CHOCORUA LAKE

LAKES LAY MONITORING PROGRAM

1985

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University of New Hampshire
Durham

by

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LAKES LAY MONITORING PROGRAM

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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.

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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 the lake, and if necessary, management techniques can be implemented to keep

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!

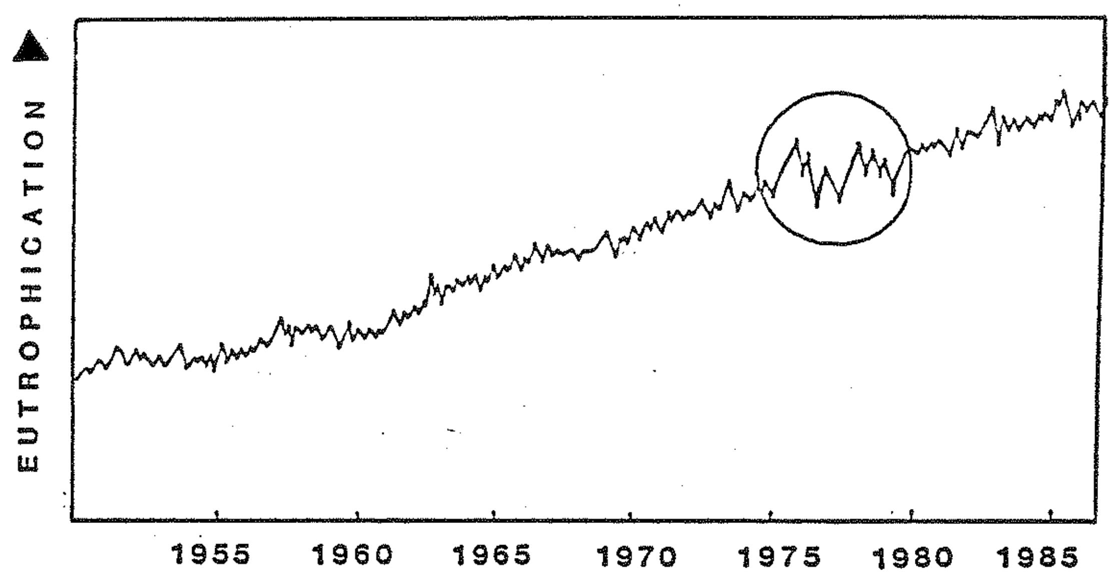

Figure 1. Long-term vs. short-term trends in a hypothetical lake approaching eutrophication.

ACKNOWLEDGEMENTS

1985 was Chocorua Lake's fifth year of participation in the Lakes Lay Monitoring Program. Dr. Arthur Baldwin was the sole monitor on the lake, and monitored one site (South Pool) a total of nine times over a 16 week period. The Freshwater Biology Group congratulates Dr. Baldwin on the quality of his work and the time and effort he put forth. We encourage him and any other members of the Chocorua Lake Association to monitor during the 1986 season.

We would also like to extend thanks to 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 LAY MONITOR DATA

1) Both water transparencies and chlorophyll a concentrations indicate that Chocorua Lake is still oligotrophic. Seasonal readings for secchi disk and chlorophyll suggest that the lake is nutrient poor and contains relatively few planktonic algae.

2) This year, alkalinity was measured frequently on the lake. Because alkalinities were low, it is very important that this parameter continue to be monitored. Alkalinity indicates the ability of water to buffer acids and may be more reliable than pH in predicting the effects of acidification on a lake. Low values such as those found this year indicate that the lake has little resistance to changes in pH due to acid precipitation.

3) pH readings taken this year were higher than in the past four years, and do not follow the pattern of decreasing pH seen from 1980 - 1984. Because pH is generally lower in lakes with little alkalinity (buffering capacity), the higher values in 1985 were surprising. However, there are many causes for fluctuations in pH which may account for the higher observations in 1985.

4) The water this year was more transparent and contained less green coloring from suspended algae than last year, but

similar to 1983. Short-term fluctuations such as these are common, possibly due to changes in weather from year to year.

5) Chocorua Lake was sampled twice in 1985 for phosphorus. The total phosphorus content in June was higher than in August. Based on the samples taken, nutrient loading into Chocorua Lake is limited.

COMMENTS AND RECOMMENDATIONS

1) We recommend that the Chocorua Lake Association continue its long-term monitoring program in 1986. The Association has established a five-year data base that can be strengthened through further monitoring. A data base resulting from several years of monitoring will be a valuable resource in the future as trends in the chemistry and biology of the lake become evident.

