MI/DEQ/WRD-18/004

Cooperative Lakes Monitoring Program

Michigan Lakes - Ours to Protect

Michigan's Citizen Volunteer Partnership for Lakes

PROGRAM MANUAL

Managed By:
Michigan Department of Environment, Great Lakes, and Energy
Michigan State University Extension
Michigan Lakes and Streams Association, Inc.
Huron River Watershed Council

Michigan Clean Water Corps

Cite as:
Bednarz, R, H. Wandell, P. Steen, P. W. Dimond, J. Latimore, and M. Wilmes. 2015, revised 2019. Cooperative Lakes Monitoring Program Manual. Michigan Department of Environment, Great Lakes, and Energy Report Number MI/DEQ/WRD-15/004.

2018 Printing.

Michigan's Lakes and the Tragedy of the Commons

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

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

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

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

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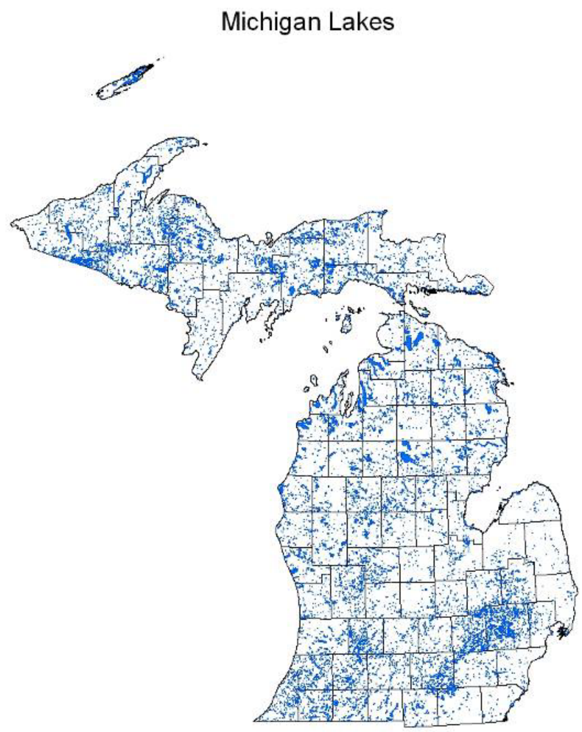
II. INTRODUCTION TO THE CLMP AND WATER QUALITY

A. MICHIGAN'S ABUNDANT LAKES AND THE NEED FOR MONITORING

Michigan's unique geographical location provides its residents 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.



Source: Michigan Department of Natural Resources, 1990.

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, we must take an active role in obtaining this information and managing their lakes.

To meet this need, the Department of Environment, Great Lakes, and Energy (EGLE), Michigan State University Extension, Michigan Lakes and Streams Association (MLSA), and the Huron River Watershed Council have partnered to implement the Cooperative Lakes Monitoring Program (CLMP). The purpose of this effort is to help volunteers monitor indicators of water quality in their lakes and document changes in lake quality. The CLMP provides sampling methods, training, workshops, technical support, quality control, and laboratory assistance to the volunteer monitors.

B. 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 lake monitoring program in the nation. The original program monitored water quality by measuring water clarity with a Secchi disk.

Dr. Jo Latimore of Michigan State University discusses aquatic plant mapping results with volunteers from Murray Lake in Kent County (MiCorps photo by Angela De Palma-Dow).

In 1992, the Michigan Department of Natural Resources and MLSA entered into a cooperative agreement to expand the program. An advanced Self-Help program was initiated that included a monitoring component for the plant nutrient phosphorus. In 1994, a side-by-side sampling component was added to the program to assure the quality of the data being collected.

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

The CLMP is a cost-effective means for EGLE to increase the baseline data available for Michigan's lakes and establish a continuous data record for determining water quality trends. As a result, the EGLE/volunteer partnership is critical to lake management in Michigan.

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 EGLE to increase baseline data for lakes state-wide.

C. THE CLMP AND MICORPS

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

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

- Training programs,
- A web site (https://micorps.net),
- An online, freely accessible database (the Michigan Data Exchange)
- An email list serve,
- An annual conference,
- Lake monitoring (CLMP), and
- Stream Monitoring (the Volunteer Stream Monitoring Program (VSMP))

D. PAST MONITORING RESULTS

CLMP monitoring results are available online. To view current and past results, visit MiCorps' Data Exchange at *https://micorps.net/* (select "Data Exchange"). On the site, you may search the database for lakes by name, county, or watershed. You can also limit the data delivered to you by date or monitoring parameter. CLMP volunteers will also find instructions on the website about how to enter their own data into the Data Exchange.

E. LAKE QUALITY

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

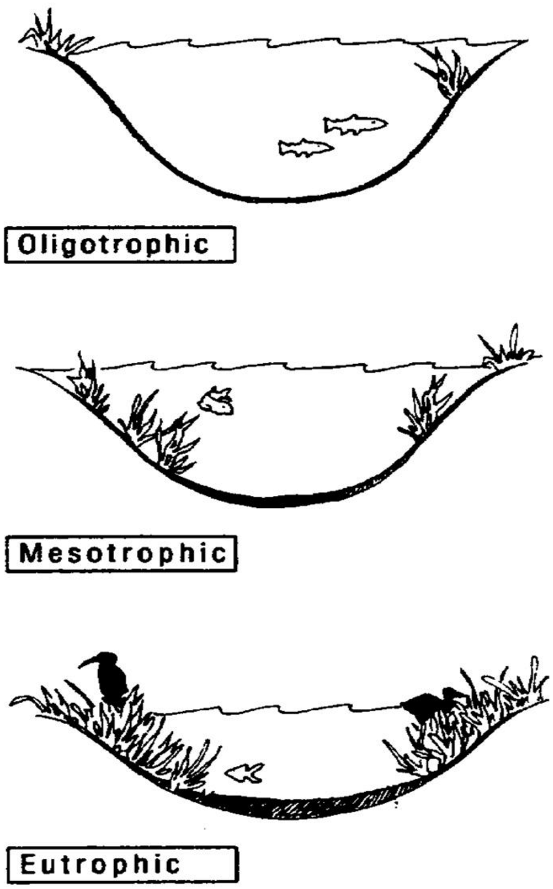
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

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 specifically to 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, while total phosphorus is sampled during the spring and late summer. These parameters are indicators of primary (algal) productivity and, if measured over many years, may document changes in the lake.

F. 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 coldwater 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 warmwater fish, such as bass and pike. Lakes that fall between these two classifications are called *mesotrophic* lakes. Lakes that exhibit extremely high productivity, such as nuisance algae and weed growth, are called *hypereutrophic* lakes.



Possible trophic states of inland lakes. [Source: Hamlin Lake Improvement Board, 1994].

G. 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 a lake's water quality and eutrophication is not an easy task. Lakes are a complex ecosystem made up of physical, chemical, and biological components in a constant state of action and interaction.

As on land, plant growth in lakes is not constant throughout the summer. Some species mature early in the season, die back, and are replaced by other species in a regular succession.

While overall population levels often reach a maximum in mid-summer, this pattern is influenced or altered by numerous factors, such as temperature, rainfall, and aquatic animals. For the same reasons lakes are different from week to week, lake water quality can fluctuate from year to year.

Given these factors, observers of lake water quality must train themselves to recognize the difference between short-term, normal fluctuations and long-term changes in lake productivity (e.g., eutrophication). Many years of reliable data collected on a consistent and regular basis are required to separate true long-term changes in lake productivity from seasonal and annual fluctuations.

A CLMP volunteer on White Lake (Oakland County) uses a Secchi disk to measure water transparency, a standard approach to assessing lake productivity. (MiCorps photo by Angela De Palma-Dow).

H. IMPORTANT MEASURES OF EUTROPHICATION

N*utrients* 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 µg/l (micrograms per liter), or ppb (parts per billion). *Phosphorus* is the most important nutrient affecting lake productivity, and is often used directly as a measure of eutrophication.

Plants are the primary users of nutrients. *Chlorophyll a* is a component of the cells of most plants, and can be used to measure the concentration of small plants in the water, such as algae. *Chlorophyll a* is measured from samples of water and reported in units of µg/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 warmwater 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. Warmwater fish, such as sunfish, bass, bullheads, and carp are more typical of a eutrophic lake.

Temperature affects the growth of plants, the release of nutrients, and the mixing of layers of water in the lake. Temperature measurements can determine if mixing occurs, moving nutrients from the lake bottom up into the surface waters promoting algae blooms.

I. LAKE PRODUCTIVITY INDEX (Trophic Status Index, TSI)

The general lake classification scheme described on page 6 puts lakes into four categories depending on biological productivity level, or trophic state: oligotrophic, mesotrophic, eutrophic, hypereutrophic. While these categories are convenient, they are somewhat misleading because 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 calculated directly from water quality data. The CLMP uses Carlson's (1977) *Trophic State Index* (TSI), to describe the productivity of the lakes enrolled in the program.

Carlson developed mathematical relationships for calculating the TSI from summer measurements of Secchi depth transparency, chlorophyll *a*, and total phosphorus in lakes. These parameters are good indirect measures of a lake's productivity, with chlorophyll *a* the most direct trophic state indicator. The TSI expresses lake productivity on a continuous numerical scale from 0 to 100, with increasing numbers indicating more productive lakes. TSI can also be used to evaluate changes within the lake over time, and to estimate other water quality parameters within the lake. You can use the chart on the next page to convert measured parameter values to TSI values to determine the trophic status category. Michigan generally classifies a TSI <38 as oligotrophic, 38-48 as mesotrophic, 48-61 as eutrophic, and >61 as hypereutrophic. Please note that the dividing lines between the trophic status categories are somewhat arbitrary. 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.

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 (µg/l)

CHL = chlorophyll *a* concentration (µg/l)

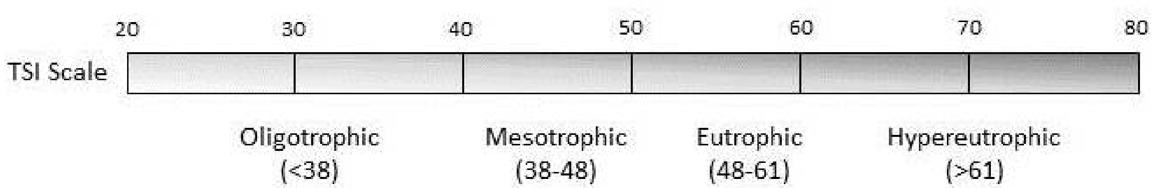
J. TSI COMPARISONS

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}.

Total Phosphorus (ppb)	TSI Value
<5	<27
6	30
8	34
10	37
12	40
15	43
18	46
21	48
24	50
32	54
36	56
42	58
48	60
>50	>61

Secchi Depth (ft)	TSI Value
>30	<28
25	31
20	34
15	38
12	42
10	44
7.5	48
6	52
4	57
<3	>61

Chlorophyll-a (ppb)	TSI Value
<1	<31
2	37
3	41
4	44
6	48
8	51
12	55
16	58
22	61
>22	>61



K. AQUATIC PLANTS

A major component of the plant kingdom in lakes is the large, leafy, rooted plants. Compared to the microscopic algae, the rooted plants are large. Sometimes they are collectively called the “macrophytes” (“macro” meaning large and “phyte” meaning plant). These macrophytes are the plants that people sometimes complain about and refer to as lake weeds.

Far from being weeds, macrophytes or rooted aquatic plants are a natural and essential part of the lake, just as grasses, shrubs and trees are a natural part of the land. Their roots are a fabric for holding sediments in place, reducing erosion and maintaining bottom stability. They provide habitat for fish, including structure for food organisms, nursery areas, foraging and predator avoidance. Waterfowl, shore birds and aquatic mammals use plants to forage on and within, and as nesting materials and cover.

Though plants are important to the lake, overabundant plants can negatively affect fish populations, fishing and the recreational activities of property owners. Rooted plant populations increase in abundance as nutrient concentrations increase in the lake. As lakes become more eutrophic, rooted plant populations increase. They are rarely a problem in oligotrophic lakes, only occasionally a problem in mesotrophic lakes, sometimes a problem in eutrophic lakes, and often a problem in hypereutrophic lakes.

However, sometimes a lake is invaded by an aquatic plant species that is not native to Michigan. In these cases, even nutrient poor oligotrophic lakes can be threatened. Some of these exotic plants, like curly-leaf pondweed, Eurasian water milfoil, starry stonewort (a macro-algae), European frog-bit, and Hydrilla can be extremely disruptive to the lake’s ecosystem and recreational activities.

To avoid a takeover by exotic plants, it is necessary to use Integrated Pest Management (IPM) strategies: monitoring, early detection, rapid response, maintenance control, and preventive management. For more information on these strategies, check out Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes (MSU Extension Water Quality Publication WQ-56, available at http://micorps.net/lake-monitoring/clmp-documents/

The CLMP offers two parameters on aquatic plants. In the Exotic Aquatic Plant Watch, volunteers concentrate on monitoring and early detection of exotic invasive plants only. In the Aquatic Plant Identification and Mapping program, volunteers identify all native and non-native plants. In both parameters, volunteers create lake maps or use digital tools to document where the plants are found.

