MORRIS LAKE

LONG LAKE

UNDERC
1982

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The University of Notre Dame Environmental Research Center (UNDERC) contains more than twenty lakes and bogs, each of which is characterized by its own unique blend of chemistry and biology. The chemistry in large part determines the relative productivity of the lake while the biology depends upon the chemistry and other factors. Morris and Long are two lakes at opposite ends of the productivity spectrum. Chemistry, phytoplankton and zooplankton are the primary distinguishing characteristics that we used.

Morris Lake is a shallow lake that contains extensive macrophytic growth among the most noticable being water lilies and waterweed (Elodea). Along the edge of the lake is a ring of alder. The surrounding shoreline is primarily composed of deciduous trees with a minimum of coniferous stands. The bottom is rocky and muddy sediment gives way to sandy bottom near the shore. There are many fallen trees in the water along the shore. The water is the color of tea and drainage is from Mullahy and Ward Lakes and into Tenderfoot Creek.

MORRIS LAKE

Epilimnion Sample from 0.5m

Hypolimnion Sample from 4.0m

		Epilimnion	Hypolimnion
Acidity	:		
- Methyl Orange		0 mg/l	0 mg/l
- Phenolphthalein		10 mg/l	26 mg/l
Alkalinity	:	40 mg/l	60 mg/l
Apparent Color	:	90 units	190 units
Calcium Hardness	:	30 mg/l	40 mg/l
Magnesium Hardness	:	15 mg/l	20 mg/l
Total Hardness	:	45 mg/l	60 mg/l
Nitrates	:	.25 mg/l	.25 mg/l
Phosphates	:	.95 mg/l	. 9 mg/l
Sulfates	:	44 mg/l	0 mg/l
pH	:	6.7	6.8
Specific Conductance	:	70	105
Secchi Disc	:	1.3m	

MORRIS LAKE PLANKTON COUNT

Scanning Lens - 4.5 Fields

1 Pass

Zooplankton

Keratella	3136/ml
Diaptomus	211/ml
Nauplius	135/ml
Eucyclops	94/ml
Bosmina	81/ml
Daphnia	67/ml
Asplancha	67/ml
Cyclops	67/ml
Limnocalanus	13/ml
Asplanchnopus	13/ml

