LOST LAKE

A Comparative Lake Survey

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Abstract

On July 14, 1993, a survey of Lost Lake, located in the Pigeon River State Forest in Otsego County, Michigan, was executed. The survey was completed by members of the University of Michigan Biological Station's Limnology class under the direction of Dr. Nancy Tuchman. The chemical, physical, and nutritional properties of the lake were determined at this time and in the following laboratory analysis. Temperature and dissolved oxygen stratifications were determined. Conductivity was uniform throughout the water column, indicating that Lost Lake is no longer meromictic. The average pH value was 7.4 suggesting relatively high alkalinity. Ammonia, nitrate, silica, magnesium, calcium and phosphate concentrations were determined by laboratory analysis and found to be typical of an oligotrophic, solution lake. The hardness values of Lost Lake are evidence of high calcium and magnesium concentrations. Light intensity was found to permeate very deep into the lake, with a compensation point located at 14 meters. Chlorophyll a values were low as expected for an oligotrophic lake. The Eckman dredge, plankton tows, and benthic sampling failed to produce high numbers of organisms. Based on these observations, we conclude that Lost Lake is no longer meromictic and is truly an oligotrophic lake.

Introduction

Lost Lake is a deep calcium carbonate lake that lies in Pigeon River County State Forest in Ostego County, Michigan (T32N, R1W; sections 2,3). The lake is circular with no shoreline development and the basin drops steeply down from the edge. The watershed is extremely steep as well and the slope of the shore and lake forms a deep conical basin. As a solution lake, Lost Lake was probably formed when ground water eroded away some of the surrounding limestone causing it to collapse, forming the basin. From the top of the steep hill, Lost Lake appears a deep emerald green color due to the abundance of calcium carbonate.

Ground water, runoff, and precipitation are the only sources of water for this oligotrophic seepage lake. Due to the steep nature of Lost Lake's shoreline and basin, the lake is sheltered from almost all wind which prevents the nutrients of the lake from mixing. In the past Lost Lake has been classified as a meromictic lake (Latta, 1962). A 1992 survey completed by Kaufman, Nida, and O'Connor hypothesized that Lost Lake no longer displayed meromictic properties. Data collected on July 14, 1993 affirms this hypothesis which we intend to prove. While we concur with 1992 hypothesis that Lost Lake is no longer meromictic, we argue that the lake shows only oligotrophic characteristics and not those associated with the "ontogenetic stage between oligotrophy and mesotrophy" (Kaufman et al., 1992).

Methods and Materials

Lost Lake was surveyed on the 14th of July 1993 by the twelve members of Dr. Nancy Tuchman's Limnology class at the University of Michigan's Biological Station. The following testing procedures were followed in accordance with Standard Methods for the Examination of Water and Wastewater (APHA, 1989).

In order to determine the different temperature strata of the lake, a Hydrolab Instrument cluster was used. Measurements were taken at 1 meter intervals from the surface to the deepest basin of the lake at 15 meters. The epilimnion was between 0-3.5 meters deep, the metalimnion occurred between 3.5-8.5 meters, and the hypolimnion fell below 8.5 meters. The temperature data collected will be of great use in analyzing the solubility of oxygen and other chemicals, nutrients found, water density, stratification, and other biological characteristics of Lost Lake.

The concentration of dissolved oxygen (mg/L) was determined in the lake at 1 meter intervals using the Hydrolab Instrument Cluster and the YSI Dissolved Oxygen Meter. A dissolved oxygen profile was constructed from these values. Hypothetical carbon dioxide values were taken as an inverse of the dissolved oxygen profile. Furthermore, the percent saturation of oxygen was determined using dissolved oxygen values, temperature values, and an Oxygen Saturation Nomagram (Wetzel, 1983).

Conductivity, measured in µmhos/cm, and pH values were also obtained using the Hydrolab Instrument Cluster at 1 meter intervals.

From the depths determined by the temperature profile of the lake, water samples were collected from each strata at 1.5 meters (epilimnion), 5.0 meters (metalimnion), and 14 meters (hypolimnion). From each strata four water samples were taken and were placed in acid washed poly bottles. The first bottle contained 125 ml of water for testing of alkalinity and hardness. The second bottle contained water filtered through .45 µm acid soaked Millipore filter using a

Swinex syringe. This bottle was acidified with concentrated sulfuric acid, and was used for testing of ammonia and nitrate. The third bottle contained untreated filtered water and was used for testing of phosphorus and silica. The fourth bottle contained 125 ml of filtered water and nitric acid. This bottle was used in testing heavy metals and cations. These bottles were refrigerated in the lab until analysis.

Using the temperature stratification information, quantitative vertical plankton tows were taken with a Wisconsin net. These vertical tows were taken from the bottom of the epilimnion to the surface, the bottom of the metalimnion to the surface, and the bottom of the hypolimnion to the surface. Soda water was added to each sample to narcotize the organisms. Koechies was added as a fixative. These tows were used to survey and quantify the phytoplankton and zooplankton present in the lake.

In order to obtain information about how far light travels through the waters of Lost Lake, a photometer was used to measure the light intensity at one meter increments in the deep basin of the lake. Several readings were taken at each meter and were averaged to obtain light intensity in μ Einstein/m^2/second. The compensation point was then calculated at a depth of one percent of surface light. A secchi disk was used to estimate the compensation point of light in Lost Lake. From the constructed light profile, depths of the upper, middle, and lower euphotic zones were calculated and water samples were obtained from a Van Dorn at 3.5 meters, 7.0 meters, 10.5 meters respectively. These water samples were filtered through .45µm Millipore filters using a Swinex syringe. The filters were then wrapped in aluminum foil and saved for chlorophyll analysis.

Using an Eckman dredge, benthic sediments and macrophytes were collected in the upper, middle, lower littoral, and pelagic zones at 1M, 1.75 m, 2.75 m, and 7.5 m respectively. Three quantitative invertebrate samples were collected in a .21 m^2 area in the littoral zone using a sampling box and dipnets. The invertebrates found were then preserved in 95 percent ethanol.

A qualitative sample of aquatic invertebrates was taken with dipnets in several areas of the littoral zone of Lost Lake and then preserved in 95 percent ethanol. To find a representation of the zooplankton and phytoplankton residing near the surface of the lake, a horizontal plankton tow was taken. The plankton found were narcotized in soda water and preserved in Koechies solution.

Before leaving Lost Lake, several species of plants were collected in areas of the littoral zone along with rocks containing calcium carbonate deposits.

Laboratory Analysis

To determine Lost Lake's alkalinity and hardness, standard titration methods, as described in Methods for the

Examination of Water and Wastewater, were used (1989). The Technicon AutoAnalyzer II was employed to determine the concentrations of ammonia, nitrate, phosphorus, and silica. To discover the abundance of the cations Ca^{++} and Mg^{++} found in the lake, The Flame Atomic Absorption Spectrophotometer was utilized. Using the Turner III Flurometer, the amount of chlorophyll A present in Lost Lake was calculated (APHA, 1989).

The zooplankton and phytoplankton from the vertical and horizontal plankton tows were identified in the laboratory for quantitative and qualitative analysis. Species lists and percent species were compiled from this data and the results are listed in figures 13-15. The benthic invertebrates and the aquatic macrophytes were compiled and put on a species composition list (Fig. 12).

Results

Temperature

The temperature profile of Lost lake displays typical summer thermal stratification. The epilimnion is defined from 3.5 meters to the surface of the lake with a temperature drop of 1.1 °C in 3.5 meters of vertical drop. The range of the metalimnion consisted of the area between 3.5 to 8.5 meters with a cumulative temperature drop of 8.6°C (See Fig. 1). The thermocline, or plane of maximum rate of temperature decrease with the respect to depth (Wetzel, 1983), occurred between 4 and 5 meters and displayed a temperature drop of 3.1°C. The hypolimnion extended from 8.5 to the sediments on the bottom of the lake (15 meters in the deepest basin).

Dissolved Oxygen

Oxygen is the most important measurable parameter in a lake (Wetzel 1983). The metabolism of all aerobic aquatic organisms is dependent on the amount of dissolved oxygen in the lake. The amount of oxygen in the lake plays a key role in the solubility of many inorganic nutrients. Changes in nutrient availibility are governed by the shifts from aerobic to anaerobic environments in lakes.