III. CLMP MONITORING PROCEDURES

In this section, background material and extensive procedures are given for each of the parameters measured in the CLMP.

Quick reference procedure checklists, current sampling schedules, data forms, and sample turn-in locations can all be obtained here: https://www.micorps.net/lake-monitoring/clmp-document/

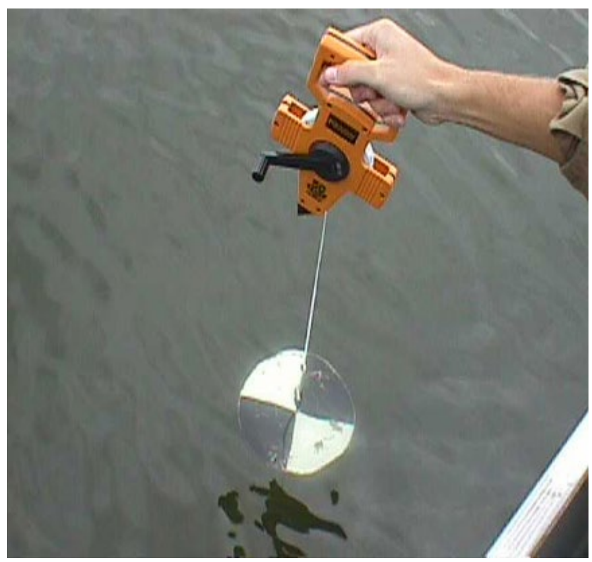
Every enrolled lake will be assigned a sample site number, also called a “Field ID #”. The Field ID # will be emailed to lead volunteers, and a master list of Field ID #’s can also be found at the CLMP Documents page mentioned above.

A. SECCHI DISK TRANSPARENCY

Introduction

Lakes with high water clarity or transparency are universally valued as exceptional quality resources. Lakes like Tahoe, Crater and Superior all evoke visions of crystal clear water, sandy beaches and no plants to hinder recreation. For almost 150 years a lake’s clarity has been used to appraise its quality. In 1865, Professor Pietro A. Secchi lowered a painted disk into the water to measure the quality of Mediterranean bays around Italy. His disk has become a standard tool used by scientists around the world to assess the general quality of lakes.

Dr. Secchi’s disk has been standardized as a 20 centimeter (about eight inches) disk, with four alternating black and white quadrants painted on the surface. The disk is attached to a measured line and lowered into the lake until it disappears from view. The water depth at which the disk disappears is the Secchi disk depth, or value, for the lake. Obviously the deeper the disk is seen the clearer the water or the greater the transparency of the lake.



The standard Secchi disk used in the CLMP. Credit: Ralph Bednarz, EGLE

A lake’s clarity or transparency is influenced by several factors, but for most lakes the amount of algae in the water is a major cause for changes in transparency. As more nutrients like phosphorus enter the lake from the watershed more algae are produced. As more algae are produced the clarity of the water decreases. In very clear lakes, Secchi disk values greater than 30 feet can be measured. On the other hand, in lakes with high nutrient inputs and abundant algae production the disk can disappear in two to three feet.

Unfortunately, the relationship between the Secchi disk value and algae as a measure of water quality is not so simple. Other factors can influence the Secchi disk value, reducing the usefulness of these measurements to appraise algae production directly. Other factors affecting Secchi disk values include: the angle of the sun in the sky, the roughness of the water surface, weather conditions (cloud cover, rain), the volunteer's eyesight, lakes shallower than their transparency, dissolved minerals in the water, suspended solids or soil particles in the water and the formation of lake marl or calcium carbonate. Consequently, Secchi disk values should only be considered as a measure of transparency and a very general indicator of algae levels. To more clearly define the levels of algae in the water, a parameter more directly measuring algae such as chlorophyll *a* must be used.

Despite these limitations, the Secchi disk value is still an important water quality measurement. When consistently done week to week and year to year, the measurements can be a useful indicator of lake quality changes and trends. Additionally, when assessed with other parameters such as chlorophyll *a* and total phosphorus, Secchi disk values can provide practical insight into a lake's water quality conditions and level of productivity or trophic status.

Training

There is no required onsite training for this parameter. However, the CLMP leadership team will be hosting training sessions for this and other parameters in April or May in conjunction with the annual spring Michigan Lakes and Streams Association's conference. Attending this training is highly recommended at least once to assure quality data collection and to develop relationships among other volunteers and resource people.

Equipment Checklist

- ☐ boating safety equipment and anchor
- ☐ copy of full procedures or quick reference procedure checklist
- ☐ data recording form
- ☐ pencil or indelible ink pen
- ☐ Secchi disk and measured line

Data Collection

1. **Sampling location, frequency, and timing**

The Secchi disk measurements need to be taken at the deepest basin in the lake. This site will be the primary sampling location for all CLMP sampling events and parameters in your lake. Secchi disk readings should be taken once a week or once every other week between mid-May and mid-September. It is important that measurements are taken for this entire monitoring period. At a minimum, eight equally spaced measurements from May to September are needed to calculate a representative average summer transparency value. If Secchi disk readings are not collected for the entire sampling period, a good summer value cannot be calculated and the data will not be comparable to summer transparency values calculated in previous or subsequent years.

It is best to measure transparency between 10:00 a.m. and 4:00 p.m. on a sunny, calm day when no heavy rain or excessive boating has occurred prior to sampling. Being consistent is important so attempt to measure at approximately the same day and same time every week.

2. Proceed to your monitoring location

On the chosen monitoring day, boat out to the deepest basin of the lake. Bad weather may make monitoring dangerous. If weather conditions are hazardous on your chosen sampling day, postpone monitoring until later in the week. If weather conditions are hazardous during the entire week, it is best to skip monitoring and miss one week's data rather than to risk your safety. DO NOT take a Secchi disk reading from the end of your dock or closer to shore than the deep basin, just to get a measurement. At the deep basin monitoring location, turn off the motor and drop anchor. The boat should be anchored to ensure the Secchi disk is straight down and not drifting at an angle. Let out enough anchor line to allow the boat to back away from any turbidity stirred up when the anchor hits the bottom sediments.

3. Prepare for monitoring

When in position, take out the Secchi disk data form provided and record the date, time, weather conditions and any other conditions you believe should be noted. Other conditions may include unusually heavy boating activity, recent heavy rains and resulting silt in the water, the formation of marl in the lake and other conditions which may affect the Secchi disk value recorded. Also record your lake's name, county and township location and Field ID # on the data form.

4. Making the Secchi disk measurement

Staying low in the boat, to avoid tipping the boat over and for better viewing of the disk, lower the Secchi disk over the **shaded** side of the boat. Continue lowering the Secchi disk by its measured line until it disappears from sight. Note the depth that it disappears. Now slowly raise the disk until it reappears. Note the depth that it reappears. The average difference, or mid-point, between the depth at which the disk disappeared and the depth it reappeared is the Secchi disk value. Record the value obtained on the Secchi disk data form. If the lake's transparency was greater than its depth (in other words, you could see the Secchi disk setting on the bottom of the lake) note this on the data form by putting the words "on bottom" in parentheses after the Secchi disk value recorded. **Do not** use sunglasses or a view-scope when taking the disk reading. If you wear glasses use un-tinted lenses for the reading.

Reporting Your Results

The MiCorps Data Exchange Network is an internet-based database designed to store data collected by volunteer monitors. This network allows you to enter data as well as to view data already entered into the database. If you can, please enter your data into the MiCorps Data Exchange found at MiCorps.net.

If you are unable to enter your own data into the MiCorps Data Exchange Network, please send your datasheet to the address below and program staff will enter your data for you. Entering your own data saves the program money and we appreciate you doing this if you are able.

Mail in your field datasheets

Whether you entered your data online or not, mail in a copy of your data sheet at the end of the season. All data must be entered into the database and hard copies mailed no later than October 31st.

Mail your copy to:

Michigan Lakes & Streams Association, Inc.
P. O. Box 303
Long Lake, MI 48743

B. TOTAL PHOSPHORUS

Introduction

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.

Phosphorus is a naturally occurring element that is found in rocks and soil. Humans use and dispose of phosphorus on a daily basis in common items such as fertilizers, foods, and cleaning agents. Lakes with developed watersheds often receive a portion of this human-generated phosphorus through runoff, septic leachate, and other sources.

Phosphorus is found in lakes in several forms that are in a constant state of flux as environmental conditions change and plants and animals live, die, and decompose in the lake. The various forms of phosphorus are constantly changing and are distributed in different locations of the lake with changing seasons. Because the forms of phosphorus are continuously changing and recycling, it is convenient to measure all of the forms of phosphorus together as total phosphorus.

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.

Training

There is no required onsite training for this parameter. However, the CLMP leadership team will be hosting training sessions for this and other parameters in April or May in conjunction with the annual spring Michigan Lakes and Streams Association's conference. Attending this training is highly recommended at least once to assure quality data collection and to develop relationships among other volunteers and resource people.

Equipment Checklist

- ☐ boating safety equipment* and anchor*
- ☐ copy of full procedures or quick reference procedure checklist
- ☐ two 250-ml plastic bottles
- ☐ total phosphorus data form
- ☐ pencil* or indelible ink pen*
- ☐ ice pack*
- ☐ total phosphorus sample labels (2)
- ☐ fine tip permanent black marker*
- ☐ towel for drying hands*
- ☐ insulated cooler bag and freezer*
- ☐ 2 zip-lock freezer bags*

*provided by volunteer

Data Collection

1. Sampling location, frequency, and timing

The total phosphorus water samples need be taken at the deepest basin in the lake. This site will be the primary sampling location for all CLMP sampling events and parameters in your lake. <u>For spring total phosphorus samples, the samples will need to be taken within 2 weeks of ice-out as judged by the volunteer.</u> <u>Summer phosphorus samples will be taken in late August through September, depending on the lake's latitude.</u> To get specific allowable sampling dates for your area of Michigan, refer to the summer total phosphorus sampling schedule.

2. Organize sampling materials.

Before proceeding to the sampling location use the equipment list, above, to organize all of the materials needed to obtain the total phosphorus samples.

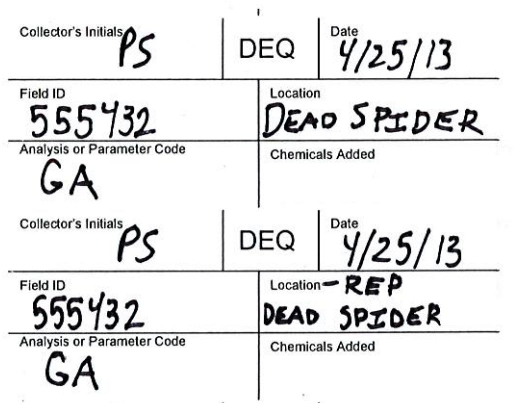
You should receive two 250 ml plastic bottles and labels in the mail prior to your sampling date. If you receive any bottles without the caps on them, please notify Jean at jean.roth@mymlsa.org. <u>DO</u> <u>NOT</u> use sample bottles that arrive without the caps on them. <u>DO NOT</u> substitute any other containers for the total phosphorus sample bottles.

3. Fill out labels and attach to bottles.

Before the bottles or labels get wet, use a **fine tip permanent black marker** to completely fill out the total phosphorus sample labels and attach the labels to the sample bottles. This is an easily overlooked step- but labeling your samples *before* you go out to the water will prevent sample mix-ups.

The information on the label should include:
Volunteer's Initials
Sampling Date
Field ID: The number assigned to your lake
Location: Lake name
Analysis or Parameter Code: Enter "GA" here.
Chemicals Added*:* Leave this blank.

For the second label, the Location should also include the letters "-REP" to designate it as the replicate, or duplicate, sample.



Example total phosphorus bottle labels, for primary sample (top) and replicate sample (bottom).

4. Proceed to your sampling location and orient boat for sampling.

Approach the sampling location from the upwind direction. Turn off boat motor and drift over the deepest point in the lake. Make sure motor exhaust or fuel leaks will not contaminate the samples. For windy days, you may need to anchor the boat to stay over the deepest point in the lake while sampling. Lower the anchor and allow the boat to drift over the sampling location before securing the anchor line. This allows you to sample outside the area where sediments may be re-suspended when the anchor hits bottom. When in position, take out the phosphorus data form and record the date, time, weather conditions, and any unusual lake conditions. Also, on the back of the phosphorus data form, draw an outline of your lake and mark the approximate sampling location.

5. Unscrew the cap and rinse the bottle with lake water

At the sampling location, take a bottle and unscrew the cap, holding the cap between two of your fingers, touching only the outside of the cap. If you touch the inside of the cap, or the cap gets dirty, dip the cap in the lake to clean. Do not wipe the cap clean or try to dry it off. Also, if you use tobacco products, do not smoke during sampling and make sure your hands and fingers are clean. Tobacco products contain phosphorus which may contaminate the samples.

Rinse bottle twice with lake water and shake out any residual water after the second rinse.

6. Collect water sample and the replicate sample

Total phosphorus samples are collected as grab samples just below the surface of the lake.

