A Limnological Survey of

Blue Lake
Mecosta Lake
and
Round Lake

Mecosta County
Michigan

August 1990

Survey conducted by:
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INTRODUCTION

A lake is a very functional and complex aquatic resource. It is also a very valuable resource, both to the natural ecosystem and to humans. Due to the impact of humans, many lakes have undergone change and are now subject to new and different pressures that could alter their character and the life within them.

Much of the early water quality work was initiated only after problems that interfered with human's use of a lake were noticed. Unfortunately, the lack of historical, baseline data made it difficult to evaluate current trends in the water quality of such lakes. The problem therefore, was more difficult to identify and correct. Because of this, it is our recommendation that surveys such as this be done regularly to maintain good records of baseline data on a lake. Such information provides a basis from which water quality trends can be evaluated and problems identified and confronted.

This report is not intended to serve as a complete guide, with all the answers to the lake's present and future management problems or needs. Rather, its purpose is to provide the residents of the lake with some basic technical data. These data will outline the present water quality of your lake, identify any current or potential problems, and provide a basis for future development and management of the lake.

CONCEPTS AND TERMINOLOGY

A clear understanding of all the components of a lake and their relationships is necessary to understand the results of this report. This first section will provide definitions and background information on the physical, chemical and biological parameters that were measured. This information should be helpful in your interpretation of the results of the survey.

LAKE CLASSIFICATION

Lakes are often described generally in terms of their overall trophic status. The scale used ranges from very **oligotrophic** to very **eutrophic** with **mesotrophic** lakes falling somewhere in between. Oligotrophic lakes are relatively unproductive (contain little living matter per unit area) while eutrophic lakes are very productive (contain much living matter per unit area). A typical oligotrophic lake is deep and cold, has very clear water and relatively little plant growth along the shore or on the bottom. A typical eutrophic lake is shallow and warm, often with green water or green surface scums and much plant growth in the lake and along the shore. Most lakes fall somewhere between these two extremes, exhibiting some characteristics of both.

PHYSICAL PARAMETERS

Temperature: Water temperature affects all aquatic life. The temperature range of different aquatic organisms varies widely. At higher temperatures the solubility of gases, particularly oxygen and carbon dioxide, decreases and thus affects the type of aquatic life that can exist. The rate of metabolism in organisms is also influenced by temperature as is the rate of decomposition of organic materials in the water.

Temperature also affects the density of water causing lakes to go through a process of **thermal stratification** or layering. Water is the most dense at 4° C (39° F), becoming less dense (lighter) as it is warmed. In early spring and late fall, the temperature of a lake is uniform from top to bottom. At this time, water density is also uniform, allowing easy mixing of the water from top to bottom. In the spring, this mixing is aided by strong winds. In the fall, cold air cools the surface causing it to sink while warmer water below rises. These periods are known as **spring mixing** and **fall turnover** (see Figure 1.). Both are very important in re-oxygenating the water and recirculating nutrients. In summer, the surface water of a lake becomes less dense as it is warmed separating it from the colder more dense water at the bottom. Such thermal stratification is maintained throughout the summer and inhibits mixing between the upper and lower layers. The warmer upper layer is termed the "**epilimnion**" and the lower layer the "**hypolimnion**". The layer that separates the upper and lower layers is the "**metalimnion**" (also commonly referred to as the "**thermocline**") and is characterized by a rapid drop in temperature with increased depth (see Figure 1.).

Transparency or Visibility: Like temperature, light exerts a very profound effect on the whole series of biological events in the water. For example, algae are the base of the food chain in a lake and need light to grow. At the same time, excess algae populations decrease the clarity of the water and thus limit light penetration. Many lakes show seasonal variations in light penetration.

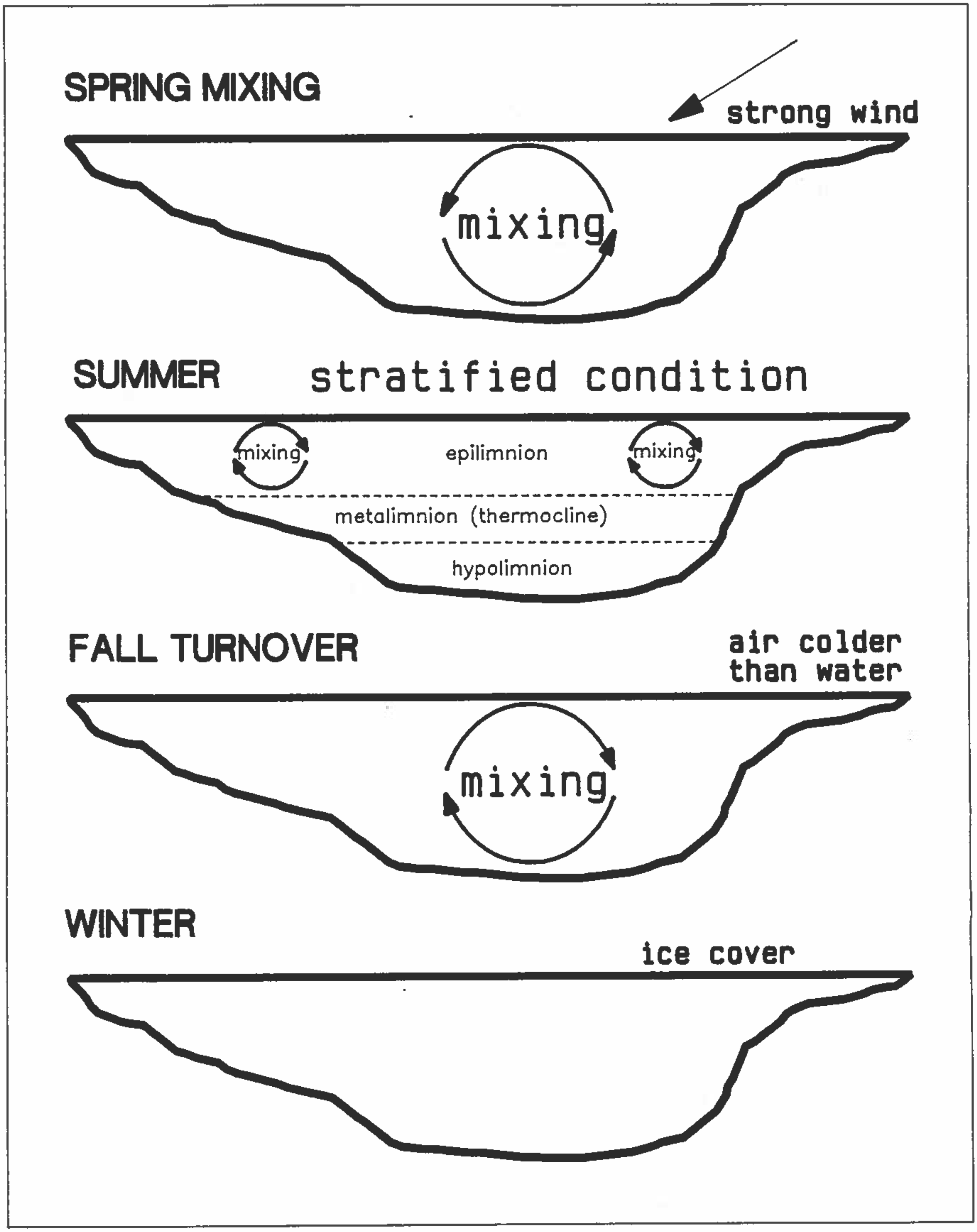


Figure 1. Typical thermal stratification in a Michigan lake.

A common device used to determine water transparency or visibility is a **Secchi disk**; a black and white disk, 20 cm (approximately 8 inches) in diameter. The Secchi disk is attached to a calibrated line and lowered into the water to the depth at which it first disappears. The disk is then lifted until it first reappears. The arithmetic mean of the two depths is considered the Secchi disk transparency or limit of visibility.

Although this method is not an actual measure of light penetration, it is a useful index of visibility if used under standard conditions and can be measured easily without the need for expensive equipment.

Morphometry: Morphometry deals with the shape of a lake and its basin. The parameters that compose the morphometry of a lake are very important factors in the dynamics of the lake. The following are some features of a lake basin:

Maximum length: length of the lake measured along its major axis (a line connecting the two most remote extremities of a lake).

Maximum width: length of the lake measured along its minor axis (a straight line connecting the most remote transverse extremities and crossing no land other than islands; the line should be approximately at right angles to the major length axis).

Mean width: area of lake divided by its maximum length.

Maximum depth: the deepest part of the lake.

Mean depth: volume of lake divided by its circumference (depth the lake would be if it were to have vertical sides and a flat bottom).

Shore Development (Sd): ratio of actual shoreline length to the length of the circumference of a circle of equal area to the lake. Shore development increases with greater shore irregularity and is a general indicator of lake productivity. Lakes with a high Sd are often more productive than those with a low Sd.

CHEMICAL PARAMETERS

Dissolved Oxygen (DO): An ample supply of dissolved oxygen is one of the most important components necessary for a normal aquatic community. Only a few species of bacteria can operate efficiently under conditions of no oxygen. The concentration of dissolved oxygen is influenced by many factors such as chemical reactions, atmospheric pressure, salinity, photosynthesis, turbulence, respiration of organisms and temperature. Oxygen solubility decreases as water temperature increases and thus, in general, warmer waters contain lower levels of dissolved oxygen. The two primary sources of oxygen in a lake are from photosynthesis and from atmospheric aeration at the water surface.

Lake stratification is important in determining the concentrations of dissolved oxygen in a lake. During spring mixing and fall turnover, oxygen is usually equally distributed throughout all depths in the lake. After stratification, however, decomposition of organic matter at the bottom of the lake begins to deplete the oxygen in the hypolimnion. Because the thermocline prevents mixing between the epilimnion and the hypolimnion, only the epilimnion is continually re-oxygenated in the summer. This becomes important for cold water fish, like trout, that need both cold water and high oxygen.

Dissolved oxygen concentrations are usually expressed in milligrams of oxygen per liter of water (mg/liter).

pH: The concentration of hydrogen ions in water is expressed as pH and indicates some general chemical conditions of the lake. The pH scale ranges from zero (very acid) to fourteen (very alkaline) with a middle value of seven being neutral. While most aquatic organisms can tolerate a reasonable pH range, they function best when the pH is at or near seven.

The present concern regarding acid rain is that it can cause pH to drop below pH 5, which is below the tolerance level for most aquatic organisms.

Alkalinity: Alkalinity is a measure of the capacity of water to neutralize acids, i.e., the buffering capacity of water. Alkalinity is generally caused by the presence of carbonates, bicarbonates and hydroxides. These are most commonly produced when calcium-type rocks such as limestone are weathered by water. Thus, the amount of alkalinity present in a lake is often determined by the geology of the area surrounding the lake.

Rather than being harmful to water quality, a moderate alkalinity concentration acts as a buffer to prevent sudden pH changes. Lakes with relatively high alkalinity are therefore less susceptible to damage from acid rain.

Alkalinity may also be considered an indicator of productivity. In general, waters with low alkalinity concentrations are biologically less productive than those with high values. Very alkaline lakes, however, can be less productive and usually contain very specialized plants and animals.

Alkalinity is usually expressed as milligrams per liter calcium carbonate (mg/liter $CaCO_3$) with low alkalinity water having less than 75 mg/liter and high alkalinity water having more than 150 mg/liter.

Hardness: Like alkalinity, hardness is not a polluting substance but rather the combined effects of several natural things and conditions. Hardness is mainly a measure of calcium and magnesium ions. Because these ions are usually tied up in the alkalinity system, hardness measures are often similar to alkalinity. Biologically, hard water lakes are usually more productive than soft water lakes. Hardness is also usually expressed as mg/liter calcium carbonate with soft water ranging from 0 - 75 mg/liter and hard water from 150 - 300 mg/liter.

Nutrients: Nutrients are substances that are needed by algae and other aquatic plants for normal growth. The three major nutrients used by plants are carbon, phosphorus and nitrogen. Carbon is readily available in the form of carbon dioxide and is usually of little concern. Both **phosphorus** and **nitrogen** are of great concern because they are the nutrients that usually limit the amount of plant and algae growth in a lake. The rate of this growth determines the trophic status of a lake.

Algae is the base of the food chain and is needed in sufficient amounts to promote good populations of higher aquatic organisms such as fish. An increase, however, in the level of these nutrients over that naturally present will often result in excess amounts of algae and aquatic plants. It is usually desirable to have sufficient nutrients to support reasonable fish populations and growth but not enough to cause nusiance growths of weeds and algae.

The most common sources of excess phosphorus and nitrogen are fertilizers and human and animal waste. Increased nutrient input from these or other sources can shift a lakes trophic status toward a more eutrophic state.

Reported concentrations of both phosphorus and nitrogen are in milligrams per liter (mg/l).

Chlorides: Chlorides, also expressed in mg/liter, usually occur in low concentrations in all natural lakes, however, excessive pollution may cause an increase in chloride concentrations. Although chlorides themselves are not very harmful, they are associated with pollutants and therefore are a general indicator of contamination from human activities. Common sources of chlorides are human and animal waste and road salts.

Conductivity: Conductivity is another general indicator of productivity. It is a measure of the ability of the water to conduct an electric current. A high conductivity indicates significant amounts of dissolved substances are present in the water. This is not necessarily bad, but does indicate that there may be pollutants present.

Because conductivity is influenced by water temperature, it is accepted practice to report conductivity in units of micromhos per centimeter of water at 25° C. This is termed specific conductance or specific conductivity.

BIOLOGICAL PARAMETERS

Plankton: Plankton is usually defined as the minute plants and animals free-floating and suspended in the water column. Planktonic organisms are found in all natural waters, but the species present and their numbers may vary greatly from one lake to another and even seasonally within a single lake. Plankton may be broken down into **phytoplankton** (algal plants) and **zooplankton** (animals).

The phytoplankton are very important since they function as the base of the aquatic food chain. The three major groups are the diatoms, green algae and blue-green algae. The numbers present of each of these can be used as an indication of lake productivity, lake type and water quality. Diatoms are usually dominant in oligotrophic lakes and are a good source of material for the food chain. Green algae are common in all lakes and help promote good fish growth. Blue-green algae are not useful as food and are aesthetically undesirable. They are a common problem in eutrophic lakes.

Zooplankton function as primary consumers, feeding on the algae. They in turn are the important source of food for small fish. The major groups of zooplankton are the cladocerans, copepods, rotifers and protozoans.

Bottom Fauna: Bottom fauna refers to a group of organisms that live in or on the lake bottom. Examples are crayfish, insects, worms and snails. These organisms are of particular importance to many fish, serving as a key food source.

The diversity of different species that are found in a lake may also indicate the quality of the environment. Some species are very intolerant of harsh conditions such as low oxygen and high organic pollution while others can tolerate these severe conditions.