As figure 2 below depicts, the amount of oxygen in Lost Lake is high. The amount of dissolved oxygen at the surface is 8.48 mg/l. This amount increases at five meters to 11.6 mg/l, forming a positive heterograde, or metalimnetic maxima caused by phytoplankton photosynthesizing. The amount of oxygen decreases in the lower metalimnion and upper hypolimnion to 8.8 mg/l. In the lower hypolimnion at 12 meters the amount of oxygen increases again to an apex of 12.19 mg/l. There is a then a rapid decrease of dissolved oxygen approaching the sediments.

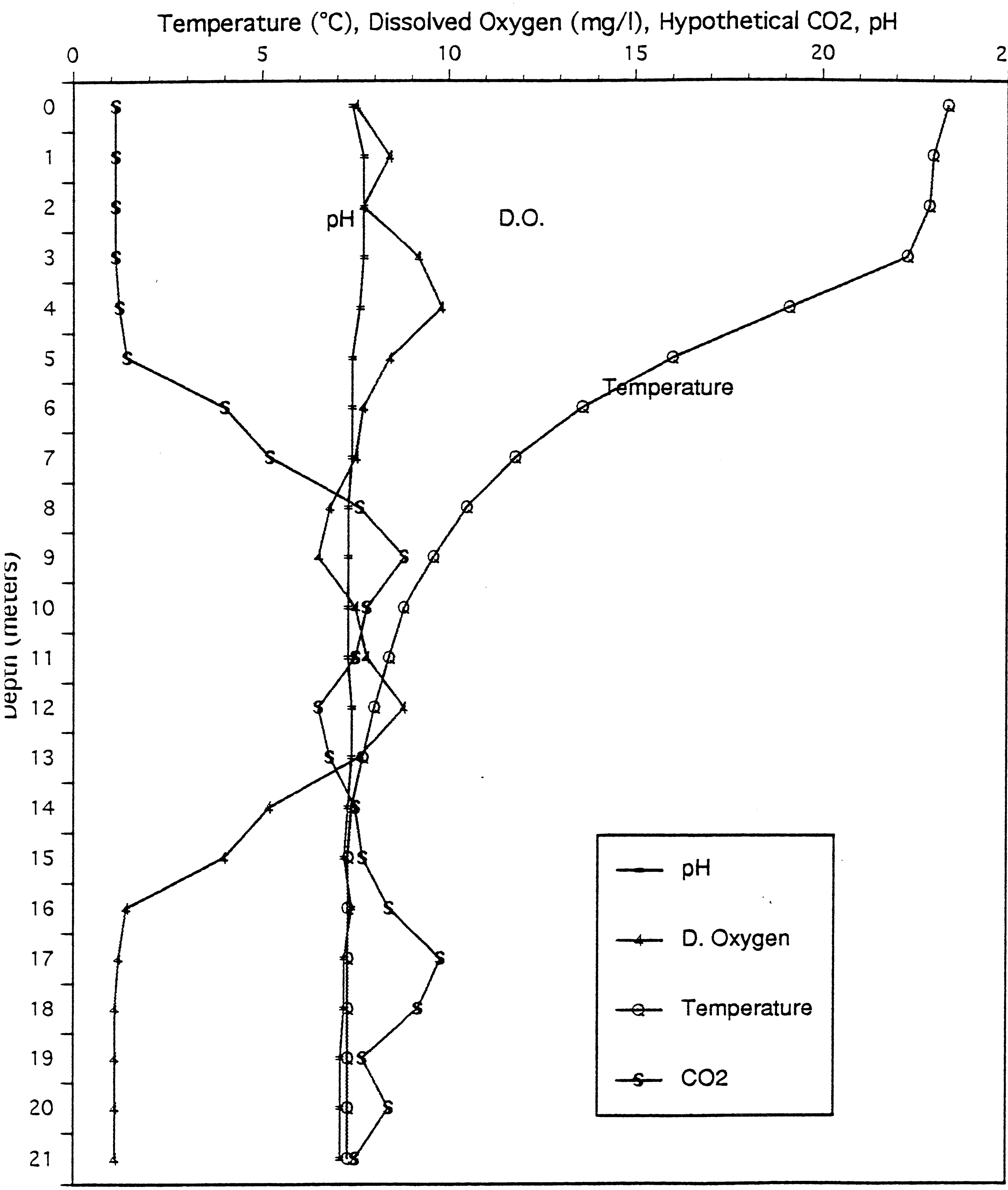
Percent oxygen saturation is another way to express the amount of oxygen in a lake. The solubility of oxygen is affected nonlinearly by temperature, and increases considerably in cold water. With the aid of a nomagram, one can obtain the percent oxygen saturation by determining the dissolved oxygen amount at a particular depth and the temperature at that depth. The percent oxygen values for Lost Lake are presented in Figure 3 below.

Carbon Dioxide

The hypothetical carbon dioxide figures graphed below were determined as an inverse of our dissolved oxygen data. The least amount of carbon dioxide found in Lost Lake is in the epilimnion and gradually increases through the metalimnion into the hypolimnion. In regions of the lake where carbon dioxide is highly utilized, chemical processes induce calcium carbonate precipitation.

In our survey of Lost Lake, rocks in the littoral zone were found with white calcium carbonate precipitate. This precipitate forms a layer on the surface of macrophytes the bottom sediments, and can inhibit light from reaching plants. This process creates a nutrient poor environment characteristic to the reduced productivity in calcareous oligotrophic lakes. This may explain the low abundance of macrophytes found in Lost Lake (Wetzel, 1983).

LOST LAKE



Temperature (°C), Dissolved Oxygen (mg/l), Hypothetical CO2, pH
0
5
10
15
20
25
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Depth (meters)
pH
D.O.
Temperature
pH
D. Oxygen
Temperature
CO2

figure

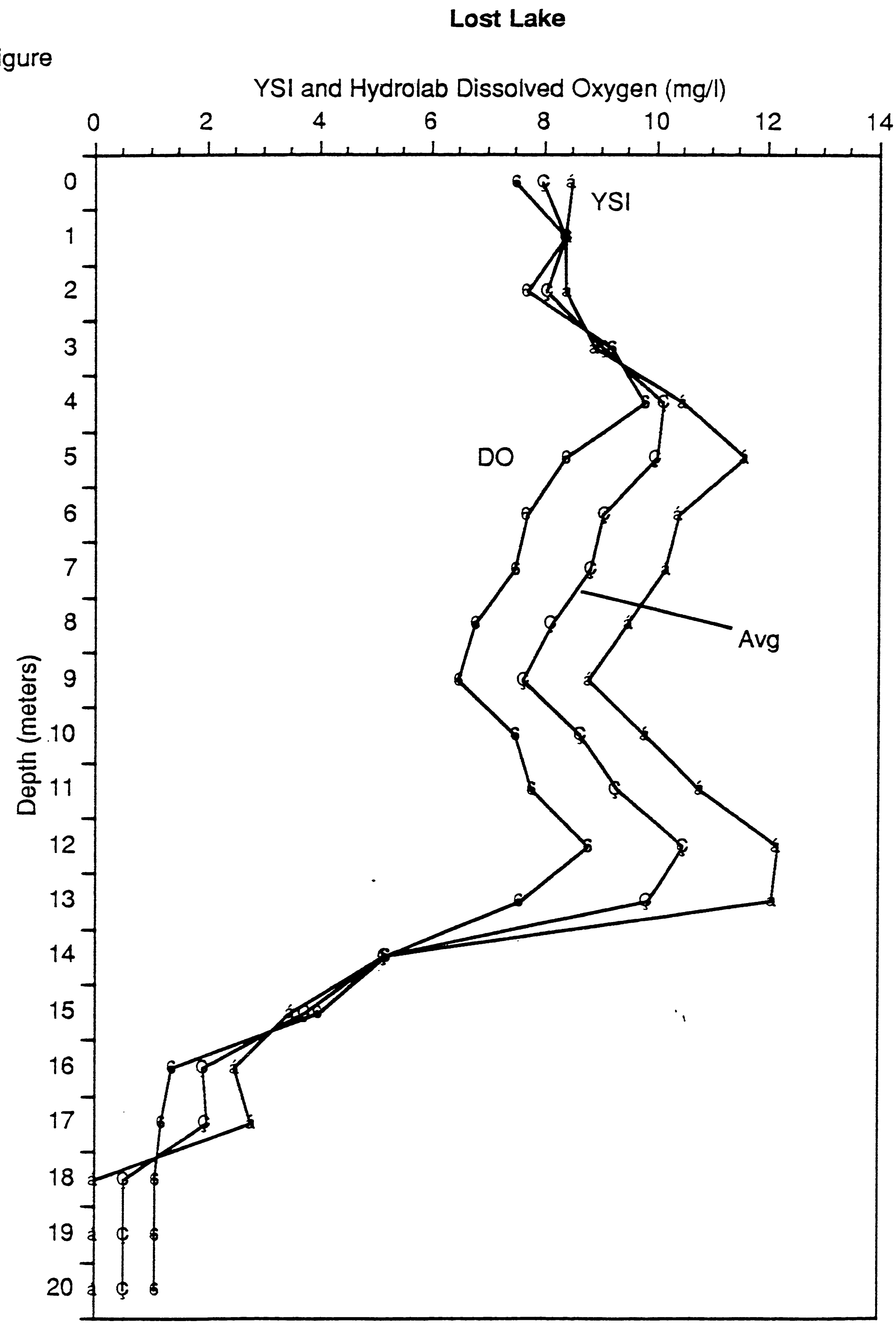
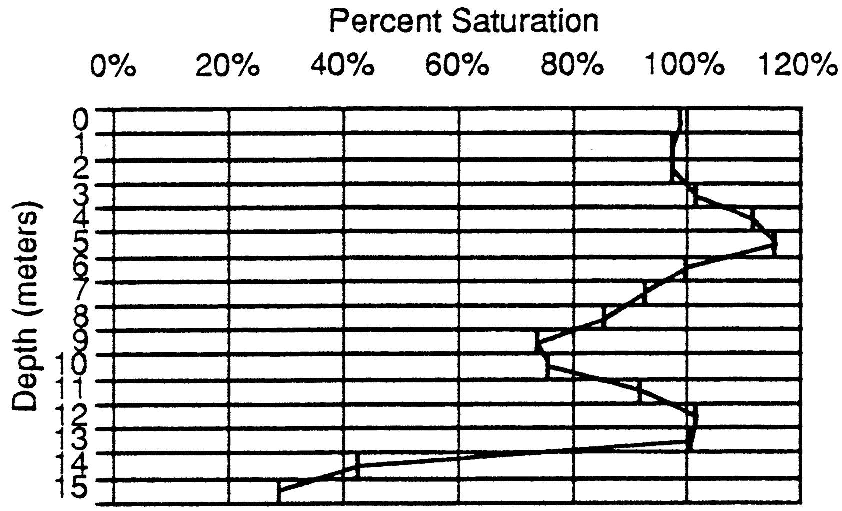