Phytoplankton

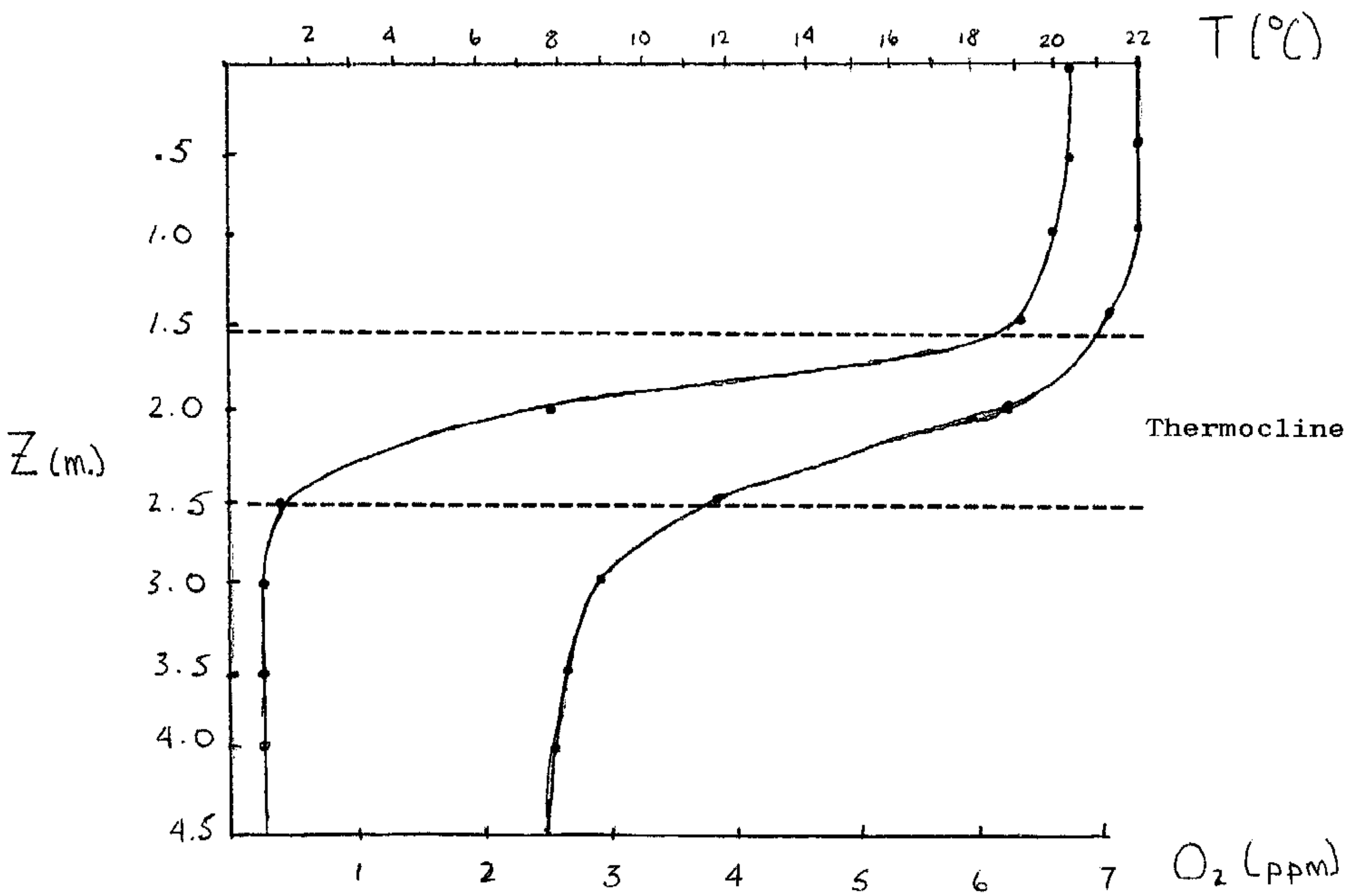
Ulothrix	140/ml

(average colony = 30 cells)

Morris Lake

Oxygen-Temperature Profile

July 27, 1982



Long is a rectangular shaped lake with deep spots at both ends separated by shallower area. The shore has a few coniferous trees, but is primarily beech and maple trees. The shore also has a small amount of *Sphagnum* moss and a few Tamarack trees. There are no visible inlets or outlets.

LONG LAKE

Epilimnion Sample from 0.5m

Hypolimnion Sample from 8.0m
(both East & West)

			West Epilimnion	East Epilimnion	West Hypolimnion	East Hypolimnion
Acidity	:	(mg/l)				
- Methyl Orange			0	0	0	0
- Phenolphthalein			65	15	65	20
Alkalinity	:	(mg/l)	5	7.5	10	7.5
Apparent Color	:	(units)	55	50	55	60
True Color	:	(units)	60	75	75	60
Calcium Hardness	:	(mg/l)	10	10	10	10
Magnesium Hardness	:	(mg/l)	17	15	10	10
Total Hardness	:	(mg/l)	27	25	20	20
Nitrates	:	(mg/l)	.65	.5	.95	.45
Phosphates	:	(mg/l)	.02	.02	.03	.02
Sulfates	:	(mg/l)	3	2	3	2
pH	:		5.7	5.7	5.6	5.9
Specific Conductance	:	(umhos)	23	22	27	30
Secchi Disc	:		1.6m	1.6m		