2) The Freshwater Biology Group (FBG) has not made a comprehensive chemical and biological survey of the lake since 1983 and we recommend scheduling another trip next year. Data from the FBG will support those from the lay monitors as well as provide information on parameters such as pH, phytoplankton, zooplankton, and other parameters that the lay monitors do not test for.

3) Results from recent scientific literature have shown that at a pH as high as 5.9, adverse changes in the food chain may occur which affect invertebrates and fish. Because Chocorua Lake has consistently had a pH less than 5.9, we are concerned with the problem of acidification. Therefore, we strongly recommend the continuation of alkalinity testing next year, as alkalinity measurements provide a reliable way to detect changes in buffering capacity and to predict changes in acidity and pH.

In addition, a study of the condition of the fish in the lake should be considered to determine the effects acidification may be having on them. Such a study could be developed through the FBG with participation of Lay Monitors (see Recommendation #6 below).

4) Phosphorus sampling should be continued in 1986. The phosphorus content of a lake is readily influenced by factors such as precipitation, land runoff, human activities and sewage, all of which may vary greatly from year to year. Thus, changes in phosphorus concentrations can come about rapidly, and it is important to detect such changes as they occur. Samples should be taken at least monthly, as those taken in the spring may represent the amount of phosphorus from spring runoff, and samples taken later in the summer could be from human activity. We recommend sampling from a deep site, from inlet or outlet streams, and from areas along the shoreline where it is suspected that nutrient loading may occur.

5) For a more accurate assessment of those factors regulating the water transparency, samples for dissolved water color should be collected. Water color is another factor in addition to chlorophyll which influences the secchi disc depth. The procedure consists of saving the filtrate from the chlorophyll filtration, and sending it to the FBG for analysis. It is a simple procedure which imparts little extra cost on the program.

6) 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 LAY MONITORS

This year, data were collected on five parameters: thermal stratification, water transparency (secchi disk depth), alkalinity, chlorophyll a concentration, and total phosphorus. Whenever possible, testing was done weekly between the hours of 9 am and 3 pm, the period of maximum sunlight penetration into the water. All samples and data were mailed to the FBG at UNH for analysis.

Temperature profiles were obtained by collecting lakewater samples at several successive depths with a modified Meyer bottle (Lind, 1979). A weighted, empty bottle with a stopper was lowered to a specific depth. At that depth, the stopper was pulled, allowing the bottle to be filled with water. The bottle was quickly pulled back up to the surface where the temperature of the sample was taken with a Taylor pocket thermometer, and recorded in degrees Celsius. This procedure was repeated at one meter intervals through the epilimnion and hypolimnion, and at half-meter intervals throughout the metalimnion.

Water transparency was measured by lowering a secchi disk (approximately 20 cm. or 8-inches) through the water off the shaded side of the boat and noting the average depth at which it disappeared upon lowering and reappeared when being raised (the cord attached to the secchi disk was marked in one-half meters). This process was done while holding a view-scope just below the surface to eliminate effects of surface reflection and wave action. This was repeated two or three times, and an average to the nearest one-tenth of a meter was recorded.

Chlorophyll a concentration was used as an index of algal biomass that is useful in determining the trophic state of the lake. A weighted plastic tube (10 meters in length) was lowered through the epilimnion, or "upper lake" to the top of the metalimnion, or "middle lake" (the depths of the epilimnion and metalinmion are determined from the temperature profile). The end of the tube above water is folded to shut off the water flow into or out of the tube. The weighted end of the tube is pulled up out of the water with an attached cord, trapping an integrated sample of water representing the upper lake in the tube. This sample is poured into a 2.5 liter plastic bottle and stored for chlorophyll filtration and alkalinity determination.

Water samples for chlorophyll filtration were filtered through a 0.45 micron membrane filter. Damp filters, containing chlorophyll-bearing algae, were air-dried for at least 15 minutes, out of the sun, to prevent decomposition or bleaching of the chlorophyll on the filter. Filters were sent to UNH where members of the FBG analyzed them for chlorophyll a.

To determine the alkalinity, a two-endpoint titration was done with 0.002 N sulfuric acid to a pH of 5.1 and 4.5. 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.

