COOPERATIVE LAKES MONITORING PROGRAM

Michigan's Citizen Volunteer
Lakes Monitoring Program

ANNUAL SUMMARY REPORT

2002

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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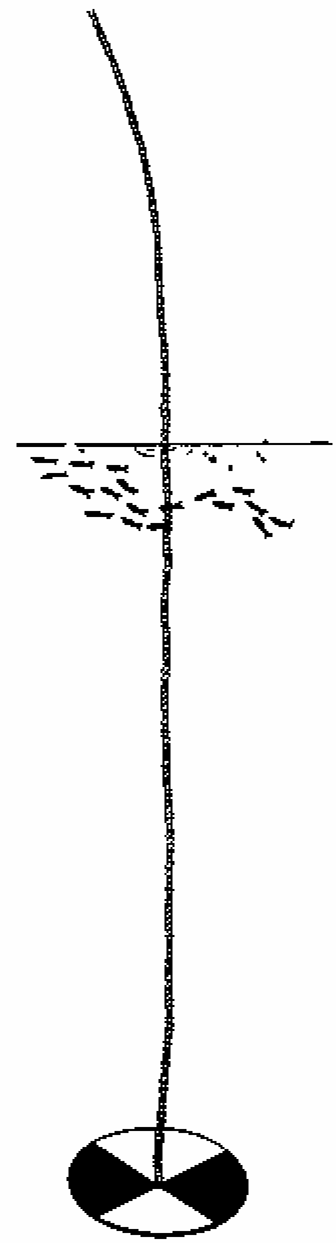

INTRODUCTION

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 man's 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

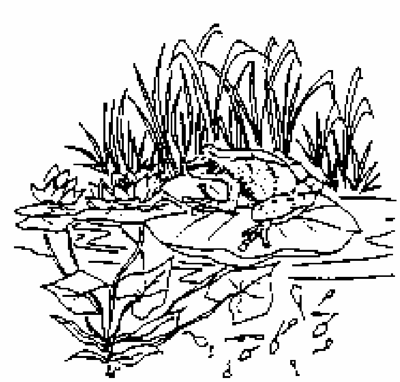
A lake's condition is influenced by many factors, such as the amount of recreational use it receives, shoreline development, and water quality. Lake *water quality* is a general term covering many aspects of lake chemistry and biology. The health of a lake is determined by its water quality.

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



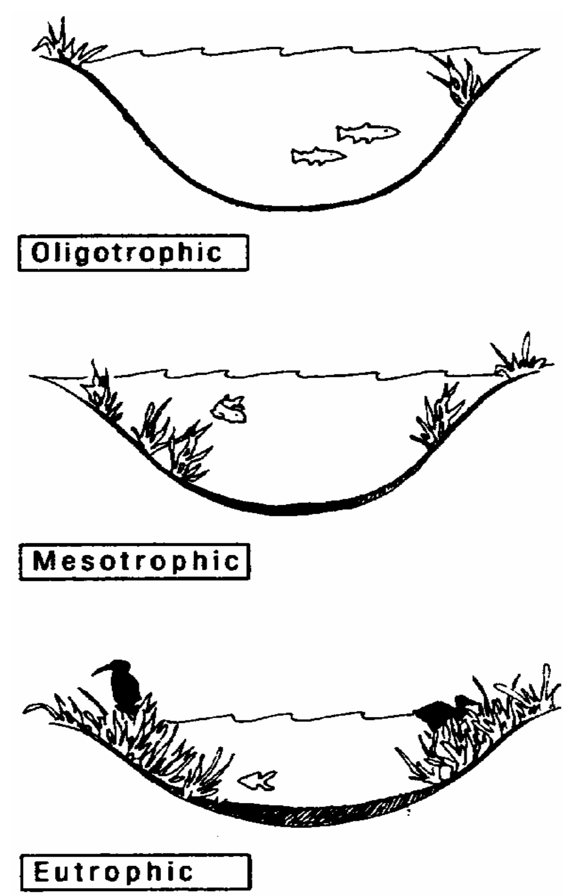
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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

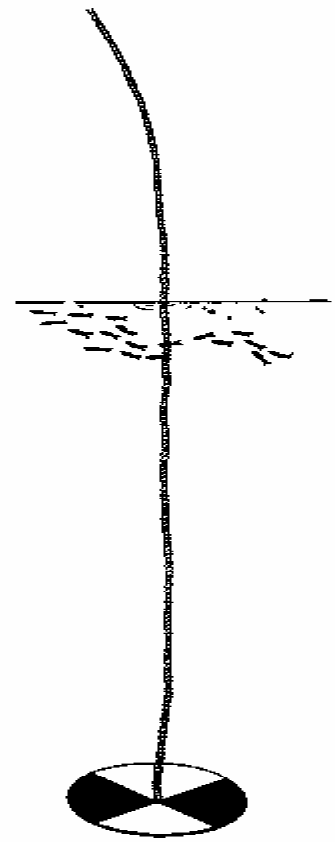
A lake's ability to support plant and animal life defines its level of productivity, or *trophic state.* Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved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

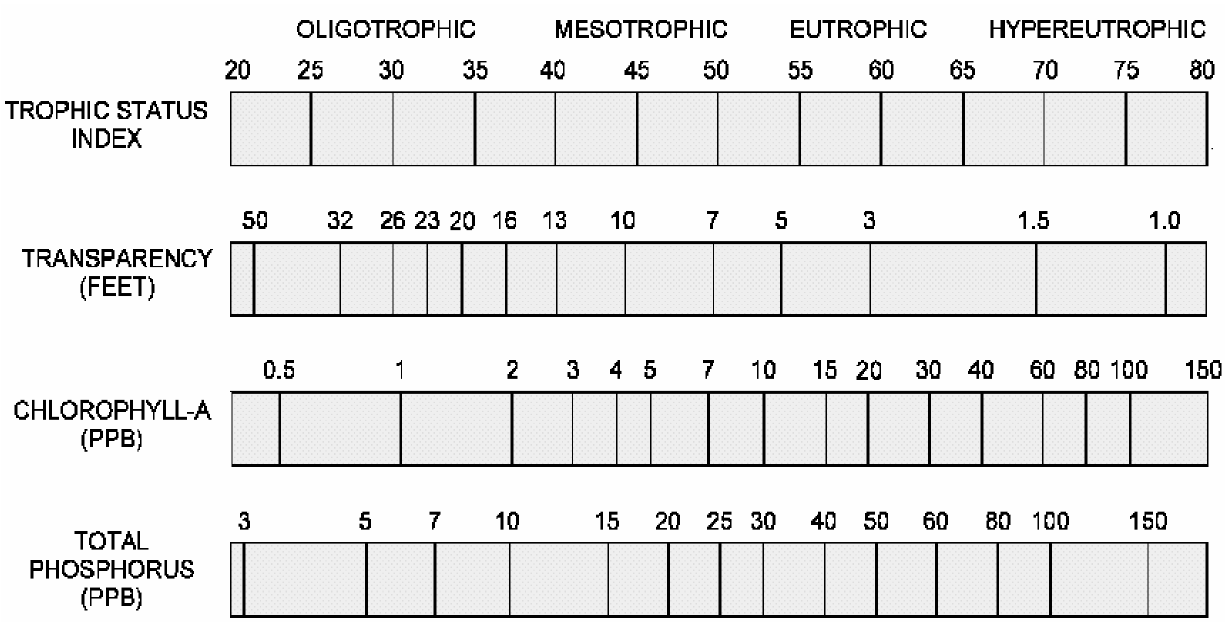
evaluate changes within the lake over time, and to estimate other water quality parameters within the lake.

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)

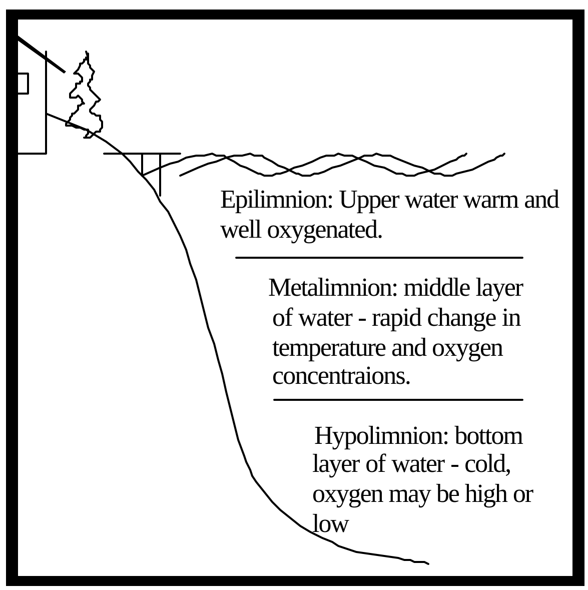
OTHER MEASURES OF LAKE PRODUCTIVITY

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.

Fish Age and Growth

The growth rate of fish should reflect the movement of energy and nutrients through the aquatic food web into a final culmination of growth in predator fish. Thus it is reasonable to expect that nutrient-poor lakes (oligotrophic) should have relatively slow growth rates for fish and that nutrient-rich lakes (eutrophic) should have relatively rapid growth rates for fish. The growth rate of fish can then be expected to follow and confirm those parameters that reflect Carlson's trophic indices, namely Secchi disk readings, summer phosphorus concentrations and chlorophyll *a* concentrations.

It is possible that some eutrophic lakes could have slow growth rates, especially in panfish such as bluegill or yellow perch. Given this situation, an interpretation could be that there is an over-population of the panfish. Thus the fish age and growth may also give insight to fish management needs for a given lake.

The age of fish can be determined by studying the scales of the fish. The scales have annual rings somewhat similar to the growth rings of trees. Scales can be removed without harm to a fish and the fish can be returned safely to the water. The length of the captured fish is measured to complete the growth rate analysis. Since the annual growth in length is proportional to the distance between the annual growth rings on the scales, it is possible to calculate the length of the fish at each year of its life. The

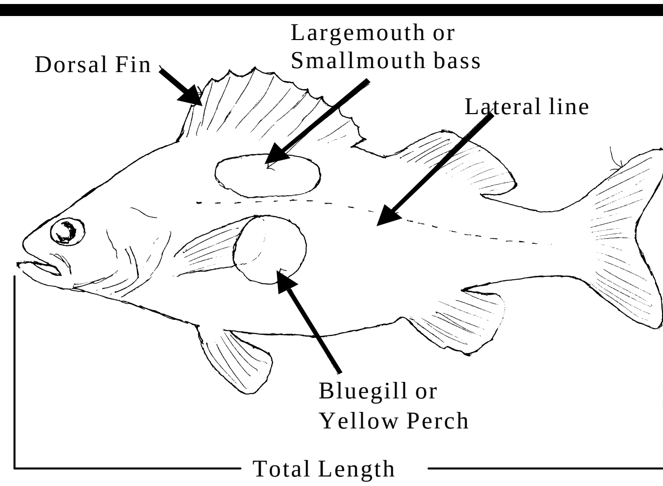


Figure shows where on the fish to collect the scales for analysis.

growth rate, once determined, can be compared to the average growth for that species for Michigan. Thus it can be determined if that species of fish, for a given lake, is growing faster, about the same, or slower than the average for Michigan lakes. To obtain a meaningful measure of fish growth it is best to study two species of fish; a panfish and a top predator. For most lakes these would be bluegill (or yellow perch) and largemouth bass (or smallmouth bass).