Lost Lake
YSI and Hydrolab Dissolved Oxygen (mg/l)
0
2
4
6
8
10
12
14
Depth (meters)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
YSI
DO
Avg

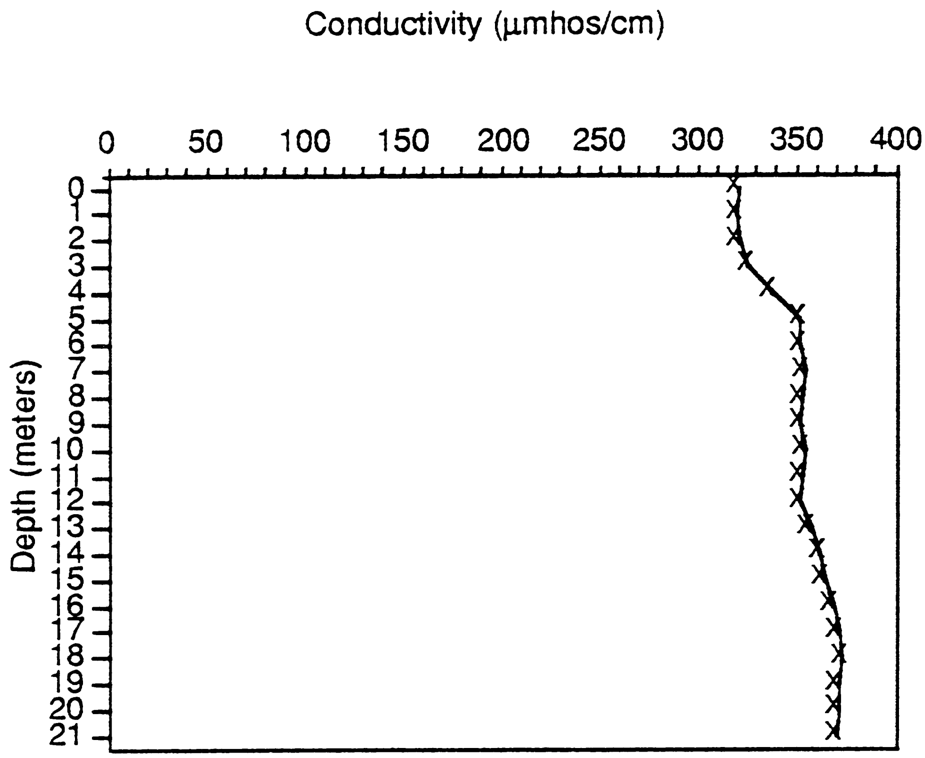
Figure 3 Percent Oxygen Saturation



Conductivity

The conductivity measurements showed a gradual increase from 320 µmhos/cm in the epilimnion to 370 µmhos/cm in the hypolimnion (Fig.4). These numbers were constant with those normally found in a solution lake. Also of note is the absence of a sharp increase in the conductivity values in the lake.

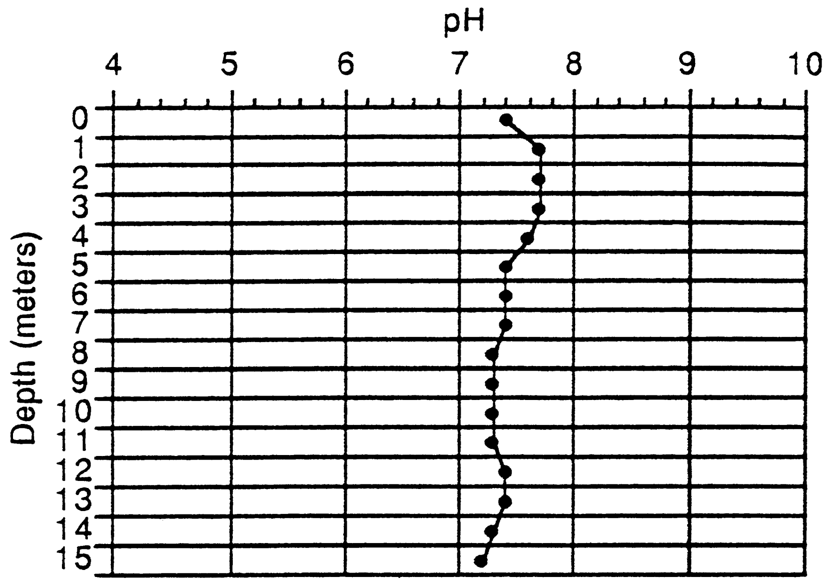
Figure 4



pH

The average pH of Lost Lake was 7.4. The highest reading was recorded in the epilimnion at 7.7 and the lowest was 7.1 in the hypolimnion (See Fig. 5).

