2002-2003

BEAR LAKE MONITORING DATA SUMMARY

Prepared for:

BEAR LAKE REGIONAL COMMISSION
Fish Haven, Idaho

Prepared by:

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INTRODUCTION

Water quality conditions were monitored in a single mid-lake station on Bear Lake during 2002-2003. The purpose of the Bear Lake monitoring program has been to:

1) Evaluate current water quality conditions in Bear Lake; and

2) Maintain the current water quality database.

Data was collected from the middle station of Bear Lake on six dates between July 16, 2002 and June 10, 2003. A map designating the sample location as well as long-term water quality plots are included in Appendix A. Raw data are presented in Appendix B. The following is a summary of the Bear Lake data.

BEAR LAKE WATER QUALITY

Bear Lake was sampled from July 2002 to June 2003. Bear Lake was sampled once during both summer stratifications as well as spring and fall turnover. The lake was sampled twice during the winter conditions. Samples were taken from the middle station (approximately 60 meters in depth) at ten meter intervals.

Surface and bottom total phosphorus (TP) concentrations were less than detection (5 μg/L) in nearly 80 percent of the samples (Figure 1). When results were less than the detection limit, half the value (2.5 μg/L) was used for sample values for statistical analysis. During the 2002 to 2003 sampling period, the total phosphorous levels were lower than ever reported from past monitoring efforts. The average surface total phosphorus concentrations in Bear Lake ranged from 4 to 9.3 μg/liter. Bottom concentrations ranged from to 4 to 72.4 μg/liter. With the exception of the November 2002 data, all total phosphorous concentrations were at or near detection. The reason for the low phosphorous concentrations may be the result of increased calcium carbonate precipitation in the lake. This is reflected in the loss of transparency (to be discussed in a later section of this report).

Average surface and bottom orthophosphorous (OP) concentrations were similar during the 2002 to 2003 monitoring program (Figure 2), ranging from less than 1.0 μg/liter to 2.0 μg/liter in the epilimnion and less than 1.0 μg/liter to 3.5 μg/liter in the hypolimnion. Less than detection results (<1 μg/L) accounted for 55 percent of the samples. The highest concentration of OP was observed in April 2003. November 2002 had the lowest concentrations during which all depths exhibited less than detection levels.

Surface total inorganic nitrogen (TIN) concentrations have stabilized at pre-1997 levels with almost all TIN expressed as ammonia (Figure 3). During the summer of 2002, total inorganic nitrogen (NH_3+NO_3+NO_2) surface concentrations ranged from 30 μg/liter to a high of 187 μg/liter at the end of September. Compared to the historical dataset, this peak was only 25 percent of the TIN encountered in 1997 (Figure 5, top).

The majority of the TIN was present as ammonia. Average surface ammonia ranged from 24 to 183 µg/liter (Figure 5, bottom) during the summer-fall of 2002 (highest concentrations). The November 2002 profile had the overall lake wide lowest ammonia concentrations. During the 2002 to 2003 sample period, there was not a noticeable hypolimnetic buildup of ammonia in the late summer samples.

Water transparency, measured with a secchi disk, ranged from 6.7 meters in July 2002 to a minimum of 3.0 meters in January 2003 (Figure 6, top). During this monitoring season, the secchi disk had transparencies greater than five meters only 50 percent of the time. It is interesting to note that the transparency has been systematically decreasing since a recorded maximum of 11.2 meters in 1996. This corresponds to the decrease in the elevation of Bear Lake.

Chlorophyll-*a* concentrations followed transparency patterns during this monitoring period, with the lowest surface chlorophyll levels (0.05 µg/liter) corresponding to the deepest secchi disk transparencies while the highest chlorophyll levels (0.41 µg/liter) were associated with the shallowest readings. It should be noted that the same pattern was evident last year with little or no relationship to chlorophyll. (Figure 6, bottom). It is believed that the transparency pattern is the result of abiotic turbidity and not biological particles (algae).

Average surface and bottom pH levels were similar to the previous monitoring years (1996-2002), ranging from a low of 7.85 and 7.99 (epilimnion and hypolimion, respectively) to a high of 8.42 and 8.55 pH units in both layers (Figure 7).

Bottom temperatures during the entire monitoring period did not exceed 3.26˚C, and the highest temperature in the epilimnion was 22.78˚C, recorded on July 16, 2002 (Figure 8). Compared to the data collected since 1996, the average epilimnetic temperature (surface and 10 meters) during this monitoring period showed an overall decrease. The lake was stratified during both summer sampling events, and had started the stratification during the second spring turnover sampling event (Figure 9).

Hypolimnetic dissolved oxygen concentrations ranged from 4.4 to 9.08 mg/liter during the monitoring period (Figure 10). Average epilimnetic concentrations of dissolved oxygen ranged from 6.79 to 10.46 mg/liter. With the exception of lower concentrations of oxygen in the hypolimnion during the summer sampling events, the year was similar to the last two monitoring seasons (2000-2002). Oxygen depressions were not as great as those seen in the 1998 to 1999 monitoring period.

SUMMARY

Plots of the long-term water quality data and a map of the long-term monitoring location are presented in Appendix A. Tables of raw data for Bear Lake are included in Appendix B.

During the 2002-2003 monitoring season, total phosphorus continued the trend toward declining levels, ranging from below detection (<5 µg/L) to 9.3 µg/liter. The lake averaged 6.1 µg/liter for the entire monitoring season. Orthophosphorus remained low as well, ranging from below detection (<1 µg/L) to 5.7 µg/liter, and averaging only 1.6 µg/liter for the entire monitoring season. Total inorganic nitrogen continued to decrease throughout 2002 and 2003 and seems to have returned to pre-1997 levels. Most of the decrease in total inorganic nitrogen

was due to the reduction of nitrate-nitrogen within the system. A slight increase in lake wide ammonia levels was observed during the summer of 2002 but returned to low levels by fall-winter.

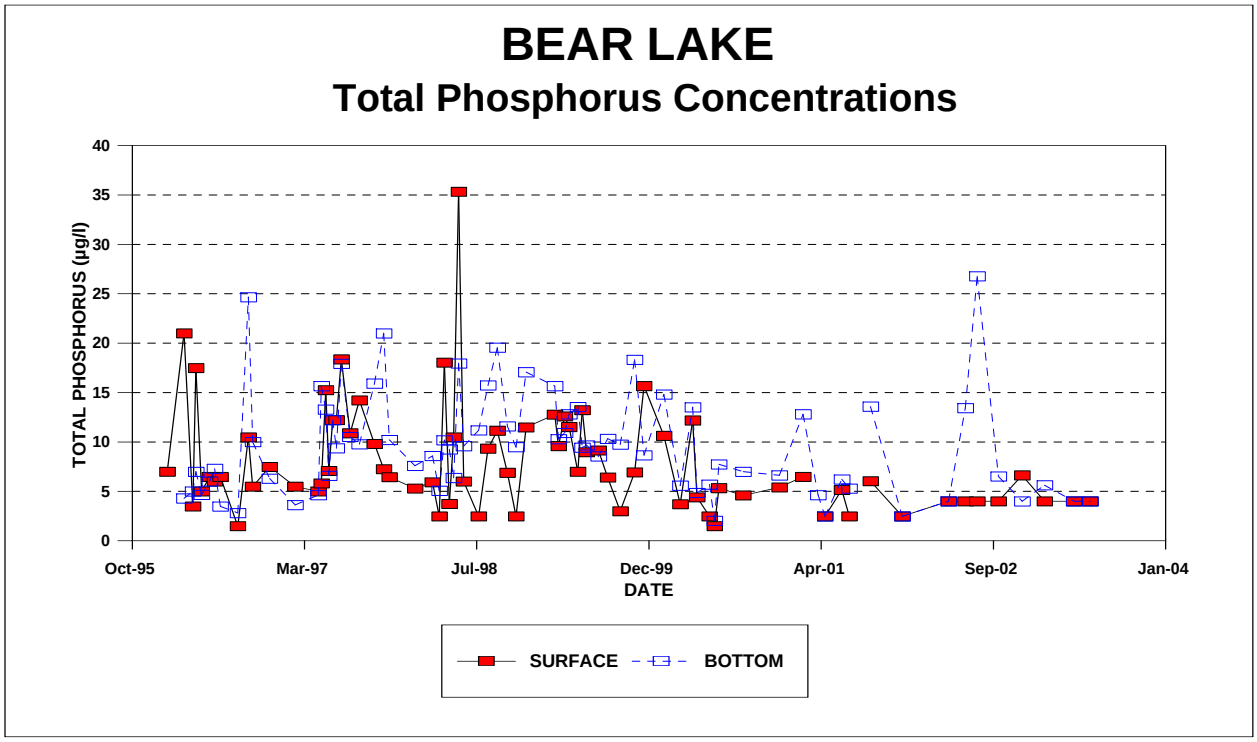
The system is currently calculated to be phosphorus limited.