After rinsing, grab the bottle around the base with tips of all fingers and thumb of one hand (i.e. the "dead-spider" grip). Turn the bottle upside down so the bottle mouth is pointed in a downward direction. Lower the bottle into the lake approximately one foot below the surface (about to your elbow). Turn the bottle sideways (i.e. horizontal) with the bottle mouth pointing in the direction the boat is drifting. When almost full, turn the bottle right-side up underwater to fill completely before lifting it out of the water. <u>Since the sample will expand when frozen, spill out a small amount of water from the bottle so it is about three-quarters full</u>. Cap the bottle and tighten cap firmly. Use your towel to dry the outside of the sample bottle before storing it in the freezer bag with the ice pack. The ice pack will slow down the biological action that could potentially change your results. This is an often overlooked step, so be sure you do it.

Repeat the process with your second bottle. This is your replicate sample. 10% of the program's replicate samples will be analyzed for data quality/data control purposes.

(Note: DO NOT collect the samples near the motor.)

7. Return to shore and freeze the sample.

After returning to shore, place the sample in a zip-lock bag. Place your data form in a separate zip-lock bag and then put it into the zip-lock bag with the water sample. Put both into the freezer and keep frozen until the turn in date.

8. Turn in your sample

Deliver the frozen total phosphorus samples and data sheet to the designated drop-off location on the designated turn-in date (according to the phosphorus schedule).

<u>**Very important:**</u>

- Your total phosphorus samples must be frozen when you drop them off
- You must include your data form with the samples.
- Your frozen samples must be received no later than noon of the scheduled turn-in date.
- Do not leave the sample outside the Collection Office door and expect it to remain frozen (and for security reasons). Therefore you must deliver samples to the Collection

Offices during normal business hours.

If you have a conflict with the scheduled turn-in date, you may contact your drop-off site to determine if you can turn it in early. Samples turned in late or not frozen will not be accepted or will be thrown out.

If you are unable to drop off your samples at the designated location on the specified turn-in date, contact the CLMP staff member responsible for sample-turn in as listed on page 2.

Reporting Your Results

While the total phosphorus sample will be analyzed by EGLE and the results entered into the data exchange by CLMP staff, the information you recorded on your datasheet (the “metadata”) also needs to be entered into the data exchange. Prior to turning in your sample and the datasheet to your designated drop off location, be sure to enter your metadata into MiCorps Data Exchange.

The MiCorps Data Exchange Network is an internet-based database designed to store data collected by volunteer monitors. This website allows you to enter data as well as to view data already entered into the database. You can find the MiCorps Data Exchange at MiCorps.net.

If you are unable to enter your own data into the MiCorps Data Exchange Network, program staff will enter your data for you after receiving your datasheet with your frozen phosphorus sample. Entering your own data saves the program money and we appreciate you doing this if you are able.

C. CHLOROPHYLL-A

Introduction

Chlorophyll is the green photosynthetic pigment in the cells of plants. The relative amount of algae in a lake can be estimated by measuring the chlorophyll concentration in the water. The amount of chlorophyll in an algal cell varies among algae species as well as with changing light conditions at different depths within the lake. Changing seasons also create different light conditions that, in turn, affect chlorophyll production. To account for some of this variability, algal chlorophyll is monitored during five mid-month sampling events over the summer season (May through September) using a water column composite sampling technique.

The chlorophyll sample is collected as a depth integrated composite water sample from the photic zone of the lake over the deepest basin in the lake. The photic zone of the lake is the upper portion of the water column where sunlight penetrates and supports growth and reproduction of free-floating algae. The lower boundary of the photic zone is twice the transparency depth as measured with a Secchi disk. The depth integrated composite sample is a water sample continuously collected from the water column as a sampling device is raised from twice the Secchi depth to the surface of the lake. The composite water sample is filtered to remove algae cells, and the filter paper is frozen and turned into EGLE for analysis.

Training

Training is **required** for this parameter. The CLMP leadership team will be hosting training sessions for this and other parameters in April or May in conjunction with the annual spring Michigan Lakes and Streams Association's conference. Attending this training is required at least once to assure quality data collection and to develop relationships among other volunteers and resource people. If you cannot attend this training in person, please watch the recorded trainings found at MiCorps.net.

Equipment Checklist

<u>Chlorophyll Sampling Equipment</u>

- ☐ boating safety equipment* and anchor*
- ☐ copy of full procedures or quick reference procedure checklist
- ☐ Secchi disk
- ☐ chlorophyll data forms (2)
- ☐ pencil* or indelible ink pen*
- ☐ zip-lock freezer bag*
- ☐ composite sampler with measured line*
- ð clothespin*

<u>Chlorophyll Filtering Equipment</u>

- ☐ 60 cc plastic syringe
- ☐ aluminum foil*
- ☐ flexible plastic tube
- ☐ filter holder
- ☐ membrane filter disks (2)
- ☐ tweezers and large safety pin*
- ☐ coffee filter* or paper towel*
- ☐ sample storage vials and caps (2)

- ☐ rectangular brown sample storage bottles (2)
- ☐ chlorophyll sample labels (2)
- ☐ magnesium carbonate (1% $MgCO_3$) solution
- ☐ fine tip permanent black marker*
- ☐ insulated cooler bag and freezer ice pack*

*provided by volunteer

Data Collection

1. Sampling location, frequency, and timing

The chlorophyll sample needs to be taken at the deepest basin in the lake. This site will be the primary sampling location for all CLMP sampling events and parameters in your lake. In general, chlorophyll sample needs to be once a month from May through September, but exact dates differ depending on the lake's latitude. To get specific allowable sampling dates for your area of Michigan, refer to the chlorophyll sampling schedule.

It is best to collect the chlorophyll sample between 10:00 a.m. and 4:00 p.m. on a sunny, calm day when no heavy rain or excessive boating has occurred prior to sampling.

For purposes of calculating TSI values, lakes must have collected samples for at least four of the five sampling events.

2. Proceed to your sampling station and orient the boat

Proceed to the deepest basin of the lake to collect the chlorophyll sample. When you are directly over the deep basin, orient the boat so it is facing the breeze and move upwind until slightly past the deepest point in the lake. Lower the anchor and allow the boat to drift back over the deepest point of the lake before securing the anchor line. This allows you to sample the water column outside the area where sediments may have re-suspended when the anchor hit bottom.

When in position, take out the chlorophyll sample data form and record the date, time, weather conditions, and any unusual lake conditions for the sampling event. Make sure you have included the lake name, county, township, Field ID #, and your name.

3. Measure Secchi transparency.

Take a Secchi disk measurement to determine the lower boundary for the composite chlorophyll sample. On the chlorophyll data form, record the Secchi transparency depth you measured. The lower boundary for the composite sample will be twice the Secchi transparency depth. Record the composite sample depth (i.e. 2 x Secchi depth) on the chlorophyll data form. (**Note**: If the deepest point in your lake is less than 2 x Secchi depth, the sample will be collected to a depth three feet above the bottom of the lake. Record this depth as the composite sample depth.)

4. Prepare composite sampler for sample collection.

Remove the sampler bottle from the weighted container and rinse the bottle with lake water. Shake out any residual lake water from the sampler bottle and secure the sampler bottle back into the weighted container. Make sure the weight is in the container, the retaining chain is around the neck of the sampler bottle, the stopper assembly is secure, the bottle cap is tightened, and the measured line is securely fastened to the composite sampler.

5. Collect composite sample for chlorophyll.

Find the mark on the measured line that corresponds to the composite sample depth (i.e. 2 x Secchi depth) you determined in step 3, above. Clip a clothespin on the measured line at this mark. Place all of the line, from the composite sampler to the clothespin mark, into the lake so the line will not get tangled when the sample is collected. Hold the composite sampler at the surface of the lake and then let it go, allowing the weighted sampler to “free fall” down through the water column until the line is fully extended with the clothespin mark at the water surface.

As soon as the line is taut, retrieve the composite sampler at a <u>slow</u>, <u>steady</u> rate. Bring the composite sampler into the boat and remove the cap and stopper assembly from the sampler bottle. The sampler bottle should be more than half full, but not completely full. If the sampler bottle is less than half full or completely full, you will have to empty the bottle and re-sample, adjusting the retrieval rate accordingly.

Note: If the deepest point in your lake is less than 2 x Secchi depth obtain the composite sample to a depth three feet above the bottom of the lake and record this depth as the composite sample depth on the chlorophyll data sheet. BE CAREFUL not to hit bottom and contaminate the sample with re-suspended sediments. If you hit bottom while sampling, move to a different location within the basin and sample again.

6. Store chlorophyll sample in rectangular (brown) bottles.

Remove the sampler bottle with composite sample from the weighted container. Swirl or shake bottle gently to mix the sample. Use a small portion of the composite sample to rinse both of the rectangular (brown) sample storage bottles. Swirl or gently shake sampler bottle again to mix sample and then fill both of the sample storage bottles. Fill the bottles only to the bottom of the neck leaving some head space in the bottles.

Before replacing the bottle cap, add five drops of the magnesium carbonate (1% $MgCO_3$) solution to each storage bottle to stabilize the chlorophyll samples. Replace and tighten cap of each sample storage bottle and gently shake to mix the added $MgCO_3$ solution with the samples. Store bottles with stabilized chlorophyll samples in the insulated cooler bag with freezer ice pack, out of direct sunlight. It is important to put the samples by an ice pack in order to slow any biological activity that could potentially change your results.

Note: The $MgCO_3$ solution is contained in the small dropper bottle in your chlorophyll sampling kit. You will need to vigorously shake the $MgCO_3$ dropper bottle before using. The $MgCO_3$ will have settled to the bottom of the bottle and will need to be re-suspended.

7. Return to shore

After stabilizing and storing the samples, empty the sampler bottle and secure the sampler bottle back into the weighted container. Organize and pack up the sampling equipment, pull up the anchor, and return to shore to filter and preserve your samples.

After returning to shore, immediately take the chlorophyll samples to your indoor location for filtering, keeping the samples out of direct sunlight.

8. Prepare filtering apparatus.

Algae cells are removed from the composite sample by filtering the sample through a membrane filter disk. The filter disk is then stored frozen in the dark until analyzed at the laboratory.

The chlorophyll filtering apparatus consists of a 60 cc plastic syringe with a Luer-Lok tip, a short flexible plastic tube, a filter holder, and filters. Unscrew the filter holder to open and note that there is a metal screen for the filter to rest on and a rubber o-ring that seals the filter holder when closed. Using tweezers, carefully remove one filter disk from the zip-lock bag and center the filter on top of the metal screen in the outlet half filter holder. With tweezers, carefully center the rubber o-ring on top of the filter disk. Place the inlet half of the filter holder over the outlet half, with filter disk, being careful not to move the rubber o-ring or filter disk. Screw tighten the two halves of the filter holder to a snug fit.

Note: DO NOT touch the filter disk with your fingers. While using tweezers to handle the filter disk, be careful not to puncture or break the filter.

9. Filter chlorophyll sample.

Slip the short flexible tube into the Luer-Lok tip of the syringe. Gently shake one of the rectangular (brown) sample bottles to mix the chlorophyll sample. Insert the flexible tube of the syringe assembly into the sample bottle and draw the sample into syringe by carefully pulling out the plunger. Empty the syringe to rinse and fill the syringe again by pulling out the plunger until the plunger end reaches the 60 cc line.

To remove the air space between the plunger end and the sample, turn the syringe so the tip with flexible tube is facing up. Tap the side of the syringe to dislodge any air bubbles that cling to the cylinder wall or plunger end. Slowly push in the plunger until the air space at the syringe tip is gone and the plunger end is lined up with the 50 cc line. Turn syringe so it is pointing down and make sure the syringe is filled to the 50 cc line without any air space or air bubbles. Note: If the air space remains or there are air bubbles in the syringe, empty the syringe and repeat the filling procedure.

Remove the flexible tube from the syringe tip. Fasten the filter holder to the syringe by sliding the inlet prong of the filter holder into the Luer-Lok tip of the syringe. The connection should be snug so the assembly will not leak during filtering. Holding the syringe and filter holder assembly upright (i.e. vertically with the filter holder assembly pointed down) begin filtering by applying steady pressure to the plunger. <u>Slowly</u> push the water sample through the filter disk. Adjust the pressure to achieve steady, rapid drops from the filter holder outlet.

(Note: Hold the syringe and filter holder assembly in one hand and use your index finger or thumb of your other hand to apply the appropriate pressure to the plunger.)

Check for leaks along the side of the filter holder assembly and cautiously screw tighten to stop any leakage. <u>DO</u> <u>NOT</u> filter too fast or push on the plunger too hard. Excessive pressure may tear the filter disk and ruin your sample. If the filter disk is damaged during filtering, you will have to repeat this step with a new filter disk.

IMPORTANT NOTE: In a few cases it may not be possible to push a 50 cc sample though the filter. In lakes that are very turbid, with Secchi disk readings of less than two or three feet, there may be so many algal cells or soil particles in the water that the filter becomes clogged before 50 cc can be pushed through. If the plunger becomes extremely hard to push, don't force it. STOP the filtering process and note the amount of cc's that have been pushed through the filter (50 cc minus the cc's of sample remaining). On the <u>Filtering Sample</u> line on the Data Form, record the amount (cc's) of water that was successfully passed through the filter. The sample is still good. The laboratory will adjust their calculations to account for the smaller sample volume.