Figure 5



Alkalinity

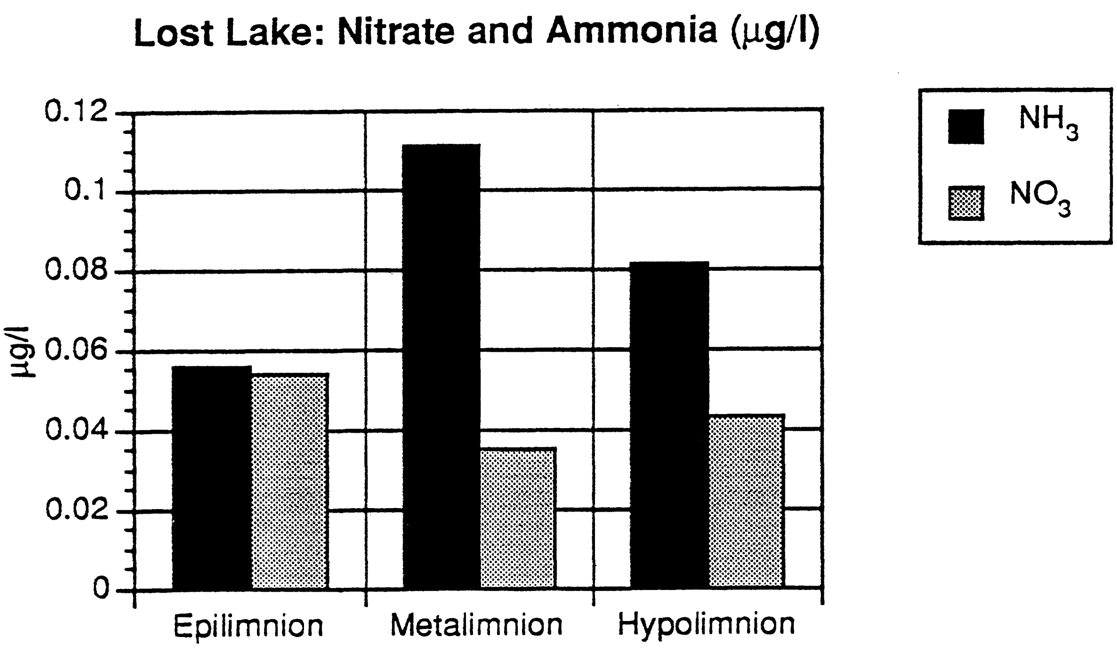
Alkalinity is defined as the ability of water to combine and neutralize protons (Tuchman, 1993). According to Wetzel, "alkalinity refers to the quantity and kinds of compounds present which collectively shift the pH to the alkaline side of neutrality" (Wetzel, 1983). Lost Lake's average pH is 7.4, which suggests that most of the ions exist in bicarbonate form. Lost Lake's alkalinity in the epilimnion was 161.625 mg $CaCO_3$/L in the midepilimnion, and 173.262 mg $CaCO_3$/L in the metalimnion, and also 173.262 mg $CaCO_3$/L in the hypolimnion.

Ammonia and Nitrate

Concentrations of nitrogen are generally low in oligotrophic lakes (Wetzel, 1983). The sources of input of nitrogen are surface runoff, rain, and groundwater. In regions that are rich in limestone, including the one in which Lost Lake is encompassed, the nitrogen in the groundwater can be a major source of annual nitrogen loading. In Lost Lake the concentrations of nitrogen are extremely low. This is at first surprising considering that nitrogen rich fertilizer was introduced into Lost Lake by Tanner. However, the nitrogen must have been quickly used up after it was introduced because even though lake has undergone at least one mix since the experiment, the productivity is low. With relatively high amounts of phosphorous, a high amount of nitrogen should make the lake more productive. The low levels of nitrogen that were recorded signify that Lost Lake is nitrogen limited and was perhaps was productive for a time after the fertilizer was introduced, but has returned to oligotrophic status again.

According to Wetzel, an oligotrophic lake should have less than .2 µg/l organic and inorganic nitrogen. In Lost Lake the concentrations are far less than .2 µg/l ranging from .035 to .054 µg/l nitrate and .056 to .111 µg/l ammonia. The concentrations of ammonia are highest in the metalimnion and the concentrations of nitrate are lowest in the metalimnion. The epilimnion contains relatively low concentrations of ammonia and high concentrations of nitrogen compared to the rest of the lake. In the anaerobic zones of the lake the nitrate is converted to ammonia by the algae living there but is not oxidized to nitrate because of the lack of oxygen. Therefore, the ammonia tends to build up in the lower sections of the lake. Although the nitrogen levels are low to begin with, the ammonia levels are low because oxygen penetrates so far into the lake that the anaerobic zone is relatively small.

Figure 6



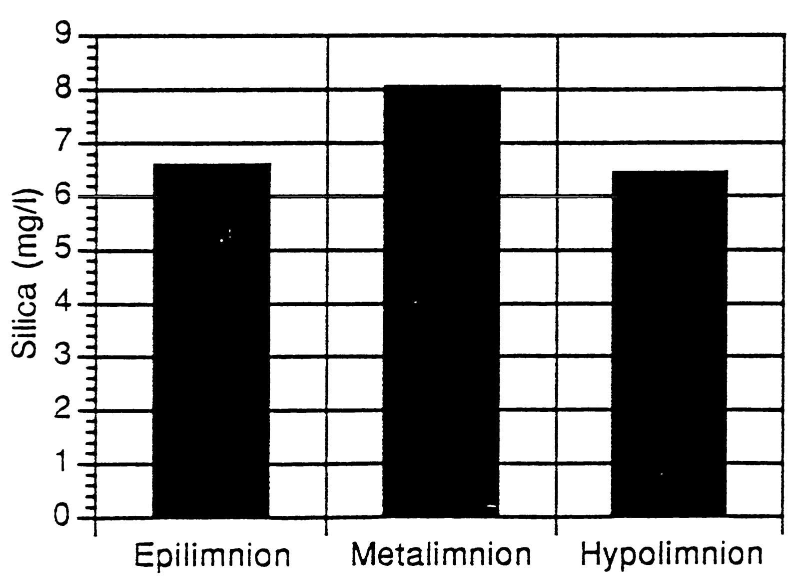
Phosphorus

Orthophosphate, the most prevalent form of inorganic phosphorus, is a major cellular constituent and nutrient in lakes. According to Wetzel, the total phosphorus in a lake can be a measure of a lake's total productivity and primary production. An overwhelming majority of phosphorous in freshwater occurs as organic phosphates, cellular constituents of biota, and is absorbed to inorganic and dead particulate organic materials (Wetzel, 1983). The levels of orthophosphate in Lost Lake in the epilimnion, metalimnion, and hypolimnion are 6.938 µg/L, 6.938 µg/L, and 6.216 µg/L respectively. Primary production in lakes is heavily dependent on the amount of phosphorous present.

Silica

Since the least amount of silica is found in lakes that drain carbonate rocks (Wetzel, 1983), Lost Lake is not expected to have a high silica content. The silica in Lost Lake increases sharply in the metalimnion and then decreases again in the hypolimnion as depicted in figure 7 below.

Figure 7 Silica Values



Magnesium

Magnesium is considered to be a necessary micro nutrient for bacteria, algae and many chlorophyllous plants. Magnesium is found in active chlorophyll. In order for photosynthetic plant matter to be functional, a magnesium porpehrin component must be present (Wetzel, 1983). Magnesium particles are relatively soluble in water, and rarely do they precipitate. Therefore, with low precipitation and fairly constant consumption rates, magnesium levels in lakes tend to remain constant, showing little signs of fluctuation. The concentrations of magnesium at Lost Lake are: epilimnion 11.45 mg/L; metaliminion 14.1 mg/L; and the hypolimnion 16.1 mg/L.

Calcium

Calcium plays an integral role in plant development and animal populations. "Hardly a group of freshwater animals exist in which the distribution of some species has not been related to calcium concentration"(Macan, 1961). Calcium is used by plants in order to carry out growth and other life functions. Although it is considered to be a micro nutrient for plants, calcium is essential. Calcium displays less solubility than magnesium, therefore it precipitates more rapidly.

Calcium in hard water lakes such as Lost Lake typically fluctuates with seasonal change. In the mid-summer months a stratification of calcium concentrations should be present. In the spring and fall months, calcium tends to display less defined stratification.

In soft water lakes, calcium does not show seasonal variations and rarely reaches the saturation levels of the hard water lakes (Wetzel, 1983). Soft water organisms are not able to utilize substantial levels of calcium and therefore the consumption rates are lower.

Calcium levels in Lost Lake were: epilimnion-- 44.5 mg/L, the metalimnion--58 mg/L, and the hypolimnion-- 58 mg/L. The lesser value in the epilimnion can be explained by phytoplankton and littoral flora undergoing photosynthetic activity.

The calcium levels of Lost Lake were considerably higher than those of other non-marl lakes in the 1993 study. The data from 1993 also showed a much higher level of stratification between the epilimnion and metalimnion than the study completed in 1992. Also noticed during the 1993 survey of Lost Lake was calcium carbonate precipitate found on rocks in Lost Lake's littoral zone. This white chalky substance was not seen in other lake's studied in Northern Michigan. A storm provoking mixing occurred previous to the completion of the 1992 study, mixing the lake water thoroughly and destroying any stratification that might have been present. It appears that such was not the case with the July 14, 1993 water samples.