RECOMMENDATIONS

1. The revised Bear Lake monitoring program is sensitive in its ability to detect changes in the physical and chemical water quality conditions in Bear Lake and should be continued.
2. Research is needed to define the relationship between Bear River inflowing water including sediments, calcium and phosphorus and Bear Lake. It is recommended that the Bear Lake Regional Commission support finding funding for research in this area. The relationship between calcium carbonate chemistry, total and orthophosphate and water transparency as well as the secondary effects on Bear Lake's trophic structure is ill defined.
3. During the technical exchange at Bear Lake in the spring of 1998, it was suggested that a detailed hydrologic budget be conducted on the lake. It is recommended that the Bear Lake Regional Commission take the lead on this task and link a nutrient budget to this effort. A detailed nutrient budget is needed for the lake. The last budgets were done 20 years ago. Significant urban development has occurred in the basin over the last two decades.
4. As noted in past years, a new environmental study (Ruzycki et al. 2001) has indicated that stocked lake trout and cutthroat troat are having an impact on the endemic prey species of Bear Lake. Funding should be sought that will allow the existing fisheries data to be entered into an electronic database for subsequent analysis.

REFERENCES

Ruzycki, J.R, W.A. Wurtsbaugh and C. Luecke. 2001. Salmonine Consumption and Competition for Endemic Prey Fishes in Bear Lake, Utah-Idaho. Transactions of the American Fisheries Society 130: 1175-1189.



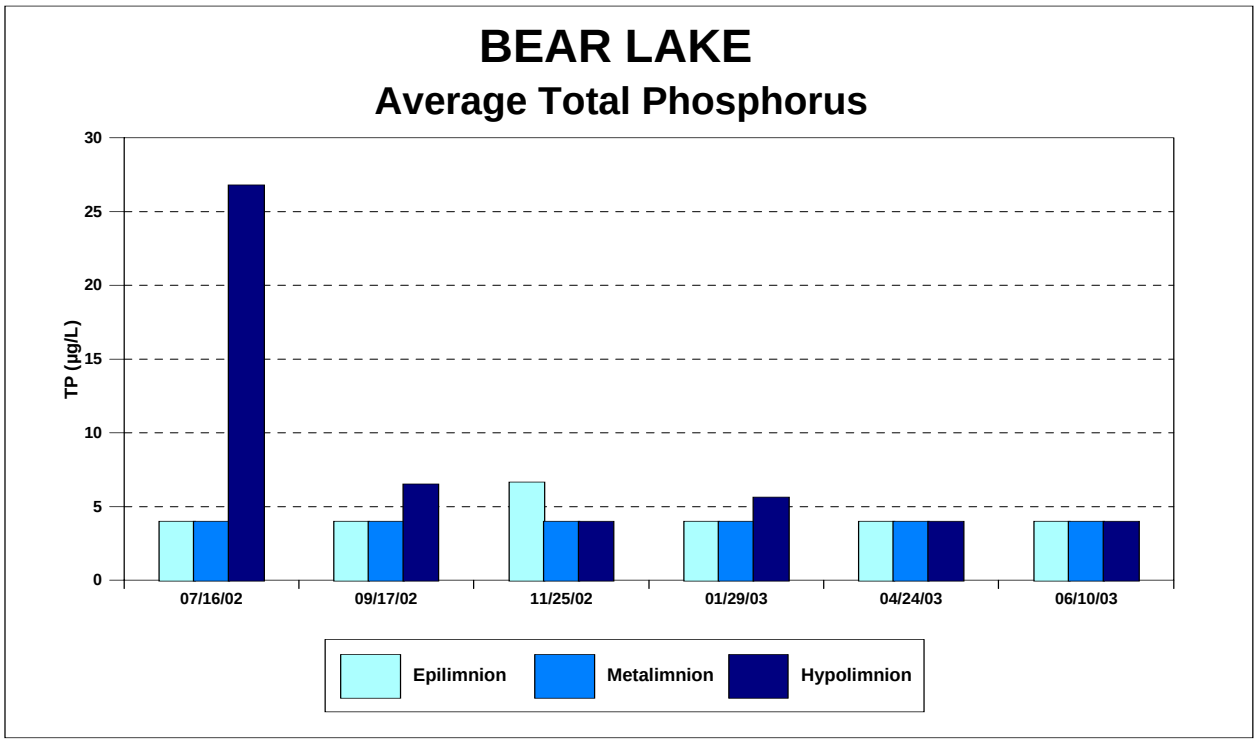


Figure 1. Concentrations of total phosphorus in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

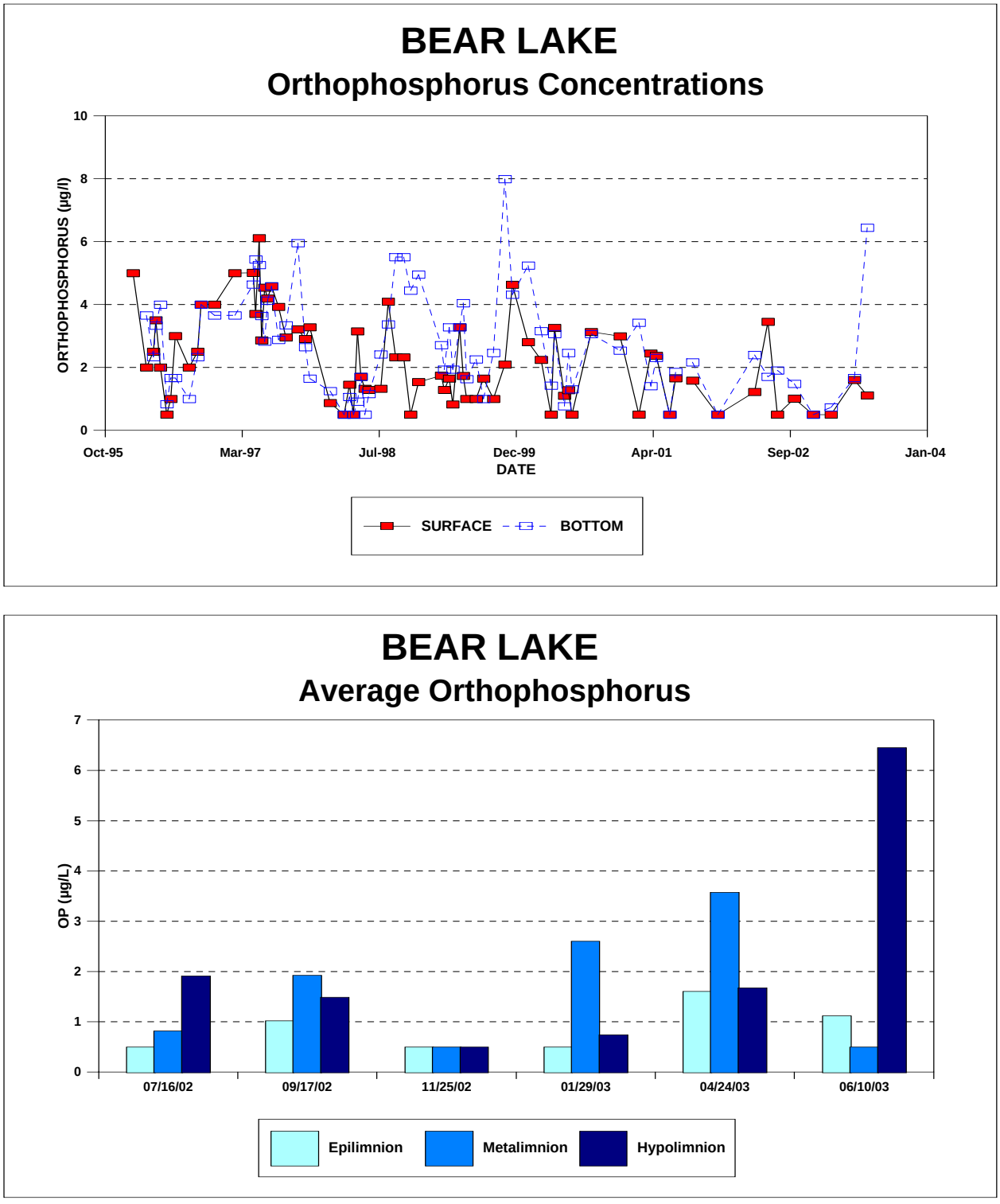


Figure 2. Concentrations of orthophosphorus in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