10. Remove the filter from holder and remove excess water.

When the syringe is empty (i.e. 50 cc of sample filtered), separate the filter holder from the syringe and carefully unscrew the filter holder to open.

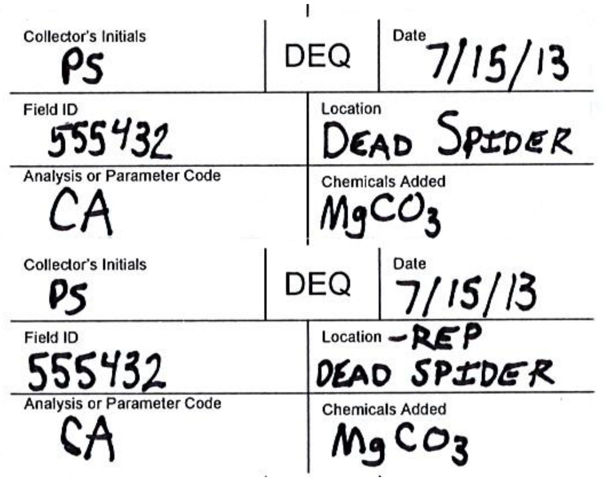
Note: At this point, the algae cells, with chlorophyll, have been removed from the composite water sample to the filter disk. Be extra careful not to touch the filter disk with your fingers.

Use the tweezers to lift out the rubber o-ring. Then, using tweezers and a large safety pin, fold the filter disk in half so the sample side of the filter (i.e. algae cells) is to the inside of the fold. Carefully, lift the folded filter disk from the filter holder and place the filter disk on a piece of paper towel, or section of a coffee filter. With the filter disk still folded in half, use the paper towel, or coffee filter, as a blotter to very gently remove any excess water from the outside of the filter disk. Using the tweezers and safety pin, fold the filter disk in half one more time so the filter disk is now folded in quarters. Continue to hold the folded filter disk with tweezers being careful not to touch the filter with your fingers.

11. Put folded filter disk in sample storage vial, label, and store in freezer.

Using the tweezers, place the folded filter disk into a sample storage vial and cap. Using only a fine tip permanent black marker, completely fill out a chlorophyll sample label and attach the label to the outside of the storage vial.

The information on the label should include:
Volunteer's Initials
Sampling Date
Field ID: The number assigned to your lake
Location: Lake name
Analysis or Parameter Code: Enter "CA" here.
Chemicals Added*:* Enter "$MgCO_3$"



Example chlorophyll vial labels, for primary sample (top) and replicate sample (bottom).

After attaching the label to the vial, cover the vial with a small piece of aluminum foil to protect the sample from light. After you filter your replicate sample, you will entirely wrap both vials together with the piece of aluminum foil. Mark the lake name and date (month/year) on the outside of the foil. Put the "foiled" sample vials into a zip-lock freezer bag and label the freezer bag with your name, the lake name, county, township and Lake Sampling Site (Field ID) Number. Fold up your data sheet, place in a separate zip-lock bag, and place it in the other zip-lock bag with your samples. Store the zip-lock bags in the freezer.

12. Filter and store a second chlorophyll sample.

For your second (i.e. replicate) chlorophyll sample repeat steps 9-11 for filtering and handling and store the vials together in the labeled zip-lock bag in your freezer.

The replicate sample will serve as a backup for the first sample should any problems occur in handling, transporting, or analyzing the sample; and 10% of lakes will have their replicate sample analyzed for quality assurance/quality control purposes.

13. Clean and dry chlorophyll sampling and filtering equipment.

After you have successfully filtered the samples and stored them in the freezer, clean the chlorophyll sampling and filtering equipment by rinsing each component with tap water (DO NOT USE DETERGENTS) and letting them air dry. When your equipment is clean and dry, loosely reassemble the filtering components and composite sampler and store the equipment in a convenient place for your next sampling event.

14. Turn in your sample

Deliver the frozen chlorophyll samples and data sheet to the designated drop-off location on the designated turn-in dates (refer to chlorophyll schedule)

There are two turn in dates for chlorophyll samples:
The June turn-in date will include your first two sets of frozen chlorophyll samples (i.e. May and June).
The late summer turn-in date for the frozen chlorophyll samples coincide with the late summer total phosphorus sampling and turn-in schedule and will include your last three sets of frozen chlorophyll samples (i.e. July, August, and September).

Very important:

- Your chlorophyll samples must be frozen when you drop them off.
- You must include your data form with the samples. Put it in a separate zip-lock bag and then put it in the zip-lock bag with the samples.
- Your frozen samples must be received no later than noon of the scheduled turn-in date.
- Do not leave the sample outside the Collection Office door and expect it to remain frozen (and for security reasons). Therefore you must deliver samples to the Collection Offices during normal business hours.

If you have a conflict with the scheduled turn-in date, you may contact your drop-off site to determine if you can turn it in early. Samples turned in late or not frozen will not be accepted or will be thrown out.

If you are unable to drop off your samples at the designated location on the specified turn-in date, you may contact the CLMP staff member responsible for sample turn-in as listed on page 2.

Reporting Your Results

While the chlorophyll samples will be analyzed by EGLE and the results entered into the data exchange by CLMP staff, the information you recorded on your datasheet (the “metadata”) also needs to be entered into the data exchange. Prior to turning in your sample and the datasheet to your designated drop off location, be sure to enter your metadata into the data exchange.

The MiCorps Data Exchange Network is an internet-based database designed to store data collected by volunteer monitors. This network allows you to enter data as well as to view data already entered into the database. You can find the MiCorps Data Exchange at MiCorps.net.

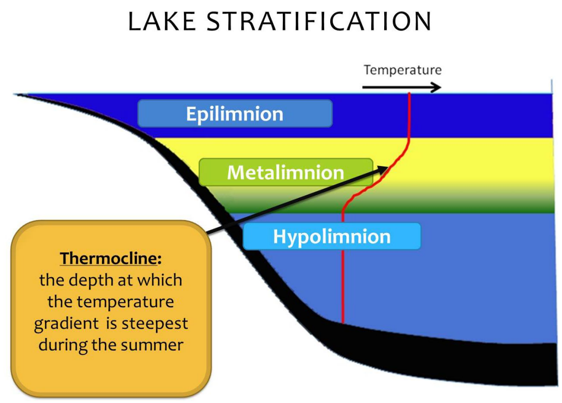
If you are unable to enter your own data into the MiCorps Data Exchange Network, program staff will enter your data for you after receiving your datasheet with your frozen chlorophyll sample. Entering your own data saves the program money and we appreciate you doing this if you are able.

D. DISSOLVED OXYGEN AND TEMPERATURE

Introduction

Dissolved oxygen and temperature are two fundamental measurements of lake productivity. The amount of dissolved oxygen in the water is an important indicator of overall lake health.

For approximately two weeks in the spring and fall, the typical lake is entirely mixed from top to bottom during a process called “overturn”, when all water in the lake is 4 degrees Celsius. In the winter there is only a small difference between the temperature of the water under the ice (0°C) and the water on the bottom (4°C). However, in the summer most lakes with sufficient depth (greater than 30 feet) are stratified into three distinct layers of different temperatures. These layers are referred to as the epilimnion (warm surface waters) and hypolimnion (cold bottom waters) which are separated by the metalimnion, or thermocline layer, a stratum of rapidly changing temperature. The physical and chemical changes within these layers influence the cycling of nutrients and other elements within the lake.



Lakes over 30 feet in depth typically stratify into three layers during the summer. Water temperature will be warmest in the upper layer (epilimnion), decline through the metalimnion, and be coldest in the hypolimnion (Figure: Michigan State University Extension).

During summer stratification the thermocline prevents dissolved oxygen produced by plant photosynthesis in the warm waters of the well-lit epilimnion from reaching the cold dark hypolimnion waters. The hypolimnion only has the dissolved oxygen it acquired during the short two-week spring overturn. This finite oxygen supply is gradually used by the bacteria in the water to decompose the dead plant and animal organic matter that rains down into the hypolimnion from the epilimnion, where it is produced. With no opportunity for re-supply the dissolved oxygen in the hypolimnion waters is gradually exhausted. The greater the supply of organic matter from the epilimnion and the smaller the volume of water in the hypolimnion the more rapid the oxygen depletion in the hypolimnion. Highly productive eutrophic lakes with small hypolimnetic volumes can lose their dissolved oxygen in a matter of a few weeks after spring overturn ends and summer stratification begins. Conversely, low productive oligotrophic lakes with large hypolimnetic volumes can retain high oxygen levels all summer.

When a lake’s hypolimnion dissolved oxygen supply is depleted, significant changes occur in the lake. Fish species like trout and whitefish that require cold water and high dissolved oxygen levels are not able to survive. With no dissolved oxygen in the water the chemistry of the bottom sediments are changed resulting in the release of the plant nutrient phosphorus into the water from the sediments. As a result, the phosphorus concentrations in the hypolimnion of productive eutrophic and hypereutrophic lakes can reach extremely high levels. During major summer storms or at fall overturn, this phosphorus can be mixed into the surface waters to produce nuisance algae blooms.

Some eutrophic lakes of moderate depth (25 to 35 feet maximum depth) can stratify, lose their hypolimnion dissolved oxygen and then destratify with each summer storm. So much phosphorus can be brought to the surface water from these temporary stratifications and destratifications that the primary source of phosphorus for the lake is not the watershed but the lake itself in the form of internal loading or recycling.

Besides the typical lake stratification pattern just described, it is now known that some Michigan lakes may not follow this pattern. Small lakes with significant depth, and situated in hilly terrain or protected from strong wind forces, may not completely circulate during spring overturn every year. Additionally, some lakes deep enough to stratify will not, if they have a long fetch oriented to the prevailing wind or are influenced by major incoming river currents. Finally, lakes with significant groundwater inflow may have low dissolved oxygen concentrations due to the influence of the groundwater instead of the lake's productivity and biological decomposition.

The dissolved oxygen and temperature regime of a lake is important to know in order to develop appropriate management plans. A lake's oxygen and temperature patterns not only influence the physical and chemical qualities of a lake but the sources and quantities of phosphorus, as well as the types of fish and animal populations.

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 thermistor. Dissolved oxygen is either measured with an electronic meter or by a chemical test. The CLMP uses an electronic meter (YSI Models 550A or Pro20) designed to measure both temperature, with a thermistor, 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.

Equipment Checklist

□ boating safety equipment* and anchor*
□ DO meter and cable/probe
□ probe cable weight
□ safety lanyard
□ quick-reference DO calibration card
□ equipment storage box and supplies
□ copy of full monitoring procedures or quick reference procedure checklist
□ DO/temperature data form(s)
□ pencil* or indelible ink pen*
□ weighted measured line*
□ Secchi disk*

*(provided by volunteer)

The CLMP has a limited number of DO meters. Enrolled lakes share meters with each other based on their proximity to each other. **There are two types of meters used by the CLMP (YSI 550A or Pro20.) In the procedures below, differences between the meters will be highlighted.**

Training

Training is required for this parameter. The CLMP leadership team will be hosting training sessions for this and other parameters in April or May in conjunction with the annual spring Michigan Lakes and Streams Association's conference.

Data Collection

1. Sampling location, frequency, and timing

Dissolved oxygen (DO) and temperature are measured from the surface to within 3 feet of the bottom, as a profile, in the deepest basin of the lake (primary sampling station). Measurements of DO and temperature should be made every two weeks from mid-May to mid-September at the same time and location that you measure Secchi disk transparency in your lake.

2. Get to know the DO/Temp Meter

All of the DO/Temperature meters are checked for "trouble-free" operation prior to distribution. New batteries are installed and the probes are fitted with a new membrane cap and fresh electrolyte solution. The probe is stored in a plastic bottle sleeve with a wetted sponge when not in use, which keeps the probe membrane from drying out. With proper storage and careful use, the membrane cap should last the entire monitoring season. However, if the membrane is damaged or gas bubbles appear in the electrolyte solution under the membrane and the meter will not calibrate, the membrane cap may have to be replaced. You have been provided with a spare membrane cap and MEA probe solution in the case that the probe membrane needs to be replaced (Refer to Appendix B: Change a D.O. Membrane). If you have any concerns or questions about damage to the probe or replacing the membrane cap, call the CLMP staff member for DO meters as listed on page 2.

The batteries in the meter should last for the entire monitoring season. However, if a "LO-BAT" message is displayed on the readout after turning the meter on, the batteries are low or damaged and they need to be replaced. The batteries are installed in the battery-chamber at the bottom of the handheld portion of the meter.

Before turning the meter on, attach the probe cable to the handheld meter cable at the bayonet connectors. The connectors have a built-in "key" to ensure proper contact alignment. Align the key, and then connect the cables by rotating the locking ring on the probe connector until it fully engages with the bayonets on the meter's connector. Check for a secure connection.

Note: the connectors should be connected by hand only! No tools should be used. The connector contacts must be kept clean and dry.

