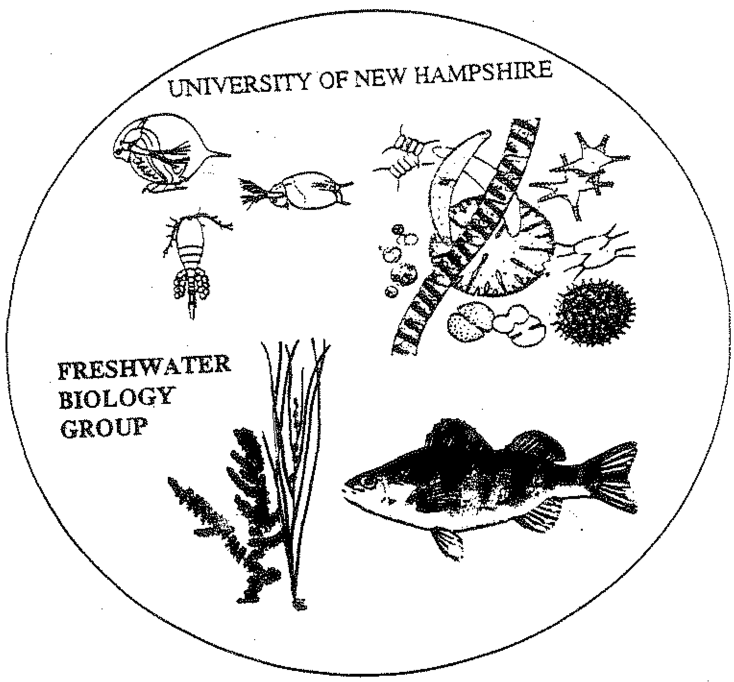
LAKE SUNAPEE
WATER QUALITY MONITORING PROGRAM
1990

by Jeffrey A. Schloss
edited by A.L.Baker and J.F.Haney
Prepared for the Lake Sunapee Protective Association



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PREFACE

This report contains the findings of a water quality survey of Lake Sunapee, in Merrimack and Sullivan Counties, New Hampshire, conducted in the summer of 1990 by the Freshwater Biology Group (**FBG**) of the University of New Hampshire at the request of the Lake Sunapee Protective Association (**LSPA**).

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1990 results as well as more detailed "Introduction" and "Results and Discussion" sections. The description of methods and materials used by the Freshwater Biology Group can be found in previous reports to the LSPA. Graphic display of data is included, in addition to listings of data in appendices, to aid visual perspective.

ACKNOWLEDGEMENTS

The Freshwater Biology Group (**FBG**) commends the Lake Sunapee Protective Association (**LSPA**) for their commitment to long-term monitoring of the water quality of Lake Sunapee. This was the fifth year of collaboration between the **FBG** and **LSPA** and the third year of participation in the NH Lakes Lay Monitoring Program.

We would like to thank the water monitoring committee (Bruce Putnam, chair) for their encouragement and for providing us with up to date information on water quality concerns and problems. Frank Hammond, Executive Director of the **LSPA** helped in the continued development of this program. Robert Skelly, President of the **LSPA** provided guidance and support; the **FBG** coordinator and field team greatly appreciate the use of his lake craft and home, as well as his hospitality. Bruce Putnam, Bruce Burdett, Frank Gordon, Bo Quakenbos and William Berlinger also should be recognized for volunteering their time and water craft for FBG sampling trips. Jane Weathers continued with the formidable task of coordinating the **LSPA** volunteer monitors (summarized in a separate report available through the LSPA).

The Freshwater Biology Group is a not-for-profit research program co-supervised by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the **FBG** summer field team included Jeffrey Schloss, Beth Ferrari, Barent Rice, Kathleen Mahoney, Elizabeth LaPointe, Maura Callahan and David Cederholm. Other **FBG** staff assisting in the fall were: Bonnie Bruce, Robert Craycraft, Sandra Weiss and John Ferraro.

The **FBG** acknowledges UNH Cooperative Extension for partial funding of the coordinator position and staff support. The College of Life Science and Agriculture Office of Academic Affairs furnished laboratory and storage space. The UNH Office of Computer Services provided computer time and data storage allocations.

Lake Volunteer Sunapee Lake and Stream Monitors

Andy and Joan Coval

Roger and Mary Topliffe

Gerald and Isabelle Cormier

Bruce and Peg Burdett

William Berlinger

Curt and Terry Chapmann

Ryan, Ethan and Allen Popp

Ken and Marion Southall

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Neil and Jane Weathers

George and Bonnie Quakenbos

Allen and Mary IveyGuy and Sharon La Vigne

William and Cecile Diamond

Richard Butterfield

Frank and Dot Gordon

Taffy Beckman

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Peter and Diane Kusinski

Vince and Lorraine Iacopino

Phyllis Cullinan

Scott Flint

Wayne and Judy La Porte

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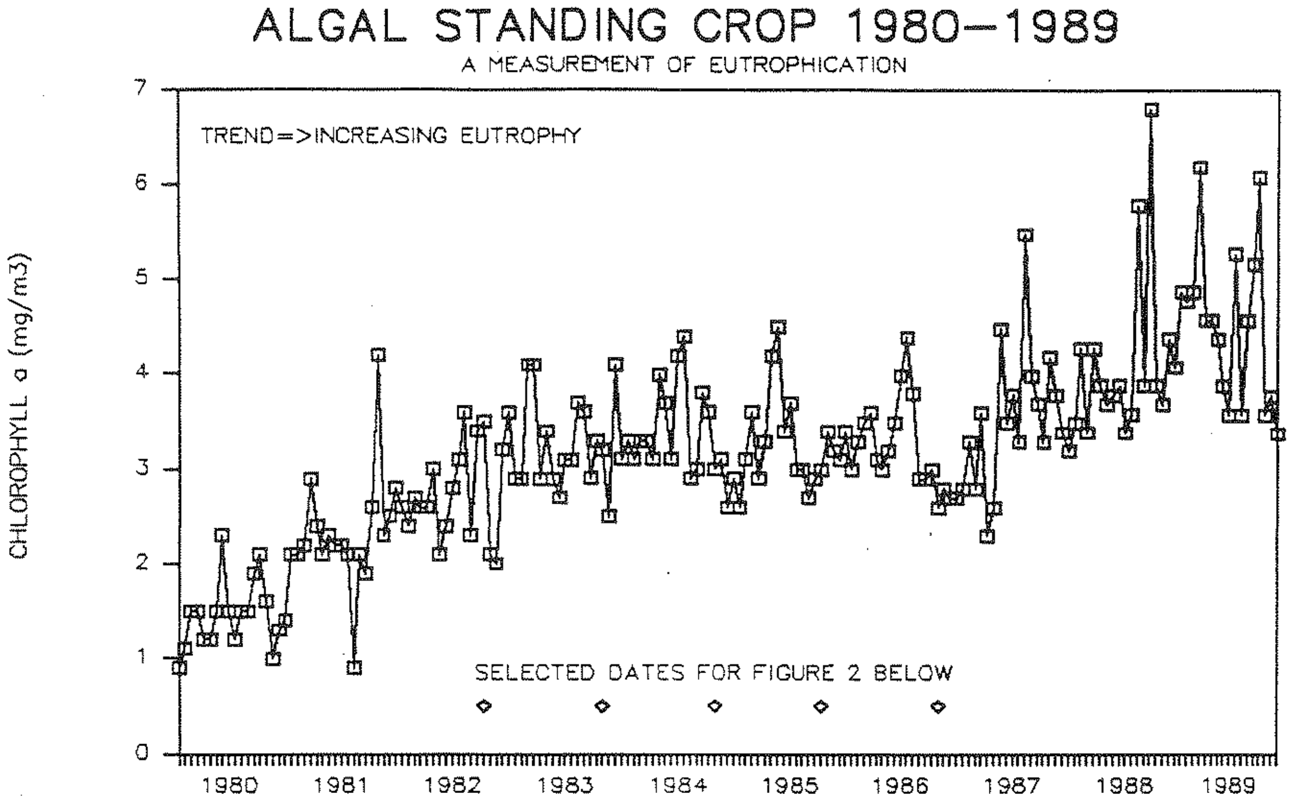
INTRODUCTION

Importance of Long-term Monitoring

A major goal of a monitoring program is to identify any short or long-term changes in the water quality of the lake. Of major concern is the detection of cultural eutrophication: increases in the productivity of the lake, the amount of algae and plant growth, due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern, as New Hampshire receives large amounts of acid precipitation, yet most of our lakes contain little mineral content to neutralize this type of pollution.

For over a decade, data collected weekly from lakes participating in the **New Hampshire Lakes Lay Monitoring Program** have indicated there is quite a variation in water quality parameters through the open water season on the majority of lakes. Short-term differences may be due to variations in weather, lake use, or other chance events. Monthly sampling of a lake during a single summer provides some useful information, but there is a greater chance that important short-term events such as algal blooms or the lake response to storm run-off will be missed. These short-term fluctuations may be unrelated to the actual long-term trend of a lake or they may be indicative of the changing status or "health" of a lake.

To determine if a change in water quality is occurring, a lake must be sampled on a frequent basis over a substantial amount of time. A poorly designed sampling program may even mislead the investigator away from the actual trend: Consider the hypothetical lake in Figure 1. Sampling only once a year during August from 1982 to 1986 would produce a plot (Fig. 2) suggesting a decrease in eutrophication. The actual long-term trend of the lake, increasing eutrophy, can only be clearly discerned by sampling additional times a year for a ten year period (Fig. 1). Frequent monitoring carried out over the course of many summers can provide the information required to distinguish between short-term



.Figure 1. The upper graph depicts weekly chlorophyll concentrations of a model lake measured weekly during ice-free conditions. The long-term trend is that of increased eutrophication (lake has become "greener"). Diamonds below the curve represent late summer (August) dates the data set was subsampled to create Figure 2.

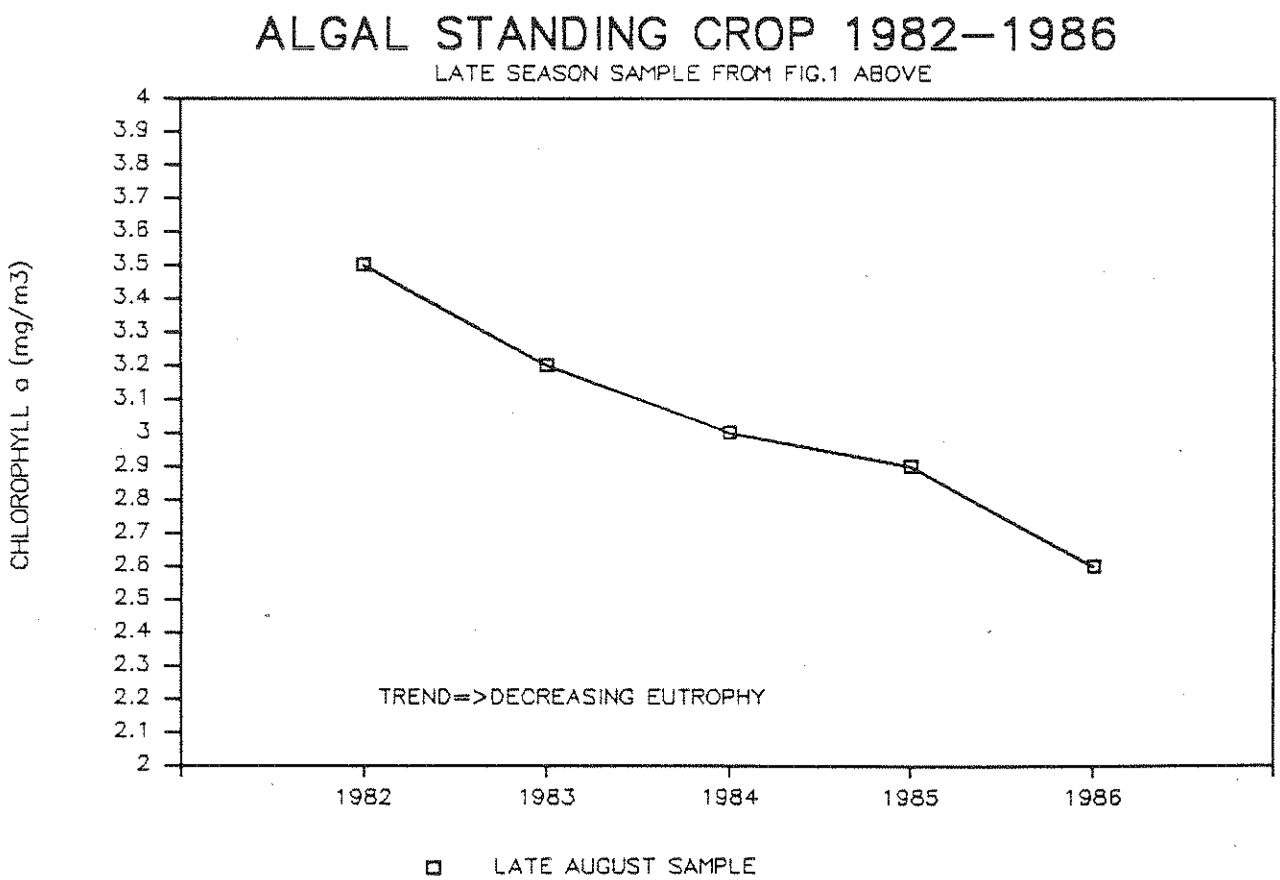


Figure 2. The lower graph depicts late summer chlorophyll data of the model lake in Figure 1. Note how limited sampling over a five year period suggests a much different trend, that of decreasing eutrophy. Thus, limited sampling can mislead the investigator of long-term trends.

fluctuation ("noise") and long-term trends ("signal"). To that end, the lake must establish a long-term data base.

The number of seasons it takes to distinguish between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long-term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. In addition, different areas of a lake may show a different response. As more data is collected, prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of the lake.

There are also short-term uses for monitoring data. The examinations and comparisons between different stations in a lake can disclose the location of a specific problem and corrective action can be initiated before the situation can become more serious. On a lighter note, much of the information collected by the **FBG** sampling trips can be used to determine the best depths for finding particular fish!.

Purpose and Scope of This Study

This was the fifth year that monitoring of Lake Sunapee was undertaken by the Freshwater Biology Group. The program of sampling was designed to continue adding data to the long-term data base established by the Lake Sunapee Protective Association, as well as to continue water testing initiated in 1986 by the **FBG**. Sampling emphasis was placed on the major coves and bays as well as the tributaries of the larger sub-watersheds of the lake. As in previous years, a more in-depth study of the three deep lake sites was also undertaken. Results from the 1986 and 1987 FBG/LSPA reports were used to streamline the sampling program in 1988 in order to expand testing at representative and/or critical sites, but this current report includes more sampling of additional sites due to the on-going lake nutrient study.

The primary purpose of this report is to discuss results of the 1990 monitoring with emphasis on current conditions of Lake Sunapee including the extent of eutrophication and the lake's susceptibility to increasing acid precipitation. This information is part of a large data base of historical and more recent data compiled and entered onto computer files for the **LSPA** including New Hampshire Fish and Game surveys of the 1930's, the edited version of the 1972 Cortell Report, the survey by the New Hampshire Water Supply and Pollution Control Commission (1979) and the Peck/IEP report (1981). Care must be taken when comparing current results with early studies. Many complications arise due to methodological differences of the various testing facilities contracted by the **LSPA** and technological improvements in testing.

NON-TECHNICAL SUMMARY 1990

This was the fifth season of sampling conducted by the Freshwater Biology Group of the University of New Hampshire on behalf of the Lake Sunapee Protective Association. The following is a brief summary of the findings. Sampling dates in 1990 were 24 March, 21 June, 6 August, 28 August and 27 September. Sampling site locations are shown in Figure 3. **As in previous years the general water quality of Lake Sunapee was excellent.** However, for a second year, certain indicators (water clarity, shallow site chlorophyll and total phosphorus) suggest a slight decline in water quality compared to earlier years. On a more positive note, a slight increase in the average buffering capacity of the lake again occurred. Continued lake monitoring in the coming year will determine if these are short-term events or an indication of a coming trend.

1) Water transparency measured by secchi disk was high, a sign of a clear, unproductive lake. At the deep water stations, the secchi disk was visible as far down as 8.0 meters (26 feet). This indicates the deep water sites on the lake are low in dissolved color and suspended matter such as algae and particulates. The range of transparency at the deep sites was 6.5 to 8.0 meters. At the Georges Mill station, the secchi disk was visible as far down as 8.6 meters (28 feet). The range of transparency at the volunteer sites was 2.3 to 8.6 meters. The 2.3 meter secchi disk reading at Job's Bay was a record low for the lake and new water clarity lows were also recorded at the outer Job's site and Herrick Cove. The 1990 average transparency of the shallow sites was lower than averages of the years 1988 and 1989. The 1990 average transparency of the deep sites of Lake Sunapee was lower than averages of the years 1986 through 1989 indicating a slight drop in water clarity.

2) Chlorophyll a concentrations for the surface waters of the deep sites were low and similar to levels measured last year. Chlorophyll levels indicate the extent of algae growth in the water. Concentrations in the mixed layer of water (the upper 8 to 10 meters)

averaged 1.8 milligrams per cubic meter (mg m^{-3}, equivalent to 1.8 parts chlorophyll per billion parts water). Generally, concentrations below 3 mg m^{-3} are indicative of less productive, clear lakes. Chlorophyll concentrations at mid-depths increased throughout the summer indicating the stratification of algae at the thermocline of the lake. Concentrations reached only as high as 3.6 mg m^{-3} at the southern deep site (Newbury). This is lower than concentrations measured in any previous year. Samples collected at the lower depths again contained mostly small motile algal cells known to stratify below the mixed layer of other lakes. Nuisance forms were in low to moderate concentrations at all deep sites. It should be noted that the many storm events during the summer could have flushed out these mid lake accumulations of algae.

At the shore and bay sites chlorophyll levels averaged 2.2 mg m^{-3}. Highest concentrations (as high as 9.3 mg m^{-3}) occurred as short-term blooms in June and late summer at all sites except Job's Bay. Most shallow sites had occasions of higher than typical chlorophyll levels in 1990 with the exception of the Georges Mill, Redwater Creek, and Herrick Cove sites.

The Herrick Cove site was inundated with a slug of nuisance blue green algae when a new drainage impoundment created by the Interstate 93 expansion overflowed over 103-A during several occasions (due to heavy storms and the destruction of a beaver dam) causing temporary blooms in the waters in the area. This is most likely a short-term disturbance but future monitoring will keep watch on this area for additional problems.

3) The average dissolved lake water color levels at Sunapee in July 1990 were low to moderate for New Hampshire lakes: less than the average lake color measured in 1988 and comparable to historical values. Color did peak at many sites along with chlorophyll blooms and storm events. Newbury Inlet, Job's Bay and Herrick Cove displayed the greatest color levels. Increases in water color from the natural breakdown of plant materials in and around a lake are not considered to be detrimental to water quality. However, in the case of Herrick Cove and the other tributary sites, high color can indicate

extensive land clearing and construction activities. Increased color can lower water transparency, and hence, change the public perception of water quality.

4) Total phosphorus levels were low throughout most of the lake sites. With one major exception, all lake sites had average phosphorus concentrations below the 15 parts per billion (ppb) level commonly thought of as the boundary between less productive and more productive lakes. The exception is the Redwater Creek Inlet site with a 110 ppb reading in June (after a storm event) and a 37 ppb average. The deep water sites displayed slightly elevated nutrient averages compared to all previous years.

Most tributary sites had lower than usual summer phosphorus levels although an occasional high reading was recorded. The Ledge Pond Brook, Herrick Cove and Newbury tributaries had higher summer averages compared to the other streams.

5) The total alkalinity, the lakes ability to buffer acid input, remains low. Spring values were lower than summer samples. Deep site alkalinity averaged 3.7 units (mg per liter $CaCO_3$) with a range of 3.1 to 4.2 units. The 1990 whole lake average, 3.9 units is slightly greater than previous years. This might be due to the limited snow pack and lower water run-off in the winter and spring of 1988-89 and 1989-1990. The pH of the surface waters of the lake remains well within the optimum range for most aquatic organisms with lower pH values during the early spring. Thus, while alkalinity remains at a critical level, the pH of the lake is displaying stability.

6) The specific conductivity of the lake remained at a low level typical of clear, clean lakes. High conductivity values can indicate the presence of septic leachate or deicing salt runoff. Testing at sites close to major roads indicated that deicing salts were not collecting in the bottom waters off of Georges Mill, Herrick Cove and Newbury as was suggested in some previous studies.

7) In-depth analyses at northern, central and southern deep water sites disclosed the typical temperature stratification patterns for northern temperate lakes. Oxygen content of the bottom waters was high this year as it was last year. The bottom oxygen concentration

remained above 5 milligrams per liter, the minimum concentration required for successful reproduction and growth of most coldwater fish (salmon and trout) down to 27 meters (81 feet) at the central deep site and 17 meters at the north and south basins. Carbon dioxide in the bottom waters was low to moderate at the northern and central sites and moderate to high at the southern site. Greater carbon dioxide in the bottom waters is typically due to the accumulation of organic matter due to increased run-off or increased lake productivity.

8) Microbiological testing was undertaken at selected sites on 28 August. Fecal coliform bacteria were present at nine of the 20 lake sites tested with high concentrations occurring at Job's Creek Cove, Blodgetts Landing and the Harbor Outlet. Of the tributaries, Chandler Brook had highly elevated levels (greater than 500 organisms per 100 milliliters). Total Coliform counts were even more numerous throughout the lake. As the sampling was done after a heavy rainstorm the lake "hotspots" were tested again on 27 September after a dry period. By the second testing all lake sites had no detectable levels of fecal coliforms and low to no total coliforms present. Tributary counts also decreased to lower but greater than typical levels.

CONCLUSION AND RECOMMENDATIONS

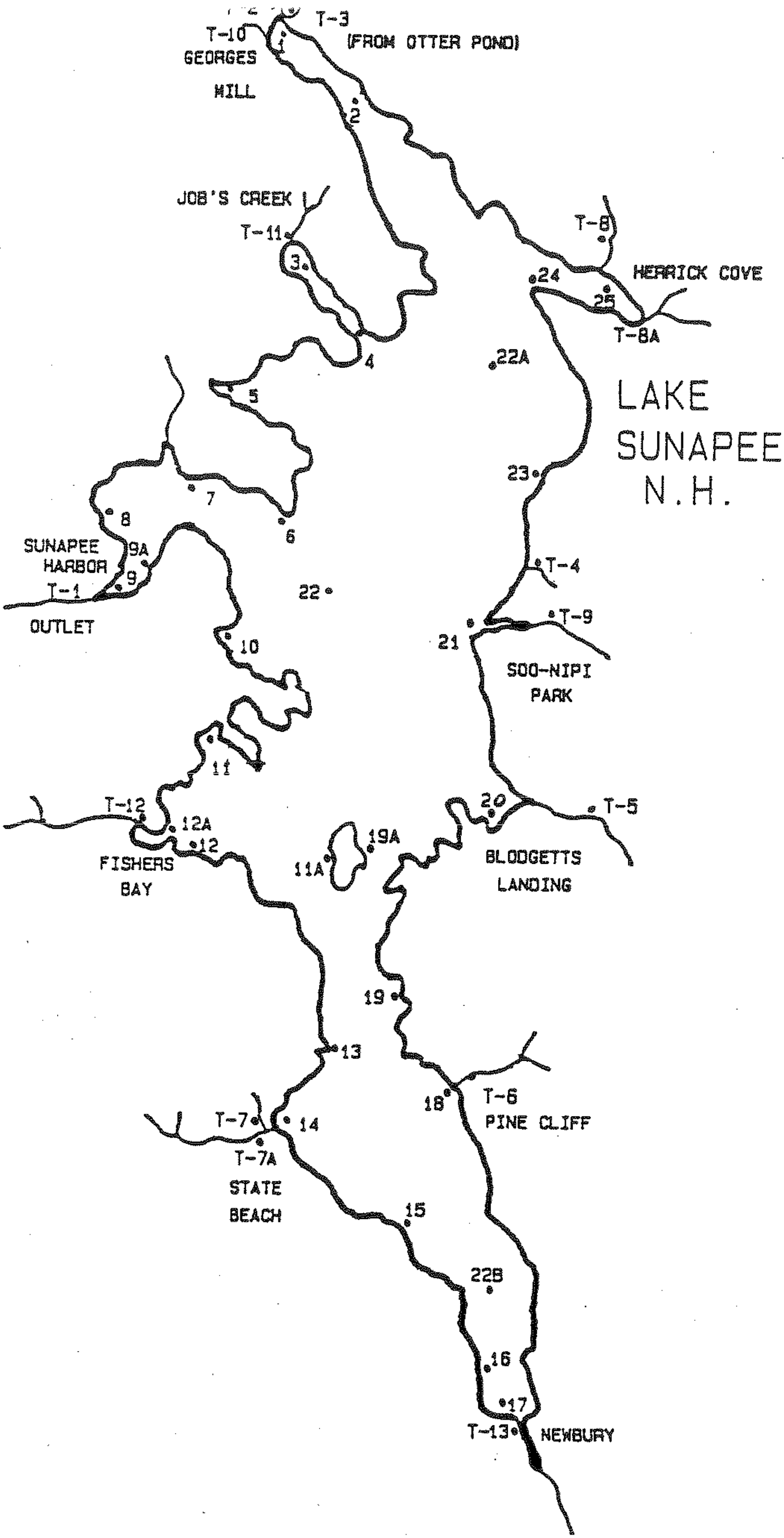
Decreases in transparency, increases in chlorophyll and total phosphorus concentrations, increases in dissolved color at certain tributaries, a decrease in light transmitted to depth, and microbiological sampling suggest that Lake Sunapee is continuing to experience a slight decline in water quality. While the overall water condition still remains in the excellent category these data (especially those taken after storm events) present the possibility that activities around the lake are creating measurable adverse effects. Thus it is important that the proper best management practices are followed in regards to current and future land use in the watershed. Shoreline areas and surrounding wetlands should be protected from modification and degradation. Vegetation should be fostered around the lake as riparian buffer zones on shore and around streams act to trap sediments and nutrients before they can enter the lake. The use of fertilizers, pesticides and herbicides should be avoided on land that is close to the shore or bordering streams that feed the lake. When construction must be done, the proper soil conservation procedures and practices should be followed. Watercraft should avoid shallow areas and maintain headway speed when operating close to shore. Although many homes on the lakeshore are or will be connected to town sewer systems, the majority of homes on the second and third "tier" around the lake have in-ground septic systems. Proper maintenance of these systems is important to maximize their effectiveness and minimize nutrient seepage into the lake. It is important to note that all activities within the lake's watershed can have a significant impact on the condition of Lake Sunapee.