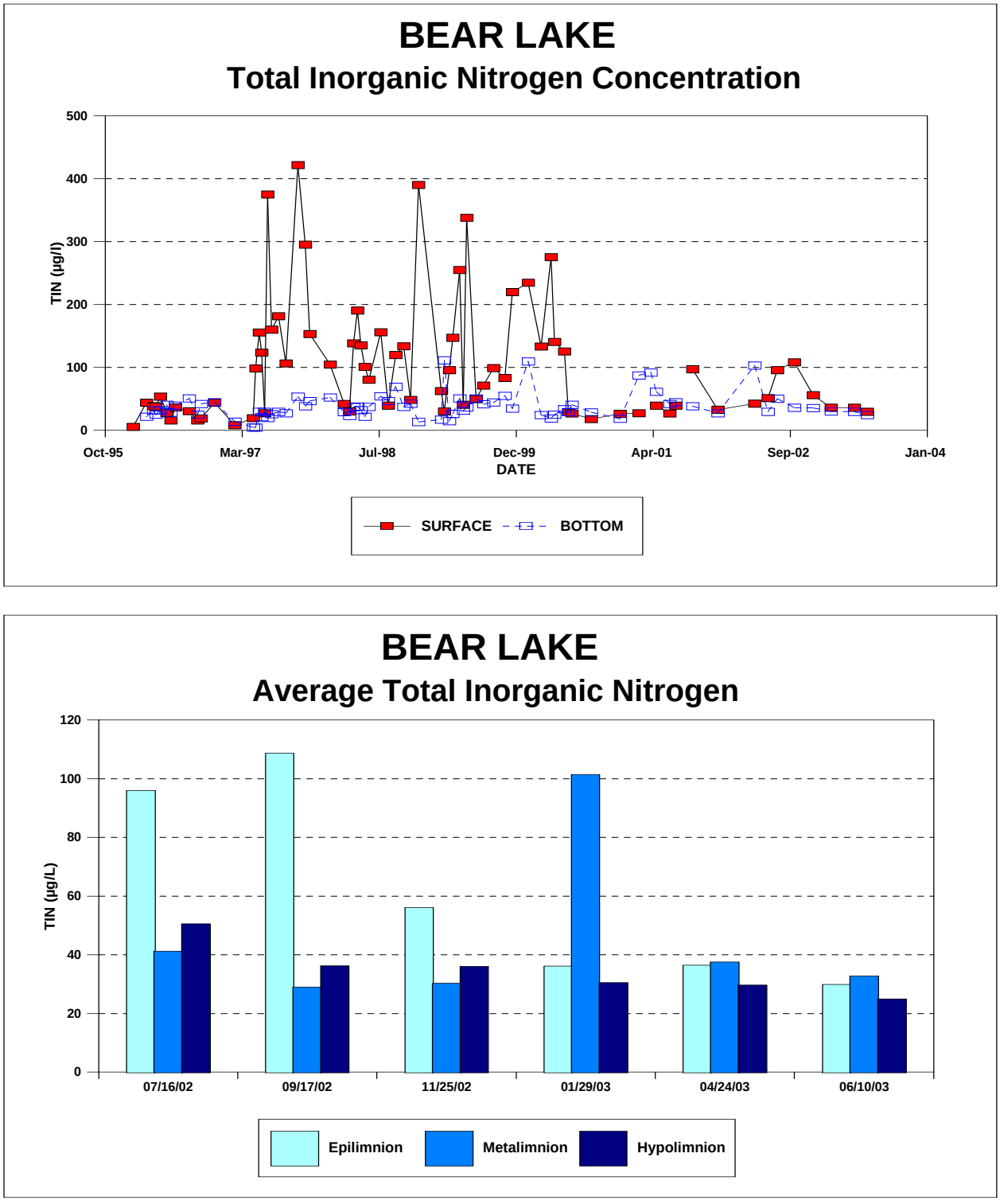


Figure 3. Concentrations of total inorganic nitrogen (NH_3+NO_3+NO_2) in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

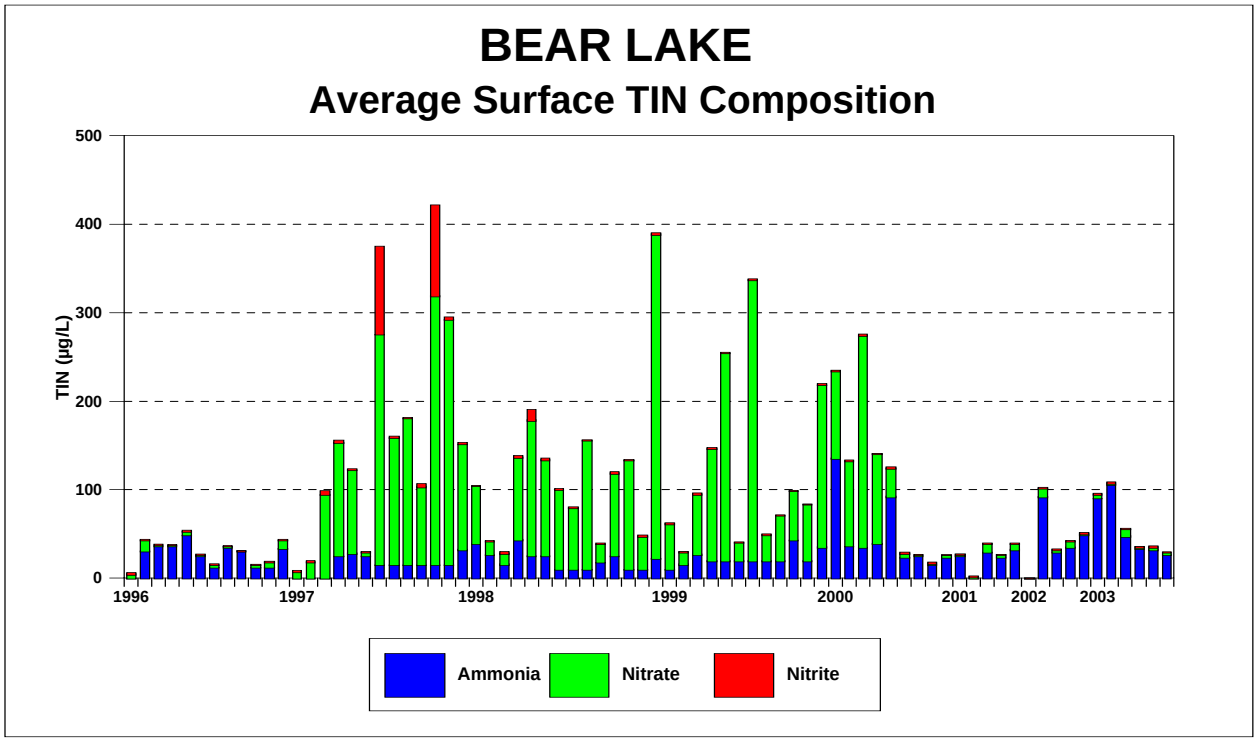


Figure 4. Total inorganic nitrogen composition of the epilimnion in Bear Lake since 1996.