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 2002 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.

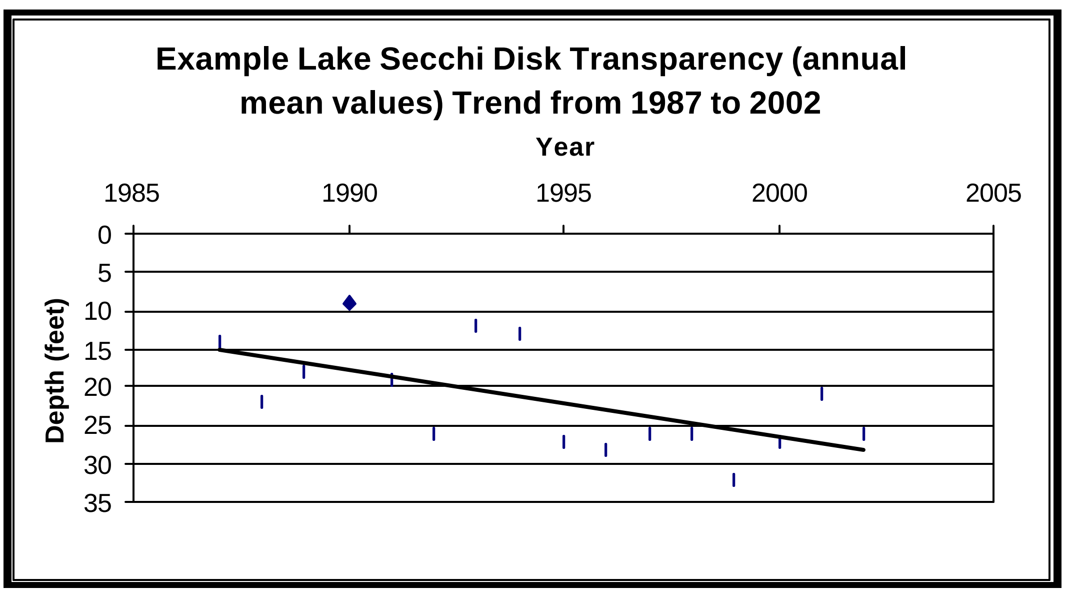
The TSI_{SD} values were calculated using Carlson's equations (see page 7) and the mean summer transparency values. (Note: the mean transparency value is converted from feet to meters for the TSI_{SD} calculation) The graphical relationship (see page 8) can be used to relate the TSI_{SD} value to the 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 2002, Secchi disk transparency data were reported for 179 lakes (235 basins). Over 3,500 transparency measurements were reported, ranging from 1.6 to 50 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 12.6 feet. The median value was 11.0 feet. The Carlson TSI_{SD} values ranged from 28 to 59 for these lakes with a mean value of 42. A Carlson TSI value of 42 is generally indicative of a good quality 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 produc-



tivity 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 2002 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 2002, samples for total phosphorus measurements were collected on 166 lakes. The spring overturn total phosphorus results ranged from <5 to 92 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 194 ug/l with 13 ug/l as the mean and 10 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 80 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).

[Please note that the 2002 late summer total phosphorus samples were analyzed at a commercial laboratory rather than the DEQ laboratory and the results may not be directly comparable to historical CLMP data.]

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. Chlorophyll samples were collected on 104 lakes in 2002. For each lake, the volunteers were asked to collect and process five sets of chlorophyll *a* samples, one set per month from May through September.

Results from the chlorophyll monitoring for 2002 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 580 chlorophyll samples were collected and processed in 2002. The chlorophyll *a* levels ranged from <1 to 52 ug/l over the five-month sampling period. The overall mean (average) was 4.7 ug/l and the median was 3 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 67 with a mean value of 42. A Carlson TSI value of 42 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 2002, CLMP participants in the dissolved oxygen/temperature project sampled 49 lakes. A total of 385 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 2002 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

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.

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 2002, CLMP participants in a pilot project sampled 2 lakes for aquatic plants. The lakes involved in the pilot project are identified in Appendix 5. The results of aquatic plant sampling varies depending upon the size, depth, volume and productivity of the lake sampled. Because of these 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. Instead of individual results, a representative data sheet is illustrated in Appendix 5 for one of the lakes. Both lakes in the 2002 pilot project were similar in productivity, with TSI values in the 30's and low 40's. Both lakes had only limited plant populations, one had Eurasian milfoil in small patches scattered about the lake. Both lakes had extensive shallow water areas, which under appropriate conditions could be colonized by exotic species.

Fish Age and Growth

One lake participated in the CLMP's fish age and growth pilot project. Scales were collected from largemouth bass and bluegill. The scales were analyzed by fish biologist, Mr. Steve Hanson to determine the size and age of the fish at capture. From these data a growth pattern was constructed for the bass and bluegill population. The results of these analyses are in Appendix 6.

The participating lake may be an oligotrophic lake (Carlson indices for 2001 CLMP were 36 for Secchi disk and 27 for phosphorus) with less than average fish growth. A comparison of largemouth bass and bluegill to Michigan's state averages suggests slower growth than the state averages. This condition may result from the low nutrient supply and resulting low plant and animal production.

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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ACKNOWLEDGMENTS

Ralph Bednarz of the Michigan Department of Environmental Quality, Water Division, and Howard Wandell from Michigan State University Department of Fisheries and Wildlife prepared this report. Brian Carley, Steve Hanson, Bruce Bonnell and volunteer samplers compiled data. Ralph Bednarz, along with Donald Winne and Pearl Bonnell of the Michigan Lake and Stream Associations, Inc., coordinate the CLMP.

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.

APPENDIXES

Appendix 1

2002 Secchi Disk Transparency Results

Appendix 2

2002 Total Phosphorus Results

Appendix 3

2002 Chlorophyll Results

Appendix 4

2002 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2002 Aquatic Plant Mapping Participating Lakes and Example Results

Appendix 6

2002 Fish Age and Growth Results

APPENDIX 1
2002 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)
Ada Impoundment	Kent	7	2.7	3.7				
Ann	Benzie	17	8.0	22.0	17.0	18.0	4.11	36
Arbutus 1	Grand Traverse	18	11.0	13.0	12.6	13.0	0.70	41
Arbutus 2	Grand Traverse	18	13.0	31.0	20.1	18.5	5.66	34
Arbutus 3	Grand Traverse	18	12.0	30.0	18.8	18.0	5.52	35
Arbutus 4	Grand Traverse	18	12.0	29.0	18.4	17.0	5.12	35
Arbutus 5	Grand Traverse	18	10.0	20.0	15.9	17.0	2.97	37
Arnold	Clare	16	13.0	28.0	17.9	17.0	3.82	35
Austin	Osceola	19	8.0	12.5	10.3	10.5	1.31	43
Avalon	Montmorency	15	17.0	42.0	28.4	26.0	8.63	29
Baldwin	Montcalm	18	7.0	17.0	11.7	12.0	3.27	42
Baldwin 1	Cass	14	10.6	20.3	14.2	12.3	3.63	39
Baldwin 2	Cass	14	12.0	17.8	14.3	14.3	1.77	39
Baldwin 3	Cass	14	10.3	25.7	15.0	13.6	4.41	38
Baldwin 4	Cass	14	9.0	20.0	13.2	12.2	3.47	40
Barlow	Barry	15	6.0	15.5	10.0	10.5	2.62	44
Baseline	Livingston	18	9.0	20.0	13.4	13.0	3.37	40
Bass	Livingston	9	7.0	15.0	10.1	10.0	2.76	44
Bear	Manistee	13	7.5	18.6	9.7	9.0	2.89	44
Bear 1	Kalkaska	15	26.0	38.0	29.7	29.0	3.27	28
Bear 2	Kalkaska	15	26.5	36.0	29.6	28.5	2.86	28
Beaton	Gogebic	7	8.5	19.0				
Beaver	Alpena	18	8.3	13.0	10.7	10.3	1.51	43
Big	Osceola	17	7.0	20.0	11.4	10.5	3.05	42
Big Bradford	Otsego	14	14.0	21.0	16.8	17.0	1.71	36
Big Crooked Lake	Kent	7	10.0	15.2				
Big Platte	Benzie	19	4.0	17.0	13.2	14.0	3.89	40
Big Twin North	Cass	16	10.0	29.0	18.5	17.3	6.64	35
Bills 1	Newaygo	17	8.0	17.5	12.4	12.0	3.48	41
Bills 2	Newaygo	15	7.0	20.0	13.0	12.0	4.34	40
Birch	Cass	19	14.0	31.0	20.5	17.0	6.16	34
Blue	Mason	14	20.0	34.5	27.5	28.3	4.35	29
Blue 1	Mecosta	18	8.0	22.0	12.3	10.0	4.60	41
Blue 2	Mecosta	18	8.0	23.0	12.2	10.0	4.72	41

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Blue 3	Mecosta	9	7.0	13.0	9.9	10.0	1.88	44
Bostwick	Kent	9	6.0	18.0	12.7	13.0	4.27	40
Brighton	Livingston	9	2.0	8.3	4.7	3.8	2.22	55
Brooks	Newaygo	15	2.5	8.0	4.0	3.5	1.61	57
Buckhorn (North)	Oakland	4	10.5	12.0				
Burkhart	Washtenaw	19	10.5	18.2	14.5	15.1	2.25	39
Byram 1	Genesee	19	7.0	17.0	10.7	10.0	2.45	43
Byram 2	Genesee	19	7.0	14.0	10.4	10.0	1.98	43
Byram 3	Genesee	19	7.0	14.0	10.3	10.0	1.82	44
Camp	Kent	18	12.5	17.0	15.2	15.0	1.24	38
Campau	Kent	19	6.0	11.0	8.5	8.0	1.65	46
Cedar	Van Buren	19	9.5	30.5	16.1	16.0	4.56	37
Cedar (BriarwoodBay)	Alcona\Iosco	14	9.1	12.7	10.8	10.8	1.17	43
Cedar (Schmidt's Pt.)	Alcona\Iosco	14	3.4	8.6	6.3	6.7	1.62	51
Center	Osceola	8	12.0	18.5	16.1	16.3	2.35	37
Chain	Iosco	16	11.0	13.0	12.3	12.0	0.60	41
Chemung	Livingston	12	10.0	15.0	12.3	12.5	1.54	41
Christiana	Cass	16	5.0	14.5	8.4	7.5	2.97	46
Clear	Berrien	16	8.0	13.5	10.8	10.8	1.86	43
Clear	Jackson	12	7.0	9.5	8.5	8.3	0.75	46
Clear	St. Joseph	7	11.0	17.5				
Clifford 1	Montcalm	19	14.0	24.0	16.7	16.0	2.31	37
Clifford 2	Montcalm	19	12.0	21.0	14.7	14.0	2.11	38
Coldwater	Branch	13	4.5	14.0	8.3	6.0	3.56	47
Coon (M)	Livingston	19	5.0	7.0	5.9	5.8	0.52	51
Coon (N)	Livingston	19	5.0	7.5	6.1	6.0	0.78	51
Coon (S)	Livingston	19	5.5	7.5	6.6	6.5	0.59	50
Corey	St. Joseph	17	7.5	20.0	12.1	10.5	3.95	41
Cowan	Kent	19	3.0	12.5	6.3	6.0	2.52	51
Cranberry	Kent	9	1.6	12.0	5.4	3.3	4.05	53
Crooked	Alcona	19	16.0	28.0	20.2	19.0	4.30	34
Crooked (Big)	Van Buren	19	12.0	16.7	14.6	14.3	1.31	38
Crooked (East)	Livingston	19	7.0	13.0	9.8	9.0	1.95	44
Crooked (West)	Livingston	18	6.0	10.0	7.4	7.5	1.36	48