LONG LAKE PLANKTON COUNT

Scanning Lens - 4.5 Fields

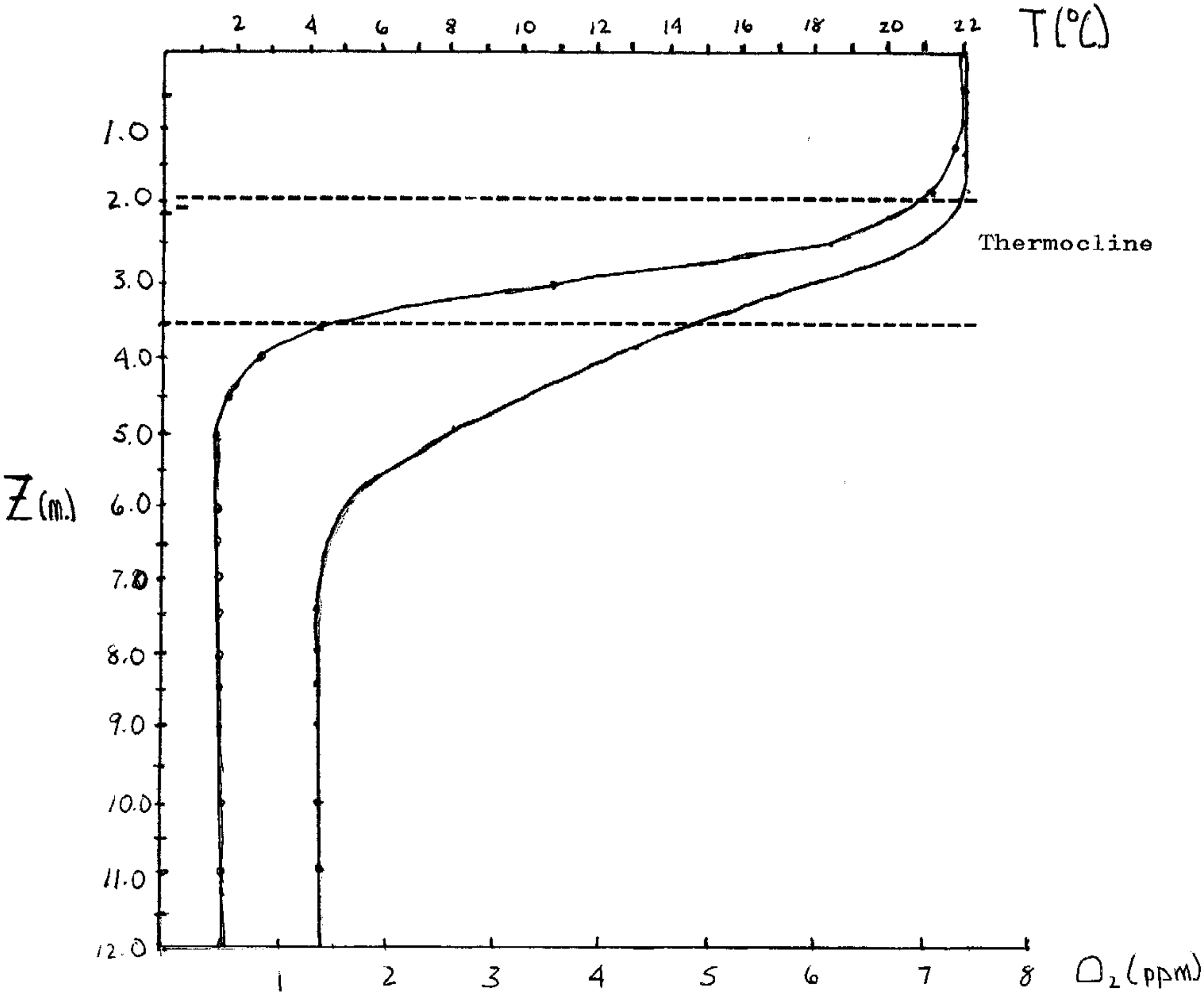
4 Passes

Zooplankton		*Phytoplankton*		
Daphnia	*85/ml*	*Eudorina*	*(colonies)*	*152/ml*
Asplanchna	*28/ml*	*(average colony = 20 cells)*		
Cyclops	*17/ml*	*Microcystis*	*(colonies)*	*56/ml*
Keratella	*12/ml*	*(average colony = 50 cells)*		
Bosmina	*6/ml*			
Polyartha	*3/ml*	*Volvox*		*11/ml*