Phosphorus samples were collected in acid-washed 250 milliliter bottles, fixed with 1.0 ml of concentrated sulfuric acid and stored frozen. They were sent to UNH for analysis. (See Methods by the Freshwater Biology Group.)

METHODS OF THE FRESHWATER BIOLOGY GROUP

Laboratory Methods

The Freshwater Biology Group (FBG) was responsible for chlorophyll a and phosphorus analyses, as well as filing and analyzing 1985 data, performing statistical tests, and determining possible trends based on past data.

The chlorophyll a content was analyzed by extracting the chlorophyll with a 90% 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 received by the FBG in a cold or frozen state, and were stored refrigerated until they were analyzed. To determine the total phosphorus content, ammonium persulfate and 11 N sulfuric acid was added to digest the total phosphorus, and the samples were auto-*claved for one hour. Then, 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 (micrograms per liter).

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 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, the results are 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

Secchi disk depth and chlorophyll a

Water transparency (secchi disk depth), was in the range from 4.4 to 6.4 meters, with an average of 5.6 meters. This year, secchi disk values were deeper in June at the beginning of the sampling season and became shallower as the summer progressed. During this same time, chlorophyll *a* concentrations fluctuated around an average of 1.0 mg per cubic meter, without an increase as time progressed. This indicates that the variation in water clarity is not entirely due to variations in phytoplankton populations and may be related to dissolved water color from humic acids or non-algal particles. As in previous years, water transparencies and chlorophyll concentrations indicate that Chocorua Lake is oligotrophic. See appendix A for chlorophyll and secchi disk data from 1982-1985.

Alkalinity and pH

Lay monitor alkalinity testing began on July 27 and was continued weekly until October 12, 1985 (Appendix B). Values at the pH 4.5 endpoint (pink) were low, ranging from 4.4 - 5.5 milligrams calcium carbonate per liter, with an average of 4.9. Values in this range are low. The average for the state of New Hampshire is about 9 milligrams per liter. A critical point occurs at an alkalinity of about 2 mg per liter when there is little or no resistance of a lake to acidification; with little buffering capacity, the pH of the water is unstable and will decrease rapidly if further acid is added.

A low pH can have adverse effects on most organisms in the lake. At a pH of 5.5 or lower, some species of fish and crustaceans fail to reproduce. Since 1979, Chocorua Lake has had pH readings ranging between 5.2 to 6.3. In 1985, the average pH was 6.7. There are many causes for pH fluctuations including time of day, season, and errors associated with use of the pH meter. We would expect pronounced seasonal and annual variations in Chocorua Lake due to its relatively short water volume retention time. For example, in dry periods the pH would probably rise as a result of biological and chemical activities; in wet seasons, the water will become more acidic in response to acid rain.

Phosphorus

Chocorua Lake was sampled twice for phosphorus. The concentration was 26.4 parts per billion (ppb) in June and 5.4 ppb in August. The former value falls in the eutrophic range and the latter in the oligotrophic range.

Recent History

Some generalizations concerning the trophic status of Chocorua Lake can be made using data available from the past six years. In the summer of 1979, the New Hampshire Water Supply and Pollution Control Commission (WSPCC) sampled the lake using parameters covered by the Lay Monitors and the FBG. Data were collected by the LLMP in 1980-1985, except 1981.

While the water transparency has fluctuated each year, over a six-year period there has been no trend. Values have ranged from 4 - 5.9 meters, all within the oligotrophic range. Since 1980, average chlorophyll concentrations have remained between 1.0 and 2.3 mg per cubic meter with little yearly variation. The chlorophyll concentration was highest in 1979 (3.4 mg per cubic meter) when the secchi disk depth was shallowest (4 meters). Except for 1979, all chlorophyll values suggest oligotrophy.

The most important problem in Chocorua Lake is potential acidity. The consistently low alkalinity and low pH indicates that Chocorua Lake could be at the threshold for major changes that would adversely effect its biota.

While it is important to continue monitoring both pH and alkalinity, recent evidence suggests that alkalinity measurements are a more reliable <u>early indicator</u> of lake acidification than pH. A study by Schindler, et al. at the Department of Fisheries and Oceans, Canada, showed adverse changes in the ecosystem composition to begin at a pH as high as 5.9. This was manifested by the disappearance of certain zooplankton species, and the failure of some species of fish to reproduce. As the pH gradually decreased from 6.8 to 5.0 during the eight-year study, there were changes in the phytoplankton species to forms adapted to acidic conditions, the disappearance of some zooplankton species and benthic crustaceans, changes in spawning behavior of lake trout, and eventually a cessation of all fish reproduction. However, during the first year of the study, more than 80% of the alkalinity disappeared, but the pH was relatively consistent. Once the buffering capacity is gone, acidification and its effects occur rapidly.