3. Calibration

For calibration and probe storage during operation and transport, the meters have a convenient chamber built into the instrument's side. If you look into the chamber, you should notice a small round sponge in the bottom. Carefully put about 10 drops of clean tap water into the chamber to wet the sponge. Turn the instrument over and allow any excess water to drain out of the chamber. The wet sponge creates a 100% water saturated air environment for probe calibration. Insert the probe into the calibration chamber.

Turn on the meter by pressing the ON/OFF button or the Power button, depending on your meter model. With the probe in the calibration chamber, allow about 15 to 20 minutes for the DO and temperature readings to stabilize.

Note: turning on the meter will activate all segments of the display for a few seconds, which will be followed by a self-test procedure that will last for several more seconds. During this power on self-test sequence, the meter's microprocessor is verifying that the system is working properly. If the meter were to detect a problem, a continuous error message would be displayed. Should a continuous error message remain on the display, contact the technical assistance number on page 2.

Note: You will need the local altitude, or elevation, to calibrate your YSI 550A DO meter. The elevation for your lake can be found on USGS topographical maps. Topographical maps can be viewed over the Internet at www.topozone.com to find lake elevations, or contact the technical support staff on page 2 for this information.

The directions below give the rest of the calibration instructions, which differ for each meter type.

Pro20: With the meter on and the probe in the calibration chamber, look at the bottom of the screen and ensure the barometer reading and salinity correction values are accurate. If the readings are accurate, continue to calibration, but if they are inaccurate, proceed to the bottom of this step for help in adjusting those values.

To calibrate the Pro20 meter, press and hold the Cal button for three seconds. The instrument will indicate "Calibrating %DO" on the display and automatically calibrate the sensor to the barometer reading and the salinity correction value. "Calibration Successful" will display for a few seconds to indicate successful calibration, then the Pro20 meter will return to the run screen. If the calibration is unsuccessful, an error message will display on the screen, and if this happens, press the Cal key to exit the error message and return to the run screen.

After successful calibration, leave the probe in the calibration sleeve and the cables connected. Carefully pack up the equipment and prepare to head out on the lake.

*If the barometer reading requires adjustment, press the UP or DOWN arrow keys from the run screen to highlight the barometer box then press enter. Use the UP or DOWN arrow keys to adjust the barometer reading to the *local, true barometric pressure.* Press ENTER to confirm and save the barometer adjustment.

Note: Weather service barometric pressure readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". The following equation will help you determine True Barometric Pressure (True BP) in mmHg for your altitude:

True BP = (Corrected BP in mmHG) – [2.5*(Local Altitude in feet/100)]

Also note that if you need to convert pressure units from inches of mercury (in) to millimeters of mercury (mmHG), simply multiply by 25.4. For example, a pressure of 29.7 in is equivalent to 754.4 mmHG).

*For freshwater, the salinity value should be 0 ppt (zero parts per thousand). If the salinity compensation value requires adjustment, press the UP or DOWN arrow keys from the run screen to highlight the salinity box, then press ENTER. Then use the UP or DOWN arrow keys to adjust the salinity compensation value to the salinity of the water you are testing. Press ENTER to confirm and save the new salinity compensation value.

550A: With the meter on and the probe in the calibration chamber, calibrate the meter by using two fingers to press and release both the DOWN ARROW (▼) and UP ARROW (▲) buttons at the same time (or DOWN ARROW slightly ahead of UP ARROW). The main display will indicate the letters CAL with the DO measurement units (% or mg/l) on the right side of the display and a small "CAL" box (lower left). Press the MODE button until "%" is displayed for the DO measurement units. Press the ENTER button (marked with an arrow pointing to the left).

The main display will indicate a number for the altitude value and a small “ALT x100ft” box (upper right). The altitude value is in hundreds of feet. For example, a number 9 here indicates 900 feet (9 x 100 feet). Use the UP or DOWN arrow keys to increase or decrease the altitude value to approximate the local altitude of your lake. When the proper altitude value appears on the display, press the ENTER button.

The meter should now indicate the current DO reading in % air saturation (main display) and the DO calibration value (lower right display). These values may not be the same. Make sure that the current DO reading (main display) is stable (not drifting up or down), then press the ENTER button

Record the DO calibration (% air saturation) reading (main display), the calibration temperature (^{o}C), and the lake altitude value on the DO/temperature data form.

The display should now indicate a small “SAL ppt” box (upper left) and a salinity value of 0.0 (zero parts per thousand) in the main display. If a different number is displayed here, use the DOWN ARROW key to decrease the salinity setting to 0.0 (for fresh water). When 0.0 is displayed press the ENTER button.

The display should return to the normal operation mode with the current calibrated DO (% air saturation) and temperature (^{o}C) readings. (*Note:* the DO calibration values should be in the range of 93 to 103% air saturation for the altitude range of 550 to 1400 feet.)

Leave the DO meter on and leave the probe in the calibration chamber (make sure that the stopper with wetted sponge stays in place). Carefully pack up the equipment in the storage box and prepare to head out on the lake.

4. Proceed to your sampling location and orient boat for sampling

Your meter should now be calibrated.

Travel to the deepest basin of the lake (primary sampling station) for the DO and temperature measurements. Approach the sampling location from the upwind direction. Turn off boat motor, lower the anchor, and allow the boat to drift over the sampling station (deepest point) before securing the anchor line. This allows you to take your DO and temperature measurements over a relatively non-disturbed area. When in position, take out the DO/temperature data form (provided with these monitoring instructions) and record your lake’s name, county, township, and Lake Sampling Site (Field ID) Number on the data form. Record your name(s) and the date, time, weather conditions and any unusual lake conditions. Circle the Meter Model type and record the CLMP Meter ID# (e.g., IL-1, IL-12, MLSA-4, etc.) which is marked on the meter and storage box. Also, on the bottom of the first page of the data form draw an outline of your lake and mark the approximate sampling location.

5. Verify sampling station depth.

With a weighted line that is marked off in feet (or your Secchi disk and line) determine the actual depth of the sampling location. Lower the weighted line until it gently contacts the bottom sediments. Note the depth and record the depth on the DO/temperature data form. (*Note:* do not use the DO cable/probe assembly for this measurement since contact with the sediments may cause probe/membrane damage.)

6. DO/temperature profile measurements.

Make sure the DO measurements are in units of mg/l and not %. Press the MODE button to switch between these measurements.

You are now ready to take the DO/temperature profile measurements. You will be measuring DO/temperature at 5-foot intervals in the upper (epilimnion) and lower (hypolimnion) part of the water column and at 2½-foot intervals through the thermocline in the metalimnion of the lake. Generally the thermocline sets up between 15-40 feet depths during the summer. The cable has been marked at 10-foot (white tape and depth indicated) and 5-foot (orange tape) intervals. The 2½-foot point is simply the mid-point between the 10-foot and 5-foot markings.

A small weight has been attached to the cable near the probe so the cable/probe will sink straight down (i.e. perpendicular) from the surface of the lake into the water column.

Note: if it is too windy the cable/probe may not remain perpendicular to the surface of the lake while taking the measurements. It is best to take the DO/temperature measurements on a calm day.

Before taking the first measurement, adjust the hand strap on the meter to fit snugly around your hand. Also, attach the safety lanyard, which is attached to the meter, to your belt, belt loop, or your wrist. These precautions will help to minimize the possibility of dropping and damaging the meter while taking the DO/temperature measurements in the lake.

For the first measurement, place the cable/probe into the lake approximately 1 foot below the surface. Gently agitate the probe sensor by jigging the probe cable a few inches. Once the DO and temperature readings stabilize record the measurements (with pencil or indelible ink pen) on the back page of the data form.

Lower the cable/probe and continue the DO/temperature measurements at each 5-foot (or 2½-foot) interval as indicated on the data form with the last measurement taken 2½-3 feet above the bottom sediments of the lake. To avoid damage to the probe/membrane, do not contact the bottom sediments. Make sure you record the DO and temperature readings for each depth interval on the data form.

(**Note**: DO meters requires continuous water movement at the probe sensor for accurate DO measurements. This is accomplished with gentle agitation (i.e. jigging the cable/probe a few inches) during the measurements. Allow sufficient time at each depth for the DO and temperature readings to stabilize before recording the results and proceeding to the next depth interval.)

See a completed example data form a few pages ahead

7. Returning the DO Meter

Dissolved oxygen meters must be returned to EGLE each fall, no later than October 31, for required EGLE maintenance activities. DO group leaders are responsible for ensuring the meters are returned to EGLE. Meters may be returned to the local EGLE or DNR office that collects chlorophyll and phosphorus samples, or transported or shipped to the MiCorps EGLE representative (Tamara Lipsey; lipseyt@michigan.gov). EGLE office locations and phone numbers are described by both phosphorus and chlorophyll sampling schedules: (https://micorps.net/lake-monitoring/clmp-documents/).

Please call the EGLE office or Tamara Lipsey (517-342-4372) to schedule the delivery of the meter.

Reporting Your Results

The MiCorps Data Exchange Network is an internet-based database designed to store data collected by volunteer monitors. This website allows you to enter data as well as to view data already entered into the database. If you can, please enter your data into the MiCorps Data Exchange found at MiCorps.net. You may enter your data into the MiCorps Data Exchange after each sampling event or at the end of the sampling season.

If you are unable to enter your own data into the MiCorps Data Exchange Network, please send your datasheet to the address listed below and program staff will enter your data for you. Entering your own data saves the program money and we appreciate you doing this if you are able.

<u>Mail in your field datasheets</u>

Whether you entered your data online or not, mail in a copy of your data sheets at the end of the season. All data must be entered into the database and hard copies mailed no later than October 31st.
Michigan Lakes and Streams Association, Inc.
P. O. Box 303
Long Lake, MI 48743

Cooperative Lakes Monitoring Program

Dissolved Oxygen and Temperature

Data Form 2013

Michigan Clean Water Corps

Lake Name: Dead Spider County: Lake Township: Inland

Lake Sampling Site (Field ID) Number: 380317 (mark location on map below)

Latitude: 44.67 °N Longitude: 85.49 °W

Volunteer Monitor Name(s): Barry Turbid

Date Sampled: 9-15-2013 Time: 12:30 pm

Weather Conditions (sunny, cloudy, windy, etc.): calm, Sunny

Unusual Conditions (heavy rain, boating, etc.): none

Sampling Station Depth (measured): 65 feet

DO/Temp. Meter (circle one): YSI Model 95D YSI Model 550A YSI Pro20

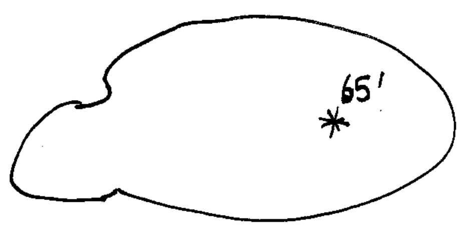
CLMP Meter ID# : MLSA-2 (If this is your meter, enter «Our Meter»)

Calibration Values (For 95D and 550A only; Pro20 does not give calibration values):
DO: 96.3 % air saturation (Must be 95-98%; Troubleshoot if out-of-range)

Temperature: 20.1 °C Lake Altitude Value: 8 (x100 ft.)

In the box below draw an outline of your lake (or attach copy of lake map). Mark your DO/temperature sampling location (this should be the deepest basin in the lake) and write the total lake depth at this location.

North



Lake Name: Dead Spider Surface Area: 240 (acres)

CLMP DO Temp Data Form Page 1 January 2013

****CAUTION: Remember to switch to mg/l mode before making oxygen measurements.****

Depth (ft.)	Temp (°C)	DO (mg/l)	Depth (ft.)	Temp (°C)	DO (mg/l)
1	20.4	9.2	37½	10.9	0.4
5	20.4	9.2	40	10.1	0.2
10	20.4	9.2	42½	9.5	0.1
15	20.3	9.1	45	9.2	0.0
17½	19.3	9.1	50	8.5	0.0
20	18.6	9.0	55	8.3	0.0
22½	18.0	8.5	60	8.2	0.0
25	16.0	7.4	~~65~~ 62.5	8.1	0.0
27½	14.0	7.0	~~70~~		
30	12.8	5.0	~~75~~		
32½	11.9	0.8	~~80~~		
35	11.5	0.7	**Note**: Take last measurement 2½-3 ft. above bottom sediments of the lake.		

Graphing: If you want to graph your data, you can print the graph from this website: http://www.micorps.net/documents/DO-TempDataPlottingForm.pdf

DATA ENTRY

Check **ONE** box:

☒ The data **have** been entered into the MiCorps Data Exchange (before October 30!) Date entered 9-20-13.

☐ The data **have not** been entered into the MiCorps Data Exchange.