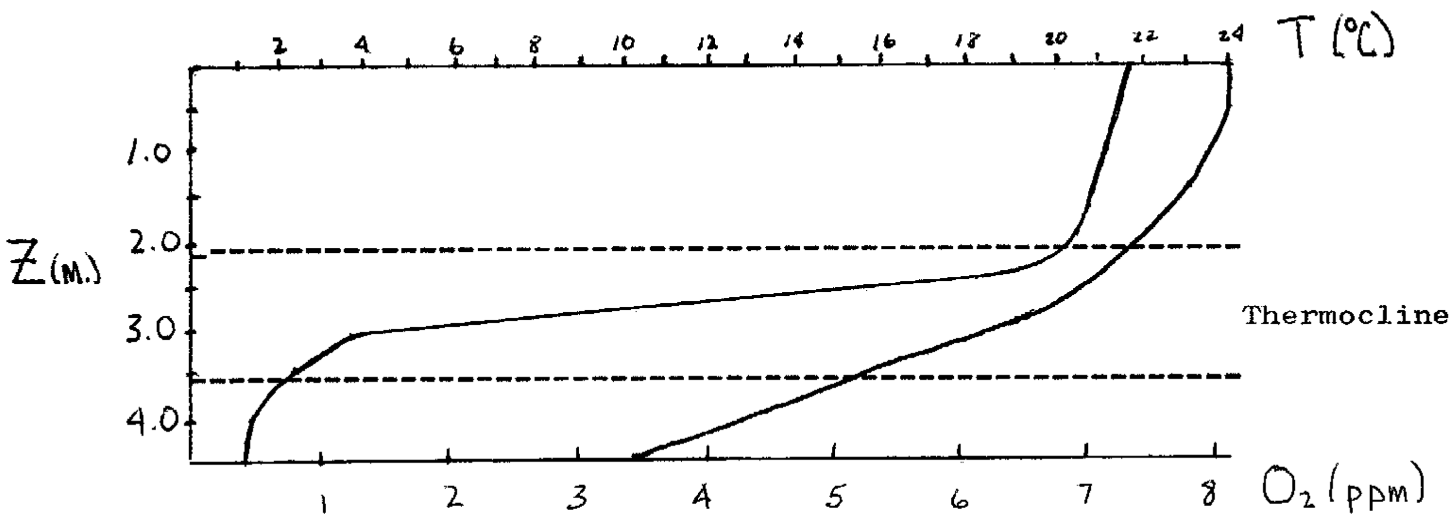
Long Lake Oxygen-Temperature Profile

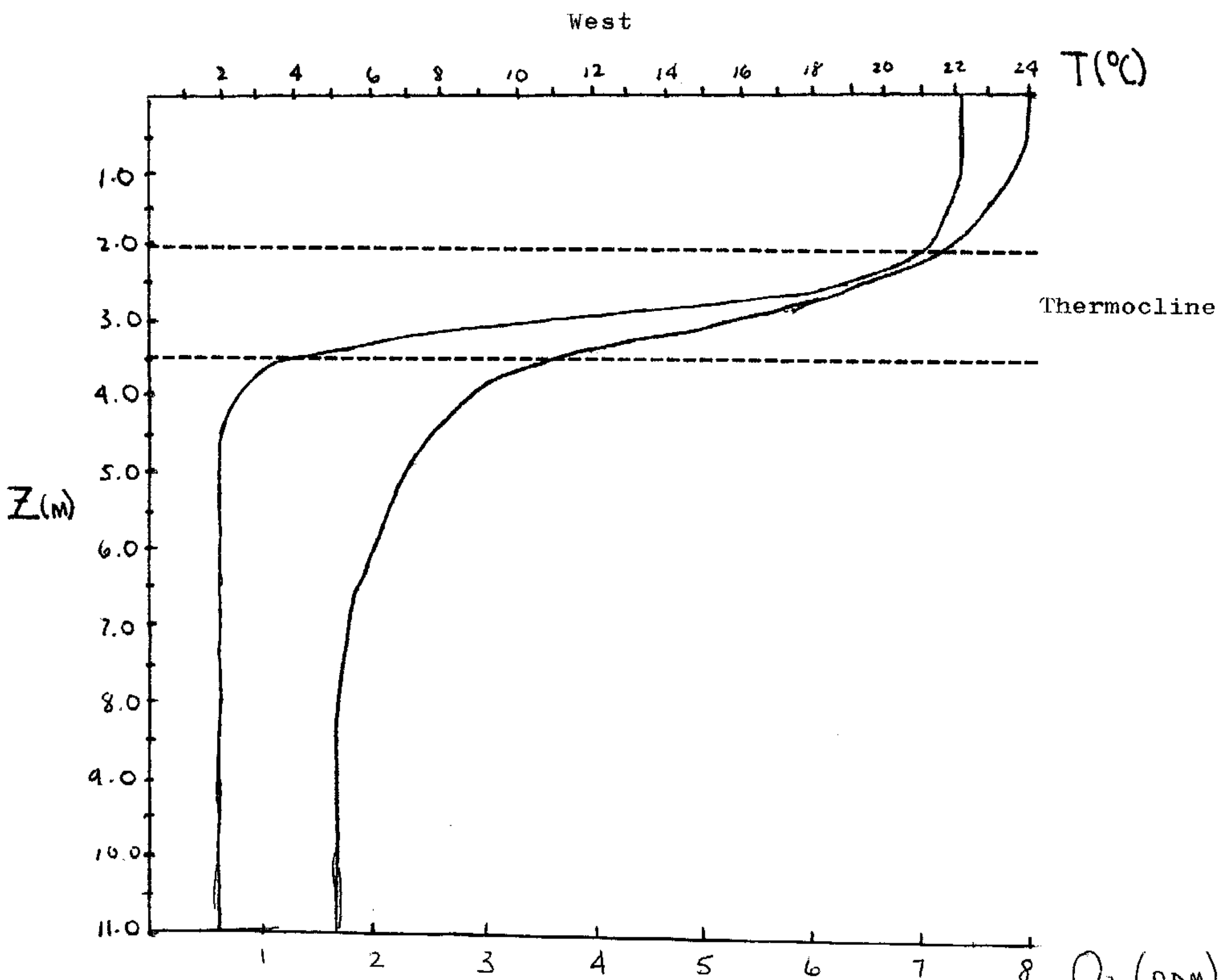
July 28, 1982

East



Middle




West
T(°C)
2
4
6
8
10
12
14
16
18
20
22
24
Z(m)
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
Thermocline
O2 (ppm)
1
2
3
4
5
6
7
8

Certain characteristics of lakes, both chemical and physical, give good clues as to the biological nature of the lake. The shape of the lake and its shoreline are two such clues. Morris lake is shallow, dish-shaped witha maximum measured depth of 4.5 meters. There is a large littoral zone with extensive macrophytic growth. The shoreline has few wind-obstructing trees. This situation enhances productivity for a number of reasons. The irregularity of the shoreline provides more land-water contact which provides more nutrients for the water. The shallow water permits more rooted macrophytes and more diversification of habitats. The primary benefit of this type of lake is that the photosynthethc zone is superimposed upon the decomposition zone. The gentle slope of the sides catches decaying leaves and other decomposing items and traps the nutrients with them. Since aquatic plants get the majority of their nutrients from the sediment, this is an important condition.