Hardness

Hardness is a combined measure of the calcium and magnesium salts which are present in a lake's water. Hardness values are used to determine the quality of water. Lost Lake's hardness values were as follows: middle epilimnion 178.26 $mgCaCO_3/ml$; middle of metalimnion 175.52 $mgCaCO_3/ml$; and the middle of the hypolimnion 176.94 $mgCaCO_3/ml$. Lakes with values over 100 ppm are considered to be hard water lakes (Tuchman, 1993). It would be expected in a calcium carbonate rich lake such as Lost Lake that a sharp increase between the epilimnion and metalimnion would be present due to the precipitating calcium out of the epilimnion, however in our situation all of the numbers were relatively even. The hardness of Lost Lake is a result of the calcium and magnesium levels which are present throughout each strata of lake water.

Figure 8

LOST LAKE HARDNESS AS REPORTED JULY 14, 1993

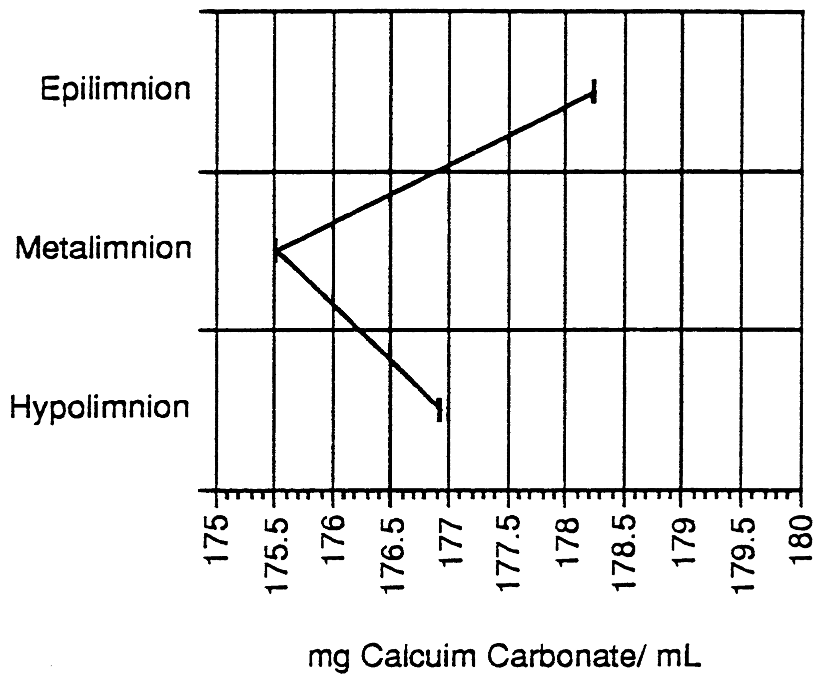
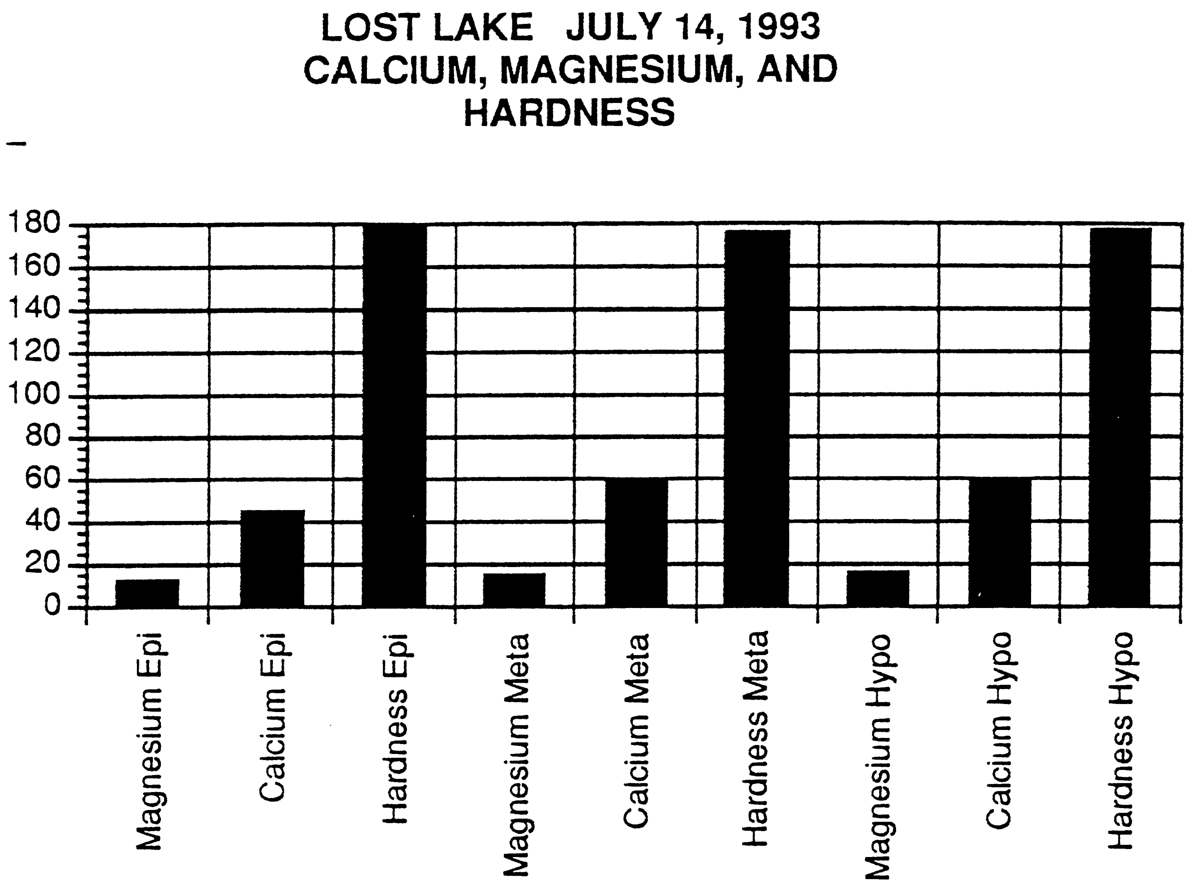
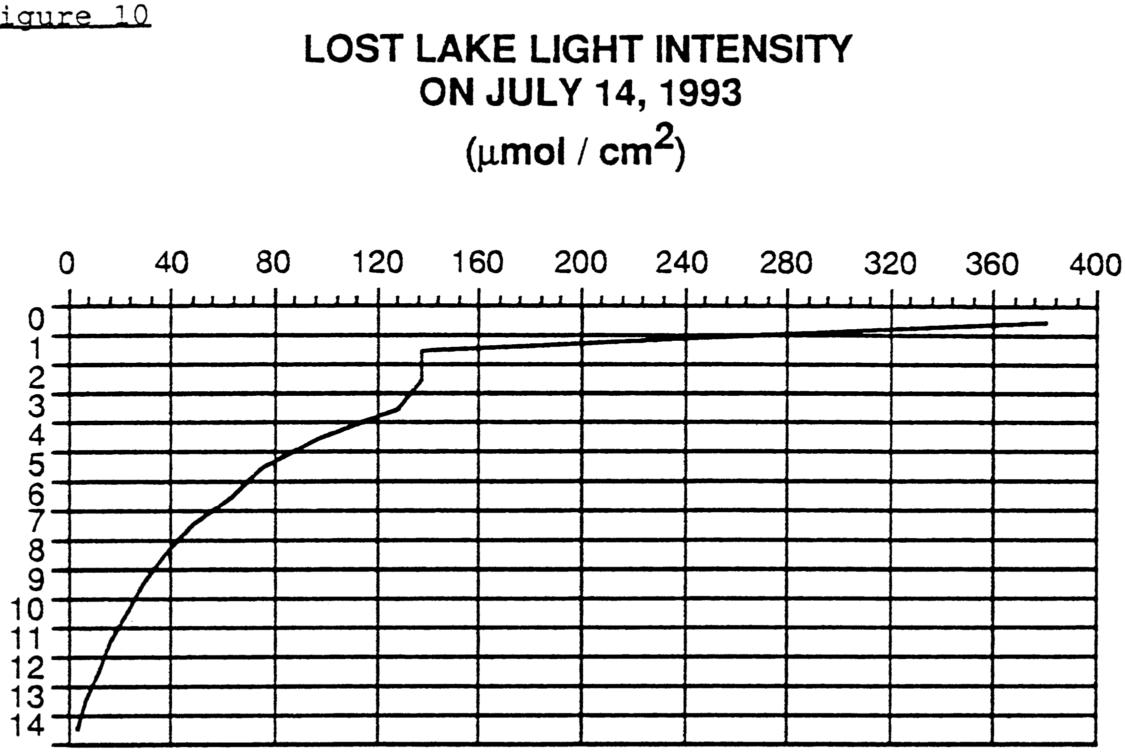