Aquatic Plants: Aquatic plants are important for birds, animals, and especially fish. They provide needed oxygen during the day, recycle nutrients, serve as a food source and provide shade, shelter, cover and enhance spawning grounds. Weed beds are particularly important for small, young fish, providing protection from predators until they reach adult size. Although aquatic plants are often considered a nuisance, a good diversity of plants is healthy for a lake. There are, however, a few that can be a problem if they become to plentiful.

Fish: Fish are one of human's most important aquatic organisms. Like other organisms, fish respond to changes in a lake system. By examining the weights, lengths and scales of fish, information can be gathered regarding their age, growth and general health. The type of fish present in a lake also is another indication of the conditions that are present in a lake. Trout are more common in oligotrophic lakes where temperatures are cool and oxygen levels are high. Bass, bluegills and pike prefer warmer temperatures and are more commonly found in lakes of greater productivity. Dominance of rough fish such as carp usually indicates lower oxygen levels and more eutrophic conditions. Good fishing does not always go hand in hand with other recreational uses of a lake, like swimming, that require clear water and no weeds. One usually has to make a compromise between the two when planning for the future management of a lake.

RESULTS AND DISCUSSION

The following results reflect the status and condition of the Tri Lakes (Blue Lake, Mecosta Lake and Round Lake) on August 14, 15, and 16, 1990 when the lakes were surveyed and samples collected.

General Description and Morphometry: The Tri-Lakes are located in Michigan in Mecosta County, all T.14 N., R.8 W, with Blue Lake in Sections 8 and 9, Mecosta in Sections 8 and 17 and Round Lake in Section 7. Hydrographic maps are shown in Figures 2, 3 and 4 for Blue, Mecosta and Round Lake respectively. The three lakes are clustered together and connected by channels. It is possible that in prehistoric time the three lakes may have been one large lake. It appears that Round Lake is upper-most in the watershed with one major inlet, Cole Creek, at the north end of the lake and a minor inlet, Burden Creek, on the northwest corner. Round Lake connects to Mecosta Lake by a channel at the southeast corner of Round Lake and enters Mecosta Lake at its northwest corner. Water flows from Round to Mecosta. Inlets to Mecosta Lake are primarily the channel from Round Lake and large spring or drainage areas on the west side and southwest corner. The outlet from Mecosta Lake to Blue Lake is from Mecosta Lake's northeast corner. Since Mecosta Lake has an elongated shape and the inlet and outlet channels are both located at the extreme north end, it would seem that there would be relatively little mixing of inlet water from Round Lake with the middle or southern part of Mecosta Lake. Some mixing could possibly occur during spring or fall mixing periods; however, during periods of stratification (90% of the time) inlet water would probably flow

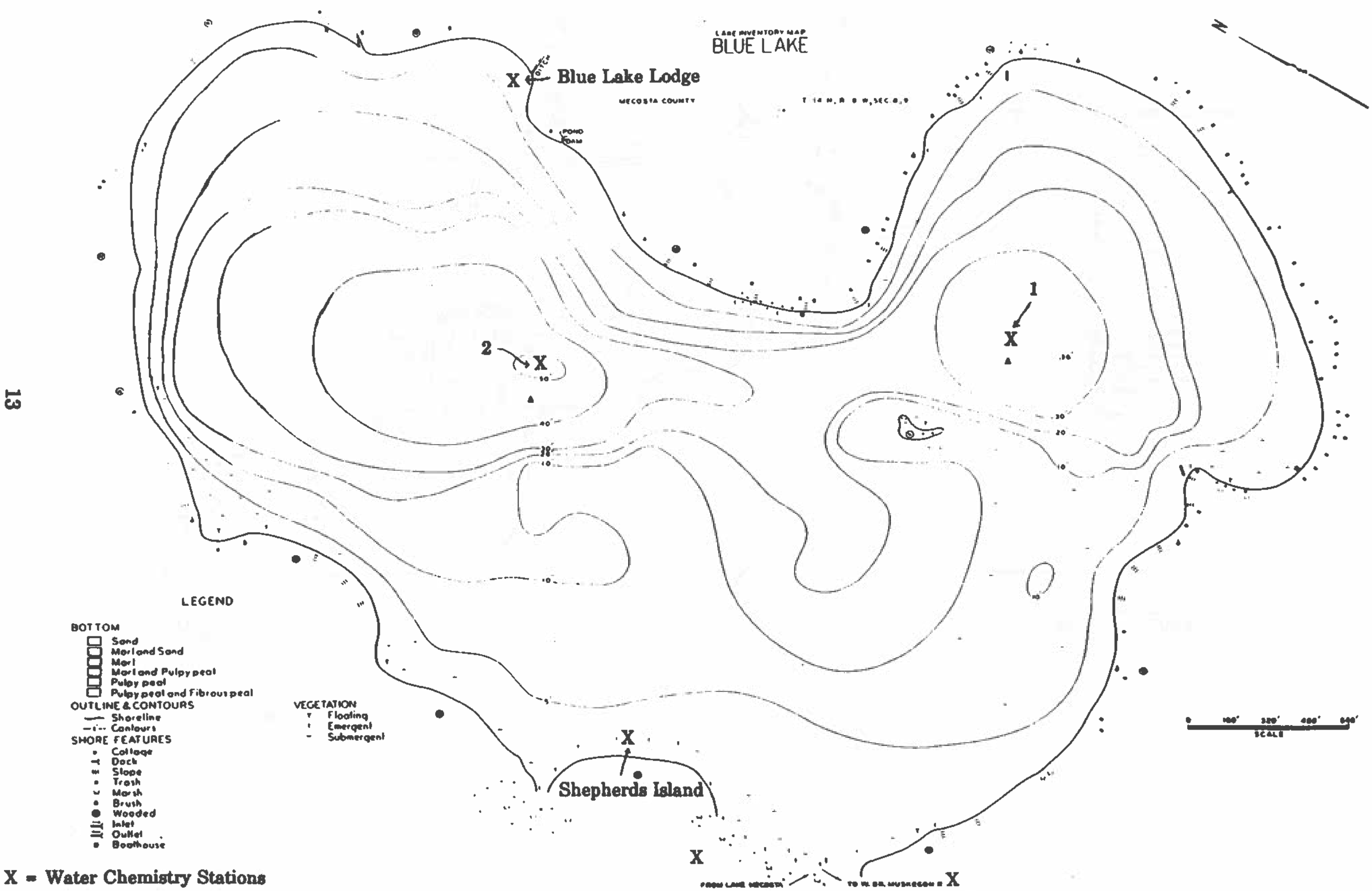


Figure 2. Hydrographic Map and Sampling locations of Blue Lake.

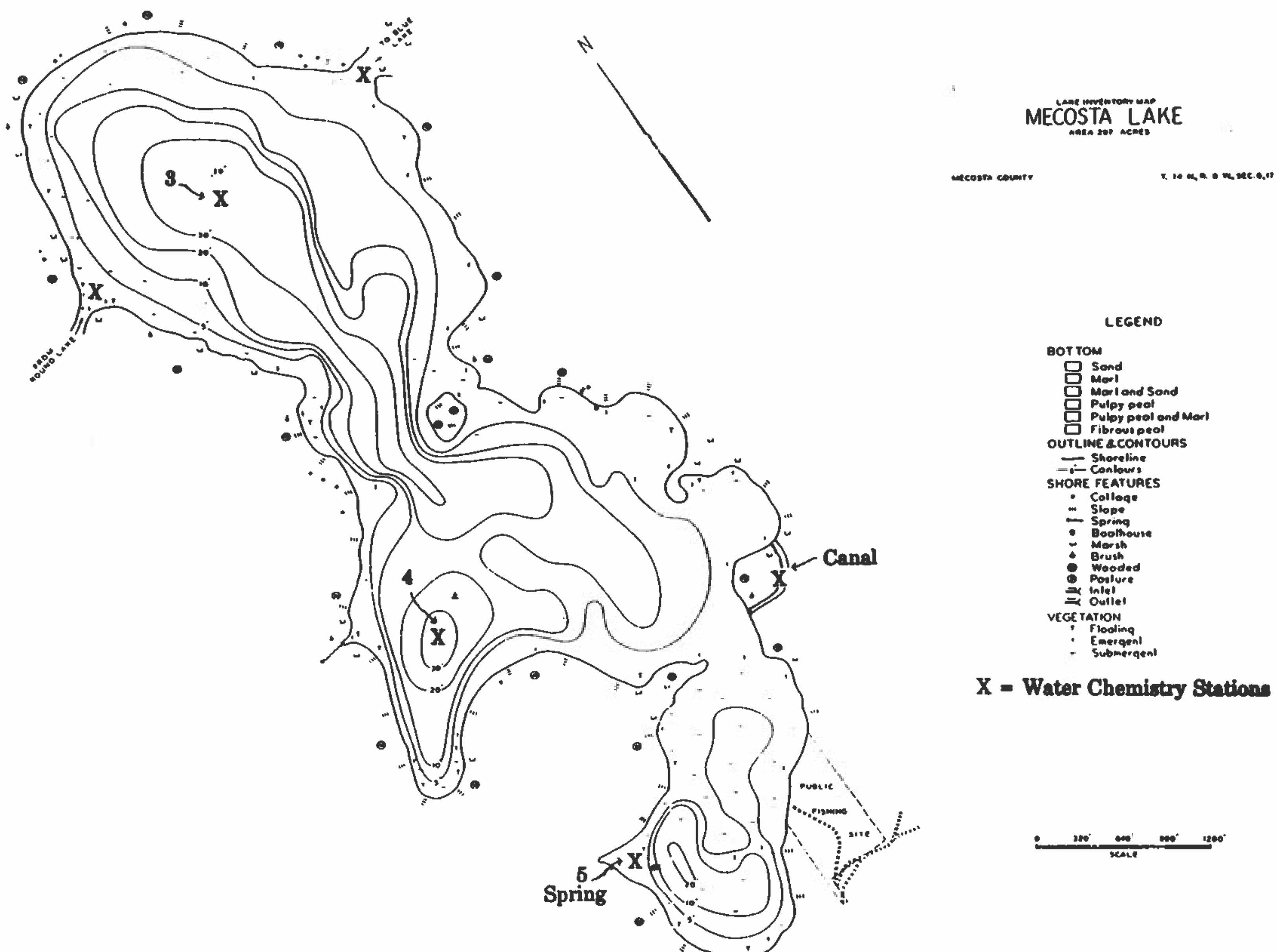


Figure 3. Hydrographic Map and Sampling locations of Mecosta Lake.

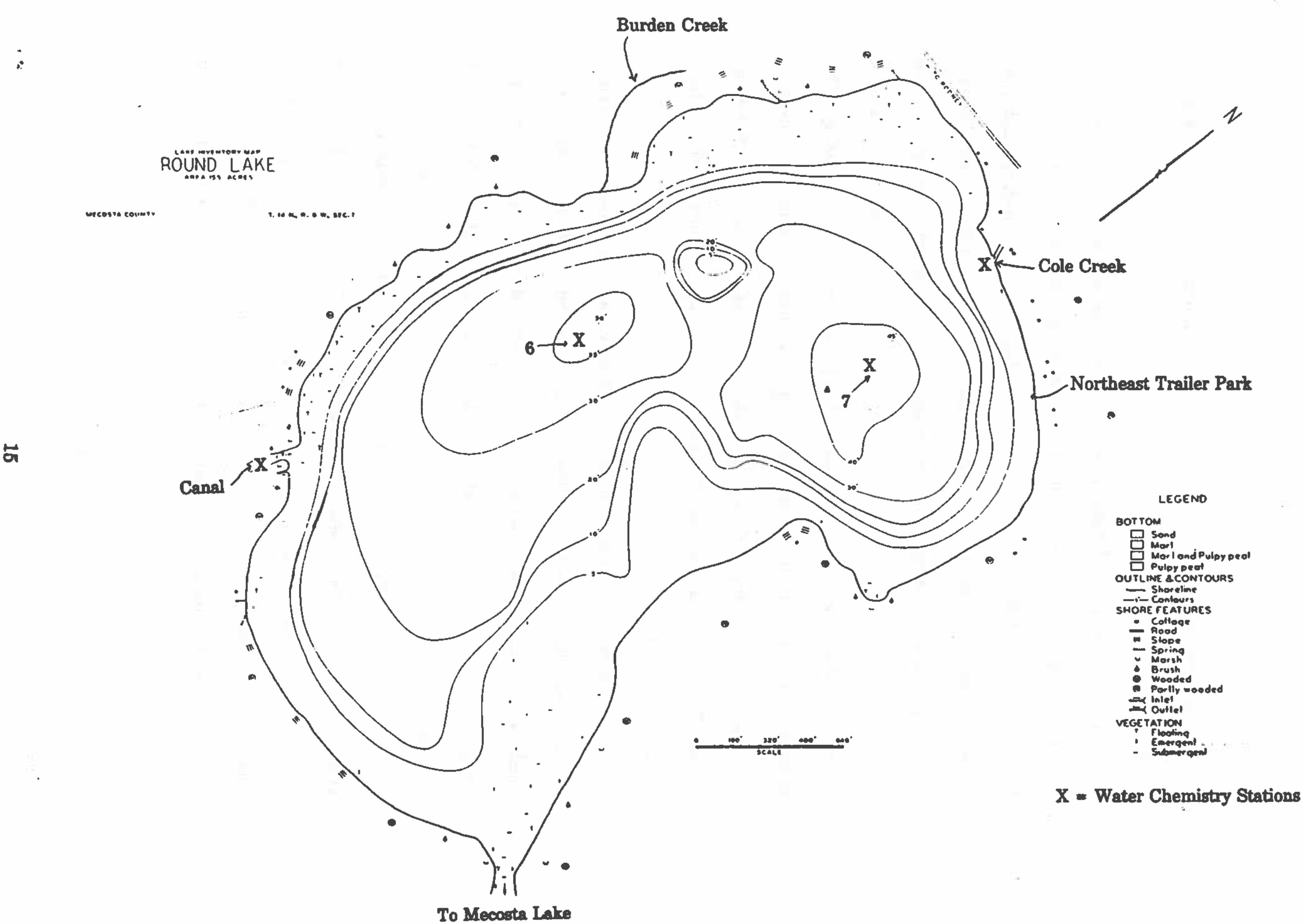


Figure 4. Hydrographic Map and Sampling locations of Round Lake.

over the surface toward the outlet. Exceptions would occur with strong north winds.

The channel from Mecosta Lake connects to the southwest corner of Blue Lake and adjacent to the main outlet of the system to the west branch of the Muskegon River. Another main inlet to the system is Gilbert Creek which is the outlet of Horsehead Lake to the north. Gilbert Creek enters the channel between Mecosta and Blue Lakes and thus encounters the outlet before entering Blue Lake. It seems that relatively little of the flow from Mecosta Lake or Gilbert Creek enters Blue Lake and thus would probably have little influence on its water quality. The lower end of Gilbert Creek is a low marsh area that may have some overflow into Blue Lake north of Shepherd's Island during high water periods; e.g. during spring runoff. There is a small inlet to Blue Lake on the east side which appears to be minor in terms of flow.