Since Morris Lake is so shallow it uaually turns over every spring and fall. The wind has plenty of opportunity to mix the water. The summer thermocline which was present at the time of our testing was about two meters from the surface. This created an epilimnion and a hypolimnion of nearly equal volume, another characteristic of productive lakes. The oxygen-temperature profile illustrates this point as well as some others. There is a plentiful oxygen supply in the epilimnion, but a very minimal amount in the hypolimnion. The epilimnion has two sources of oxygen. The first is mixing with the atmosphere at the air-water interface. The second is the large amount of photosynthesis going on in the euphotic zone. This oxygen is prevented from mixing with the hypolimnion by the thermocline. The hypolimnion generally has no significant sources of oxygen since photosynthesis does not occur at that depth in this lake. Decomposition and respiration by the few organisms there rapidly deplete the oxygen supply and summer stagnation is in effect. Iron oxidation to form insoluble ferric hydrate is another source of oxygen depletion. The low oxygen readings may in fact be false, that is, not due to oxygen at all, but rather caused by hydrogen sulfide (H_2S) which is a result of anaerobic decomposition.

The presence of the thermocline also isolates nutrients in the epilimnion and the hypolimnion. Phosphorous in the form of phasphates is considered to be a limiting factor in productivity. As the summer progresses, the phosphates are removed from their usable form to a variety of organic forms. Replacement sources such as eroding rock can not renew the supply quickly enough. The nutrients lost in stratification are not attainable until the next turnover. Morris Lake was relatively high in phosphates at the time of testing. This indicates that the phasphates were very high in the spring and also that the lake is still capable of sustaining a great amount of biological activity. Nitrates are another nutrient which are sometimes thaought to limit phytoplankton growth. They are necessary to insure the proper development of chlorophyll and are needed in lesser amounts than phosphates. The amount present in Morris Lake is sufficient to maintain the high productivity level. Sulfates comprise a third nutrient required tor maximum productivity. There is plenty in the epilimnion, but strangely none in the hypolimnion. One possible explanation is that iron (which is abundant in this lake) combines with the sulfates in the absence of oxygen to produce ferrous sulfate.

A very good indicator of a lake's productivity is its hardness. Magnesium and calcium are extremely important in aquatic habitats. Calcium is needed to monitor the proper translocation of carbohydrates in macrophytes. It is also an important component of plant tissue as well as an excellent facilitator for the availability of ather ions. Finally, it acts as an antidoting agent reducing the harmful effects of single salt solutions of sodium and potassium. Magnesium is required in lesser quantity as a phosphate carrier and chlorophyll developing agent. Sources of thses two ions are eroding rock and ground water entering the lake. Morris Lake is high in both calcium and magnesium and this is one reason for the success of the macrophytes as well as the phytoplankton. Differences in concentration between the epilimnion and the hypolimnion are due to carbonated water freeing them from the mud, plankton decomposition and precipitation as $CaCO_3$.

Not only are calcium and magnesium vital to plant success in Morris, they also play a large role in the buffering process of the lake. Alkalinity is due in great part to the ability of thses two ions to fix carbon dioxide into calcium and magnesium carbonate. The buffering system works according to the following equation:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^=$$

As can be seen, this is a reversible process designed to maintain equilibrium. As CO_2 is withdrawn from the water by the photosynthetic plants, the eauation proceeds to the left and bicarbonate changes to carbonic acid. Corresponding to this transformation is a change in the hydrogen ion concentration. Likewise, CO_2 may be added by respiration and decomposition which would move the equation back to the right and subsequently add more hydrogen ions. The benefit of this system is that equilibrium and pH are maintained. The job of the calcium and the magnesium is to fix the bicarbonate at the endpoint of the reaction, The more plants there are (and Morris has plenty) the greater the CO_2 uptake and the greater the alkalinity. High alkalinity allows greater amounts of acid to be introduced before an appreciable pH change occurs.

