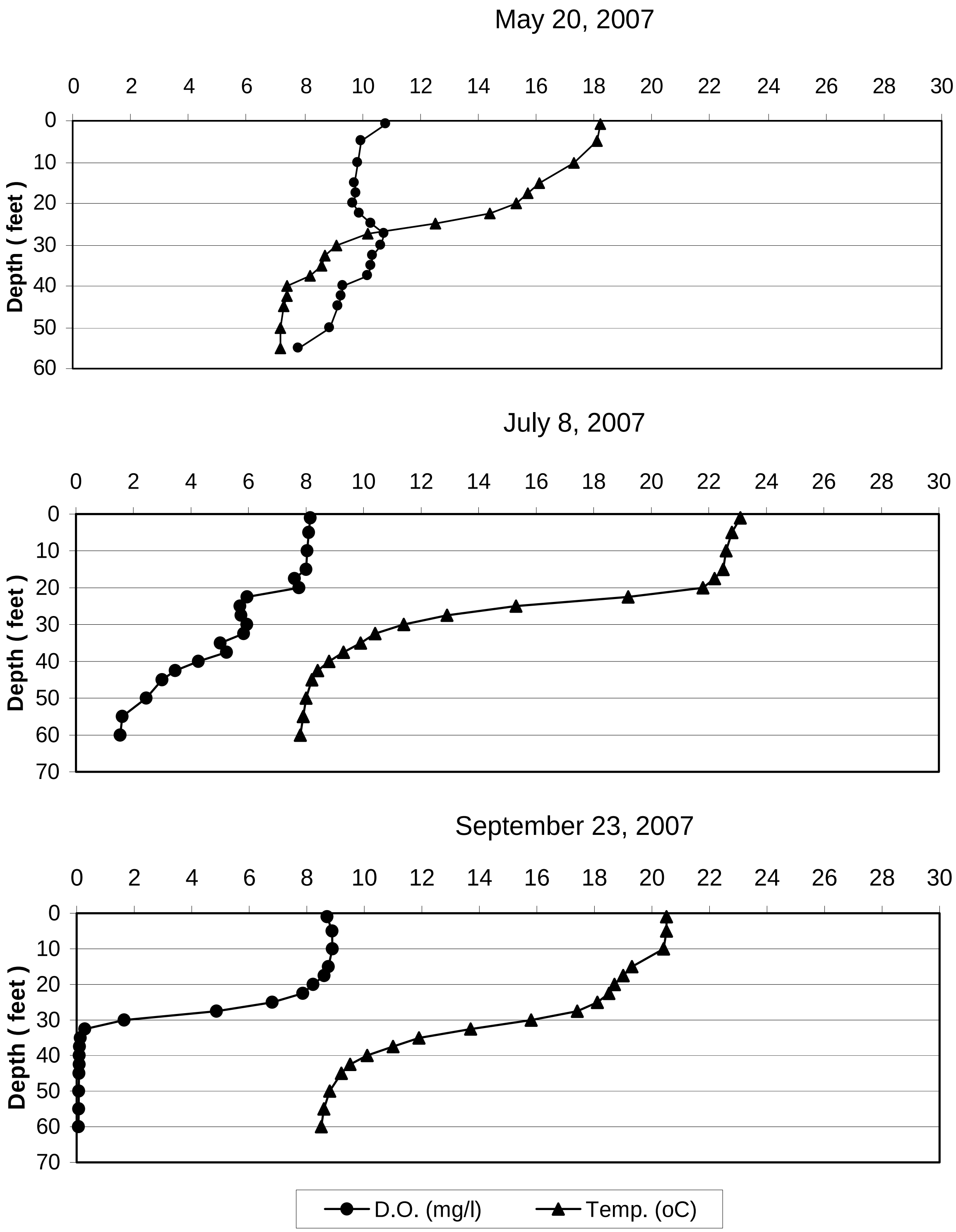


September 8, 2007



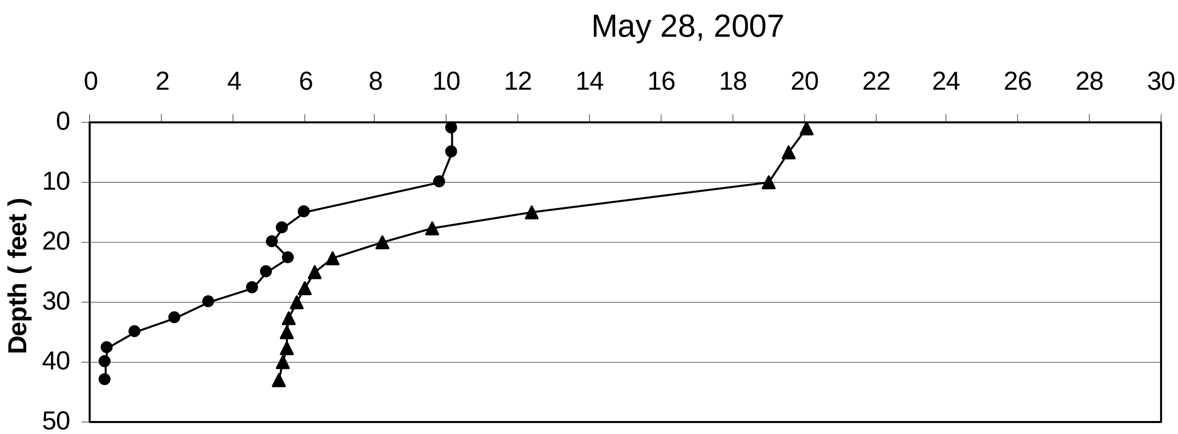
Mesotrophic Lake with a Small Volume Hypolimnion

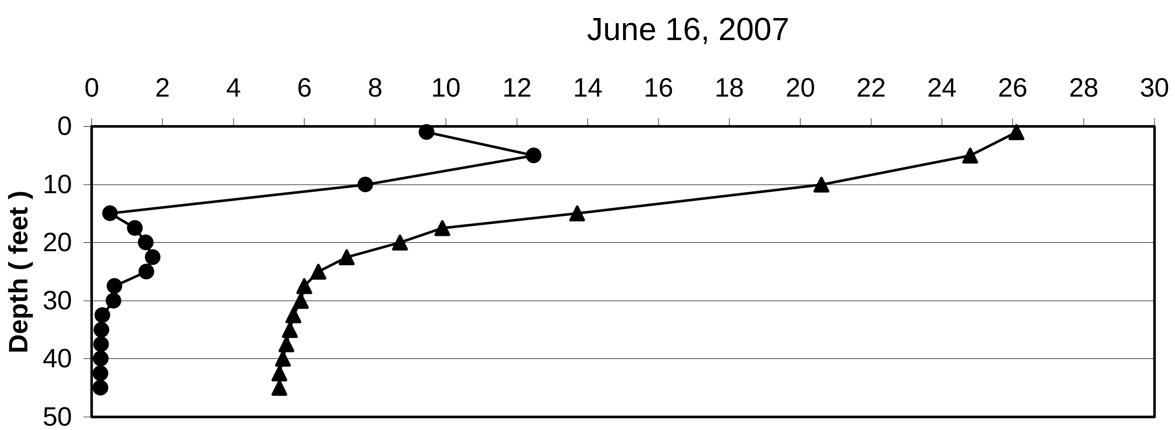
Round Lake in Lenawee County is a mesotrophic lake with a small volume hypolimnion. As a mesotrophic lake it produces moderate amounts of organic material that must be decomposed. Its hypolimnion has a limited oxygen supply that is gradually depleted by the decomposition of the organic material, which 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.

