

HORSESHOE POND  
LAKES LAY MONITORING PROGRAM  
1985

Freshwater Biology Group (FBG)  
University of New Hampshire  
Durham

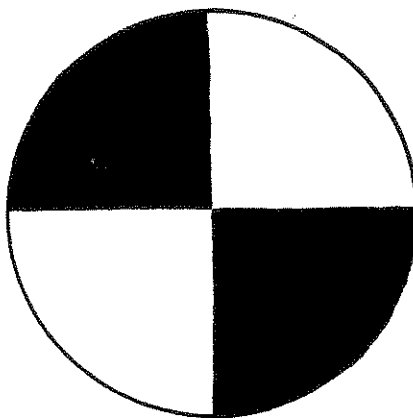
by

Tracy E. Kenealy

Coauthored and edited by

A.L. Baker

J.F. Haney



LAKES LAY MONITORING PROGRAM

To obtain more information about the Lakes Lay Monitoring Program (LLMP) contact the LLMP Coordinator (T. Kenealy) at (603)-862-3848, Dr. Baker at 862-3845 or Dr. Haney at 862-2106.

TABLE OF CONTENTS

PREFACE.....iii  
ACKNOWLEDGEMENTS.....v  
NON-TECHNICAL SUMMARY OF 1985 MONITOR DATA.....1  
COMMENTS AND RECOMMENDATIONS.....3  
METHODS OF THE FRESHWATER BIOLOGY GROUP, UNH.....5  
RESULTS AND DISCUSSION OF THE FBG.....11  
REFERENCES.....17  
APPENDIX A: LAY MONITOR DATA  
    Water Transparency and Chlorophyll a, 1983.....A-1

This is a LEVEL II report. (See last page for definition.)

All data in this report are available to any person or organization upon request and payment of costs involved.



## PREFACE

### Importance of long-term monitoring

Lake monitoring carried out weekly over the course of several consecutive summers benefits the lake in a number of ways. The resulting data not only indicate the lake's condition for a particular summer, but they also suggest what it was like in the past, and make it possible to predict its condition in the future.

For this reason, it is important to distinguish between short-term and long-term results. As an example, a 30 year time-span may provide evidence for a long-term trend towards eutrophy (Fig. 1). Yet, if one looks at data over a 1-5 year time-span, one sees only short-term fluctuations; there are no apparent trends nor is it possible to separate the "signal" from "noise". Chlorophyll, water transparency, and phosphorus may fluctuate from year to year in response to annual variations in climate and activity on the lake, and may be unrelated to long-term trends. The more such "noise" in the data, whether due to real or analytical variations, the longer a monitoring program must continue to demonstrate long-term trends.

### Use of long-term trends

Long-term trends serve several important functions. From them, past deterioration of the lake can be recognized. They can also be used to forecast the future condition of

They can also be used to forecast the future condition of the lake, and if necessary, management techniques can be implemented to keep potential problems from becoming worse. Finally, long-term trends provide a basis for evaluation of existing management programs so that necessary changes may be brought about.

It takes a great deal of motivation, perseverance, and a love for one's lake to be a lay monitor. Sometimes it may seem to be an inconvenience, or to be discouraging when it's unclear just what a year's worth of hard work means with respect to the "big picture" of the lake. Yet, each observation by a lay monitor is a significant contribution.

Thus, continuation of data collection is important. The LLMP data base is becoming more comprehensive and valuable each year. We are pleased with the interest and commitment of lakeshore volunteers. Keep up the great work!