The acidity of Morris Lake is critical for a number of reasons. First is the situation just mentioned. A significant amount of acid in a lake with lao alkalinity would have drastic effects. The second is that the acidity may adversely effect the tissues of the organisms. Also it may effect the cell's ability to absorb oxygen and give off carbon dioxide, as well as effecting the permeability of the membrane. Organisms have specific tolerance ranges and maximum productivity is only attainable within these ranges. It is common for the hypolimnion to be more acidic than the epilimnion. Since oxygen is depleted in the hypolimnion free carbon dioxide is accumulated through decomposition. The acidity in Morris Lake is low enough that it does not have any fo these harmful effects.

Conductivity measures the electrolytes, the acids bases and salts in solution with water. As would be expected by the large amount of calcium, magnesium and iron, the specific conductance is high. Vertical distribution of electrolytes is due to various chemical and biological procesess which are restricted to the epilimnion and the hypolimnion.

The color of the water was tea brown. The apparent color is due to living and nonliving suspended particles. The true color is due to colloidal substances. Iron and humic acids are largely responsible for the dark color. The difference between epilimnion and hypolimnion is primarily due to the unequal distribution of iron. Even though the water is so dark photosynthesis can still occur in quantity since most of the macrophytes and plankton are in the upper portions of the water column.

When all of these factors, chemical and physical, are combined the bottom line is that Morris Lake is a very productive lake in terms of plankton and macrophytes.

Phytoplankton productivity can control the biological activity of a lake since it responsible for primary production. The conditions for plankton survival in Morris Lake are very good. There is a lot of shallow water and a large euphotic zone. Vital nutrients such as magnesium, calcium, phosphates and carbon dioxide are in abundance. The photosynthetic and decomposition zones overlap and the water is calm enough to allow colony and filament growth.

The interesting point about phtoplankton is the variety that was found. There are three sources of phytoplankton listings which are references concerning what may possibly be found. The guide to UNDERC, the formalized sample taken in late July, and the fresh sample taken during the middle of August. The guide listed Dinobryon as abundant and Ceratium as present. The fresh sample had Ceratium abundant and Fragellaria present. The preserved sample had only Ulothrix. This apparent inconsistency is due to the fact that each species has its own seasonal cycle. Beyond the seasonal maxima which correspond with the spring and fall turnovers, phytoplankton also has peaks and valleys during the summer period. Since the three sources are from different times of the year the listing of the different species and the number of each would vary. At the time of our collection, Ulothrix was at a pulse, and all others were at a minima. Other factors effecting the distribution of the plankton are the winds which may blow certain species away while others mantain their position. This makes the sampling site important. Discriminatory grazing by zooplankters, the time of day and the depth of the tow are also factors. Even though Ulothrix was the only phytoplankton that was counted, enough samples were analized to conclude that the primary production in Morris Lake was considerable.

The success of the phytoplankton would predict a corresponding success in the zooplankton. The most abundant by far is the winter form of Keratella, a filter feeder. Another filter feeder Diaptomus was also very abundant. These are successful because they will eat any phytoplankton available, which means they have an ample food supply throughout the entire summer. The cladocerans (Daphnia and Bosmina) are detritus and phtoplankton feeders, so they do well. Some of the rotifers are predatory and there are so many Keratella and other small plankters that they do well also.

Discrepencies similar to those in the phytoplankton can be accounted for by realizing that the zooplankters react differntly to light, food availability, dissolved gases, temperature, size, and age of the individual. Their reactions to these conditions dictate their vertical position in the water column. The number of zoo plankters also is associated with the number of phytoplankters. A surge in the zoo plankton population can be expected shortly after a phytoplankton pulse.

Morris Lake is noted for its stunted Northern pike population. These carnivores have huge appetites and their normal diet consists of perch, black bass, sunfishes, crawfishes, frogs and large aquatic insects. However these are not present in sufficient quantity for natural development. Since there are few intermediate consumers, the zooplankton flourishes and the pike suffer.