Figure 3. Location of sampling sites at Lake Sunapee, New Hampshire. Numbering is consistent with previous sampling done by Bent and Cassista with additional sites added as discussed in the text.

TABLE 1 LOCATION OF SITES AT LAKE SUNAPEE SAMPLED IN 1990

Site #	DESCRIPTION
LAKE:	
2	GEORGES MILLS AT BUOY*
3	JOBS CREEK BAY*
4	JOBS CREEK NECK AT SPEED BUOY*
5	GARDENER BAY AT SPEED BUOY+
7	SUNAPEE HARBOR OFF DEWEY BEACH+
9	SUNAPEE HARBOR AT DOCK+
9A	INDIAN CAVE DOCK*
11A	GREAT ISLAND WEST SIDE+
12	FISHERS BAY SOUTH*
12A	OFF RED WATER CREEK INLET*
14	STATE PARK BEACH AT FLOATS+
17	NEWBURY OFF OF MARINA MOORING*
18	PINE CLIFF+
20	BLODGETTS LANDING+
21	SOO-NIPI PARK BETWEEN INLETS+
22	CENTRAL DEEP BASIN (HEDGE HOG)x
22A	NORTHERN DEEP BASINx
22B	SOUTHERN DEEP BASIN BELOW HAYS REEFx
24	HERRICK COVE NECK+
25	HERRICK COVE*
TRIBUTARIES:	
T1	OUTLET TO SUGAR RIVER
T2	LEDGE POND BROOK CULVERT
T3	OTTER POND BROOK FROM OTTER POND
T4	KING HILL BROOK
T5	BLODGETT BROOK
T6	PINE CLIFF BROOK
T7	CHANDLER BROOK
T7A	JOHNSON BROOK
T8	HERRICK MID-COVE BROOK
T8A	HERRICK COVE BROOK
T9	PIKE BROOK
T10	EAGLE ROCK BROOK
T11	JOBS CREEK
T12	RED WATER CREEK AT ROAD
T13	NEWBURY SOUTHERN INLET

*-Shallow shore or bay site sampled by FBG and volunteer monitors.
+-Shallow shore or bay site sampled by FBG only.
x-Deep sites intensively sampled by FBG (site 22B also sampled by volunteers).
Sites T-1 through T-7, and T-11 through T-12 also sampled by volunteers.


T-2
T-3
(FROM OTTER POND)
T-10
GEORGES
MILL
1
2
JOB'S CREEK
T-11
3
T-8
HERRICK COVE
24
25
T-8A
4
22A
LAKE
SUNAPEE
N.H.
5
23
7
8
6
SUNAPEE
HARBOR
9A
9
T-1
OUTLET
22
T-4
T-9
21
10
SOO-NIPI
PARK
11
20
T-5
T-12
12A
12
19A
11A
FISHERS
BAY
BLODGETTS
LANDING
19
13
18
T-6
PINE CLIFF
T-7
14
T-7A
STATE
BEACH
15
22B
16
17
T-13
NEWBURY

RESULTS AND DISCUSSION

Site Locations

The university field team visited Lake Sunapee on five dates in 1990. On three dates, 21 June, 28 August and 27 September the Freshwater Biology Group collected surficial lake water at 20 near-shore sites, 12 tributary sites, 1 outlet site and one to three deep water stations. Tributaries and selected shallow sites were also sampled by the FBG on 24 March and 6 August. Locations and site numbering was similar to those used in previous years at Lake Sunapee by Bent and Cassista. Sites include areas near inlets, bays or other areas of concern such as beaches and developments. Numbering of the lake sites starts at Georges Mills and continues counter-clockwise around the lake (Figure 3). The tributary sites represent six of the larger inlets to the lake (T-2 through T-7) while T-8 was chosen as a representative stream in the Herrick Cove area that was at a convenient location. Sites T-8A, and T-9 through T-13 were added in 1989 for the nutrient budget study and represent Herrick Cove Inlet, a southern Soo-Nippi tributary: Pike Brook, Eagle Rock Creek, Job's Creek, Red Water Creek and the Newbury Inlet respectively. The lake outlet site was sampled immediately above the dam at the water level gauge (site T-1). Deep water stations that were investigated more extensively were the northern (site 22A), central (site 22) and southern (site 22B) basins of the lake. An attempt was made to sample every site of the lake as time, weather conditions and materials permitted.

Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of secchi disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

Secchi disk measurements were taken at the three deep stations as well as 12 of the near-shore sites (8 of the near-shore sites were usually too shallow and the disk would hit bottom before it could disappear). Transparency values of greater than 4 meters are typical of clear, less productive lakes. Lake Sunapee had a relatively high transparency, between 6.5 and 8.2 meters at the deep sites and 4.0 to 9.0 meters at the near-shore sites throughout the summer.

Figure 4 displays the deep site results from 1990 and compares them to 1986 through 1990 measurements. Secchi disk depth and hence, the transparency of the water, increased as the summer progressed in 1986, showed no consistent pattern in 1987 and was consistently at about 8 meters during 1988. In 1989 and 1990, average transparency was reduced at all sites. As in earlier years, transparency increased at the central deep site (22) as the summer progressed. The northern site also increased in transparency as the summer progressed while the southern site had a slight transparency decrease through the summer. The central site had the maximum transparency for the season in August of 8.2 meters compared to the 1988 maximum of 10.5 meters at this same site. Reduction of transparency might be due to the slight increase in algae (see Chlorophyll and Phytoplankton sections below), an increase in suspended sediment from watershed development, increases in dissolved color (for the northern site only), or a combination of the factors above.

At the Georges Mill station, the secchi disk was visible as far down as 8.6 meters (28 feet). The range of transparency at the volunteer sites was 2.3 to 8.6 meters. The 2.3 meter secchi disk reading at Job's Bay was a record low for the lake and new water clarity lows were also recorded at the outer Job's site and Herrick Cove. The 1990 average transparency of the shallow sites was lower than averages of the years 1988 and 1989 (Figure 5).

Weekly transparency measurements made by volunteer lake monitors compared well with the FBG results (see Appendix A for data and graphs). They indicate that some of the

Figure 4. - Lake Sunapee 1986-90 Secchi Disk Transparency. Extent of secchi disk depth penetration into the lake for 1986, 1987 1988 and 1990 FBG sampling trips for the three deep lake sites 22 (black bars), 22A (dark hatched bars) and 22B (dotted bars). Dates of sampling are indicated on the X (horizontal) axis.

FBG SECCHI DISK TRANSPARENCY
DEEP SITES-LAKE SUNAPEE 1986-90

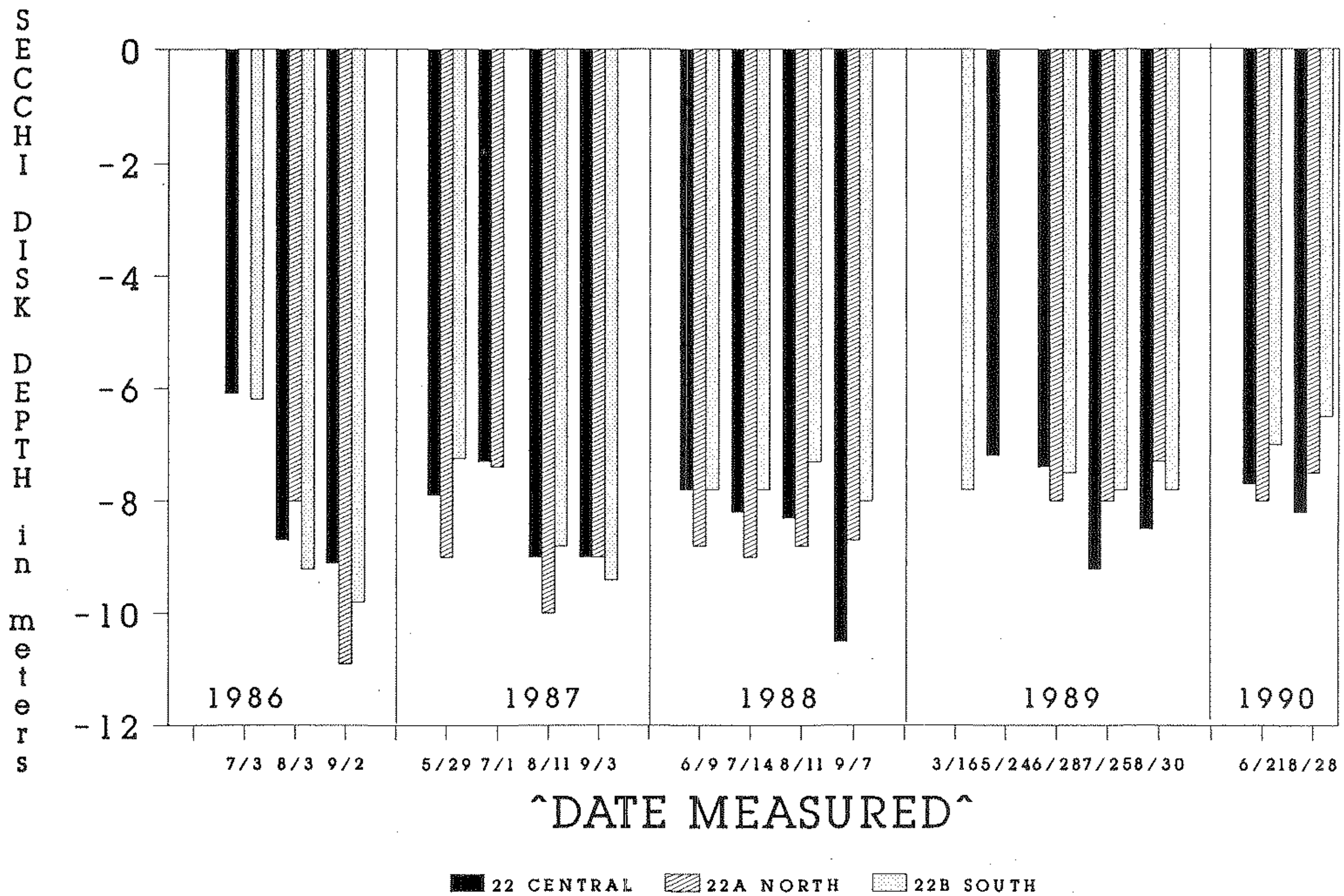
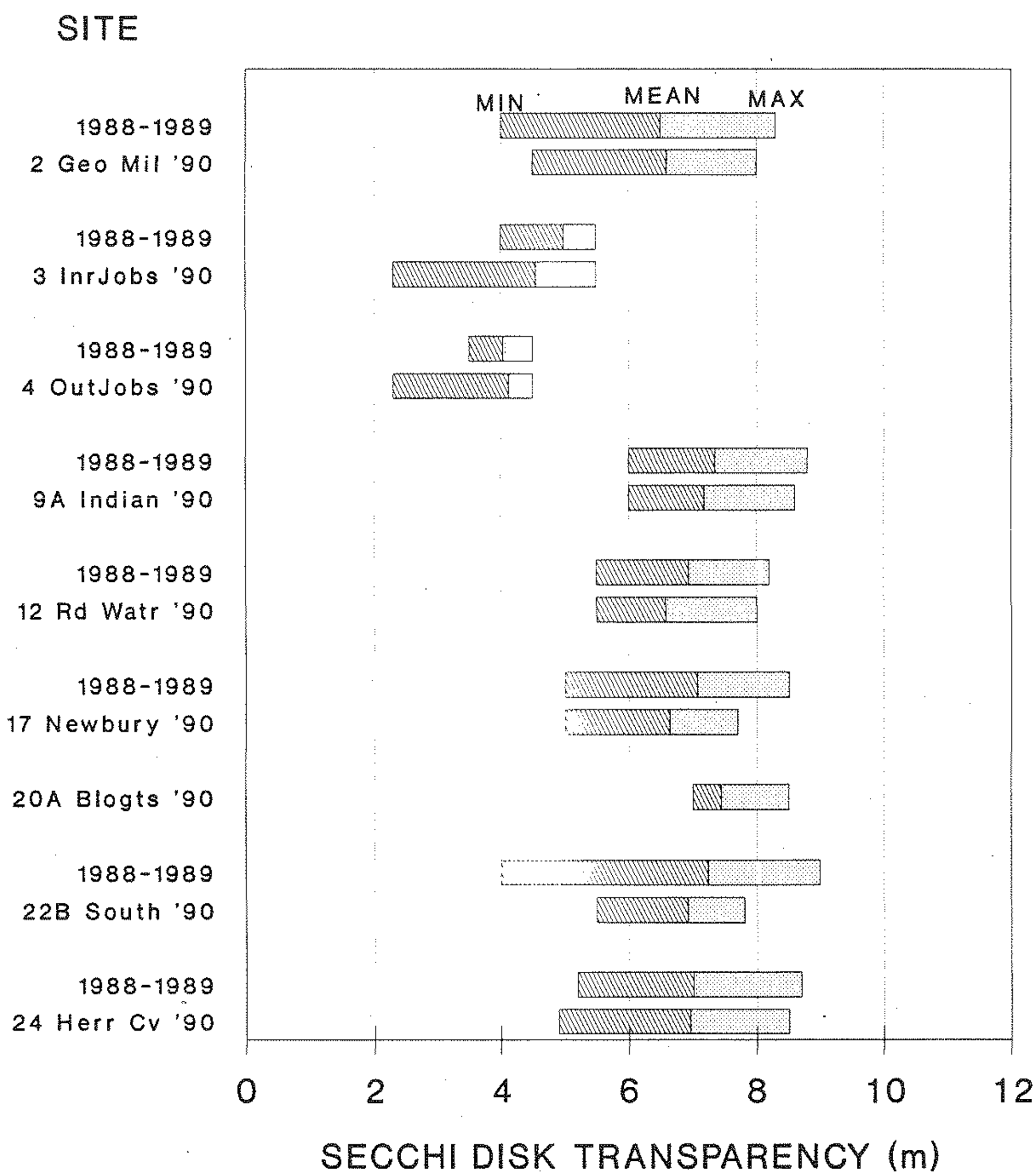


Figure 5 - Comparison of Lake Sunapee 1990 Lay Monitor Secchi Disk Transparency data with 1988-89 data. Minimum, Mean and Maximum values for each site are indicated as shown in the first bar. Secchi disk readings are taken to the nearest 0.1 meter.

COMPARISON: 1990 TO HISTORICAL DATA
LAKE SUNAPEE LAY MONITOR DATA
SECCHI DISK TRANSPARENCY



The higher number = clearer water

bays and coves (Herrick, Jobs and the southern end of the lake) take a longer time to clear after a storm event. This is important information indicating that these areas are more susceptible to pollutants such as nutrients and sediment from the lake watershed. Water clarity decreased as algae growth increased but the greatest decrease in clarity was generally due to inflows of dissolved organic matter (see color section below) or a combination of both phenomena.

Chlorophyll *a*

The chlorophyll *a* concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Summer chlorophyll *a* concentrations average above 7 mg m^{-3} (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels, and average summer chlorophyll *a* concentrations are generally less than 3 mg m^{-3}. **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll *a* generally between 3 mg m^{-3} and 7 mg m^{-3}. Lake Sunapee is generally considered to be oligotrophic in character, with some of the shallow embayments and coves approaching mesotrophic conditions on occasion.

Chlorophyll of the upper mixed water layer (epilimnion; see Figure 11 and Stratification section below) was sampled at selected sites on most dates (Figure 6A). Chlorophyll a concentrations for the surface waters of the deep sites were low and similar to levels measured last year. Chlorophyll levels indicate the extent of algae growth in the water. Concentrations in the mixed layer of water (the upper 8 to 10 meters) averaged 1.8 milligrams per cubic meter (mg m^{-3}, equivalent to 1.8 parts chlorophyll per billion parts water). Generally, concentrations below 3 mg m^{-3} are indicative of less productive, clear lakes.

Since 1987 testing has been done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentrations at mid-depths slightly increased throughout the summer indicating the stratification of some algae at the thermocline of the lake. Concentrations reached only as high as 3.6 mg m^{-3} at the southern deep site. This is lower than concentrations measured in any previous year. Samples collected at the lower depths again contained mostly small motile algal cells known to stratify below the mixed layer Chlorophyll concentrations of the integrated samples of the deep sites were always less than samples taken at the middle of the metalimnion (Fig. 6B). These results in conjunction with microscopic examination of the samples (see Phytoplankton section below) confirm the presence of small populations of stratifying algae. It should be noted that the many storm events during the summer could have flushed out these mid lake accumulations of algae. These populations will be monitored in the future as they may be an indication of increased nutrient loading into the lake.

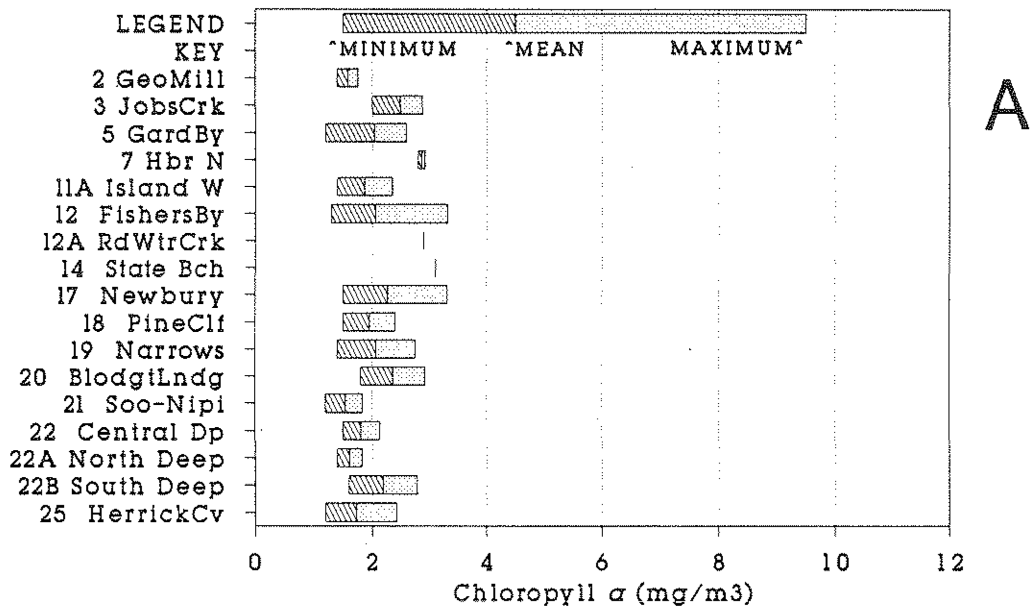
At the shore and bay sites chlorophyll levels averaged 2.2 mg m^{-3}. Highest concentrations (as high as 9.3 mg m^{-3}) occurred as short-term blooms in June and late summer following storm events at all sites except Job's Bay. Most shallow sites had occasions of higher than typical chlorophyll levels in 1990 with the exception of the Georges Mill, Redwater Creek, and Herrick Cove sites (Figure 7 for comparisons and Figures 8A and 9A for seasonal trends).

The Herrick Cove site was inundated with a slug of nuisance blue green algae when a new drainage impoundment created by the Interstate 93 expansion overflowed over 103-A during several occasions (due to heavy storms and the destruction of a beaver dam) causing temporary surface blooms in the waters in the area. The nuisance algae were in a thin surface layer thus total integrated chlorophyll samples at Herrick Cove did not reach levels as high as the Newbury shallows (site 17), Blodgetts Landing (20A) or Indian Cave

Figure 6 (A)- Lake Sunapee 1990. Concentration of chlorophyll a for selected lake sites. Minimum, maximum and average chlorophyll *a* concentrations in mg per m^3 of chlorophyll *a*.

(B)- Comparison of chlorophyll a concentrations in the epilimnion (upper lake; black bars) and metalimnion (mid-lake depths; hatched bars) of the deep water sites. Integrated sampling was done to measure the epilimnion and point sampling was done for the metalimnion. Chlorophyll *a* concentrations in mg per m^3 of chlorophyll *a*.

CHLOROPHYLL α CONCENTRATION
LAKE SUNAPEE 1990



FBG TEAM JUNE AND AUGUST SAMPLING DATES

CHLOROPHYLL AT DEPTH
LAKE SUNAPEE DEEP SITES 1990

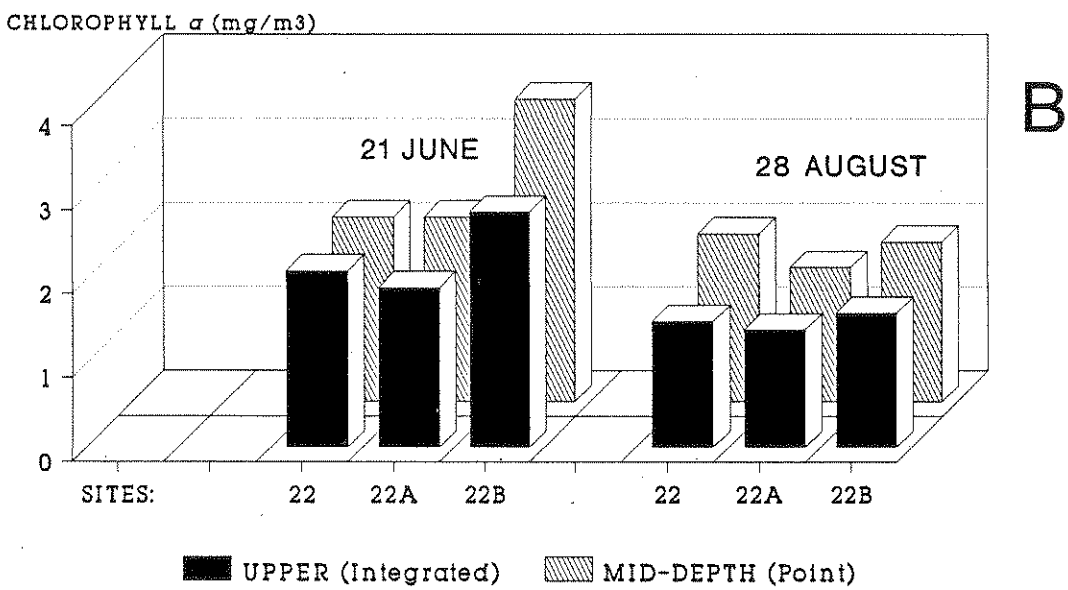
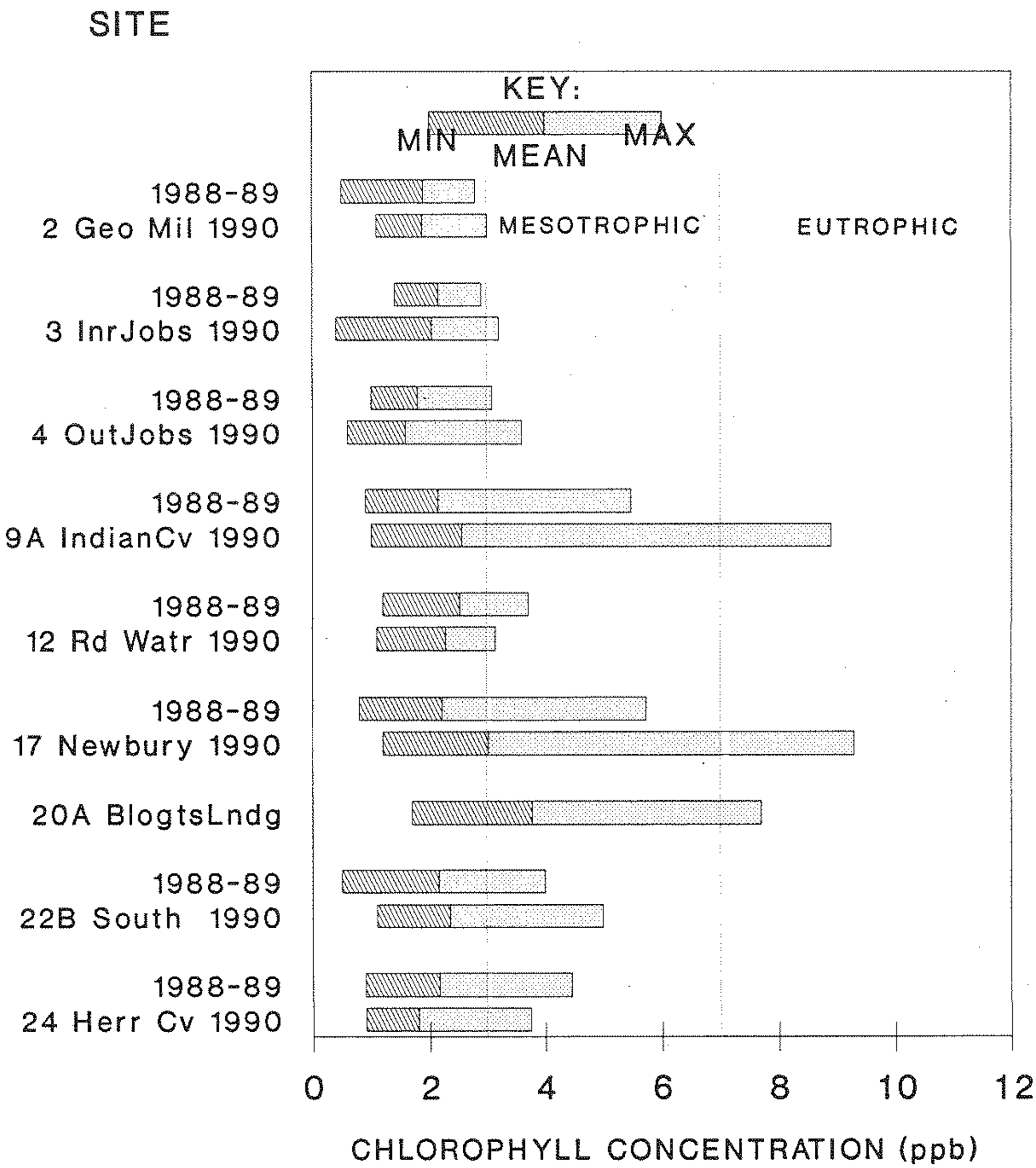


Figure 7 - Comparison of Lake Sunapee 1990 Lay Monitor Chlorophyll a data with 1988-89 data. Minimum, Mean and Maximum values for each site are indicated as shown in the first bar. Chlorophyll a concentration is measured in milligrams per cubic meter which is equivalent to parts per billion.

