BOW LAKE

LAKE LAY MONITORING PROGRAM

1983

Freshwater Biology Group (FBG)

University of New Hampshire

Durham

by

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PREFACE

The present 'mini-report' is submitted as a brief summarization of the first-year pilot study of Bow Lake by the Freshwater Biology Group, within the Lake Lay Monitoring Program at the University of New Hampshire. Bow Lake's involvement in the program this year is a preliminary step to obtain baseline data on the lake.

ACKNOWLEDGEMENTS

Members of our Freshwater Biology Group field team included Kim Babbitt, Dan Hayes, Wayne Boisselle, Tom Balf, and Mike Martin. Dan was team leader, and was responsible for coordinating all data analysis and interpretation. He and Tom were the zooplankton experts. Mike was the phytoplankton expert. Kim and Wayne specialized in phosphorus and chlorophyll *a* analysis. All members of the team helped in data organization and filing. Also, all team members participated in field trips throughout the summer.

This report has been produced in large part with data management and word processing programs on the UNH DEC-10 computer. Graphics were produced with program UPLOT, written by Professor Baker, and the CALCOMP drum plotter

available on the DEC-10 system. The Office cf Computer Services kindly provided computer time and data storaqe space for the Lake Lay Monitoring Program.

INTRODUCTION

This report presents the finding of the 1983 summer study of Bow Lake. The study was conducted jointly by the Freshwater Biology Group (FBG), University of New Hampshire, and by the Bow Lake Association, as part of the Lake Lay Monitoring Program (LLMP). The LLMP is a long-term water quality monitoring program that relies heavily on the efforts of lay persons. In Durham, the LLMP is conducted by Dr. Alan L. Baker (Associate Professor of Botany) and Dr. James F. Haney (Associate Professor of Zoology), who direct a team of graduate and undergraduate students especially trained in aquatic ecology and lake management. Space and research facilities were provided by the Departments of Botany and Zoology at the University of New Hampshire. Secretarial services were provided by the Department of Zoology.

The LLMP is a cooperative effort between the FBG and cooperating lake associations, conservation commissions, and municipalities. Funding for the program is derived solely by contributions from the participating groups. During 1983, the participating groups included: Walker Pond Protection Association, Town of Hudson, Town of Salem, Town of Merrimack, Town of Amherst, Lake Chocorua Conservation Federation, Bow Lake Association, Lake Winnipesaukee Association, Squam Lake Association, Merrymeeting Lake Association, Pleasant Lake Association, Naticook Lake

Association, Bow Lake Association, and Lake Kanasatka Watershed Association.

The LLMP has two major goals: first, to carry out scientific investigations on participating lakes in order to provide a data-base on lake biology, physics, and chemistry; and second, to educate people about lakes and their management. A broad data-base on lakes is necessary for their proper management, but is often lacking. Through the efforts of lay monitors and FBG members, such a data base can be provided. This commitment is long-term due to the long period of time it may require a lake to exhibit signs of disturbance. Continued monitoring from year to year is essential for the early detection of changes in lake conditions.

Education is probably the single most important goal of the LLMP. Through education, people's awareness of lakes and human activities that may influence lakes is heightened.