The lakes are all modest in size, but all have good depth relative to their surface area, depth sufficient to allow summer stratification. Round Lake, the smallest of the three, has a surface area of 62.6 hectares (155 acres), a maximum length of 1,183 meters (3,883 ft. or 0.74 miles) a maximum depth of 13.7 meters (45 feet), a shoreline length of 3,565 meters (11,695 feet or 2.2 miles) and a shore development (Sd) of 1.27. Mecosta Lake is the largest of the three with a surface area of 120 hectares (297 acres), a maximum length of 2,300 meters (7,546 feet or 1.43 miles), a maximum depth of 11.9 meters (39 feet), a shoreline length of 8,016 meters (26,301 feet or 4.98 miles) and a shore development of 2.06. Blue Lake has a surface area of 95 hectares (235 acres), a maximum length of 1,561 meters (5,120 feet or 0.97 miles), a maximum depth of 15.2 meters (50 feet), a shoreline length of 4,600 meters (15,090 feet or 2.86 miles) and a shore development of 1.33 (Table 1).

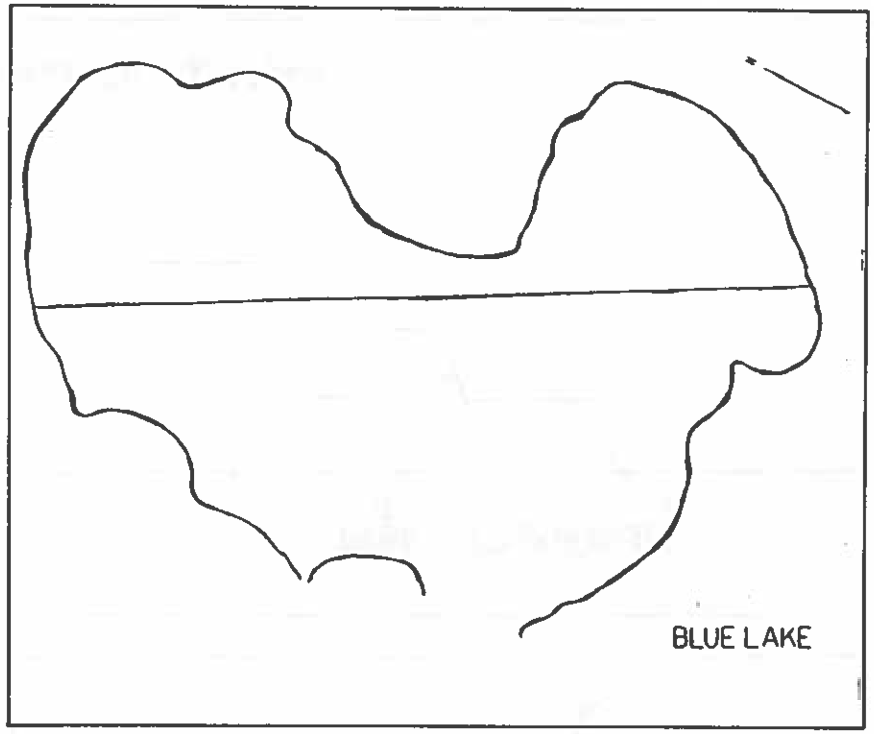
Table 1. Morphological dimensions of Blue, Mecosta and Round Lakes, Mecosta County.

Parameter	Blue	Mecosta	Round
Surface Area			
Hectares	94.9	119.9	62.6
Acres	235	297	155
Maximum Length			
Meters	1560.7.3	2300.0	1183.4
Feet	5120	7546	3883
Miles	0.97	1.43	0.74
Maximum Depth			
Meters	15.2	11.9	13.7
Feet	50	39	45
Shoreline			
Meters	4600	8016	3565
Feet	15,090	26,301	11,695
Miles	2.86	4.98	2.21
Shore - Development	1.33	2.06	1.27

All three lakes have multiple basins that are oriented in a general north-south direction. Round Lake has a north basin 45 feet deep and a second basin 36 feet deep somewhat to the southwest of the first. Mecosta Lake has its deepest basin, 39 feet, at the north end, a basin 33 feet deep to the south along the west side and a 20 foot basin at the south end. The Blue Lake basins are 50 feet in the north central part and 36 feet in the south central part. These basins are numbered on the maps in Figures 2, 3 and 4 and are the locations where depth profiles for temperature, oxygen and conductivity were measured and where samples for water chemistry were collected. Depth profiles are plotted in Figures 5, 6, and 7 along the major axes of the lakes thus depicting the relative bottom contours, the deep areas and the stratification.

Round Lake and Blue Lake have somewhat round shapes and relatively regular shorelines. Mecosta Lake is elongated and has a more irregular, dissected shoreline. The shore development (Sd) reflects the shape of the lake with the Sd of Mecosta Lake (2.06) being higher than that of Round (1.27) or Blue Lake (1.33). Lakes with higher shore development values are often more productive because they have more shallow littoral area relative to the overall surface area. This provides more area where the sunlight penetrates to the bottom causing more growth of aquatic macrophytes (weeds) if nutrients are available. Probably of more significance is that a high Sd means there is more shoreline relative to the surface area of the lake thus allowing for more dwellings to be located on such lakes. This in turn allows for greater human use per unit of surface area and thus greater potential impact from congestion on the lake, and nutrient inputs from faulty septic systems or lawn fertilization. However, public access to lakes is often more significant in terms of recreational carrying capacity than is the number of lake homeowners. Of course, proper attention to set-backs, green belts, septic system location and minimum lawn fertilization can minimize the impact of lake-side dwellings.

Many lakes in Michigan were mapped in the early 1940's by the Fisheries Division of the Michigan Department of Natural Resources (MDNR - then the



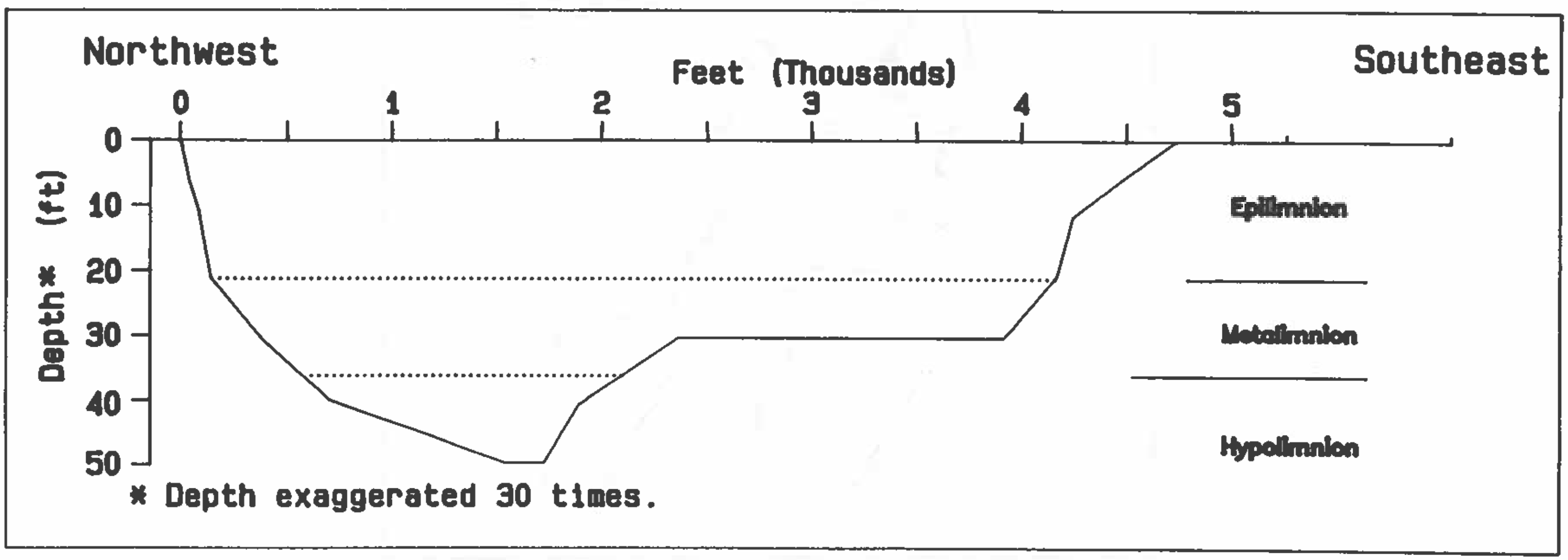


Figure 5. Depth profile of Blue Lake along the northwest - southeast major axis.

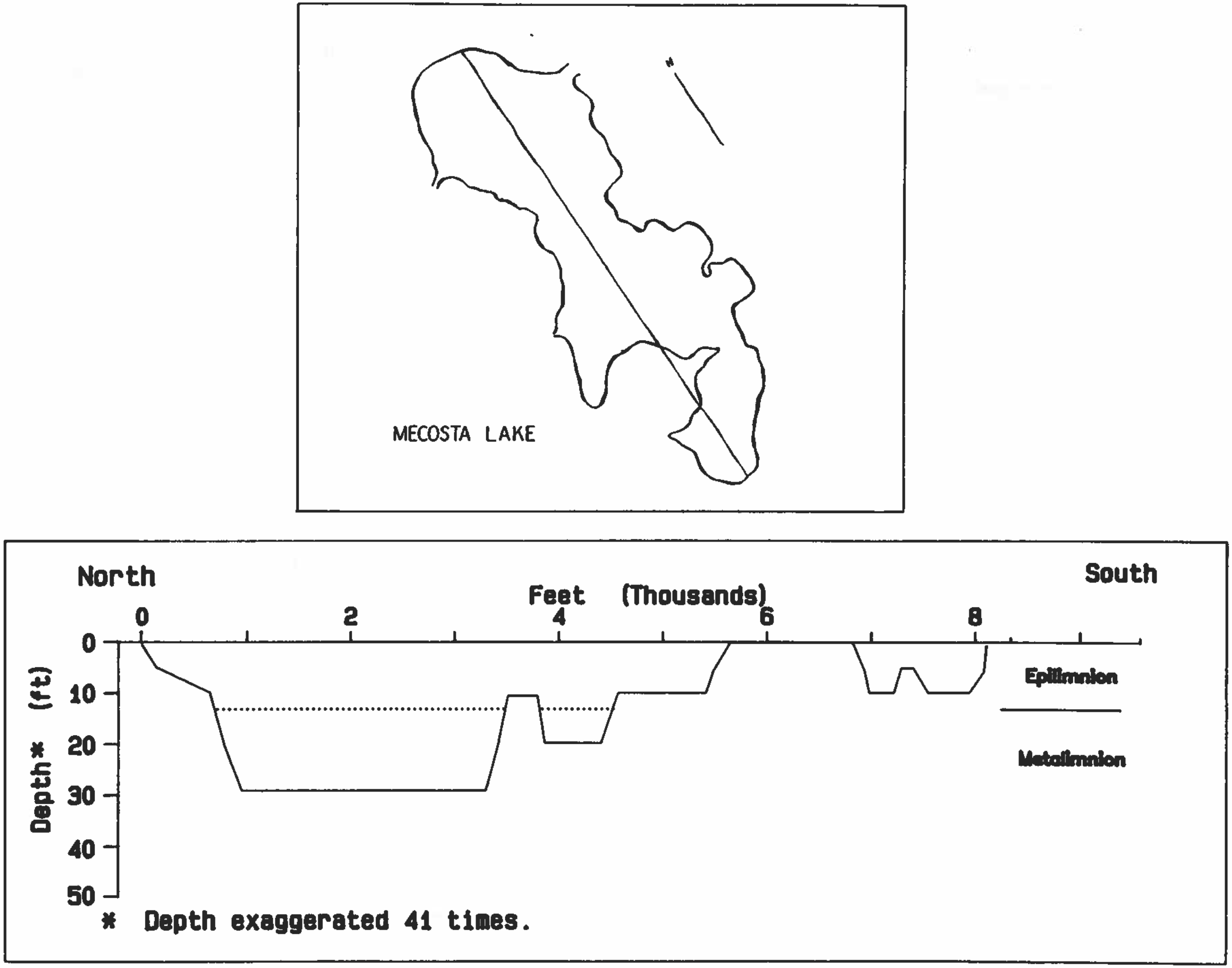
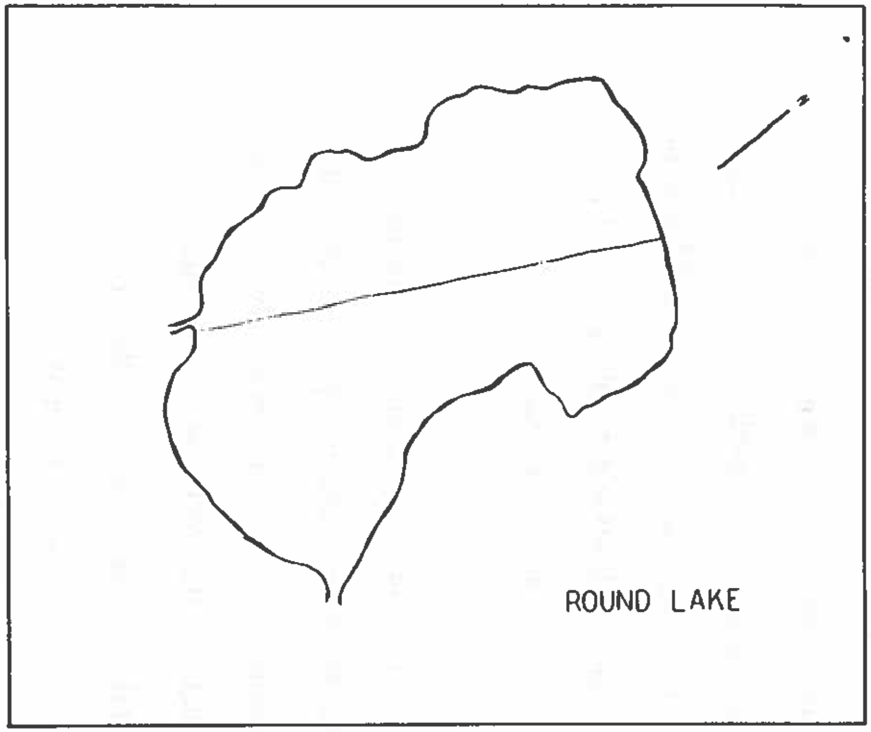


Figure 6. Depth profile of Mecosta Lake along the north - south major axis.