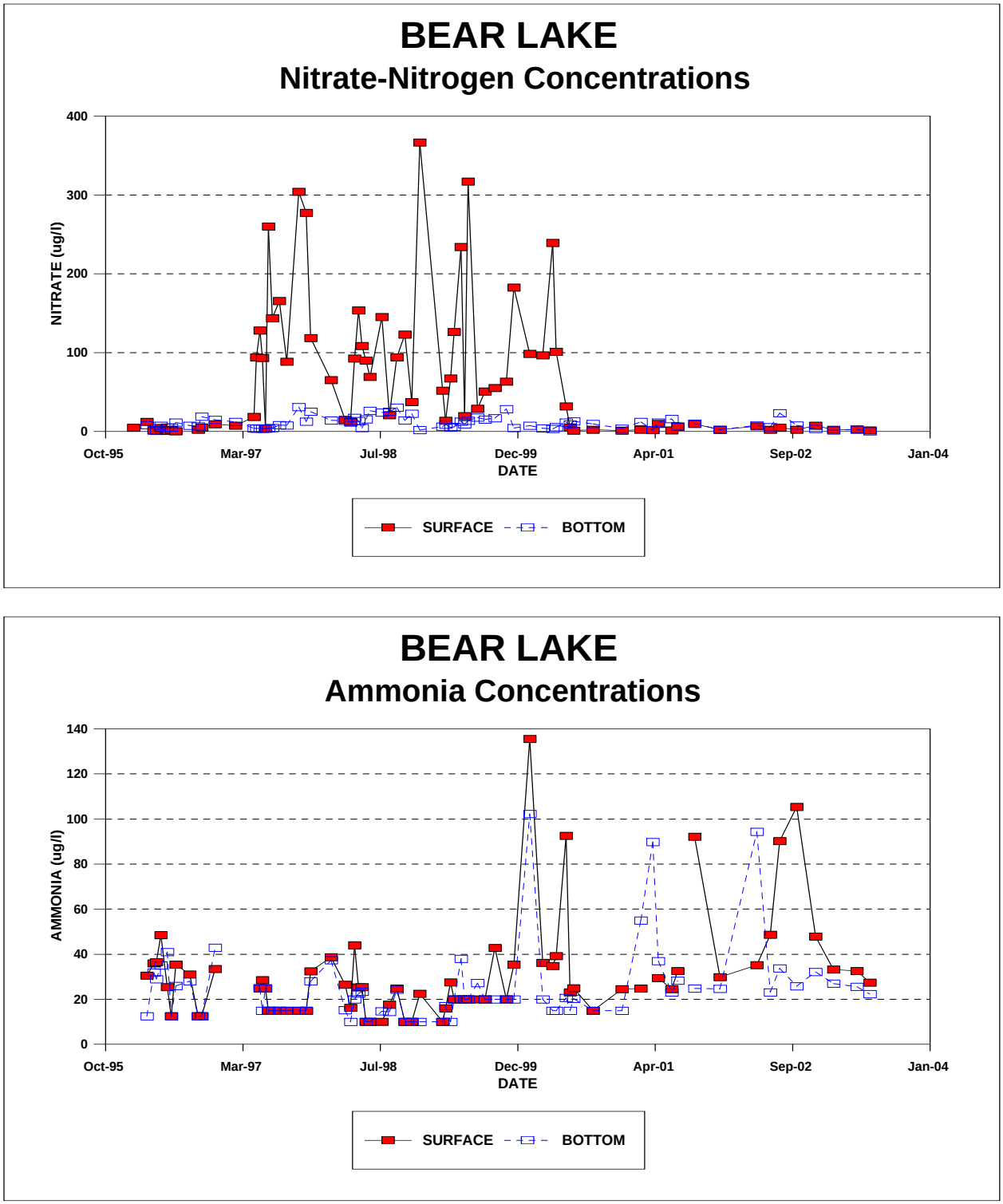


Figure 5. Concentrations of nitrate-nitrogen (above) and ammonia (below) in the surface and bottom waters of Bear Lake since 1996.

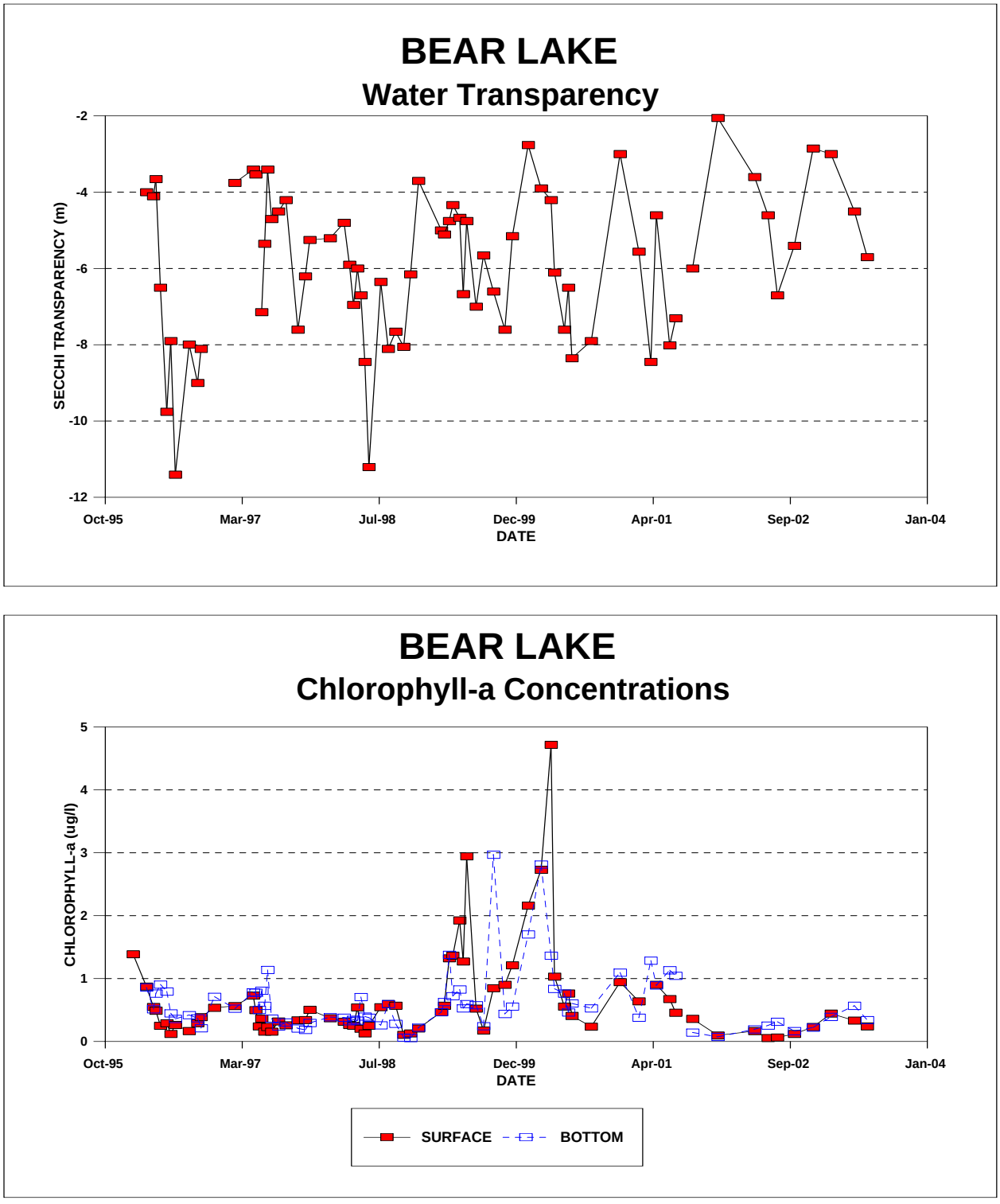


Figure 6. Water transparency (above) and surface and bottom chlorophyll-a concentrations in Bear Lake since 1996.

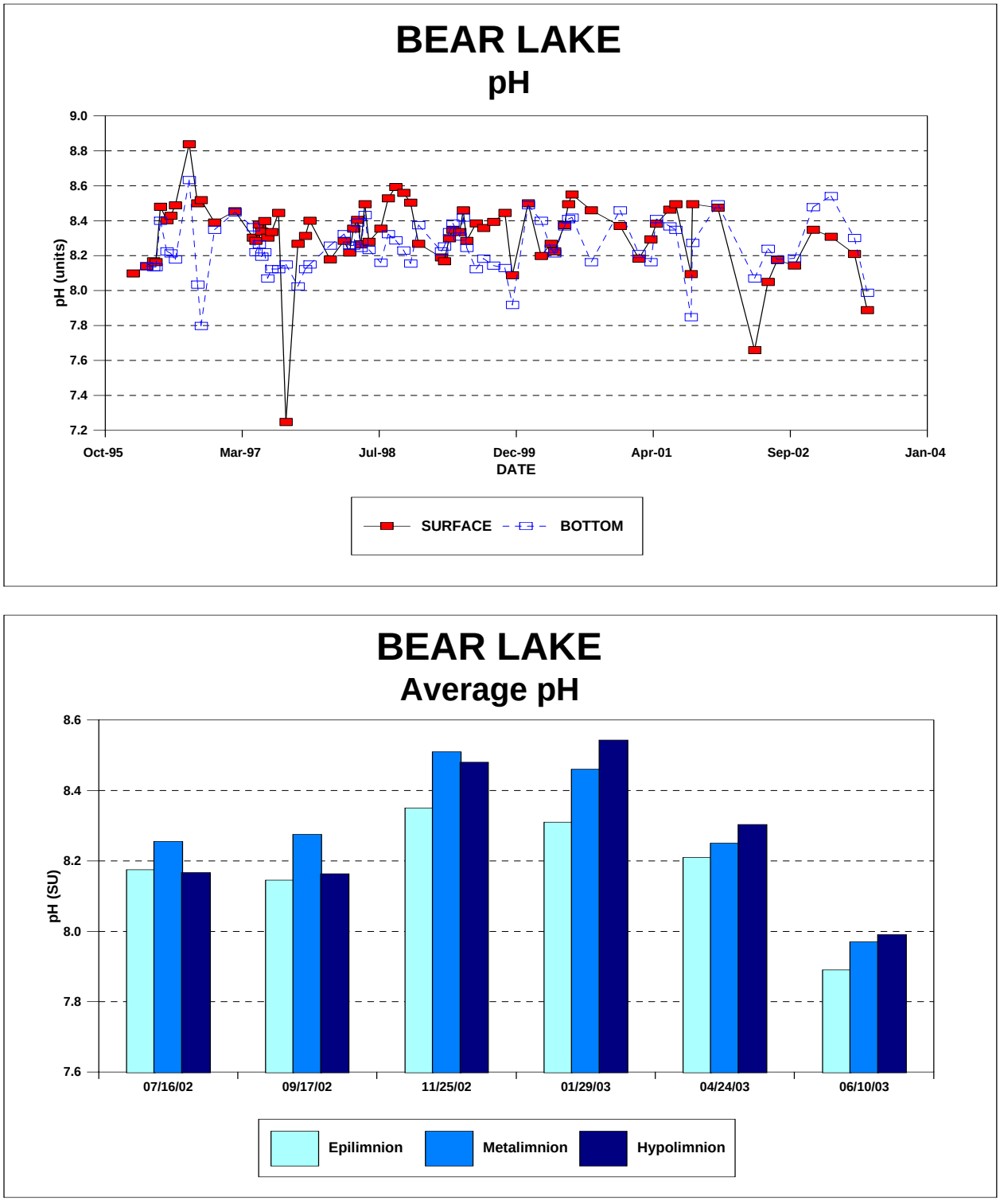


Figure 7. pH levels in the surface and bottom waters of Bear Lake since 1996 (above) and average levels within each layer of the lake for the monitoring period (below).