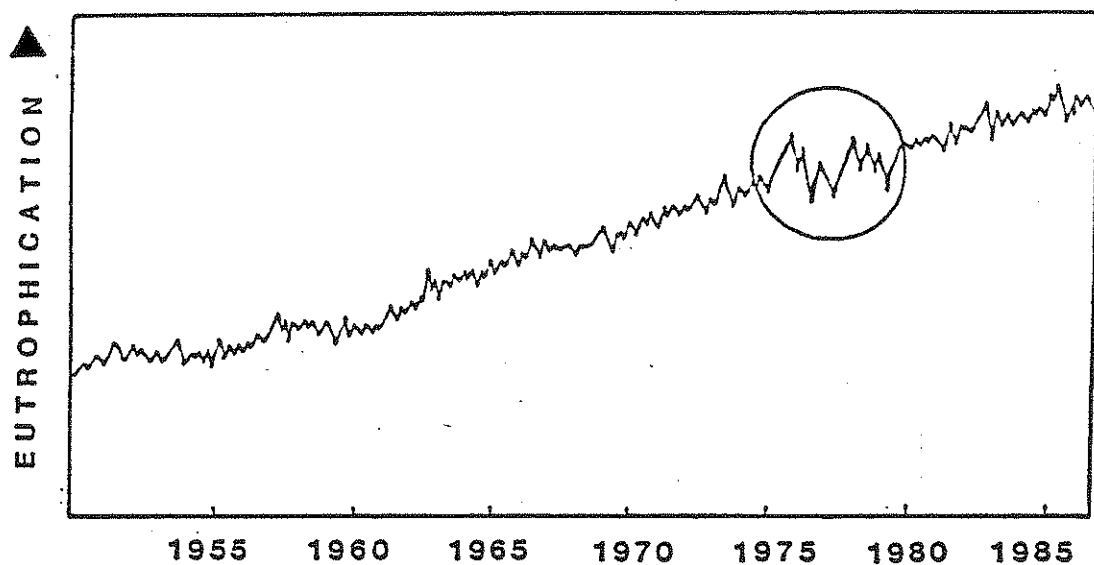


Figure 1. Long-term vs. short-term trends in a hypothetical lake approaching eutrophication.

## ACKNOWLEDGEMENTS

Horseshoe Pond has participated in the Lakes Lay Monitoring Program since 1983. The program continued in 1984 under the direction of Mr. David Soule. There were no lay monitors available to sample the lake in 1985, but the Freshwater Biology Group visited and sampled the pond three times during the summer.

Members of the Freshwater Biology Group (FBG) included Kim Babbitt, Henry Burke, Tracy Kenealy, Sandra Lord, Elizabeth Trieff, Celia Acacia, and Deb Thunburg. Kim was the LLMP Coordinator, and was responsible for arranging the field trips and supervising the research team. Liz and Sandy were responsible for phosphorus, Henry for equipment production and upkeep, Celia for phytoplankton, and Deb for zooplankton. Tracy was responsible for data entry and analysis, and for writing the reports in the fall. All members of the FBG participated in the field work and lab analyses.

We would also like to recognize the UNH Office of Computer Services for their provision of computer time and data storage space. The final text is available on an IBM-compatible diskette.

## NON-TECHNICAL SUMMARY OF 1985 DATA

1) Both water transparencies and chlorophyll a concentrations indicate that Horseshoe Pond is mesotrophic. Seasonal readings for secchi disk and chlorophyll suggest that Horseshoe Pond is nutrient-rich and contains moderate numbers of planktonic algae.

2) Levels of total phosphorus were high, and indicate mesotrophic conditions. High phosphorus levels suggest that nutrient loading into the pond may be high.

3) Results from the Freshwater Biology Group (FBG) indicate that an oxygen peak was present during the summer at approximately 3 meters on Horseshoe Pond. An oxygen peak indicates a layer of planktonic algae at that depth. It is characteristic of mesotrophic conditions and of a lake that is becoming eutrophic.

4) The dissolved water color was high on one of the FBG test dates, indicating that the water has some staining from dissolved humic substances (dark-colored organic matter). Water color is another factor in addition to the chlorophyll concentration which influences the secchi disk depth.

5) The water in 1985 was more transparent and contained less green coloring from suspended algae than 1984, but similar to 1983. Short-term fluctuations such as these are common, possibly due to changes in weather from year to year.



