Cooperative Lakes Monitoring Program

Michigan's Citizen Volunteer Lakes Monitoring Program

ANNUAL SUMMARY REPORT

2003

a partnership for Michigan's lakes

Michigan's Citizen Volunteers
Michigan Lake & Stream Associations, Inc.
Michigan Department of Environmental Quality
Fisheries and Wildlife Department – Michigan State University

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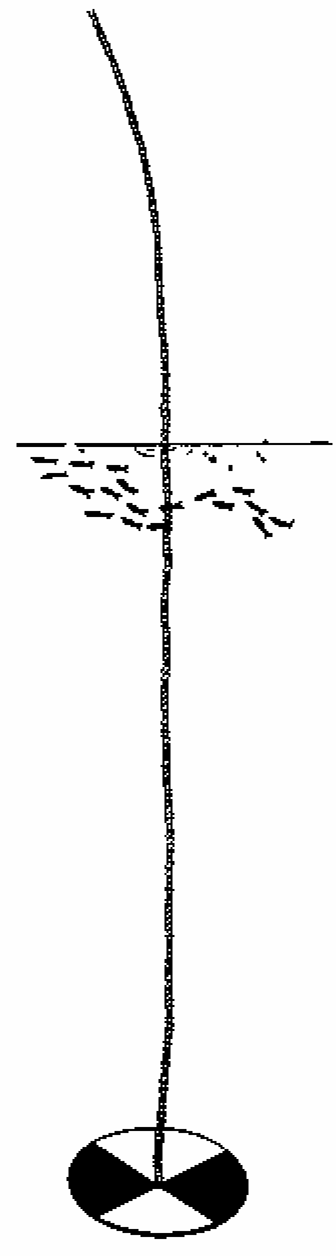

INTRODUCTION

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.

Michigan's abundant water resources...

...include over 11,000 inland lakes.

To meet this need, the Department of Environmental Quality's (DEQ) Water Division 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 was designed for lake property owners to monitor water quality by measuring water clarity with a Secchi disk. In 1992, the DEQ Land and Water Management Division (then part of the Department of Natural Resources) and the ML&SA entered into a cooperative agreement to expand the basic program. An advanced Self-Help program was

"working together to protect lakes"

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initiated in 1993 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 Michigan's citizens an opportunity to participate in environmental management and learn more about their lakes. Currently, the CLMP supports monitoring components for basic indicators of primary productivity in lakes, including Secchi disk transparency, total phosphorus, chlorophyll *a*, dissolved oxygen and temperature.

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

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 lake 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

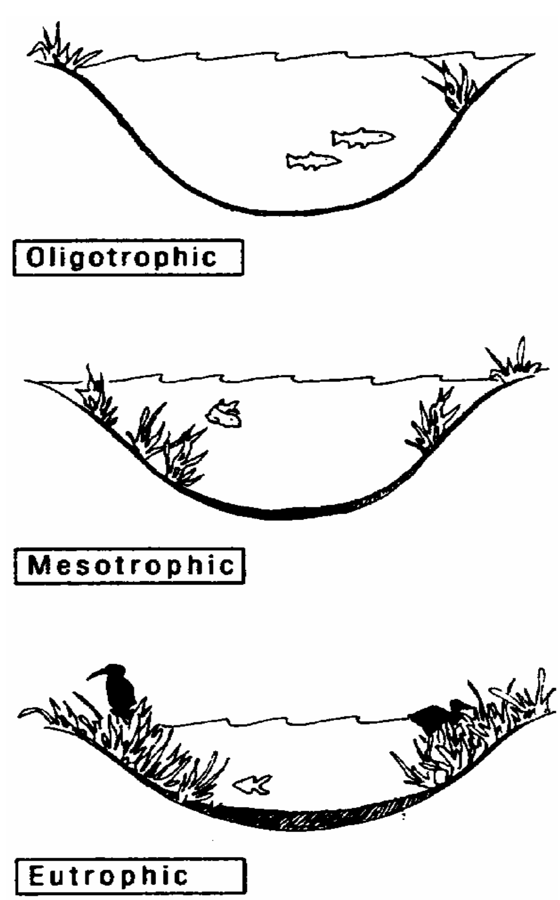
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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

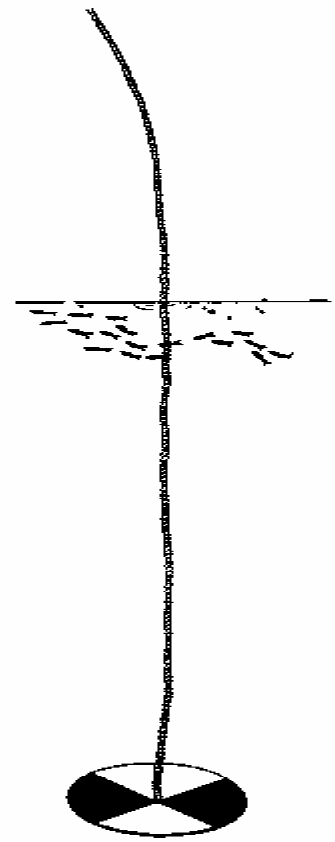
A lake's ability to support plant and animal life defines its level of productivity, or *trophic state.* Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved 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. A sample of warm water fish, such as sunfish, bass, bullheads, and carp is 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)

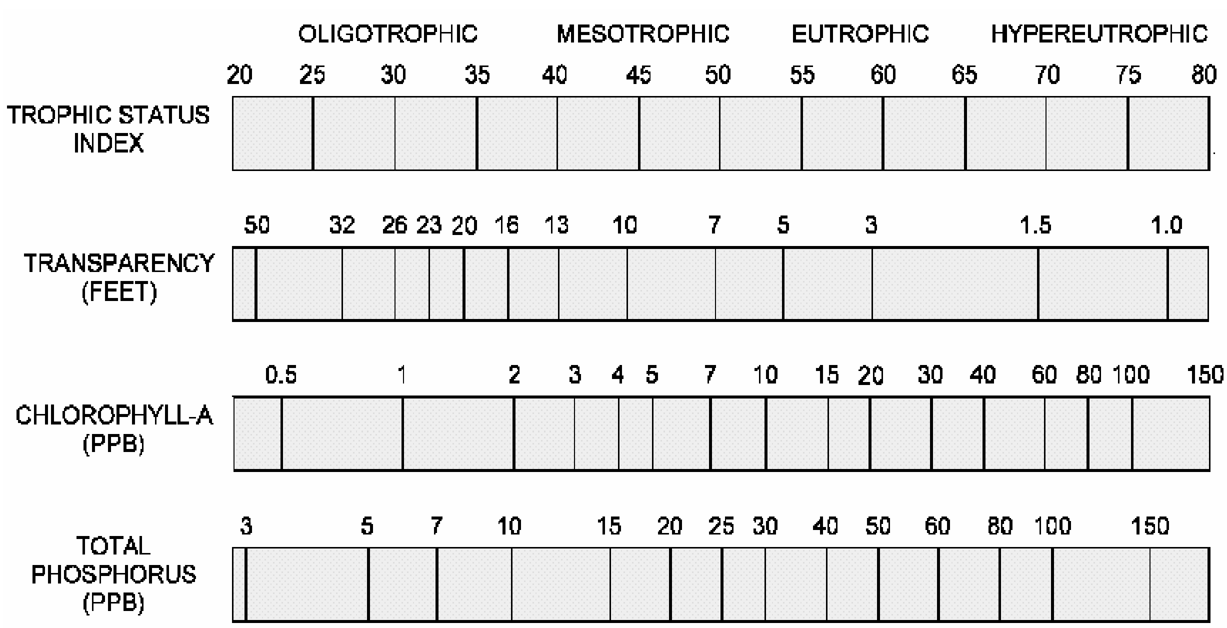
evaluate changes within the lake over time, and to estimate other water quality parameters within the lake.

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)

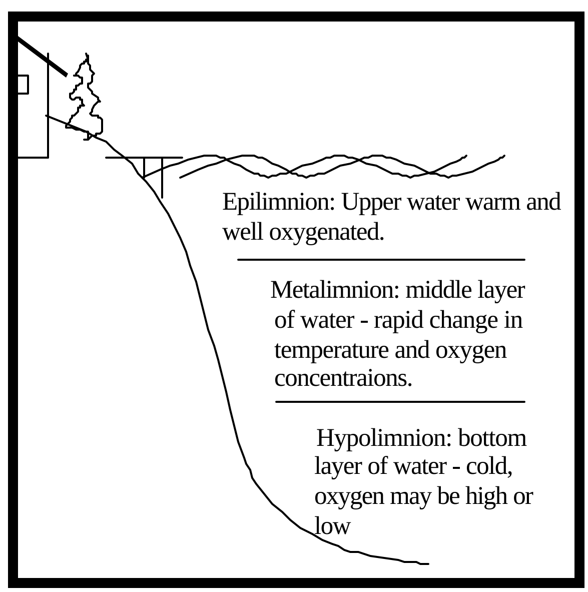
OTHER MEASURES OF LAKE PRODUCTIVITY

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 Centigrade. In the winter there is only a few degrees difference between the water under the ice (0 degrees Centigrade) and the water on the bottom (4 degrees Centigrade). 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 mater 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 spe-

cies 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 45 feet deep) can stratify, lose its 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

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 2003 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.

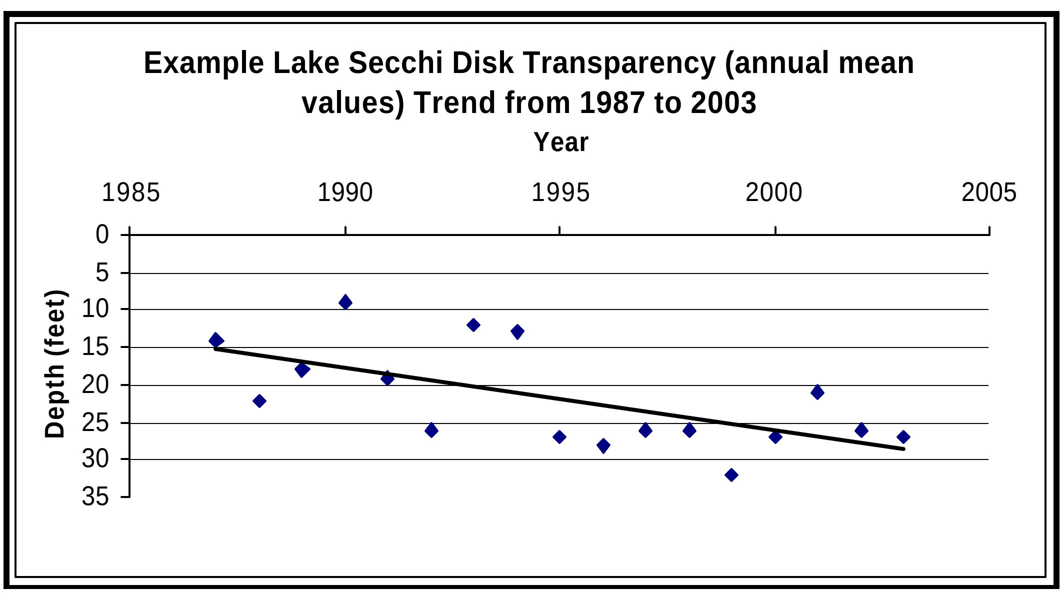
The data range and standard deviation gives an indication of seasonal variability in transparency in the lake. Lakes with highly variable Secchi disk readings need to be sampled frequently to provide a representative mean summer transparency value. Few measurements and inconsistent sampling periods for 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 2003, Secchi disk transparency data were reported for 170 lakes (210 basins). Over 3,200 transparency measurements were reported, ranging from 0.4 to 55 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. The median value was 11.5 feet. The Carlson TSI_{SD} values ranged from 26 to 62 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 2003 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 2003, samples for total phosphorus measurements were collected on 162 lakes. The spring overturn total phosphorus results ranged from <5 to 120 ug/l with a mean (average) of 15 ug/l and a median value of 12 ug/l. The late summer total phosphorus results ranged from <5 to 410 ug/l with 18 ug/l as the mean and 11 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 91 for these lakes with a mean value of 40.5. A Carlson TSI value of 40.5 is generally indicative of a good quality mesotrophic lake (see page 8).