COMPARISON: 1990 TO HISTORICAL DATA
LAKE SUNAPEE CHLOROPHYLL
LAY MONITOR DATA



The higher number = more algae

(9A) (see Figures 8A and 9A). This is most likely a short-term disturbance but future FBG and volunteer monitoring will keep watch on this area for additional problems.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from humic substances, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters.

The average dissolved lake water color levels at Sunapee in July 1990 were low to moderate for New Hampshire lakes: 8 to 10 color units. This is comparable to 1989 values at most sites and about twice that of typical lake color levels from 1972 to present (5 ptu). Color did peak at many sites along with chlorophyll blooms and storm events. Newbury Inlet, Job's Bay and Herrick Cove displayed the greatest color levels (Figures 8B and 9B). Increases in dissolved color can be due to deforestation, erosion or other by-products of development within the watershed or increased run-off from wetlands areas. In the case of Herrick Cove the high color pulses were due to the drainage of the wetland area between the lake and the highway at times of heavy rains and when the beaver dam was broken. The Newbury and Jobs Creek Cove sites also experienced wetland drainage following storm events.

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human-related activity in a watershed. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton.

Total phosphorus levels were low throughout most of the lake sites (Figure 10A). With one major exception, all lake sites had average phosphorus concentrations below the 15 parts per billion (ppb) level commonly thought of as the boundary between less productive and more productive lakes. The exception is the Redwater Creek Inlet site with a 110 ppb reading in June (after a storm event) and a 37 ppb average. This site has had a history of high phosphorus levels after storm events due to new development. The data do not support the contention that the high levels are due to beaver activity upstream from the development as samples taken there (the tributary site 12) were lower throughout the summer.

The deep water sites displayed slightly elevated nutrient averages compared to all previous years. The Newbury deep site had a 15 ppb concentration in the bottom waters indicating an slight accumulation of nutrient from lake, watershed or sediment sources.

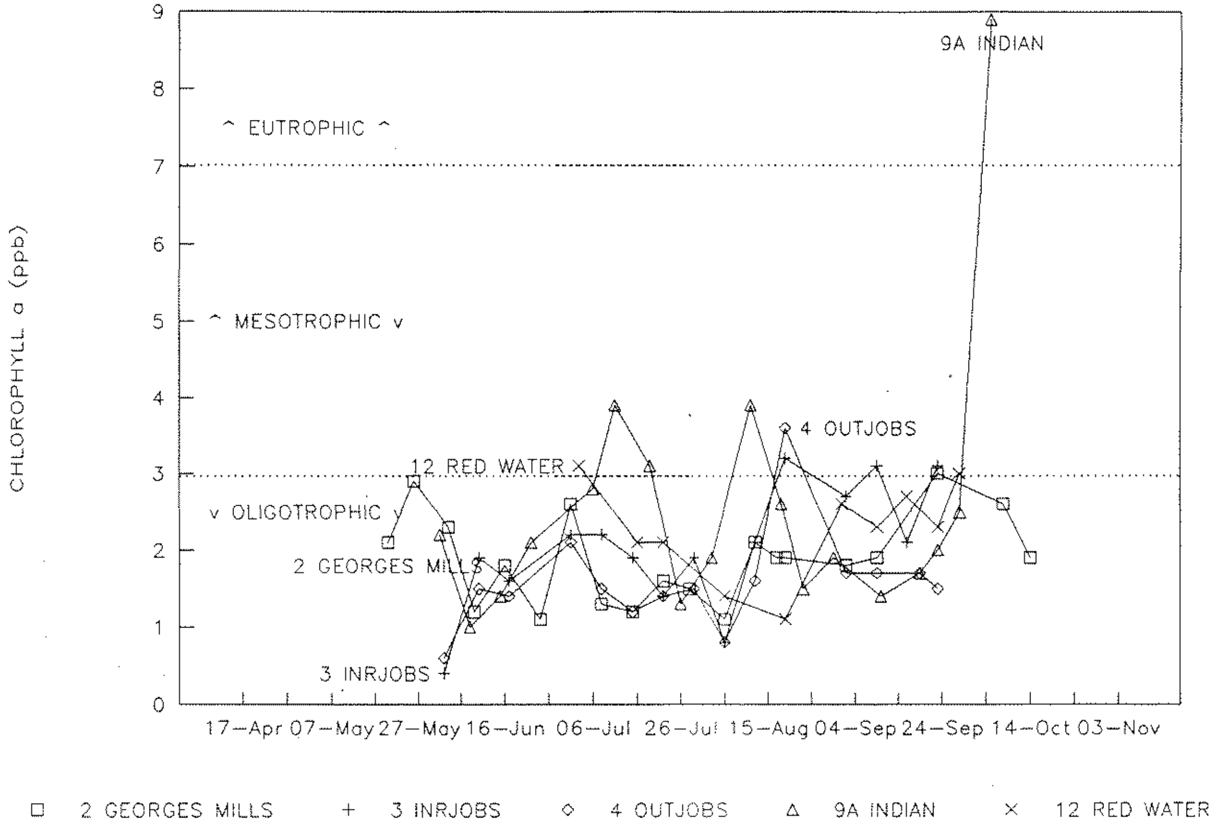
Most tributary sites had lower than usual summer phosphorus levels (Figure 10B), with the exception of Herrick Cove Brook, although an occasional high reading was recorded. The Ledge Pond Brook and Newbury tributaries also had higher summer averages compared to the other streams. Storm events combined with construction activities allowed for the chance to sample nutrient runoff at impacted areas. At Georges Mill, where sewer construction was ongoing in 1990, a small side stream that runs into the Otter Brook tributary was sampled on August 6, before and after it passed through a cleared and "scraped" area from the sewer construction. About 30 minutes after a heavy rain started to fall the reading before was 2 ppb while the concentration of the sediment laden effluent was 92 ppb. Bailing and sediment curtains were in place by the end of the month after this problem was reported.

Figure 8A - Lake Sunapee 1990. Seasonal trends for chlorophyll a concentration of lay monitor sites. Chlorophyll a concentrations in mg per m^3 of chlorophyll a. Dotted lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 8B - Lake Sunapee 1990. Seasonal trends for dissolved color concentration of lay monitor sites. Color expressed as platinum-cobalt units (ptu).

LAKE SUNAPEE

CHLOROPHYL CONCENTRATION 1990



LAKE SUNAPEE

DISSOLVED COLOR CONCENTRATION 1990

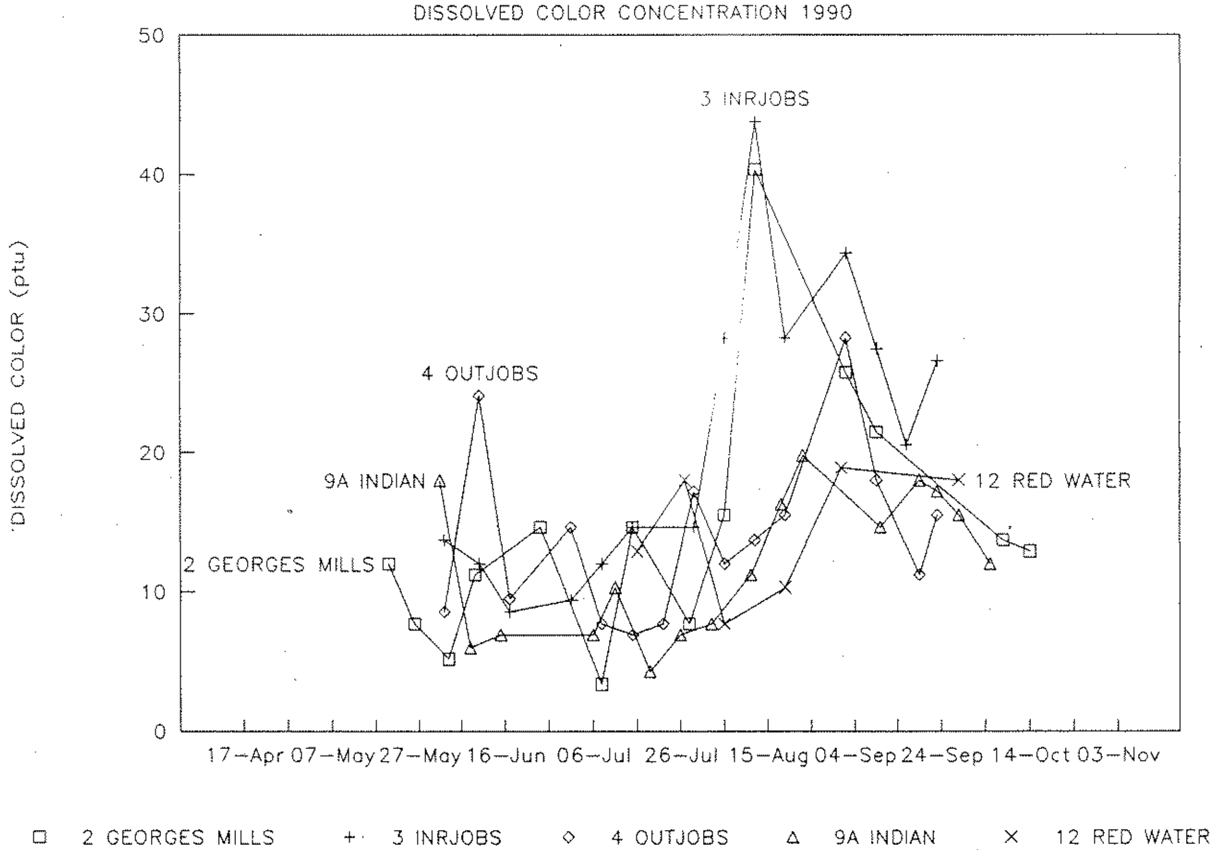
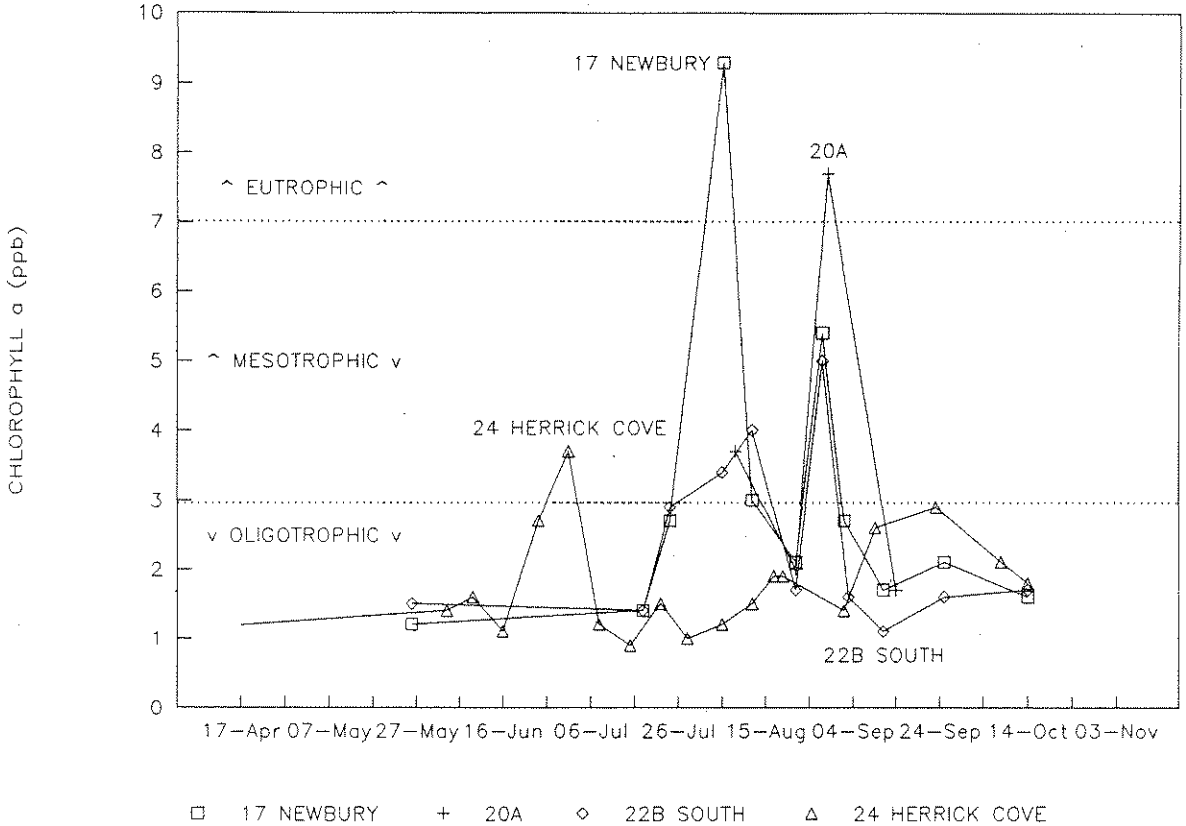


Figure 9A - Lake Sunapee 1990. Seasonal trends for chlorophyll a concentration of lay monitor sites. Chlorophyll a concentrations in mg per m^3 of chlorophyll a. Dotted lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 9B - Lake Sunapee 1990. Seasonal trends for dissolved color concentration of lay monitor sites. Color expressed as platinum-cobalt units (ptu).

LAKE SUNAPEE

CHLOROPHYL CONCENTRATION 1990



LAKE SUNAPEE

DISSOLVED COLOR CONCENTRATION 1990

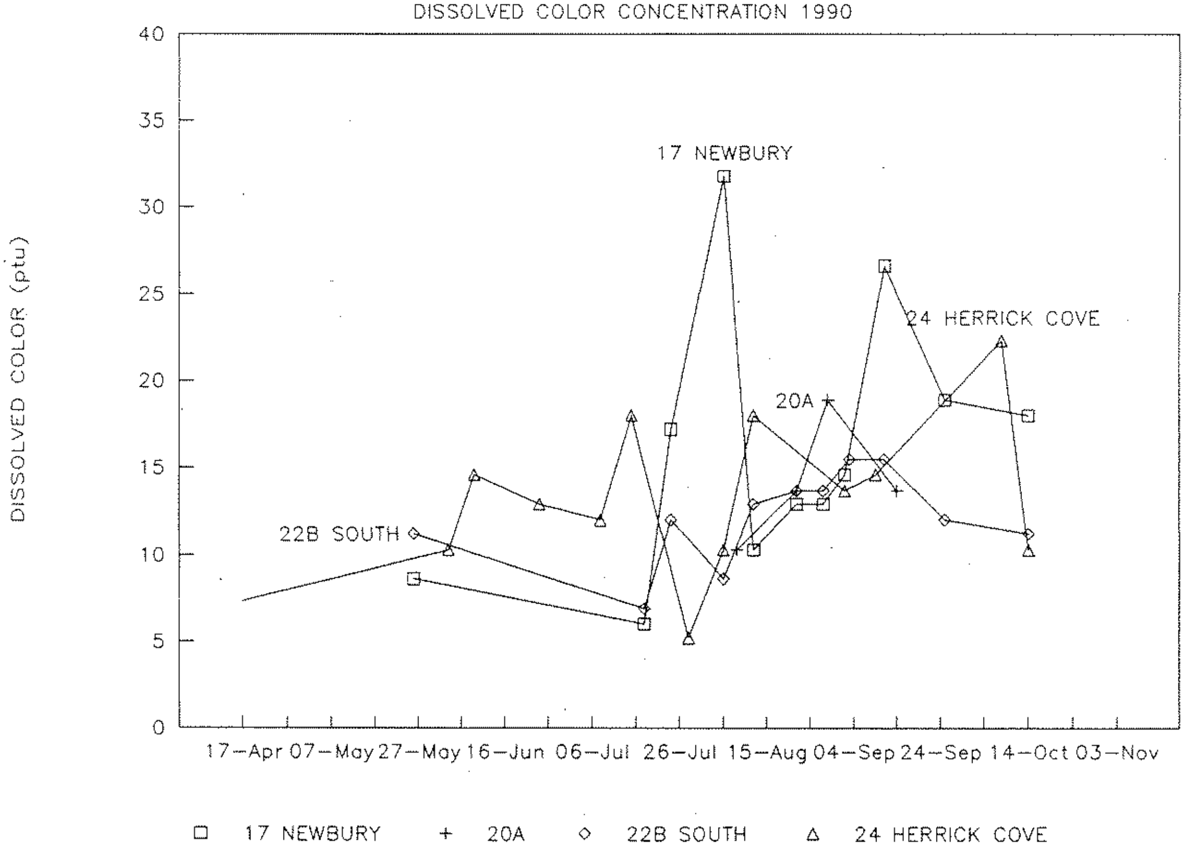
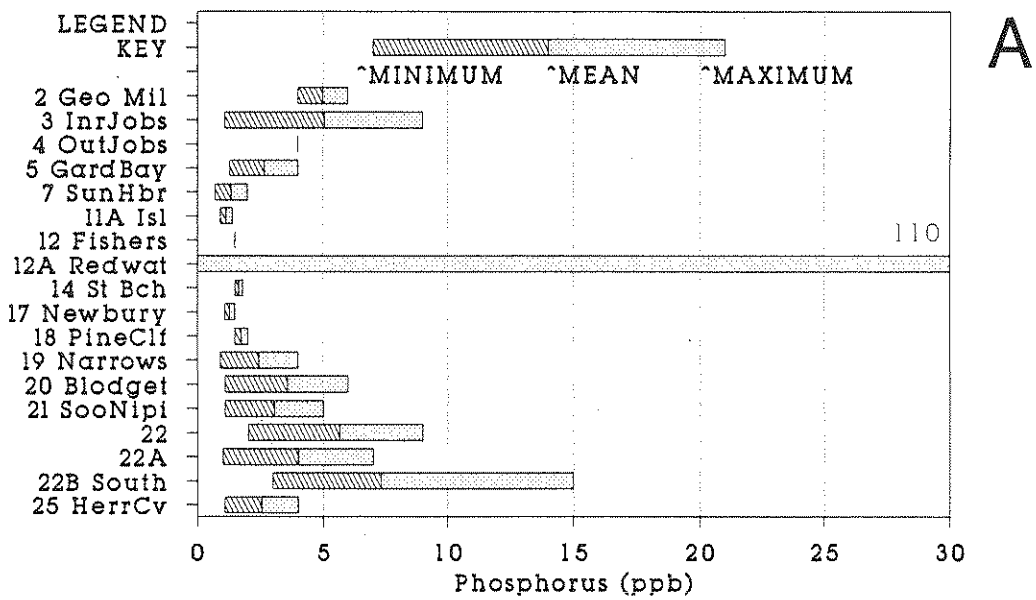


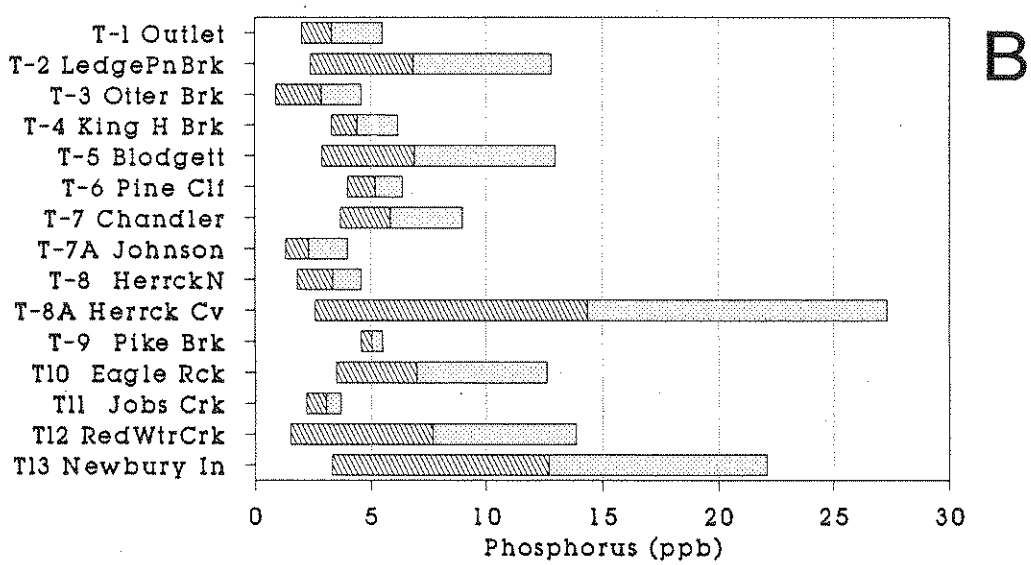
Figure 10A. Lake Sunapee 1990. Concentration of Total Phosphorus at lake sites. Minimum, Mean and Maximum values are shown by bar pattern as indicated. Concentrations are in parts per billion which is equivalent to micrograms per liter.

10B. Lake Sunapee 1990. Concentration of Total Phosphorus at tributary sites. Bar pattern as described for Figure 8A above. Concentrations are in parts per billion which is equivalent to micrograms per liter. Note that scale is higher than Figure 8A.

TOTAL PHOSPHORUS
SUNAPEE: LAKE SITES 1990 (JUNE-SEPT)



TOTAL PHOSPHORUS
LAKE SUNAPEE: TRIBUTARY SITES 1990
(March-October)



pH

The pH is a way of expressing the acidic level of lake water, and is measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (ie: a change in 1 pH unit reflects a ten-fold difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

The pH levels of Lake Sunapee surface water were in the range 6.5 to 7.2 units with the majority of values above 6.8. Slightly lower pH values occurred at the tributaries; The summer pH levels were well within the optimum range for most aquatic organisms.

Survey of the historical data indicates that the pH of Lake Sunapee has consistently been measured as around 6.5 units since 1939. Although not monitored often in the past, it would be safe to say that the pH has attained optimum levels throughout times of monitoring. The early spring data for 1989 measured in May suggests the lake has a slight pH depression when the lake receives the brunt of acidic input. Such a depression could adversely affect the developing phases of many aquatic organisms.