## COMMENTS AND RECOMMENDATIONS

1) We strongly recommend that weekly lay monitoring be resumed on Horseshoe Pond. Variations in trophic indicators (water transparency, chlorophyll a and total phosphorus) occur throughout the summer. A data base resulting from several years of monitoring, and which manifests such seasonal trends, will be a valuable resource in the future as long-term trends in the water quality become evident.

2) We recommend that samples be collected for total phosphorus concentration. Phosphorus levels found by the FBG in 1985 were relatively high and suggest that nutrient loading may be occurring in Horseshoe Pond. Phosphorus levels can fluctuate from year to year in response to annual variations in the climate and activity in and around the lake. Phosphorus is usually the least abundant (most limiting) nutrient in a lake, and high concentrations will cause increased production, which in turn may accelerate the eutrophication process.

3) As a general addition to our Lakes Lay Monitoring Program, we are suggesting that each lake in the Program begin monitoring the condition of the fish taken from the

lake. The "Fish Monitoring" will require that at least one lay monitor record the species, length and weight and collect a sample of fish scales for each fish examined. In most lakes this will involve periodic creel census of sport fishermen on the lake. Equipment required will cost approximately \$100. Special instruction will be given to the lay monitors who chose to measure this parameter.

Length-to-weight ratios give a measure of the nutritional condition of the fish. Analysis of the fish scales (to be done at UNH) will tell how old each fish is. Together, these data will be extremely useful indicators of the health of the fish populations in the lake, and, of course, the "health" of the lake.

## METHODS OF THE FRESHWATER BIOLOGY GROUP

The Freshwater Biology Group (FBG) research team took three trips to the lake and conducted several tests which included measurements of sunlight penetration into the water, dissolved oxygen, alkalinity, free (unbound) carbon dioxide, pH, specific conductivity, chlorophyll a, total phosphorus, and a survey of the microscopic plants (phytoplankton) and animals (zooplankton) present. The FBG was also responsible for chlorophyll a and phosphorus analysis of lay monitor samples, as well as filing and analyzing 1985 data, performing statistical tests, and determining possible trends based on past data.

### Field and Laboratory Methods

On the lake, a dissolved oxygen and temperature profile was taken using a Yellow Springs Instruments Model 54A Oxygen/Temperature meter with a submersible probe. Readings were taken at one-meter intervals throughout the epilimnion and hypolimnion, and at one-half meter intervals through the metalimnion.

Sunlight and skylight penetration into the water was measured with a Whitney submersible photometer model LMA-8A, off the sunny side of the boat. From the relative light

intensities which were recorded, the coefficient of light extinction was later determined.

Samples for water chemistry (dissolved oxygen, alkalinity, free (unbound) carbon dioxide, pH, and specific conductivity) were collected with a 3-liter Van Dorn bottle at depths which represented the surface, mid-epilimnion, metalimnion, and hypolimnion. Alkalinity, free carbon dioxide, and pH samples were stored on ice in 250 milliliter polyethylene bottles and were analyzed in the field within 1 to 2 hours of sampling. Specific conductivity samples were analyzed in the FBG lab at room temperature.

In addition to the oxygen profile taken, the dissolved oxygen (DO) concentration of specific lakewater samples (epilimnetic and hypolimnetic) was determined chemically using the Winkler method for dissolved oxygen. The precision of the method allows us to check the accuracy of the electronic probe, so that adjustments could be made in the probe readings if necessary. In the Winkler method, water is collected in Biological Oxygen Demand (BOD) bottles and fixed with manganese sulfate and alkali-iodine-azide. A loose precipitate (floc) of manganous hydroxide is formed that will absorb any dissolved oxygen present. The sample is then acidified with concentrated sulfuric acid in the presence of iodide, and iodine is released in a quantity equal to the amount of dissolved oxygen present.

To determine the alkalinity, a two-endpoint titration was done with 0.002 N sulfuric acid to a pH of 4.5 and 5.1. The endpoint indicator used was methyl red/bromocresol green. The amount of titrant used (dilute sulfuric acid) was recorded to the nearest 0.1 ml, representing the equivalent milligrams of calcium carbonate per liter.