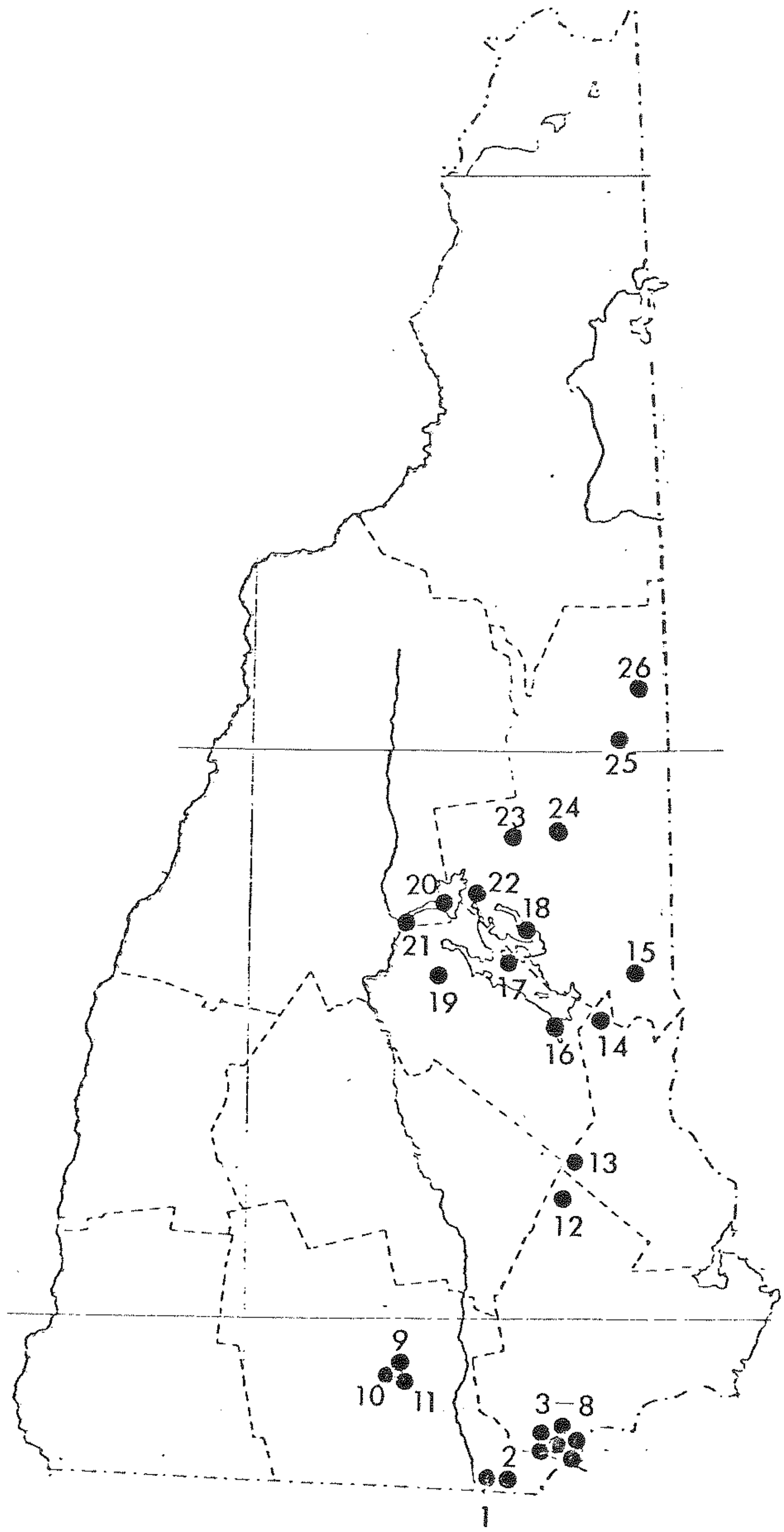

Figure 1.

Key to Figure 1: Lakes previously or presently in the LLMP of New Hampshire.

Map Location	Lake Name	Number of FBG Observations	Number of Lay Observations
1	Ottarnic Pond	11	37
2	Robinson Pond	10	79
3	Arlington Mill Resevoir	20	78
4	Canobie Lake	15	29
5	Millville Lake	10	84
6	Shadow Lake	9	17
7	World's End Pond	0	12
8	Captain's Pond	0	7
9	Naticook Pond	2	9
10	Horseshoe Pond	0	14
11	Baboosic Lake	11	48
12	Pleasant Lake	6	72
13	Bow Lake	2	0
14	Merrymeeting Lake	12	58
15	Lovell Lake	2	0
	Lake Winnipesaukee		
16	Alton Bay	2	85
17	Long Island	0	38
18	Moultonborough Bay	26	172
19	Winona Lake	4	4
20	Squam Lake	18	358
21	Little Squam Lake	14	76
22	Kanasatka Lake	0	3
23	Bearcamp Pond	7	86
24	Silver Lake	2	50
25	Lake Chocorua	9	16
26	Conway Lake	5	28

Brief Non-technical Summary

1) The water quality in Bow Lake is "good" because of the high water clarity (deep Secchi disk depth), and low amount of algae (chlorophyll a).

2) pH in Bow Lake was low (acidic) on Sept. 1, 1983. The sources and effects of this acidity are uncertain at the present.

3) The phosphorus concentration in lakewater samples indicates low loading of phosphorus into Bow Lake. Samples from stream sites A and E had high phosphorus concentrations, and indicate that these inlets may be major sources of phosphorus.

4) The data collected by the Freshwater Biology Group represents a beginning on a long-term data base for Bow Lake. These data represent only a single point in time, and can not be used to detect changes in water quality nearly as well as an entire season's worth of data. We hope that the Bow Lake Association will begin lay monitoring in 1984.

Comments and Recommendations for Bow Lake 1983

1) The data collected on Sept. 1, 1983 represents only a single data point for comparison. The value of a one day test is small compared to a full summer's testing by lay monitors. We recommend that lay monitors begin measuring lakewater transparency and chlorophyll _a_ concentrations as early in the spring as possible.

2) A program of phosphorus sampling should be initiated during 1984. Samples early in the spring are important since this is often the period of highest nutrient loading.

3) To examine the effect of seasonal changes in water color on Secchi disk depth, water samples for dissolved lakewater color should be collected.