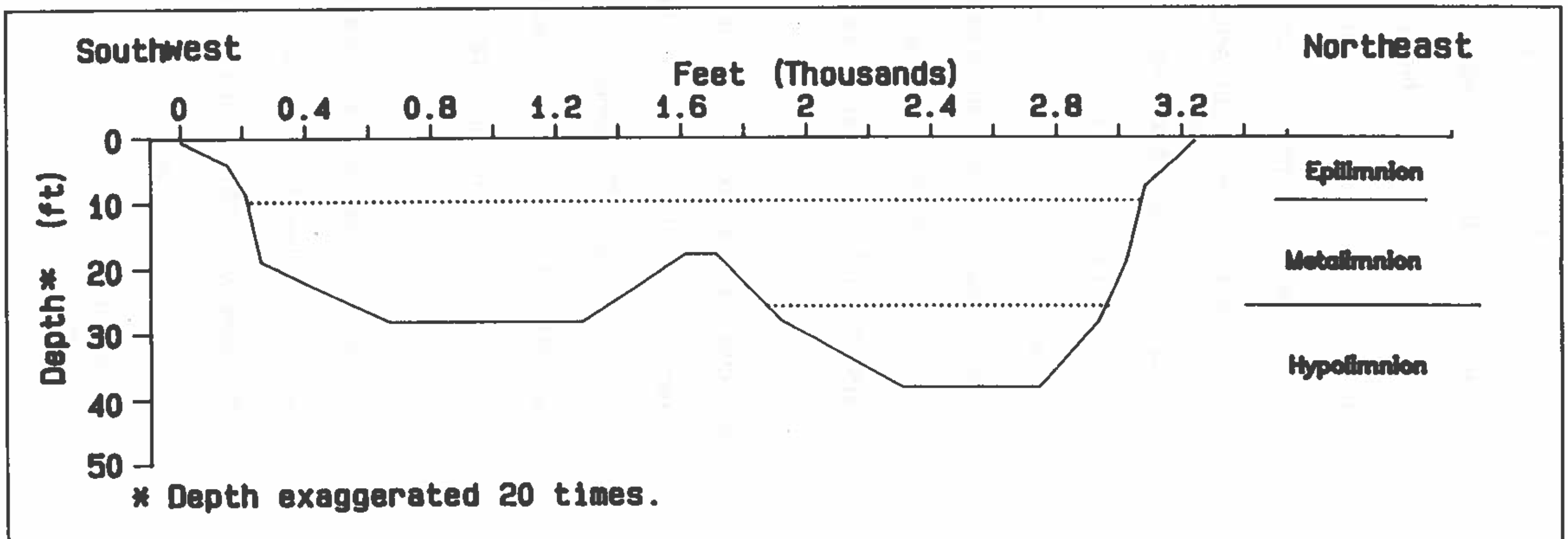


Figure 7. Depth profile of Round Lake along the southwest - northeast major axis.

Department of Conservation). The Tri Lakes were thus mapped in 1940. The time elapsed since then is 50 years, a significant time for us humans, but rather insignificant for a reasonable size lake. As is the usual case, we found no changes in the depths of the deep basins of the three lakes from that on the 1940 maps. Sedimentation of organic matter, while no doubt occurring, has not been a problem. The general process of sedimentation is for aquatic weeds produced in the shallow areas (usually 12 feet or less) and the plankton produced in the open water areas to settle downward along the basin slopes toward the deep areas. Wave action and seasonal mixing assist in this process. Some of the organic matter that settles is broken down and recycled by bottom dwelling animals and bacteria. Having deep areas and significant volume of deep water in lakes is generally good and your lakes have these deep areas as shown on the maps and the depth profiles (Figs. 2-7).

Transparency or Visibility: Secchi disk data from many Michigan lakes that participate in the MDNR Inland Lake Self-Help Program are presented in their Annual Reports. Our secchi disk readings for the Tri Lakes are given in Table 2. and are compared there with other data for the Tri Lakes. Our readings are similar to those from other sources taken in other years. While Secchi disk readings vary seasonally with the presence or absence of plankton blooms, the readings for your lakes have a small range, usually from 2.7 to 3.5 meters, the exception being Mecosta Lake in August of 1975 (Table 2), and average slightly over 3 meters for all three lakes. Your lakes are near the reported average for the Self-Help Lakes. Interpretation can be that your lakes are moderately productive and reasonably clear.

Table 2. Secchi Disk readings (meters) for Round, Mecosta and Blue Lake.

Date	Round	Mecosta	Blue
Aug. 1990	3.2	3.0 - 3.3	3.0 - 3.3
1989 ($\bar{x}$)[1]	2.93	3.0	3.4
1977, '81-85($\bar{x}$)[1]	2.7	3.0	3.0
Summer '83[2]	3.2 - 3.5		
Aug. '75[3]		1.5 - 2.1	
Apr. '78[3]	3.0	3.6 - 4.3	

[1]MDNR, Self-Help Program
[2]Ferris State College Report
[3]Aquatic Consulting Services

Parameter Depth Profiles: Temperature, dissolved oxygen and conductivity measurements were taken at one meter intervals from top to bottom over the deep holes of each basin in all three lakes. The data for each basin are presented in Appendix 1. and profiles for the basins by lake are graphed in Figures 8, 9 and 10. It will be helpful to refer to these graphs while reading the discussion on temperature, oxygen and conductivity.

Temperature: All basins of all three lakes were thermally stratified (layered) in mid August, 1990. This was expected as a normal condition and was the reason for doing the study in August. The lakes were probably stratified since the spring overturn in May. Temperatures ranged from 22-23°C (71.6-73.4°F) at the surface of the lakes to lows near the lake bottoms of 9.1°C (48.4°F) for Blue Lake, 10.0°C (50.0°F) for Mecosta Lake and 7.6°C (45.6°F) for Round Lake. Lakes in the temperate zones of the world usually stratify in the summer if they are deep enough. The middle layer or metalimnion is distinguished by a rapid drop in temperature with increasing depth. The metalimnion was between 7 and 11 meters at Station 1 and between 6 and 11 meters at Station 2 in Blue Lake; below 4 meters at Station 3 and below 5 meters at Station 4 in Mecosta Lake and between 4 meters and 8 meters at Station 6 and between 3 meters and 8 meters at Station 7 in Round Lake (Figs. 8, 9, and 10). These temperature profiles are typical of normal temperate zone lakes and lakes normally managed for warm - and cool - water fish (e.g. bass, pike, sunfishes, and walleye).

Dissolved Oxygen: Dissolved oxygen (DO) concentrations measured indicated well-oxygenated water in all three lakes in their epilimnions (top layer) and into the upper part of the metalimnions (middle layer) (Figs. 8, 9, and 10). DO was at 5.0 mg/L or higher as deep as 4.5 meters (14.8 feet) in Round Lake, as deep as 5.4 meters (17.7 feet) in Mecosta Lake and the best in Blue Lake where the 5.0 mg/L or better went as deep as 6.5 meters (21.3 feet). DO at 5.0 mg/L would be sufficient for the species of fish living in the Tri Lakes. While fish can survive at concentrations below 5.0 mg/L for considerable time periods, it is possible that stress will occur after extended periods. Concentrations below 2.0 mg/L probably result in discomfort in most fish species and few fish would be found in such locations for any length of time. Anglers would be wise to note the depths of adequate DO on the figures as they relate to mid and late summer locations of fish.

After the spring and fall periods of mixing the lakes are usually uniformly oxygenated to or close to the bottom. Once stratification occurs, the oxygen in the

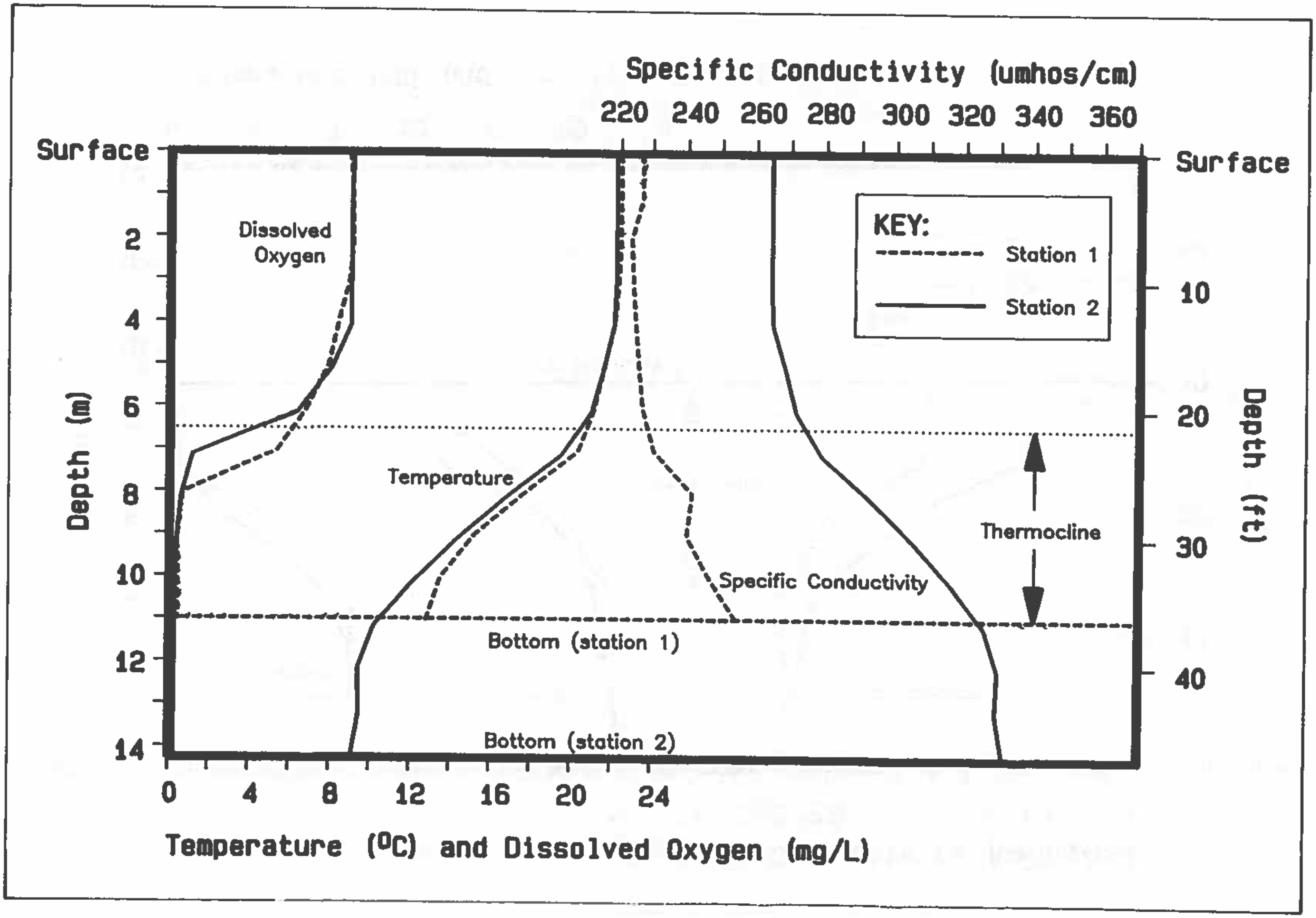


Figure 8. Temperature, oxygen and conductivity profiles for stations 1 and 2, Blue Lake on August 14, 1990.

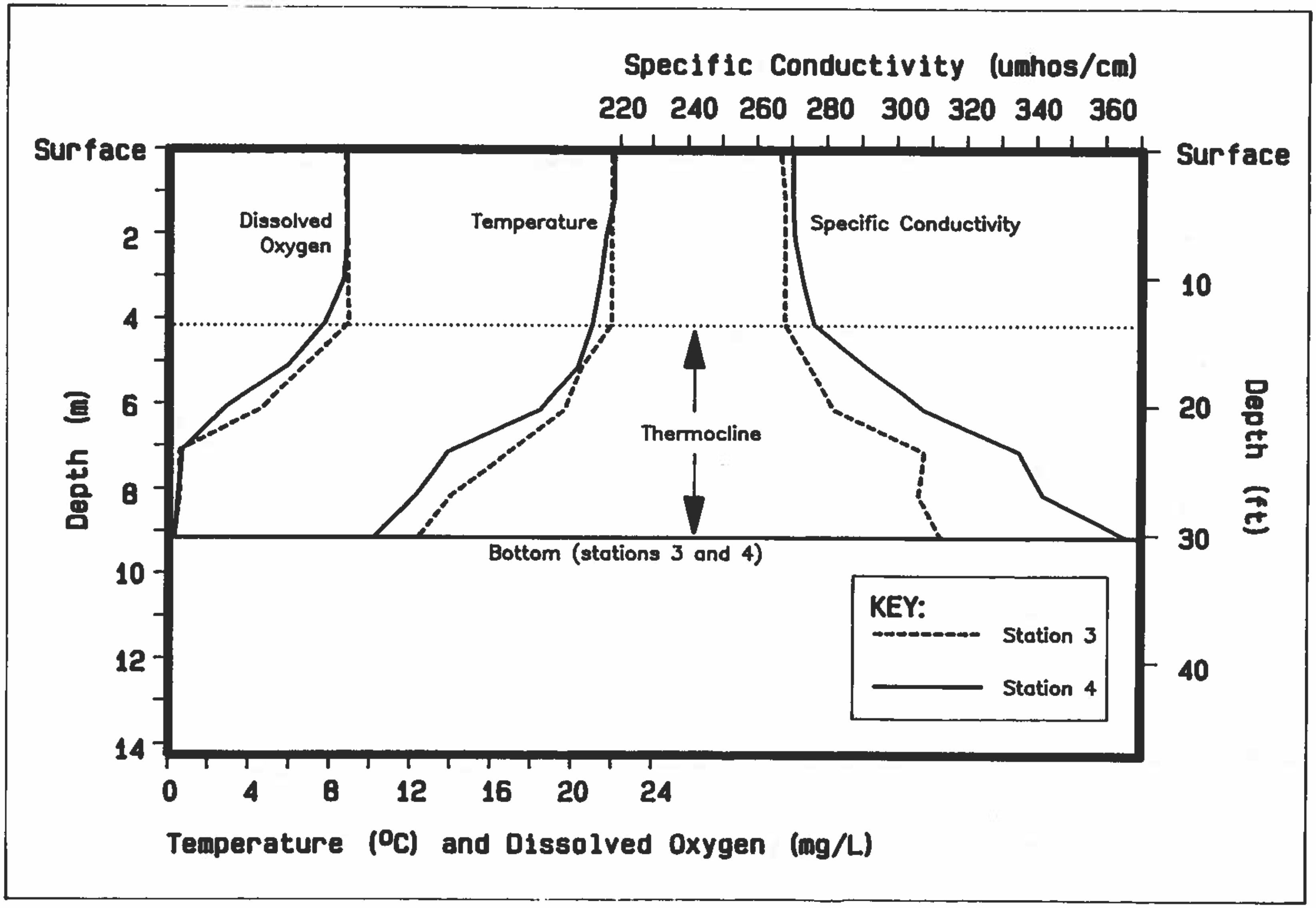


Figure 9. Temperature, oxygen and conductivity profiles for stations 3 and 4, Mecosta Lake on August 14, 1990.