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically, lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock of lake watersheds. Earlier FBG and DES measurements indicated that a drop in alkalinity has taken place at Lake Sunapee (Figure 11) which implies a moderate vulnerability to acid rain.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada (Schindler et al 1985), gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

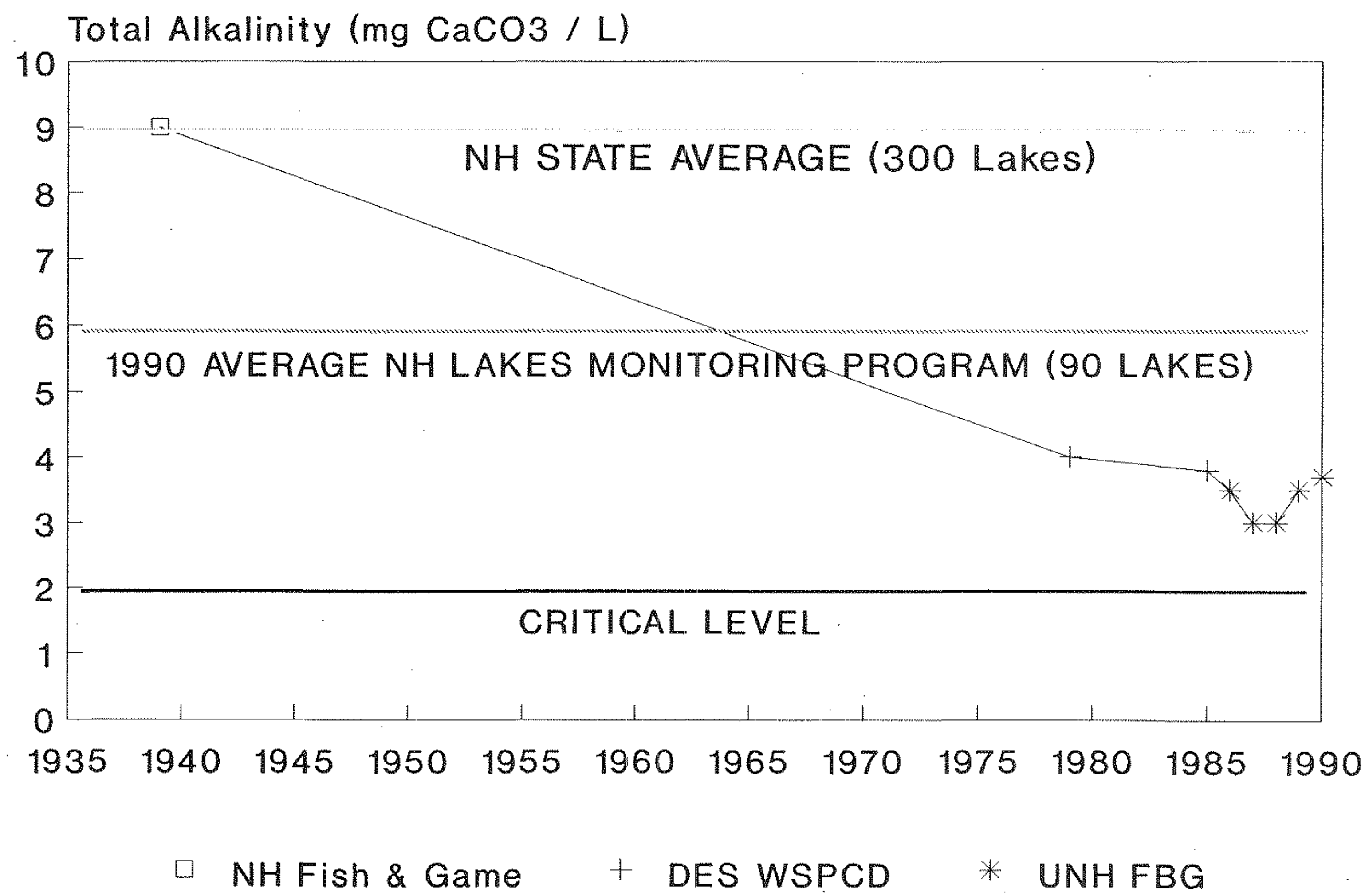
The analysis of alkalinity employed by the **Freshwater Biology Group** includes use of a dilute titrant allowing an order of magnitude (ten-fold) greater sensitivity and precision than the standard method (APHA 1987). Two endpoints are recorded during each analysis. The first endpoint (grey color of dye; pH endpoint of 5.1) approximates low level alkalinity values (Wetzel and Likens 1979, Godfrey 1988) while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically with the methyl-orange endpoint method.

Low level alkalinity readings at all deep and lake shore sites were low, with a range of 2.2 to 4.2 mg per liter with a deep site average of 3.7 units and a whole lake average of 3.9 mg per liter. A depression in alkalinity was measured in the surface of the lake during a major rain event in early August. Alkalinity levels at the tributary sites were low to moderate with high alkalinity occurring at the Herrick Cove tributaries. The average alkalinity of lakes throughout New Hampshire is approximately 9 mg per liter (Baker, unpublished) while the average alkalinity of the lakes studied by the **Freshwater Biology Group** in 1990 was 6.0 mg per liter with a range of 1.2 to 32 mg per liter.

The earliest known alkalinity measurements of standard methods (an 1898 Soo-Nipi Lodge brochure lists an albumen alkalinity measurement from a New York lab) are those from the N.H. Fish and Game (Warfel 1939, Newell 1977). Methyl-Orange alkalinity ranged from 7.5 to 15 mg per liter from May through August in 1939. Forty years later the state Water Supply and Pollution Control Commission reported a value of 4 mg per liter (fixed-endpoint). Current low level values described above fluctuate above and below

Figure 11. Lake Sunapee 1990 Low level alkalinity readings 1939 to the present. Total alkalinity is reported as milligrams per liter (parts per million) calcium carbonate alkalinity. NH average computed from data 1979 through present. NH lakes program data is more comparative to Lake Sunapee as program lakes tend to be those clear clean lake in New Hampshire that are at similar levels of use and development. Source of data is indicated by symbol type.

LAKE SUNAPEE LOW LEVEL ALKALINITY



Data: NH FISH & GAME, WSPCD, UNH FBG

this value. However, for best comparisons to the early testing the pink endpoint data should be used. These values for the past four years are on the average of 5 mg per liter. Thus, while Lake Sunapee alkalinity has dropped significantly, the current trend is not as clear since the techniques of low level alkalinity monitoring are relatively new and there are not enough data collected. In any case, the lake alkalinity is low and approaching a critical level, which seems to affect pH stability, particularly in the early spring.

Specific Conductivity

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Deep lake site surface conductivity values had a range of 70 to 79 *u*S (conductivity is reported as a micro-Sieman which is equivalent to a micro-mho per centimeter squared) and shallow site conductivities were in the range of 70 to 81 *u*S (see Appendix B). The 1990 results are comparable to previous year's values. The average conductivity of all lakes studied by the **FBG** in 1990 was 86 *u*S with a range of 25 to 370 *u*S.

Historically, sites at George's Mill and Herrick Cove have had high conductivities attributed to run-off from deicing salts. Because salt water tends to sink, conductivity profiles of these two sites, along with the Newbury basin and the three deep water sites for comparison, were again obtained. All sites had less than a 5 *u*S difference between the upper and lower water. Profiles should be continued in the future since there can be vast differences in the amount of deicing salts used depending upon winter weather and there is now a significant highway drainage change at Herrick Cove.

Stratification in the Deep Water Sites

A profile of temperature for a typical New Hampshire Lake (Figure 12) shows a distinct pattern of temperature stratification developing, as the months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water

(hypolimnion). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the **thermocline** or **metalimnion**. Temperature profiles of Lake Sunapee are typical of deep water, clear lakes (Figures 13 through 16).

Dissolved oxygen profiles (Figure 13 through 16) indicate the extent of declining oxygen concentrations in the lower waters. All three deep sites displayed the typical pattern of clear lakes, a slight to moderate decline in hypolimnetic oxygen as the summer progressed. Concentrations of oxygen at all sites were indicative of a healthy lake. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter in the cool deep waters. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter.

The oxygen peaks occurring at mid-lake depths in August at all three deep sites support the findings of metalimnetic algal populations (discussed above) occurring at all sites. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of **photosynthesis**, collecting in regions of high algal concentrations.

.Underwater Light

Underwater light available to photosynthetic organisms penetrates to deep depths in Lake Sunapee. The photic zone of a lake is the volume of water capable of supporting photosynthesis. It is generally considered to be delineated by the water's surface and the level where light is reduced, by the absorption and scattering properties of the lake water, to one percent of the surface intensity. The one percent depth is sometimes termed the **compensation depth**. Knowledge of light penetration is important when considering lake productivity and in studies of submerged vegetation.

Figure 12. Typical temperature conditions of a New Hampshire lake in summer. Illustration shows the temperature stratification that occurs on deep lakes such as Lake Sunapee. Temperature data is plotted and the three water layers are delineated.

TYPICAL TEMPERATURE CONDITIONS : SUMMER
NEW HAMPSHIRE - DEEP LAKE

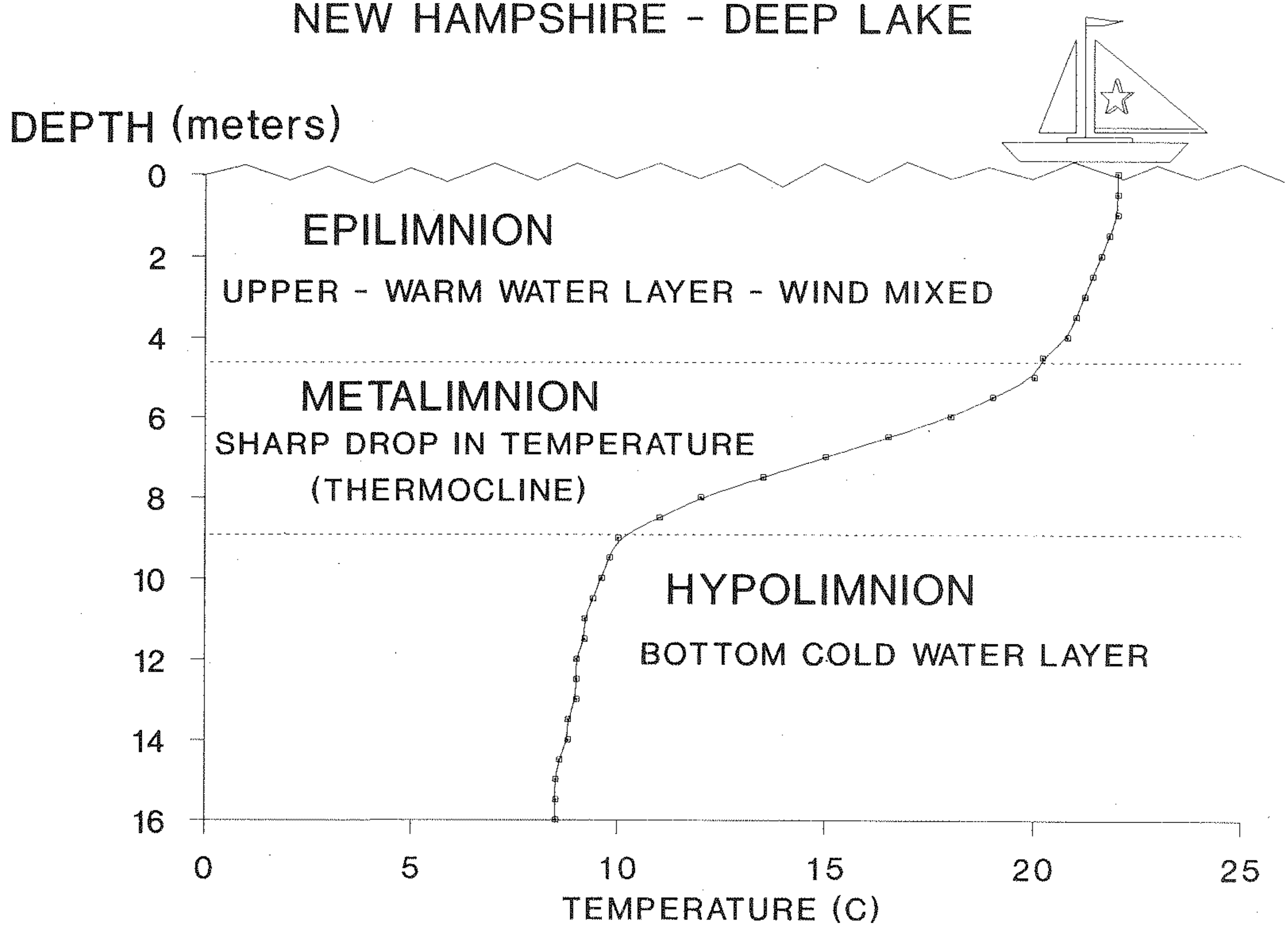
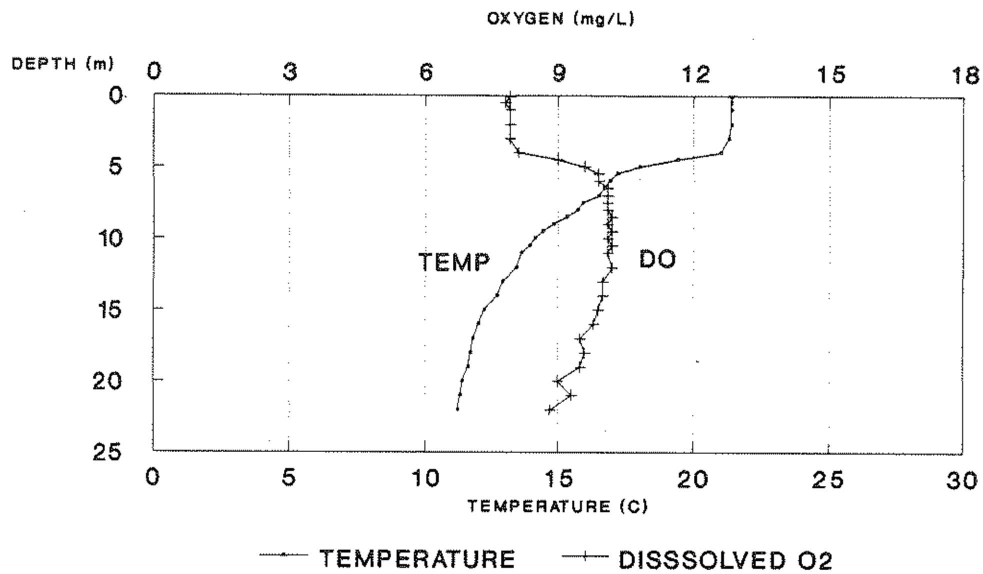


Figure 13. Lake Sunapee 1990. Profiles of temperature in degrees Centigrade (horizontal axis; solid line) and dissolved oxygen in milligrams per liter (horizontal axis; dotted line) versus depth in meters (vertical axis with the lake surface at the top of the graph) for lake deep site 22 Central on 21 July (top) and 28 August (bottom).

TEMPERATURE - OXYGEN PROFILE
SUNAPEE LAKE SITE 22
JULY 21, 1990



TEMPERATURE - OXYGEN PROFILE
SUNAPEE SITE 22
AUGUST 28, 1990

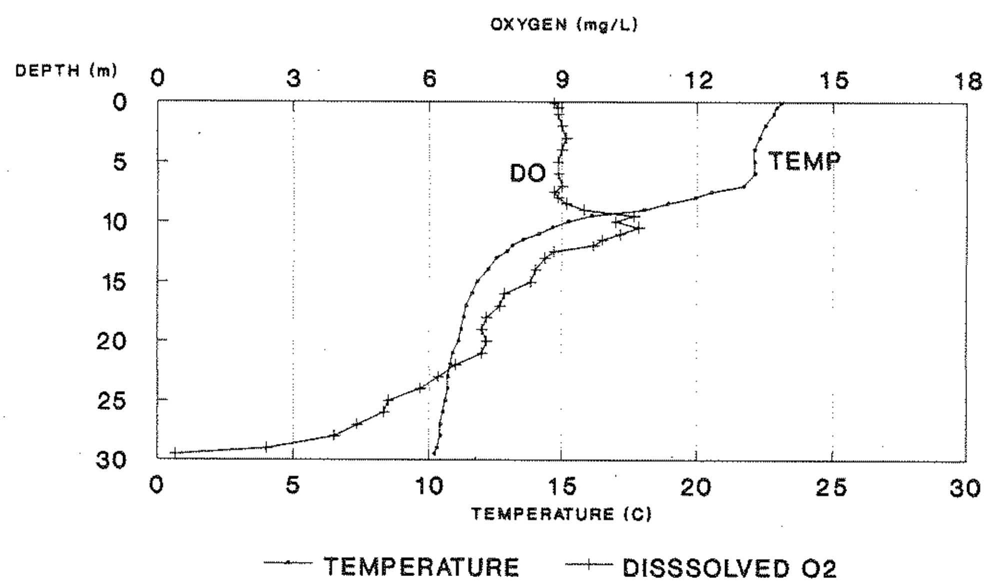
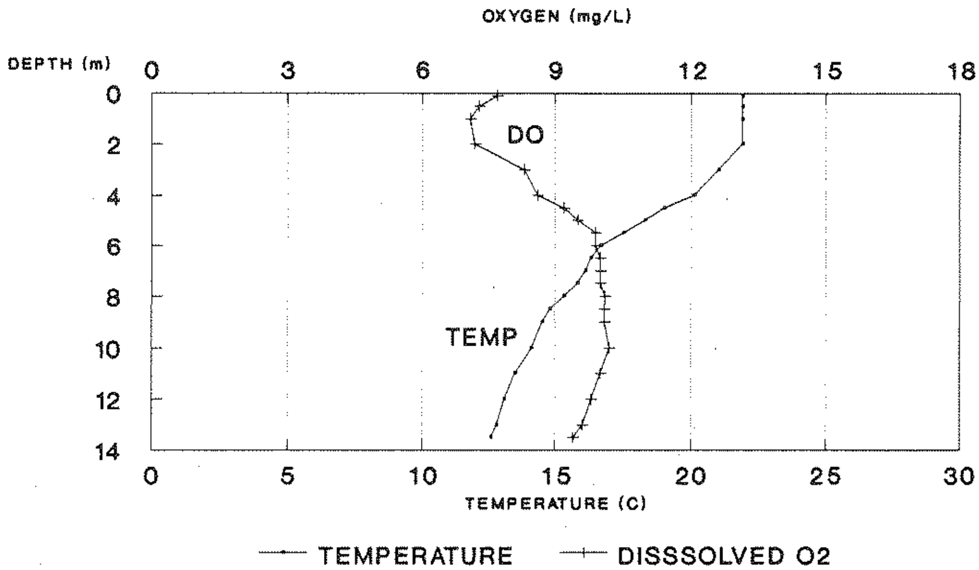


Figure 14. Lake Sunapee 1990. Profiles of temperature in degrees Centigrade (horizontal axis; solid line) and dissolved oxygen in milligrams per liter (horizontal axis; dotted line) versus depth in meters (vertical axis with the lake surface at the top of the graph) for lake deep site 22A North on 21 July (top) and 28 August (bottom).

TEMPERATURE - OXYGEN PROFILE
SUNAPEE LAKE SITE 22A
JULY 21, 1990



TEMPERATURE - OXYGEN PROFILE
SUNAPEE SITE 22A
AUGUST 28, 1990

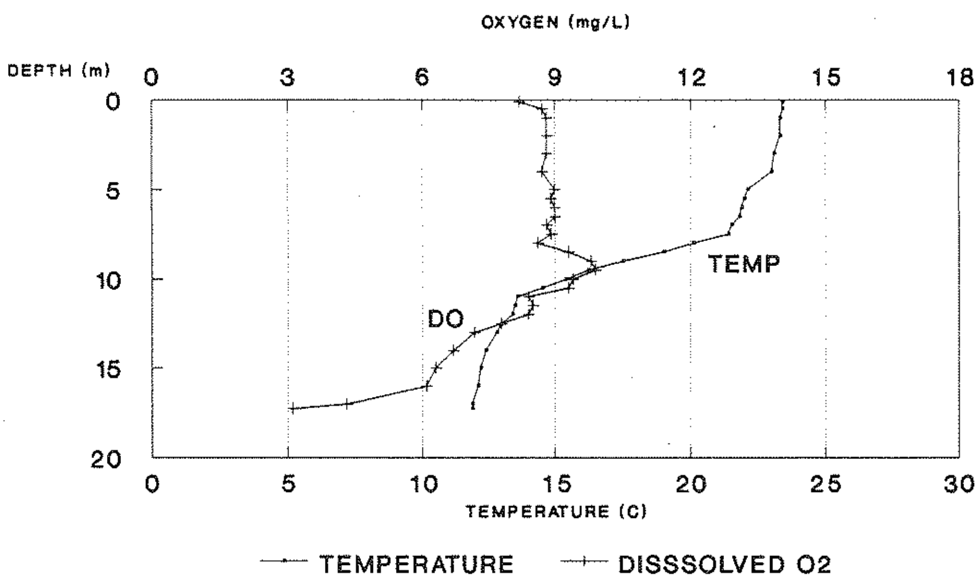
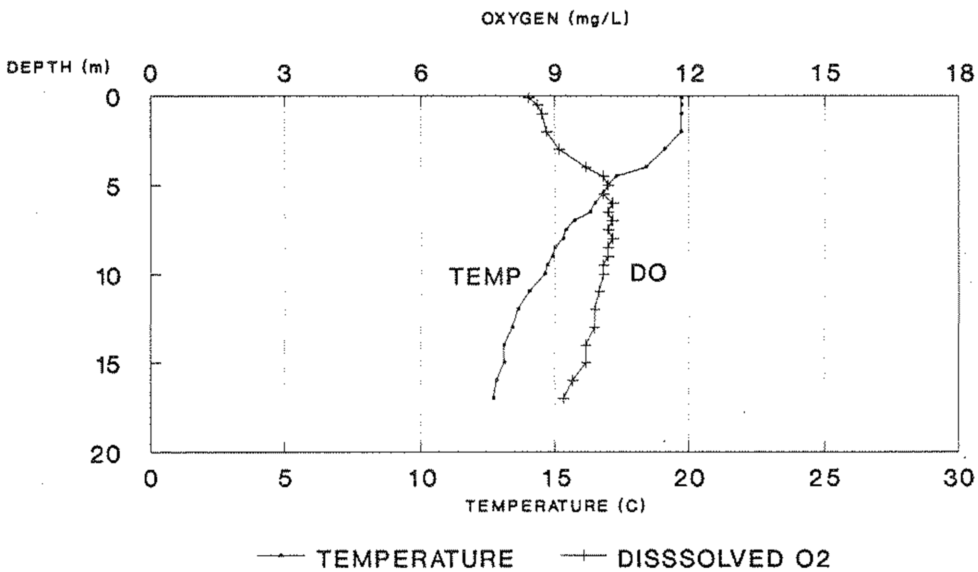


Figure 15. Lake Sunapee 1990. Profiles of temperature in degrees Centigrade (horizontal axis; solid line) and dissolved oxygen in milligrams per liter (horizontal axis; dotted line) versus depth in meters (vertical axis with the lake surface at the top of the graph) for lake deep site 22B South on 21 July (top) and 28 August (bottom).