Executive Summary for Bow Lake 1983

1) Bow Lake is oligotrophic based on Secchi disk depth, chlorophyll *a* concentration, and total phosphorus. The chlorophyll *a* concentration was low on Sept. 1 with 0.7-0.8 milligrams per cubic meter. The Secchi disk depth on Sept. 1 was deep at 7.8 meters. Total phosphorus concentrations in lakewater samples were low with 8.2-8.4 micrograms per liter.

2) Phytoplankton densities were low (432 - 495 cells per milliliter). *Merismopedia* was the dominant phytoplankton species on Sept. 1. Crustacean zooplankton densities were low (8 animals per liter). The dominant zooplankton was calanoid copepods and *Diaphanosoma*.

3) The pH on Sept. 1 was 5.9 at both lake sites. Such low values can be detrimental to many lake organisms. Earlier (April-May) measurements of pH are necessary, however, to evaluate the acid rain effects during the critical period following spring thaw. The alkalinity averaged 4.3 mg per liter.

3) Dissolved oxygen in the cold, deep water fell below the critical limit for fish such as trout and salmon, however there was a zone of water in the thermocline that could support these fish.

4) The salt and chloride ion content of lakewater in Bow Lake was relatively low, indicating low inputs of salts such as

through road salting or sewage.

5) Compared to other lakes in the LLMP, Bow Lake is lightly stained with humic acids.

RESULTS AND DISCUSSION OF FRESHWATER BIOLOGY GROUP DATA

Temperature and Dissolved Oxygen

Bow Lake was thermally stratified on Sept. 1, 1983 (Fig. 2). Dissolved oxygen concentrations fell to low concentrations (less than 3 parts per million) in the hypolimnion. These concentrations are below the tolerance level for cold-water fish, and will limit the distribution of these fish to the thermocline. The growth of these fish may also be adversely affected. The rate of oxygen depletion appears to be slow, and indicates low productivity.

Water Clarity and Dissolved Color

The Secchi disk depth measured on Sept. 1 was 7.8 meters at the deep site. This is a relatively deep transparency, and indicates oligotrophy. The site chosen near the dam was too shallow to allow a transparency measurement.