APPENDIX 1
2002 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)
Crystal	Benzie	5	22.0	27.0				
Crystal	Hillsdale	19	11.5	18.0	13.2	13.0	1.57	40
Crystal	Newaygo	12	13.0	36.0	24.0	24.5	7.54	31
Cub	Kalkaska	18	17.0	21.0	19.3	19.5	1.46	34
Deer	Alger	8	7.0	10.5	8.1	7.5	1.36	47
Derby	Montcalm	17	13.0	23.0	17.2	17.0	2.44	36
Devils	Lenawee	8	7.0	24.0	12.8	11.0	5.93	40
Diamond	Cass	19	5.0	25.0	12.0	11.0	5.65	41
Donnell	Cass	5	6.0	18.0				
Eagle	Allegan/Van Buren	18	13.5	17.0	15.7	16.0	0.91	37
East Twin	Montmorency	17	7.0	15.5	10.8	11.0	1.65	43
Emerald	Newaygo	18	10.0	21.0	15.8	16.5	2.97	37
Evans	Lenawee	17	12.0	31.5	20.0	18.0	5.52	34
Fair	Barry	16	8.1	14.2	11.0	10.8	1.72	42
Farwell	Jackson	19	9.0	21.0	13.3	11.5	4.35	40
Fenton	Genesee	5	13.0	15.5				
Fish	Van Buren	19	6.0	13.0	9.1	9.0	1.79	45
Fisher	St. Joseph	19	8.0	31.8	17.0	13.5	8.86	36
Freska	Kent	15	6.5	16.0	9.6	9.0	2.50	44
Gill/Gut	Livingston	14	11.7	14.5	13.0	12.8	0.78	40
Glen (Big)	Leelanau	14	14.0	23.0	17.2	16.5	2.85	36
Gourdneck	Kalamazoo	19	5.0	24.0	12.6	13.0	5.37	41
Gratiot	Keweenaw	16	15.7	23.8	18.9	18.5	2.14	35
Green 1	Oakland	16	9.0	21.0	13.4	12.8	3.57	40
Green 2	Oakland	16	9.0	23.0	15.5	14.5	3.90	38
Green 3	Oakland	16	9.0	22.0	15.3	14.0	3.54	38
Green 4	Oakland	15	9.0	24.0	15.4	15.0	3.71	38
Gulliver	Schoolcraft	18	10.2	13.2	11.8	11.9	1.03	42
Gunn	Mason	19	11.0	20.0	15.8	15.5	2.78	37
Hamburg	Livingston	19	12.6	20.5	15.5	14.5	2.39	38
Harper	Lake	18	13.0	21.0	16.7	17.0	1.96	37
Hess	Newaygo	18	2.0	6.0	3.5	3.0	1.25	59
High	Kent	8	9.6	15.5	12.3	12.0	2.52	41
Horsehead	Mecosta	18	9.5	16.2	11.7	11.0	1.67	42

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI$_{SD}$ (transparency)
Hubbard 1	Alcona	12	10.0	30.0	18.6	18.5	6.14	35
Hubbard 2	Alcona	12	12.0	31.0	19.8	18.5	5.59	34
Hubbard 3	Alcona	12	14.0	30.0	20.6	20.0	4.44	34
Hubbard 4	Alcona	12	12.0	27.0	20.5	19.8	4.87	34
Hubbard 5	Alcona	12	13.0	28.0	20.8	22.0	4.74	33
Hubbard 6	Alcona	18	13.0	31.0	20.9	19.5	5.67	33
Hubbard 7	Alcona	12	11.0	29.0	18.9	18.0	6.07	35
Hunter 1	Gladwin	18	9.5	15.0	11.7	11.0	1.39	42
Hunter 2	Gladwin	18	10.0	15.0	12.0	12.0	1.61	41
Hunter's 1	Alcona	13	12.5	17.5	14.9	15.0	1.69	38
Hunter's 2	Alcona	13	12.0	15.5	13.9	14.0	1.08	39
Hutchins	Allegan	18	6.0	15.0	10.4	10.1	1.85	43
Indian	Kalamazoo	13	8.0	27.0	15.0	12.0	6.96	38
Indian	Montcalm	17	6.0	14.0	9.5	9.0	2.27	45
Indian 1	Osceola	17	17.0	27.0	23.1	24.0	2.93	32
Indian 2	Osceola	17	15.0	26.0	22.5	23.0	2.70	32
Island	Grand Traverse	14	14.0	28.0	20.0	18.5	4.74	34
Jewell	Alcona	14	8.5	12.0	9.8	9.5	1.07	44
Jordan	Barry	19	3.6	11.4	6.0	5.4	2.18	51
Juno	Cass	16	4.5	12.0	7.4	6.8	2.04	48
Keeler	Van Buren	9	9.0	11.0	10.1	10.5	0.65	44
Klinger	St. Joseph	18	4.5	26.0	12.8	8.3	8.06	40
Lake George	Clare	19	6.0	14.0	8.9	8.5	1.97	46
Lake Margrethe 1	Crawford	18	12.0	30.0	16.8	14.0	4.60	36
Lake Mud\Yellow R.	Genesee	19	3.0	6.5	4.7	4.5	1.00	55
Lake Nepessing	Lapeer	19	7.0	16.0	12.0	12.0	2.43	41
Lake of the Woods	Van Buren	14	7.0	13.5	9.6	10.0	1.88	44
Lakeville	Oakland	19	11.0	29.0	19.1	21.0	6.48	35
Lancelot 1	Gladwin	10	4.0	13.0	8.5	8.5	3.10	46
Lancelot 2	Gladwin	10	4.0	14.0	8.9	9.3	3.42	46
Lancelot 3	Gladwin	10	6.0	15.0	10.7	9.8	3.37	43
Lancer 1	Gladwin	8	6.0	8.0	6.8	6.5	0.89	50
Lancer 2	Gladwin	8	6.0	13.0	10.1	11.0	2.42	44
Lancer 3	Gladwin	8	6.0	8.0	6.9	6.5	0.99	49

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSISD
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
Lancer 4	Gladwin	8	4.0	6.0	5.3	5.0	0.71	53
Lancer 5	Gladwin	8	4.0	7.0	5.6	6.0	0.92	52
Lansing	Ingham	19	8.2	12.4	10.0	9.9	1.10	44
Leelanau (North)	Leelanau	12	8.0	28.0	17.8	18.0	6.74	36
Leisure	Shiawassee	15	5.2	13.4	9.2	8.3	2.84	45
Lily	Clare	12	7.0	11.5	9.9	10.8	1.58	44
Lime	Kent	16	9.5	16.5	13.3	13.5	1.91	40
Little Bradford 1	Otsego	19	13.0	14.0	13.5	14.0	0.51	40
Little Crooked	Cass	12	12.7	20.4	16.8	16.9	2.54	36
Little Fisher	St. Joseph	19	7.0	13.5	10.2	10.5	1.90	44
Little Glen	Leelanau	17	3.5	7.0	5.4	5.5	0.93	53
Little Paw Paw	Berrien	15	4.9	8.5	7.0	7.1	0.91	49
Little Pine Island 1	Kent	19	7.1	15.0	10.1	10.2	2.19	44
Little Pine Island 2	Kent	19	7.3	13.1	10.1	10.8	2.10	44
Little Twin	Cass	14	3.2	17.3	10.9	11.0	4.31	43
Long	Branch	13	4.5	8.5	6.4	7.0	1.26	50
Long	Grand Traverse	18	20.0	46.0	29.4	29.0	7.38	28
Long	Iosco	5	10.0	14.0				
Long(Sylvania)	Gogebic	18	11.0	15.0	12.3	12.0	0.91	41
Long(West)	Gogebic	18	11.0	14.0	12.3	12.0	0.89	41
Lower Hamlin	Mason	18	7.5	16.0	11.6	11.0	2.28	42
Marl 1	Genesee	13	3.5	11.5	7.2	7.0	2.61	49
Meadowlake	Oakland	17	7.0	16.0	10.7	10.0	2.71	43
Mecosta	Mecosta	9	5.5	14.0	7.4	6.0	2.71	48
Middle	Kent	14	9.5	16.5	12.4	12.0	1.94	41
Mill	Van Buren	12	9.5	15.0	11.6	11.5	1.77	42
Moon	Gogebic	18	14.0	29.0	21.3	20.0	4.43	33
Mullett - 2	Cheboygan	9	12.0	17.0	14.9	16.0	2.20	38
Mullett - Jan	Cheboygan	15	15.5	18.0	16.6	16.5	0.78	37
Mullett - Red Pine Pt.	Cheboygan	13	12.5	22.3	17.4	16.8	2.95	36
Murray	Kent	17	4.4	12.0	7.3	6.6	2.55	49
North	Alcona	17	9.0	15.0	12.3	13.0	1.65	41
Oneida	Livingston	14	7.1	15.0	11.7	11.6	2.18	42
Ore	Livingston	14	5.0	15.0	8.4	7.5	3.37	46

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSI$_{SD}$
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
Orion	Oakland	7	16.3	22.4				
Osterhout	Allegan	10	8.0	10.0	8.9	9.0	0.74	46
Painter	Cass	16	4.0	7.5	6.0	6.3	1.20	51
Paw Paw 1	Berrien	11	3.1	8.9	6.7	7.1	1.79	50
Paw Paw 2	Berrien	11	3.2	9.8	6.7	7.1	1.90	50
Paw Paw 3	Berrien	11	3.2	8.4	6.4	7.1	1.70	50
Pentwater	Oceana	9	6.0	8.5	6.8	6.5	0.86	49
Perch	Hillsdale	19	7.7	10.3	9.3	9.3	0.78	45
Pleasant 1	Washtenaw	19	6.7	11.5	9.4	9.7	1.52	45
Pleasant 1	Wexford	13	4.4	6.3	5.0	5.0	0.54	54
Pleasant 2	Washtenaw	19	6.8	11.8	9.2	8.8	1.53	45
Pleasant 3	Washtenaw	19	6.9	11.5	9.0	9.2	1.42	45
Ponemah	Genesee	19	3.6	10.3	6.7	6.2	2.07	50
Portage	Livingston/Washtenaw	16	5.5	17.0	11.6	11.3	3.96	42
Puterbaugh 1, 2, & 3	Cass	18	8.0	22.0	13.3	14.0	3.93	40
Randall	Branch	16	3.5	9.0	5.6	5.0	1.72	52
Reeds	Kent	10	4.1	11.2	6.8	6.1	2.29	49
Reynolds (Lower)	Van Buren	14	12.0	14.0	13.3	13.5	0.70	40
Reynolds (Upper)	Van Buren	14	20.0	22.0	20.8	20.8	0.75	33
Robinson	Newaygo	19	6.0	11.0	8.7	9.0	1.81	46
Round	Clinton	17	8.7	15.2	10.5	10.0	1.61	43
Round	Lenawee	11	9.0	20.0	13.9	12.5	4.49	39
Round 1	Mecosta	9	7.0	11.0	8.9	9.0	1.18	46
Round 2	Mecosta	15	6.0	12.0	9.1	9.0	1.64	45
Round 3	Mecosta	14	7.0	11.0	9.4	9.0	1.28	45
Sage	Ogemaw	19	11.5	15.5	13.0	12.5	1.31	40
Sanford	Benzie	5	18.0	21.0				
Sanford	Midland	15	6.3	13.8	8.6	8.8	2.05	46
Sapphire	Missaukee	19	8.0	9.0	8.6	8.5	0.37	46
School Section 1	Mecosta	19	9.0	14.5	10.5	10.0	1.73	43
School Section 2	Mecosta	19	8.0	14.0	10.2	9.1	2.03	44
School Section 3	Mecosta	19	6.2	13.0	9.1	8.1	1.99	45
Sherwood	Oakland	16	5.0	11.0	8.1	7.5	1.71	47
Shingle	Clare	17	8.0	15.0	10.8	10.0	2.07	43