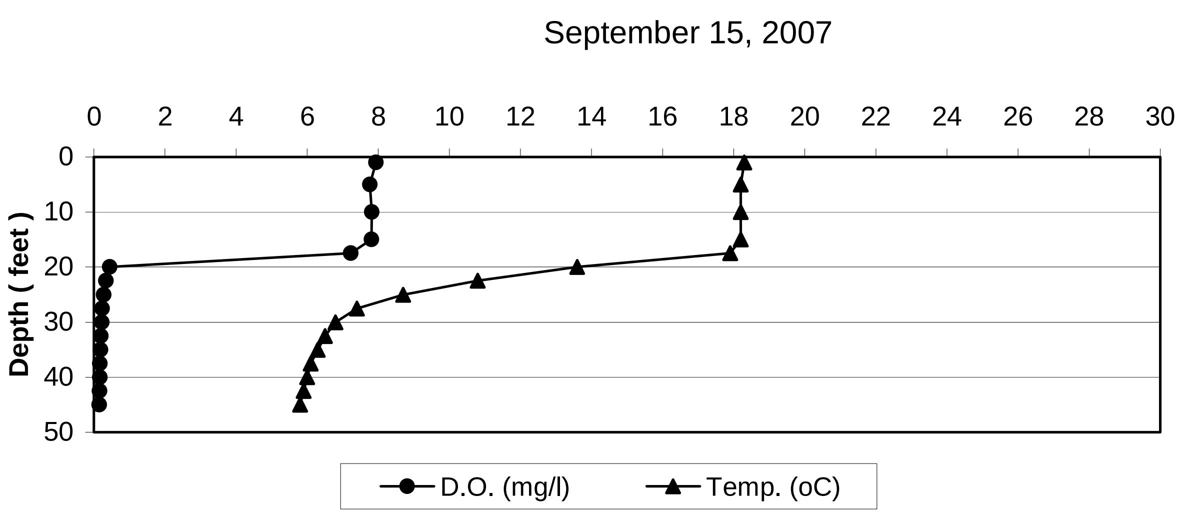


Eutrophic Lake with a Moderate Volume Hypolimnion

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.