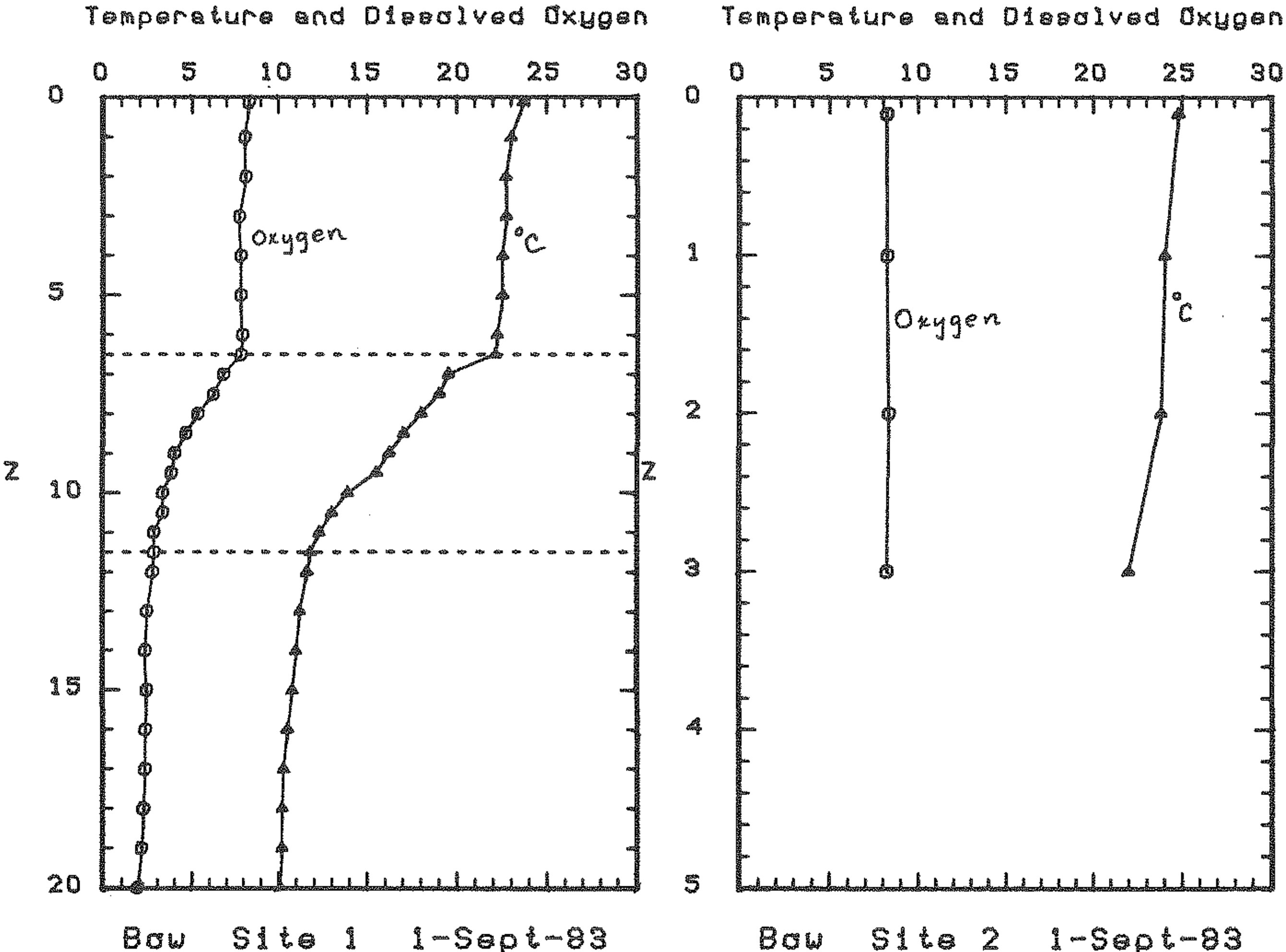

Figure 2. Profiles of temperature "▲" (degrees Celsius) and oxygen "o" (milligrams per liter). Depth scale is in meters.

Sunlight is quickly absorbed and scattered in lakewater by dissolved coloring material and by suspended particles. A value describing the attenuation of sunlight in lakewater is <u>k</u>, the 'extinction coefficient of diffuse downwelling light'. At the deep site, <u>k</u> was 0.475. Relative to other lakes in the LLMP, this is a low value and corresponds to the deep Secchi disk depth (Fig. 5).

Dissolved water color, primarily due to humic acids, averaged 0.016 per meter, a moderately low value (Fig. 3). Water color is one of the major factors affecting lakewater transparency.

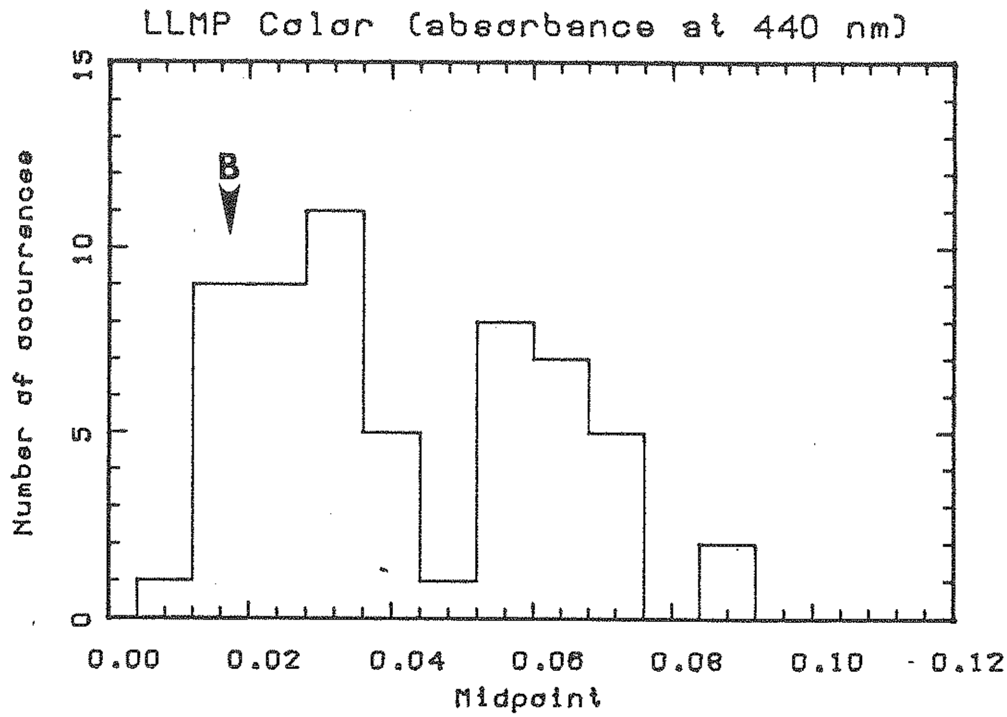

Figure 3. Frequency distribution of dissolved color of lakes in the LLMP. Mean value at Bow Lake is indicated with the arrow-head.