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Silver	Grand Traverse	19	16.0	50.0	28.5	25.0	11.58	29
Silver	Livingston	17	11.0	24.0	15.2	13.0	4.10	38
Silver 1	Genesee	19	9.0	19.0	12.4	10.0	3.63	41
Silver 2	Genesee	19	9.0	19.5	12.3	10.0	3.76	41
Silver 3	Genesee	19	9.0	19.5	11.9	10.0	3.24	41
Smallwood	Gladwin	5	5.5	11.0				
Spider 1	Grand Traverse	14	14.0	26.0	18.6	17.0	4.05	35
Spider 2	Grand Traverse	14	13.0	27.0	17.6	16.5	4.09	36
Spider 3	Grand Traverse	14	11.0	24.0	16.0	15.0	3.62	37
Starvation	Kalkaska	7	18.0	26.2				
Stone Ledge	Wexford	18	7.0	12.0	10.3	11.0	1.87	44
Strawberry	Livingston	19	5.3	9.7	7.2	6.6	1.55	49
Sylvan	Newaygo	18	9.5	27.0	16.3	15.3	4.50	37
Tan	Oakland	4	14.0	20.0				
Taylor	Oakland	19	16.0	21.0	18.3	18.0	1.45	35
Upper Hamlin	Mason	19	7.0	13.0	9.2	8.5	1.98	45
Upper Long	Oakland	15	2.5	15.5	7.9	8.0	3.54	47
Upper Sherwood	Oakland	8	5.0	7.9	6.6	6.5	1.04	50
Van Etten	Iosco	18	3.0	10.0	5.7	5.0	2.11	52
Vaughn	Alcona	11	8.5	13.5	11.0	11.0	1.72	42
Viking	Otsego	19	7.0	14.0	10.2	10.0	2.43	44
Vineyard	Jackson	17	7.0	24.0	12.8	10.5	5.81	40
Walled	Oakland	12	15.3	25.3	22.0	22.1	3.33	33
Wells	Osceola	19	9.0	20.0	14.2	14.0	3.44	39
West Twin	Montmorency	16	9.0	11.0	10.4	10.5	0.66	43
White	Oakland	9	15.0	25.0	18.6	18.0	3.10	35
Wildwood 1	Cheboygan	17	8.0	12.0	10.2	10.1	1.30	44
Wildwood 2	Cheboygan	17	7.1	11.0	9.5	10.0	1.23	45
Woods	Kalamazoo	17	7.0	17.0	11.8	12.0	2.50	42
Zukey 1	Livingston	9	5.0	12.0	7.5	7.0	2.47	48
Zukey 2	Livingston	9	5.6	19.6	11.4	10.8	4.30	42

APPENDIX 2
2002 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

		Total Phosphorus (ug/l)								Carlson
Lake	**County**	**Spring Overturn**				**Late Summer****				**TSI$_{TP}$****
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
ADA DAM	KENT	57				37				56
ANN	BENZIE	5				4 T				<27
ARBUTUS	GR. TRAVERSE	8				6				30
ARNOLD	CLARE	11				7				32
AUSTIN	OSCEOLA	17	9	25		*				
AVALON	MONTMORENCY	2 T				4 T				<27
BALDWIN	CASS	9				8				34
BALDWIN	MONTCALM	16				12				40
BARLOW	BARRY	10				4 T				<27
BASS	KENT	11				*				
BASS	LIVINGSTON	9				6				30
BEAR	KALKASKA	7				2 <				<27
BIG	OSCEOLA	13				15				43
BIG BRADFORD	OTSEGO	15				7				32
BIG CROOKED	KENT	14				18				46
BIG CROOKED	VAN BUREN	*				4 T	4 T			<27
BIG GLEN	LEELANAU	10				2 <				<27
BIG PINE ISLAND	KENT	31				17				45
BILLS	NEWAYGO	5		7		5	10			27
BIRCH	CASS	10				3 T				<27
BLUE	MASON	9				6				30
BLUE	MECOSTA	5				8				34
BOSTWICK	KENT	12				24				50
BRIGHTON	LIVINGSTON	25				74	58			66
BROOKS	NEWAYGO	23				24				50
BUCKHORN	OAKLAND	17				*				
BURKHART	WASHTENAW	11				6				30
CASCADE DAM	KENT	65				36 b				56
CEDAR	ALCONA/IOSCO	8				11				39
CEDAR	VAN BUREN	6				20	6	6	6	47
CHAIN	IOSCO	10				6				30
CHEMUNG	LIVINGSTON	19				11				39
CHILSON POND	LIVINGSTON	15				20 #				47
CHRISTIANA	CASS	13				10				37
CHURCH	KENT	*				*				

APPENDIX 2
2002 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)
CLEAR	BERRIEN	14				4 T				<27
CLEAR	JACKSON	8				14				42
CLIFFORD	MONTCALM	17				11				39
COREY	ST. JOSEPH	9				3 T				<27
COWAN	KENT	40				21	30			48
CRANBERRY	KENT/OTTAWA	*				194 #				
CROCKERY	OTTAWA	40				11 #	20			39
CROOKED	ALCONA	4 T				6				30
CROOKED	CLARE					13				41
CROOKED	LIVINGSTON	17		21		17		26		45
CRYSTAL	BENZIE	*				5 a				27
CRYSTAL	HILLSDALE	*				10				37
CRYSTAL	NEWAYGO	15	12	12		9	10	13		36
CUB	KALKASKA	7				4 T				<27
DEAN	KENT	11				15				43
DEER	ALGER	10				10 ht				37
DERBY	MONTCALM	7	8			8				34
DEVILS	LENAWEE	7				9				36
DIAMOND	CASS	9				2 <				<27
DONNELL	CASS					6				30
EAGLE	ALLEGAN	9				4 T				<27
EAST TWIN	MONTMORENCY	6				15				43
EMERALD	NEWAYGO	11	11			7				32
EVANS	LENAWEE	13				6				30
FAIR	BARRY					5				27
FARWELL	JACKSON	7				*				
FENTON	GENESEE	8				12				40
FISH	LIVINGSTON	20				8	4 T			34
FISH	VAN BUREN	17				11				39
FISHERS	ST. JOSEPH	6		8		4 T	2 T			<27
FOREST	OAKLAND	*				*				
FRESKA	KENT	21				11				39
GEORGE	CLARE	13				9				36
GILL	LIVINGSTON	20				12				40
GOURDNECK	KALAMAZOO	6	9	8		*				

APPENDIX 2
2002 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)
GRATIOT	KEWEENAU					15				43
GREEN	OAKLAND	10				7				32
GULLIVER	SCHOOLCRAFT	11				11 ht	10 ht			39
GUN	BARRY					5				27
GUNN	MASON	9				7				32
HAMBURG	LIVINGSTON	13				5				27
HARPER	LAKE	12	19	12	14	5				27
HESS	NEWAYGO	38				35				55
HIGH	KENT	14				18				46
HORSEHEAD	MECOSTA	16				*				
HUBBARD	ALCONA	3 T				4 T				<27
HUNTERS	ALCONA	21				15				43
HUTCHINS	ALLEGAN	12				*				
INCHWAGH	LIVINGSTON	24	22			33				55
INDIAN	MONTCALM	13				22	17			49
ISLAND	OAKLAND	*				*				
ISLAND	GR. TRAVERSE	6				5				27
JEWELL	ALCONA	9	12			*				
JORDAN	IONIA/BARRY	54				22				49
JUNO	CASS	14				13				41
KEELER	VAN BUREN	8				7	7	8		32
KLINGER	ST. JOSEPH	9				4 T				<27
L PINE ISLAND	KENT	19				16				44
LAKEVILLE	OAKLAND	7	8			11				39
LANCELOT	GLADWIN	23				14				42
LANCER	GLADWIN	12				22				49
LANSING	INGHAM	18				12				40
LILY	CLARE	16		14		11		19	19	39
LIME	KENT	470 nh	390 nh			12 #	14	15		40
LIMEKILN	LIVINGSTON	29		29		25		32		51
LITTLE CROOKED	VAN BUREN	*				11				39
LITTLE FISHERS	ST. JOSEPH	9		9		6				30
LITTLE GLEN	LEELANAU	8				10				37
LONG	GOGEBIC	9	12			6 ht				30
LONG	GR. TRAVERSE	*				2 T				<27

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep	Late Summer** Vol	Rep	DEQ	Rep	Carlson TSI TP** (summer TP)
LONG	IOSCO	11				8				34
LONG	KENT	*				*				
LOWER HAMLIN	MASON	17				22				49
LOWER LONG	OAKLAND	*				*				
MARGRETHE	CRAWFORD	*				5				27
MARL	GENESEE	8				5				27
MEADOW	OAKLAND	92				17 c	19 c	17		45
MECOSTA	MECOSTA	8				9				36
MOON	GOGEBIC	6				4 T,ht				<27
MUD	GENESEE	30				36				56
MULLETT	CHEBOYGAN	4 T				*				
MURRAY	KENT	36				9				36
NEPESSING	LAPEER	11	13			20	24			47
NORTH	ALCONA	18				13	19			41
OLIN	KENT	*				*				
ONEIDA	LIVINGSTON	13				9				36
ORE	LIVINGSTON	17				10				37
ORION	OAKLAND	*				*				
OSTERHOUT	ALLEGAN	12				9				36
OXBOW	OAKLAND	18				*				
PAINTER	CASS	15				18				46
PENTWATER	OCEANA	16				17				45
PERCH	HILLSDALE	16				12	15			40
PLEASANT	WASHTENAW	16				17				45
PLEASANT	WEXFORD	18				21	25			48
PORTAGE	LIVINGSTON	14	10			7				32
PRATT	GLADWIN	8		11		5				27
PUTERBAUGH	CASS	3 T	5			6				30
RANDALL	BRANCH	23	15	13	12	14	19			42
REEDS	KENT	33				21				48
ROBINSON	NEWAYGO	25		25		16				44
ROUND	CLINTON	19				13				41
ROUND	LENAWEE	10				10				37
ROUND	MECOSTA	19				10				37
SAGE	OGEMAW	10				9				36