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 2003 volunteers collected a minimum of four samples on 92 lakes.

Results from the chlorophyll monitoring for 2003 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 one-third of the lakes. About 545 chlorophyll samples were collected and processed in 2003. The chlorophyll *a* levels ranged from <1 to 97 ug/l over the five-month sampling period. The overall mean (average) was 4.3 ug/l and the median was 2.7 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 59 with a mean value of 41. A Carlson TSI value of 41 is generally indicative of a mesotrophic lake (see page 8).

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) 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.

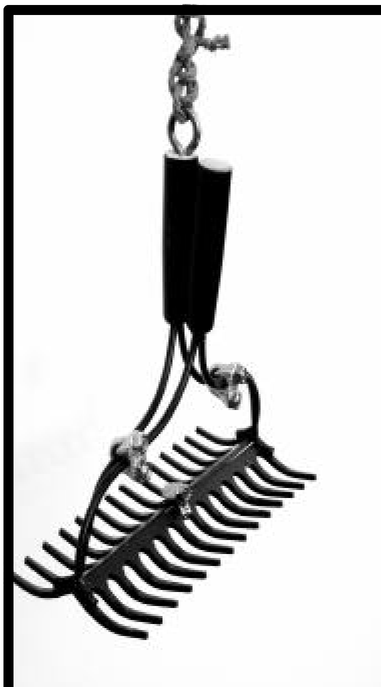
During 2003, CLMP participants in

the dissolved oxygen/temperature project sampled 35 lakes. A total of 274 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 2003 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, an oligotrophic/mesotrophic lake with a large volume hypolimnion, an oligotrophic/mesotrophic lake with a small hypolimnion, a eutrophic lake with a small hypolimnion, and a mesotrophic lake which weakly stratifies during the summer. A sixth pattern not represented is the very shallow lake, with a maximum depth of less than 15 feet. These lakes usually have the same temperature and dissolved oxygen concentrations from surface-to-bottom as a result of frequent mixing.

Aquatic Plant Mapping

To create the aquatic plant map and data sheets, sampling transects were identified around the lake. Along each transect, plant samples were collected at the one, four and eight foot depths with a constructed sampling rake. The rake was tossed out into the lake and retrieved from the four compass directions. The density of each plant species was determined by its presence on one, two, three or all four of the rake tosses. The data from all the transects were 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, CLMP participants in a



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.

pilot project sampled 2 lakes for aquatic plants (Windover Lake, Clare County and Big Glen Lake, Leelanau County). Windover Lake had limited to moderate plant growth, while Big Glen Lake had sparse plant growth. No evidence of Eurasian milfoil was recorded for either lake. Eurasian milfoil is an exotic plant that has caused major problems for North American lakes. While similar in appearance to native milfoils, see figure below, it is significantly more recreationally disruptive.

Because of varied results and the amount of individual data collected, each lake's results are not included in this report. Each participating lake community will have their individual aquatic plant distribution maps and data sheets.

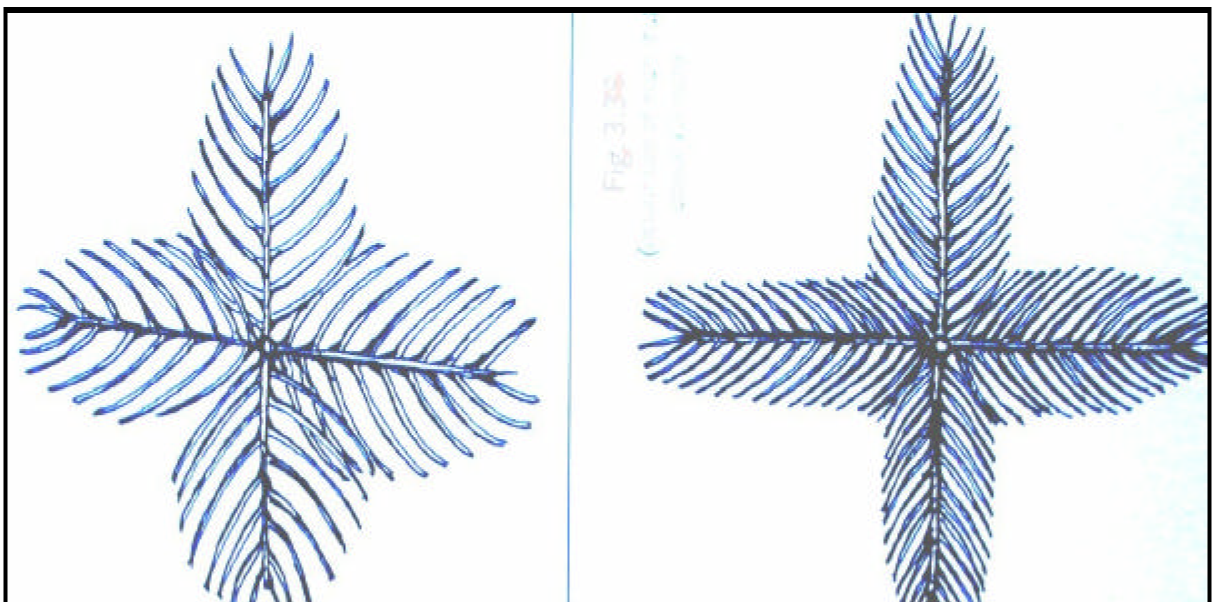
During 2003, an evaluation of the aquatic plant monitoring project was made (Wandell, 2003). The evaluation had two goals:

- Determine if citizen volunteers with training and minor professional assistance can produce an acceptable aquatic plant qualification assessment.

- Do aquatic plant qualification procedures used by the CLMP compare reasonably with qualification procedures used by the DEQ.

For the evaluation three aquatic plant surveys were conducted at Windover Lake. One survey was done by DEQ staff using DEQ methods, (*Procedures for Aquatic Plant Surveys*). The other two surveys were done using the CLMP method described in Wandell and Wolfson (2000). Two lake residents, trained by the CLMP, conducted one survey (Volunteer/Citizen survey). Limnolo-

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

gists from Michigan State University Department of Fisheries and Wildlife and DEQ conducted the second survey (Volunteer/Professional survey) using the same sampling sites as the citizen survey.

A summary of the evaluation results are included in Appendix 5.

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.

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Thank you to the dedicated volunteers who have made the CLMP one of the nations most successful citizen volunteer lakes monitoring programs. Special thank you is extended to Niles Kevern and Joe Landis for their help in building the chlorophyll sampling and filtering equipment and to Ralph Vogel for constructing the Secchi disks for the CLMP.

The Michigan Department of Environmental Quality will not discriminate against any individual or group on the basis of race, sex, religion, age, national origin, color, marital status, disability, or political beliefs. Questions or concerns should be directed to the Office of Personnel Services, PO Box 30473, Lansing, MI 48909.

APPENDIXES

Appendix 1

2003 Secchi Disk Transparency Results

Appendix 2

2003 Total Phosphorus Results

Appendix 3

2003 Chlorophyll Results

Appendix 4

2003 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2003 Aquatic Plant Monitoring Evaluation

APPENDIX 1
2003 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Ann	Benzie	19	10.0	29.0	19.7	18.0	5.91	34
Arbutus 1	Grand Traverse	19	10.0	13.0	12.6	13.0	0.90	41
Arbutus 2	Grand Traverse	19	12.0	28.0	16.8	15.0	5.07	36
Arbutus 3	Grand Traverse	19	11.0	22.0	15.0	14.0	3.64	38
Arbutus 4	Grand Traverse	19	10.0	21.0	14.7	14.0	2.87	38
Arbutus 5	Grand Traverse	19	10.0	17.0	12.6	13.0	1.77	41
Arnold	Clare	16	14.0	25.0	18.5	18.5	2.61	35
Austin	Osceola	18	8.0	13.5	11.2	11.3	1.57	42
Avalon	Montmorency	19	14.0	30.5	22.5	22.2	5.39	32
Baldwin	Montcalm	19	7.5	18.2	11.5	10.3	3.53	42
Baldwin 1	Cass	5	7.3	19.5				
Baldwin 2	Cass	5	8.8	17.0				
Baldwin 3	Cass	5	7.5	21.8				
Baldwin 4	Cass	5	6.5	21.0				
Barlow	Barry	12	6.0	15.0	8.1	6.8	2.99	47
Bass	Kent	18	7.0	13.0	10.4	10.0	1.66	43
Bear	Manistee	13	7.5	12.0	9.7	9.5	1.27	44
Bear 1	Kalkaska	11	27.0	48.5	34.0	31.5	6.79	26
Bear 2	Kalkaska	11	26.5	49.5	33.8	30.5	7.28	26
Beaver	Alpena	17	11.0	19.7	15.5	15.8	2.25	38
Big	Osceola	19	11.5	31.0	18.9	19.0	6.60	35
Big Bradford	Otsego	7	15.0	19.0				
Big Platte	Benzie	19	9.0	23.0	13.8	14.0	3.45	39
Big Twin North	Cass	17	6.5	15.0	10.2	11.0	2.73	44
Bills 1	Newaygo	13	6.0	15.0	10.7	10.0	3.38	43
Bills 2	Newaygo	17	5.5	13.0	9.2	10.0	2.57	45
Birch	Cass	19	10.0	33.0	19.3	14.0	9.02	34
Blue	Mason	12	19.0	32.5	27.4	28.8	4.11	29
Blue 1	Mecosta	18	8.0	24.0	13.8	11.0	5.44	39
Blue 2	Mecosta	18	9.0	26.0	14.1	12.0	5.36	39
Bostwick	Kent	7	4.0	18.0				
Brighton	Livingston	1	5.0	5.0				
Brooks	Newaygo	11	2.5	3.5	3.0	3.0	0.35	61
Buckhorn (North)	Oakland	18	7.0	16.5	10.9	10.0	3.06	43