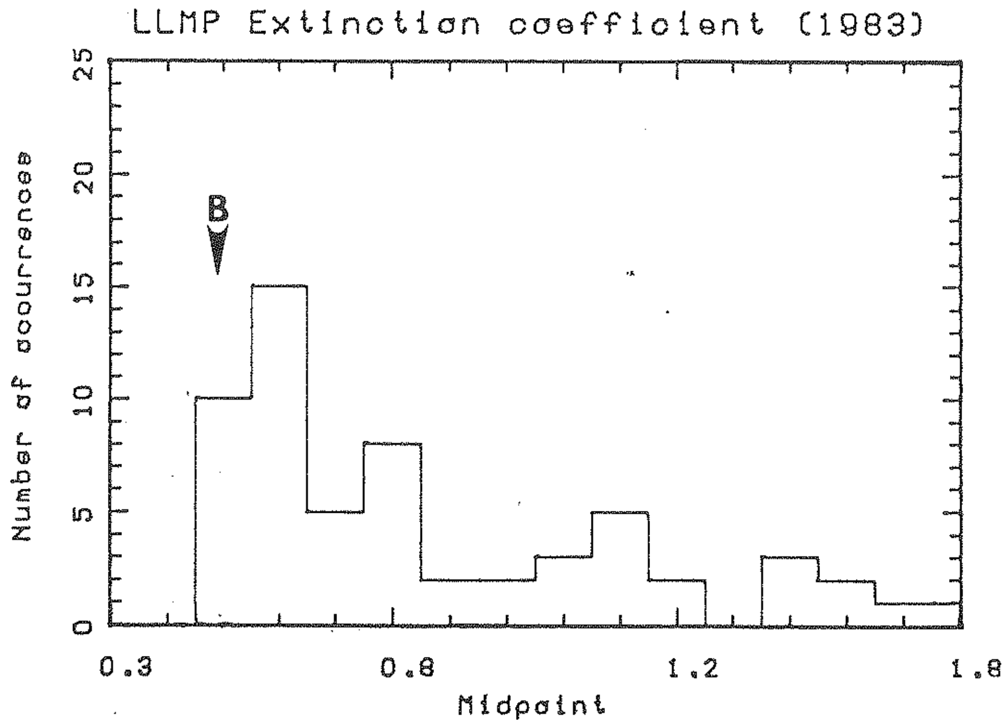

Figure 4. Frequency distribution of k, the extinction coefficient of diffuse downwelling light of lakes in the LLMP, showing mean of Bow Lake.

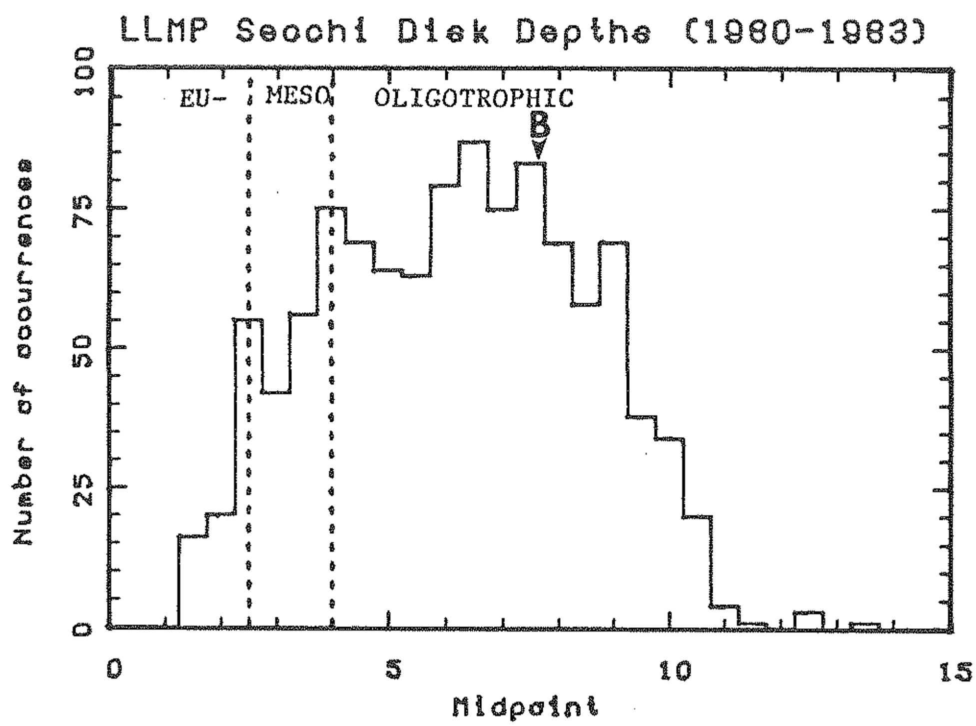

Figure 5. Frequency distribution of all observations of lake transparency (Secchi disk depth) in the LLMP. Arrow indicates mean value (1983) in Bow Lake.

Chlorophyll a

Chlorophyll a concentrations on Sept. 1 were low, in the range 0.7-0.8 milligrams per cubic meter, an indication of oligotrophy. Also, the mean chlorophyll value during 1983 was one of the lowest in the LLMP (Fig. 6).