Free carbon dioxide concentration was determined by titrating the fresh lakewater samples with 0.0027 N Sodium Hydroxide to a final pH of 8.3, using the dye phenolphthalein as the end-point indicator.

Lakewater pH was measured with a digital pH meter (Orion model 231) equipped with a combination probe (Orion Co.)

Specific conductivity was measured with a Barnstead Conductivity Bridge Model PM-70CB, with a model B-10 probe (cell constant = 1.0). Corrections were made for sample temperatures with a standard curve.

Samples to be analyzed for chlorophyll a, total phosphorus, phytoplankton, and zooplankton were collected with a vertical tube sampler into a 2.5 liter plastic bottle. Chlorophyll samples were filtered through a 0.45 micron membrane filter and air-dried until analysis. The chlorophyll a content was analyzed by extracting the chlorophyll with a 95% acetone solution saturated with magnesium carbonate. The samples were then centrifuged and their light absorbance read at two standard wavelengths (663 and 750 nanometers).

Phosphorus samples were fixed with 1.0 milliliter of concentrated sulfuric acid and stored refrigerated until analysis. Also, phosphorus samples from lay monitors were received by the FBG in a refrigerated or frozen state, and stored cold until analysis. To determine the total phosphorus content, ammonium persulfate and 11 N sulfuric acid was added to digest the total phosphorus, and the samples were autoclaved for one hour. A single-reagent method was employed using potassium antimony tartrate, ammonium molybdate, and a fresh solution of ascorbic acid (E.P.A. 1979). Absorbance of the blue phosphorus complex was measured with a spectrophotometer at 650 nm. Each sample was analyzed twice and an average of the two values taken as the phosphorus content in parts per billion.

Phytoplankton samples were fixed with iodine (Lugol's solution) immediately after collection. The preserved samples were later counted with an inverted microscope after settling for 24 hours in counting chambers. At least 200 individual algal "units" were counted with a modified scan technique (Baker, 1973).

Zooplankton samples were collected by taking a plankton tow through the oxygenated portion of the water (>0.5 ppm oxygen) using a 30 cm diameter, 150 micron porosity plankton net. Samples were immediately preserved in a 4% formalin-sucrose solution (Haney and Hall, 1973) and subsampled with a 1-milliliter Hensen-Stemple pipet. Sufficient subsamples

were taken to insure that at least 100 zooplankters were counted.

#### How the data are analyzed

Incoming data are received through the mail during the sampling season and are first filed in an "incoming data" book. This provides temporary storage until the corresponding chlorophyll and/or phosphorus sample for each data sheet is analyzed. All data, including date, lake, site, secchi disk depth, chlorophyll a and phosphorus content, alkalinity, and color measurements, are filed and stored on a computerized data-management system of the University of New Hampshire. Data can be easily retrieved by lake, sampling station or date, and used for individual reports and for each year.

Statistical treatment of the data for each lake includes a comparison of seasonal tendencies found throughout the year, monthly means for the different parameters tested, and confidence levels for each site. The same comparisons mentioned above are made on a yearly basis if the lake has been in the program for two years or more. If sufficient data are available from several years, regression analyses and other statistical tests are performed. Such analyses may identify trends and help explain variations in the data (eg. secchi disk depth, chlorophyll a, color). In addition, data is compared with other lakes in the program and to published water quality

classifications. Trophic boundaries of Forsberg and Ryding (1980) are used to classify each lake.



## RESULTS AND DISCUSSION OF FBG DATA

The Freshwater Biology Group (FBG) sampled Horseshoe Pond at site "1 Deep" on June 7, July 11, and August 23, 1985. See Figure 2 for FBG sampling site, and Appendix A for lay monitor data for 1983.



Figure 2. Horseshoe Pond, Town of Merrimack, New Hampshire. Outline map and location of 1985 sampling sites.