APPENDIX 1
2003 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)
Burkhart	Washtenaw	19	10.5	19.0	13.7	14.0	2.18	39
Byram 1	Genesee	19	8.0	26.0	15.5	17.0	5.98	38
Byram 2	Genesee	19	8.0	28.0	15.6	17.0	6.15	37
Byram 3	Genesee	19	8.0	23.0	14.9	17.0	5.14	38
Camp	Kent	13	11.3	22.0	14.7	14.0	2.83	38
Campau	Kent	19	5.0	9.0	5.9	5.0	1.49	52
Cedar	Van Buren	19	9.5	25.0	14.9	12.0	5.28	38
Cedar(BriarwoodBay)	Alcona/Iosco	6	9.0	12.0				
Cedar(Schmidt's Pt.)	Alcona/Iosco	7	4.5	9.0				
Center	Osceola	10	14.0	20.0	16.6	16.5	2.01	37
Chain	Iosco	12	10.0	13.0	11.9	12.5	1.24	41
Chemung	Livingston	12	10.0	20.0	13.7	13.5	2.99	39
Christiana	Cass	14	4.0	10.5	7.6	7.8	2.09	48
Clear	Jackson	15	7.0	11.0	8.6	8.0	1.52	46
Clear	St. Joseph	10	9.7	13.5	12.3	12.8	1.32	41
Clifford 1	Montcalm	14	8.0	24.0	17.7	18.0	4.30	36
Corey	St. Joseph	18	7.5	18.0	11.0	9.0	3.69	43
Cowan	Kent	19	6.0	9.5	7.8	8.0	1.01	47
Crooked	Alcona	18	14.0	17.5	15.6	15.8	1.04	37
Crooked	Kalamazoo	19	9.4	26.5	17.2	15.5	5.56	36
Crooked (Big)	Van Buren	19	9.0	21.0	12.7	12.5	2.76	41
Crystal	Benzie	6	19.0	30.0				
Crystal	Newaygo	9	12.0	41.0	21.4	16.0	9.74	33
Cub	Kalkaska	18	16.0	23.0	20.1	20.0	2.39	34
Deer	Alger	10	6.0	9.0	7.8	8.0	0.98	48
Derby	Montcalm	16	12.5	24.0	17.8	18.5	3.63	36
Devils	Lenawee	8	7.0	21.0	11.1	8.5	5.11	42
Diamond	Cass	19	6.0	18.0	11.1	10.0	4.68	42
Eagle	Allegan/Van Buren	19	9.0	17.0	12.3	12.0	1.91	41
East Twin	Montmorency	8	7.3	10.3	7.9	7.7	0.98	47
Emerald	Newaygo	14	8.0	15.0	11.6	11.8	2.09	42
Evans	Lenawee	19	14.5	31.5	19.3	17.0	4.94	34
Fair	Barry	14	8.7	16.2	12.0	11.8	2.30	41
Fenton	Genesee	6	15.0	17.0				

APPENDIX 1
2003 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)
Fish	Livingston	11	6.5	17.0	11.9	11.5	3.82	41
Fish	Van Buren	18	6.5	13.5	8.5	8.0	1.74	46
Fisher	St. Joseph	19	6.0	15.5	10.4	9.5	2.95	43
Freska	Kent	11	5.3	14.5	9.2	9.4	2.28	45
George	Clare	19	7.0	11.0	8.9	9.0	1.34	46
Gill/Gut	Livingston	13	7.7	12.3	11.1	11.7	1.59	42
Gilletts	Jackson	7	8.3	9.8				
Glen (Big)	Leelanau	17	12.0	23.0	16.6	16.0	2.74	37
Glen (Little)	Leelanau	17	4.5	8.0	6.0	6.0	1.00	51
Gourdneck	Kalamazoo	18	6.0	27.0	13.5	12.5	6.52	40
Gratiot	Keweenaw	16	15.2	21.7	18.2	18.7	1.77	35
Gunn	Mason	19	10.5	20.0	13.4	13.0	2.49	40
Hamburg	Livingston	18	9.5	23.0	13.4	13.0	3.26	40
Hamilton	Dickinson	14	12.0	16.0	13.8	14.0	1.23	39
Harper	Lake	16	7.0	26.0	13.3	10.3	5.72	40
Hawk	Oakland	16	6.5	13.4	9.5	9.1	2.12	45
Hess	Newaygo	18	1.7	6.0	2.9	2.8	1.10	62
Hicks	Osceola	15	4.7	11.5	7.6	7.2	1.69	48
High	Kent	8	11.3	18.6	14.9	14.8	2.82	38
Houghton 1	Roscommon	19	5.0	10.0	7.7	8.0	1.35	48
Houghton 2	Roscommon	14	5.5	10.5	7.6	8.0	1.47	48
Hubbard 1	Alcona	18	9.2	28.0	14.2	13.3	4.82	39
Hubbard 2	Alcona	18	11.0	28.0	14.7	13.3	4.42	38
Hubbard 3	Alcona	11	10.0	32.0	15.6	14.0	6.38	38
Hubbard 4	Alcona	11	10.0	28.0	15.5	14.0	5.66	38
Hubbard 5	Alcona	11	10.0	27.0	14.4	13.0	5.21	39
Hubbard 6	Alcona	18	10.0	29.0	14.8	13.8	4.81	38
Hubbard 7	Alcona	18	8.6	28.0	14.5	14.0	4.54	39
Hunter 1	Gladwin	16	8.0	16.0	12.4	12.3	2.35	41
Hutchins	Allegan	16	8.5	16.3	11.1	10.4	2.27	42
Indian	Kalamazoo	12	7.0	20.0	10.3	8.3	4.46	44
Indian	Osceola	18	17.0	27.0	22.1	21.5	3.08	33
Island	Grand Traverse	13	14.0	29.0	18.5	15.0	5.19	35
Island (Beach Area)	Ogemaw	18	12.5	22.2	16.3	15.5	3.15	37

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Island 1	Ogemaw	18	12.5	24.4	17.0	16.1	3.37	36
Jewell	Alcona	15	8.0	12.0	9.6	9.0	1.65	44
Juno	Cass	14	4.5	8.5	6.8	7.0	1.25	50
Keeler	Van Buren	10	2.0	10.5	6.4	7.0	2.93	50
Kirkwood	Oakland	19	2.6	8.0	4.5	4.3	1.31	56
Klinger	St. Joseph	17	6.5	20.5	11.6	11.5	4.52	42
Lake Margrethe 1	Crawford	19	12.0	30.0	16.7	14.0	5.90	36
Lake Nepessing	Lapeer	19	8.0	20.0	13.4	12.0	3.95	40
Lake of the Woods	Van Buren	11	6.0	21.0	11.2	9.0	4.85	42
Lakeville	Oakland	18	9.0	23.5	14.2	13.3	4.46	39
Lancelot 1	Gladwin	10	6.5	10.5	8.5	8.0	1.44	46
Lancelot 2	Gladwin	10	6.5	12.5	9.3	9.3	2.02	45
Lancelot 3	Gladwin	10	7.5	13.0	10.7	11.8	2.10	43
Lancer 1	Gladwin	10	6.0	8.0	7.2	7.0	0.79	49
Lancer 2	Gladwin	9	8.0	11.0	9.6	10.0	1.13	45
Lancer 3	Gladwin	9	7.0	10.0	8.5	9.0	1.00	46
Lancer 4	Gladwin	9	5.0	5.0	5.0	5.0	0.00	54
Lancer 5	Gladwin	9	5.0	7.0	5.8	6.0	0.67	52
Lansing	Ingham	19	4.5	11.3	7.9	7.8	2.01	47
Leelanau (North)	Leelanau	14	10.0	33.0	19.4	20.5	8.62	34
Leelanau (South)	Leelanau	13	5.6	26.0	14.9	14.4	7.85	38
Leisure	Shiawassee	17	5.3	14.2	10.7	11.3	2.32	43
Lily	Clare	16	7.0	9.0	8.0	8.1	0.77	47
Lime	Kent	13	6.0	14.6	11.0	11.0	2.33	43
Little Crooked	Van Buren	14	13.0	18.6	13.9	13.6	1.38	39
Little Fisher	St. Joseph	19	5.5	13.0	8.6	8.3	1.81	46
Little Paw Paw	Berrien	16	5.3	10.3	7.1	6.1	1.83	49
Little Pine Island 1	Kent	19	7.2	15.7	10.5	9.0	3.08	43
Little Pine Island 2	Kent	19	7.3	16.7	10.7	8.9	3.30	43
Little Twin	Cass	16	4.8	12.3	9.1	9.3	2.15	45
Long	Grand Traverse	19	20.0	55.0	30.8	25.0	10.99	28
Long	Iosco	13	9.4	19.0	11.2	10.6	2.43	42
Long	Montmorency	17	9.0	24.0	13.7	13.0	3.77	39

APPENDIX 1
2003 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Long(Sylvania)	Gogebic	15	11.0	14.0	12.5	13.0	0.92	41
Long(West)	Gogebic	15	11.0	14.0	12.5	13.0	0.99	41
Louise	Dickinson	14	10.0	22.0	15.1	15.0	2.96	38
Lower Hamlin	Mason	16	9.0	16.0	13.1	13.0	2.33	40
Magician	Cass	16	14.8	20.4	17.3	17.4	1.90	36
Marl 1	Genesee	15	8.0	15.5	10.8	10.0	2.23	43
Mary	Dickinson	14	11.0	22.0	15.3	15.0	3.09	38
Mecosta	Mecosta	10	8.0	18.5	12.4	11.5	3.49	41
Mill	Van Buren	12	12.0	17.0	14.4	14.0	1.52	39
Moon	Gogebic	16	14.0	26.0	19.8	20.0	3.85	34
Muskellunge 1	Montcalm	7	3.2	17.0				
Muskellunge 2	Montcalm	12	4.7	10.3	7.8	8.3	2.02	48
North	Alcona	18	12.0	26.0	18.0	18.0	3.25	35
Oneida	Livingston	13	7.5	11.8	9.2	9.5	1.21	45
Ore	Livingston	17	4.0	15.0	9.3	7.0	4.30	45
Orion	Oakland	9	10.0	16.0	12.9	12.0	2.10	40
Osterhout	Allegan	10	5.0	9.0	6.3	5.0	1.77	51
Oxbow	Oakland	10	11.0	22.0	14.8	14.5	3.58	38
Painter	Cass	14	4.0	6.5	5.4	5.3	0.97	53
Pentwater 1	Oceana	7	4.5	10.0				
Pentwater 2	Oceana	7	4.2	8.6				
Pentwater 4	Oceana	7	4.8	10.5				
Pentwater 5	Oceana	7	5.6	13.0				
Perch	Hillsdale	19	8.0	9.3	8.5	8.3	0.42	46
Pleasant	St. Joseph	13	9.5	15.0	11.9	11.0	1.69	41
Pleasant 1	Washtenaw	18	6.3	13.2	8.7	8.3	1.57	46
Pleasant 2	Washtenaw	18	6.4	12.6	8.6	8.2	1.48	46
Pleasant 1	Wexford	17	4.3	6.5	5.3	5.3	0.58	53
Ponemah	Genesee	19	6.3	13.3	9.4	9.2	2.24	45
Portage	Livingston	14	5.9	19.7	12.8	12.5	3.81	40
Pratt	Gladwin	18	6.0	25.3	15.2	9.4	8.60	38
Pretty	Mecosta	12	8.3	14.1	10.1	9.6	1.80	44
Puterbaugh	Cass	16	8.0	14.0	11.1	10.9	1.73	42
Randall	Branch	15	4.5	12.5	8.3	8.5	2.53	47