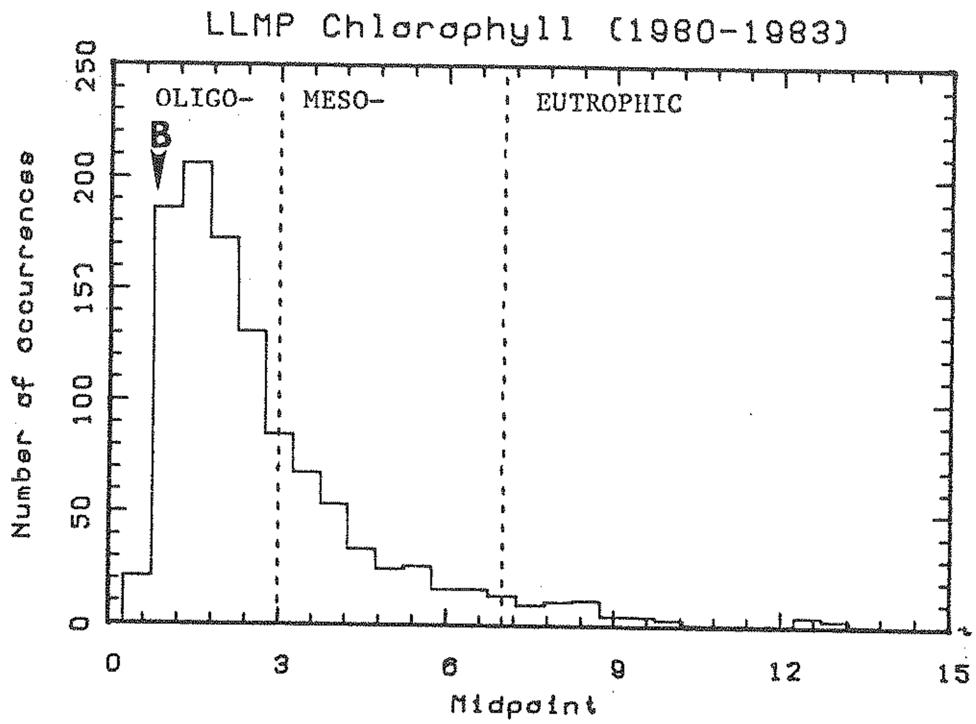

Figure 6. Histogram of all chlorophyll concentrations in the LLMP. Arrow marks mean value at Bow Lake.

Total Phosphorus

Total phosphorus is usually the most important nutrient limiting algal growth in freshwater systems. Its concentration can indicate the potential for algal growth. Two lake sites and seven stream sites were sampled for total phosphorus concentrations (Fig. 7). Concentrations at the open water sites were low, with approximately 8 micrograms per liter at both sites. Phosphorus concentrations of the inlets and bays around the lake were variable, with highest concentrations in the inlet to Caswell Cove, and an inlet to a beaver pond near the 'reservoir' (Table 1).

Total phosphorus concentration in the open water was low relative to other New Hampshire lakes in the monitoring program (Fig. 8).

Table 1. Phosphorus concentrations measured on September 1, 1983.

	Site	Phosphorus (ppb)
	1 Deep Site	8.4
	2 Dam	8.2
→	A Inlet to Caswell Cove	104.4
	B Bow Lake Estates	12.0
	C Bow Lake Estates 2	8.4
	D Piper Cove	5.6
→	E Inlet to beaver pond	127.4
	F The 'reservoir'	29.7
	G Foss Farm Stream	12.4