TEMPERATURE - OXYGEN PROFILE
SUNAPEE LAKE SITE 22B SOUTH
JULY 21, 1990



TEMPERATURE - OXYGEN PROFILE
SUNAPEE SITE 22B
AUGUST 28, 1990

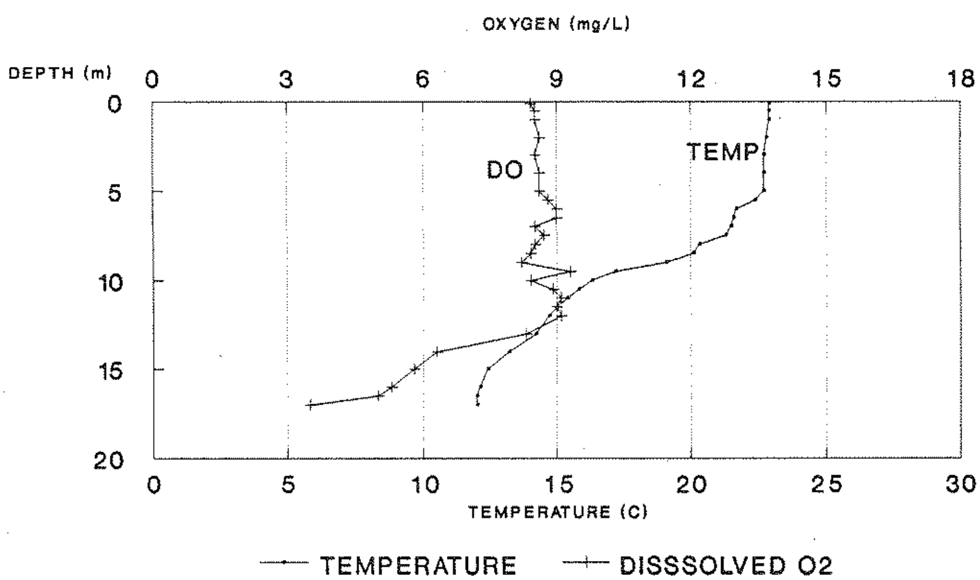
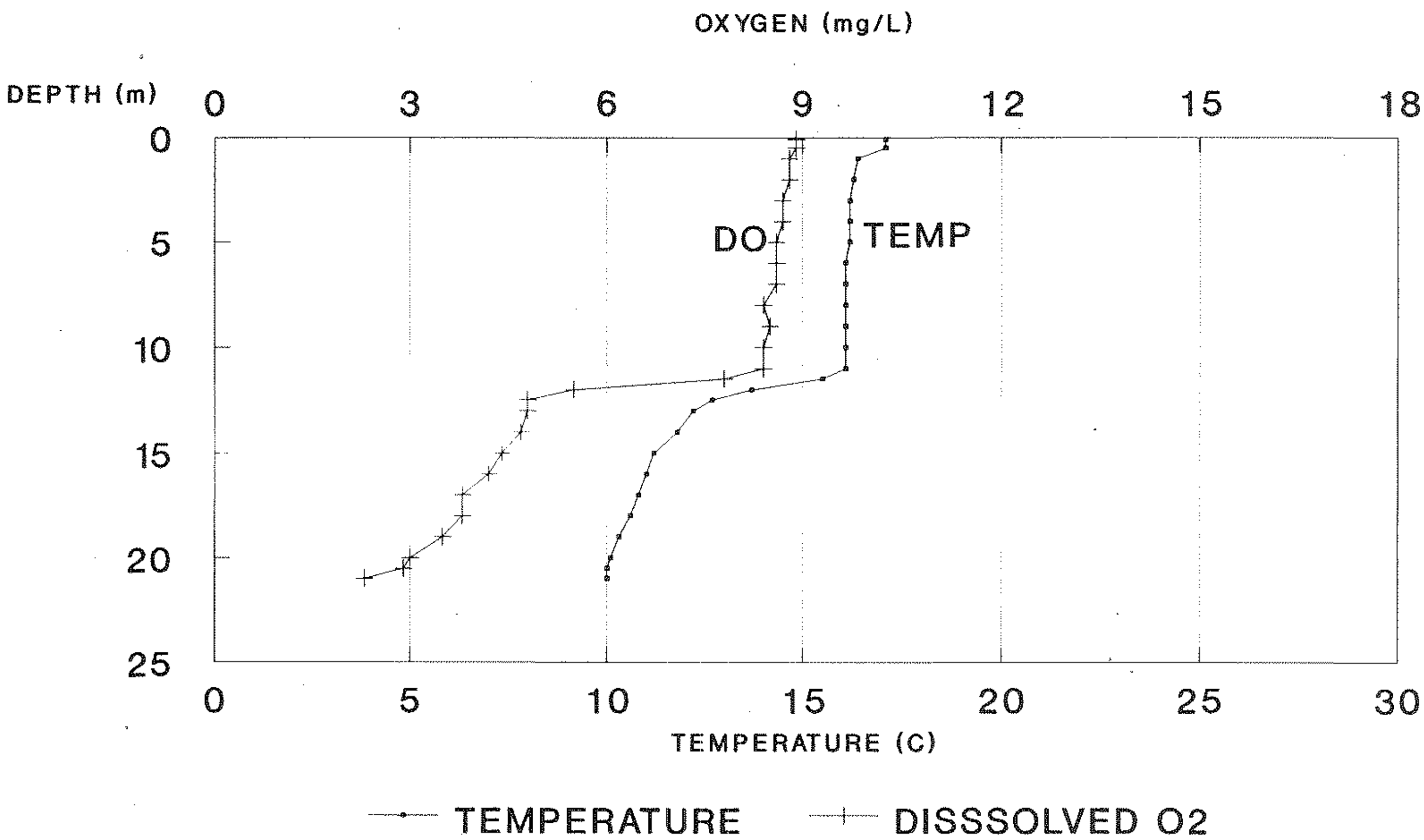


Figure 16. Lake Sunapee 1990. Profiles of temperature in degrees Centigrade (horizontal axis; solid line) and dissolved oxygen in milligrams per liter (horizontal axis; dotted line) versus depth in meters (vertical axis with the lake surface at the top of the graph) for lake deep site 22 Central on 10 October.

TEMPERATURE - OXYGEN PROFILE
SUNAPEE SITE 22
OCTOBER 10, 1990



The compensation depths for the central site (22) ranged from 12 to 14 meters. The northern site (22A) one percent light depth ranged from 11 to 15 meters. The southernbasin (22B) had a range from 12.5 to 14 meters. All sites had maximum light penetration during the July sampling date. From 1986 through 1989, the deepest compensation depths measured were about 15 meters, 19 meters and 19 meters respectively for the northern central and southern sites. 1990 values were lower than typical. This is the second year in which underwater light penetration had a slight decline.

Indicator Bacteria

Coliform bacteria in water indicate the possibility of fecal contamination. Although they are usually considered harmless to humans, they are much easier to test for than harmful pathogenic enteric bacteria (**Salmonella**, **Shigella** etc.) and viruses that may be present in fecal material. **Total coliform** includes all coliform bacteria which arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **fecal streptococcus** (sometimes referred to as **enterococcus**) has also been monitored in the past at Lake Sunapee. The ratio of fecal coliform to fecal strep may be useful in suggesting the animal source of a fresh contamination. Desirable levels for a Class A water body is less than 50 total coliform organisms per 100 milliliters.

Microbiological testing was undertaken at selected sites on 28 August. Fecal coliform bacteria were present at nine of the 20 lake sites tested with high concentrations occurring at Job's Creek Cove, Blodgetts Landing and the Harbor Outlet (Table 2). Of the tributaries, Chandler Brook had highly elevated levels (greater than 500 organisms per 100 milliliters). Total Coliform counts were even more numerous throughout the lake. The August sampling was done during a period of heavy rains. Sampling of the lake collected by volunteers also showed elevated levels through Labor Day. As Total Coliform counts can increase greatly due to the runoff of naturally occurring bacteria in the soils, the lake

TABLE 2 Total and Fecal Coliform Bacteria Densities

Lake Sunapee 28 August and 27 September 1990. Reported as numbers per 100 ml.

SITE	Total Coliform 8/28	Total Coliform 9/27	Fecal Coliform 8/28	Fecal Coliform 9/27
2	58	2	<1	<1
3	TNTC	5	75	<1
4	TNTC	<1	1	--
5	230	1	2	<1
5 Bot	484	3	1	<1
7	<1	<1	5	<1
9A	TNTC	<1	<1	<1
10	<1	--	<1	--
11	34	--	2	--
11A	<1	--	<1	--
12	<1	--	<1	--
14	15	<1	6	<1
17	4	4	2	<1
18	<1	--	<1	--
19	<1	--	<1	--
20	TNTC	<1	99	<1
21	TNTC	3	<1	<1
22	<1	--	<1	--
22A	<1	--	<1	--
22B	<1	--	<1	--
24	<1	--	<1	--
25	<1	--	<1	--
Tributaries and Outlet (T1):				
T1	TNTC	8	79	<2
T2	TNTC	460	22	4
T3	--	12	--	<2
T4	TNTC	1304	50	48
T5	TNTC	1032	73	36
T6	TNTC	756	25	4
T7	TNTC	TNTC	500	14
T7A	TNTC	1432	28	48
T8A	TNTC	TNTC	5	34
T9	TNTC	241	32	2
T10	TNTC	420	8	4
T11	TNTC	TNTC	<1	6
T12	TNTC	TNTC	110	--
T13	TNTC	TNTC	37	22

TNTC = Too Numerous to Count   <1 = Less than one "hotspots" were tested again on 27 September after a dry period. By the second testing all lake sites had no detectable levels of fecal coliforms and low to no total coliforms present. Tributary levels also decreased to lower but still greater than typical levels.

Phytoplankton

The planktonic community includes microbial organisms that represent diverse life forms, including photosynthetic as well as non-photosynthetic types, and including bacteria, algae, crustaceans and insect larvae. The zooplankton are considered below in a separate section.

Phytoplankton were collected on two dates in 1990 (21 June and 28 August) for three deep sites in Lake Sunapee (22, 22A and 22B) and on 28 August at Herrick Cove following the reported "bloom". Because planktonic algae or "phytoplankton" tend to undergo rapid seasonal cycles on a time scale of days and weeks, the levels of populations found should be considered to be most representative of the two collection dates and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

The composition and concentration of phytoplankton in Lake Sunapee was generally typical of open-water plankton in relatively clear and unproductive lake water. In Lake Sunapee, as well as the majority of New Hampshire lakes, a common seasonal cycle of phytoplankton succession occurs (Figures 17 through 19) with Bacillariophyceae or "diatoms" tending to be most abundant in April-June and October-November in past years, in the surface or epilimnion. During June, the Chrysophyceae, the class of "golden" or "golden-brown" algae dominated at the north and central deep sites (22 and 22A) while green algae (Chlorophyceae) dominated at the southern site. Blue-green bacteria (Cyanophyceae) were the dominants in August at the Northern and Southern deep sites while golden algae remained dominant at the central site.

The algae in the integrated lake samples of the northern and central sites were diverse and generally indicative of a pristine system. Algae at the metalimnion were less diverse and some nuisance types were found at the southern and northern sites. The southern deep site metalimnetic sample from June was dominated by the green desmid Closterium to a very high degree. This species is generally more common in more boggy or highly vegetated systems.

The Herrick Cove tributary sample mostly contained the blue green algae Merismopedia and Euglena. The former is a common nuisance species during blooms and the latter is common in ponds with accumulations of organic matter. The drainage/beaver pond formed in the wetland between the cove and Interstate 89 which is the major source of the tributary had a similar composition of algae.

Zooplankton

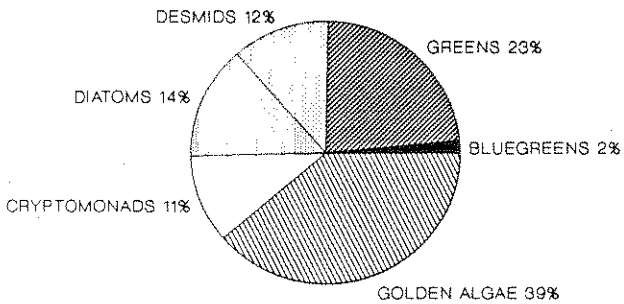
There are three groups of zooplankton that are generally dominant in lakes: the **protozoa, rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints made it necessary to sample only the larger zooplankton (macrozooplankton; larger than 80 microns; 1 million microns make up a meter). Thus, zooplankton analysis was restricted only to the larger crustaceans. Crustacean zooplankton are very sensitive to pollutants and are commonly used to indicate the presence of toxic substances in water. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods**.

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species may control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake.

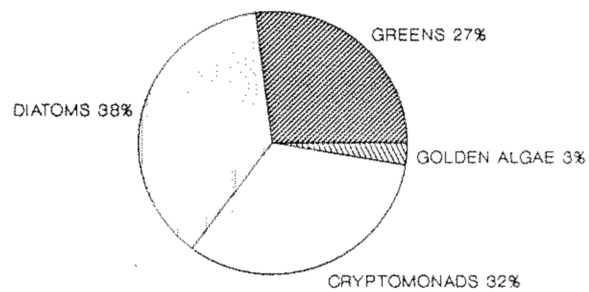
Figure 17. Lake Sunapee 1990. Relative percent by algal group (pie diagrams) for various dates for deep site 22 Central. Dates and depth sampled are indicated above the pie diagrams. For a discussion of the various algal groups see text.

LAKE SUNAPEE

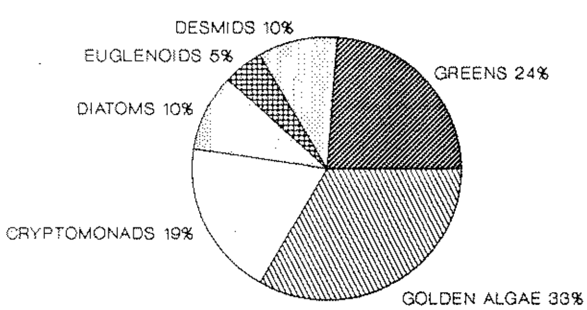
SITE 22
21 JUN 90 0-4.0m



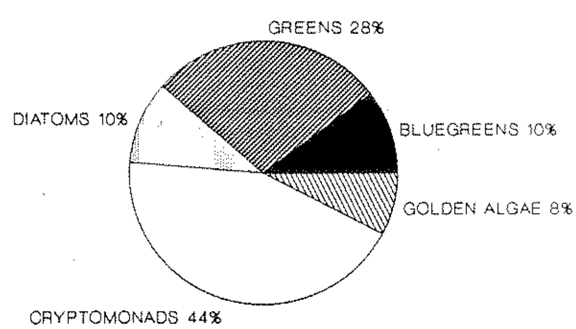
SITE 22
21 JUN 90 8.5m



SITE 22
28 AUG 90 0-7.0m



SITE 22
28 AUG 90 9.5m

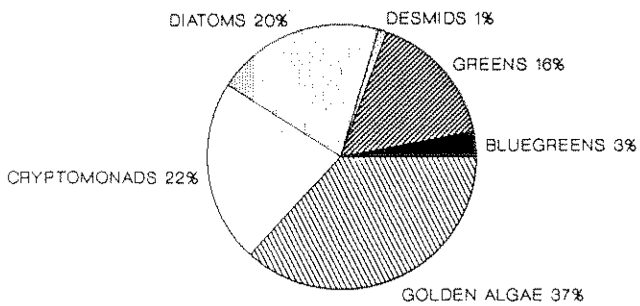


PHYTOPLANKTON ABUNDANCE % BY ALGAL GROUP

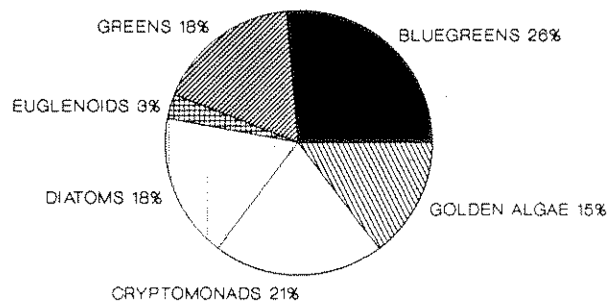
Figure 18. Lake Sunapee 1990. Relative percent by algal group (pie diagrams) for various dates for deep site 22A North. Dates and depth sampled are indicated above the pie diagrams. For a discussion of the various algal groups see text.

LAKE SUNAPEE

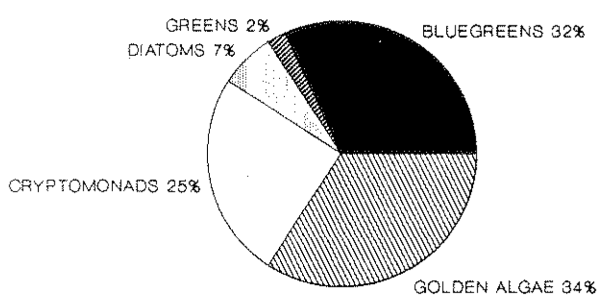
SITE 22A
21 JUN 90 0-4.0m



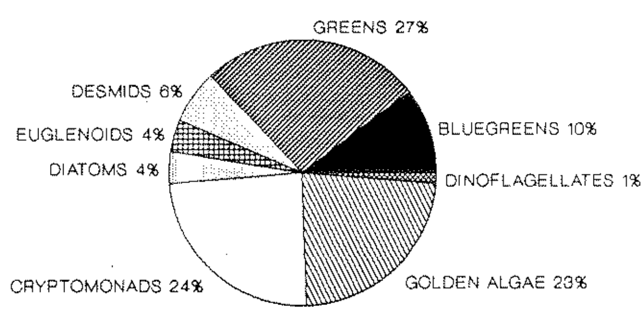
SITE 22A
21 JUN 90 8.0m



SITE 22A
28 AUG 90 0-7.5m



SITE 22A
28 AUG 90 9.5m

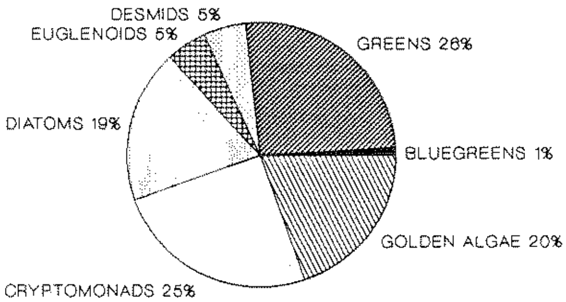


PHYTOPLANKTON ABUNDANCE % BY ALGAL GROUP

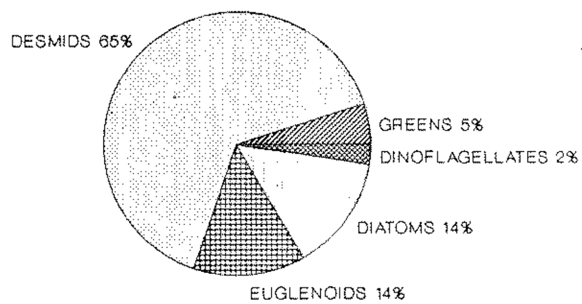
Figure 19. Lake Sunapee 1990. Relative percent by algal group (pie diagrams) for various dates for deep site 22B South. Dates and depth sampled are indicated above the pie diagrams. For a discussion of the various algal groups see text.

LAKE SUNAPEE

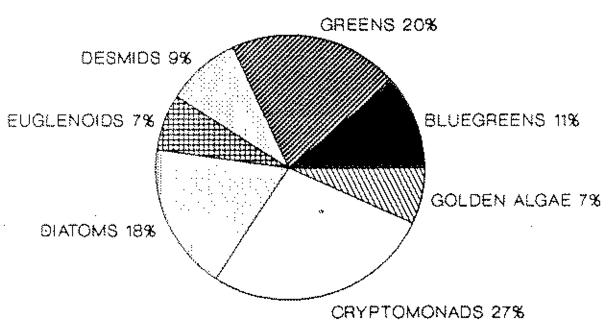
SITE 22B SOUTH
21 JUN 90 0-4.0m



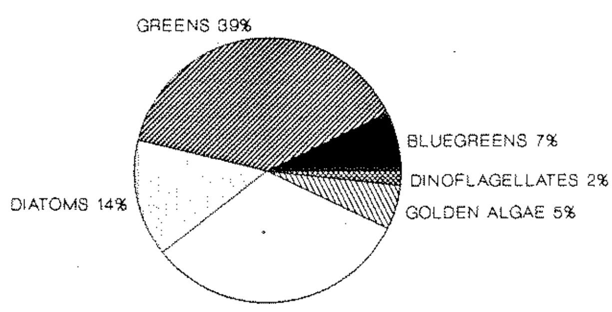
SITE 22B SOUTH
21 JUN 90 8.0m



SITE 22B SOUTH
28 AUG 90 0-6.0m



SITE 22B SOUTH
28 AUG 80 9.5m

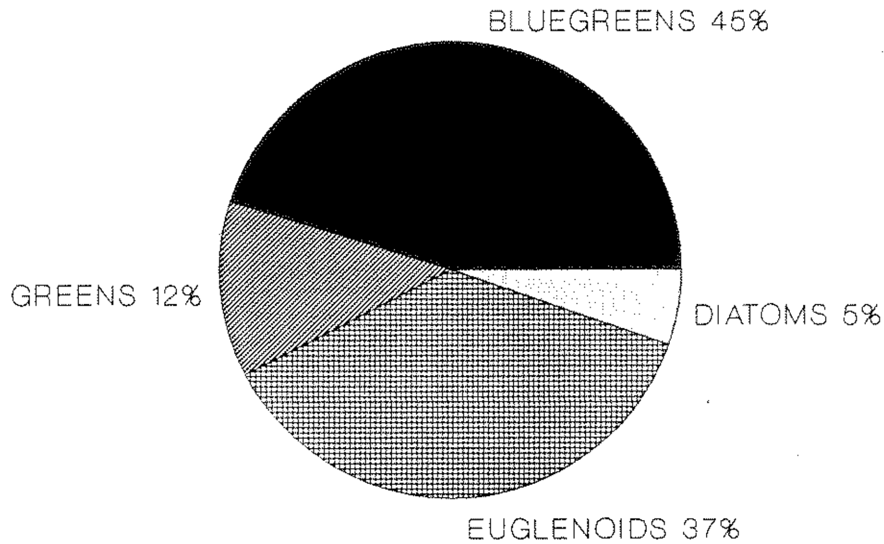


PHYTOPLANKTON ABUNDANCE % BY ALGAL GROUP

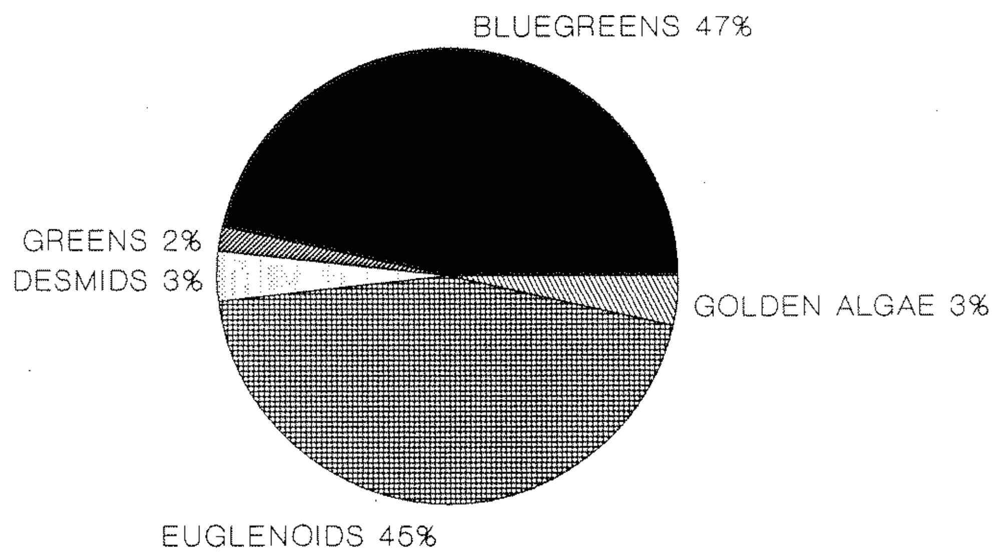
Figure 20. Lake Sunapee 1990. Relative percent by algal group (pie diagrams) for the Herrick Cove Tributary. For a discussion of the various algal groups see text.

LAKE SUNAPEE

SITE T-8
28 AUG 90 1.0m
HERRICK COVE INLET

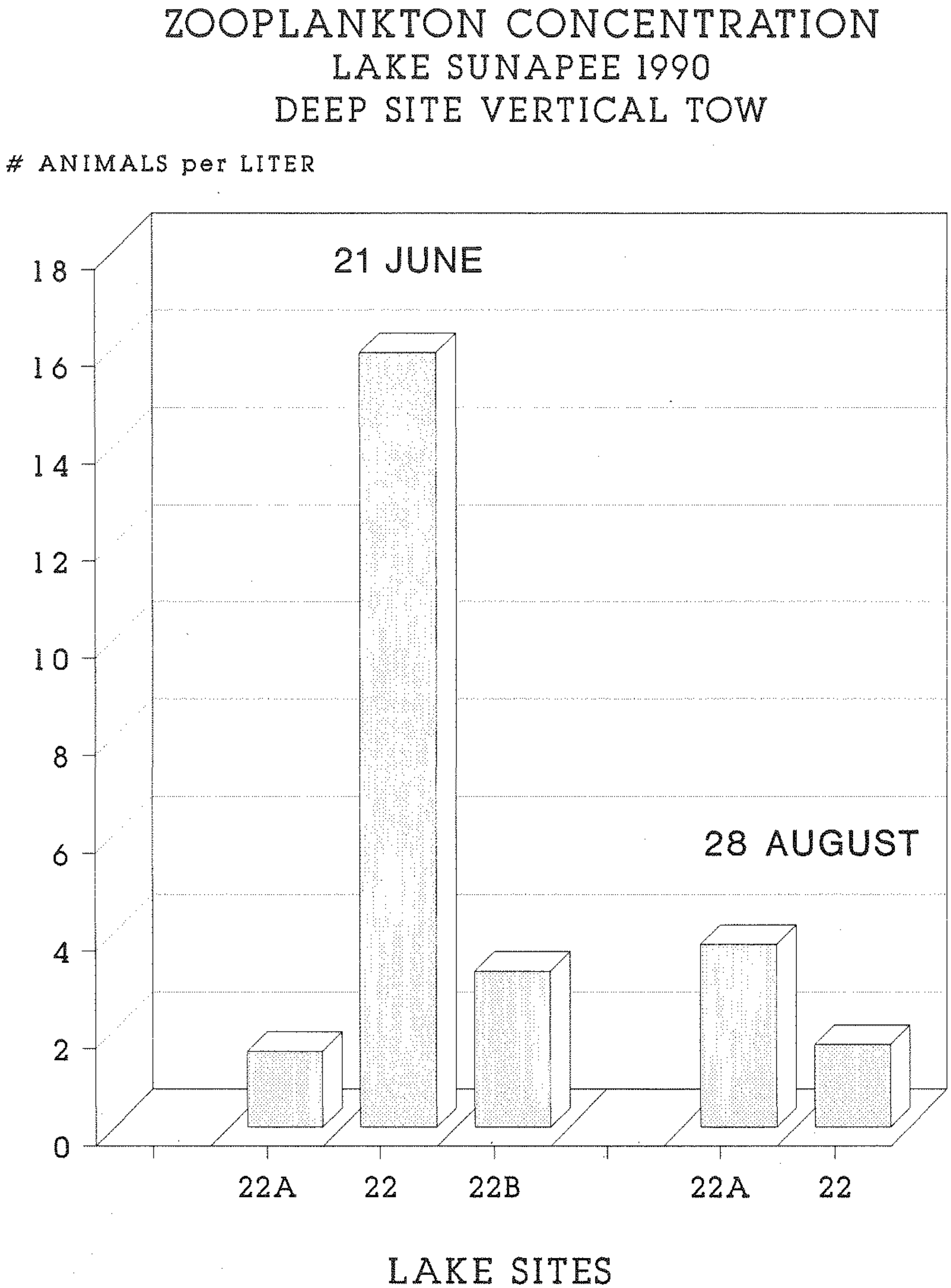


SITE T-8
28 AUG 90 1.0m
WETLAND SIDE



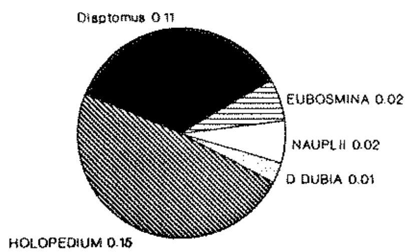
PHYTOPLANKTON ABUNDANCE % BY ALGAL GROUP

Figure 21. Lake Sunapee 1990. Zooplankton density at the deep lake sites 22, 22A and 22B. Bars are grouped according to date. Numbers are in animals per liter and represent a vertical zooplankton tow. Only Macrozooplankton (80 microns and larger) are reported.