APPENDIX 1
2003 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Ranger	Otsego	12	15.0	20.0	17.3	17.0	1.51	36
Reeds	Kent	12	3.6	12.7	8.2	8.4	2.79	47
Reynolds (Lower)	Van Buren	6	10.5	13.0				
Reynolds (Upper)	Van Buren	6	9.0	18.0				
Robinson	Newaygo	19	6.0	12.0	9.0	9.0	1.94	45
Round	Clinton	15	7.5	14.0	9.9	9.5	1.60	44
Round	Lenawee	10	6.8	25.8	13.4	10.4	6.77	40
Round 1	Mecosta	10	8.0	19.0	14.2	15.3	3.27	39
Sage 1	Ogemaw	18	12.5	20.0	15.0	14.5	2.07	38
Sapphire	Missaukee	14	7.5	8.0	7.5	7.5	0.13	48
School Section 1	Mecosta	19	7.4	18.0	11.2	10.5	2.46	42
School Section 3	Mecosta	19	7.8	14.0	10.6	10.4	1.95	43
Sherwood	Oakland	16	11.0	14.0	12.7	13.0	0.83	41
Shingle	Clare	18	9.0	15.0	11.0	11.0	1.52	43
Silver	Grand Traverse	19	14.5	42.5	24.9	22.0	9.24	31
Silver	Livingston	19	10.0	21.0	13.7	12.5	3.01	39
Silver 1	Genesee	18	7.5	17.0	11.5	10.7	3.64	42
Silver 2	Genesee	18	7.5	17.0	11.4	10.8	3.54	42
Smallwood	Gladwin	19	5.0	11.5	7.2	7.0	2.02	49
Spider 1	Grand Traverse	17	11.0	33.0	19.1	15.0	7.93	35
Spider 2	Grand Traverse	17	11.0	29.0	17.5	14.0	6.47	36
Spider 3	Grand Traverse	17	9.0	27.0	17.1	15.0	6.43	36
Starvation	Kalkaska	9	18.0	25.7	22.2	22.0	2.69	32
Stone Ledge	Wexford	15	7.0	13.0	9.3	9.0	1.54	45
Strawberry	Livingston	18	4.3	11.2	8.1	8.6	2.00	47
Sylvan	Newaygo	14	8.0	27.0	12.5	11.0	5.03	41
Taylor	Oakland	18	16.0	18.0	17.3	17.0	0.59	36
Thurston Pond	Washtenaw	7	0.4	1.3				
Upper Hamlin	Mason	16	6.0	13.0	9.9	10.5	2.39	44
Van Etten	Iosco	8	3.5	5.0	4.4	4.5	0.52	56
Vaughn	Alcona	13	6.5	16.0	11.0	11.5	2.56	43
Viking	Otsego	19	10.0	14.0	12.1	13.0	1.45	41
Vineyard	Jackson	19	7.0	31.0	14.9	13.0	7.93	38
Wells	Osceola	19	12.0	20.0	16.2	16.5	2.19	37

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSI_{SD}
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
West Twin	Montmorency	19	9.5	13.0	11.0	11.0	1.07	43
White	Oakland	10	15.0	26.0	19.2	19.0	2.84	35
Wildwood 1	Cheboygan	12	4.0	9.6	7.7	8.2	1.79	48
Wildwood 2	Cheboygan	13	5.5	9.3	7.9	8.5	1.34	47
Windover	Clare	9	11.0	24.0	17.3	18.0	4.28	36
Woods	Kalamazoo	17	6.5	19.5	11.4	11.0	3.98	42
Zukey 1	Livingston	9	5.0	9.0	7.1	7.0	1.27	49

APPENDIX 2
2003 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)
ADA DAM	KENT	*				*				
ANN	BENZIE	6				8	6	9		34
ARBUTUS	GR. TRAVERSE	5				10				37
ARNOLD	CLARE	6				9				36
AVALON	MONTMORENCY	13		4 T		7		7		32
BALDWIN	CASS	12				*				
BALDWIN	MONTCALM	11				12	12			40
BARLOW	BARRY	10				7				32
BASS	KENT	7				11				39
BASS	LIVINGSTON	11				7				32
BEAR	KALKASKA	4 T				5				27
BIG	OSCEOLA	11				16				44
BIG BRADFORD	OTSEGO	16		11		9 d,e				36
BIG CROOKED	KENT	8				24				50
BIG CROOKED	VAN BUREN	*				7				32
BIG PINE ISLAND	KENT	15				*				
BILLS	NEWAYGO	4 T				8				34
BIRCH	CASS	7				9				36
BLUE	MASON	22				10	15			37
BLUE	MECOSTA	3 T				6				30
BOSTWICK	KENT	6				24				50
BRIGHTON	LIVINGSTON	33				40				57
BROOKS	NEWAYGO	25	25			32				54
BUCKHORN	OAKLAND	20				13				41
BURKHART	WASHTENAW	7				12	10	10		40
CASCADE DAM	KENT	50 a				*				
CEDAR	ALCONA/IOSCO	*				11				39
CEDAR	VAN BUREN	9				9				36
CENTER	OSCEOLA	7		9		9		10		36
CHAIN	IOSCO	15				12				40
CHEMUNG	LIVINGSTON	16				12				40
CHRISTIANA	CASS	23				16				44
CLEAR	BERRIEN	13		13		*				
CLIFFORD	MONTCALM	*				12				40
COREY	ST. JOSEPH	6				9				36

APPENDIX 2
2003 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l)								Carlson
		Spring Overturn				Late Summer				TSI$_{TP}$
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
COWAN	KENT	*				*		32	33	
CRANBERRY	KENT/OTTAWA	46				200 b				81
CROCKERY	OTTAWA	24				21 f				48
CROOKED	ALCONA	8				15				43
CROOKED	BARRY					*				
CROOKED	KALAMAZOO	18		16	15	9	9	10		36
CROOKED	LIVINGSTON	23				11				39
CRYSTAL	BENZIE	6				7				32
CRYSTAL	HILLSDALE	9				10				37
CRYSTAL	NEWAYGO	10				8				34
CUB	KALKASKA	3 T				6				30
DEER	ALGER	12				8				34
DERBY	MONTCALM	3 T	4 T			6	8			30
DEVILS	LENAWEE	7				*				
DIAMOND	CASS	9				7				32
DONNELL	CASS					*				
EAGLE	ALLEGAN	12				*				
EMERALD	NEWAYGO	*		11		9	9	7		36
EVANS	LENAWEE	10				11				39
FAIR	BARRY	9				10				37
FARWELL	JACKSON	6	9			*				
FENTON	GENESEE	10				9				36
FISH	LIVINGSTON	15				*				
FISH	VAN BUREN	11				12				40
FISHER	ST. JOSEPH	8				7				32
FISHER, LITTLE	ST. JOSEPH	9				12				40
FRESKA	KENT	16				10				37
GEORGE	CLARE	9				16				44
GILL	LIVINGSTON	20				12				40
GLEN, BIG	LEELANAU	4 T				3 T				<27
GLEN, LITTLE	LEELANAU	6				10				37
GOURDNECK	KALAMAZOO					*				
GRATIOT	KEWEENAU	*								
GRAVEL	VAN BUREN	7	7			11	14			39
GUNN	MASON	5				11				39

		Total Phosphorus (ug/l)								Carlson
Lake	County	Spring Overturn				Late Summer				TSI TP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
HAMBURG	LIVINGSTON	12				8	8			34
HAMILTON	DICKINSON	19				10				37
HAMLIN, LOWER	MASON	11				23				49
HAMLIN, UPPER	MASON	12				38				57
HARPER	LAKE	*				13				41
HESS	NEWAYGO	49				27	26	38	32	52
HICKS	OSCEOLA	17	17	22		19		22		47
HIGGINS	ROSCOMMON	10 b				*				
HIGH	KENT	16				13				41
HORSEHEAD	MECOSTA	*				*				
HOUGHTON	ROSCOMMON	14	14			17				45
HUBBARD	ALCONA	4 T				10				37
HUNTERS	ALCONA	14				13				41
HUTCHINS	ALLEGAN	16				16				44
INCHWAGH	LIVINGSTON	28				*				
INDIAN	KALAMAZOO	9	8	9		9		8		36
INDIAN	MONTCALM	14 b								
INDIAN	OSCEOLA	13	11	14	20	13				41
ISLAND	OGEMAW/IOSCO	11 c				11	11			39
ISLAND	GR. TRAVERSE	5				12				40
JEWELL	ALCONA					12				40
JORDAN	IONIA/BARRY					*				
JUNO	CASS	31				24				50
KEELER	VAN BUREN	12				63 nh				
KLINGER	ST. JOSEPH	*				10				37
LAKEVILLE	OAKLAND	12				10				37
LANCELOT	GLADWIN	20				28				52
LANCER	GLADWIN	16				16				44
LANSING	INGHAM	11				17				45
LILY	CLARE	19				18				46
LIME	KENT	120	119			10				37
LIMEKILN	LIVINGSTON	68				60				63
LITTLE CROOKED	VAN BUREN	*				11				39
L PINE ISLAND	KENT					*				
LONG	GOGEBIC	12	15			7	10			32

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSI$_{TP}$ (summer TP)
LONG	GR. TRAVERSE	4 T	4 T			5				27
LONG	IOSCO	8				8				34
LONG	MONTMORENCY	6		2 <		9		6	5	36
LOTUS	OAKLAND					*				
LOUISE	DICKINSON	16				9				36
MACEDAY	OAKLAND					*				
MAGICIAN	CASS	5	4 T	11		12				40
MARGRETHE	CRAWFORD	4 T				9				36
MARL	GENESEE	9				7				32
MARY	DICKINSON	26				9				36
MEADOW	OAKLAND					*				
MECOSTA	MECOSTA	5				10				37
MOON	GOGEBIC	9				5				27
MULLETT	CHEBOYGAN	10 b				*				
MURRAY	KENT	31				9				36
MUSKELLUNGE	MONTCALM	17	12	19	18	15				43
NEPESSING	LAPEER	18	14			19				47
NORTH	ALCONA	10				17				45
ONEIDA	LIVINGSTON	13				13				41
ORE	LIVINGSTON	20	17			12				40
ORION	OAKLAND	12				14		12	13	42
OSTERHOUT	ALLEGAN	13				18				46
OXBOW	OAKLAND	12				11				39
PAINTER	CASS	34				26				51
PARKE	OAKLAND	*								
PENTWATER	OCEANA	*				32				54
PERCH	HILLSDALE	12				16				44
PLEASANT	WASHTENAW	17				*				
PLEASANT	WEXFORD	13				24	20			50
PONEMAH	GENESEE	22	20	26						
PORTAGE	LIVINGSTON	19				13				41
PRETTY	MECOSTA	14				*				
PUTERBAUGH	CASS	*				9	7			36
RANDALL	BRANCH	*				31				54
RANGER	OTSEGO					11				39