### Temperature and Dissolved Oxygen

Horseshoe Pond was thermally stratified during all three trips made by the FBG. The thermocline was found at three meters in June and August and at one meter in July.

On all FBG trips, oxygen was abundant in the epilimnion, it decreased rapidly throughout the metalimnion, and was depleted in the hypolimnion. This lack of oxygen in the hypolimnion and lower metalimnion limits the distribution of fish and other organisms to the upper, oxygenated water.

A metalimnetic oxygen maximum (peak) was present at 3 meters during the summer. An oxygen peak indicates the presence of an algal bloom at that depth, and is often characteristic of a mesotrophic lake approaching eutrophy.

### Water Transparency

Water transparencies (secchi disk depths) measured by the FBG were 3.2 meters in June, 4.0 m in July, and 2.6 m in August. Based on secchi disk depths, Horseshoe Pond is mesotrophic.

### Chlorophyll a and Dissolved Water Color

Water transparency is affected by three major factors: the numbers of planktonic algae in the water column (assessed by the chlorophyll a concentration), the dissolved water color, and amounts of suspended particulate matter in the water. By measuring two of these parameters, the

chlorophyll concentration and the dissolved water color, the relative influence each has on the secchi disk depth can be estimated.

Chlorophyll a concentrations were 2.4 milligrams per cubic meter in June, 1.0 in July, and 2.1 in August. The lowest concentration was found in July, and corresponds to the highest water transparency measured by the FBG.

Dissolved water color is the brown coloring of lakewater due primarily to dissolved humic acids (from dark-colored organic matter) and is measured as the absorbance of light per 5 centimeters. On Horseshoe Pond, the water color was 0.02 in June and July, and 0.03 in August. The average water color for lakes in the LLMP is between 0.01 and 0.02. The water color measured on Horseshoe in August indicates relatively high staining, and corresponds to the lowest water transparency measured by the FBG. The water transparency on Horseshoe Pond appears to be regulated both by algal density and the dissolved water color.

#### Total Phosphorus

Total phosphorus concentrations were 19.6 micrograms per liter (parts per billion) in June, 8.1 in July, and 16.7 in August. The two highest concentrations fall in the mesotrophic range, and the lowest level falls in the oligotrophic range. The low concentration in July probably attributes to the relatively low chlorophyll concentration on that date, thus the higher water transparency.

Phosphorus is usually the most limiting (least abundant) nutrient in a lake, and high phosphorus levels will cause increased phytoplankton production, which in turn may accelerate the eutrophication process. High levels of phosphorus, such as those found in June and August, indicate that nutrient loading into the lake may be occurring.

In 1985, the water transparency was higher, the chlorophyll a concentrations were lower, and levels of total phosphorus were lower than in 1984. The overall water quality in 1985 was similar to 1983. Fluctuations such as these may be due to differences in the weather from year to year, as similar results were found for many other lakes in the LLMP. Trends towards increasing or decreasing water quality are not evident from these three years of data.

#### Alkalinity, pH, and Carbon Dioxide

Surface values of alkalinity were in the range from 18.0 to 18.8 milligrams calcium carbonate per liter during the three FBG trips. Alkalinity increased throughout the water column, and was very high in the hypolimnion where the range was between 52.4 and 78 mg per liter. This indicates a great deal of respiratory activity by benthic anaerobic bacteria, since oxygen was depleted in the hypolimnion. Carbon dioxide from respiration accumulates (see below) and is converted to bicarbonate, which will contribute to high levels of bicarbonate alkalinity and carbon dioxide.

Epilimnetic pH values were between 6.9 and 7.2. The pH decreased slightly through the water column and was 6.6 on all three test dates. Both the pH and buffering capacity of Horseshoe Pond are high, indicating that the pond has sufficient resistance to acidification.

On all three test dates, levels of free (unbound) carbon dioxide were low at the surface, with a range of 1.4 to 3.7 parts per million. In the hypolimnion, carbon dioxide accumulated, with a range of 12 to 24.4 ppm. High levels of carbon dioxide in the hypolimnion indicate bacterial respiration in the sediments.