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep	Late Summer** Vol	Rep	DEQ	Rep	Carlson TSITP** (summer TP)
SANDY BOTTOM	LIVINGSTON	23		23		10	9	14		37
SANFORD	BENZIE	14				6	8			30
SANFORD	MIDLAND	16	15			17 #	17			45
SAPPHIRE	MISSAUKEE	13				17				45
SCHOOL SEC.	MECOSTA	7				6				30
SHANGRA-LA	LIVINGSTON	8				9				36
SHINGLE	CLARE	12				9				36
SILVER	GENESEE	4 T				2 <				<27
SILVER	GR. TRAVERSE	7				5				27
SMALLWOOD	GLADWIN	14				12				40
SPIDER	GR. TRAVERSE	6				5				27
STONE LEDGE	WEXFORD	17				22				49
STRAWBERRY	LIVINGSTON	16				23				49
SWAN	IRON	*				13 ht	16 ht			41
SYLVAN	NEWAYGO	27				6	11			30
TAN	OAKLAND					16				44
TAYLOR	OAKLAND	19				13				41
TWIN - BIG	CASS	7				4 T				<27
TWIN - LITTLE	CASS	5				2 T				<27
U. SHERWOOD	OAKLAND	19				17				45
UPPER HAMLIN	MASON	18				19				47
UPPER LONG	OAKLAND	37				33	24	36		55
VAN ETTAN	IOSCO	29				33				55
VAUGHN	ALCONA	18				14				42
VERSLUIS	KENT	*				*				
VIKING	OTSEGO	18				17	15			45
VINEYARD	JACKSON	11				3 T				<27
WALLED	OAKLAND	10				13				41
WELLS	OSCEOLA	9	13	18		7		13		32
WEST TWIN	MONTMORENCY	8				11				39
WHITE	OAKLAND	6				10				37
WILDWOOD	CHEBOYGAN	12	10			16				44
WOLF	LAKE	8				6	7			30
WOODS	KALAMAZOO	23				5				27

* 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 a representative sample questionable.

\# Sample fell outside of laboratory established control limits; sample must be considered an estimate.

ht Recommended holding time was exceeded before sample was analyzed.

a Sample turned in unfrozen.

b Sample not collected properly

c No field sheet turned in with sample

NOTE: Due to sample capacity constraints at the DEQ laboratory, the 2002 CLMP late-summer total phosphorus samples were analyzed at an approved commercial laboratory. The results appear to exhibit a slightly low bias, which may be due to some minor differences in the analytical procedures used at the labs. Thus, the 2002 late-summer total phosphorus results and the Carlson TSI_{TP} values may not be directly comparable to historical CLMP data on your lake.

APPENDIX 3
2002 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l)					Mean	Median	Std. Devia-tion	Carlson TSICHL
		May	June	July	Aug	Sept				
ADA DAM	KENT	6 a	22 a	28	29 ac	31	23.2	28	10.2	63
ANN	BENZIE	2	2	3	2	3	2.4	2	0.5	37
ARBUTUS	GRAND TR	1 <	1 <	2	2	2	1.4	2	0.8	37
ARNOLD	CLARE	1	*	2	2	2	1.8	2	0.5	37
B. PINE ISLAND	KENT	*	*	*	*	8				
BALDWIN	MONTCALM	2	6	4	5	8	5.0	5	2.2	46
BARLOW	BARRY	1	2	2	2	3	2.0	2	0.7	37
BASS	KENT	1	1	1	*	*				
BASS	LIVINGSTON	1	2	2	3	1	1.8	2	0.8	37
Vol/Rep				2						
MDEQ				2						
MDEQ/Rep				2						
BIG	OSCEOLA	*	2	5	8	5	5.0	5	2.4	46
BIG CROOKED	KENT	2 a	1 <a	4 a	5 c	2 c	2.7	2	1.8	37
BIRCH	CASS	2	1 <	2	2	1	1.5	2	0.7	37
BLUE	MECOSTA	1 <	2	3	3	4	2.5	3	1.3	41
BOSTWICK	KENT	1 <b	2 b	4 b	6	4	3.3	4	2.1	44
BRADFORD	OTSEGO	2	2	1	2 c	2 c	1.8	2	0.4	37
Vol/Rep				2						
BROOKS	NEWAYGO	10	7	12	10 a	9	9.6	10	1.8	53
Vol/Rep				14						
BURKHART	WASHTENAW	2	3	2	3	6	3.2	3	1.6	41
CASCADE DAM	KENT	*	*	*	*	*				
CEDAR	ALCONA	2	2	3	5	5	3.4	3	1.5	41
CEDAR	VAN BUREN	2	5	2	3	3	3.0	3	1.2	41
MDEQ						3				
MDEQ/Rep						3				
CHRISTIANA	CASS	3	2	7	6	7	5.0	6	2.3	48
CHURCH	KENT	*	*	*	*	*				
CLEAR	BERRIEN	*	5	4	3	6	4.5	4.5	1.3	45
COREY	ST. JOSEPH	2	2	2	3 d	3 d	2.4	2	0.5	37
COWAN	KENT	1	3	6	17	27	10.8	6	11.0	48
CRANBERRY	KENT/OTT	8 a	2	16	52	15	18.6	15	19.5	57

APPENDIX 3
2002 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	May	June	July	Aug	Sept	Mean	Median	Std. Devia- tion	Carlson TSICHL
		Chlorophyll *a* (ug/l)								
CROCKERY	OTTAWA	13	5	10	8	2	7.6	8	4.3	51
Vol/Rep					8					
CROOKED	ALCONA	1	1 <	5	6	3	3.1	3	2.4	41
CROOKED	CLARE	*	5	2	4	6	4.3	4.5	1.7	45
CROOKED	LIVINGSTON	*	5 ac	4 c	*	10				
MDEQ						10				
MDEQ/Rep.						11				
CROOKED, BIG	VAN BUREN	4	4	3	3	2	3.2	3	0.8	41
CROOKED, LITTLE	VAN BUREN	1 a	2	3	7	6	3.8	3	2.6	41
CRYSTAL	BENZIE	2	*	1 <	*	1 <e				
CRYSTAL	HILLSDALE	1 <	2	2	5	3	2.5	2	1.7	37
Vol/Rep		1								
MDEQ		2								
MDEQ/Rep.		2								
CRYSTAL	NEWAYGO	2	2	2	2	4	2.4	2	0.9	37
Vol/Rep				1						
MDEQ						4				
MDEQ/Rep.						4				
DEER	ALGER	1	2	4	6	6	3.8	4	2.3	44
DERBY	MONTCALM	1	3	3	1	2	2.0	2	1.0	37
DEVILS	LENAWEE	2 a	1 <	3	5	3	2.7	3	1.6	41
DIAMOND	CASS	3	1 <	4	3	3	2.7	3	1.3	41
EAGLE	ALLEGAN	*	1	3	4	5	3.3	3.5	1.7	43
Vol/Rep			2							
EVANS	LENAWEE	1	1 <	2	4	8	3.1	2	3.0	37
FAIR	BARRY	2	4	4	5	2	3.4	4	1.3	44
FARWELL	JACKSON	1 <	1 <	1 <	1 <	1 <	<1	<1	0.0	<31
FENTON	GENESEE	1 <	1	2	2	3	1.7	2	1.0	37
FISH	LIVINGSTON	*	*	*	*	2				
FISH	VAN BUREN	2	3	6	17	13	8.2	6	6.5	48
FISHER	ST. JOSEPH	1 <	1 <	1	4	4	2.0	1	1.8	31
Vol/Rep				1						
FISHER, Little	ST. JOSEPH	3	2	4	2	1	2.4	2	1.1	37

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia- tion	Carlson TSICHL
FOREST	OAKLAND	*	*	*	*	*				
FRESKA	KENT	4	3	6	10	24	9.4	6	8.6	48
Vol/Rep			3							
GEORGE	CLARE	5	3	5	5	11	5.8	5	3.0	46
MDEQ			5							
MDEQ/Rep.			5							
GLEN, BIG	LEELANAU	3	2	1 <	1 <	1	1.4	1	1.1	31
GLEN, LITTLE	LEELANAU	2	2	2	3	3	2.4	2	0.5	37
GREEN	OAKLAND	1	2	2	2 b	3	2.0	2	0.7	37
Vol/Rep		1 <								
GULLIVER	SCHOOLCRAFT	1 <	2	3	5	6	3.3	3	2.2	41
Vol/Rep					6					
GUNN	MASON	3	3	2	2	4	2.8	3	0.8	41
HAMLIN, LOWER	MASON	2	1	8	4	4	3.8	4	2.7	44
HAMLIN, UPPER	MASON	3	2	6	13	8	6.4	6	4.4	48
HARPER	LAKE	1	2	2	3	4	2.4	2	1.1	37
Vol/Rep						4				
HESS	NEWAYGO	12	17	13	12	9	12.6	12	2.9	55
HIGH	KENT	2	4	4	4	9	4.6	4	2.6	44
Vol/Rep		2								
HORSEHEAD	MECOSTA	*	*	*	*	*				
HUBBARD	ALCONA	1 <a	1 <	1 <	2	1	<1	<1	0.7	<31
Vol/Rep			1 <							
INCHWAGH	LIVINGSTON	*	*	*	*	15				
INDIAN	MONTCALM	2	1 <	5	5	4	3.3	4	2.0	44
ISLAND	GRAND TR	2	1 <	1	3 a	2	1.7	2	1.0	37
ISLAND	OAKLAND	*	*	*	*	*				
JORDAN	IONIA	*	*	*	*	*				
JUNO	CASS	4	4	6	9	8	6.2	6	2.3	48
KEELER	VAN BUREN	1 <	1 <	1	1 <	6	1.7	<1	2.4	<31
Vol/Rep					1 <					
MDEQ						3				

APPENDIX 3
2002 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	May	June	July (Chlorophyll *a* (ug/l))	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
MDEQ/Rep.						3				
KLINGER	ST. JOSEPH	1 <	1 <	5	4	4	2.8	4	2.1	44
LAKEVILLE	OAKLAND	1 <	1	1 <	3	6	2.2	1	2.4	31
LANCELOT	GLADWIN	1 <	1 <	2	4 a	6	2.6	2	2.4	37
LANCER	GLADWIN	2	3	6	7 a	10	5.6	6	3.2	48
LANSING	INGHAM	1	3	3	4	4	3.0	3	1.2	41
LILY	CLARE	1 <a	2	4	2	2	2.1	2	1.2	37
Vol/Rep		1 <a								
MDEQ						2				
MDEQ/Rep.						2				
LIMEKILN	LIVINGSTON	*	9 ac	16 c	19	16	15.0	16	4.2	58
MDEQ						22				
MDEQ/Rep.						22				
LITTLE PINE ISLAND	KENT	4	3	9	*	*				
LONG	GRAND TR	2	1 <	1	2	2	1.5	2	0.7	37
LONG	IOSCO	2	2	2	4	3	2.6	2	0.9	37
LONG	KENT	*	*	*	*	*				
MDEQ					4					
MDEQ/Rep.					3					
LOWER LONG	OAKLAND	*	*	*	*	*				
MARGRETHE	CRAWFORD	1 <	1 <	2	1	1	1.0	1	0.6	31
MEADOW	OAKLAND	4 d	*	*	*	7 c				
MDEQ						3				
MDEQ/Rep.						3				
MECOSTA	MECOSTA	*	1 <b	4 ab	1 <	5	2.5	2.3	2.3	39
MOON	GOGEBIC	2	4	4	4	9	4.6	4	2.6	44
Vol/Rep			3							
MUD	GENESEE	9	5	48	46	39	29.4	39	20.8	67
MURRAY	KENT	7	7	3	3	4	4.8	4	2.0	44
NEPESSING	LAPEER	2	2	2	7	5	3.6	2	2.3	37
NORTH	ALCONA	6	2	5	4	7	4.8	5	1.9	46
OLIN	KENT	*	*	*	*	*				
MDEQ					2					