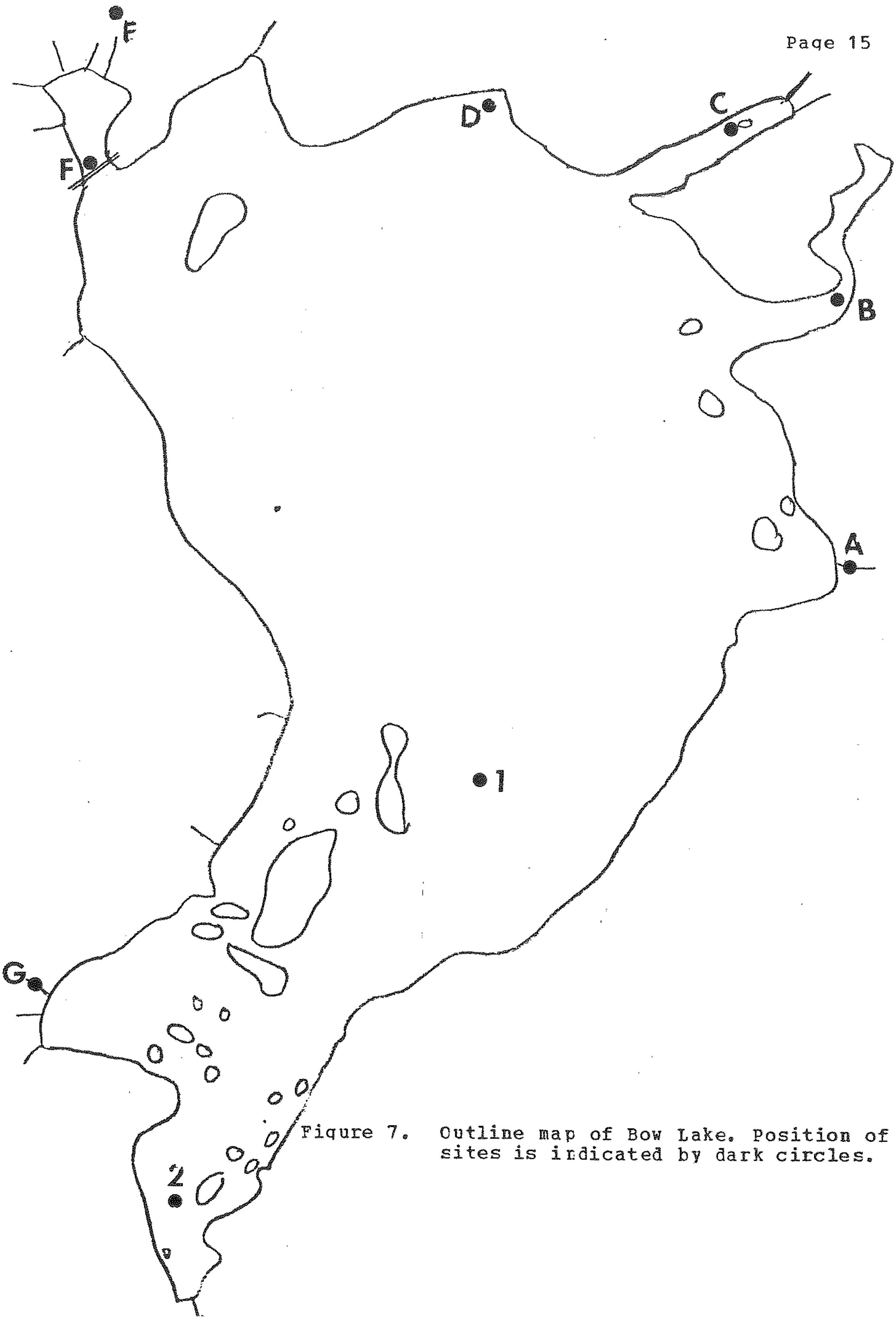

Figure 7. Outline map of Bow Lake. Position of study sites is indicated by dark circles.

Alkalinity, pH, and Free Carbon Dioxide

The pH values of surface water in Bow Lake were low, 5.9 at both open water sites. Alkalinity was low for New Hampshire, with an average of 4.3 milligrams calcium carbonate per liter. The Environmental Protection Agency classifies lakes with alkalinities less than 10 milligrams per liter as 'highly sensitive' to the effects of acid rain. The New Hampshire Water Supply and Pollution Control Commission measured an alkalinity of 3.0 mg per liter in 1978. The New Hampshire Fish and Game Department surveyed the lake in 1937 and 1952 and measured alkalinities of 4.0 and 4.6 mg per liter, respectively.

Free carbon dioxide accumulated in the thermocline and hypolimnion of Bow Lake, lowering the pH of these layers of lakewater (Fig. 9). The amount of free carbon dioxide in the deep waters indicates low to moderate productivity in Bow Lake.

Specific Conductivity

Bow Lake has a relatively low salt content, indicated by the low (31.2-32.0 micromhos per cm) specific conductivities. This indicates that inputs of road salt, and/or sewage are low in Bow Lake.

Phytoplankton

Phytoplankton densities on Sept. 1 were relatively low, 432-495 cells per milliliter at the two open water sites. Dominant at both sites were blue-green bacteria (*Merismopedia*), and Chlorophytes (small flagellated forms). The dominance of blue-green bacteria is often an indication of eutrophication, but in the case of *Merismopedia* this may not be the case. We have found *Merismopedia* in several other lakes with low alkalinities, and this genus may be more indicative of this condition. Other important groups included: Diatoms (*Tabellaria*, *Cyclotella*), Cryptomonads (*Chroomonas*) and Chrysophytes (*Kephyrion*).

Zooplankton

Zooplankton densities were also low in Bow Lake, with only 8 organisms per liter at the deep site. Dominant planktors were calanoid copepods, and *Diaphanosoma*, but the community also had *Holopedium*, *Bosmina*, *Daphnia*, and cyclopoid copepods in relative abundance. The low density of zooplankton in Bow Lake is probably related to the low density of phytoplankton in the lake.