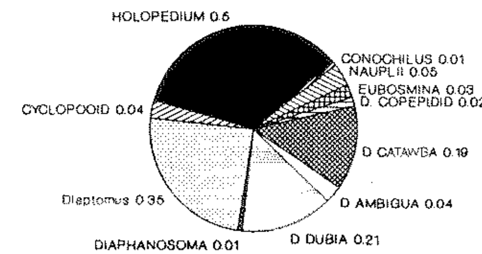
ZOOPLANKTON CONCENTRATION
LAKE SUNAPEE 1990
DEEP SITE VERTICAL TOW
ANIMALS per LITER
21 JUNE
28 AUGUST
0
2
4
6
8
10
12
14
16
18
22A
22
22B
22A
22
LAKE SITES

Figure 22. Lake Sunapee 1990. Relative percent by macrozooplankton group (pie diagrams) for deep sites of Lake Sunapee on representative dates. Pie diagrams are labeled above with date and depth of the net tow.



SUNAPEE LAKE 22B
ZOOPLANKTON 0-16.5m
21 JUNE 1990

NUMBERS SHOWN ARE # ANIMALS PER LITER



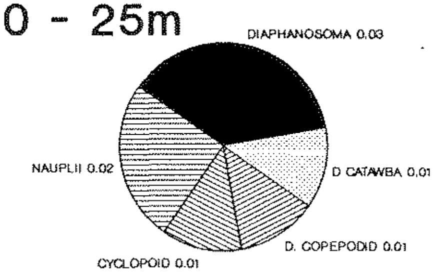
SUNAPEE LAKE SITE 22A
ZOOPLANKTON 0-13m
21 JUNE 1990

NUMBERS SHOWN ARE # ANIMALS PER LITER

ZOOPLANKTON DIVERSITY
LAKE SUNAPEE 1990

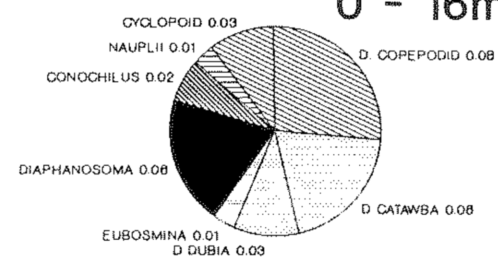
SUNAPEE 22
ZOOPLANKTON DATA
28 AUGUST 1990

0 - 25m



SUNAPEE 22A
ZOOPLANKTON DATA
28 AUGUST 1990

0 - 16m



As discussed above for phytoplankton, zooplankton undergo seasonal population cycles and the results discussed below are most representative of the four collection dates and not necessarily of other times during the ice-free season.

Concentrations of macrozooplankton had a range of 1.2 to 15.6 organisms per liter (Figure 21). Less than 10 organisms per liter is considered to be a low density. 1990 Sunapee densities were generally low and comparable to 1988 levels. Other years yielded greater concentrations of animals. Greater number of animals were present at site 22 in June. This is a deeper site and possibly the animals remained in the lower colder waters of the lake given the warmer than usual surface temperatures of this year.

The composition and concentration of macrozooplankton crustaceans in Lake Sunapee was typical of open water plankton in relatively clear and unproductive lakes. Figure 22 displays the relative abundance of various macrozooplankton species. The central site, 22 had the highest diversity of macrozooplankton including as many as three different species of Daphnia (D. catawba, D. dubia, D. ambigua). These large crustacean "water fleas" are important grazers of phytoplankton and an excellent food source for fish. High diversity, particularly at the central site is an indication of a complex food web where both fish and invertebrate (aquatic insect) predators of zooplankton are present. This, in turn, is an indication that the site is relatively pristine as more productive or impaired lakes usually can only support limited diversity within the aquatic food web.

June samples were generally dominated by the herbivorous copepod Diaptomus. The Daphnia were a dominant or co-dominant with the gelatinous sheathed cladoceran Holopedium group in August at all sites. This is reverse that of the more typical pattern for oligotrophic lakes and historically for Lake Sunapee. Whether this represents any significant change or is the result of the weather or a different fish stocking schedule or some other externality is not known.

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Lake Sunapee Data on file as of 03/16/1991

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Lake Sunapee, NH
-- subset of trophic indicators, all sites, 1990

1990 SUMMARY

Average transparency:	6.4	(1990:	115	values;	2.3 -	8.6	range)
Average chlorophyll:	2.2	(1990:	123	values;	0.4 -	9.3	range)
Average phosphorus:	8.8	(1990:	6	values;	1.3 -	36.6	range)
Average alk (gray):	3.9	(1990:	115	values;	0.1 -	6.8	range)
Average alk (pink):	5.3	(1990:	115	values;	1.0 -	9.5	range)
Average color, 440:	14.7	(1990:	104	values;	3.4 -	43.8	range)
Average Trib. phos:	12.8	(1990:	28	values;	0.9 -	143.3	range)

Site	Date	Trans-parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
2 Geo Mil	05/20/1990	6.5	2.1	---	4.2	5.5	12.0
2 Geo Mil	05/26/1990	8.0	2.9	---	4.7	6.8	7.7
2 Geo Mil	06/03/1990	8.0	2.3	---	5.7	6.7	5.2
2 Geo Mil	06/09/1990	6.5	1.2	---	4.8	5.7	11.2
2 Geo Mil	06/16/1990	7.5	1.8	---	4.5	7.7	---
2 Geo Mil	06/24/1990	5.5	1.1	---	---	---	14.6
2 Geo Mil	07/01/1990	6.5	2.6	---	4.5	5.1	---
2 Geo Mil	07/08/1990	7.0	1.3	---	4.1	5.2	3.4
2 Geo Mil	07/15/1990	7.6	1.2	---	4.0	5.0	14.6
2 Geo Mil	07/22/1990	7.5	1.6	---	5.3	5.8	---
2 Geo Mil	07/28/1990	5.5	1.5	---	4.2	5.5	7.7
2 Geo Mil	08/05/1990	8.0	1.1	---	3.7	4.5	15.5
2 Geo Mil	08/12/1990	4.5	2.1	---	5.0	6.0	40.4
2 Geo Mil	08/17/1990	6.0	1.9	---	4.9	7.3	---
2 Geo Mil	08/19/1990	5.3	1.9	---	4.6	7.7	---
2 Geo Mil	09/02/1990	7.3	1.8	---	4.6	5.4	25.8
2 Geo Mil	09/09/1990	7.2	1.9	---	5.0	7.0	21.5
2 Geo Mil	09/23/1990	5.5	3.0	---	4.2	7.8	---
2 Geo Mil	10/08/1990	6.0	2.6	---	5.1	4.5	13.7
2 Geo Mil	10/14/1990	6.0	1.9	---	4.7	6.0	12.9
3 InrJobs	06/02/1990	Bot.	0.4	---	---	---	13.7
3 InrJobs	06/10/1990	2.8	1.9	---	---	---	12.0
3 InrJobs.	06/17/1990	5.5	1.6	---	---	---	8.6
3 InrJobs	07/01/1990	5.5	2.2	---	---	---	9.4
3 InrJobs	07/08/1990	5.5	2.2	---	3.7	4.5	12.0
3 InrJobs	07/15/1990	5.5	1.9	---	1.0	3.3	14.6
3 InrJobs	07/22/1990	5.5	1.4	---	1.5	2.6	---
3 InrJobs	07/29/1990	4.5	1.9	---	1.6	2.5	14.6
3 InrJobs	08/05/1990	5.0	0.8	---	1.7	2.0	28.3
3 InrJobs	08/12/1990	3.8	2.1	---	1.8	2.3	43.8
3 InrJobs	08/19/1990	4.3	3.2	---	0.6	1.0	28.3

Lake Sunapee Data on file as of 03/16/1991

Site	Date	Trans-parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
3 InrJobs	09/02/1990	4.5	2.7	---	1.0	2.2	34.4
3 InrJobs	09/09/1990	4.5	3.1	---	1.0	2.8	27.5
3 InrJobs	09/16/1990	2.3	2.1	---	0.7	1.1	20.6
3 InrJobs	09/23/1990	Bot.	3.1	---	1.8	3.2	26.6
3 InrJobs	10/20/1990	---	---	3.1	---	---	---
4 OutJobs	06/02/1990	Bot.	0.6	---	---	---	8.6
4 OutJobs	06/10/1990	2.3	1.5	---	---	---	24.1
4 OutJobs	06/17/1990	4.5	1.4	---	---	---	9.5
4 OutJobs	07/01/1990	Bot.	2.1	---	---	---	14.6
4 OutJobs	07/08/1990	Bot.	1.5	---	2.0	4.4	7.7
4 OutJobs	07/15/1990	4.3	1.2	---	0.1	1.0	6.9
4 OutJobs	07/22/1990	Bot.	1.4	---	2.2	3.0	7.7
4 OutJobs	07/29/1990	4.5	1.5	---	1.7	2.6	17.2
4 OutJobs	08/05/1990	4.3	0.8	---	---	---	12.0
4 OutJobs	08/12/1990	Bot.	1.6	---	1.6	2.5	13.7
4 OutJobs	08/19/1990	4.5	3.6	---	0.5	2.0	15.5
4 OutJobs	09/02/1990	4.5	1.7	---	1.1	1.8	28.3
4 OutJobs	09/09/1990	4.3	1.7	---	1.8	2.2	18.0
4 OutJobs	09/19/1990	4.0	1.7	---	0.9	1.2	11.2
4 OutJobs	09/23/1990	4.0	1.5	---	2.2	3.5	15.5
5 GardBay	08/14/1990	---	---	1.3	---	---	---
9A Indian	06/01/1990	7.5	2.2	---	6.5	9.5	18.0
9A Indian	06/08/1990	7.1	1.0	---	4.2	6.9	6.0
9A Indian	06/15/1990	7.1	1.4	---	4.4	6.6	6.9
9A Indian	06/22/1990	6.8	2.1	---	4.0	6.3	---
9A Indian	06/29/1990	7.2	---	---	4.5	8.5	---
9A Indian	07/06/1990	6.7	2.8	---	4.3	6.9	6.9
9A Indian	07/11/1990	7.0	3.9	---	4.7	7.0	10.3
9A Indian	07/19/1990	8.6	3.1	---	4.5	5.9	4.3
9A Indian	07/26/1990	7.2	1.3	---	3.5	6.0	6.9
9A Indian	08/02/1990	7.3	1.9	---	5.1	8.9	7.7
9A Indian	08/11/1990	7.5	3.9	---	4.5	7.3	11.2
9A Indian	08/18/1990	7.0	2.6	---	5.7	8.6	16.3
9A Indian	08/23/1990	6.6	1.5	---	5.2	7.8	19.8
9A Indian	08/30/1990	6.7	1.9	---	4.0	5.1	---
9A Indian	09/10/1990	6.0	1.4	---	5.8	7.0	14.6
9A Indian	09/19/1990	8.5	1.7	---	6.8	8.6	18.0
9A Indian	09/23/1990	8.3	2.0	---	5.5	6.0	17.2
9A Indian	09/28/1990	6.8	2.5	---	5.2	8.2	15.5
9A Indian	10/05/1990	6.5	8.9	---	4.9	9.2	12.0
12 Rd Watr	07/03/1990	6.5	3.1	---	4.2	5.0	---
12 Rd Watr	07/16/1990	7.0	2.1	---	5.0	6.3	12.9
12 Rd Watr	07/22/1990	7.1	2.1	---	5.2	6.1	---
12 Rd Watr	07/27/1990	7.0	---	---	4.8	5.6	18.0
12 Rd Watr	08/05/1990	8.0	1.4	---	4.5	5.2	7.7
12 Rd Watr	08/19/1990	6.0	1.1	---	3.9	6.0	10.3
12 Rd Watr	09/01/1990	6.0	2.6	---	5.1	5.6	18.9
12 Rd Watr	09/09/1990	6.7	2.3	---	4.0	4.7	---

Lake Sunapee Data on file as of 03/16/1991

Site	Date	Trans-parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
12 Rd Watr	09/16/1990	Bot.	2.7	---	4.0	4.7	---
12 Rd Watr	09/23/1990	5.5	2.3	---	4.1	4.5	---
12 Rd Watr	09/28/1990	6.0	3.0	---	4.3	4.9	18.0
12A RedWtr	07/24/1990	---	---	36.6	---	---	---
12A RedWtr	09/03/1990	---	---	8.8	---	---	---
17 Newbury	05/26/1990	6.7	1.2	---	3.8	4.3	8.6
17 Newbury	07/18/1990	7.7	1.4	---	4.7	7.4	6.0
17 Newbury	07/24/1990	5.0	2.7	---	4.0	5.4	17.2
17 Newbury	08/05/1990	6.8	9.3	---	4.0	4.8	31.8
17 Newbury	08/12/1990	---	3.0	---	3.6	4.6	10.3
17 Newbury	08/22/1990	7.5	2.1	---	5.0	7.0	12.9
17 Newbury	08/28/1990	6.0	5.4	1.3	4.1	6.3	12.9
17 Newbury	09/02/1990	6.0	2.7	---	4.4	6.2	14.6
17 Newbury	09/11/1990	7.5	1.7	---	4.5	6.0	26.6
17 Newbury	09/25/1990	7.2	2.1	---	4.0	6.5	18.9
17 Newbury	10/14/1990	6.0	1.6	---	3.5	4.7	18.0
20A	08/08/1990	8.5	3.7	---	4.2	6.1	10.3
20A	08/22/1990	7.0	2.0	---	3.5	4.2	13.7
20A	08/29/1990	7.0	7.7	---	3.2	4.1	18.9
20A	09/14/1990	7.3	1.7	---	3.5	4.8	13.7
22B South	05/26/1990	7.2	1.5	---	3.6	4.1	11.2
22B South	07/18/1990	7.3	1.4	---	4.0	6.0	6.9
22B South	07/24/1990	6.0	2.9	---	4.6	6.0	12.0
22B South	08/05/1990	7.8	3.4	---	3.9	5.0	8.6
22B South	08/12/1990	---	4.0	---	4.2	4.5	12.9
22B South	08/22/1990	7.5	1.7	---	4.0	5.2	13.7
22B South	08/28/1990	5.5	5.0	---	3.8	5.8	13.7
22B South	09/03/1990	6.3	1.6	---	4.7	6.5	15.5
22B South	09/11/1990	7.5	1.1	---	4.5	5.7	15.5
22B South	09/25/1990	7.5	1.6	---	4.0	6.0	12.0
22B South	10/14/1990	6.6	1.7	---	3.6	4.8	11.2
24 Herr Cv	03/26/1990	7.5	1.1	---	4.6	6.4	6.0
24 Herr Cv	06/03/1990	8.5	1.4	---	4.2	5.1	10.3
24 Herr Cv	06/09/1990	8.3	1.6	---	4.5	5.2	14.6
24 Herr Cv	06/16/1990	8.0	1.1	---	4.5	6.2	---
24 Herr Cv	06/24/1990	6.1	2.7	---	4.9	6.3	12.9
24 Herr Cv	07/01/1990	6.3	3.7	---	4.5	5.3	---
24 Herr Cv	07/08/1990	6.5	1.2	---	4.4	5.3	12.0
24 Herr Cv	07/15/1990	8.5	0.9	---	4.0	4.9	18.0
24 Herr Cv	07/22/1990	7.0	1.5	---	5.4	5.9	---
24 Herr Cv	07/28/1990	6.5	1.0	---	4.3	5.5	5.2
24 Herr Cv	08/05/1990	7.5	1.2	---	4.3	5.0	10.3
24 Herr Cv	08/12/1990	6.8	1.5	---	5.0	5.9	18.0
24 Herr Cv	08/17/1990	6.5	1.9	---	4.1	5.2	---
24 Herr Cv	08/19/1990	4.9	1.9	---	4.2	5.6	---
24 Herr Cv	09/02/1990	6.3	1.4	---	4.5	5.5	13.7
24 Herr Cv	09/09/1990	7.0	2.6	---	3.8	5.6	14.6
24 Herr Cv	09/23/1990	5.5	2.9	---	5.4	7.8	---

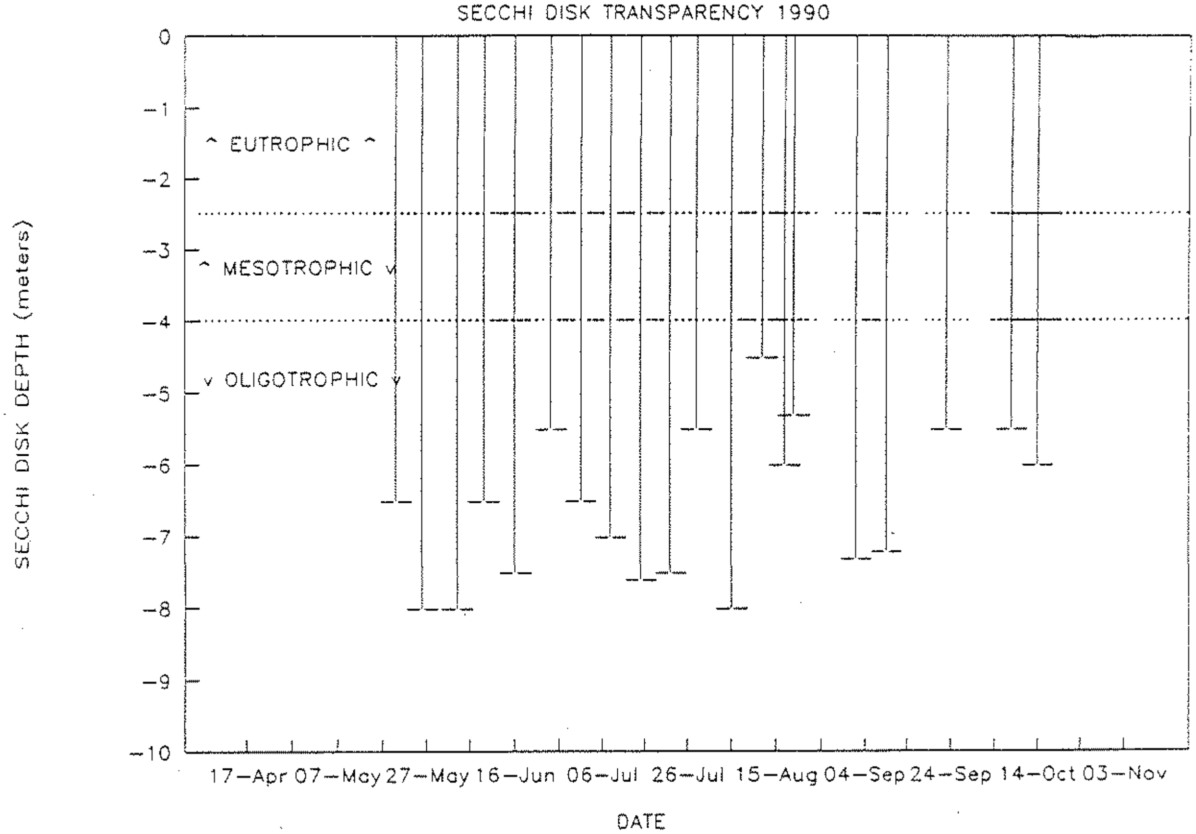
Lake Sunapee Data on file as of 03/16/1991

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
24 Herr Cv	10/08/1990	7.2	2.1	---	5.2	4.7	22.3
24 Herr Cv	10/14/1990	7.3	1.8	---	4.4	5.5	10.3
25	06/28/1990	---	---	1.5	---	---	---
Chand. Brk	07/25/1990	---	---	2.4	---	---	---
Johns Brk	07/27/1990	---	---	0.9	---	---	---
Johns Brk	09/12/1990	---	---	1.3	---	---	---
T2	05/15/1990	---	---	3.5	---	---	---
T2	06/12/1990	---	---	4.2	---	---	---
T2	07/12/1990	---	---	1.5	---	---	---
T2	08/05/1990	---	---	3.1	---	---	---
T2	09/25/1990	---	---	2.0	---	---	---
T2	10/20/1990	---	---	2.2	---	---	---
T2	11/08/1990	---	---	1.8	---	---	---
T3	03/15/1990	---	---	2.8	---	---	---
T3	07/12/1990	---	---	1.5	---	---	---
T3	08/05/1990	---	---	7.3	---	---	---
T3	09/25/1990	---	---	1.3	---	---	---
T3	10/08/1990	---	---	1.1	---	---	---
T4	08/14/1990	---	---	1.8	---	---	---
T4	09/08/1990	---	---	2.2	---	---	---
T4	10/05/1990	---	---	0.9	---	---	---
T4	10/24/1990	---	---	5.7	---	---	---
T4	10/24/1990	---	---	3.3	---	---	---
T5	07/23/1990	---	---	3.7	---	---	---
T5	09/19/1990	---	---	6.2	---	---	---
T5	11/06/1990	---	---	15.4	---	---	---
T8	07/27/1990	---	---	143.3	---	---	---
T8	08/26/1990	---	---	3.3	---	---	---
T8	09/16/1990	---	---	0.9	---	---	---
T8A	08/26/1990	---	---	20.7	---	---	---
T8A	09/16/1990	---	---	115.3	---	---	---