APPENDIX 3
2002 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
		Chlorophyll *a* (ug/l)								
MDEQ/Rep.					2					
ORE	LIVINGSTON	*	2	2	2	3	2.3	2	0.5	37
ORION	OAKLAND	*	*	*	*	*				
OSTERHOUT	ALLEGAN	3	6	6	4	4	4.6	4	1.3	44
OXBOW	OAKLAND	*	*	*	*	*				
PAINTER	CASS	4	4	25	25	8	13.2	8	10.9	51
PENTWATER	OCEANA	4	6	5	11	11	7.4	6	3.4	48
PERCH	HILLSDALE	2	1 <	2	2	1 <	1.4	2	0.8	37
MDEQ		3								
MDEQ/Rep.		3								
ROBINSON	NEWAYGO	9	17	6	10	22	12.8	10	6.5	53
ROUND	CLINTON	10	6	8	7	5	7.2	7	1.9	50
ROUND	KENT	*	*	*	*	*				
ROUND	LENAWEE	*	1	2	4	2	2.3	2	1.3	37
ROUND	MECOSTA	*	2 b	3 ab	1 <	8	3.4	2.5	3.3	40
SAGE	OGEMAW	2	2	3	3	3	2.6	3	0.5	41
SANDY BOTTOM	LIVINGSTON	*	4 ac	6 c	*	2				
MDEQ						3				
MDEQ/Rep.						2				
SAPPHIRE	MISSAUKEE	1 <	3	3	3	2	2.3	3	1.1	41
SCHOOL SECTION	MECOSTA	2	3	2	4	4	3.0	3	1.0	41
SHINGLE	CLARE	4	4	5	4	6	4.6	4	0.9	44
Vol/Rep			5							
MDEQ			5							
MDEQ/Rep.			5							
SILVER	GENESEE	1	1 <	2	4	2	1.9	2	1.3	37
Vol/Rep						3				
SPIDER	GRAND TR	*	2	4	3	4	3.3	3.5	1.0	43
STONE LEDGE	WEXFORD	1	2	1	7	4	3.0	2	2.5	37
STRAW-BERRY	LIVINGSTON	3	1 <	10	7	10	6.1	7	4.2	50
MDEQ				13						
MDEQ/Rep.				12						

Lake	County	May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
		Chlorophyll *a* (ug/l)								
TWIN, BIG	CASS	1	1 <	2	3	2	1.7	2	1.0	37
TWIN, LITTLE	CASS	1	3	3	2	2	2.2	2	0.8	37
TWIN, EAST	MONTMORENCY	2	2 a	2	6	4	3.2	2	1.8	37
TWIN, WEST	MONTMORENCY	3	3 a	2	4	4	3.2	3	0.8	41
UPPER SHERWOOD	OAKLAND	3	9	4	10	6	6.4	6	3.0	48
Vol/Rep					7					
UPPER LONG	OAKLAND	2	9	10	8	10	7.8	9	3.3	52
MDEQ						32				
MDEQ/Rep.						33				
VAN ETTAN	IOSCO	2	4	4	35	7	10.4	4	13.9	44
VIKING	OTSEGO	20	35	7	12	*	18.5	16	12.2	58
VINEYARD	JACKSON	1 a	1	3	3 b	3	2.2	3	1.1	41
WALLED	OAKLAND	1 <a	1 a	2	3	2	1.7	2	1.0	37
WELLS	OSCEOLA	3	2	4	5	3	3.4	3	1.1	41
Vol/Rep						3				
MDEQ						4				
MDEQ/Rep.						4				
WHITE	OAKLAND	1	12	2	2	3	4.0	2	4.5	37
WOODS	KALKASKA	2	11	3	7	25	9.6	7	9.3	50

< Sample value is less than limit of quantification (1 ug/l).

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

a Sample not collected during the designated sampling period.

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

c No field sheets were turned in with the sample.

d No date or time data on the field sheet and/or label

e Sample received unfrozen.

APPENDIX 4
2002 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lakes
Benzie	Lake Ann
Cass	Big Twin Lake
	Christiana Lake
	Diamond Lake
	Juno Lake
	Little Twin Lake
	Painter Lake
Clare	Lake George
	Shingle Lake
Grand Traverse	Island Lake
Kent	Ada Dam Impoundment
	Big Crooked Lake
	Bostwick Lake
	Cascade Dam Impoundment
	Cowan Lake
	Freska Lake
	High Lake
	Lime Lake
	Murray Lake
Kent/Ottawa	Cranberry Lake
Leelanau	Glen Lake (Big)
	Glen Lake (Little)
Lenawee	Devils Lake
	Round Lake
Livingston	Bass Lake
	Lake Chemung
	Strawberry Lake
Mecosta	Blue Lake
	Horsehead Lake
	Mecosta
	Round Lake

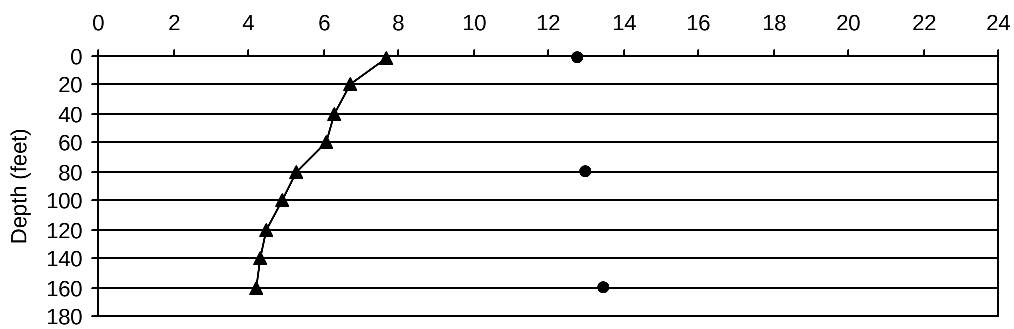
County	Participating Lakes
Newaygo	Brooks Lake Crystal Lake Hess Lake Robinson Lake
Oakland	Forest Lake Green Lake Island Lake Lakeville Lake Lower Long Lake Meadow Lake Upper Long Lake Walled Lake
St. Joseph	Corey Lake Fisher Lake Little Fisher Lake
Van Buren	Big Crooked Lake Cedar Lake Little Crooked 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.

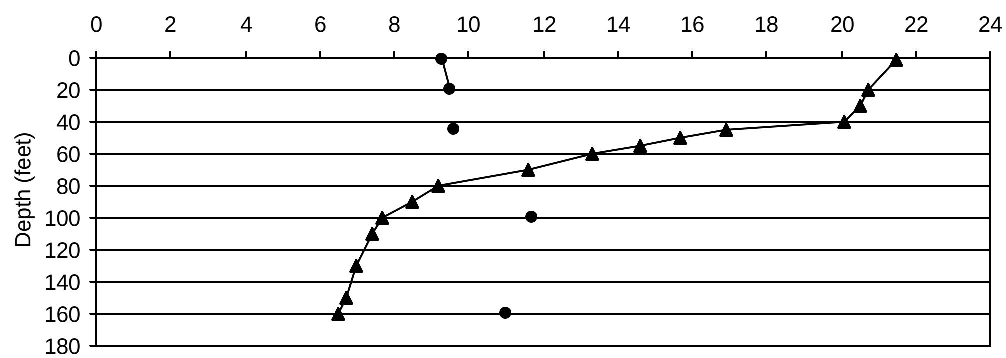
Oligotrophic Lake with a Very Large Volume Hypolimnion

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.