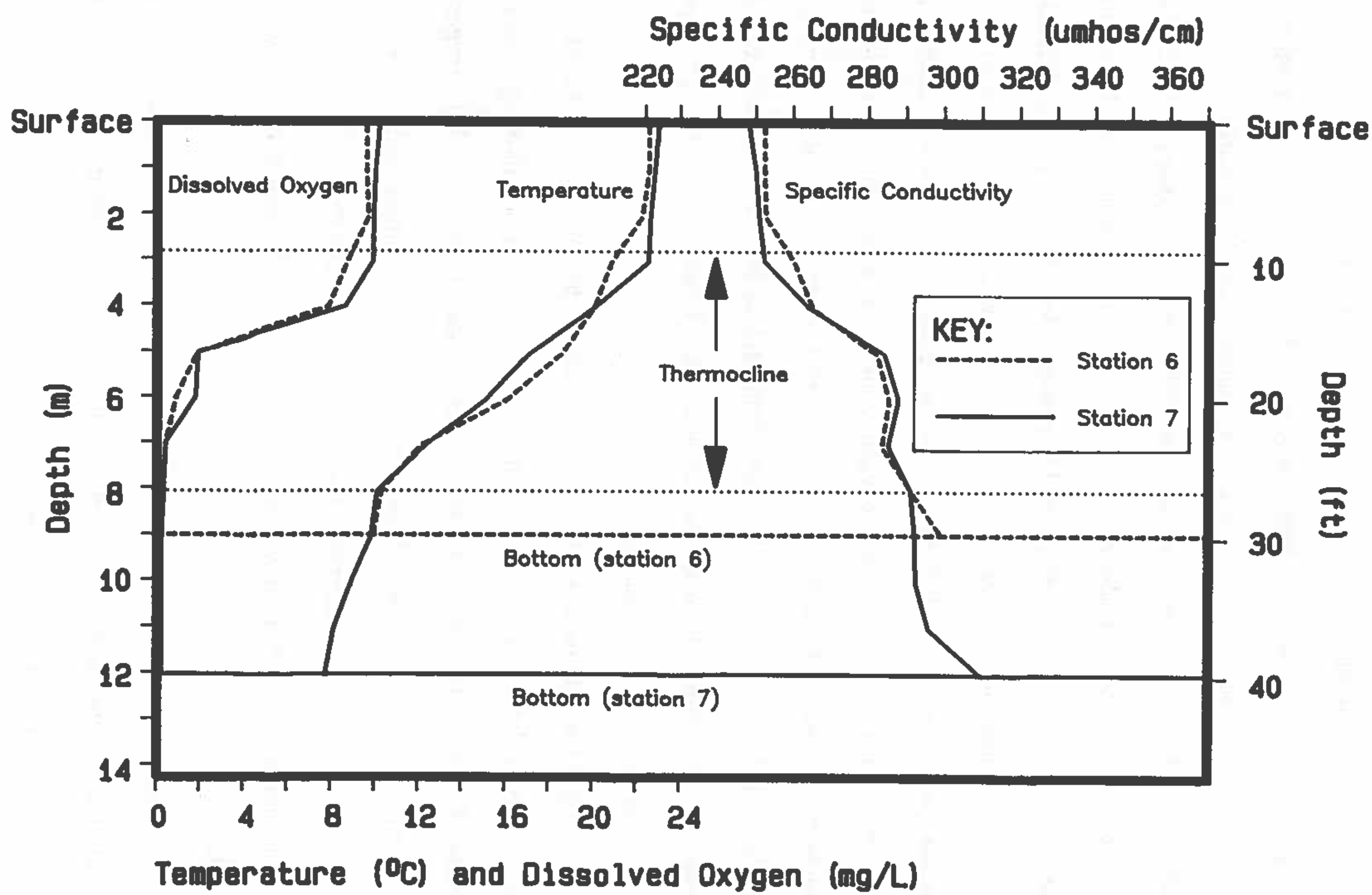


Figure 10. Temperature, oxygen and conductivity profiles for stations 6 and 7, Round Lake on August 14, 1990.

deep areas near the bottom begins to be consumed by the respiration of bacteria as they decompose organic matter that has settled out. Further, plankton that settle toward the bottom also reach depths where sunlight is low and their respiration dominates the photosynthesis/respiration relation, thus contributing to the depletion of DO in the deeper areas. Generally, the richer (more nutrients) and more productive the lake, the greater will be the oxygen depletion. This reflects the organic food base for bacteria and the respiration of plankton populations.

This depletion of oxygen in the bottom layers of a lake is common in the summer and winter stratification periods, being usually more pronounced in the summer. Since the extent of the oxygen depletion is a reflection of productivity it also is an indication of a lake's trophic state and is important in determining the species of fish that can live in the lake. Fish such as trout that must have cold water therefore would have to have oxygen in the lower layer of the lake where the cold water exists in the summers.

While consumption of oxygen also occurs in the upper layer of a lake, it is continually replenished from atmospheric aeration and by the photosynthesis of plants. Reoxygenation is usually greatest at or near the surface while oxygen-consuming organisms settle out and accumulate in the denser layers of water near the top of or in the metalimnion. Here, oxygen is usually depleted faster than it can be replenished, resulting in a decrease in DO that continues and expands with depth.

Based on oxygen depletion, the Tri lakes rank from Round Lake as the most productive to Blue Lake as the least productive. Fish growth might be slightly better in Round Lake relative to Blue Lake; however, many other factors are involved in fish growth. This situation in other terms would place Blue Lake as the best with Round Lake as the third ranking of your three lakes.

Conductivity: Specific conductance ranged from about 226 micromhos/cm at the surface of Station 1 on Blue Lake to a high of about 365 micromhos/cm at the bottom of Station 4 on Mecosta Lake (Figs. 8, 9, and 10). Generally surface water values were similar as were the profiles and deep water values. The profiles of the Round Lake Stations were nearly identical, the two Mecosta Lake profiles were close and the two Blue Lake profiles were similar in shape but about 40 micromhos/cm apart. This probably only serves to reveal that the two basins are quite separate in terms of water exchange with the shallower Station 1 perhaps receiving more spring water in the deep area. This assumes the spring water to have a slightly lower specific conductance. Spring water would likewise have a more moderate temperature and this appears in Figure 8 as a slightly warmer water at 11 meters for Station 1 and for Station 2. A similar situation appears in Mecosta Lake at the lower depths.

These specific conductance levels are within the range expected for unpolluted hard water lakes. Conductance values typically increase with depth due to the gradual settling of precipitated particles and their dissolving near the bottom and the release of ions from decaying organic sediments at or near the bottom. We look for high values at other sampling locations relative to the open lake values to indicate possible input of chemicals (nutrients or contaminants).

Conductivity was measured at several sites around the lakes (Table 3). Higher values, over 300 micromhos/cm, were measured at Station 5 (the spring) on

Table 3. Alkalinity, Hardness, Chloride, pH and Conductance values for Blue, Mecosta and Round Lakes in August, 1990.

Lake and Location	Alkalinity (mg/L)	Hardness (mg/L)	pH	Chloride (mg/L)	Sp. Cond. (μmohos/cm)
Blue L.:					
Surface					
Sta. 1	128	138	8.85	8.5	
Sta. 2	129	128	8.88	6.5	
Mid-depth					
Sta. 1	131	144	8.33	7.5	
Sta. 2	142	150	7.79	13.5	
Bottom					
Sta. 1	149	160	7.78	6.5	
Sta. 2	154	158	7.75	7.0	
Blue L. Lodge				6.0	270
Shepherd's Is.					261
Blue-Mecosta Channel					284
Gilbert Creek					296
Mecosta L.:					
Surface					
Sta. 3	126	136	8.66	2.5	
Sta. 4	137	140	8.67	7.0	
Mid-depth					
Sta. 3	143	143	7.74	7.0	
Sta. 4	147	150	7.89	8.0	
Bottom					
Sta. 3	146	160	7.61	6.5	
Sta. 4	182	188	7.59	4.5	
Sta. 5 (Spring)	135	142	8.65	9.5	319-400
So. End				9.0	

Table 3. Continued

Lake and Location	Alkalinity (mg/L)	Hardness (mg/L)	pH	Chloride (mg/L)	Sp. Cond. (μmohos/cm)
Round L:					
Surface					
Sta. 6	128	130	8.8	6.5	
Sta. 7	124	126	8.75	6.0	
Mid-depth					
Sta. 6	139	152	7.58	6.5	
Sta. 7	149	148	7.9	6.5	
Bottom					
Sta. 6	157	162	7.53	5.5	
Sta. 7	167	160	7.58	5.0	
Canal				9-10	342-384
Cole Creek				5.5	290

*Specific conductivity reported at 25°C.

Mecosta Lake and in the canal on the south end of Round Lake (this may be the area known as Pine Shores?). These specific conductance values would indicate an input of some ionized chemicals, possibly nutrients. Conductivity slightly higher than the open lake values were measured at the Cole Creek inlet (290 micromhos/cm) and Gilbert Creek inlet (296 micromhos/cm). These inlets have discharges higher than the above sites, thus their values, even though only slightly higher than the open lake, could represent significant inputs. Gilbert Creek flow exits to the outlet of the Tri lakes. Cole Creek, however, enters directly to Round Lake in the area of dense macrophyte (plant) growth and would appear to be contributing to that situation (problem). A slightly higher value at the south end of Mecosta Lake probably reflects the inflow from the spring at Station 5. Other measurements were similar to the open lake measurements.

Conductivity was measured in 1975 on the north and south basins of Mecosta Lake by Aquatic Consulting Services. Their measurements were very similar to ours. Conductivity reported for spring runoff by Engineering Design, Inc. indicated high values for Pine Shores, Lake Mecosta Bay (our Station 5) and Baar Creek (an area near the canal on Round Lake). We assume the values reported by others were standardized to 25°C.

Alkalinity, Hardness, pH, and Chloride: Water samples for the determination of these parameters were collected from the surface, mid-depth and bottom over the deep basins (Stations 1, 2, 3, 4, 6 and 7). These parameters were measured also at the Cole Creek inlet on Round Lake and at Station 5 on Mecosta Lake. These results are given in Table 3.

pH: The pH values ranged from a low of 7.53 to a high of 8.8. This is a narrow range around neutrality and is normal and expected for Michigan hardwater lakes. pH values near the bottom of deep basins are usually lower than those at the surface due to differences in the amount of free carbon dioxide. Photosynthesis uses up carbon dioxide and results in an increase in the pH. Thus we find higher values, such as 8.8 at the surface of Station 1. Respiration, the predominate process in the deep water near the bottom, releases carbon dioxide and results in a decrease in the pH. We see this as a value of 7.53 near the bottom of Station 6 on Round Lake.

Alkalinity: Alkalinity in the surface waters of the three lakes was quite similar varying only from 124 to 137 mg $CaCO_3$/l. These lakes are thus moderately hardwater lakes and would be expected to be moderately productive. This alkalinity provides good buffer capacity and protects the lakes from damage from acid deposition ("acid rain"). Alkalinity is typically higher near the bottom of the deep basins of a lake than at the surface. This again, is due to differences in carbon dioxide resulting from photosynthesis at the surface and respiration near the bottom. Uptake of carbon dioxide by phytoplankton (algae) and macrophytes (aquatic weeds) often results in the formation of small particles of calcium carbonate when the pH exceeds 8.3. These particles are called marl. Marl formed at the surface sinks to the bottom where it redissolves in a pH below 8.3. This causes higher alkalinity values near the bottom especially in the summer. Marl also appears as a whitish crust on the leaves of aquatic plants in the summer. This process also is normal and expected in hardwater lakes.

The alkalinity of Cole Creek was somewhat higher than the surface water of Round Lake, but lower than the deep water values, a situation of no importance.

Hardness: Hardness values were only slightly higher than the alkalinity. These two parameters are similar in character and tend to confirm the other when similar in concentration. Changes in hardness from top to bottom are usually linked to the changes in alkalinity. Hardness in excess of alkalinity is common and usually indicates the presence of chlorides, sulfates, nitrates and organic acids, all of which may contribute to hardness but not to alkalinity. The hardness values of the three lakes are normal.

Chlorides: Chlorides are a component of human and other animal wastes and are very soluble in water. While chlorides are not harmful to aquatic life, because of their soluble nature and association, they are a good indicator of leaking septic systems and possible runoff from farm feed-lots.

Values ranged from a low of 2.5 mg/l in Mecosta Lake to a high of 13.5 mg/l in Blue Lake. Concentrations less than 20 mg/l generally indicate no problem. The most common values on the three lakes were between 4.5 and 7.5 mg/l. Values for Horsehead Lake in 1988 were between 2 and 4 mg/l indicating little contribution from that lake to Gilbert Creek. Several areas in the Tri Lakes were higher than the "background" concentrations and should be noted. These areas are Station 5 (the spring) on Mecosta Lake, the canal on Round Lake and surprisingly, the mid-depth sample at Station 2 on Blue Lake; these were 9.0, 10.0, and 13.5

mg/l respectively. These sites will be further discussed in the conclusions and recommendations of this report.

Nutrients: Nutrients considered are phosphorus and nitrogen. Because of the changing nature of phosphorus, we only analyze and report total phosphorus. While nitrogen has a similar nature, we do analyze for nitrite/nitrate and Kjeldahl (organic) nitrogen with these combined as total nitrogen. Concentrations of phosphorus and nitrogen by lake and sampling site are given in Table 4.

Phosphorus concentrations were low and normal for mesotrophic lakes. We sampled water on each lake over the deep basins and combined, for each lake, the two samples from the surface, the mid-depth and near the bottom. Since plankton and marl drift downward toward the lake bottom, it is common in August to find concentrations of nutrients higher at the mid-depth and highest near the bottom. This was true for phosphorus in Mecosta and Round Lake, but not so for Blue Lake. The average total phosphorus for Mecosta, Blue and Round Lakes was 0.013, 0.018 and 0.023 mg/liter respectively. Many lakes have values around 0.025 mg/liter (Horsehead Lake in 1989 averaged 0.023 mg/liter). Total phosphorus reported by Aquatic Consulting Services for Mecosta Lake in August of 1975 averaged 0.014 mg/liter. Storet data, retrieved and reported by MDNR, gives average total phosphorus concentrations for early September, 1985 for Blue Lake as 0.013 mg/liter; for Round Lake as 0.02 mg/liter. Our values are very close to these other reports. Aquatic Consulting Services reported total phosphorus values for the Canadian Lakes from 1984 to 1989; these values ranged from highs of 0.08 in 1985

Table 4. Total Phosphorus, Nitrite-Nitrate, Total Kjeldahl Nitrogen, and Total Nitrogen values for Blue, Mecosta and Round Lakes in August, 1990.