<< End of 1990 listing, 158 records >>

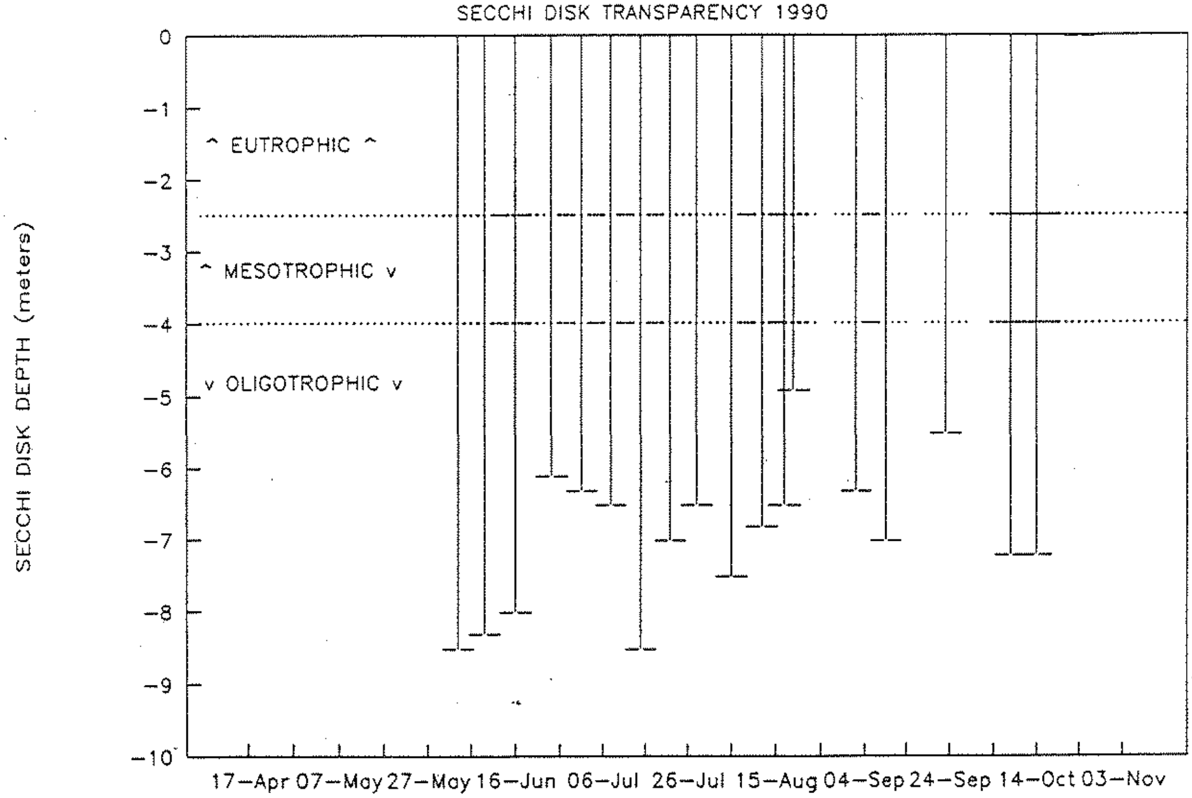
LAKE SUNAPEE – SITE 2 GEORGES MILLS

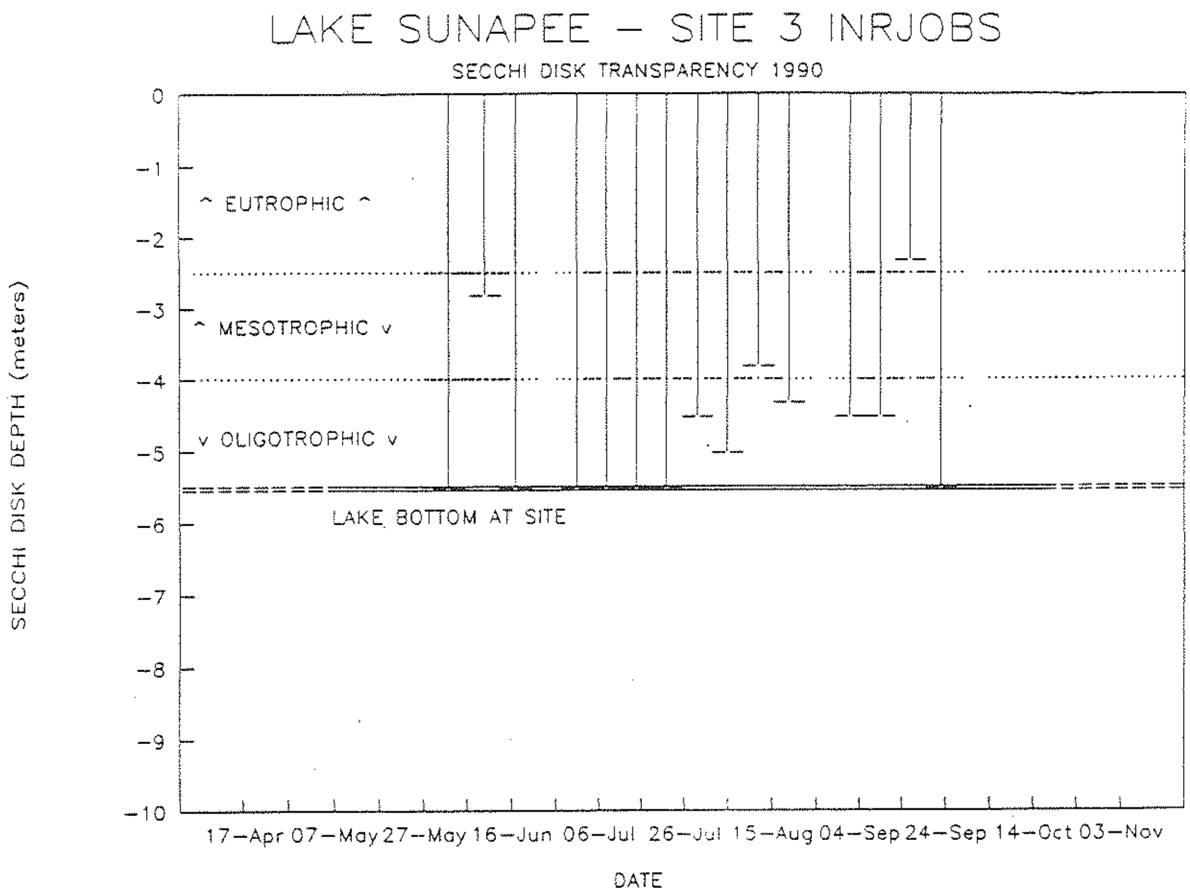
SECCHI DISK TRANSPARENCY 1990

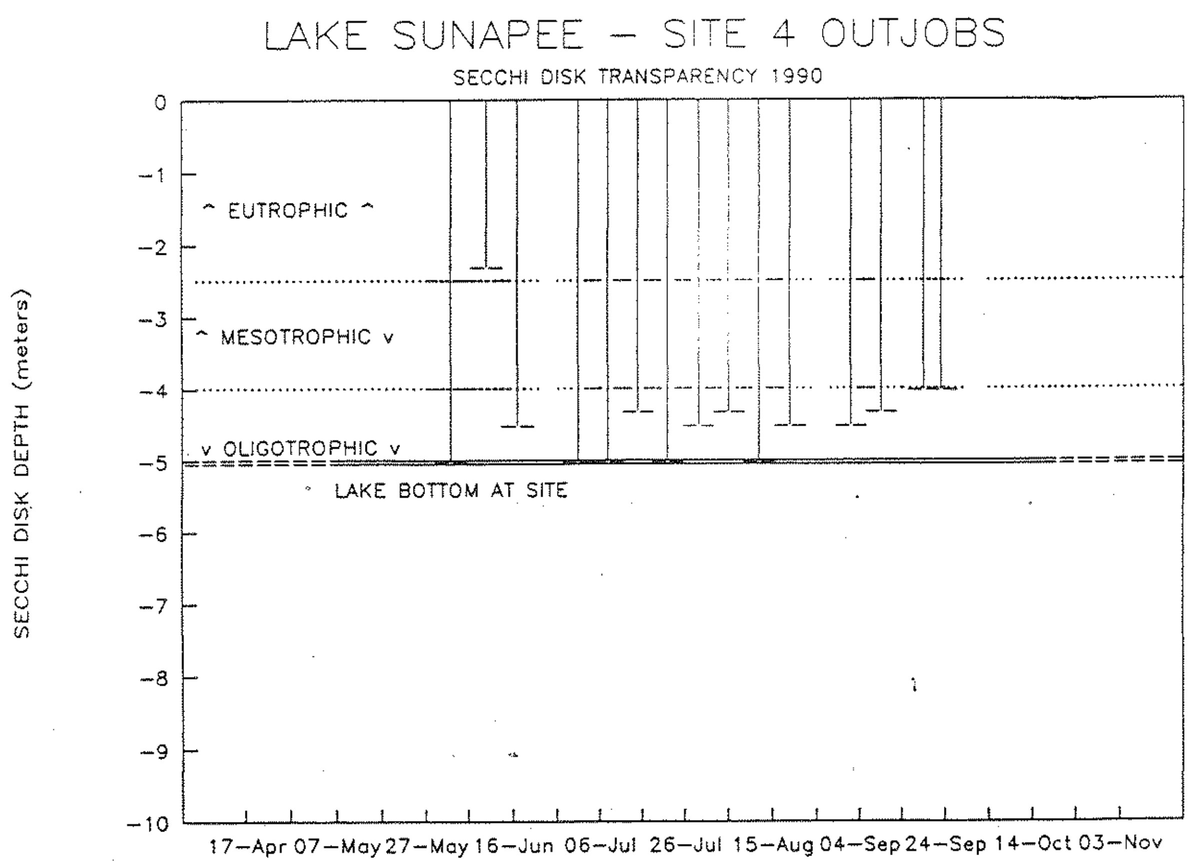


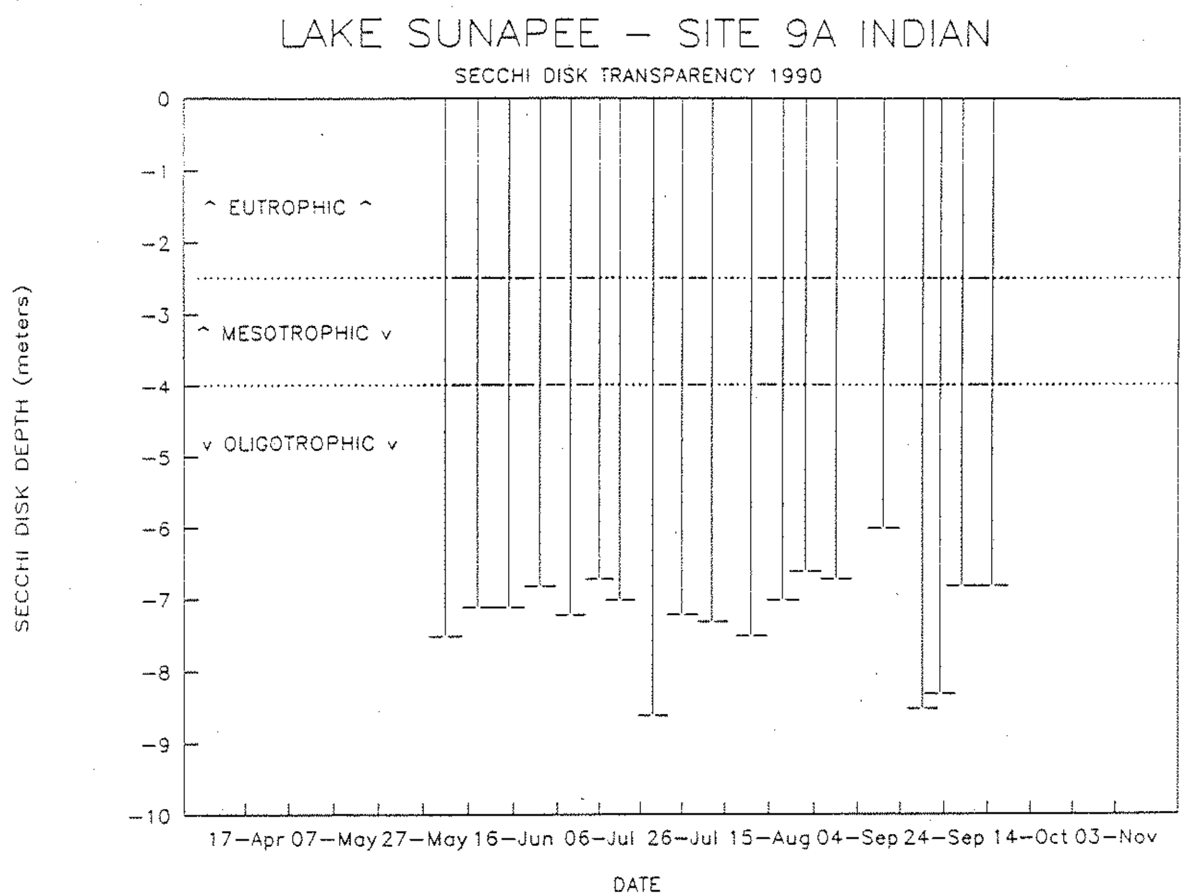
LAKE SUNAPEE – SITE 24 HERRICK COVE

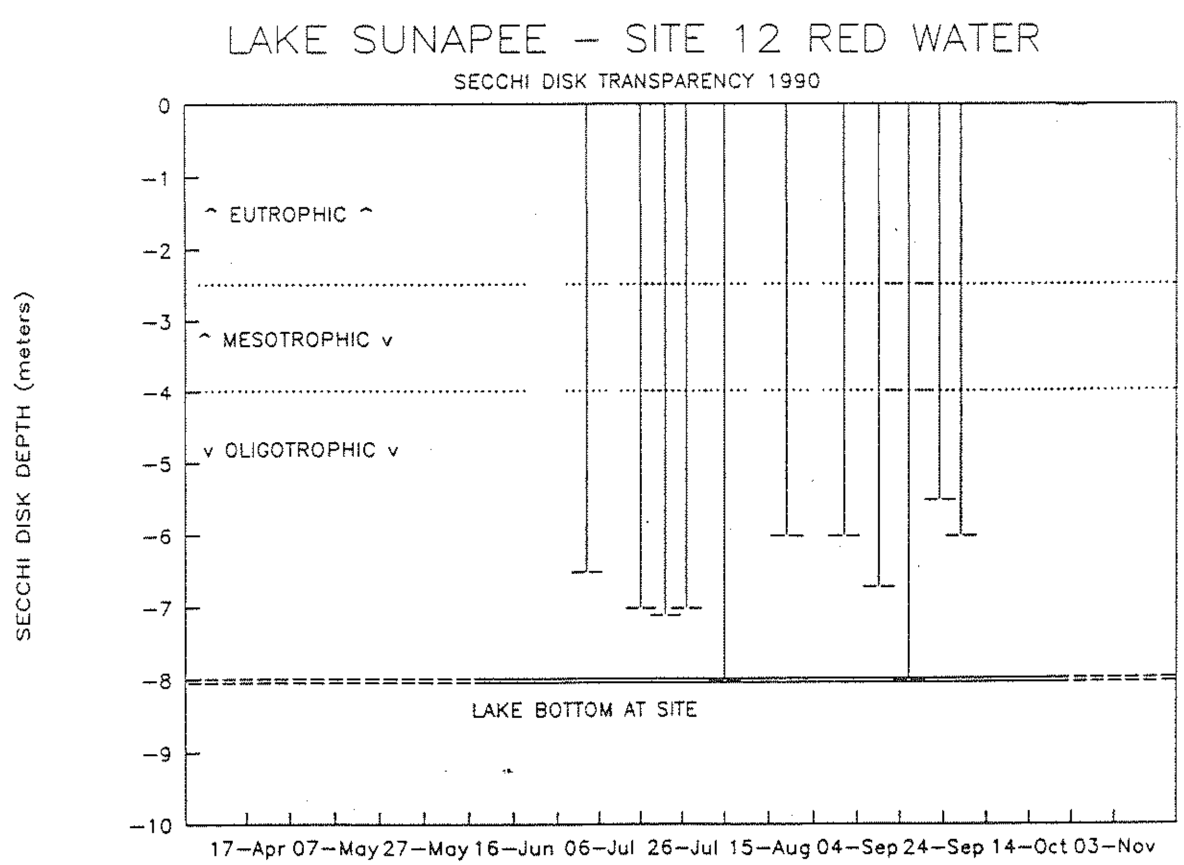
SECCHI DISK TRANSPARENCY 1990

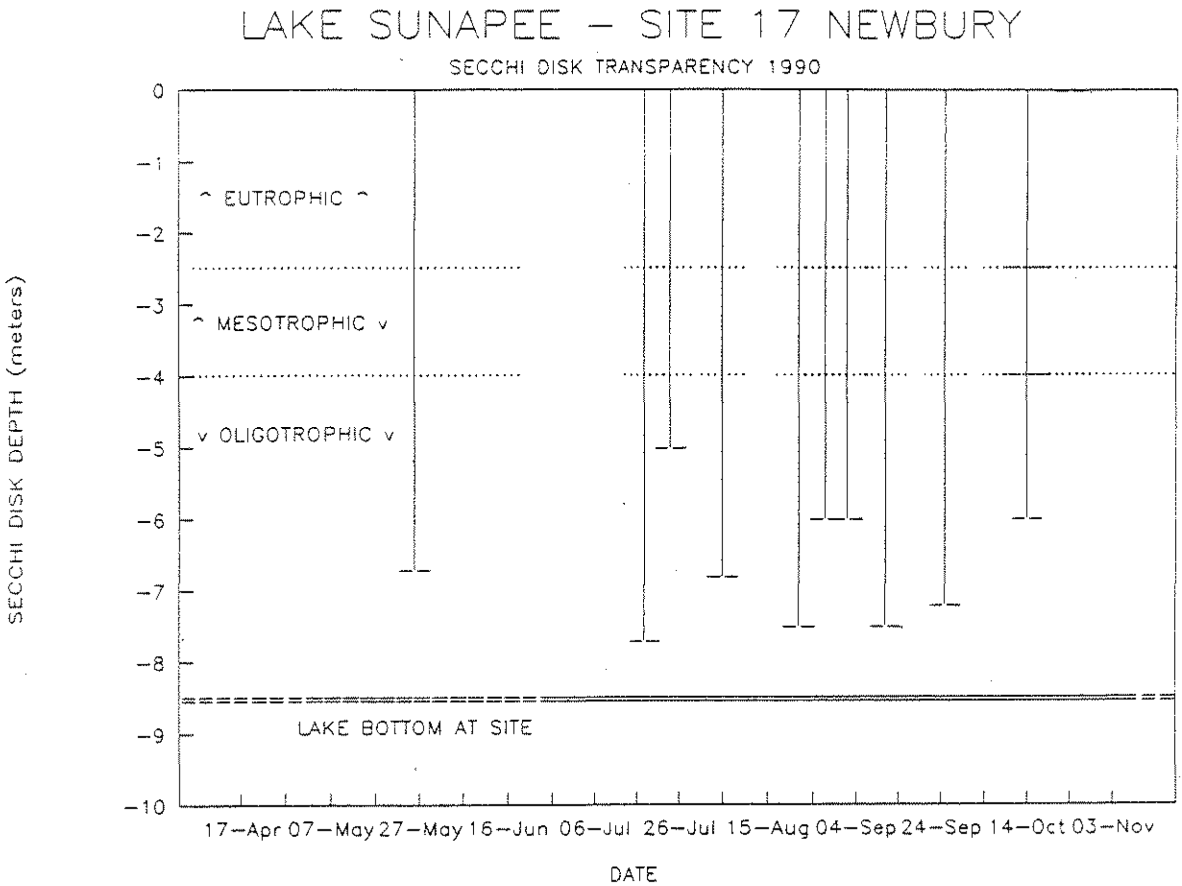


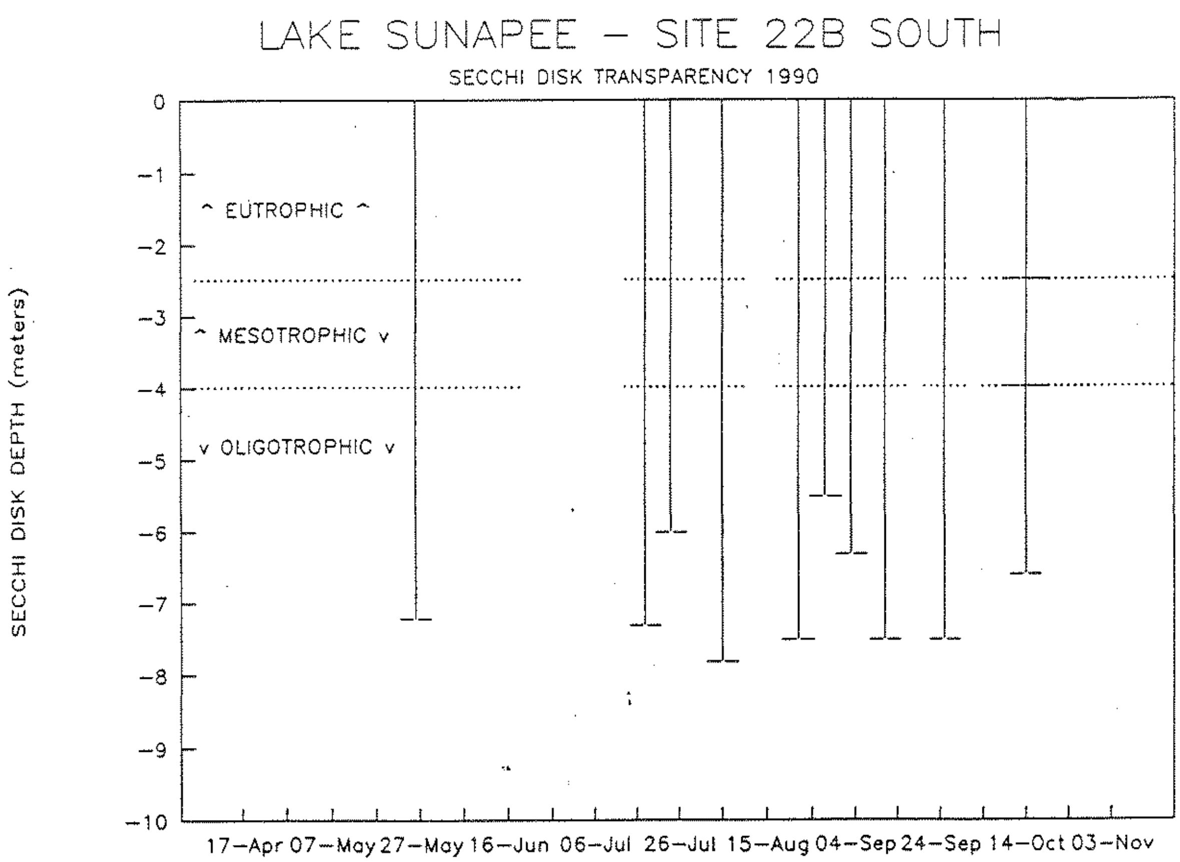

LAKE SUNAPEE – SITE 3 INRJOBS
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
17–Apr 07–May 27–May 16–Jun 06–Jul 26–Jul 15–Aug 04–Sep 24–Sep 14–Oct 03–Nov
DATE

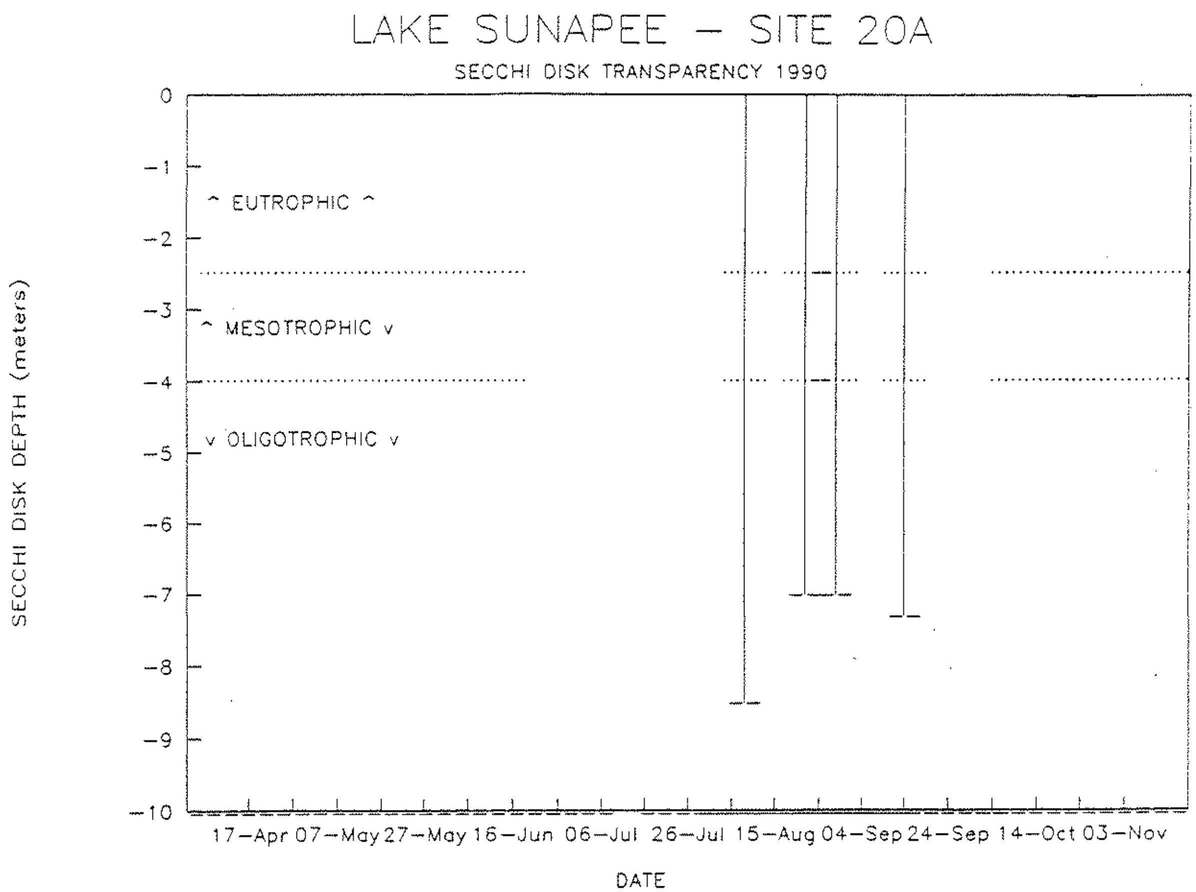

LAKE SUNAPEE – SITE 4 OUTJOBS
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
17–Apr 07–May 27–May 16–Jun 06–Jul 26–Jul 15–Aug 04–Sep 24–Sep 14–Oct 03–Nov