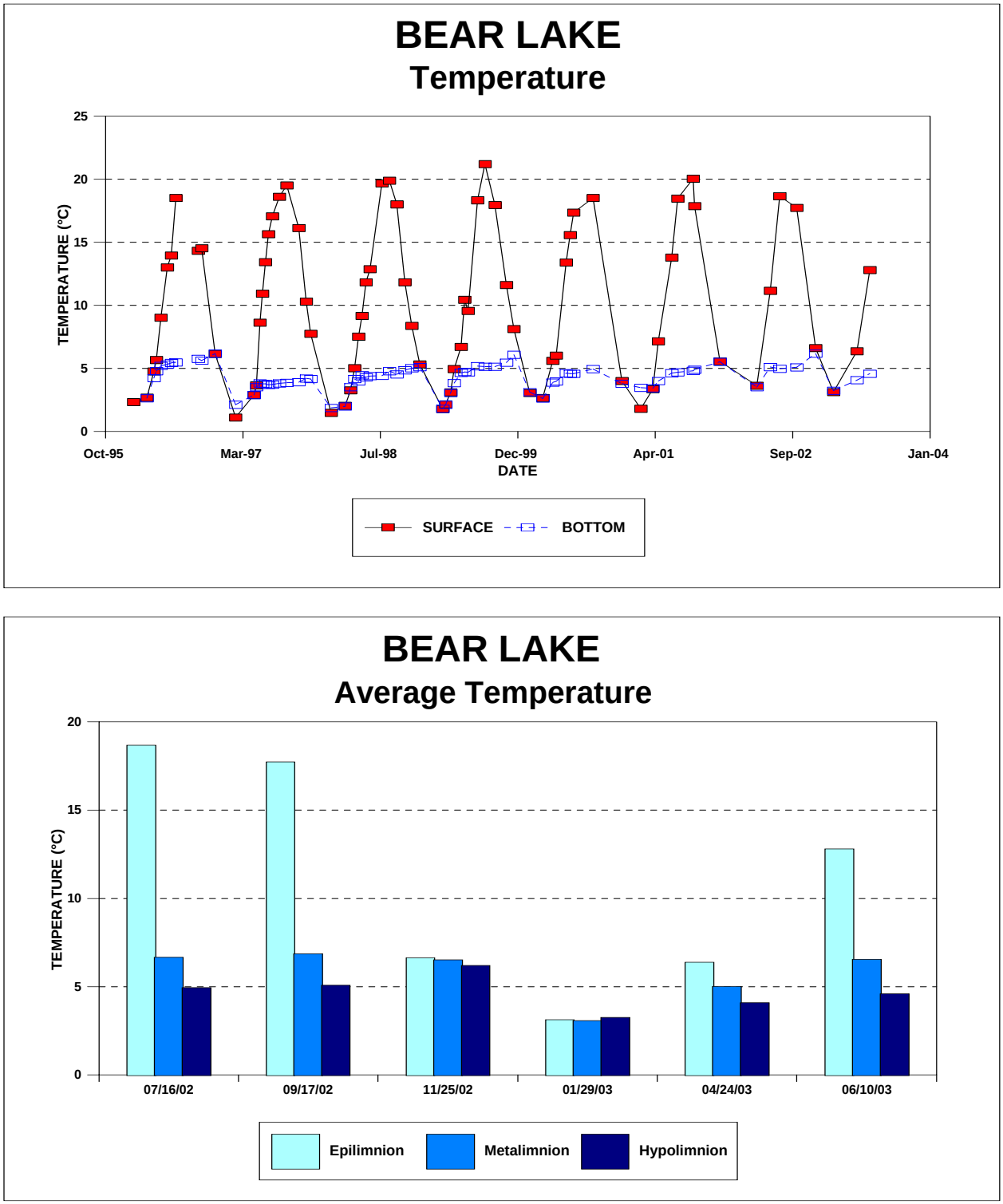


Figure 8. Temperature of the surface and bottom waters of Bear Lake since 1996 (above) and average temperature within each layer of the lake for the monitoring period (below).

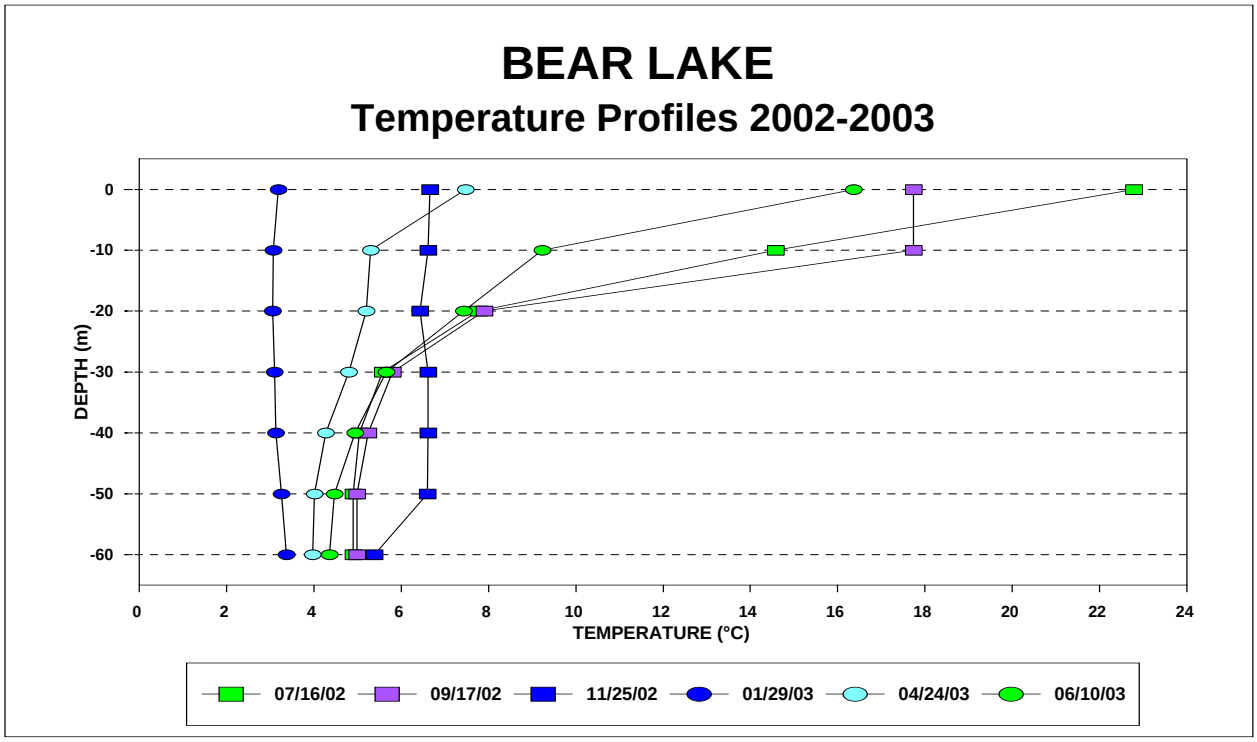


Figure 9. Temperature profiles of Bear Lake for each sampling event during the monitoring period. Green indicates summer stratification, cyan is spring turnover, purple and blue are fall and winter conditions, respectively.