DATA SHEET TURN IN

No matter what box you check above, please do the following:

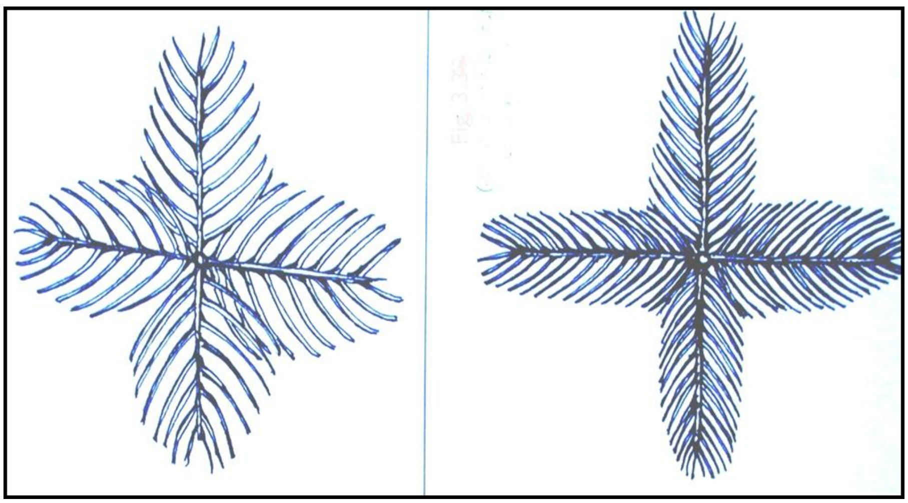
Make a copy for your records, and mail data form by October 30 to: ✓

The address here changes year to year. Refer to the actual data sheet to get the current address.

E. EXOTIC AQUATIC PLANT WATCH

Introduction

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. However, sometimes a lake is invaded by an aquatic plant species that is not native to Michigan. Some of these exotic plants, like Curly-leaf Pondweed, Eurasian Milfoil, Starry Stonewort, European frog-bit and Hydrilla can be extremely disruptive to the lake's ecosystem and recreational activities.



Stem cross sections at a leaf node of a typical native milfoil (left) and Eurasian milfoil, an invasive, non-native plant (right). Note that Eurasian milfoil has more leaflets on each leaf than native milfoils. Eurasian milfoil generally has more than 12 leaflets on one side of the leaf's central axis, while native milfoils have fewer than 12.

To avoid a takeover by exotic plants, it is necessary to use Integrated Pest Management (IPM) strategies: monitoring, early detection, rapid response, maintenance control and preventive management. For more information on these strategies, check out Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes (MSU Extension Water Quality Publication WQ-56, available electronically at https://micorps.net/lake-monitoring/clmp-documents/ .

The purpose of this Cooperative Lakes Monitoring Program (CLMP) monitoring project is to provide lake communities with a strategy for monitoring for extremely troublesome exotic aquatic plants, so the community can detect early infestations of these disruptive species. If detected early the community can use IPM strategies to reduce the probability that the exotic infestation will cause significant disruptions to the lake ecosystem and recreational uses. Monitoring by the lake community is recommended even if a professional plant management company has been hired. Independent monitoring will help the community verify the success of plant management efforts and identify future needs.

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

Volunteer participants are trained to identify select exotic aquatic plants of concern for Michigan lakes: currently, curly-leaf pondweed, Eurasian milfoil, starry stonewort, European frog-bit, and Hydrilla. Using a GPS unit, volunteers survey their lakes and map the location of any exotic plant beds with the GPS unit, or by hand.

Training

Training is **required** for this parameter. The CLMP leadership team will be hosting training sessions for this and other parameters in April or May in conjunction with the annual spring Michigan Lakes and Streams Association's conference. Attending this training is highly recommended at least once to assure quality data collection and to develop relationships among other volunteers and resource people.

At this training, volunteers will receive training in exotic plant identification, detailed instruction on the sampling procedures, and have a chance to ask questions about invasive plant monitoring and management with experts and volunteers from other lake communities.

Equipment Checklist

□ boating safety equipment and anchor
□ copy of these monitoring procedures
□ copy of data form
□ plant identification guides (*A Michigan Boater's Guide to Invasive Aquatic Plants*, [MSU Extension E-31891], and other supplemental materials)
□ a depth map of the lake
□ global positioning system (GPS) unit (optional)
□ camera (digital preferred)
□ weighted sounding line
□ weighted rake and retrieving line (see Appendix)
□ zip-lock bags, and marker for labeling
□ trash bags
□ clipboard
□ pencil or indelible ink pen

Sample Collection

Collect your samples between mid-June to mid-August when the weather is good. (Additional surveys later in the summer can be conducted, but are not required.) On the chosen monitoring day, prepare the boat, safety equipment, monitoring equipment, and supplies. If the lake to be monitored is large, multiple sampling teams may be needed or one sampling team may require several days.

Develop a systematic procedure for covering the lake from shore out to the 15-foot depth contour (in most lakes, rooted aquatic plants do not grow well in water deeper than 15 feet). Space sampling locations evenly across the lake to get good coverage. Also, be sure to sample in areas where there is a high likelihood that invasive species could be introduced to your lake, including near boat launches, marinas, and stream inlets that connect to lakes upstream.

To sample, carefully toss your collection rake into the water and pull up plants. (Instructions for building your own rake are on page 48.)

Be sure to also look around the area for plants you may not have collected with your rake. While moving around your lake, collect plants and compare them with the identification guides. If you find an exotic plant, use your GPS unit to identify the colony's coordinates. (*You may use your unit's default coordinate system, but if possible, report coordinates in decimal degrees).*

Also, use pencil or indelible pen to mark the location of the plant on a paper lake depth map. Use a numbering system to identify each location on the map, and on a separate sheet identify each numbered location's GPS coordinates and the species found there.

(Alternatively, use your GPS coordinates and Google Maps or Google Earth online to create a map. For more information on using Google Earth visit the following links for "marking places" (earth.google.com/userguide/v4/ug_placemarks.html) and "Importing data from GPS devices" (https://support.google.com/earth/answer/148095?hl=en).)

If you find a plant that you are uncertain about, you can send a picture or small sample of the plant to Michigan State University. Take a six-inch piece of the plant, pat it dry but not completely dry, wrap in slightly damp paper towel, and place in a small plastic bag. Contact MSU support staff prior to sending plant samples for mailing instructions and timing (contact information on page 2). Your samples will be identified and you will be contacted with the results.

Do not throw exotic aquatic plants that you collect on your sampling rake back into the lake. Keep the plants in the bottom of the boat, or place in trash bags, and dispose when you return to shore.

Continue sampling and locating exotic plant colonies until the entire lake has been sampled. If time permits you may want to do two surveys, one in early summer (mid-June to July) and a second in late summer (September).

Photographs

Photographs are an excellent way to document the plants you find. When photographing plants, it helps to lay the plant on a light-colored background, with the leaves spread out so that distinguishing features can easily be seen (leaf shape, size, number of leaflets, etc.). If you are unsure of the identity of a plant, a few good photos could eliminate the need to ship actual specimens to MSU Extension for identification; instead, a quick email with a few digital photos may be sufficient for expert identification, and a faster response. Photographs of plants from your lake can also be a useful tool for educating neighbors and members of your lake community about the plants that are found in your lake, and a good reference for you for future surveys.

A volunteer on Murray Lake (Kent County) removes aquatic plants from a sampling rake while conducting the Exotic Aquatic Plant Watch. Volunteers learn to survey their lakes for invasive plants that can adversely impact lake health (MiCorps photo by Angela De Palma-Dow).

Monitoring Report

Volunteers with the exotic aquatic plant watch should create a monitoring report. Use the Exotic Aquatic Plant Watch data sheet as the cover for your report. Complete the data sheet and attach your lake map or Google Earth map and GPS coordinate sheet. You may also wish to include photographs or other supporting materials.

Please note – **a report should be completed even if no exotic plants are found**. Simply fill out the Exotic Aquatic Plant Watch data sheet and indicate that the survey was conducted, but no exotic plants were found. This simple report will serve as a record of your monitoring efforts for your lake community and for the CLMP program.

When your report is complete, send a copy to the contact listed on the Exotic Plant Watch data sheet. You may send a paper copy, or provide an electronic copy via email. Be sure to keep a complete copy of the report for your own records!

Quality Assurance/Quality Control

As part of the quality assurance/quality control (QA/QC) process for the CLMP, you may be asked to submit plant samples, or MiCorps staff may coordinate with you to conduct side-by-side sampling on your lake. If your lake is selected for the QA/QC process, you will be contacted directly.

F. AQUATIC PLANT IDENTIFICATION AND MAPPING

Introduction

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. In this situation, it is 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 will greatly aid management projects.

The Aquatic Plant Identification and Mapping parameter is the most labor-intensive volunteer activity within the CLMP. Typically, a team of volunteers from each enrolled lake is involved, with assistance from a MiCorps biologist.

Preparation begins with volunteers attending a half-day intensive training on aquatic plant identification and mapping techniques. Prior to heading to the lake, the volunteers develop a sampling strategy for their lake, based on size and known areas of plant growth. Sampling transects (straight lines parallel to shore) are identified, along which plant samples are collected, generally at the one, four and eight foot depths with a constructed sampling rake. The rake is tossed out into the lake and retrieved from the four compass directions. The density of each plant species is determined by its presence on one, two, three or all four of the rake tosses. The sampling effort often requires several days. The data from all the transects then are used to create a plant distribution map and report.

Quantifying the aquatic plant populations of a lake is not an easy task. On many lakes, people working off the water surface can't even see the plants growing below. Additionally, sampling procedures which will collect aquatic plant data that can be statistically analyzed are complicated and time consuming. Consequently, the Cooperative Lakes Monitoring Program (CLMP) is testing qualitative techniques that allow volunteer monitors to generally assess the aquatic plants in their lake. This assessment may be viewed as a "snapshot" of the species of plants in the lake, their general location and relative abundance. Although not quantitative, the CLMP's assessment will provide valuable information about a lake's aquatic plants that is often missing in many lake and aquatic plant management programs.

The procedure used in the CLMP assessment is written up in the book, *A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes*. Copies of this book may be obtained from Michigan Lakes and Streams Association, Inc.

(MLSA) or Michigan State University Extension. As discussed in the book, the assessment procedure may be slightly modified to accommodate the volunteer monitor's skills and resources.

Training

On-site training is **required** for this parameter. The CLMP leadership team will be hosting training sessions for this and other parameters in April or May in conjunction with the annual spring Michigan Lakes and Streams Association's conference.

Equipment Checklist

□ boating safety equipment and anchor
□ copy of monitoring procedures (*A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes*)
□ a depth map of the lake
□ field recording sheets
□ weighted sounding line
□ weighted rake and retrieving line
□ zip-lock bags
□ clipboard
□ pencil or indelible ink pen
□ camera (optional; digital preferred)

Sample Collection

Sample collection procedures are detailed in Chapter 5 of *A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes* by Wandell and Wolfson (2007). Additionally, this reference provides information on aquatic plant identification (Chapter 3) and how to make a plant collection (Chapter 4). A plant collection can aid with volunteer training for the plant mapping project.

Photographs

Photographs are an excellent way to document the plants you find. When photographing plants, it helps to lay the plant on a light-colored background, with the leaves spread out so that distinguishing features can easily be seen (leaf shape, size, number of leaflets, etc.). If you are unsure of the identity of a plant, a few good photos could eliminate the need to ship actual specimens to MSU for identification; instead, a quick email with a few digital photos may be sufficient for expert identification, and a faster response. Photographs of plants from your lake can also be a useful tool for educating neighbors and members of your lake community about the plants that are found in your lake, and a good reference for you for future surveys.

Reporting Results

When the aquatic plant sampling is over, complete the aquatic plant map and data sheet as described in the book by Wandell and Wolfson. Make a good copy of the map and data sheet and mail both along with the lake map delineating sampling stations and a list of the aquatic plant identification code numbers used in the mapping project for species identification to the aquatic plant contact listed on page 2.

G. SCORE THE SHORE

Introduction

Healthy shorelines are an important and valuable component of the lake ecosystem. The shoreline area is a transition zone between water and land, and is a very diverse environment that provides habitat for a great variety of fish, plants, birds, and other animals. A healthy shoreline area is also essential for maintaining water quality, slowing runoff, and limiting erosion.

However, Michigan's inland lake shorelines are threatened. Extensive development, often combined with poor shoreline management practices, can reduce or eliminate natural shoreline habitat and replace it with lawn and artificial erosion control such as seawalls and rock. As a result, shoreline vegetation is dramatically altered, habitat is lost, and water quality declines.

Therefore, the MiCorps Cooperative Lakes Monitoring Program has introduced a new monitoring program – Score the Shore – that enables volunteers to assess the quality of their lake's shoreline habitat.

Uses of the Data

The information gathered during this assessment will allow lake communities to identify high-quality areas that can be protected, as well as opportunities for improvement. Score the Shore data, combined with educational resources describing the value of healthy shorelines and how to restore and maintain them, can be incorporated into lake management planning and used for educating lakefront property owners. The Michigan Natural Shoreline Partnership (MNSP) is a collaboration of agencies and professionals that promotes natural shoreline practices to protect Michigan's inland lakes. The MNSP website (www.mishorelinepartnership.org) includes materials and information that can be used in educational efforts. MNSP also offers training for professional educators and landscape contractors, and maintains a list of trained educators who may be available to speak to your community about natural shorelines.

Score the Shore data, just like all CLMP data, is available to any interested parties through the MiCorps Data Exchange. State agency staff and researchers regularly access CLMP data to better understand and manage Michigan's inland lakes.