LAKE SUNAPEE – SITE 9A INDIAN
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
17–Apr 07–May 27–May 16–Jun 06–Jul 26–Jul 15–Aug 04–Sep 24–Sep 14–Oct 03–Nov
DATE


LAKE SUNAPEE – SITE 12 RED WATER
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
17–Apr 07–May 27–May 16–Jun 06–Jul 26–Jul 15–Aug 04–Sep 24–Sep 14–Oct 03–Nov


LAKE SUNAPEE – SITE 17 NEWBURY
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
17–Apr 07–May 27–May 16–Jun 06–Jul 26–Jul 15–Aug 04–Sep 24–Sep 14–Oct 03–Nov
DATE


LAKE SUNAPEE – SITE 22B SOUTH
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
17–Apr 07–May 27–May 16–Jun 06–Jul 26–Jul 15–Aug 04–Sep 24–Sep 14–Oct 03–Nov



LAKE SUNAPEE - SITE 20A
SECCHI DISK TRANSPARENCY 1990
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
17-Apr 07-May 27-May 16-Jun 06-Jul 26-Jul 15-Aug 04-Sep 24-Sep 14-Oct 03-Nov
DATE

Lake Sunapee Deep Sites 1990 FBG Data

Depth Specific Data-

Site	Date	Depth (m)	pH	Alk Gray end pt.	Alk Pink end pt.	CO2 mg l	Spec. Cond. umho	Disc. sample T-Phos ppb
22B South	06/21/1990	2.0	6.9	4.0	4.6	1.6	79.0	---
22B South	06/21/1990	8.0	6.8	4.2	5.0	1.9	79.1	---
22B South	06/21/1990	16.0	6.9	4.1	5.0	4.1	78.9	3.0
22A North	06/21/1990	0.5	6.9	4.2	5.2	1.1	77.2	---
22A North	06/21/1990	2.0	7.0	4.0	4.9	1.2	73.8	---
22A North	06/21/1990	8.0	7.0	4.1	5.3	1.8	78.5	---
22A North	06/21/1990	13.0	6.9	4.0	4.6	2.9	75.0	7.0
22 Central	06/21/1990	0.5	7.0	4.0	4.6	1.6	70.2	---
22 Central	06/21/1990	2.0	7.0	3.7	4.3	1.0	72.4	---
22 Central	06/21/1990	8.5	7.0	3.9	4.6	1.9	77.7	---
22 Central	06/21/1990	21.0	6.8	3.8	4.5	4.0	71.2	6.0
22A North	08/28/1990	0.5	6.9	3.6	4.4	1.7	74.7	1.0
22A North	08/28/1990	4.0	6.8	3.2	4.1	0.9	78.0	---
22A North	08/28/1990	9.5	6.8	3.8	4.7	2.2	74.2	---
22A North	08/28/1990	16.0	6.8	4.1	4.9	5.3	77.2	4.0
22B South	08/28/1990	0.5	6.9	3.1	4.0	1.2	69.9	4.0
22B South	08/28/1990	3.0	6.8	3.3	4.1	1.0	71.4	---
22B South	08/28/1990	9.5	6.7	3.3	3.8	2.6	71.5	---
22B South	08/28/1990	15.0	6.7	3.4	4.0	7.9	74.3	15.0
22 Central	08/28/1990	0.5	6.9	3.5	4.0	1.0	72.5	2.0
22 Central	08/28/1990	3.0	6.8	3.6	4.2	1.4	72.0	---
22 Central	08/28/1990	9.5	6.8	3.7	4.2	2.0	74.0	---
22 Central	08/28/1990	25.0	6.7	3.6	4.2	7.0	76.0	9.0

Integrated Data-

Date	Site	SD Trans-parency (m)	Chloro-phyll a (ppb)	Meta-lim. Chloro-phyll a (ppb)	Color (Co-Pt Units)	Total Phos. (ppb)	Coef. down-welling light
06/21/1990	22 Central	7.7	2.1	2.2	8.5	3.1	0.32
06/21/1990	22A North	8.0	1.9	2.2	9.3	7.7	0.31
06/21/1990	22B South	7.0	2.8	3.6	9.3	9.9	0.33
08/28/1990	22 Central	8.2	1.5	2.0	-1.0	2.1	0.39
08/28/1990	22A North	7.5	1.4	1.6	-1.0	4.4	0.43
08/28/1990	22B South	6.5	1.6	1.9	-1.0	5.4	0.37

Date	Site	pH	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. umho	Disc. sample T-Phos ppb	SD Trans-parency (m)	Chloro-phyll a (ppb)	Color (Co-Pt Units)
03/24/1990	Brown Hill	---	---	---	50.5	7.1	---	---	---
03/24/1990	T-1	---	---	---	80.7	3.1	---	---	---
03/24/1990	T-2	---	---	---	53.2	12.8	---	---	---
03/24/1990	T-3	---	---	---	88.3	3.1	---	---	---
03/24/1990	T-4	---	---	---	64.4	6.2	---	---	---
03/24/1990	T-5	---	---	---	41.6	2.9	---	---	---
03/24/1990	T-7	---	---	---	80.1	9.0	---	---	---
03/24/1990	T-7A	---	---	---	41.9	2.4	---	---	---
03/24/1990	T-8	---	---	---	390.0	4.6	---	---	---
03/24/1990	T-8A	---	---	---	160.0	3.7	---	---	---
03/24/1990	T-9	---	---	---	36.2	4.6	---	---	---
03/24/1990	T10	---	---	---	515.0	3.5	---	---	---
03/24/1990	T11	---	---	---	48.5	3.3	---	---	---
03/24/1990	T13	---	---	---	65.7	3.3	---	---	---
06/21/1990	2 Geo Mil	6.9	3.5	4.3	---	6.0	6.6	1.4	9.2
06/21/1990	3 InrJobs	6.9	3.4	3.8	---	1.1	Bot.	2.6	14.6
06/21/1990	5 GardBay	6.8	3.5	4.2	---	1.3	7.2	2.6	9.2
06/21/1990	7 SunHbr	6.9	3.7	4.2	---	0.7	6.5	2.8	9.3
06/21/1990	11A Isl	6.7	3.6	4.1	---	0.9	6.9	2.3	9.2
06/21/1990	12 Fishers	6.8	3.5	4.1	---	1.5	6.1	3.3	8.8
06/21/1990	12A Redwat	---	---	---	---	110.3	Bot.	2.9	9.1
06/21/1990	14 St Bch	6.6	3.5	4.0	---	1.8	Bot.	3.1	9.9
06/21/1990	17 Newbury	6.6	3.5	4.0	---	1.5	6.2	3.3	9.1
06/21/1990	18 PineClf	6.5	3.5	3.9	---	1.5	6.3	2.4	9.1
06/21/1990	19 Narrows	6.9	3.5	4.2	---	0.9	5.6	2.7	9.4
06/21/1990	20 Blodget	6.9	3.7	4.2	---	1.1	4.7	2.9	9.1
06/21/1990	21 SooNipi	6.9	3.5	4.1	---	1.1	Bot.	1.6	10.3
06/21/1990	25 HerrCv	6.7	3.8	4.4	---	1.1	7.3	1.6	20.6
06/21/1990	Bog	6.1	---	---	276.0	---	---	---	---
06/21/1990	T-1	6.9	---	---	72.1	2.6	---	---	---
06/21/1990	T-2	6.2	---	---	341.0	3.3	---	5.1	19.8
06/21/1990	T-3	6.0	---	---	75.3	4.6	---	---	---
06/21/1990	T-4	6.1	---	---	131.0	3.3	---	---	---
06/21/1990	T-5	6.0	---	---	105.0	4.9	---	---	---
06/21/1990	T-6	6.5	---	---	136.0	4.0	---	---	---

Date	Site	pH	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. umho	Disc. sample T-Phos ppb	SD Trans-parency (m)	Chloro-phyll a (ppb)	Color (Co-Pt Units)
06/21/1990	T-7	6.6	---	---	145.0	6.4	---	---	---
06/21/1990	T-7A	6.7	---	---	70.1	1.3	---	---	---
06/21/1990	T-8	6.6	---	---	494.0	1.8	---	---	---
06/21/1990	T-8A	6.4	---	---	303.0	24.0	---	---	---
06/21/1990	T10	6.4	---	---	744.0	12.6	---	---	---
06/21/1990	T11	---	---	---	229.0	3.7	---	---	---
06/21/1990	T13	6.4	---	---	72.0	---	---	---	---
08/06/1990	2 Geo Mil	6.7	2.3	2.8	76.5	---	---	1.8	7.5
08/06/1990	3 InrJobs	6.8	2.3	2.7	78.7	---	---	2.9	4.0
08/06/1990	5 GardBay	6.8	2.3	2.6	80.9	---	---	2.3	---
08/06/1990	7 SunHbr	6.7	2.7	3.1	76.6	---	---	---	---
08/06/1990	12 Fishers	6.7	2.4	2.7	77.1	---	---	1.3	0.3
08/06/1990	17 Newbury	6.6	2.2	2.6	76.2	---	---	1.5	4.9
08/06/1990	20 Blodget	6.8	2.3	2.7	77.6	---	---	---	7.5
08/06/1990	21 SooNipi	6.8	2.2	2.6	76.7	---	---	1.2	2.3
08/06/1990	25 HerrCv	6.5	2.3	2.8	79.4	---	---	1.2	1.5
08/06/1990	Brown Hill	---	---	---	---	22.7	---	---	---
08/06/1990	T-1	6.7	2.4	2.7	78.8	5.5	---	---	---
08/06/1990	T-2	6.8	7.8	8.2	91.0	2.4	---	---	---
08/06/1990	T-3after	6.8	1.0	1.3	112.0	97.5	---	---	---
08/06/1990	T-3before	6.7	2.8	3.3	76.8	2.0	---	---	---
08/06/1990	T-4	6.6	5.4	5.8	102.9	4.2	---	---	---
08/06/1990	T-5	6.8	2.1	2.7	61.4	13.0	---	1.2	---
08/06/1990	T-6	6.5	4.4	4.7	82.4	6.4	---	---	---
08/06/1990	T-7	6.5	5.6	6.1	138.3	3.7	---	---	---
08/06/1990	T-7A	6.6	3.8	4.2	109.8	1.5	---	---	---
08/06/1990	T-8A	6.2	10.6	11.8	248.0	27.3	---	---	---
08/06/1990	T-9	6.6	---	---	102.9	---	---	---	---
08/06/1990	T10	6.7	9.8	10.3	443.0	4.9	---	---	---
08/06/1990	T11	6.7	2.3	2.7	74.0	2.2	---	---	---
08/06/1990	T12	6.4	7.8	8.7	84.3	13.9	---	---	---
08/06/1990	T13	6.3	4.4	4.9	119.9	22.1	---	---	---
08/28/1990	2 Geo Mil	6.9	---	---	---	4.0	6.5	1.6	15.5
08/28/1990	3 InrJobs	6.8	---	---	---	9.0	4.5	2.0	24.9

Date	Site	pH	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. umho	Disc. sample T-Phos ppb	SD Trans-parency (m)	Chloro-phyll a (ppb)	Color (Co-Pt Units)
08/28/1990	4 OutJobs	---	---	---	---	4.0	---	---	---
08/28/1990	5 GardBay	7.0	---	---	---	4.0	7.3	1.2	11.2
08/28/1990	7 SunHbr	6.9	---	---	---	2.0	8.0	2.9	11.2
08/28/1990	11A Isl	6.8	---	---	---	1.4	6.5	1.4	12.9
08/28/1990	12 Fishers	6.9	---	---	---	---	Bot.	1.6	12.9
08/28/1990	14 St Bch	6.9	---	---	---	1.5	Bot.	---	14.6
08/28/1990	17 Newbury	7.0	---	---	---	1.1	7.0	2.0	9.4
08/28/1990	18 PineClf	6.9	---	---	---	2.0	Bot.	1.5	11.2
08/28/1990	19 Narrows	7.0	---	---	---	4.0	Bot.	1.4	11.2
08/28/1990	20 Blodget	6.8	---	---	---	6.0	Bot.	1.8	71.3
08/28/1990	21 SooNipi	6.9	---	---	---	5.0	Bot.	1.9	---
08/28/1990	25 HerrCv	6.9	---	---	---	4.0	6.6	2.4	16.3
08/28/1990	T-1	---	3.5	4.0	85.9	2.0	---	---	---
08/28/1990	T-2	---	6.7	7.5	37.0	9.0	---	---	105.7
08/28/1990	T-3	---	4.0	4.8	79.8	0.9	---	---	32.6
08/28/1990	T-4	---	2.1	3.3	70.7	4.0	---	---	---
08/28/1990	T-5	---	1.1	1.9	32.4	---	---	---	---
08/28/1990	T-6	---	2.1	2.7	30.3	---	---	---	---
08/28/1990	T-7	---	6.5	7.4	91.3	4.4	---	---	74.7
08/28/1990	T-7A	---	---	---	50.5	4.0	---	---	39.5
08/28/1990	T-8	---	12.6	13.6	143.1	3.7	---	---	---
08/28/1990	T-8A	---	15.5	16.6	257.0	2.6	---	---	---
08/28/1990	T-9	---	3.1	3.9	40.5	5.5	---	---	---
08/28/1990	T10	---	15.5	16.5	322.0	---	---	---	---
08/28/1990	T11	---	0.6	1.5	72.9	---	---	---	---
08/28/1990	T12	---	4.9	6.1	63.9	1.5	---	---	---
08/28/1990	T13	---	4.1	4.9	94.7	---	---	---	---
09/27/1990	2 Geo Mil	7.2	4.0	4.8	75.1	---	---	---	---
09/27/1990	3 InrJobs	7.2	3.9	4.6	76.0	---	---	---	---
09/27/1990	5 GardBay	7.2	3.9	4.7	73.4	---	---	---	---
09/27/1990	7 SunHbr	7.1	3.8	4.7	72.8	---	---	---	---
09/27/1990	11A Isl	7.2	3.9	4.9	72.6	---	---	---	---
09/27/1990	12 Fishers	7.2	3.7	4.4	71.9	---	---	---	---
09/27/1990	12A Redwat	7.1	4.9	5.3	70.6	---	---	---	---
09/27/1990	14 St Bch	7.0	2.2	3.0	70.6	---	---	---	---

LAKE SUNAPEE SHALLOW LAKE SITES AND TRIBUTARIES FBG DATA 1990

Date	Site	pH	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. umho	Disc. sample T-Phos ppb	SD Trans-parency (m)	Chloro-phyll a (ppb)	Color (Co-Pt Units)
09/27/1990	17 Newbury	7.0	3.8	4.6	70.3	---	---	---	---
09/27/1990	18 PineClf	6.9	3.9	4.4	70.6	---	---	---	---
09/27/1990	19 Narrows	7.0	4.2	4.4	70.4	---	---	---	---
09/27/1990	20 Blodget	7.0	3.9	4.7	70.9	---	---	---	---
09/27/1990	21 SooNipi	7.0	3.8	4.5	74.1	---	---	---	---
09/27/1990	25 HerrCv	7.0	4.0	4.5	75.2	---	---	---	---
09/27/1990	T-1	---	---	---	74.8	---	---	---	23.2
09/27/1990	T-2	---	---	---	65.2	---	---	---	59.3
09/27/1990	T-3	---	---	---	84.0	---	---	---	27.5
09/27/1990	T-4	---	---	---	69.4	---	---	---	73.9
09/27/1990	T-5	---	---	---	33.6	---	---	---	209.6
09/27/1990	T-6	---	---	---	51.5	---	---	---	9.4
09/27/1990	T-7	---	---	---	115.0	---	---	---	44.7
09/27/1990	T-7A	---	---	---	50.3	---	---	---	29.2
09/27/1990	T-8A	---	---	---	202.0	---	---	---	486.2
09/27/1990	T-9	---	---	---	49.0	---	---	---	61.0
09/27/1990	T10	---	---	---	472.0	---	---	---	20.6
09/27/1990	T11	---	---	---	100.0	---	---	---	169.2
09/27/1990	T13	---	---	---	113.0	---	---	---	47.2

Lake Sunapee Underwater Irradiance (Relative Percent) FBG Data 1990

Site 22B DEPTH (m)	21 June 90 LIGHT % of 0.1m	Site 22A DEPTH (m)	21 June 90 LIGHT % of 0.1m	Site 22 DEPTH (m)	21 June 90 LIGHT % of 0.1m	Site 22A DEPTH (m)	28 August 90 LIGHT % of 0.1m
0.100	100.000	0.100	100.000	0.100	100.000	0.100	100.000
0.500	71.000	0.500	68.000	0.500	43.000	0.500	72.000
1.000	43.000	1.000	49.000	1.000	31.000	1.000	51.000
2.000	31.000	2.000	35.000	2.000	21.000	2.000	41.000
3.000	25.000	3.000	27.000	3.000	15.000	3.000	29.000
4.000	18.000	4.000	21.000	4.000	13.000	4.000	17.000
5.000	13.000	5.000	17.000	5.000	9.500	5.000	10.000
6.000	9.000	6.000	11.000	6.000	6.900	6.000	7.000
7.000	6.300	7.000	9.000	7.000	5.000	7.000	4.400
8.000	4.700	8.000	6.700	8.000	3.700	8.000	3.100
9.000	3.500	9.000	4.800	9.000	2.700	9.000	2.100
10.000	2.500	10.000	3.500	10.000	2.000	10.000	1.500
11.000	1.800	11.000	2.700	11.000	1.500	11.000	1.000
12.000	1.400	12.000	2.000	12.000	1.100	12.000	0.670
13.000	1.000	13.000	1.500	13.000	0.700	13.000	0.440
14.000	0.800	13.500	1.100	14.000	0.510	14.000	0.280
15.000	0.580			15.000	0.380	15.000	0.170
16.000	0.410			16.000	0.270	16.000	0.080
17.000	0.280			17.000	0.200	16.500	0.061
				18.000	0.130		
				19.000	0.100		
				20.000	0.050		
				21.000	0.018		

Site 22B DEPTH (m)	28 August 90 LIGHT % of 0.1m
0.100	100.000
0.500	71.000
1.000	59.000
2.000	41.000
3.000	30.000
4.000	20.000
5.000	16.000
6.000	11.000
7.000	9.000
8.000	6.000
9.000	4.000
10.000	3.200
11.000	2.000
12.000	1.200
13.000	0.900
14.000	0.640
15.000	0.370
16.000	0.230
16.500	0.150

Site 22 DEPTH (m)	28 August 90 LIGHT % of 0.1m
0.100	100.000
0.500	78.000
1.000	61.000
2.000	45.000
3.000	27.000
4.000	19.000
5.000	12.000
6.000	9.000
7.000	6.100
8.000	4.100
9.000	2.800
10.000	2.100
11.000	1.600
12.000	1.100
13.000	0.900
14.000	0.630
15.000	0.470
16.000	0.300
17.000	0.200
18.000	0.120
19.000	0.080
20.000	0.036
21.000	0.007

Lake Sunapee Deep Site Temperature-Oxygen Profiles FBG Data 1990

Site 22B 21 June 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	19.7	8.4
0.50	19.7	8.6
1.00	19.7	8.7
2.00	19.7	8.8
3.00	19.1	9.1
4.00	18.4	9.7
4.50	17.3	10.1
5.00	17.0	10.2
5.50	16.8	10.1
6.00	16.5	10.3
6.50	16.3	10.2
7.00	15.7	10.3
7.50	15.4	10.2
8.00	15.3	10.3
8.50	15.0	10.2
9.00	14.9	10.2
9.50	14.7	10.1
10.00	14.6	10.1
11.00	14.0	10.0
12.00	13.6	9.9
13.00	13.4	9.9
14.00	13.1	9.7
15.00	13.1	9.7
16.00	12.8	9.4
17.00	12.7	9.2

Site 22A 21 June 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	21.9	7.7
0.50	21.9	7.3
1.00	21.9	7.1
2.00	21.9	7.2
3.00	21.0	8.3
4.00	20.1	8.6
4.50	19.0	9.2
5.00	18.3	9.5
5.50	17.5	9.9
6.00	16.7	9.9
6.50	16.3	10.0
7.00	16.1	10.0
7.50	15.8	10.0
8.00	15.3	10.1
8.50	14.8	10.1
9.00	14.5	10.1
10.00	14.1	10.2
11.00	13.5	10.0
12.00	13.1	9.8
13.00	12.8	9.6
13.50	12.6	9.4

Site 22 21 June 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	21.4	7.9
0.50	21.4	7.8
1.00	21.4	7.9
2.00	21.4	7.9
3.00	21.3	7.9
4.00	21.0	8.1
4.50	19.4	9.0
5.00	18.0	9.6
5.50	17.2	9.9
6.00	16.9	9.9
6.50	16.7	10.1
7.00	16.5	10.1
7.50	15.9	10.1
8.00	15.7	10.1
8.50	15.3	10.2
9.00	14.8	10.1
9.50	14.4	10.2
10.00	14.1	10.1
10.50	13.9	10.2
11.00	13.6	10.1
12.00	13.4	10.2
13.00	12.9	10.0
14.00	12.7	10.0
15.00	12.2	9.9
16.00	12.0	9.8
17.00	11.8	9.5
18.00	11.7	9.6
19.00	11.6	9.5
20.00	11.4	9.0
21.00	11.3	9.3
22.00	11.2	8.8

Site 22A 28 August 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	23.4	8.2
0.50	23.4	8.7
1.00	23.3	8.8
2.00	23.3	8.8
3.00	23.1	8.8
4.00	23.0	8.7
5.00	22.1	9.0
5.50	22.0	8.9
6.00	21.9	9.0
6.50	21.8	9.0
7.00	21.5	8.8
7.50	21.4	8.9
8.00	20.1	8.6
8.50	19.0	9.3
9.00	17.5	9.8
9.50	16.2	9.9
10.00	15.4	9.4
10.50	14.5	9.3
11.00	13.6	8.4
11.50	13.5	8.5
12.00	13.4	8.4
12.50	13.0	7.8
13.00	12.8	7.2
14.00	12.4	6.7
15.00	12.2	6.3
16.00	12.1	6.1
17.00	11.9	4.3
17.25	11.9	3.1

Site 22B 28 August 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	22.9	8.4
0.50	22.9	8.5
1.00	22.9	8.5
2.00	22.8	8.6
3.00	22.7	8.5
4.00	22.7	8.6
5.00	22.7	8.6
5.50	22.4	8.8
6.00	21.7	9.0
6.50	21.6	9.0
7.00	21.5	8.5
7.50	21.3	8.7
8.00	20.3	8.5
8.50	20.1	8.4
9.00	19.1	8.2
9.50	17.2	9.3
10.00	16.3	8.4
10.50	15.8	8.9
11.00	15.4	9.1
11.50	15.0	9.0
12.00	14.7	9.1
13.00	14.2	8.3
14.00	13.2	6.3
15.00	12.4	5.8
16.00	12.1	5.3
16.50	12.0	5.0
17.00	12.0	3.5

Site 22 28 August 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	23.1	8.8
0.50	22.9	8.9
1.00	22.8	8.9
2.00	22.5	9.0
3.00	22.3	9.1
4.00	22.1	9.0
5.00	22.1	8.9
6.00	22.1	8.9
7.00	21.7	9.0
7.50	20.5	8.8
8.00	19.9	8.9
8.50	18.9	9.1
9.00	18.0	9.5
9.50	16.1	10.6
10.00	15.2	10.2
10.50	14.6	10.7
11.00	14.1	10.3
11.50	13.5	9.9
12.00	13.1	9.7
12.50	12.9	8.8
13.00	12.5	8.6
14.00	12.2	8.4
15.00	11.8	8.3
16.00	11.6	7.7
17.00	11.4	7.6
18.00	11.3	7.3
19.00	11.2	7.2
20.00	11.1	7.3
21.00	10.9	7.2
22.00	10.8	6.6
23.00	10.7	6.2
24.00	10.7	5.8
25.00	10.6	5.1
26.00	10.5	5.0
27.00	10.4	4.4
28.00	10.4	3.9
29.00	10.3	2.4
29.50	10.2	0.4

Site 22 4 October 90

Depth (m)	Temperature	Diss. oxygen (mg l)
0.10	17.1	8.9
0.50	17.1	8.9
1.00	16.4	8.8
2.00	16.3	8.8
3.00	16.2	8.7
4.00	16.2	8.7
5.00	16.2	8.6
6.00	16.1	8.6
7.00	16.1	8.6
8.00	16.1	8.4
9.00	16.1	8.5
10.00	16.1	8.4
11.00	16.1	8.4
11.50	15.5	7.8
12.00	13.7	5.5
12.50	12.7	4.8
13.00	12.2	4.8
14.00	11.8	4.7
15.00	11.2	4.4
16.00	11.0	4.2
17.00	10.8	3.8
18.00	10.6	3.8
19.00	10.3	3.5
20.00	10.1	3.0
20.50	10.0	2.9
21.00	10.0	2.3