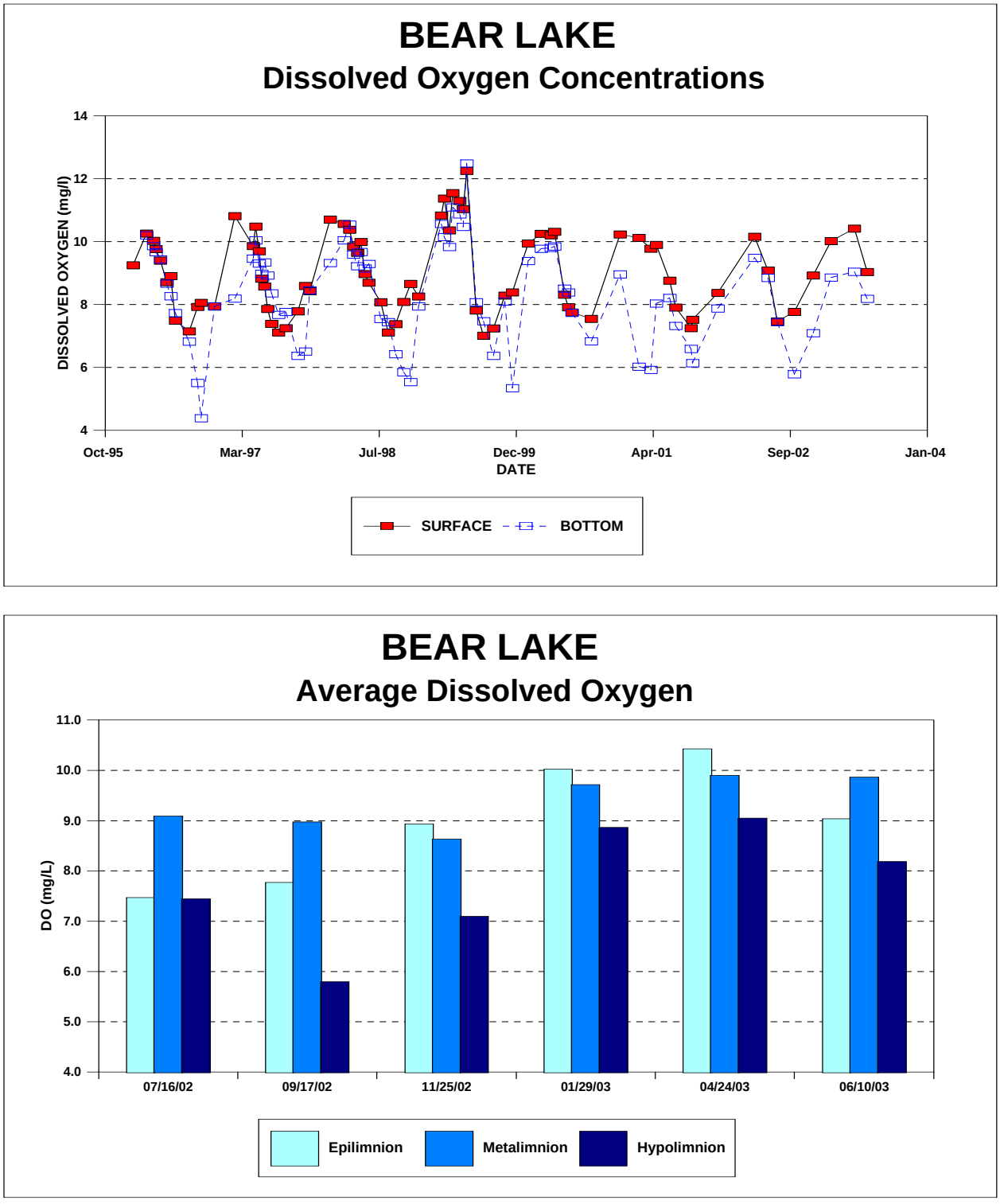
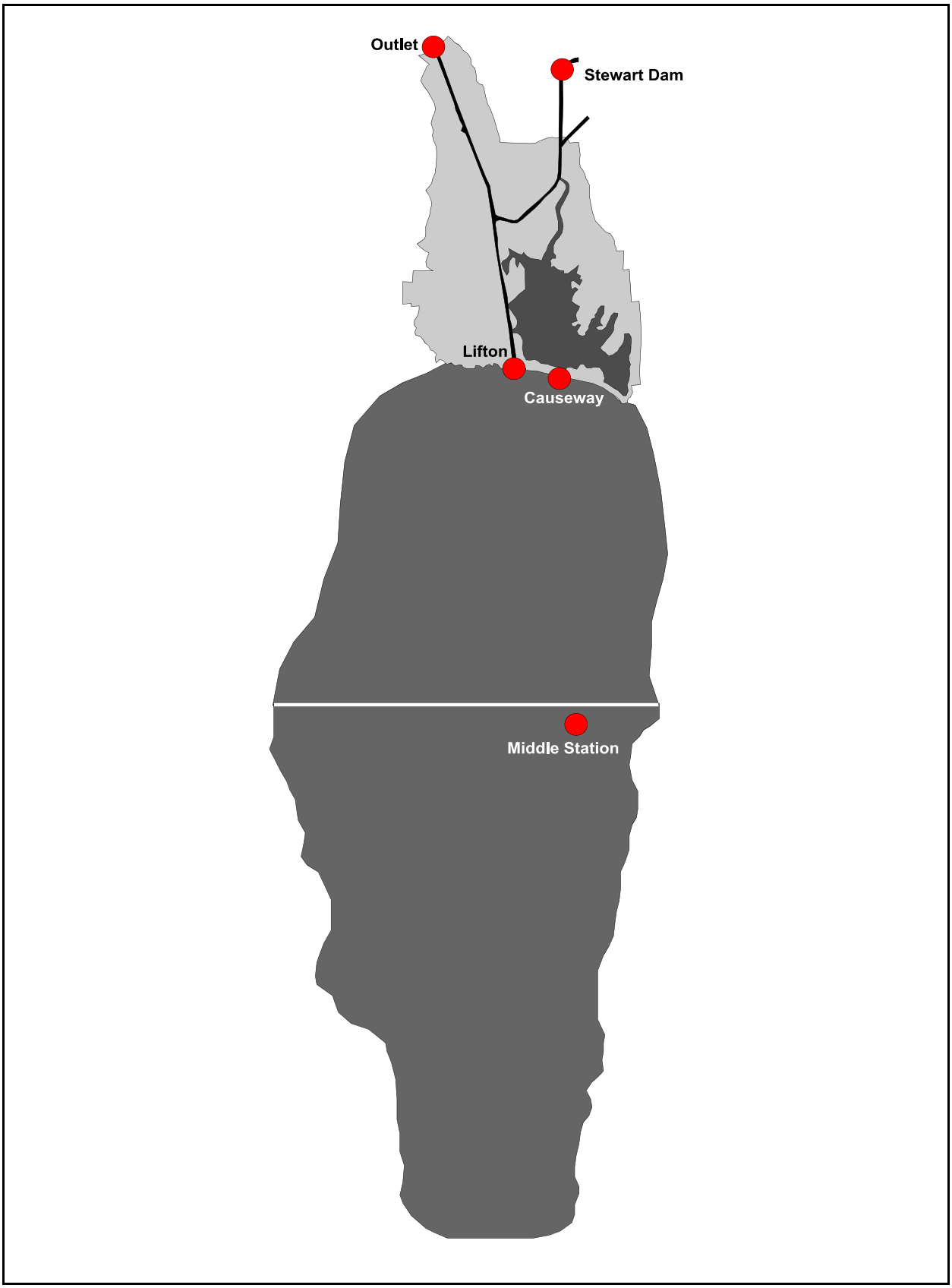
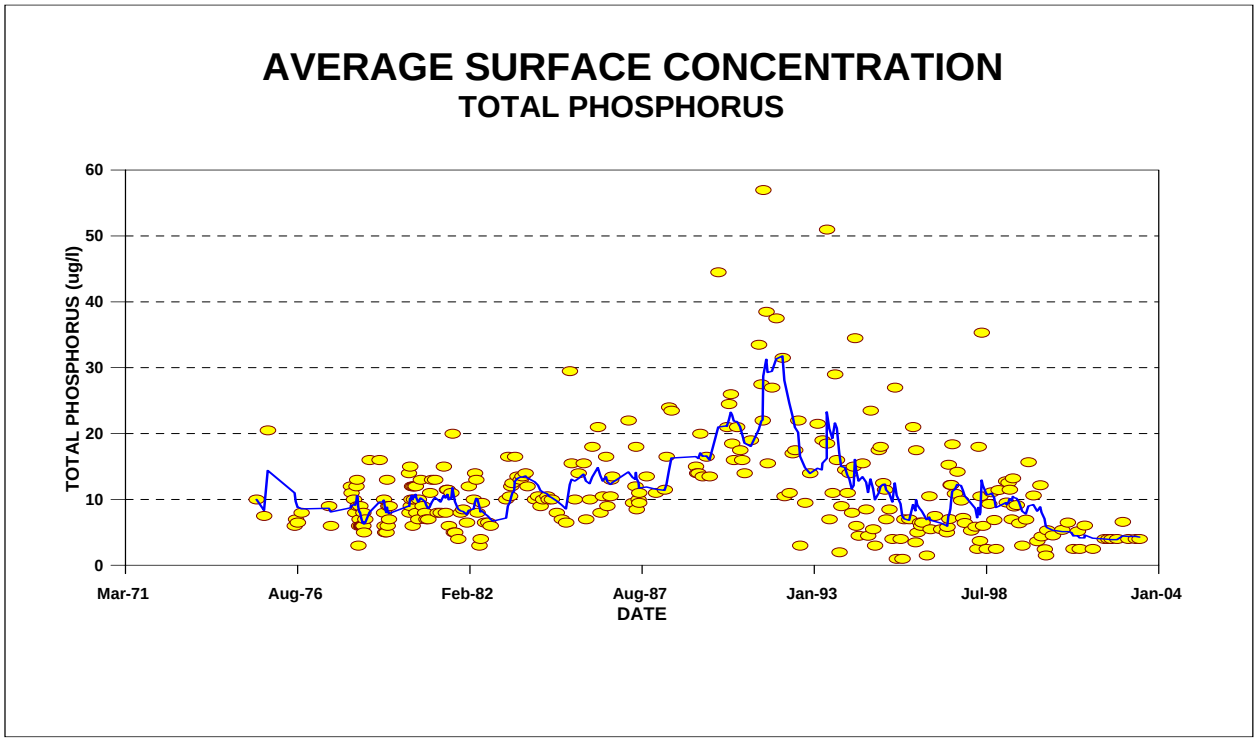