In contrast to Morris Lake, Long is one of the less productive lakes on the property. Many of the characteristics responsible for Morris's great biological activity are reversed in Long. The first such characteristic is the shape of the of the lake. Long has two deep ends with steep sloping sides. The photosynthetic and decomposition zones do not overlap because 1) the euphotic zone has a much smaller area and 2) the decomposed material does not stay on the sides but instead falls all the way to the bottom.

A glance at the three oxygen-temperature profiles for the three regions reveals some interseting points. The ends of the lake are so deep that they are very difficult to turnover. As a byproduct, the thermocline is high in the water column creating a hypolimnion that has much greater volume than the epilinion. This is typical of relatively unproductive lakes. The epilimnion has a good oxygen supply but renewed oxygen comes only from mixing at the surface and phtoplankton, no macrophytes to speak of. The hypolimnion is also without significant oxygen supply. Decomposition and respiration uses up the available supply. As a result, the vast majority of the biological activity is restricted to the epilimnion just as in Morris. The profiles also indicate that the thermocline is consistant over the entire lake. Therefore the epilimnion is one water mass and the two hypolimnions can be considered as separates water masses, each capable of its own distinct chemistry. However both hypolimnions were basically the same, possibly because they had not been isolated long enough to develop individually.

A noticable difference between Long And Morris Lakes is in the nutrient department. Whereas Morris was high in phosphates, nitrates and sulfates, Long is just the opposite. Both the phosphates and the sulfates are very low. This could be because it is late the summer and they were used up. Another and more likely possibility is that there just were not that many there to begin with. There are plenty of nitrates, but as has been previously noted, phosphates are generally the limiting factor. Whatever the reason for its scarcity the phosphates present can only support a minimum of biological activity.

The magnesium and calcium that are so essential to plants and to the buffering system are present, but only in low concentrations. This severly limits the plant growth, and the buffering capacity is quite restricted. Since Long has no inlets or outlets it has no water entering the lake and therefore lacks this source of ions. The Sphagnum also may be affecting the ion supply. The uronic acid of Sphagnum exchanges hydrogen ion (increases acidity) for calcium and magnesium ion further depleting the source.

The acidity of Long is much higher than Morris due to the poor buffering capacity and the presence of Sphagnum. This indicates that Long is on its way to becoming a bog.

AS would be expected, the specific conductance of Long Lake is low emphasizing the fact that this lake is low in magnesium, calcium and iron. The color also is not as dark as Morris since again there is not as much iron mor as many macrophytes producing humic acid.

Phytoplankton does fairly well in Long Lake. It has a wide variety of species, but not a lot of each species. This is also typical of relatively unproductive lakes. An interesting note is that colonial forms predominate possibly because there is no flow in the water and it is easier to maintain colonies and filaments in such an environment. The conditions for planktonic photosynthesis are fair with the clear calm water. However the necessary nutrients are not in great supply, and this is a limiting factor. That species that we netted were most likely at a pulse at the time, and other species were not.

The zooplankton were similar to those found in Morris, but in lesser numbers. The majority of them are phtoplanktonic filter feeders with a few predatory rotifers. Because of the limited phytoplakton there is naturally a limited zooplankton count. Another reason for the limited zooplankton count is the presence of lower level consumers such as bass which regulary feed on them..

The broadest generalization to be drawn from this report is Morris is a productive lake while Long is an unproductive lake that is most likely turning into a bog. More subtle points are all of those discussed in relation to chemistry and biological activity. Any differences in these lakes when compared to past years could very likely be attributed to the different testing time.

Bibliography

1. Birge, Edward A. and Chancey Juday. The Inland Lakes of Wisconsin. The Plankton. Madison, Wis. Published by the state. 1922.

2. Davis, Charles C. The Marine and Fresh-water Plankton. Michigan State University Press. 1955

3. Welch, Paul S. Limnology. McGraw-Hill Book Company. 1952