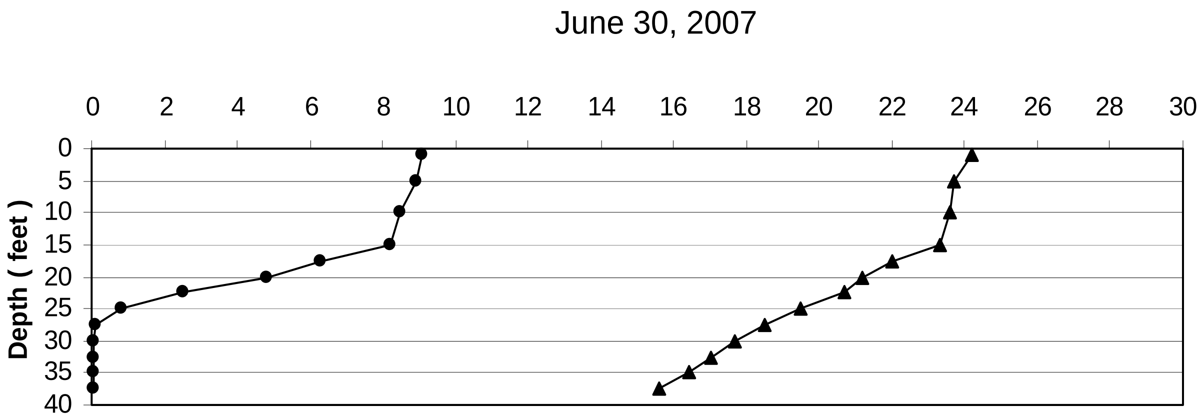


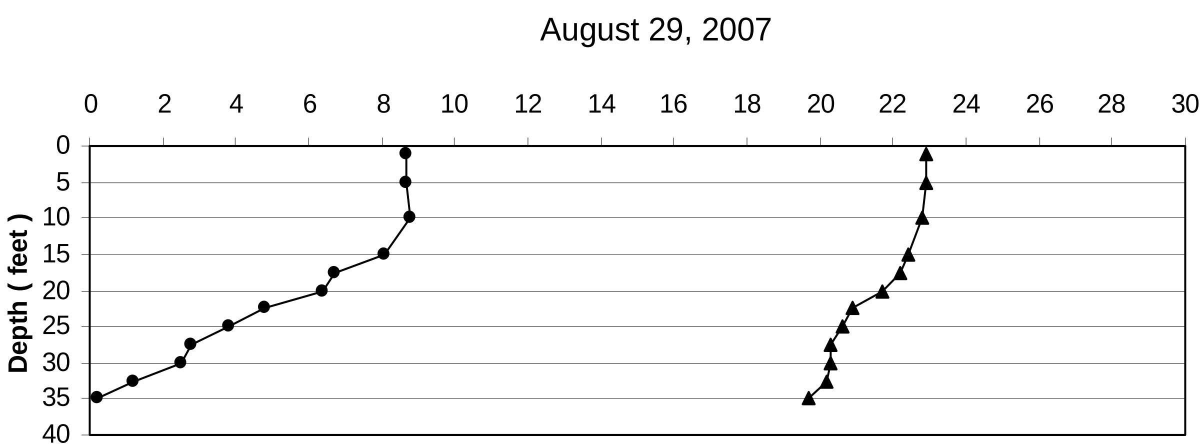


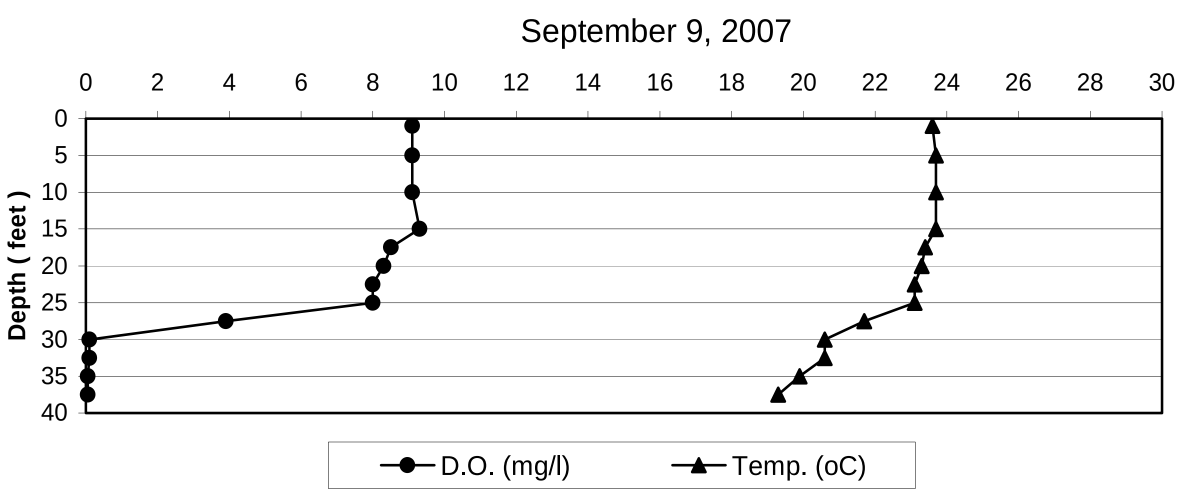


Shallow Meso/Eutrophic Lake that does not Maintain Summer Stratification

Upper Hamlin Lake in Mason County is a shallow meso/eutrophic lake basin with insufficient depth to maintain stratification all summer. As a meso/eutrophic lake it produces moderately large amounts of organic material that must be decomposed. Its hypolimnion, if present, has a small oxygen supply that is rapidly 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 early 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 quickly lost.







APPENDIX 5
2007 COOPERATIVE LAKES MONITORING PROGRAM
AQUATIC PLANT MAPPING RESULTS

Two lakes participated in the 2007 CLMP aquatic plant mapping project. They were Big Fisher Lake in Leelanau County and Viking Lake in Otsego County. Big Fisher Lake has productivity, with TSI values generally in the 30's. Viking Lake is much more productive with TSI values generally in the low 50's. Viking Lake has a high algal turbidity. The CLMP plant mapping project revealed that both lakes had limited plant populations consisting of a good diversity of species, none of which dominated. No exotic species were found in either lake.

As an example of the work completed in the CLMP aquatic plant mapping project the whole lake reporting data sheet for Big Fisher Lake is presented below. These data are from a survey done on the lake in June. In addition to the data sheet each lake monitoring team produced aquatic plant maps for their lake.

Plant Number	Plant Name	Distribution (# of sites where observed)	Average Density
20	Stonewort	15	2.208
41	Coontail	4	0.708
30	Large-leaf Pondweed	6	0.458
12	White water lily	3	0.125
52	Sago Pondweed	1	0.083
36	Waterweed	1	0.042
42	Clasping-leaf Pondweed	1	0.042