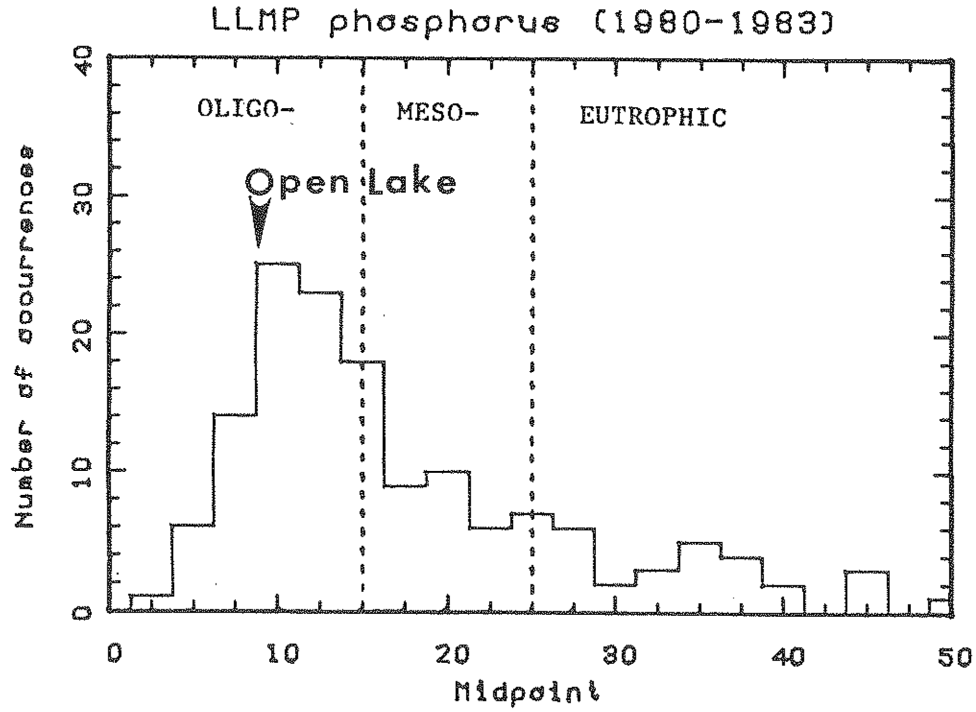

Figure 8. Histogram of all phosphorus values in the LLMP. Position of the arrow indicates the value at Bow Lake.

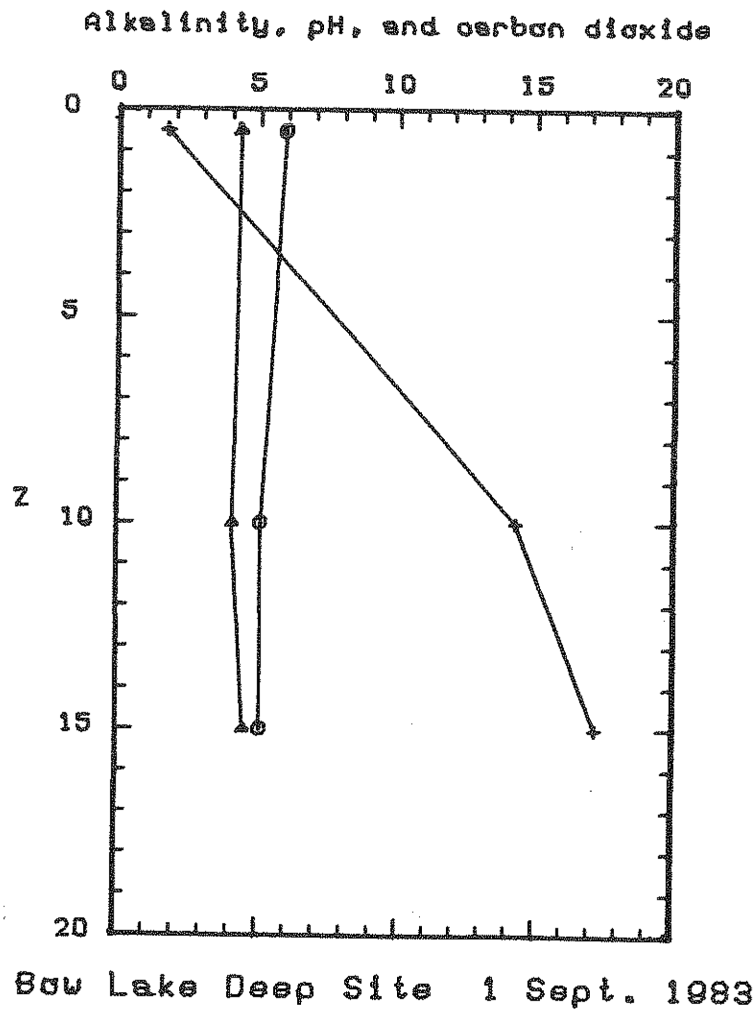

Figure 9. Alkalinity (mg l^{-1}) pH and carbon dioxide (mg l^{-1}).

Depth scale is in meters.