Lake and Location	Total Phosphorus (mg/L)	Nitrite-Nitrate (mg/L)	TKN (mg/L)	Total Nitrogen (mg/L)
Blue Lake:				
Sta. 1 & 2				
Surface	0.019	0.017	0.441	0.458
Mid-depth	0.018	0.016	0.470	0.486
Bottom	0.017	0.020	1.080	1.100
MEAN	0.018	0.018	0.664	0.682
Blue L. Lodge	0.014	0.015		
Shepherd's Is.	0.003	0.015	0.637	0.652
Gilbert Creek (inlet)	0.016	0.018	0.399	0.417
Muskegon R. Dam (outlet)	0.012	0.018	0.381	0.399
Mecosta Lake:				
Sta. 3 & 4				
Surface	0.008	0.017	0.429	0.446
Mid-depth	0.010	0.016	0.488	0.504
Bottom	0.021	0.020	1.398	1.418
MEAN	0.013	0.018	0.772	0.790
Sta. 5 (Spring)	0.016	0.017	0.512	0.529
Round Lake:				
Sta. 6 & 7				
Surface	0.012	0.014	0.385	0.399
Mid-depth	0.017	0.015	0.447	0.462
Bottom	0.041	0.018	1.641	1.659
MEAN	0.023	0.016	0.824	0.840
Canal	0.008	0.019	0.458	0.477
Cole Creek	0.016	0.066	0.186	0.252
N.E. Trailer Park	0.014	0.015	0.447	0.462

and 0.10 in 1988 to lows of 0.02 in 1984 and 1989 (all in mg/liter). Engineering Design, Inc. reported spring run-off values for the Tri Lakes in 1990; however, their data are only for orthophosphate and thus cannot be compared to total phosphorus values.

Phosphorus concentrations on Blue Lake at the small inlet near the lodge, and at Shepherd's Island were both lower than the average for Blue Lake open water (Table 4). On Round Lake, phosphorus concentrations at the mouth of Cole Creek, off the weed beds at the north end and in the canal at the southwest were all lower than the open water values (Table 4).

A sample taken from the spring area at the southwest end of Mecosta Lake was higher than the open water phosphorus of Mecosta Lake (Table 4).

Based on our phosphorus concentrations reported here, we would say that the Tri Lakes in 1990 do not have a phosphorus problem. Only the southwest spring of Mecosta Lake appears to be contributing phosphorus at a concentration over the average lake values. We are unable to explain the inverse concentrations of phosphorus in the deep basins of Blue Lake.

Our nitrogen concentrations for the Tri Lakes are given in Table 4. Nitrite (NO_2) and nitrate (NO_3) concentrations ranged from 0.014 to 0.020 mg/liter on the three lakes and are essentially the same. Nitrate is the available form of nitrogen that is taken up by plants. Concentrations at all extra sampling sites on the three lakes were about the same (or less) as the open water concentration except for the Cole Creek inlet. The nitrate concentration at Cole Creek was 0.066 mg/liter or over four times as high as the open lake concentration of Round Lake. Cole Creek appears to be a site of concern here. It is possible that in this location nitrate may be limiting aquatic macrophyte growth. A high input of nitrate from Cole Creek could then partly explain the dense weed growth at the north end of Round Lake.

The Kjeldahl (organic) nitrogen and thus the total nitrogen concentrations given in Table 4 are quite normal for mid-Michigan lakes. Concentrations of total nitrogen given by Aquatic Consulting Services for 1975 for Mecosta Lake are slightly lower than ours. Nitrate concentrations reported by Engineering Design, Inc. for the 1990 spring run-off were seven to ten times higher than our values. These may reflect a strong watershed contribution of nitrate to the lakes. Storet data for 1985 reported by MDNR for Blue Lake gave spring nitrate concentrations higher than ours, but September values were lower than ours with the same being true for Round Lake. The storet data for total Kjeldahl nitrogen for 1985 was nearly identical to ours for Blue and Round Lakes.

Nitrogen concentrations do not appear to be a problem in the Tri Lakes.

Plankton: Water bottle samples were taken to collect phytoplankton (plant) and vertical tows with a Wisconsin Net were used to collect zooplankton (animal) from the open water areas of the three lakes. The identification and abundance of the phytoplankton is given in Table 5 and the zooplankton in Table 6. The phytoplankton populations were dominated by several species of blue-green algae in all three lakes with lesser populations of diatoms in Mecosta Lake. Diatoms were rare in Blue and Round Lakes. Ceratium, a member of the Pyrrhophyta, was abundant in Blue and Round Lakes.

Table 5: Phytoplankton of Round (R), Blue (B), and Mecosta (M) Lakes.

Identification	Density*
Phylum Cyanopyta - Blue-greens	
Anabaena sp.	Abundant (M) - Rare (B)
Chroococcus sp.	Abundant
Spirulina sp.	Abundant (M) - Common (B)
Nodularia sp.	Abundant (B) - Common (M)
Microcystis sp.	Abundant (M,R) - Common (B)
Oscillatoria sp	Rare (B)
Merismopedia sp.	Common (B)
Unknown filamentous blue-green	Abundant (B)
Phylum Chrysophyta - Yellow-greens	
Chrysosphaerella sp.	Rare
Dinobryan sp.	Rare
Diatoms:	
Cyclotella sp.	Common (M) - Rare (B)
Navicula sp.	Common (M) - Rare
Fragillaria sp.	Common (M)
Cymbella sp.	Rare
Melosira sp.	Rare (B)
Opephora sp.	Rare (M)
Diploneis sp.	Rare (M)
Tabellaria sp.	Rare (M)
Gyrosegma sp.	Rare (M)
Phylum Pyrrhophyta	
Gymnodinium sp.	Rare (M)
Peridinium sp.	Common (B)
Ceratium sp.	Abundant (B,R) - Rare (M)
Phylum Euglenophyta	
Phacus sp.	Abundant
Phylum Chlorophyta - Greens	
Scenedesmus sp.	Rare

*No designation indicates that density in all three lakes.

TRI-LAKES ASSOCIATION

DECEMBER 1, 1990 MEETING

The regular meeting of the Tri-Lakes Association was held at Connor's Supper Club at 10:00 A.M. Saturday, Dec. 1, 1990. The meeting was called to order by President Bonnie Cleeves.
Alan Anderson introduced Dr. Niles Kevern from MSU Fisheries and Wildlife Dept. Dr. Kevern gave an oral report of his August 1990 water testing of the Tri-Lakes. A copy of his report was provided for each Board member.
The minutes from the November meeting were accepted as read.
The Treasurer's report was approved with an ending balance of $3,942.20.
Rod Cully reported that all of the gypsy moth forms were completed and turned in on time.
Motion made, seconded and passed by unanimous vote to request the DNR to establish a 14" minimum for large mouth bass in Round Lake, Lake Mecosta and Blue Lake, as recommended by Dr. Kevern.
Winter golf volunteers were requested.
Bonnie reminded everyone to attend the Board dinner at Connor's tonight.
Motion seconded and passed to have the next Tri-Lakes meeting on April 6, 1991.
Motion made and seconded to adjourn.

Respectfully submitted,

Frieda N. Anderson
Acting Secretary

10443 Midshore Dr.
Mecosta, MI 49332

Dec. 17, 1990

DEC 20 1990

Mr. John Trimberger
350 Ottawa, NE
Grand Rapids, MI 49503

Dear Mr. Trimberger:

Per our phone conversation, enclosed is a copy of the minutes of the December 1st meeting of the Tri-Lakes Association Board of Directors. Also, enclosed is a copy of Dr. Kevern's survey of the Tri-Lakes done in August 1990.

Per Dr. Kevern's recommendation, we would like to request that the DNR establish a 14" minimum size for bass for Round Lake, Lake Mecosta, and Blue Lake, Mecosta County. Dr. Kevern's suggestion is found on Pages 53 and 54.

I can understand that it is probably too late to put this regulation into effect for 1991, but we will urge our members to follow this guideline.

Please keep me informed of the status of this rule change. Thank you for your cooperation.

Sincerely,

Alan D. Anderson

Alan D. Anderson, Chairman
Tri-Lakes Improvement Board

ADA/fna

Table 6. Zooplankton of Round, Mecosta and Blue Lakes.

Identification	Density: Round	Density: Blue	Density: Mecosta
Cladocera			
Bosminidae			
Bosmina longirostris	C	C*	C
Daphnidae			
Daphnia retrocurva	R	VC*	VC*
Daphnia pulex	NP	R	R
Ceriodaphnia sp.	R	R	R
Holopedidae			
Diaphanosoma sp.	C	R	C
Leptodoridae			
Leptodora kindti	NP	R	R
Copedoda			
Cyclopoida	VC*	C*	VC*
Calanoida	VC	C*	C
Diptera			
Culicidae			
Chaoborus sp.	R	R	R
Rotatoria			
Brachionidae			
Keratella sp.	C	R	R
nauplii larvae	C	C	C

NP = Not Present
R = Rare, less than 1/liter
C = Common, between 1 and 8/liter
VC = Very common, over 8/liter
* Dominated sampl

The zooplankton were dominated by copepods (Cyclopoida) in all three lakes along with the larger Cladocerans (Daphnia and Bosmina). Nauplii larvae of the zooplankton were common in all three lakes.

The dominance of blue-greens in the phytoplankton is not uncommon in Michigan lakes in late summer. In the Tri Lakes there was a strong dominance by the blue-greens at the expense of the green algae and diatoms. The blue-greens are often not consumed by the zooplankton to the extent that greens and diatoms are eaten and thus represent an undesirable situation. This "non inclusion" in the food web may contribute eventually to less fish growth and possible nuisance accumulation of the blue-green algae. Many blue-green algae can fix nitrogen gas as nitrate and thus in waters where nitrate is limiting these blue-greens usually have an advantage. Again, this situation may indicate a nitrate limitation.

The presence of some of the larger zooplankton such as the copepods and cladocerans is a good sign. These zooplankton graze effectively on the phytoplankton and thus might explain the lower numbers of the diatom and green algae. Sampling at one point in time makes interpretation of plankton data somewhat tenuous; however, the above projections are definite possibilities. Generally speaking, the zooplankton populations are reasonable and should be an adequate food base for growth of larval and juvenile fish.

Aquatic Plants: Approximately 15 species of aquatic plants were collected and identified. Most of these were found in Round Lake while lesser numbers of species were found in Mecosta and Blue Lakes. The shallow channels between the lakes, Gilbert Creek and the outlet to the west branch of the Muskegon River had notable plant beds. Specimens of these plants were collected by use of a rake. The plants, their distribution and density, are listed in Table 7 and shown in Figures 11, 12 and 13.

Table 7. Submergent macrophytes identified in Round, Mecosta and Blue Lakes.*

Plant Name	Round	Mecosta	Blue
Vallisneria americana (wild celery)	common	common	rare
Elodea canadensis (water weed)	common	patchy	rare
Najas flexilis (naiad)	patchy	patchy	NP
Ceratophyllum dermersum (coontail)	rare	NP	NP
Potamogeton zosteriformis (pondweed)	rare	NP	NP
Potamogeton richardsonii (pondweed)	common	rare	NP
Potamogeton pectinatus (sago pondweed)	common	rare	NP
Potamogeton gramineus (pondweed)	rare	rare	NP
Potamogeton amplifolius (large-leaf pondweed)	common	common	common
Myriophyllum spicatum (eurasian milfoil)	abundant	rare	NP
Myriophyllum exalbescens (northern milfoil)	abundant	common	rare
Myriophyllum sp (milfoil)	rare	NP	NP
Chara sp	abundant	abundant	common

*See Figs. 11, 12 and 13 for location detail. NP = Not Present

It is common for aquatic plants to occur in the littoral zones of lakes and in shallow channels and inlets where sediment may accumulate allowing for the plants to take root. The channels between the lakes and the outlet have moderate to dense beds of plants; however, the use of the channels and outlet by boats have kept these waterways open. This is a common situation and we would not recommend anything other than to continue boat traffic on the waterways. The inlet from Gilbert Creek has dense beds of plants, largely Potamogeton pectinatus, Ceratoptyllum demersum (coontail) and Myriophyllum verticulatum (green milfoil). Unless there is a need for

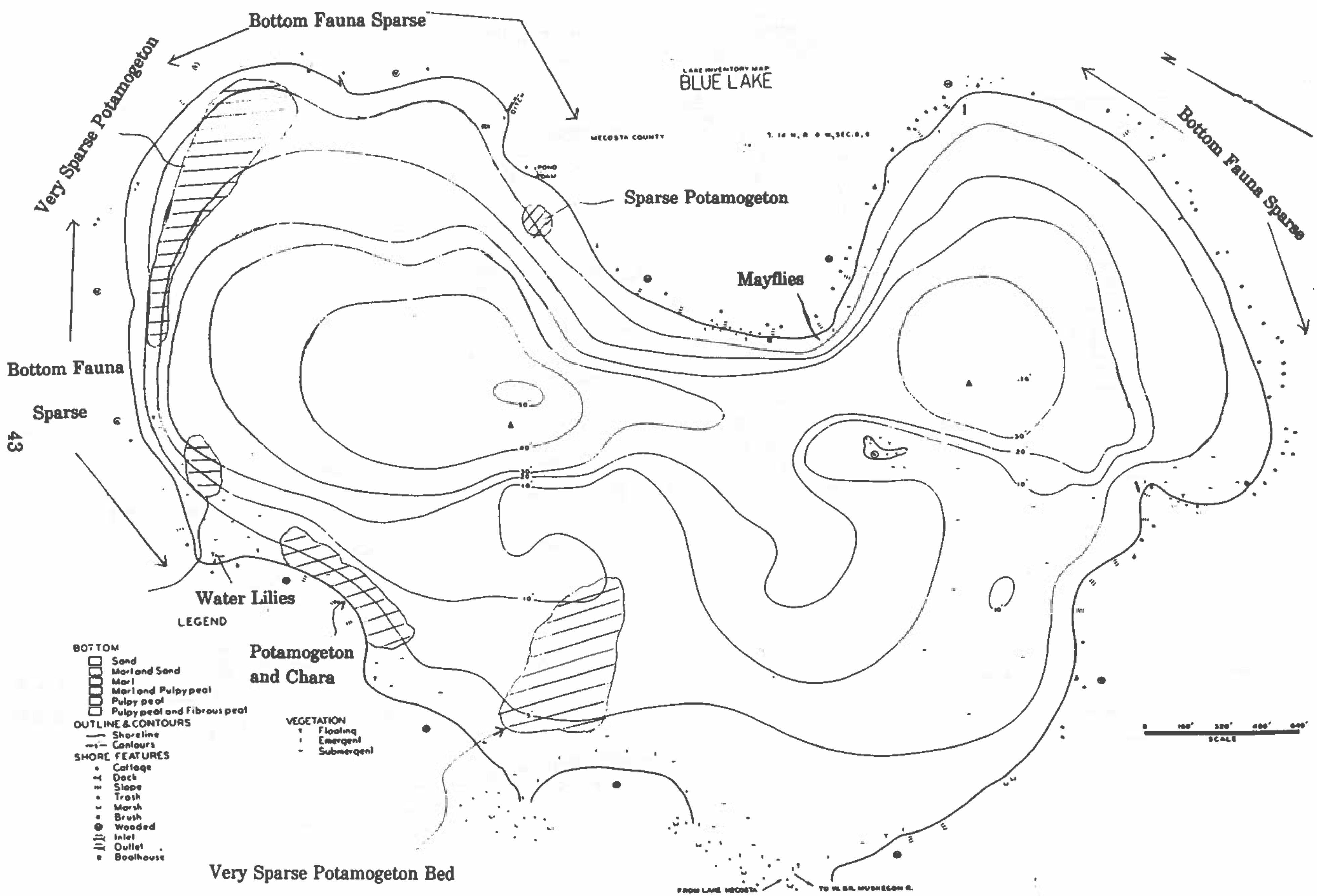


Figure 11. Distribution and density of aquatic plants and bottom fauna in Blue Lake.