APPENDIX 2
2003 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)
ROBINSON	NEWAYGO	38				16				44
ROUND	CLINTON	18		18		15	17	17		43
ROUND	LENAWEE	9				12				40
ROUND	MECOSTA	17				10				37
SAGE	OGEMAW	8				11				39
SANDY BOTTOM	LIVINGSTON	30				17				45
SANFORD	BENZIE					6				30
SAPPHIRE	MISSAUKEE	6				14				42
SCHOOL SEC.	MECOSTA	10				12				40
SHAN-GRI-LA	LIVINGSTON	13				11				39
SHINGLE	CLARE	19				11				39
SILVER	GENESEE	6				9				36
SILVER	GR. TRAVERSE	5				7		8		32
SILVER	LIVINGSTON	4 T	6			13				41
SMALLWOOD	GLADWIN	13	12			22	26			49
SPIDER	GR. TRAVERSE	5				10				37
STARVATION	KALKASKA	5				*				
STONE LEDGE	WEXFORD	20				18				46
STRAWBERRY	LIVINGSTON	17				*				
SYLVAN	NEWAYGO	*		14		8		9		34
TAYLOR	OAKLAND					12				40
THURSTON POND	WASHTENAW	93				410				91
TWIN - BIG	CASS	9				6				30
TWIN - LITTLE	CASS	13				10				37
TWIN, EAST	MONTMORENCY	*				16				44
TWIN, WEST	MONTMORENCY	*				*				
U. SHERWOOD	OAKLAND	28	34			44 a				
VAN ETTAN	IOSCO	*				40				57
VAUGHN	ALCONA	15				15				43
VIKING	OTSEGO	19	16			27				52
VINEYARD	JACKSON	14				8				34
WALLED	OAKLAND	*				*				
WELLS	OSCEOLA	12				11		11		39
WHITE	OAKLAND	7				12	12			40
WILDWOOD	CHEBOYGAN	*				14	14	15		42

APPENDIX 2
2003 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring Overturn				Late Summer				Carlson TSI$_{TP}$
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
WINDOVER	CLARE	7				10				37
WOODS	KALAMAZOO	21				16				44

* No lake sample received, or sample turned in too late to process.

T Value reported is less than limit of quantification (5 ug/l).

< Value is less than method detection limit (2 ug/l)

nh Non-homogeneous sample made analysis of sample questionable.

a Samples not collected by established procedures

b Samples arrived late, turned in with the following weeks samples

c Sample bottles cracked and leaking - water transferred to other bottles and turned in following week.

d Sample bottles over full.

e No labels on sample bottles.

f No field sheet received.

APPENDIX 3
2003 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
ADA DAM	KENT	*	*	*	*	*				
ANN	BENZIE	2.1	1.3	2.8	1.6	1.5	1.9	1.6	0.6	35
Vol/Rep						1.5				
MDEQ						1.6				
MDEQ/Rep						1.6				
ARBUTUS	GRAND TR.	1.5	1.1	3.0	2.1	3.0	2.1	2.1	0.9	38
ARNOLD	CLARE	1.7	1.2	2.2	2.4	2.9	2.1	2.2	0.7	38
AVALON	MONTMORENCY	*	*	1.0 a	4.0	1.4				
MDEQ						1.5				
MDEQ/Rep						1.5				
BALDWIN	MONTCALM	1.0 <	7.6	1.8	2.9	2.5	3.1	2.5	2.7	40
BARLOW	BARRY	3.5	*	3.5	1.9	2.6 a	2.9	3.05	0.8	42
BASS	KENT	*	5.3	3.7	3.3	2.5	3.7	3.5	1.2	43
BIG BRADFORD	OTSEGO	1.6	1.1	1.9	2.2	2.3	1.8	1.9	0.5	37
BIG LAKE	OSCEOLA	1.0 <	1.0 <	1.2	8.6	8.9 a	3.9	1.2	4.4	32
BIG PINE ISLAND	KENT	3.5	6.6	8.2	*	*				
Vol/Rep				4.8						
BILLS	NEWAYGO	6.0	3.4	2.0	*	2.6	3.5	3	1.8	41
BIRCH	CASS	2.3	1.4	*	*	*				
BLUE	MECOSTA	1.0 <	1.7	3.0	2.9	2.1	2.0	2.1	0.8	38
BOSTWICK	KENT	1.0 a	1.0 <,a	3.6 a	5.1	10.0	4.0	3.6	3.8	43
BROOKS	NEWAYGO	7.8	9.3	18.0	9.2	13.0 a	11.5	9.3	4.1	52
BURKHART	WASHTENAW	2.6	2.6	4.5	8.3	4.0	4.4	4	2.3	44
Vol/Rep						3.4				
MDEQ						4.7				
MDEQ/Rep						5.2				
CASCADE DAM	KENT	*	*	*	*	*				
CEDAR	ALCONA/IOSCO	1.5 a	*	3.7	7.1	5.3	4.4	4.5	2.4	45
Vol/Rep		1.0 <								
CEDAR	VAN BUREN	1.8	1.2	2.8	2.8	3.1	2.3	2.8	0.8	41
CHEMUNG	LIVINGSTON	1.0 <	4.5	1.5	1.7	1.6	2.0	1.6	1.5	35
Vol/Rep					3.1					
CHRISTIANA	CASS	2.9	2.8	5.7	4.8	9.2	5.1	4.8	2.6	46

APPENDIX 3
2003 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l)					Mean	Median	Std. Deviation	Carlson TSICHL
		May	June	July	Aug	Sept				
CLEAR	BERRIEN	*	*	*	*	*				
MDEQ			2.1							
MDEQ/Rep			2.1							
COREY	ST. JOSEPH	1.8	3.3	2.5	3.1	2.2	2.6	2.5	0.6	40
COWAN	KENT	1.2	4.2	12.0	*	*				
MDEQ						17.0				
MDEQ/Rep						19.0				
CRANBERRY	KENT/OTTAWA	*	*	22.0	97.0	41.0				
CROCKERY	OTTAWA	*	32.0	*	*	8.8				
CROOKED	ALCONA	2.4	2.9	8.1	4.4	3.1	4.2	3.1	2.3	42
CROOKED	KALAMAZOO	2.3	1.1 a	5.4	3.3	1.2	2.7	2.3	1.8	39
MDEQ						6.3				
MDEQ/Rep						6.5				
CROOKED	LIVINGSTON	*	*	3.6	*	4.4				
CROOKED, BIG	KENT	*	*	*	*	*				
CROOKED, BIG	VAN BUREN	7.4	1.8	3.7	2.6	3.0	3.7	3	2.2	41
CROOKED, LITTLE	VAN BUREN	2.2	2.3	5.8	6.5	5.1	4.4	5.1	2.0	47
CRYSTAL	BENZIE	1.0 <	1.0 <	1.0 <	1.0	1.0	<1.0	<1.0	0.3	<31
CRYSTAL	HILLSDALE	2.0	1.5	4.3	3.0	3.6	2.9	3	1.1	41
CRYSTAL	NEWAYGO	1.5	1.1	1.9	2.4	2.1	1.8	1.9	0.5	37
DEER	ALGER	1.0 <	1.5	3.1	4.9	4.1	2.8	3.1	1.8	42
Vol/Rep				3.5						
DERBY	MONTCALM	1.0	1.0 <	1.6	1.7	1.7	1.3	1.6	0.5	35
DEVILS	LENAWEE	1.0 <,a	1.0 <	5.9	2.8	3.5 a	2.6	2.8	2.3	41
DIAMOND	CASS	1.0 <	1.0 <	4.5	4.3	2.6	2.5	2.6	2.0	40
EAGLE	ALLEGAN	2.9	1.5	3.1	*	*				
MDEQ			1.8							
MDEQ/Rep			1.9							
EVANS	LENAWEE	1.0 <	2.9	1.6	3.5	6.6	3.0	2.9	2.3	41
FAIR	BARRY	1.8	2.9	4.7	3.7	5.7 a	3.8	3.7	1.5	43
FARWELL	JACKSON	*	*	*	*	*				
FENTON	GENESEE	1.5	1.2	1.0 <	1.5	1.5	1.2	1.5	0.4	35

Lake	County	Chlorophyll *a* (ug/l)							
		May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
FISH	LIVINGSTON	*	*	2.2	*	*				
FISH	VAN BUREN	*	15.0	7.2	6.7	64.0	23.2	11.1	27.4	54
Vol/Rep					6.7	65.0				
FISHER	ST. JOSEPH	1.5	2.4	2.5	2.0	2.5	2.2	2.4	0.4	39
Vol/Rep				2.5						
FISHER, LITTLE	ST. JOSEPH	2.2	4.6	2.0	2.6	2.7	2.8	2.6	1.0	40
FRESKA	KENT	3.6 a	4.3	9.9	8.4	8.5	6.9	8.4	2.8	51
GEORGE	CLARE	1.0 <	1.0 <	7.0	5.2	6.4	3.9	5.2	3.2	47
GLEN, BIG	LEELANAU	2.4	1.1	1.0	1.0 <	1.0 <	1.1	1	0.8	31
GLEN, LITTLE	LEELANAU	3.1	2.2	2.2	1.7	1.8	2.2	2.2	0.6	38
GUNN	MASON	2.4	3.2	5.0	2.4	3.8	3.4	3.2	1.1	42
HAMLIN, LOWER	MASON	1.9	1.6	5.4	5.1	4.5	3.7	4.5	1.8	45
HAMLIN, UPPER	MASON	2.7	4.0	6.8	9.1	12.0	6.9	6.8	3.8	49
HARPER	LAKE	*	2.4	2.4	2.3	2.3	2.4	2.35	0.1	39
HESS	NEWAYGO	5.6	3.2	11.0	3.8 a	5.9	5.9	5.6	3.1	47
MDEQ						8.5				
MDEQ/Rep						7.8				
HIGGINS	ROSCOMMON	1.0 <,a	1.0 <	1.0 <,a	*	*				
HIGH	KENT	2.4	3.8	2.7	4.5	5.9	3.9	3.8	1.4	44
HOUGHTON	ROSCOMMON	c,d	1.0 <,c	*	3.0	1.6				
MDEQ					2.4					
MDEQ/Rep					2.6					
HUBBARD	ALCONA	1.0 <	4.7	3.8	1.5	d	2.6	2.65	2.0	40
INCHWAGH	LIVINGSTON	*	*	9.1	*	*				
INDIAN	KALAMAZOO	1.3	2.7	1.6	1.9	2.5	2.0	1.9	0.6	37
MDEQ						2.6				
MDEQ/Rep						2.1				
INDIAN	OSCEOLA	1.0 <	1.0	2.3	8.3	4.5	3.3	2.3	3.2	39
Vol/Rep		1.4								
MDEQ		2.4								
MDEQ/Rep		2.5								
ISLAND	GRAND TR.	2.1	2.0	3.3 a	3.3	2.1	2.6	2.1	0.7	38