It is important to understand that Score the Shore is a descriptive process for assessing shoreline quality on Michigan's inland lakes. It is also a valuable educational tool. Score the Shore is not a regulatory program, nor is it intended to tell people what they can and cannot do on their property. The Michigan Department of Environment, Great Lakes, and Energy's Inland Lakes and Streams Program has responsibility for shoreline protection on public lakes. To learn about their shoreline protection program, including construction permitting and recommendations for shoreline management, visit https://www.michigan.gov/egle/0,9429,7-135-3313_3681---,00.html.

Training

Training is required for this parameter. The CLMP leadership team will host annual training sessions. At this training, volunteers will receive training in how to conduct the Score the Shore survey, and have a chance to ask questions about shoreline monitoring and management with experts and volunteers from other lake communities.

Equipment Checklist

- ☐ Boat
- ☐ Boating safety equipment
- ☐ Copies of Data Forms
- ☐ Copy of these Procedures
- ☐ Pencils or waterproof pens
- ☐ Clipboard(s)
- ☐ GPS unit*
- ☐ Camera* (digital if possible)
- ☐ Binoculars*
- ☐ 2 tally counters*

*optional

Survey Procedure

1. Survey planning, frequency and timing

The time commitment required to complete the Score the Shore survey depends on the size of your lake. Before conducting the survey, time is needed to review the procedures and establish shoreline sections. Shoreline sections are approximately 1000’ in length. You will complete a Data Form for each shoreline section. Score the Shore is most efficient when conducted by a team of volunteers (see below). When you begin, surveying a single section may take you 30 minutes or more. You’ll get faster as you move around the lake and become familiar with the required observations.

The survey is best completed during the summer, when vegetation is abundant and easy to observe both in the water and on land. Making observations in the middle of the day can make it easier to view underwater vegetation. It is fine to conduct the survey over the course of several days or even weeks; just be sure to keep careful track of where you stop and start.

In most cases, it is not necessary to conduct a Score the Shore survey every year. Shoreline conditions on *most* lakes do not change dramatically from year to year. You may conduct the survey as frequently as you wish, perhaps once every three to five years.

To complete this survey, you will be boating near shore and making observations about shoreline properties. Remember to be a good neighbor, and respect the privacy of others on the lake while conducting the survey. It's a good practice to let your neighbors know that the survey will be conducted, and to respond to any questions or concerns. They may want to join you in your monitoring efforts!

2. Prepare for the survey

Step 1 - Establish your survey sections in advance. You will assess the entire shoreline of your lake, in 1000-foot sections. **It is not critical that the sections be exactly 1000 feet long. Do not worry about following every curve in the shoreline.**

To establish the sections in advance, using one of the following methods:

1. Using a lake map, mark off sections of shoreline that are approximately 1000 feet long. This will serve as a general guide. Then, boat around the lake (prior to conducting the survey) to identify landmarks (houses, docks, trees, etc.) or record GPS coordinates (latitude and longitude) that establish the start and endpoints of each section. A GPS-enabled device is not required for this method.
2. Travel around the lake by boat with a GPS-enabled device that tells you when you have traveled 1000 feet. Pick landmarks, or GPS coordinates a set distance from shore, to define the sections.

Number the sections sequentially (1, 2, 3…) and record the appropriate section number on your Data Forms while conducting the survey.

Note – Canals and Channels: In general, narrow canals and channels that provide access to the lake experience different conditions, and are maintained differently, than the lake itself, and typically should not be included in the Score the Shore survey.

Step 2 – Review the Helpful Hints on Navigation, Estimating Percentages, and Teamwork, below, before conducting the survey.

Helpful Hint: **Navigation**

This survey is designed to be conducted by boat. Plan to survey on a relatively calm day(s), with limited boat traffic, so you can easily navigate your boat around the shoreline of your lake.

You may find that it is easiest to make more than one pass with your boat along the length of the 1000' section to make your observations. For example, estimating what percentage of the 1000' section is covered with a seawall may be easier at a distance (perhaps 100 yards from shore), while observing downed trees and vegetation is easier from a closer proximity (perhaps 20-30 yards from shore). Remember to navigate safely and be aware of obstacles! Binoculars may come in handy.

The Data Form is organized so you can easily observe all required characteristics in three passes. You do not have to collect the data in this order, but we recommend giving it a try!

Helpful Hint: **Estimating Percentages**

The Data Form frequently asks you to categorize shoreline characteristics as a percentage of the length of the 1000' foot section, like this:

_____ None _____ <10% _____ 10-25% _____ 25-75% _____ >75%

These are broad categories (especially 25-75%) but were chosen carefully to (1) effectively reflect each characteristic's impact on shoreline habitat quality, and (2) keep the survey process efficient and time-effective. With a bit of practice, you should become comfortable with estimating these categories fairly quickly as you move around the lake.

Helpful Hint: Teamwork

Score the Shore is most efficient when conducted by a team of volunteers. Be sure everyone is familiar with these procedures and the forms before you begin. The boat driver will need to focus on locating the start point of each segment and navigating the boat so the observers can see the shoreline features easily. Make sure all observers agree on start and end of section before observations begin. The observers on the boat may want to divide up features to observe, and the team should work together to agree on their answers on the Data Form. To maintain consistency, the same team of observers should conduct the entire survey if possible. Upon reaching the end of the section, the driver should idle the boat until all observers reach consensus on the answers to each question on the Data Form. Make sure one person is designated to record the final, agreed-upon answers.

3. Conducting the Survey

Navigate to the beginning of your first 1000' section to begin the survey. At the top of your Data Form, record the section number, lake name/county, and date, as well as the GPS coordinates of your boat's location OR a landmark on shore at the start of the section. Navigate the length of the section and complete the Data Form as described below.

Homes/Major Buildings: the number of homes or other significant structures (restaurants, yacht clubs, etc.) visible from the water within the section. Do not count

small sheds or other minor structures. The optional tally counters, or “clickers”, can help with counting these and other features during your survey.

Docks/Boatlifts: A dock with a boatlift counts as one.

Littoral (Aquatic) Zone Characteristics and Shoreline Erosion: For the purposes of this survey, the littoral zone is the aquatic zone between your boat and the shore when you are making these observations (approximately 20-30 yards from shore). If the lake bottom drops off quickly, you may make the observations closer to shore. If the lake level is low, and there are exposed areas along the shoreline that are at least sometimes under water, include this drawdown area in your littoral zone assessment.

% Emergent/Floating vegetation (Fig. 1): Emergent vegetation includes plants that grow up out of the water, like cattails and pickerelweed. Floating vegetation includes plants like water lilies and duckweed. Estimate the percent coverage in this section.

% Submerged vegetation (Fig. 2): These are plants that grow completely under the water (perhaps except for the tips/flowers), including milfoil, coontail, and pondweeds. Estimate the percent coverage in this section. Glare, turbidity, or low light can make observations of submerged vegetation difficult. Conducting the survey mid-day make it easier. If you cannot see to observe submerged vegetation, indicate this on the Data Form.


Fig. 1. Emergent and floating vegetation


Fig. 2. Submerged vegetation

Is aquatic plant management evident/known?: If you know that plants are being controlled (sprayed, harvested, etc.), you can note that here, even if you can’t see evidence at the time of the survey. If you don’t know, it’s not evident – so check “No”. “Minor” plant management is limited weed treatment or removal, for example, just around docks or small swimming areas. “Major” management is removal of most or all aquatic plants in a large area.

Amount of Downed Trees/Woody Debris: Estimate the total number of submerged or partially submerged fallen trees, branches, and logs in the entire section. Focus your estimate on wood at least 3" in diameter.

Erosion along shoreline (Figs. 3-4): Do you see any? If so, how would you characterize it? Sand beaches are not necessarily active erosion sites; include them only if there is evidence that the sand is actively eroding into the lake. Include erosion caused by natural action of wind, waves, or ice, as well as erosion caused by human activity (e.g., boat wakes, soil disturbance).

Fig. 3. Moderate erosion, due to extent along quite a bit of shoreline

Fig. 4. Severe, localized erosion

Riparian (Land Near Shore) Zone Characteristics: The riparian zone is the area of land closest to the water.

% Maintained lawn, Maintained/Artificial Beach, or Impervious: Estimate the percentage of the total section length. If you are working on a sand-bottom lake, do not include natural beaches in this estimate. "Impervious" refers to artificial surfaces like pavement, compacted gravel, and other surfaces which water cannot penetrate.

% Unmowed Vegetation Belt (Fig. 5): Estimate the percentage of the total section length that is covered by vegetation other than lawn.

Average Unmowed Vegetation Belt Depth (Fig. 6): How far upland from the water's edge does unmowed vegetation extend?

Fig. 5. Narrow, unmowed vegetation belt, above

Fig. 6. If unmowed vegetation is so dense you

sloped artificial erosion control *can't tell how far it goes back, choose >40 feet.*

Shoreline Erosion Control Practices:

Vertical Artificial (Fig. 7): Estimate the percentage of the section length covered by vertical, artificial erosion control structures. Check each type of structure you observe (seawall, boulders/rock walls, other) that are clearly vertical (or nearly so).

Sloped Artificial (Fig. 8): Estimate the percentage of the section length covered by sloped, artificial erosion control structures. Check each type of structure you observe (concrete, riprap, other) that are not clearly vertical.

Fig. 7. Vertical artificial erosion control includes seawalls, boulders, and rock walls.

Fig. 8. Sloped artificial erosion control includes rock and riprap, even in minor amounts.

Bioengineering (Figs. 9-10): This is the intentional use of natural materials to combat erosion, including intentionally placed stumps, branch bundles, and coir (coconut fiber) rolls. Estimate the percentage of the section length covered by bioengineering.

Fig. 9. Coir (coconut fiber) logs are a type of bioengineered erosion control.

Fig. 10. Intentionally placed stumps and brush bundles are also used for bioengineered erosion control.

Record the GPS coordinates or landmark at the end of this section.

Comments or Concerns: There is room on the back of the page to include any notes about unusual observations, observations that were difficult to make or estimate, photos taken, or any other comments or concerns about this section.

Before moving on to the next shoreline section, take a moment to make sure everyone agrees on the answers recorded on the Data Form.

4. Scoring

Many of the items on the Data Form include a point value, in parentheses, that ranges from 4 to -4. After completing a Data Form, tally the points that apply to the observations you made. There are boxes for the subtotals for the three main parts of the Data Form (Littoral Zone, Riparian Zone, and Erosion Control). On the back of each Data Form, there are instructions for converting these subtotals to a 0-100 scale. This bit of additional math will make your scores easier for others to interpret.

When the survey is complete, calculate the Development Density and Overall Shore Score for your lake by following the instructions on the Survey Cover Sheet. Development Density and Overall Shore Score are often related.

5. Completing the Report

A complete Score the Shore report includes the following elements:

1. Survey Cover Sheet:

> The Survey Cover Sheet should be completed at the end of the survey, and should accompany your set of Data Forms for submission to MiCorps (see Reporting Your Results, below).
>
> Your Lake Sampling Site (Field ID) Number will be provided to you by the CLMP; if you have not received a number for your lake, leave this blank, and contact CLMP staff for assistance.

2. Set of all Data Forms, one for each shoreline section.

3. Survey Map

> Include a map that indicates the general locations of the numbered shoreline sections in your survey. The map may be hand-drawn or computer-generated.

4. Photographs (optional)

> Photographs are an excellent way to document shoreline conditions. You may submit copies of photographs with your report. Be sure to label the photos in a manner that

indicates both the shoreline section where they were taken, and the date.

Quality Assurance/Quality Control

As part of the quality assurance/quality control (QA/QC) process for the CLMP, MiCorps staff may coordinate with you to conduct side-by-side scoring on your lake. If your lake is selected for the QA/QC process, you will be contacted directly.

Reporting Your Results

Volunteers are able to enter their data into the MiCorps Data Exchange, like all parameters. You can also submit electronic pictures, but please be sure to follow the directions given on the Data Exchange. Also, because of technical limitations at this time, all of the sections must be entered in a single session.

Whether you enter data or not: Send a paper copy to the address given on the data sheet, or provide an electronic copy via email to the address below on this page. Be sure to keep a complete copy of the report for your own records!

All data must be entered and the copies received **no later than October 31th**. Information received after this date may not be included in your lake's CLMP Annual Report.