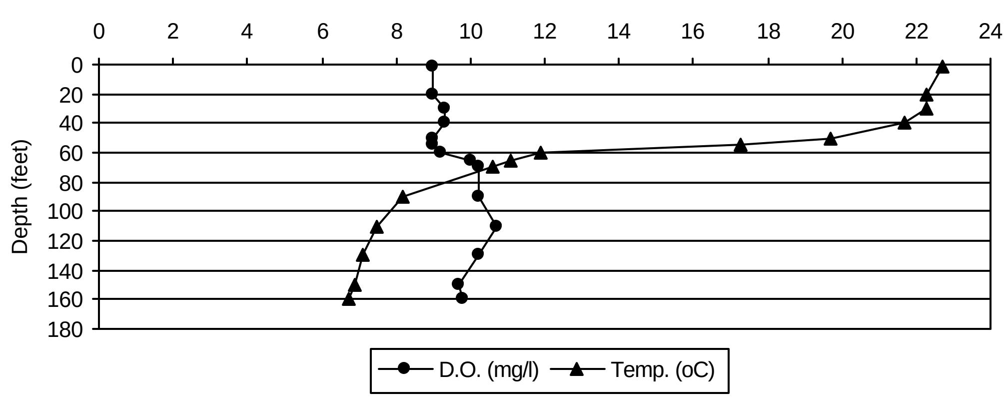
May 2, 1990



July 11, 1990

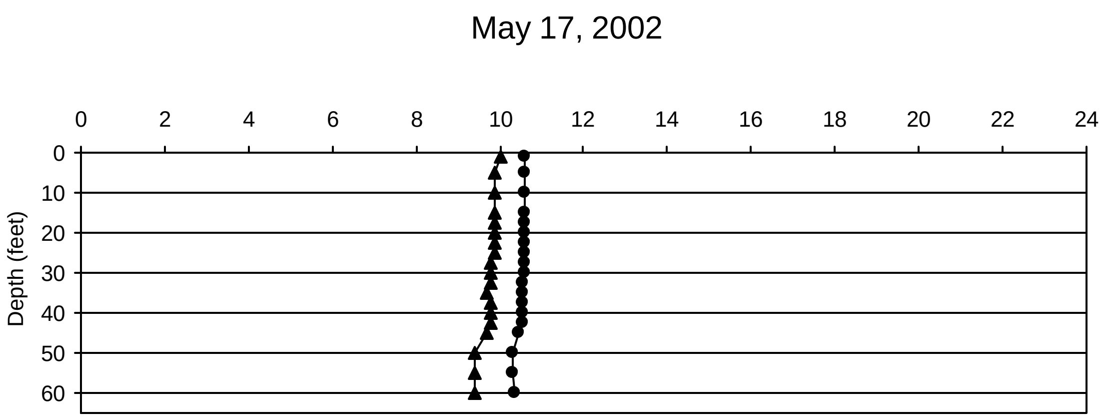


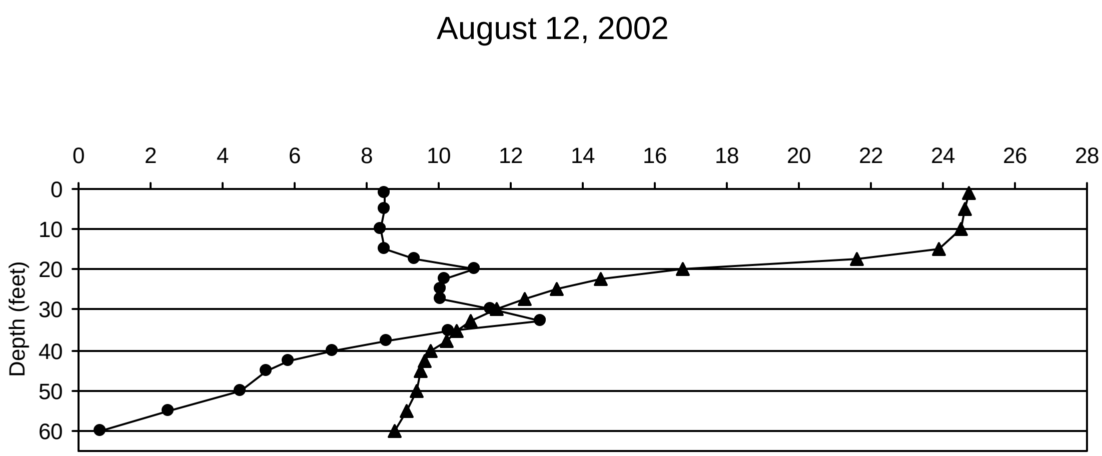
September 5, 1990

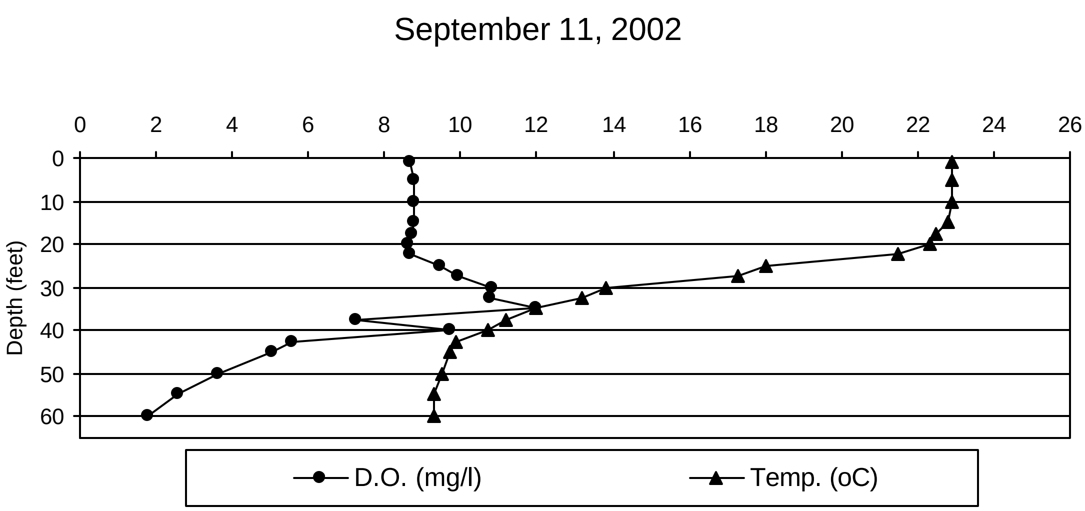


Oligotrophic/Mesotrophic Lake with a Large Volume Hypolimnion

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.



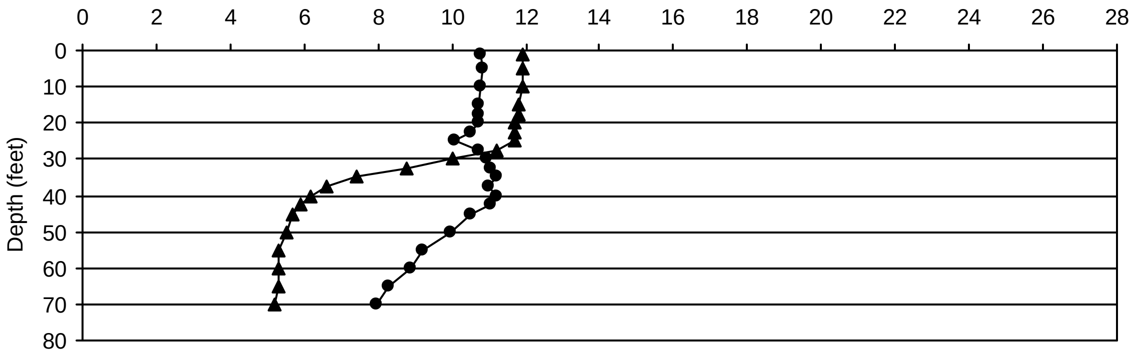




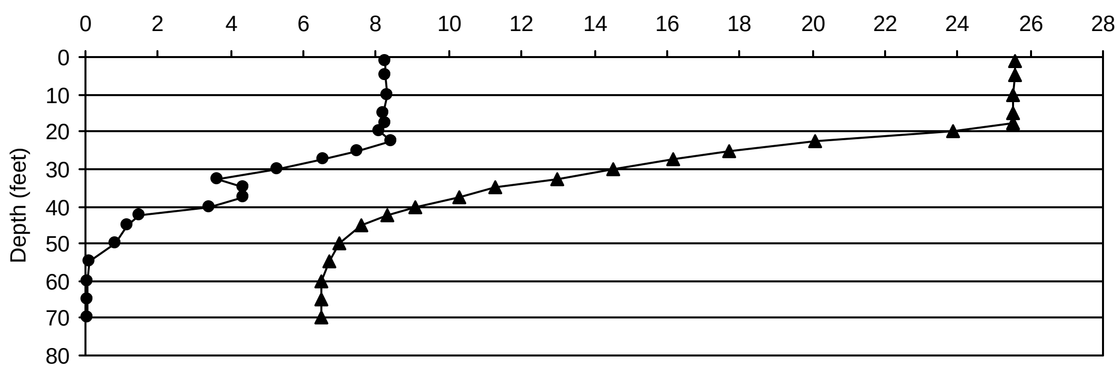
Oligotrophic/Mesotrophic Lake with a Small Volume Hypolimnion

Crystal Lake in Newaygo 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.

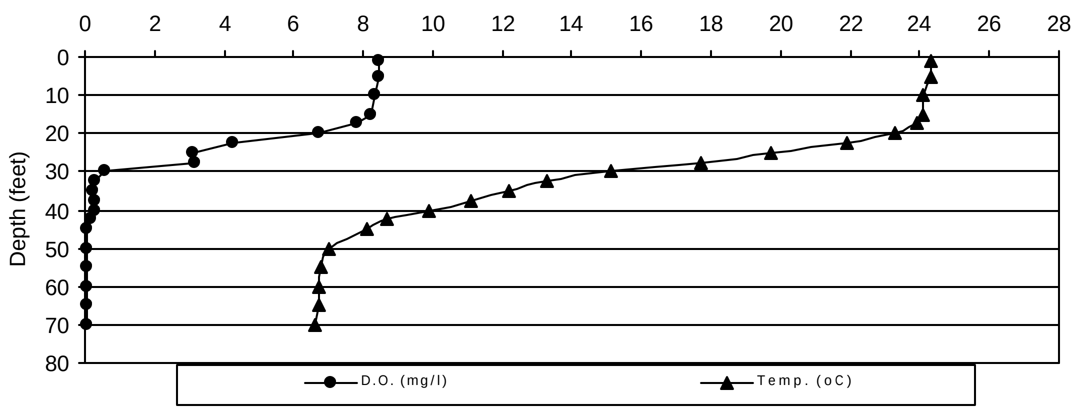
May 11, 2002



August 16, 2002



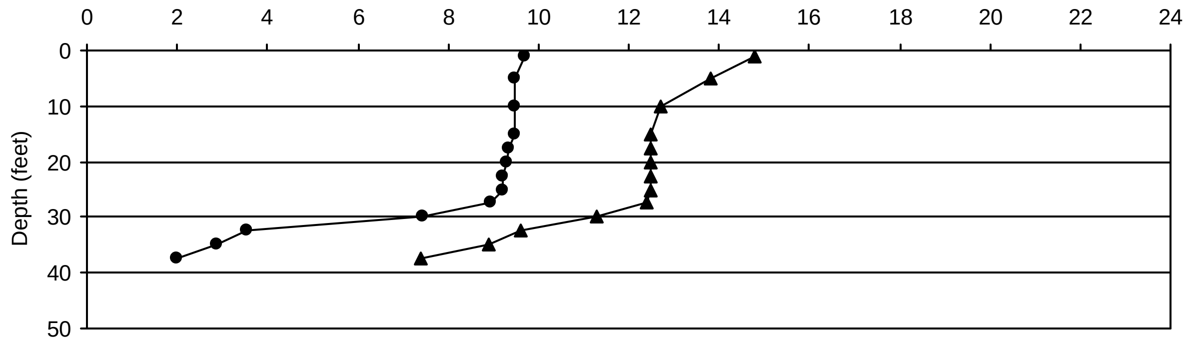
September 11, 2002



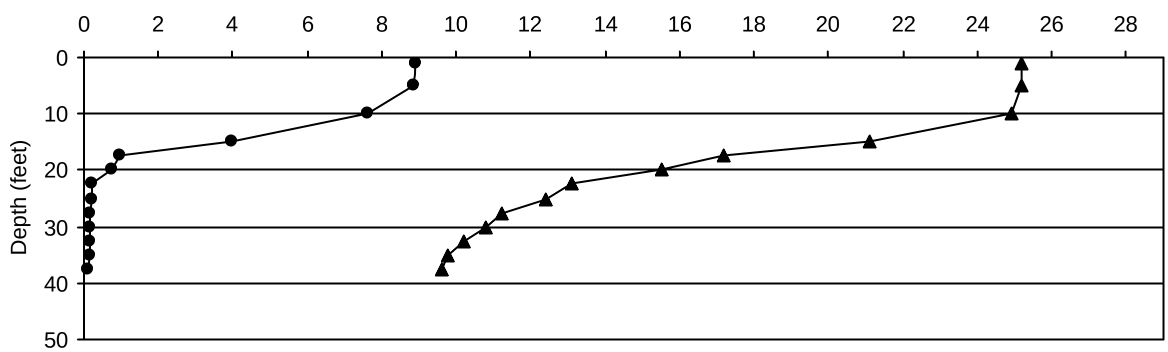
Mesotrophic/Eutrophic Lake with a Small Volume Hypolimnion

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.