In addition to alkalinity and pH monitoring, the analysis of trace metal concentrations in the lakewater is another way to detect effects of acidification. In general, increased acidity causes an increase in the solubility of many trace metals such as aluminum, zinc, cadmium and copper. Acid rain causes aluminum to be leached from drainage basins if the soils are poorly buffered, and high concentrations of aluminum as well as other micronutrients are toxic.

As the low alkalinity and pH of Chocorua Lake are cause for concern, a study of the effects acidification may be having on the lake should be considered. Such a study may include an analysis of trace-metal concentrations such as aluminum, and an investigation of the abundance and condition of phytoplankton, zooplankton and fish.

If further information regarding future studies is desired, the Freshwater Biology Group would be happy to discuss such possibilities.

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APPENDIX A

LLMP -- Lay Monitor Data: Chocorua Jan-09-86 15:54.20

Date	Lake	Site	SDD	Chl
Aug-16-82	Chocorua	1 South	6.00	---
Aug-22-82	Chocorua	1 South	4.60	---
Aug-28-82	Chocorua	1 South	4.50	1.78
Sep-05-82	Chocorua	1 South	4.00	2.71
Apr-08-83	Chocorua	1 South	5.50	.86
May-01-83	Chocorua	1 South	---	1.14
May-16-83	Chocorua	1 South	5.30	1.00
May-29-83	Chocorua	1 South	---	.29
Jun-12-83	Chocorua	1 South	4.50	.43
Jun-17-83	Chocorua	1 South	3.25	3.75
Jun-23-83	Chocorua	1 South	3.25	4.39
Jun-28-83	Chocorua	1 South	---	1.28
Jul-01-83	Chocorua	1 South	3.10	2.55
Jul-04-83	Chocorua	1 South	5.40	.57
Jul-10-83	Chocorua	1 South	6.40	.57
Jul-11-83	Chocorua	1 South	3.50	5.43
Jul-16-83	Chocorua	1 South	4.60	1.00
Jul-25-83	Chocorua	1 South	5.50	.86
Aug-10-83	Chocorua	1 South	5.60	.51
Sep-02-83	Chocorua	1 South	6.00	.71
Sep-25-83	Chocorua	1 South	5.60	1.43
Oct-10-83	Chocorua	1 South	5.00	1.00
Jul-05-84	Chocorua	1 South	5.00	1.43
Jul-15-84	Chocorua	1 South	4.00	1.57
Jul-21-84	Chocorua	1 South	3.50	1.14
Aug-22-84	Chocorua	1 South	5.00	---
Aug-30-84	Chocorua	1 South	5.30	.29
Sep-16-84	Chocorua	1 South	5.50	1.00
Oct-07-84	Chocorua	1 South	5.00	1.00
Jun-23-85	Chocorua	1 South	6.40	.57
Jun-24-85	Chocorua	1 South	---	---
Jul-07-85	Chocorua	1 South	6.20	1.14
Jul-19-85	Chocorua	1 South	6.50	.86
Jul-27-85	Chocorua	1 South	5.90	.71
Aug-06-85	Chocorua	1 South	5.70	1.43
Aug-19-85	Chocorua	1 South	5.20	1.57
Aug-28-85	Chocorua	1 South	---	---

Aug-28-85	Chocorua	1 South	4.80	1.14
Sep-14-85	Chocorua	1 South	4.90	.57
Oct-12-85	Chocorua	1 South	4.40	.86

>>> END OF LIST <<<

APPENDIX B

LLMP -- Lay Monitor Data: Chocorua Feb-21-86 12:01.48

Date	Lake	Site	Alk (ppm)	Tot-P
Jun-24-85	Chocorua	1 South	---	26.4
Jul-27-85	Chocorua	1 South	5.4	---
Aug-06-85	Chocorua	1 South	4.6	---
Aug-28-85	Chocorua	1 South	---	5.4
Aug-28-85	Chocorua	1 South	4.4	---
Sep-14-85	Chocorua	1 South	4.8	---
Oct-12-85	Chocorua	1 South	5.5	---

>>> 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.