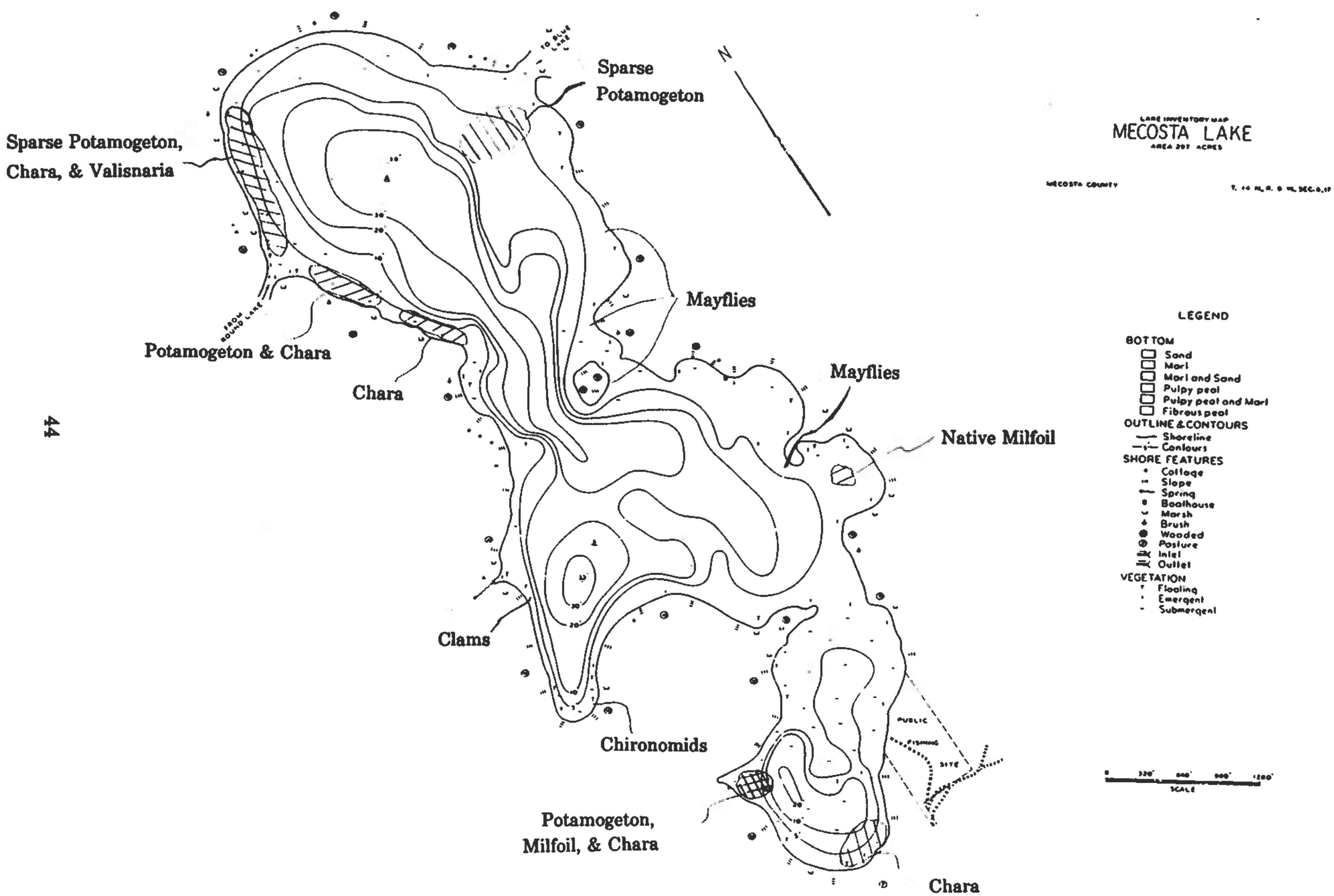


Figure 12. Distribution and density of aquatic plants and bottom fauna in Mecosta Lake.

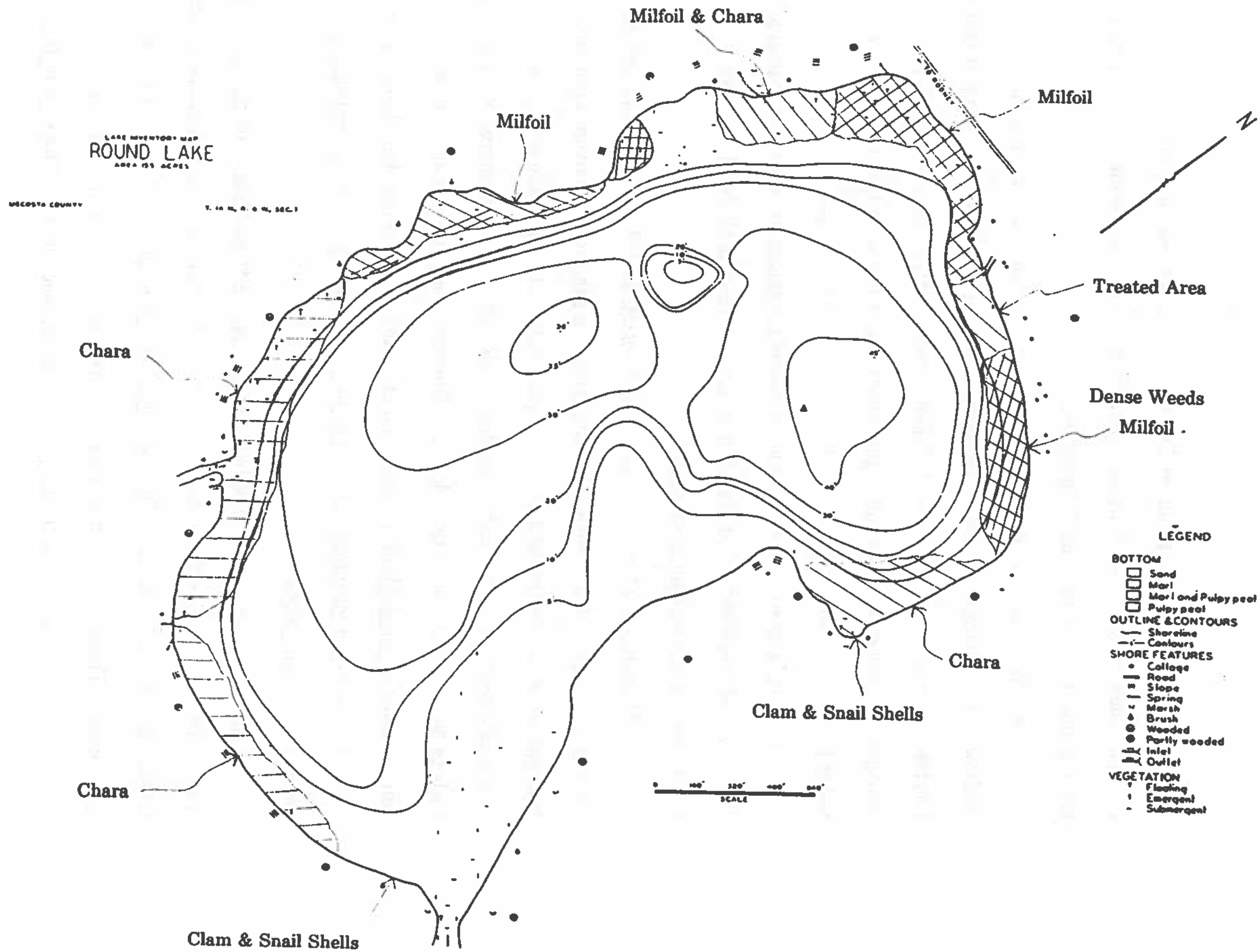


Figure 13. Distribution and density of aquatic plants and bottom fauna in Round Lake.

boat or canoe traffic to go up Gilbert Creek we would not see these plants as a problem; conversely, these plants may serve to effectively trap sediment and nutrients coming into the channel from Gilbert Creek.

Over the three lakes proper and in general we found extensive beds of Chara in shallow areas. Chara has a low growth form and often invades where raking or cutting has been used to control plants with higher growth forms. Chara is typical of moderate to hardwater lakes and is generally not a problem. A few sparse beds of water lilies were found in near-shore bay areas of all three lakes.

In Blue Lake we found only sparse beds of Potamogeton, mostly amplifolius, the large leaf pondweed. This sparse growth and very modest distribution we view as not a problem and actually good for fish.

In Mecosta Lake we found Vallisneria americana (wild celery), Potamogeton amplifolius (large-leaf pondweed) and Myriophyllum exalbescen (northern milfoil) to be common along the northwest shore with some scattered beds at the south end (especially near the spring) and along the middle part of the east shore. We view these beds to be sparse to moderate in density. The beds along the east shore bays may contain some Myriophyllum spicatum (eurasian milfoil), however, that identification is suspect. We do not view Mecosta Lake as having any weed problems requiring any concerted control efforts.

The plant growth in Round Lake is more extensive and has some problem areas. Table 7 lists five species of plants as common and two species of milfoil as abundant. Chara likewise was abundant. The plant beds at the north end of Round Lake are quite dense. These beds are near shore, covering much of the shore to the five foot contour and in some areas extending out to the ten foot contour. The area in front of the east trailer park was especially dense and appears to be impeding use of the boat docking facilities there. The area to the west is somewhat less dense as is the area along the west side where Burden Creek enters. We are concerned about the source of nutrients that is causing these dense plant beds. Cole Creek is a possibility; otherwise, leaking septic systems, surface runoff and boating use are possibilities. The trailer park to the west is on high ground and septic systems would appear to be removed as a problem. These beds on the north end contain plants that we identified as eurasian milfoil. While we seldom recommend chemical control of plants, this area may benefit from an initial chemical control effort. Later, the plants may then be controlled by near shore harvest.

We were supplied with previous reports by Mr. Alan Anderson. One report was dated September, 1989 and titled Tri-Lakes, Morton Township, Mecosta County, Amendment to the Improvement Study. The copy we were given revealed no authorship or source. We found this report to be in much agreement with our findings regarding the presence and location of plants. That report suggested eurasian milfoil on the east side of Mecosta Lake. We did not make a positive identification of eurasian milfoil at that location. We would encourage you to watch this area but not to enact control there at this time. The report gave an excellent overview of control methods, including expensive dredging. Our general recommendation is to use control only at the north end of Round Lake at this time. We do not see other areas as problems. Our usual recommendation is for lake-front owners to cooperate by using hand cutters and rakes to remove plants from their own areas by working individually or in friendly groups. These hand devices are inexpensive and used a few days each year, usually in late June, will provide good control over time.

Philosophically, where there are nutrients and sunlight you will have plant growth. Life would not exist if this were not true. If the higher plants (macrophytes) are controlled, then the nutrients will be used by some other plant. Often these are Chara, attached algae or phytoplankton. Often, we simply trade one problem for another and spend considerable money in a never ending process. In these cases, we often are working against "Mother Nature" and she is very persistent. The ultimate control is, of course, to find any excessive, non-natural, source of nutrients coming in from the watershed and try to stop that input. That should be your goal, to identify and put into effect the best watershed management practices.

Bottom Fauna: A small ponar grab sampler was used to take bottom samples of various bottom types around the littoral zone of the three lakes. Several groups of organisms were found and identified. In Blue Lake we found Palpomyia tibialis, one of the biting midges of the family Ceratopogonidae, a few burrowing mayflies of the genus Ephemera, and numerous amphipods, Hyalella asteca. There were a few representatives of Diptera larvae, oligochaetes (aquatic earthworms), leeches, dragonfly nymphs of the genus Gomphus, caddis fly larvae, and a number of fingernail clams of the familes Sphaeriidae and Physidae.

In Mecosta Lake we found Ephemera mayflies to be common along the east shore, a few caddisflies, snails of the families Lymnaeidae and Planorbidae, also fingernail clams, oligochaetes, and many diptera larvae. Amphipods also were common. In Round Lake there were great numbers of empty snail and fingernail clam shells, but we found fewer numbers of mayflies and amphipods than in Blue or Mecosta Lakes.

Although other species are probably present in the lakes, particularly at other times of the year, those found probably represent species that are most abundant and thus of greatest importance. Substrate (bottom type) appears to be more favorable for the desirable organisms in Blue and Mecosta Lakes where there is more clean gravel. The gravel areas are usually more evident on the wave swept shores; in this case, on the east side of the lakes. The presence of fair (Blue Lake) to good (Mecosta Lake) populations of mayflies and amphipods is an indication of good water quality. These organisms are sensitive to pollutants and require good oxygen levels. While we found a few mayflies and amphipods in Round Lake, there were less than in the other two lakes. The larger members of the bottom fauna, such as the burrowing mayflies and amphipods are an important food source for fish. Although mayflies were present in good numbers in some areas along the east shore of Mecosta Lake, we had hoped to see more widespread presence and greater numbers of mayflies. This aspect will be discussed more in the section on fish.

Fish: We depended on angler-caught fish for this portion of the survey. Numbers of samples were reasonable for bluegill and rock bass for Blue Lake and Mecosta Lake. We had a few largemouth bass and yellow perch also from Blue and Mecosta Lakes. We did not receive any fish scale samples from Round Lake. Our data are presented in Table 8 for Blue Lake and Table 9 for Mecosta Lake.