APPENDIX 3
2003 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
		Chlorophyll *a* (ug/l)								
JEWELL	ALCONA	2.5	3.3	4.0	3.4 a	4.0	3.4	3.4	0.6	43
JUNO	CASS	4.8	6.0	8.7	12.0	13.0	8.9	8.7	3.6	52
KEELER	VAN BUREN	3.6	2.6	5.1	11.0	5.1	5.5	5.1	3.3	47
KLINGER	ST. JOSEPH	2.4	1.4	2.5	3.9	2.8 a	2.6	2.5	0.9	40
LAKEVILLE	OAKLAND	1.0 <	2.0	2.2	2.3	3.0 a	2.0	2.2	0.9	38
LANCELOT	GLADWIN	1.3	3.0	2.9	3.6	4.4	3.0	3	1.1	41
LANCER	GLADWIN	2.1	6.2	4.5	4.2	3.2	4.0	4.2	1.5	45
LANSING	INGHAM	1.0 <	2.2	4.4	3.6	2.2	2.6	2.2	1.5	38
LILY	CLARE	*	2.1	2.1 a	2.2	1.0 <	1.7	2.1	0.8	38
LIMEKILN	LIVINGSTON	*	*	26.0	*	27.0				
LITTLE PINE ISLAND	KENT	*	*	*	*	*				
LONG	GRAND TR.	1.0 <	1.0	2.0	1.7	2.3	1.5	1.7	0.7	36
LONG	IOSCO	1.3	1.9	2.1	3.9	3.3	2.5	2.1	1.1	38
LONG	MONTMORENCY	1.0 <,a	1.0 <	1.0 <	1.0 <	1.0 <	<1.0	<1.0	0.0	<31
MARGRETHE	CRAWFORD	2.7	1.0 <	1.5	1.2	2.1	1.6	1.5	0.8	35
MECOSTA	MECOSTA	2.7 a	2.9	2.6	1.2	1.8	2.2	2.6	0.7	40
MOON	GOGEBIC	2.0 a	3.4	2.8	2.2	2.1	2.5	2.2	0.6	38
MULLETT	CHEBOYGAN	*	*	*	*	*				
MURRAY	KENT	*	*	*	*	*				
NEPESSING	LAPEER	1.2 a	1.3	2.6	4.9	3.9	2.8	2.6	1.6	40
NORTH	ALCONA	1.6	1.5	1.9	6.4	11.0	4.5	1.9	4.2	37
ORE	LIVINGSTON	1.3	1.1	2.0	5.8	2.2	2.5	2	1.9	37
ORION	OAKLAND	*	2.0	3.3	*	1.6				
MDEQ						2.1				
MDEQ/Rep						2.1				
OSTERHOUT	ALLEGAN	*	4.4	8.0	3.4	3.8 a	4.9	4.1	2.1	44
MDEQ			6.0							
MDEQ/Rep			5.5							
OXBOW	OAKLAND	1.7	2.3	2.5	*	1.0 <,a	1.9	2	0.7	37
Vol/Rep		1.7								
MDEQ		1.5								
MDEQ/Rep		1.7								
PAINTER	CASS	4.3	9.8	11.0	22.0	30.0	15.4	11	10.4	54
PENTWATER	OCEANA	3.2	4.0	14.0	29.0	17.0	13.4	14	10.6	56

Lake	County	Chlorophyll *a* (ug/l)					Mean	Median	Std. Deviation	Carlson TSI_{CHL}
		May	June	July	Aug	Sept				
PERCH	HILLSDALE	1.7	1.0 <	2.1	1.8	1.4	1.5	1.7	0.6	36
ROBINSON	NEWAYGO	13.0	6.4	12.0	6.2	3.5	8.2	6.4	4.1	49
Vol/Rep					5.9					
ROUND	CLINTON	3.8	3.5	5.8	5.2	4.1	4.5	4.1	1.0	44
MDEQ						4.9				
MDEQ/Rep						5.1				
ROUND	LENAWEE	4.4 a	1.0 <	4.8	3.5	3.1	3.3	3.5	1.7	43
ROUND	MECOSTA	6.4 a	1.7	2.9	4.8	3.4	3.8	3.4	1.8	43
SAGE	OGEMAW	1.1	2.3	2.3	2.0	4.2	2.4	2.3	1.1	39
SANDY BOTTOM	LIVINGSTON	*	*	2.7	*	2.4				
SAPPHIRE	MISSAUKEE	2.6 a	5.2	3.3	3.1	2.5	3.3	3.1	1.1	42
SCHOOL SECTION	MECOSTA	1.0 <	2.7	3.5	1.0 <	1.2	1.7	1.2	1.4	32
SHINGLE	CLARE	2.9	5.7	5.6	3.8	5.1	4.6	5.1	1.2	47
SILVER	GRAND TR.	1.0 <	1.1	2.0	1.5	1.6	1.3	1.5	0.6	35
MDEQ						2.1				
MDEQ/Rep						2.1				
SMALLWOOD	GLADWIN	5.7 c	1.3 c	5.6 c	1.0 <	3.4	3.4	3.4	2.3	43
Vol/Rep					1.6					
MDEQ					2.4					
MDEQ/Rep					2.7					
SPIDER	GRAND TR.	1.0 <	1.3	3.5	4.8	4.5	2.9	3.5	1.9	43
STARVATION	KALKASKA	*	3.3	3.4	1.8 b,c	*				
STONE LEDGE	WEXFORD	3.3	2.5	4.4	*	*				
STRAW-BERRY	LIVINGSTON	2.3	3.4	5.2	*	*				
TWIN, BIG	CASS	2.9	2.9	3.5	2.5	2.6	2.9	2.9	0.4	41
Vol/Rep			3.0							
TWIN, EAST	MONTMORENCY	*	2.5 c	5.5 c	4.0 c	3.6 c	3.9	3.8	1.2	44
TWIN, LITTLE	CASS	1.0 <	3.5	2.8	2.7	3.4 a	2.6	2.8	1.2	41
TWIN, WEST	MONTMORENCY	*	*	*	*	*				
VAN ETTAN	IOSCO	*	*	8.9 a	15.0	10.0				
VIKING	OTSEGO	12.0	8.7	4.5	13.0	8.0	9.2	8.7	3.4	52

APPENDIX 3
2003 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}
Vol/Rep			7.1							
VINEYARD	JACKSON	1.0 <	1.5	3.3	2.6	2.5	2.1	2.5	1.1	40
WALLED	OAKLAND	*	*	*	*	*				
WELLS	OSCEOLA	4.1	2.7	3.4	2.7 c	2.5	3.1	2.7	0.7	40
MDEQ		3.6				2.6				
MDEQ/Rep		3.9				2.8				
WHITE	OAKLAND	1.2	1.4	3.6	2.0	2.2	2.1	2	0.9	37
WINDOVER	CLARE	2.0	3.5	2.5	2.6	1.9	2.5	2.5	0.6	40
WOODS	KALAMAZOO	3.6	28.0	2.3	32.0	18.0	16.8	18	13.6	59

< Sample value is less than limit of quantification (1.0 ug/l).

* no sample received or sample turned in too late to process

a Sample not collected during the designated sampling period.

b No field sheets were turned in with the sample.

c Samples not wrapped in aluminum foil or very poorly wrapped in aluminum foil.

d No filter in vial, only blue separator sheet

APPENDIX 4
2003 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Benzie	Lake Ann
Cass	Big Twin Lake
	Little Twin Lake
Clare	Lake George
	Shingle Lake
	Windover Lake
Grand Traverse	Silver Lake
Kalamazoo	Crooked Lake
	Indian Lake
Kent	Bostwick Lake
	Cowan Lake
	Freska Lake
	High Lake
	Lime Lake
	Murray Lake
Lenawee	Devils Lake
	Round Lake
Livingston	Lake Chemung
	Strawberry Lake
Mason	Gunn Lake
	Hamlin Lake
Mecosta	Blue Lake
	Mecosta Lake
	Round Lake
Montcalm	Derby Lake
Newaygo	Crystal Lake
	Hess Lake
	Robinson Lake

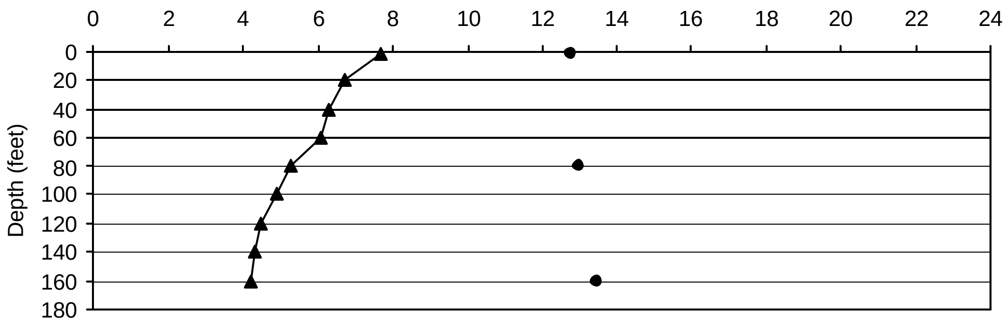
County	Participating Lakes
Oakland	Lake Orion Oxbow Lake
St. Joseph	Corey Lake Fisher Lake Little Fisher Lake
Van Buren	Cedar Lake

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 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 mesotrophic/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 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.

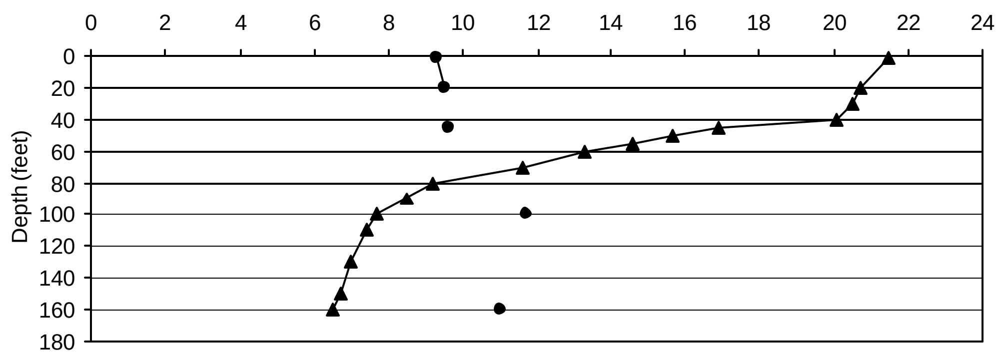
Oligotrophic Lake with a Very Large Volume Hypolimnion

Elk Lake in Grand Traverse 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.