Figure 9



Magnesium expressed in (mg/l) Calcium expressed in (mgCa /l)
Hardness expressed in (mg CaCO / ml)

Figure 10

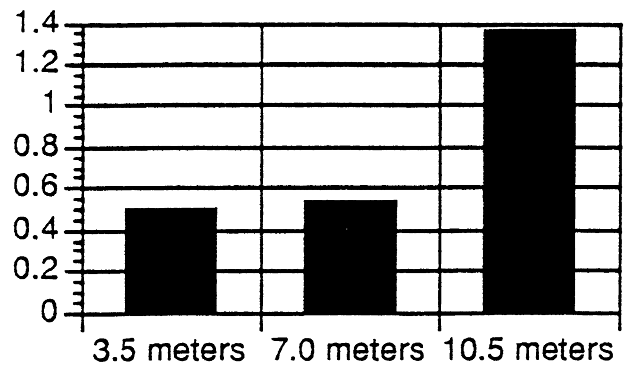


Chlorophyll a

Chlorophyll a is used to determine the amount of phytoplankton biomass in a lake. It provides an estimate of the primary productivity of a lake. The amounts of chlorophyll a in the three layers of Lost Lake are .50 µg/L in the epilimnion, .54 µg/L in the metalimnion, and 1.37 µg/L in the hypolimnion. In Lost Lake most of the chlorophyll a is concentrated in the hypolimnion. The biomass decreases slightly from the epilimnion to the metalimnion.

Figure 11

LOST LAKE JULY 14, 1993
CHLOROPHYLL A
(μg / l)



Eckman Dredge

An Eckman Dredge was used to determine the physical properties of the benthic sediments of Lost Lake. Four samples were taken, one in the upper littoral zone (1 m), one in the mid-littoral zone (1.75 m), one in the lower littoral are (2.75 m), and one in the profundal zone (7.5 m).

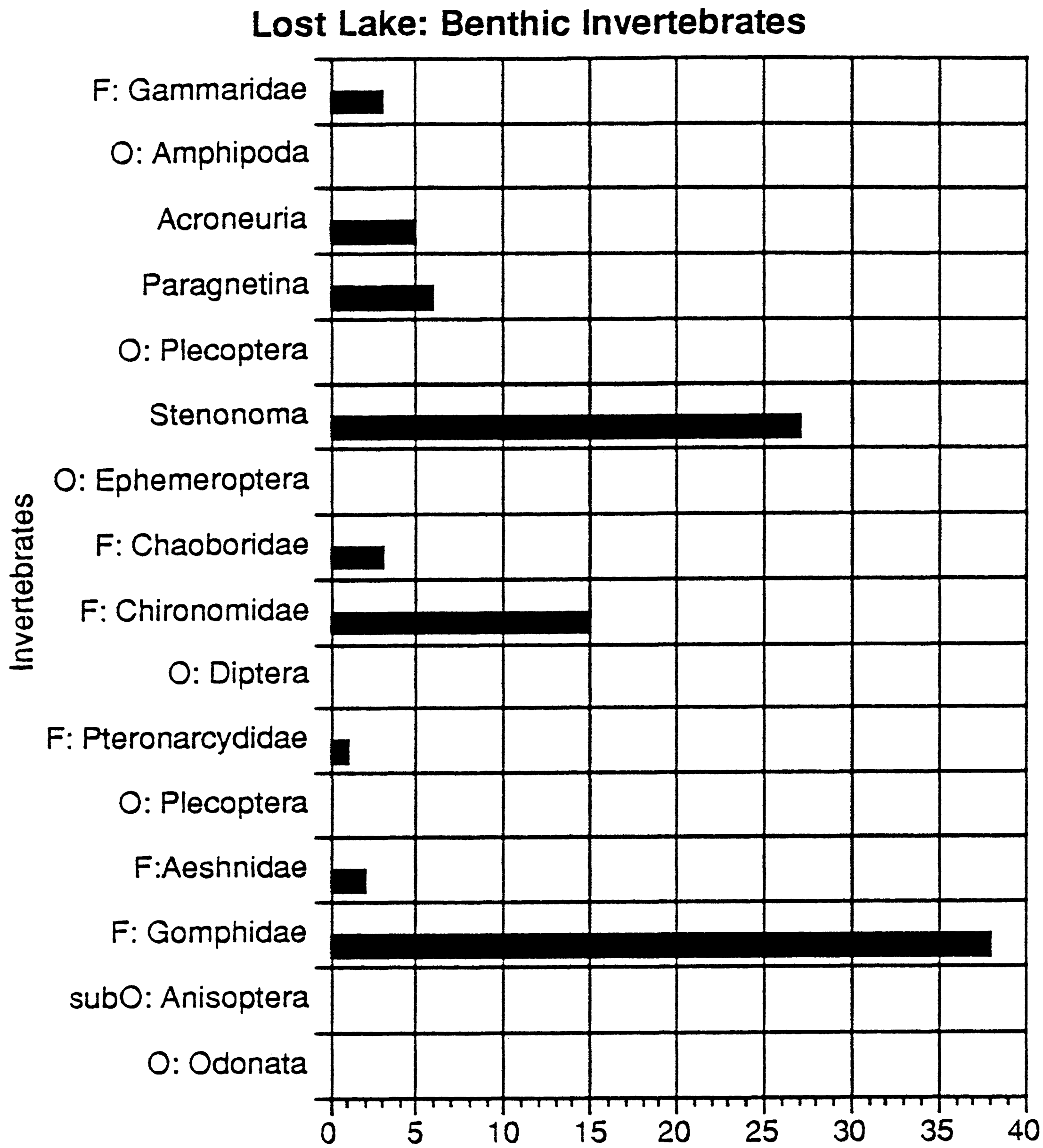
Table 1

SEDIMENT ANALYSIS

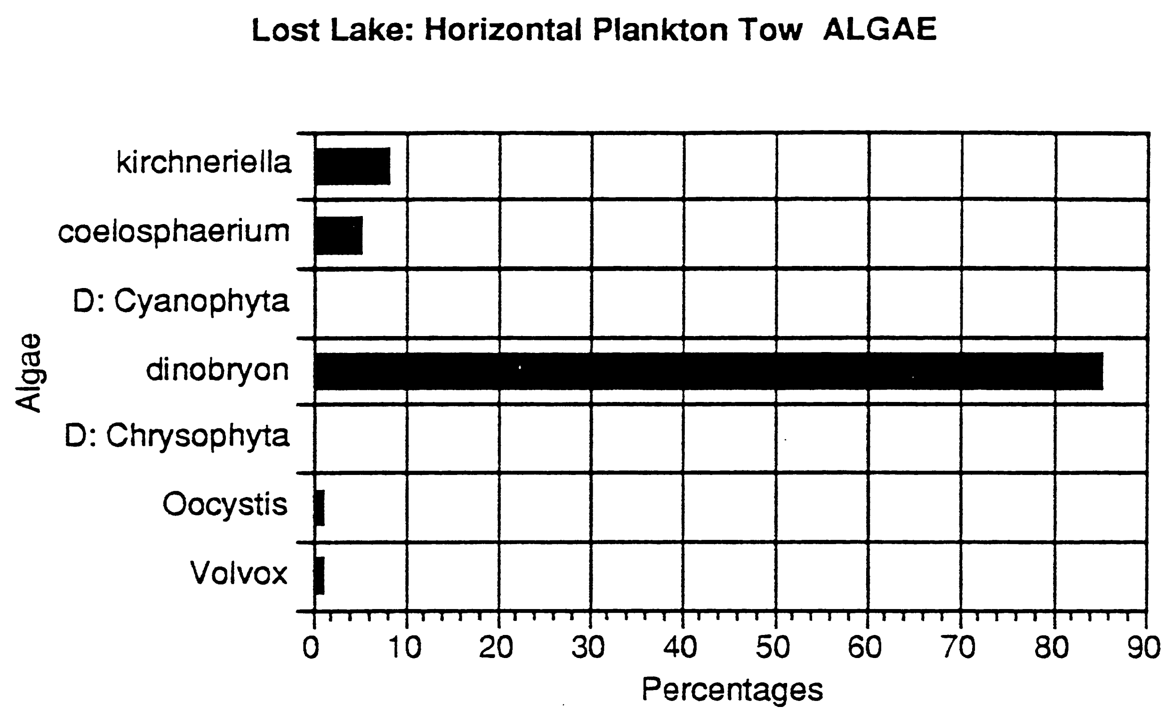
	upper littoral	mid-littoral	lower littoral	profundal
temperature	warm	cool	cool	very cold
color	whitish	gray	gray	darker gray
texture	smooth, soft, moderately grainy; much organic material	smooth, soft, moderately grainy	smooth, soft moderately grainy	smooth, soft fine grainy particles
smell	fishy	sulfur, rotten eggs	sulfur, rotten eggs	stronger sulfur/rotten egg

The benthic invertebrates that the Eckman dredge team found were few and far between. There were a few *chaoborus* and many Molluscs. Other than crayfish, life in the littoral zone was not abundant. This scarcity of organisms was expected due to the oligotrophic nature of this lake.