We had 16 bluegill samples and 10 rock bass samples from Blue Lake. All fish were aged using the scale samples provided. Lengths at earlier ages were back-calculated from the annuli on the scales. Bluegill in Blue Lake get off to a very slow start and gradually grow faster as they become older; by ages 7 and 8 they are close to

Table 8. The maximum, minimum, and average lengths (inches) for age groups of Blue Lake (BL) fish compared to the average for the State of Michigan (MI, bold face).

			Species*			
	Range		RKB	LMB	BLG	YLP
Age	Average	N:	10	2	16	2
III	minimum				3.3	
	maximum				3.3	
	BL avg.				3.3	
	MI avg.				**5.5**	
IV	minimum			11.3		7.4
	maximum			11.3		7.4
	BL avg.			11.3		7.4
	MI avg.			**12.2**		**8.0**
V	minimum		7.0		5.0	
	maximum		7.5		6.0	
	BL avg.		7.3		5.6	
	MI avg.		**7.4**		**7.0**	
VI	minimum		7.5	15.0	6.25	
	maximum		8.5	15.0	7.0	
	BL avg.		8.1	15.0	6.5	
	MI avg.		**8.2**	**15.1**	**7.5**	
VII	minimum		8.8		7.0	
	maximum		8.8		8.6	
	BL avg.		8.8		7.5	
	MI avg.		**8.9**		**7.9**	
VIII	minimum		9.5		8.0	
	maximum		9.5		8.0	
	BL avg.		9.5		8.0	
	MI avg.		**9.6**		**8.6**	

*RKB = Rock Bass; LMB = Largemouth Bass, BLG = Bluegill and YLP = Yellow Perch

Table 9. The maximum, minimum, and average lengths (inches) for age groups of Mecosta Lake (ML) fish compared to the average for the State of Michigan (MI, bold face).

			Species*			
	Range		RKB	LMB	BLG	YLP
Age	Average	N:	9	4	14	4
II	minimum			6.5		5.5
	maximum			6.5		5.9
	ML avg.			6.5		5.7
	MI avg.			**8.6**		**6.1**
III	minimum			8.0		
	maximum			10.0		
	ML avg.			9.0		
	MI avg.			**10.6**		
IV	minimum				3.0	7.5
	maximum				6.0	7.5
	ML avg.				4.2	7.5
	MI avg.				**6.4**	**8.0**
V	minimum		6.8		5.5	
	maximum		7.0		7.0	
	ML avg.		6.9		6.1	
	MI avg.		**7.4**		**7.0**	
VI	minimum		8.0	15.8	6.3	
	maximum		8.5	15.8	7.0	
	ML avg.		8.3	15.8	6.6	
	MI avg.		**8.2**	**15.1**	**7.5**	
VII	minimum		8.8		6.5	
	maximum		9.0		6.5	
	ML avg.		8.9		6.5	
	MI avg.		**8.9**		**7.9**	
VIII	minimum		10.0		8.0	
	maximum		10.0		8.0	
	ML avg.		10.0		8.0	
	MI avg.		**9.6**		**8.6**	

*RKB = Rock Bass; LMB = Large mouth Bass; BLG = Bluegill and YLP = Yellow Perch.

the State average. At age 3, they are 2.2 inches less than the State average; at age 5 they are 1.4 inches less, at age 6, 1.0 inch less; at age 7, 0.4 inch less and at age 8, 0.6 inch less. Thus there is considerable difference at age 3, but very little at age 7 or 8.

We had no young rock bass, these samples beginning with fish at age 5. The rock bass, for practical comparison, were about the same as the State average. We had two yellow perch, both age 4 and these were 0.6 inch less than the State average. We had one age 4 and one age 6 largemouth that were the same as the State average.

From Mecosta Lake, we had 14 bluegill scale samples beginning with fish at age 4. These bluegills showed a similar relationship to the State average as did the Blue Lake bluegills. At age 4, the fish were 2.2 inches less; at ages 5 and 6, 0.9 inch less. Older bluegill (2 in the sample) were inconsistent, with the age 8 fish being near the State average. We had nine rock bass from Mecosta Lake beginning with age 5 fish. The rock bass ranged from slightly below the State average at age 5 to slightly above the State average for fish at ages 6, 7, and 8. We had four largemouth bass and four yellow perch from mecosta Lake. An age 2 bass was 2.1 inches less than the State average; age 3 fish were 1.6 inches less and an age 6 fish was 0.7 inch larger than the State average. Three of the perch were age 2 and one was age 4; all were slightly less than the State average.

Overall, it appears that the younger age fish are small, but these fish recover and are near the State averages by ages 6 to 8. One interpretation of this situation is that there is much good spawning area for these fish resulting in an over production of larval and juvenile fish for the amount of small-sized food (e.g. zooplankton) available. Our zooplankton samples appear to support this interpretation as does the low bottom fauna population. It would appear that the lakes have a reasonable minnow population that allow the fish to grow faster once they reach a size large enough to eat the minnows.

One management strategy that is used in such situations is to increase the large predator fish population so as to reduce the number of the small bluegills. This allows the limited zooplankton and bottom fauna populations to better serve a smaller number of bluegill and rock bass. Largemouth bass are an effective predator on small bluegills especially when the bass reach a large size. Some lake associations have requested and obtained from MDNR, a larger size limit for bass on their lake. As an example, the size limit for largemouth bass on Horsehead Lake is 14 inches compared with the general 12-inch limit. This allows for more larger bass to prey on and reduce the over abundant small bluegill population. This has been effective in Horsehead Lake. We suggest this as a good strategy. An even further consideration is to promote catch and release fishing for bass among the anglers on your lakes.

MDNR provided us with fish data they collected on Blue Lake and Mecosta Lake (possibly in 1978) and for Round Lake in 1983. Their data showed the number of fish collected by species and the range of the lengths. The range in all cases extended well into the catchable size. Their statement for Round Lake was "Good populations of catchable black crappie and largemouth bass. Good population of tiger muskie but most under legal size. Growth of black crappie and northern pike above state average. Largemouth bass growth equal to state average, bluegill and perch below. Good fishing for crappie and bass. Good fishing for tiger muskie but most run 26-30 inches." These DNR data will be submitted to your Board.

Generally speaking, it appears that your lakes have good populations of fish. The size distribution might be improved by increasing the size limit on largemouth bass to 14 inches.

Trophic State Index: The MDNR uses the Trophic State Index (TSI) to determine the status of Michigan lakes. In 1989 they assigned the following TSI values: Blue Lake 42, Mecosta Lake 44 and Round Lake 45. Our values, based upon the average of two Secchi disk readings on each lake was 43 for all three lakes. This value indicates a mesotrophic status and is essentially the same as the MDNR values. The mesotrophic status may well be the best for all-around lake use.

The TSI can be calculated based on the total phosphorus concentrations of the surface waters. On this basis we determined the TSI to be 47 for Blue Lake, 34 for Mecosta Lake and 40 for Round Lake. Because phosphorus concentrations can change so easily, it is somewhat tenuous to base judgements on single values. It does appear that these TSI values based on phosphorus concentrations are about the same as those based on the Secchi disk readings. We believe all three lakes to be mesotrophic.

CONCLUSIONS

All three lakes appear to be of good quality. Considering all parameters we rank Blue and Mecosta to be nearly the same and both somewhat better than Round lake. On the basis of oxygen at depths and less plant growth, Blue Lake has an edge over Mecosta Lake; however, based on bottom fauna populations available for fish growth, Mecosta may be better. All three lakes are capable of supporting a variety of recreational uses as well as a variety of aquatic organisms. Your lakes should be considered of great value both economically and ecologically and judging from your concerns and actions you already realize that.

Most of the parameters sampled were normal for moderately hardwater lakes having a mesotrophic status. These normal parameters include dissolved oxygen, specific conductivity, pH, alkalinity, hardness, chloride, phosphorus and nitrogen. Aquatic life including phytoplankton, zooplankton, bottom fauna and fish were normal in species present. The bottom fauna were somewhat sparse. There was a dominance of blue-green algae in the phytoplankton of all lakes and this was not unexpected for August. While these forms are not desirable, their abundance was not high enough to be a concern.

The aquatic macrophytes (weeds) were typical of mid-Michigan lakes and, with the exception of the north end of Round lake, should not be considered a problem.

We congratulate the Board and Lake Associations for being aware and active and for having a limnological survey of the Tri Lakes. We suggest a repeat survey in about 10 years to compare with this study. Our specific recommendations follow. Keep up the good work!

RECOMMENDATIONS

1. Some type of lake monitoring or water analysis program should be continued. Knowing the general conditions of your lakes from this and previous studies is a good start. Monitoring for changes in the limnological conditions will be important in the future.

Continue to participate in the MDNR Self-Help Program. Do another overall limnological survey in 10 years and compare with this study.

The following were identified as possible problem areas. These areas should have further detailed attention to determine the existence or seriousness of the problem.

Cole Creek had a high specific conductivity and high nitrate concentrations. The input from Cole Creek could be partly responsible for the dense weed growth in the north end of Round Lake. We suggest a careful check of the Cole Creek watershed and further water sampling for nutrients several times during the year.

The spring, station 5, at the southwest end of Mecosta Lake was high in specific conductivity and in chloride concentration. This site should be sampled again for nutrients and the relevant watershed area examined for possible septic system input.

The canal on the southwest side of Round Lake had high specific conductivity and chloride concentrations. This area should be sampled again for nutrients and the area checked for possible leaking septic systems.

2. Areas that are suspected of septic system input should be checked for coliform bacteria. These examinations often will be done by County Health Departments or the Michigan Department of Public Health.

3. Septic systems should be checked periodically to insure that they are working properly. Septic systems should be pumped every 3-5 years if used only seasonally and more often for permanent residences.

4. Consider proposing to the membership, a petition to MDNR Fisheries Division, to increase the bass size limit to 14 inches. This would allow for larger bass to help reduce the number of small bluegill and sunfish thus making better fishing.

5. Fertilizers, pesticides and herbicides should be used sparingly, if at all, near the lake. Once used, it is very difficult to prevent these chemicals from eventually reaching the lake. In the water, their affects are usually undesirable.

6. Control of aquatic plants that become a nuisance near boat docks, swimming beaches or access sites should involve the cutting and removal of plants, not the use of herbicides. The effect of herbicides on plants is only a temporary solution while their effect on other organisms in the lake may be more long term. Plants that die from herbicides remain in the lake and decompose. Not only does this contribute to the richness of the lake bottom, but the nutrients stored in the plants are released back into the water. This helps promote future plant growth rather than discouraging it. By cutting and removing plants, potential organic matter and nutrients are removed from the water. This helps prevent increased plant growth in later years and, thus, is a better approach to controlling nuisance plants than herbicides. The one exception to this philosophy may be the need to use chemicals to gain an initial control over the dense weed beds near the north shore of Round lake.

Dense growths of aquatic plants are problems only when they interfere with desirable activities, such as swimming, water skiing or the movement of boats. Aquatic plants are a normal component of lakes and are necessary as substrate for organisms and cover (hiding places) for small fish. Some fish such as crappies and yellow perch often spawn over such weed beds.

Weed beds will increase or decrease depending on climatic conditions of temperature, sunlight, precipitation (water depth) and nutrients. Don't let one or two years of good growth panic your association into widespread control measures. We note that nearly all of the present plant beds were on the MDNR maps drawn in the 1940s. The situation has not changed much in nearly 50 years.

If weed growth problems exist near shore in front of cottage owners property, we encourage the owners to use the small cutters and rakes to take care of their own waterfront area. This approach is environmentally safe and helps to remove the plants and some of the contained nutrients.

7. Low areas, marshes and other vulnerable shoreline areas should be protected from destruction. Filling of these areas for homes, beaches, or docks may cause a depletion or even extinction of certain fish or wildlife species from your lakes. We noted several loons on Blue Lake and Mecosta Lake while we were sampling. <u>You are fortunate in having loons on your lakes</u>. <u>Protect their nesting areas</u>. Consider joining the Michigan Loon Association and educating your association members about loons.

8. Should further home or building development begin, all construction should be kept at a distance from the shoreline. Keeping a green belt of natural vegetation along the

shoreline serves as a buffer against erosion and nutrient input as well as preserving the integrity and natural beauty of the area.

9. Your associations and Board should develop a watershed approach for protecting your lakes. The watersheds of your lakes should be examined for possible nutrient input by drainage to your lakes. Well vegetated watersheds offer the best protection and development may cause problems if not done in an environmentally sound manner. We suggest that you obtain the books "Protecting Inland Lakes", "You Can Make a Difference" and "A Watershed Management Guidebook" from the MDNR, Land and Water Management Division. These are new publications in 1990 and are very helpful.

Appendix 1. Temperature, Oxygen, and Conductivity Profile Data For August 14, 1990

DEPTH (meters)	TEMPERATURE (C)		DISOLVED OXYGEN (mg/l)		SPECIFIC CONDUCTANCE (umhos/cm at 25 C)	
BLUE LAKE						
STATION:	1	2	1	2	1	2
0	22.5	22.3	8.9	9.0	226	264
1	22.5	22.3	9.1	8.9	226	264
2	22.5	22.3	9.1	8.9	223	264
3	22.4	22.3	8.9	8.9	223	264
4	22.2	22.2	8.3	8.9	224	264
5	21.7	21.7	7.8	7.9	225	268
6	21.2	21.1	6.7	6.2	226	271
7	20.4	19.6	5.2	0.9	229	278
8	17.7	16.8	0.4	0.3	241	292
9	15.2	14.3	0.2	0.1	239	305
10	13.5	12.1	0.2	0.0	246	316
11	12.8	10.2	0.2	0.0	254	325
12		9.4		0.0		329
13		9.5		0.0		329
14		9.1		0.0		331
MECOSTA LAKE						
STATION:	3	4	3	4	3	4
0	22.8	23.0	9.2	9.3	267	270
1	22.8	23.0	9.2	9.3	268	270
2	22.8	22.5	9.3	9.3	268	271
3	22.8	22.2	9.3	9.1	268	274
4	22.8	21.8	9.4	8.1	268	277
5	21.2	21.0	7.0	6.1	275	292
6	20.3	19.0	4.7	2.7	282	308
7	17.3	14.0	0.3	0.4	308	336
8	14.2	12.3	0.3	0.2	306	342
9	12.4	10.0	0.0	0.0	313	367
ROUND LAKE						
STATION:	6	7	6	7	6	7
0	22.5	23.0	9.6	10.2	252	248
1	22.5	22.8	9.6	10.0	252	250
2	22.2	22.6	9.7	9.9	252	250
3	20.8	22.5	8.7	9.9	260	252
4	20.0	20.0	7.8	8.6	265	264
5	18.5	17.0	1.7	1.7	283	284
6	16.0	15.0	0.7	1.6	286	288
7	12.0	12.2	0.2	0.2	284	285
8	10.2	10.0	0.1	0.1	292	291
9	9.8	9.7	0.0	0.0	300	293
10		8.8		0.0		293
11		8.0		0.0		296
12		7.6		0.0		310