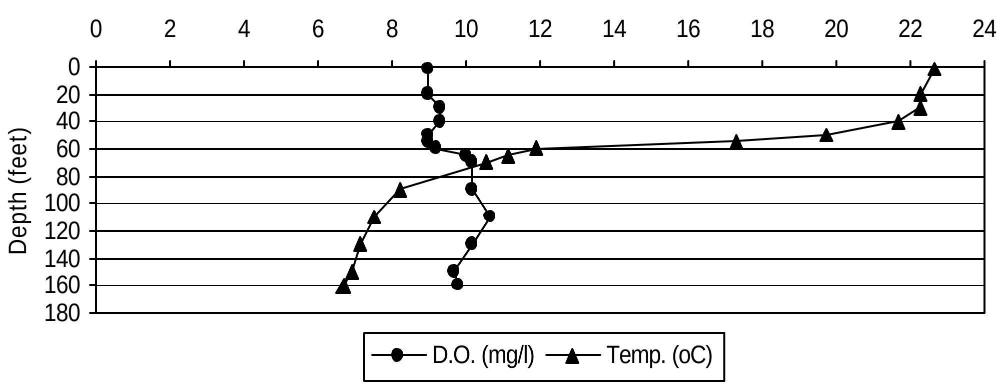
May 2, 1990



July 11, 1990



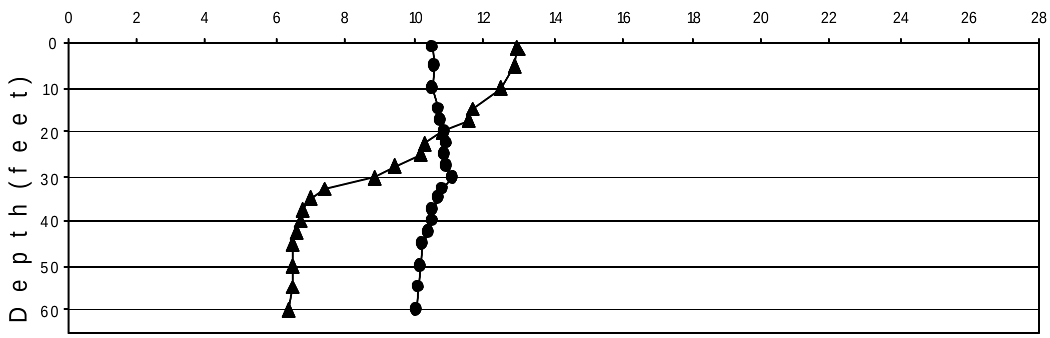
September 5, 1990



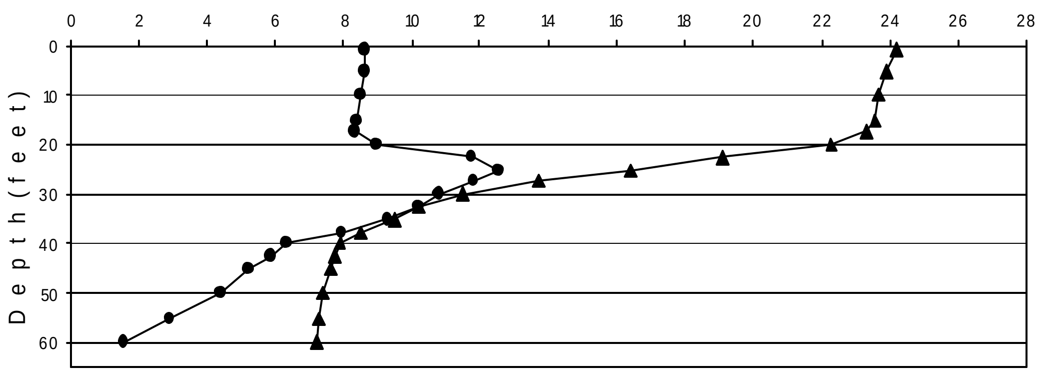
Oligotrophic/Mesotrophic Lake with a Large Volume Hypolimnion

Lake Ann in Benzie County is an oligotrophic/mesotrophic lake with a large hypolimnion. It produces minor 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 even into late summer (September). Also, note that oxygen concentrations at mid-depth (20 to 40 feet) are higher than at the surface. This is due to a layer of deep algae producing oxygen in the colder water, which can hold more dissolved oxygen.

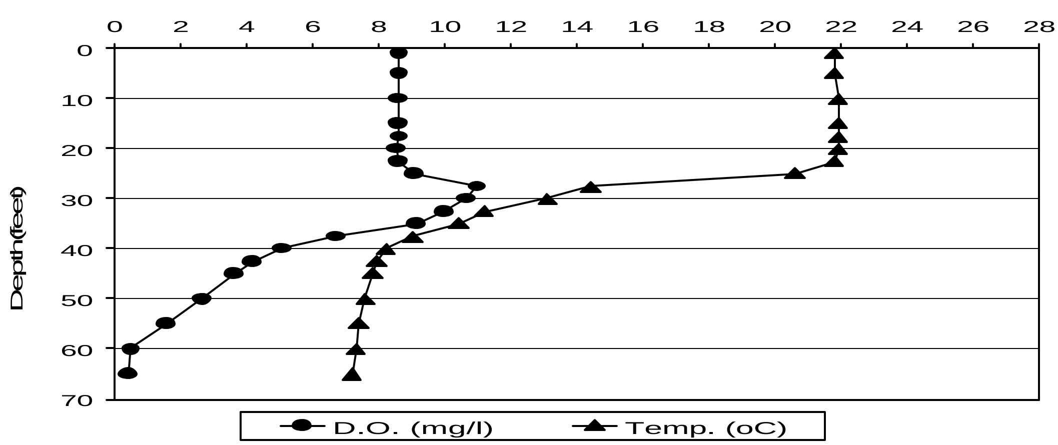
May 16, 2003



August 14, 2003



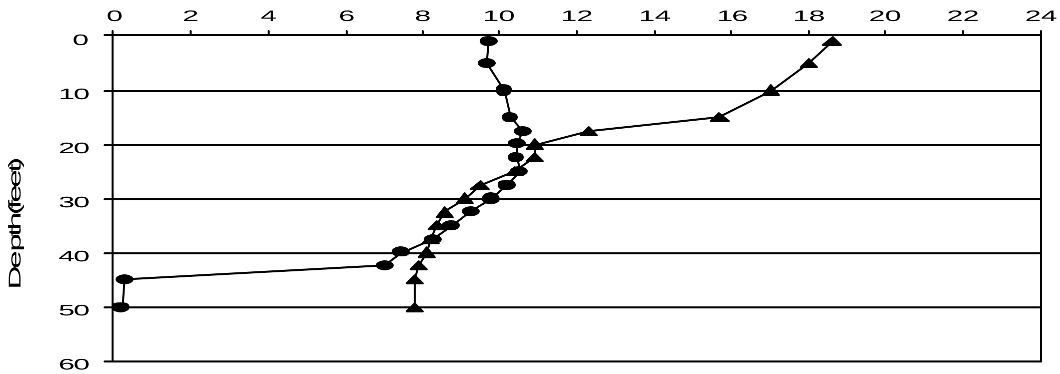
September 4, 2003



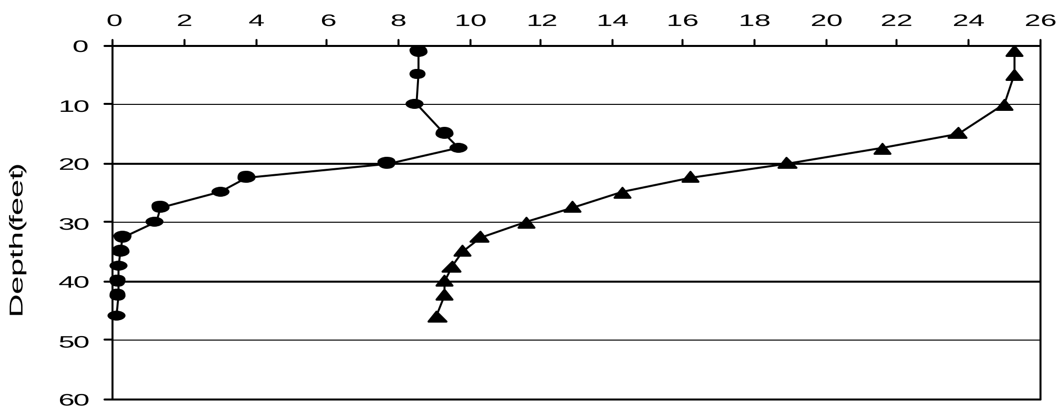
Oligotrophic/Mesotrophic Lake with a Small Volume Hypolimnion

Big Twin Lake in Cass County is an oligotrophic/mesotrophic lake with a small volume hypolimnion. As an oligotrophic/mesotrophic lake it produces minor 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 high in the hypolimnion into mid-summer, but by August oxygen is gone in the deepest waters, and by late-summer (September) the entire hypolimnion is without oxygen.