Figure 12


Lost Lake: Benthic Invertebrates
Invertebrates
F: Gammaridae
O: Amphipoda
Acroneuria
Paragnetina
O: Plecoptera
Stenonoma
O: Ephemeroptera
F: Chaoboridae
F: Chironomidae
O: Diptera
F: Pteronarcydidae
O: Plecoptera
F:Aeshnidae
F: Gomphidae
subO: Anisoptera
O: Odonata
0
5
10
15
20
25
30
35
40

Figures 13 and 14



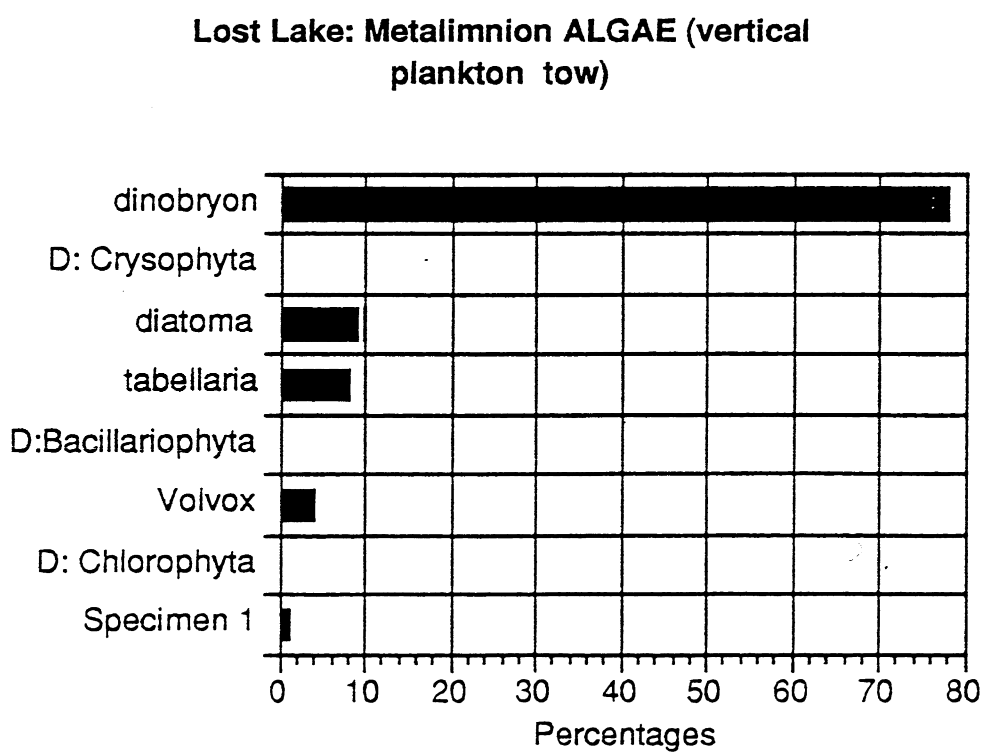
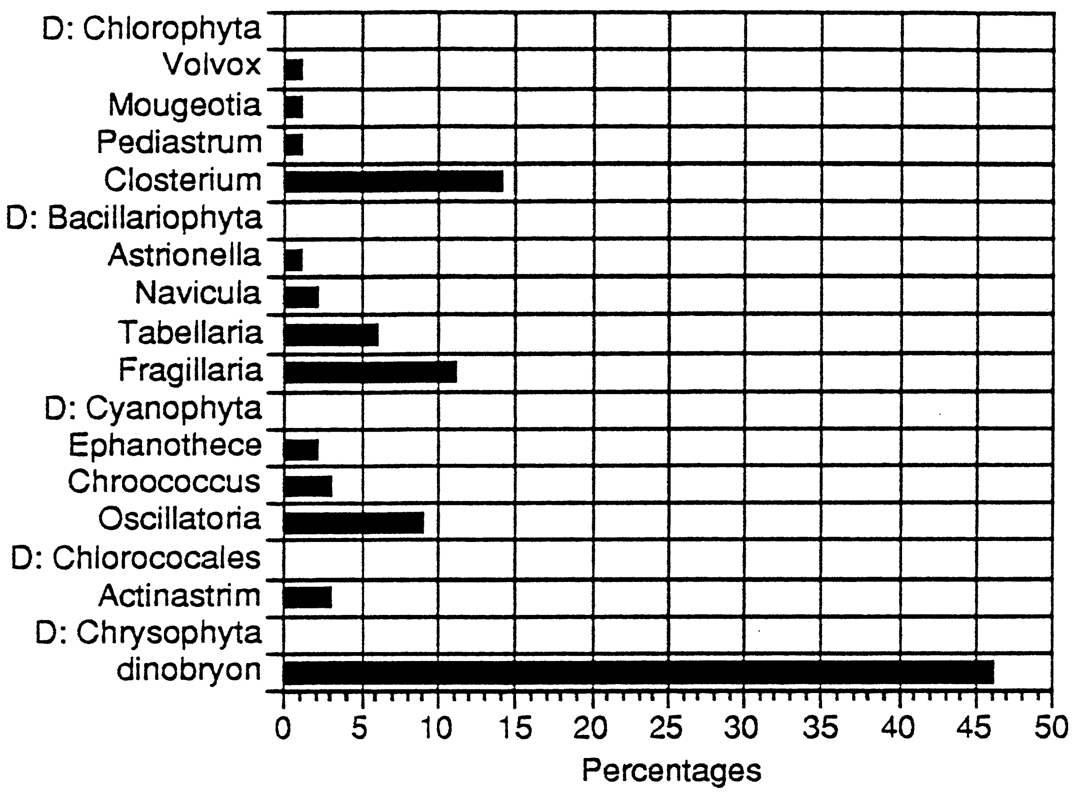


Figure 15

Lost Lake: Hypolimnion Algae (vertical plankton tow)



Macrophytes

The variety of macrophytes found in Lost Lake was sparce. Swamp milkweed, Asclupia Incarnata Graninie, was found in the upper littoral zone. In the middle littoral zone Nymphaea Fontinalis, or water lillies were collected and identified. Lost Lake's lack of macrophyte variety can be attributed to its oligotrophic status. As a solution lake, the only allocthonous input into Lost Lake is from groundwater seepage and runoff, while in other lakes variety of plants can be attributed to river or stream inputs.

Fish

Like the macrophytes, there was little variety in the fish found while seining. As shown in the figure 16 below, 13.3 percent of the fish found were white suckers and 6.6 percent were longnose suckers. The only other organisms found in the seins were crayfish. These results were somewhat expected due to the oligotrophic status of Lost Lake. The reason the crayfish population is high can be attributed to their herbivorous feeding habits. Lost Lake probably does not have all of the five trophic levels that more productive lakes have. Due to the lack of food resources, animals of higher trophic status are not present in the lake.