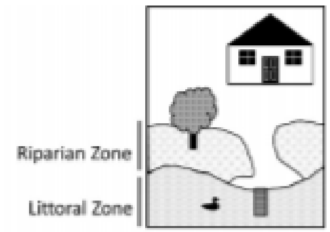
Technical Support and Contact Information

Should you have any questions or comments about the Score the Shore procedures or forms, or have problems during the scoring process, please contact:

Dr. Jo Latimore
latimor1@msu.edu

Section #: _____ Lake/County:_______________________________ Date:___________

GPS/Landmark at Start of Section: ____



PASS 1 (Boat is 100 yards from shore):

Number of: Homes/Major Buildings: _________

Docks/Boatlifts:________

PASS 2 (Boat is 20-30 yards from shore):

Littoral (Aquatic) Zone Characteristics and Shoreline Erosion: **Littoral Zone Raw Score:** ☐

% Emergent/Floating Vegetation___ None (0) ____ <10% (1) ___ 10-25% (2) ___ 25-75% (3) ____ >75% (4)

% Submerged Vegetation ___ None (0) ____ <10% (1) ___ 10-25% (2) ___ 25-75% (3) ____ >75% (4)

_____ Unable to see

Is aquatic plant management evident/known? ____ No (0) ____ Minor (at docks, swim areas; -1) ____ Major (-2)

Amount of Downed Trees/Woody Debris: ____ None (0) ____ Few: 1-5 (1) ____ Several: 6-15 (2) ___ Many: 16+ (3)

Erosion along shoreline (check one):___ None observed (0) ____ Minor (-1) ___ Moderate (-2) ___ Severe (-3)

PASS 3 (Boat back out to 100 yards from shore):

Riparian (Land Near Shore) Zone Characteristics: **Riparian Zone Raw Score:** ☐

% Maintained Lawn, Maintained/Artificial Beach, or Impervious (% of total section length):

_____ None (0) _____ <10% (-1) _____ 10-25% (-2) _____ 25-75% (-3) _____ >75% (-4)

% Unmowed Vegetation Belt (any vegetation other than lawn; % of total section length):

_____ None (0) _____ <10% (1) _____ 10-25% (2) _____ 25-75% (3) _____ >75% (4)

Average Unmowed Vegetation Belt Depth:

_____ None (0) _____ < 10 ft. (1) _____ 10-40 ft. (2) _____ > 40 ft. (3)

Shoreline Erosion Control Practices: **Erosion Control Raw Score:** ☐

Vertical Artificial: _____ None (0) ____ <10% (-1) ____ 10-25% (-2) ___ 25-75% (-3) ____ >75% (-4)

Types of Vertical Structure (check all that apply) _____ Seawall _____ Boulders /Rock Walls

_____Other - describe:

Sloped Artificial: _____ None (0) ____ <10% (-1) ____ 10-25% (-2) ___ 25-75% (-3) ____ >75% (-4)

Types of Sloped Artificial (check all that apply) _____ Concrete _____ Rock/Riprap

_____ Other - describe:

Bioengineering (e.g. coir logs, branch bundles):

___ None (0) ___ <10% (-0.5) ___ 10-25% (-1) ___ 25-75%(-1.5) ____ >75% (-2)

GPS/Landmark at End of Section: __________________________

Go to back for Final Scoring and Comments

IV. APPENDICES

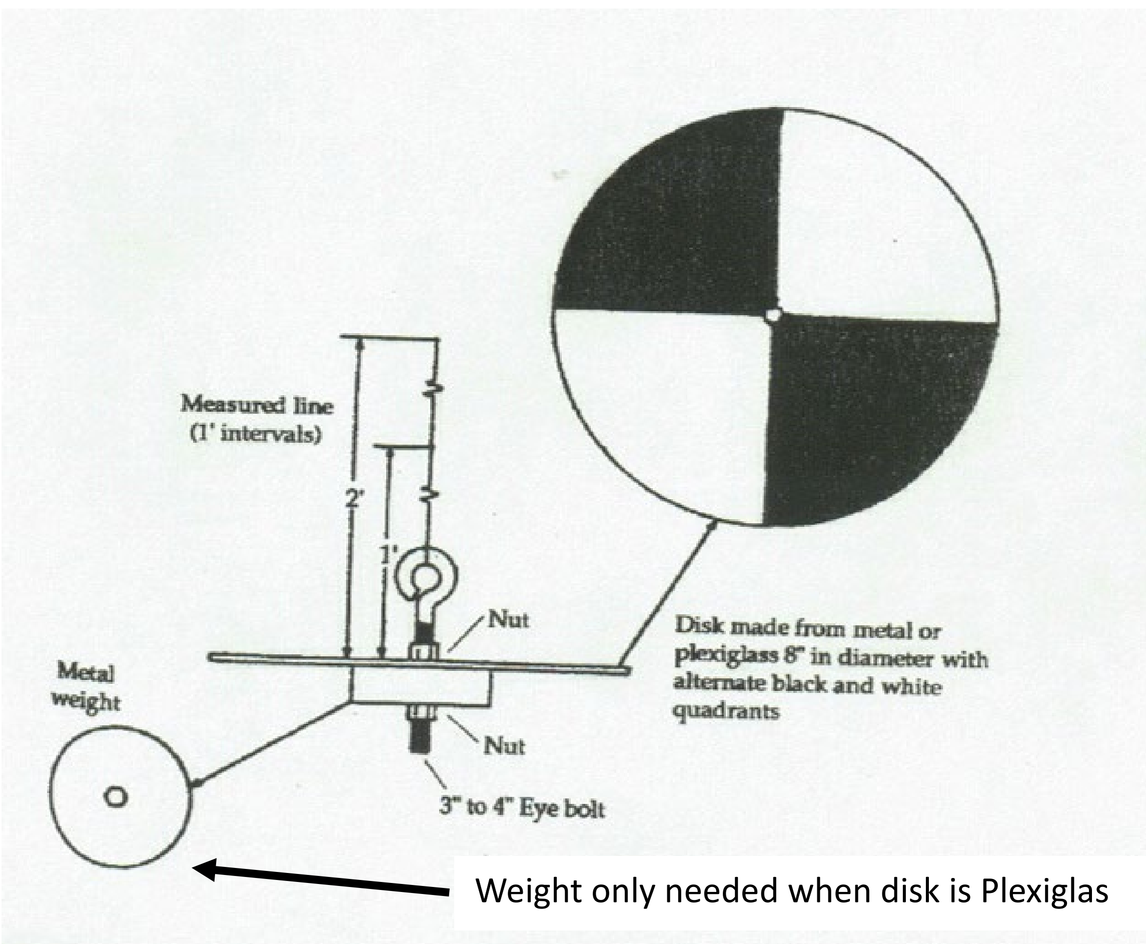
A. MAKING A SECCHI DISK

1. It is recommended that the 8 inch diameter Secchi Disk be made out of 1/8 inch thick steel plate. The disk could be made out of Plexiglas, but the Plexiglas does not hold up will in use. In addition, weight(s) would be to be added to make sure that the disk sinks properly.

2. Drill a center hold ¼ inch in diameter for the eye bolt to which the measuring tape is attached.

3. Paint both sides of the disk with a good quality black anti-rust enamel. After the primer has thoroughly dried, paint the alternate quadrants with white antirust gloss enamel.

4. Secure a waterproof measuring tape, with a minimum length of 50 feet, from a biological supply company and attach firmly to the eye bolt. Secure the eyebolt to the disk by placing a nut on both sides of the plate as shown in the diagram below. Hammer the end of the eye bolt to prevent the nut from dropping off. ---Directions by Ralph Vogel, Emeritus CLMP Volunteer



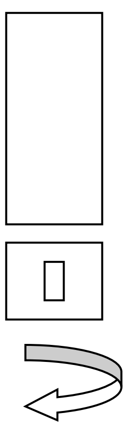
B. CHANGING A DISSOLVED OXYGEN METER MEMBRANE

WARNINGS

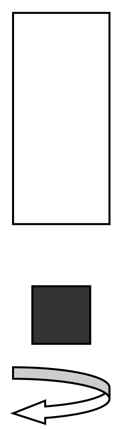
Use only YSI oxygen probe electrolyte solution in the membrane cap. Any other solution will damage the oxygen sensor.

Do NOT touch the membrane surface.

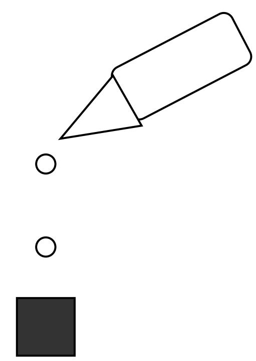
1. To install a new membrane cap on your dissolved oxygen probe:
2. Unscrew and remove the probe sensor guard.
3. Unscrew and remove the old membrane cap.
4. Thoroughly rinse the sensor tip with distilled water.
5. Hold the new membrane cap and add 8 to 9 drops of oxygen probe electrolyte solution (about half full).
6. Tap the bottom of the cap with your finger a few times to remove any trapped air bubbles.
7. Screw the new membrane cap onto the probe tightly by hand (to prevent leakage of electrolyte). A small amount of probe solution should overflow.
8. Shake off any probe solution and rinse the stainless steel thoroughly with distilled water to prevent corrosion.
9. Screw the sensor guard onto the probe tightly by hand.



Unscrew guard (Step 2)

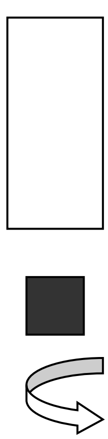


Unscrew old membrane cap (Step 3)

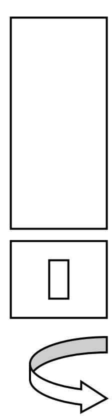


Fill new membrane cap with 8-9 drops of oxygen probe electrolyte solution. (Step 5)

Tap cap with finger to remove bubbles. (Step 6)

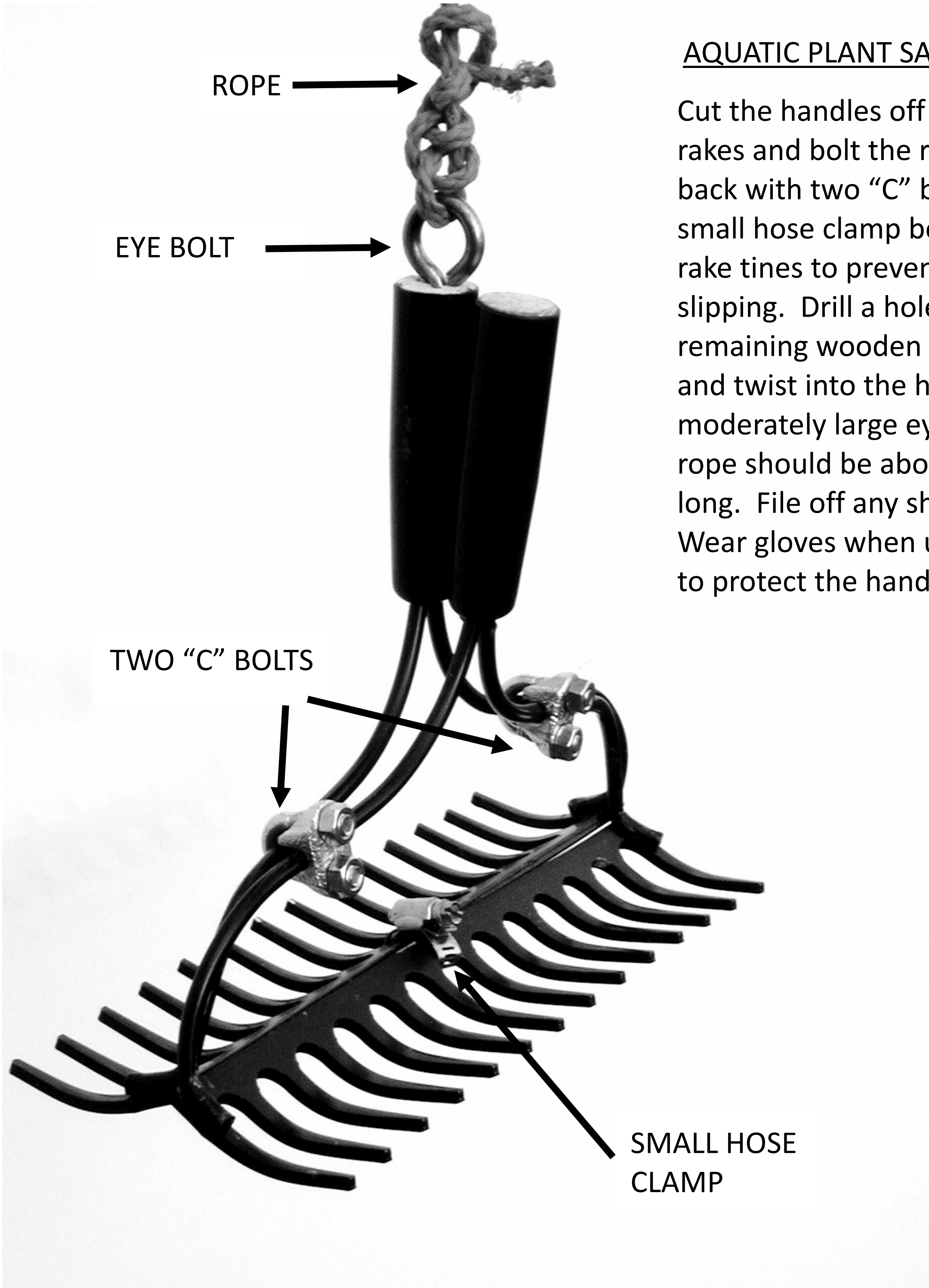


Screw on new membrane cap tightly by hand. (Step 7)



Screw guard on tightly by hand. (Step 9)

C. BUILD AN AQUATIC PLANT SAMPLING RAKE



<u>AQUATIC PLANT SAMPLING RAKE</u>

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.

D. REFERENCES

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