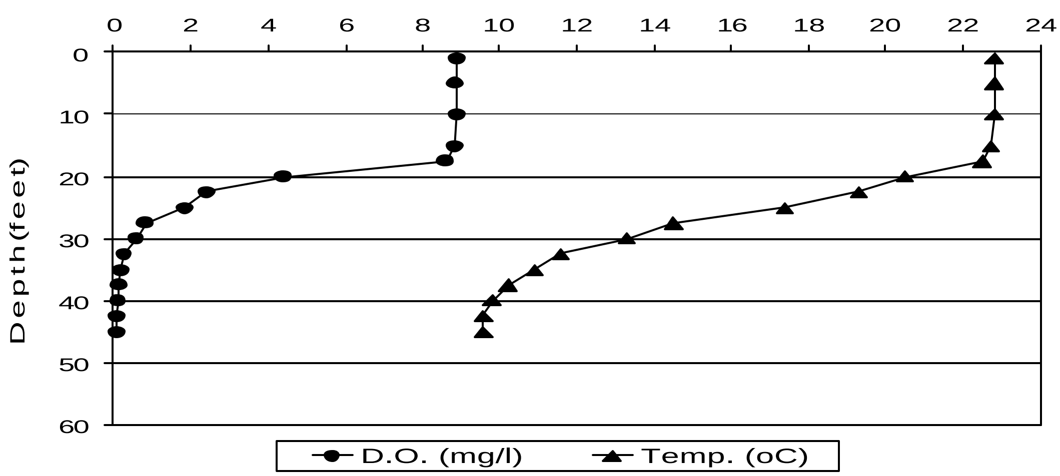
May 10, 2003



July 31, 2003

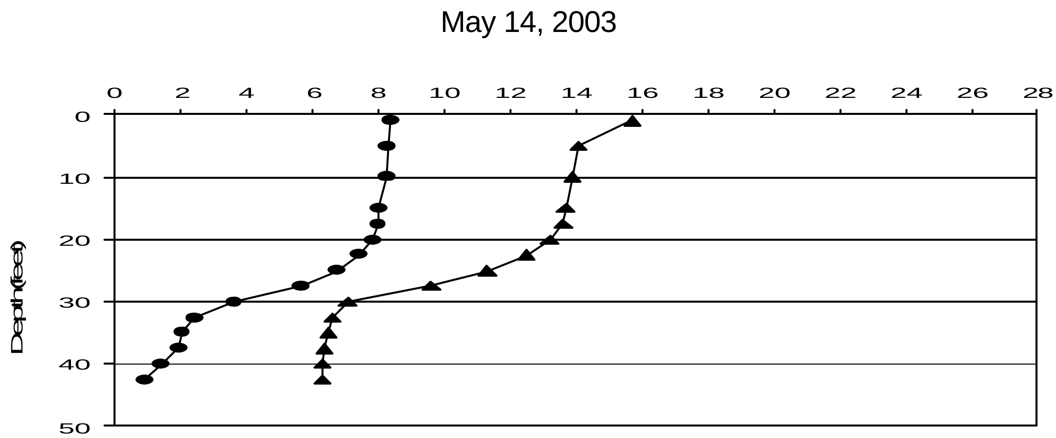


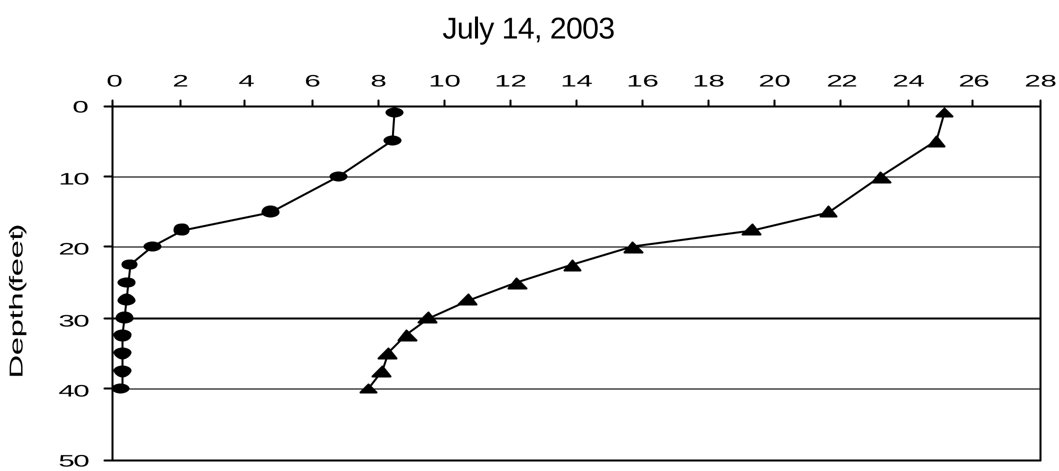
September 15, 2003

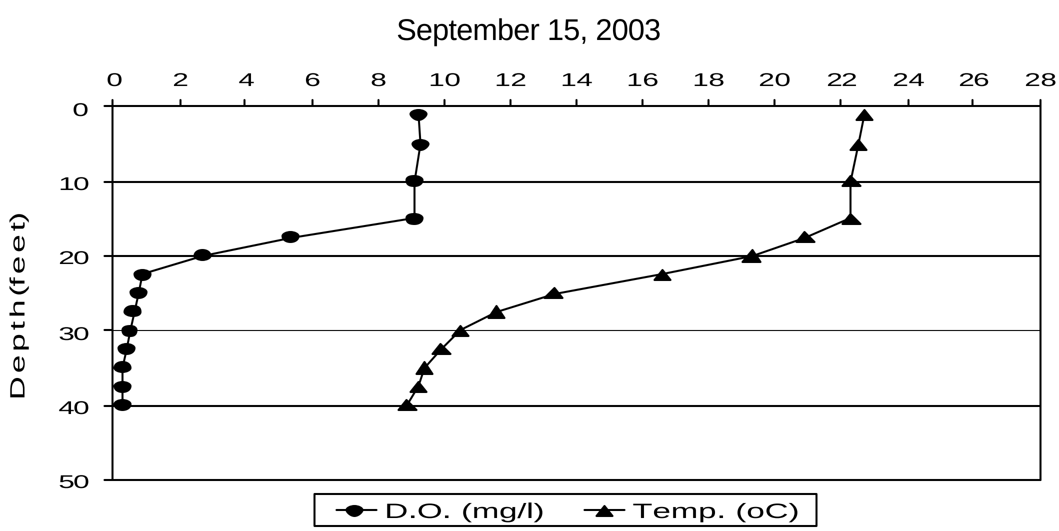


Mesotrophic/Eutrophic Lake with a Small Volume Hypolimnion

Strawberry Lake in Livingston County is a mesotrophic/eutrophic lake with a small volume hypolimnion. As a productive lake it produces abundant amounts of organic material that must be decomposed. Its hypolimnion has a small 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.



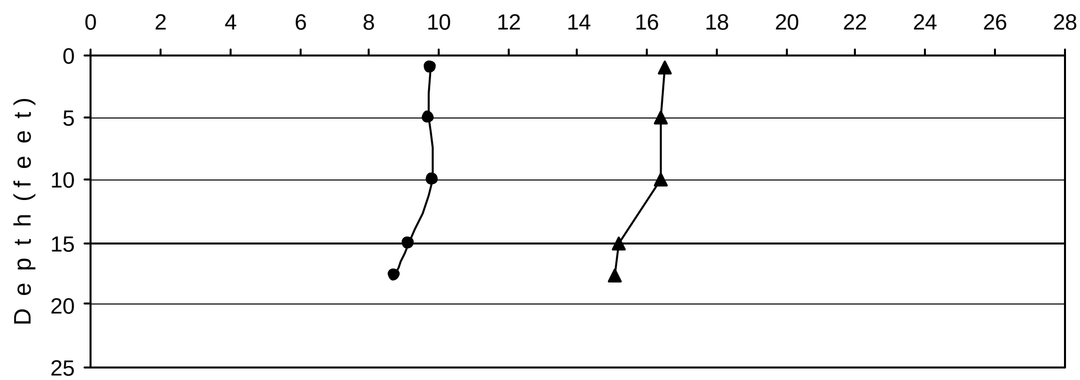




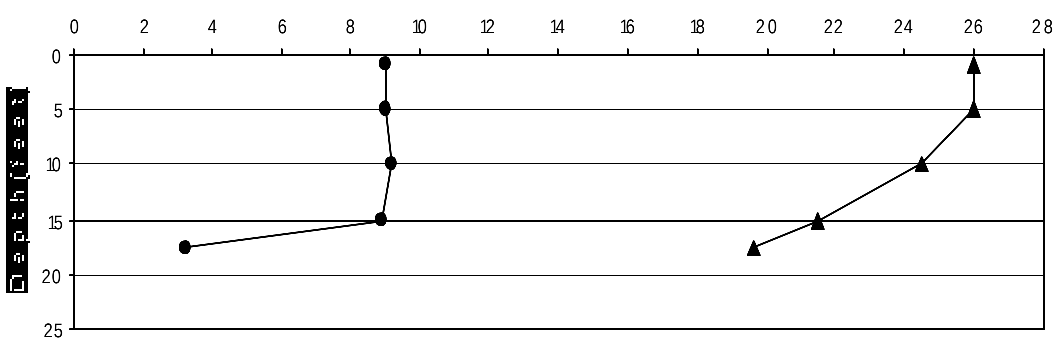
Shallow Mesotrophic Lake that does not Maintain Summer Stratification

Bostwick Lake in Kent County is a shallow mesotrophic lake with insufficient depth to maintain stratification all summer. As a mesotrophic lake it produces moderate amounts of organic material that must be decomposed. Its hypolimnion, if present, has a very 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 within a few weeks of spring overturn. 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.

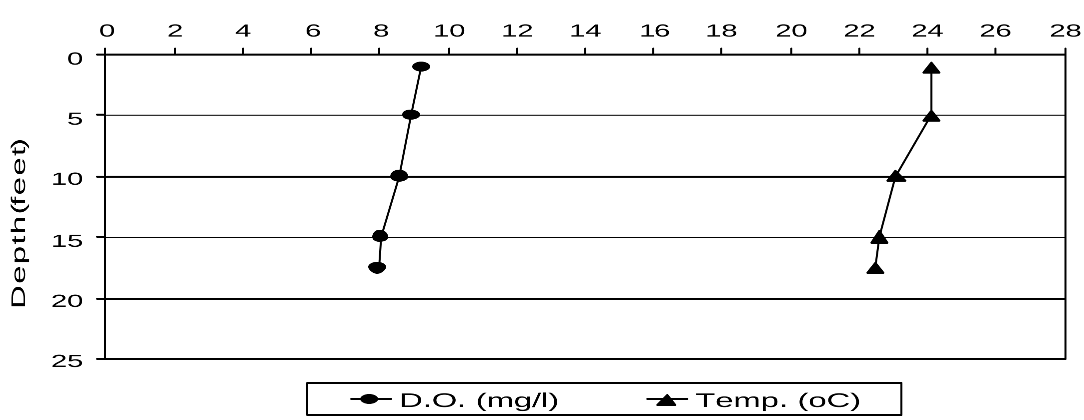
May 22, 2003



July 2, 2003



September 2, 2003



APPENDIX 5
2003 COOPERATIVE LAKES MONITORING PROGRAM
AQUATIC PLANT MONITORING EVALUATION

The results of the three surveys done on Windover Lake to evaluate the CLMP aquatic plant monitoring project are found in the table on the next page. All three surveys had similar results and had the following in common.

- Windover Lake has a highly diverse population of aquatic plants.
- No exotic species were reported.
- Stonewort was the most abundant plant and was present at nearly every sampling site.
- Three or four other submersed species were common, present in at least 30% of the sampling sites.
- Except for stonewort dense colonies of other submersed species were rare.
- White and yellow water lilies and arrowhead were identified as the common emergent plant species.

The citizen survey and professional limnologist survey results using CLMP sampling methods were remarkably similar. The DEQ survey results were similar to the two CLMP survey results but did differ in minor ways. These disparities are likely due to the difference in the DEQ and CLMP methods. The CLMP methods are rigid. Only plants collected on the sampling site transect are identified. The DEQ method allows the sampler to identify any plants seen in the sampling area.

The greater plant identification freedom of the DEQ method should result in more species being identified, particularly emergent species that are clearly visible, which was the case. The DEQ survey identified three emergent species, smartweed, pickerelweed, and iris and one submergent species, large-leaf pondweed not identified in either of the CLMP surveys.

The water quality data collected by the citizen samplers as part of the CLMP indicate that Windover Lake has conditions that border between oligotrophic and mesotrophic or low to moderate fertility. The plant community reflects this fertility level by being highly diverse and with all species, except stonewort being present in low to moderate levels.

The study of aquatic plant survey methods at Windover Lake suggest that:

- Citizen volunteers are capable of conducting good qualitative aquatic plant surveys if properly trained and provided limited professional assistance,
- Volunteer survey methods compare reasonably well with DEQ methods to qualify aquatic plant species, densities and distributions in a lake.

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

Table 1. Aquatic Plants found in Windover Lake, Clare County during three surveys in 2003.

DEQ Survey		Volunteer/Citizen Survey		Volunteer/Professional Survey	
Plants	Cumulative Cover	Plants	Lakewide Density	Plants	Lakewide Density
Stonewort	65.45	Stonewort	3.3	Stonewort	3.5
Wild celery	20.97	Wild celery	1.5	Wild celery	1.5
Illinois pondweed	13.70	Variable pondweed	0.8	Northern milfoil	0.7
Northern milfoil	6.48	Northern milfoil	0.7	Variable pondweed	0.6
White water lily	3.67	White water lily	0.4	White water lily	0.5
Flat-stem pondweed	3.48	Flat-stem pondweed	0.3	Yellow water lily	0.4
Arrowhead	3.30	Fern pondweed	0.3	Arrowhead	0.4
Pickerelweed	1.97	Waterweed	0.3	Naiad	0.4
Yellow water lily	1.55	Yellow water lily	0.2	Flat-stem pondweed	0.3
Cattail	1.06	Cattail	0.2	Bulrush	0.2
Thin-leaf pondweed	0.70	Arrowhead	0.2	Illinois pondweed	0.2
Fern pondweed	0.67	Bulrush	0.2	Coontail	0.2
Bulrush	0.48	Coontail	0.2	Thin-leaf pondweed	0.1
Smartweed	0.39	Thin-leaf pondweed	0.1	Cattail	0.1
Floating-leaf pondweed	0.18	Illinois pondweed	0.1	Waterweed	0.1
Rush	0.09	Floating-leaf pondweed	0.1	Lesser duckweed	0.1
Large-leaf pondweed	0.06	Naiad	0.1	Fern pondweed	0.0
Naiad	0.03	Bladderwort	0.1	Floating-leaf pondweed	0.0
Bladderwort	0.03	Rush	0.1	Rush	0.0
Iris	0.03				