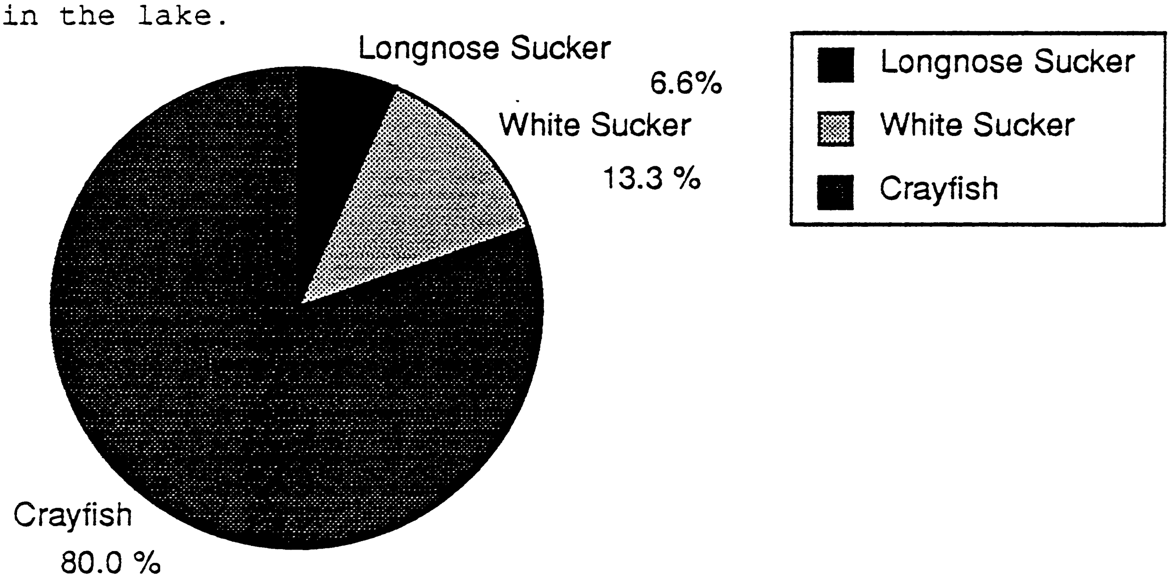


Figure 16

Discussion

Lost Lake, defined as an oligotrophic lake, displays several of the light attenuation characteristics found in such lakes. Without a vast amount of zooplankton and phytoplankton, lignins, tannins or humic acids to internally shade the lake, the one percent compensation point of absorbed light was found at 14 meters (See Fig. 10). In our study the compensation point was three meters deeper than the results of the 1992 study showed (Kaufman et al., 1992). The 1993 study was executed on a very cloudy day with low overhead light intensity.

The depth of the compensation point helps to affirm the assumption that Lost Lake is oligotrophic. Lakes with compensation points in the range 5.4 - 28.3 meters are commonly oligotrophic (Wetzel, 1983).

The pH of Lost Lake is ideal for a solution lake because the high content of calcium carbonate acts as a buffer to prevent the lake from becoming more acidic.

The conductivity of Lost Lake suggests that it is no longer a meromictic lake as previous data proposed. If Lost Lake were meromictic, we would have expected the conductivity to increase a great deal as we reached the monolimnion. However, it only increased 50 µmhos/cm which is fairly steady when compared with the data from 1965 when Lost Lake was recorded as meromictic. In 1965 the conductivity at 48 feet was above 550 µmhos/cm, while our data at that depth shows conductivity at approximately 373 µmhos/cm. Data taken in 1930 shows that Lost Lake was not meromictic at this time either. A fertilizer was applied to Lost Lake in 1949 by a scientist named Tanner which could have caused subsequent meromixis to occur as the ions settled out. However the other solution lakes in the area that were fertilized did not become meromictic as a result of the experiment (Latta, 1962).

Turnover in a sink lake like Lost Lake is difficult because of the lack of shoreline development, the steep banks, and the small surface area. However, a violent storm with high winds would be successful in overcoming these properties, mixing the lake, and thus dispersing the monolimnion. Lost Lake probably experienced such a turnover as a result of a storm, is no longer a meromictic lake. and is now stratified in a normal fashion. However, it is possible that as more calcium carbonate erodes, the ions will begin to settle to the bottom once again to form a monolimnion and reestablish the meromictic properties of the lake.

The difficulty of turnover of Lost Lake could explain why the fertilizer added to the lake settled to the bottom. If the other solution lakes in the area that Tanner experimented with were not as sheltered as Lost Lake, were shallower, and had more shoreline development, the monolimnion would not have had time to form due to the mixing of the lake.

Our data correlates with the conductivity data for 1992 which ranged from 312 µmhos/cm to 362 µmhos/cm (Kaufman et al., 1992). Their conclusion was that Lost Lake could not be classified as meromictic anymore. If there was a monolimnion, the conductivity should be fairly steady all the way down and show a large increase at the monolimnion.

Diatoms are the largest contributor of silica in a lake. Their dry weight is made up of 25 to 60 percent silica (Goldman and Horne, 1983). Diatoms dominate after the spring turnover and after the silica is used up will decline as the green algae take over to use nitrogen. The main reason diatoms decline in a lake during the later summer months is the decline in silica. As the diatoms die, the frustrules sink to the bottom to settle in the sediments.

In an oligotrophic lake the silica content is expected to increase from epilimnion, through the metalimnion and reach the highest levels at the hypolimnion (Wetzel, 1983). However, Lost Lake experiences an increase in the metalimnion which then decreases in the hypolimnion. The amount of silica in the metalimnion is probably due to a high quantity of diatoms living at that level.

Chlorophyll a is used to determine the amount of phytoplankton biomass and to estimate the primary productivity in a lake. The chlorophyll a in Lost Lake increases from epilimnion to hypolimnion. The chlorophyll a at the dividing line between epilimnion and metalimnion (3.5 meters) corresponds to an increase in dissolved oxygen. The phytoplankton at that depth produces oxygen that contributes to the dissolved oxygen content. The chlorophyll a concentrations increases to 1.37 µg/l at a depth of 10.5 meters in the upper hypolimnion. This large increase in chlorophyll a indicates that most of the phytoplankton biomass is located in the hypolimnion. Because of its oligotrophic status, the light penetrates well into the upper hypolimnion allowing algae to live at these depths. Although the light intensity is low, the algae have adapted and are able to survive (Wetzel, 1983). It is also possible that the algae in the hypolimnion are responding to high nutrients that remain stratified in the summer months and are unavailable in the upper levels of the lake.

Since Lost Lake is an oligotrophic lake there is not a large population of microscopic organisms. In fact, in the epilimnion our vertical plankton tow showed only a few Copepod *cyclopoids*. More zooplankton were found in the metalimnion with Daphnia the most abundant at this level. Daphnia were also plentiful in the hypolimnion. Many zooplankton are herbivores so they are located in the sections of the water column where phytoplankton are also found.

The horizontal plankton tow showed more species of zooplankton. The most frequent were still Daphnia but copepods and Collembola were found as well. Copepods reproduce all year round so there were many copepids in the naplier stages in addition to the adult Copepods (Pennak, 1989) We also saw *keratella* from phylum Rotifera in the horizontal plankton tow.

We recorded a greater variety of zooplankton than algae in Lost Lake. The most common algae was *dinobryon* which is in the division Chrysophyta. This algae species was present in all levels of the lake. Most of the algae in Lost Lake is located in the upper hypolimnion. This also corresponds to the increase in chlorophyll a concentration. Many phytoplankton, cyanophyton in particular, have adapted to the lower light levels in the deeper waters. Cyanophytes have adapted to the lower light intensity through chromatic adaptation. This a process by which the algae produce more phycoerythrin in response to the greenish blue light that penetrates deepest into the water. This pigment causes that algae to change in color to red or violet and helps them to attain the maximum assimilation of light possible (Rhineheim, 1985). In the hypolimnion we found three varieties of cyanophyta and four kinds of diatoms. Our horizontal plankton tow showed more algae than the vertical plankton tow of the epilimnion (the vertical tow showed no algae). The horizontal tow was dragged around the whole lake while the vertical plankton tow was concentrated in only one area. We saw numerous *dinobryon* in addition to a few Chlorophyta, for example, *oocystis* and some Cyanophyta, namely *kirchneriella*.

Conclusion

From the data that has been collected from Lost Lake, we have concluded that it displays characteristics which are oligotropohic and, despite past data, no longer meromictic. Productivity of algae and zooplankton are extremely low and benthic invertebrates are scarce. Light penetration is not deterred by high populations of zooplankton and algae. Low ammonia and nitrogen values also suggest that Lost Lake is oligotrophic. However, Lost Lake does display properties which are non-oligotrophic and thus fail to completely support our hypothesis. The dissolved oxygen curve is an orthograde curve typically found in a more productive lake. High levels of phosphorous also suggest greater productivity than what was observed in plankton samples. Based on the data collected on July 14, 1993, our oligotrophic hypothesis is not wholly supported.

Lost Lake has lost its meromictic qualities. Conductivity is relatively uniform without a substanial increase in the hypolimnion which would indicate a monolimnion. A temeprature increase in the hypolimnion, typical of monolimnion with higher salinity, was not present. Lost Lake displays no meromictic qualities suggesting that the previously documented monolimnion is no longer present.

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