#### Specific Conductivity

The specific conductivity in Horseshoe Pond was very high, with an average of 414.6 micromhos in June, 444.5 in July, and 406.8 in August. Values in this range indicate that the lake receives high inputs of road salts and/or raw sewage. Either source is probable on Horseshoe, as phosphorus levels were also relatively high. Also, the steep watershed around the lake may facilitate runoff into the pond from the Daniel Webster Highway and Island Drive.

#### Phytoplankton

The density of phytoplankton was high on Horseshoe Pond. On all three sampling dates, the dominant phytoplankton groups were the Chlorophyceae (green algae) and Chrysophyceae (golden algae). In June, the epilimnetic

density (0-1 meters) was 7080 cells per milliliter (cells/ml). A sample taken at 3.3 meters, corresponding to the depth of the oxygen peak on the same day, had 9420 cells/ml, and was dominated by the Chlorophytes.

The phytoplankton density was lowest in July, with 2232 cells/ml in the epilimnion (0-3 m). Chrysochromulina was an abundant chrysophyte. A sample taken at 3 meters, corresponding to the oxygen peak, had 6888 cells/ml. The Chrysophyceae were dominant, with high populations of Chrysochromulina, and the Chlorophyceae were also abundant with large numbers of Nephrocytium.

The phytoplankton density was highest in August, with 14,040 cells/ml in the epilimnion (0-3 m). The dominant chlorophytes were Crucigenia, and colonial green algae. The dominant Chrysophytes were Kephyrion, Synura, and Chrysochromulina.

### Zooplankton

The density of herbivorous zooplankton was moderate on Horseshoe Pond. In June, there were 38.3 animals per liter. Kellicottia longispina and Daphnia pygmaeus were co-dominant. By August, dominance shifted to the cyclopoid copepods, which are predacious zooplankters. The dominant herbivores in August were Kellicottia boston and Daphnia parvula. Due to an error of the FBG, no zooplankton data are available for July.

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APPENDIX A

LLMP -- Lay Monitor Data: Horseshoe				
Date	Lake	Site	Feb-22-86 SDD	12:59.11 Chl
Jul-14-83	Horseshoe	1 Deep	2.33	1.22
Jul-14-83	Horseshoe	1 Deep	2.50	3.45
Jul-20-83	Horseshoe	1 Deep	2.75	1.43
Jul-20-83	Horseshoe	1 Deep	2.25	1.53
Jul-27-83	Horseshoe	1 Deep	6.10	4.72
Jul-27-83	Horseshoe	1 Deep	2.20	4.28
Aug-03-83	Horseshoe	1 Deep	2.25	1.67
Aug-03-83	Horseshoe	1 Deep	2.30	1.31
Aug-17-83	Horseshoe	1 Deep	2.75	2.14
Aug-17-83	Horseshoe	1 Deep	2.30	1.67
Aug-24-83	Horseshoe	1 Deep	2.80	2.14
Aug-24-83	Horseshoe	1 Deep	2.50	1.31
Aug-31-83	Horseshoe	1 Deep	2.70	2.14
Aug-31-83	Horseshoe	1 Deep	2.80	2.62

>>> END OF LIST <<<



NOTE

There are three levels of reports available to participating lake associations in the LLMP. They are differentiated as follows:

LEVEL I - This is a basic report that includes sections on the methods employed, comments and recommendations, and a brief summary of results. It also contains an appendix listing data from the present and past years.

LEVEL II - This is a mid-level report that includes methods employed, a non-technical summary of lay monitor and FBG data, comments and recommendations and an in-depth results and discussion section. It contains an appendix listing data from the present and past years.

LEVEL III - This is a full report which includes the following sections: methods employed, a non-technical summary, comments and recommendations, a technical summary, and a complete results and discussion section supplemented by computerized graphics. It also contains 3-4 appendixes: a listing of present-year and past data, limnological concepts and technical terms, and a glossary.