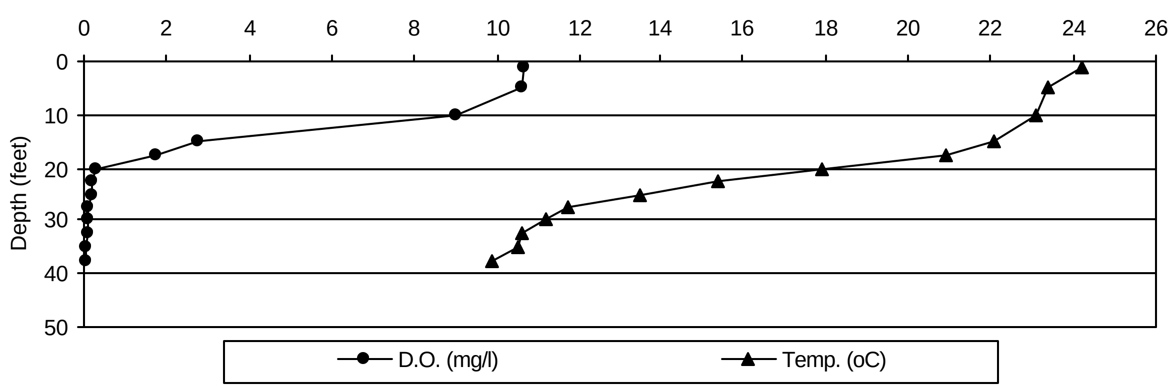
May 15, 2002



July 11, 2002



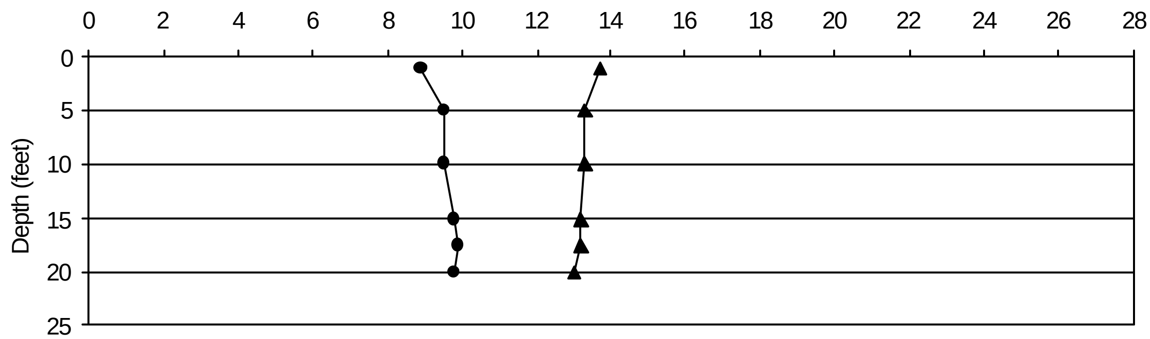
September 14, 2002



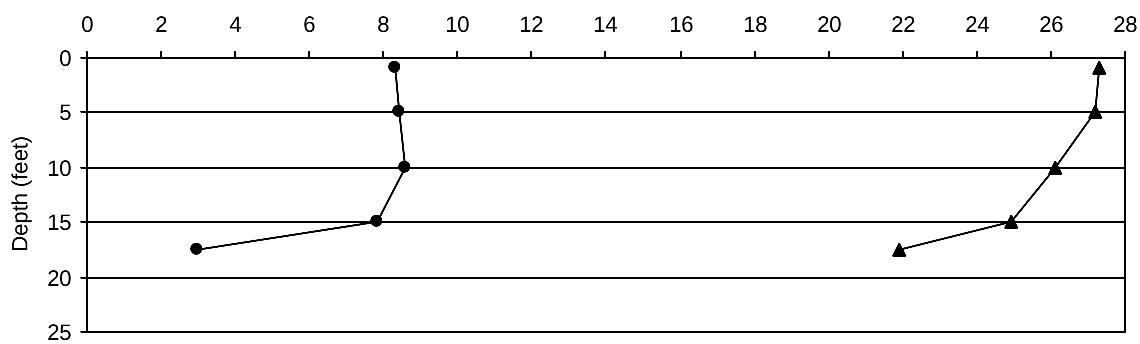
Shallow Mesotrophic Lake that does not Maintain Summer Stratification

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.

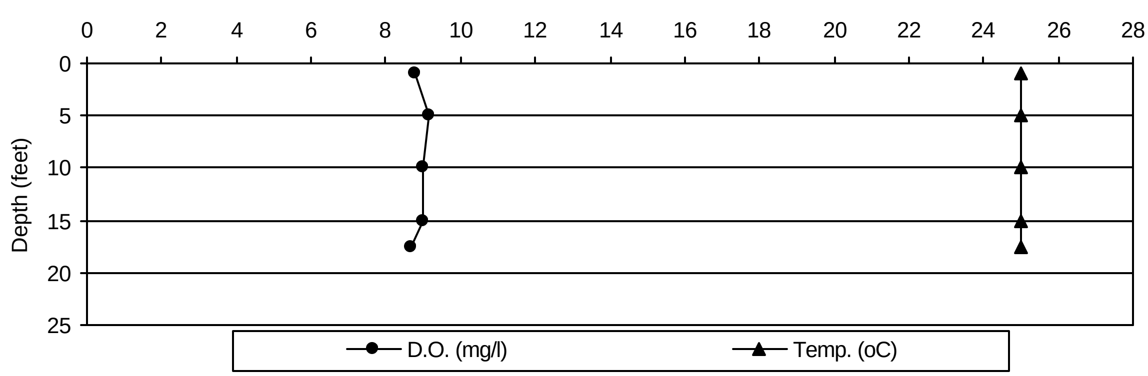
May 15, 2002



July 14, 2002



September 2, 2002



APPENDIX 5
2002 COOPERATIVE LAKES MONITORING PROGRAM
AQUATIC PLANT MAPPING

Two lakes participated in the 2002 CLMP aquatic plant mapping pilot project. They were Lake Margrethe in Crawford County, and Little Glen Lake in Leelanau County. Both lakes have similar productivity, with TSI values generally in the 30's and low 40's. The CLMP plant mapping project revealed that both lakes had limited plant populations consisting of a good diversity of species, none of which dominated. Only Lake Margrethe had Eurasian milfoil in small patches scattered about the lake. Both lakes have extensive shallow areas of water less than ten feet deep, which if conditions are appropriate could make the lakes susceptible to significant exotic species infestations.

As an example of the work completed in the CLMP aquatic plant mapping pilot project the whole lake reporting data sheet for Little Glen Lake is presented below. These data are from a survey done on the lake in September and October. Another survey was done in May and June. In addition to the data sheet each lake monitoring team produced lake maps and plant distribution sheets.

Plant Number	Plant Name	Distribution (# of sites where observed)	Average Density
20	Stonewort	36	0.96
21	Bushy pondweed	3	0.05
22	Fern pondweed	2	0.05
30	Large-leaf pondweed	11	0.15
31	Variable pondweed	7	0.10
32	Thin-leaf pondweed	1	0.01
34	Wild Celery	12	0.23
36	Elodea (Waterweed)	13	0.33
40	Native milfoil	4	0.06
42	Clasping-leaf pondweed	5	0.08
47	Water marigold	10	0.36
48	Bladderwort	1	0.01
51	Curly-leaf pondweed	8	0.15
52	Sago pondweed	1	0.01

APPENDIX 6
2002 COOPERATIVE LAKES MONITORING PROGRAM
FISH AGE AND GROWTH ANALYSIS

One lake participated in the 2002 CLMP fish age and growth pilot project, Silver Lake Genesee County.

Silver Lake

Silver Lake appears to be an oligotrophic lake (Carlson indices for Silver Lake in the 2001 CLMP were 36 for Secchi disk and 27 for phosphorus) with less than average fish growth. A comparison of Silver Lake largemouth bass and bluegill to Michigan's state averages suggests growth differs from the state averages (Figure 1). For instance, the estimated age at which largemouth bass reach legal capture size (14 inches) in Silver Lake is estimated to be approximately 6 years, whereas the state average is 5 1/2 years. It may be concluded from these results that the growth rates of bass and bluegill in Silver Lake are low for Michigan, and conditions controlling fish growth are also expected to be less than optimal.

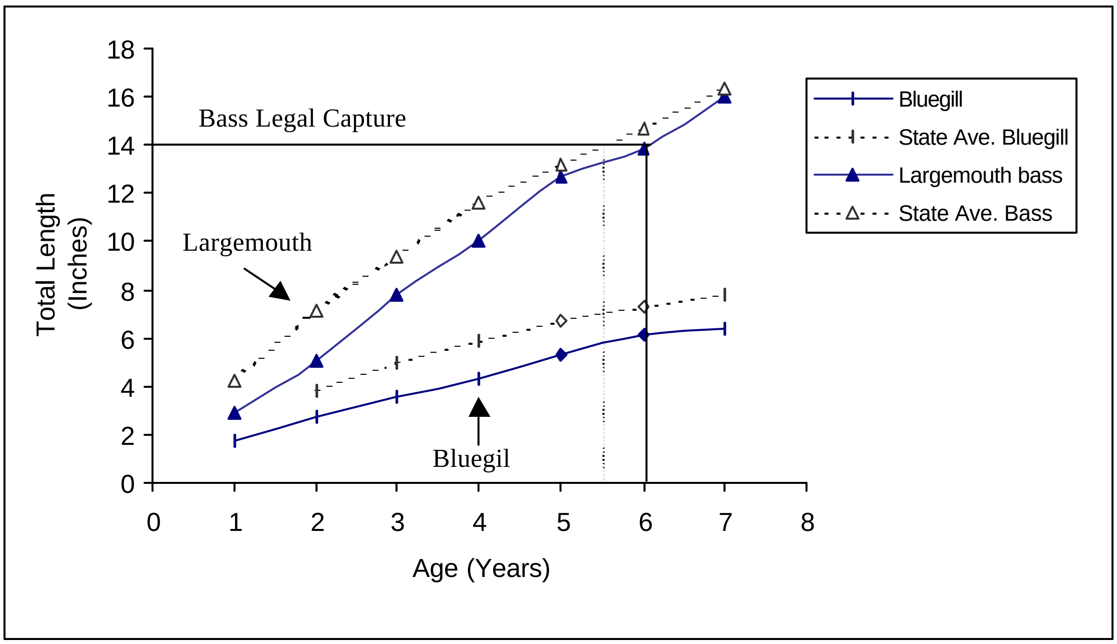


Figure 1. Silver Lake largemouth bass and bluegill length-at-age compared to the historic state averages. Values indicate sample means ±1 standard deviation. No error estimates are associated with state averages.

There are many factors that potentially affect fish growth, such as the age structure and abundance of fish populations. Thus, fish population characteristics are influenced by environmental conditions, such as temperature, habitat, and angling pressure.

Changes in these conditions, whether over long periods of time or abrupt changes, ultimately affects fish growth.

Within Silver Lake, there appears to be conditions that limit fish growth. If Silver Lake is oligotrophic - its low nutrient supply will limit the production of algae and rooted plants. Fewer plants will in turn limit the production of animals all the way up the food chain from the microscopic zooplankton to the large predator fish. This condition will result in fewer slower growing fish. This could mean that Silver Lake is susceptible to over harvest of large predator fish. If too many large predator fish like bass and pike are caught and harvested their ability to control the populations of pray fish like bluegill and perch could be diminished. This out-of-balance predator/pray relationship could create an undesirable stunted fish population. However, additional information pertaining to the abundance, size and age structure of each species, and environmental factors such as habitat quality and lake productivity, needs to be analyzed to conclusively determine why growth appears to be below average.