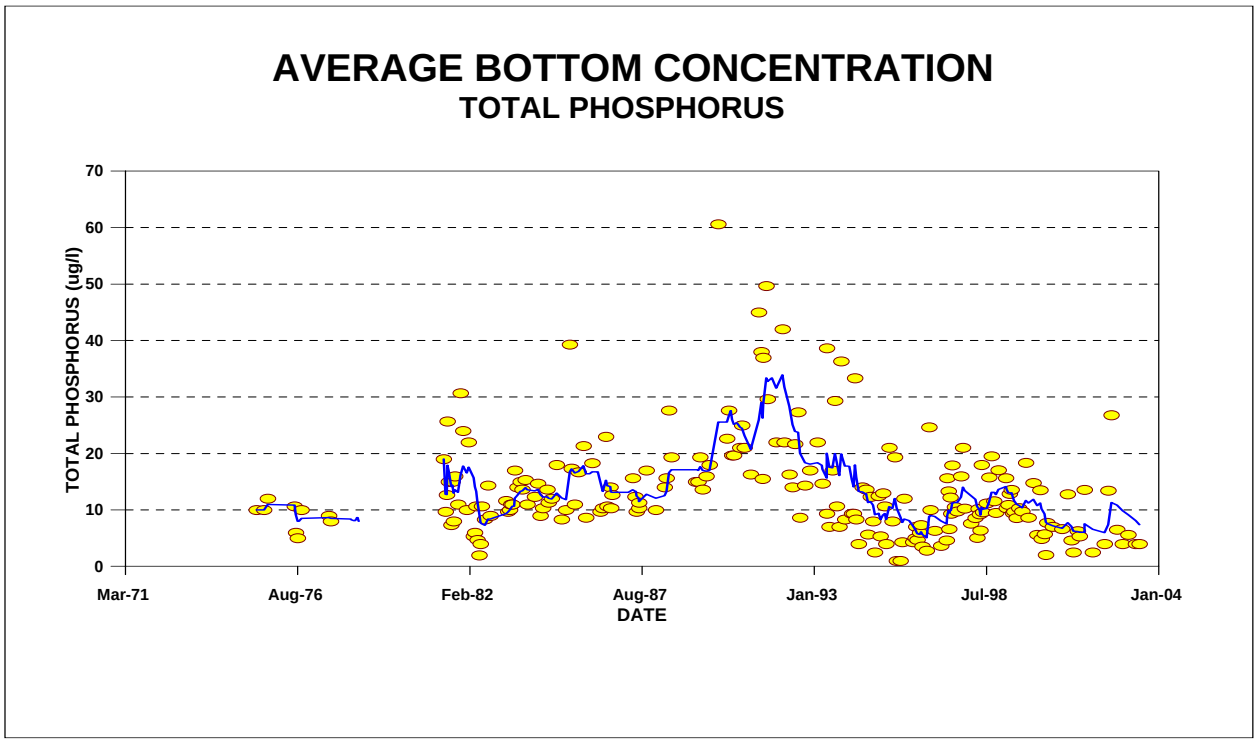
Figure 10. Dissolved oxygen concentrations in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

APPENDIX A

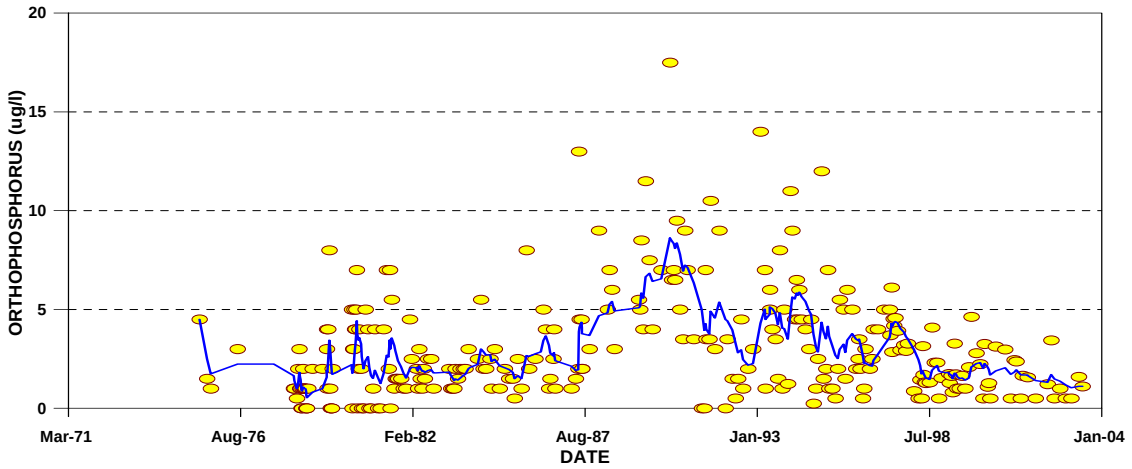
Graphs of Long-term Water Quality Data Monitoring Locations


Outlet
Stewart Dam
Lifton
Causeway
Middle Station

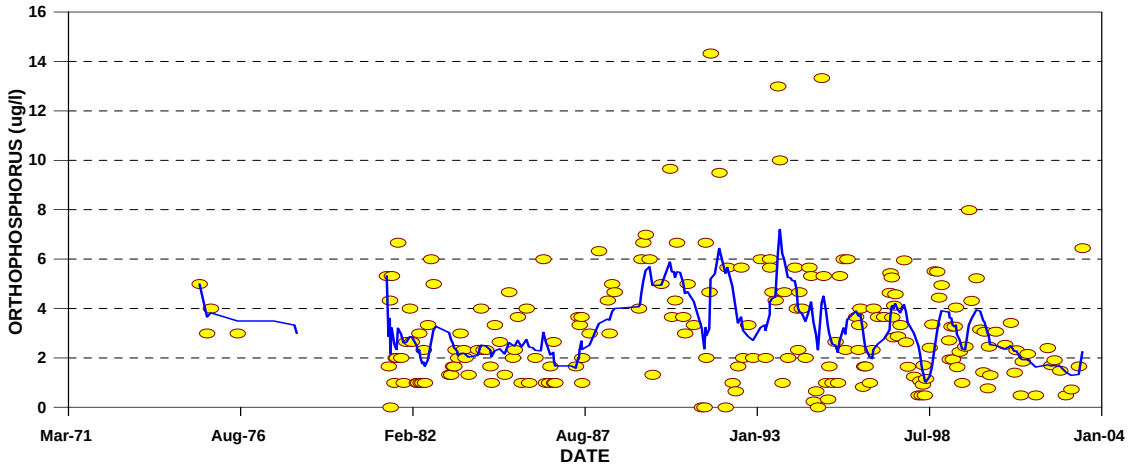

AVERAGE SURFACE CONCENTRATION
TOTAL PHOSPHORUS
TOTAL PHOSPHORUS (ug/l)
60
50
40
30
20
10
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE

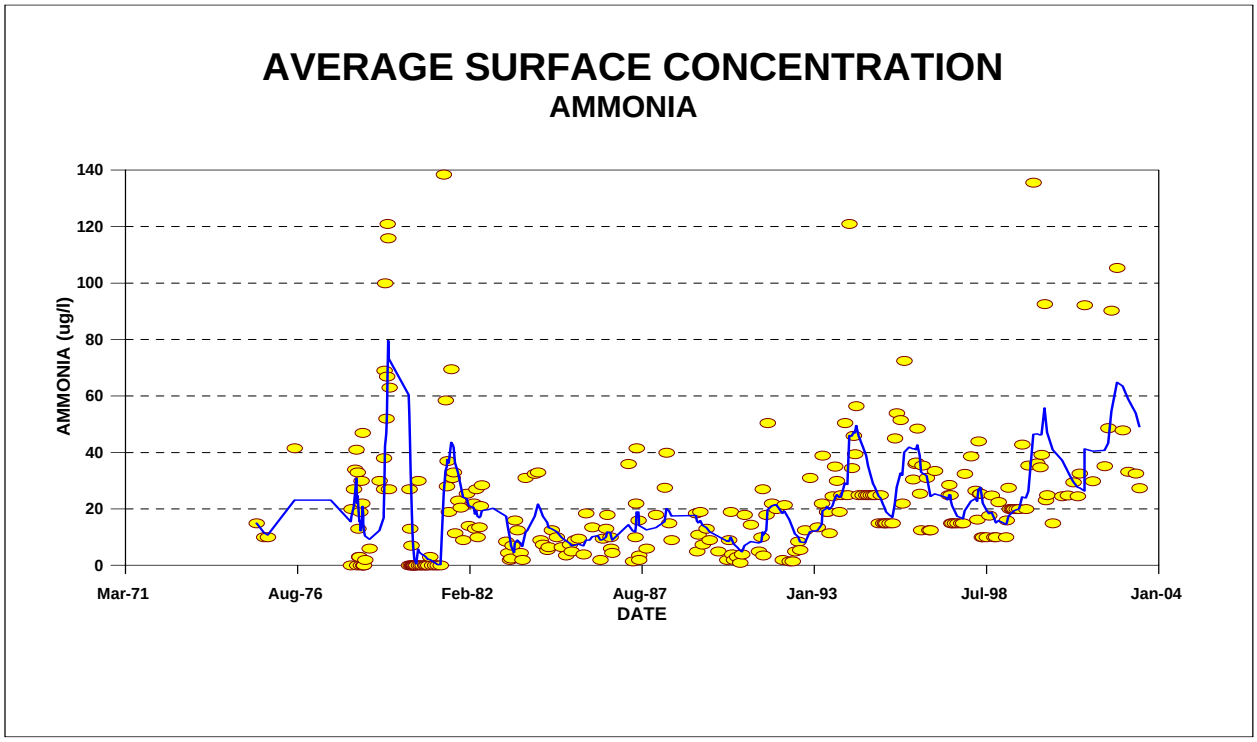

AVERAGE BOTTOM CONCENTRATION
TOTAL PHOSPHORUS
TOTAL PHOSPHORUS (ug/l)
70
60
50
40
30
20
10
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE

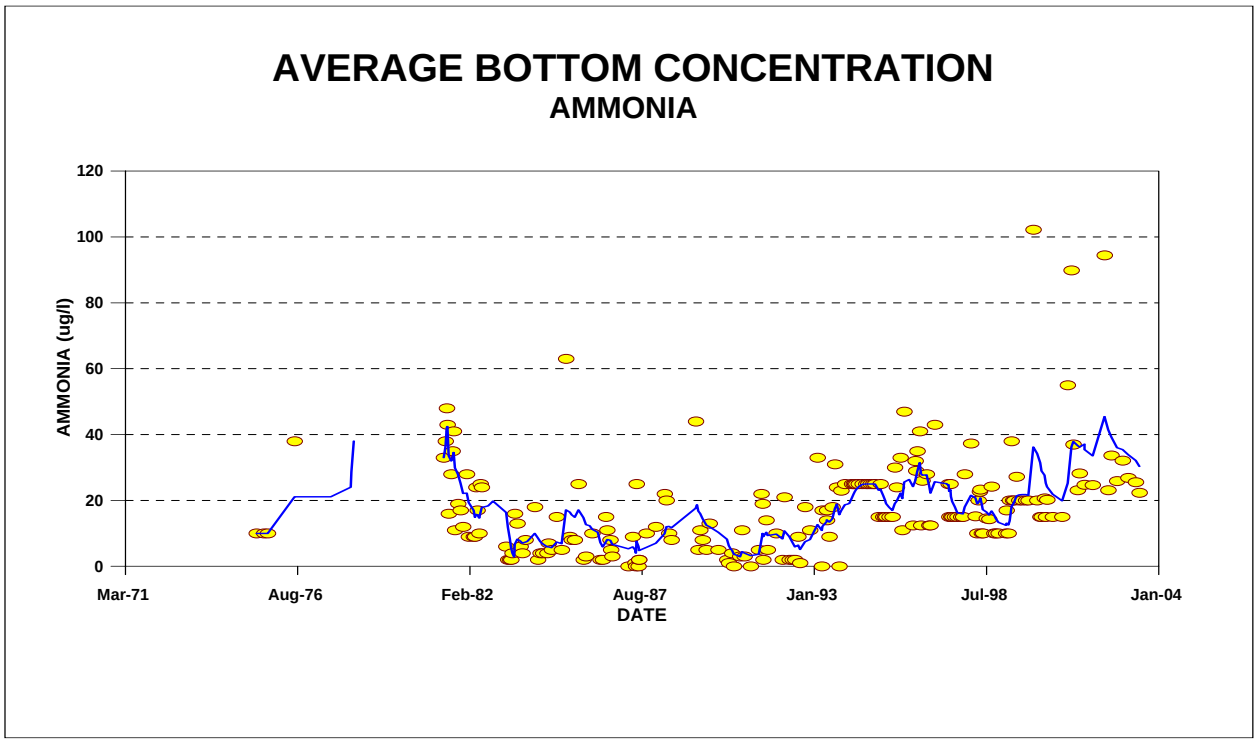
AVERAGE SURFACE CONCENTRATION
ORTHOPHOSPHORUS

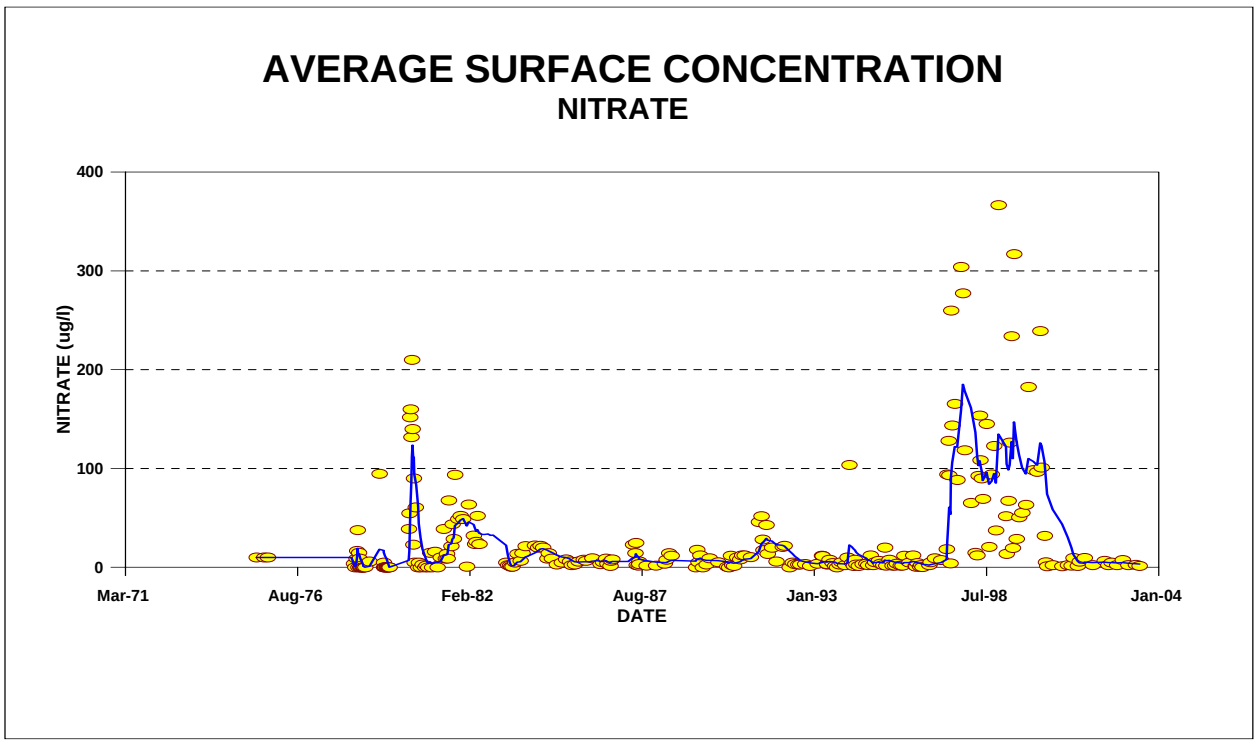


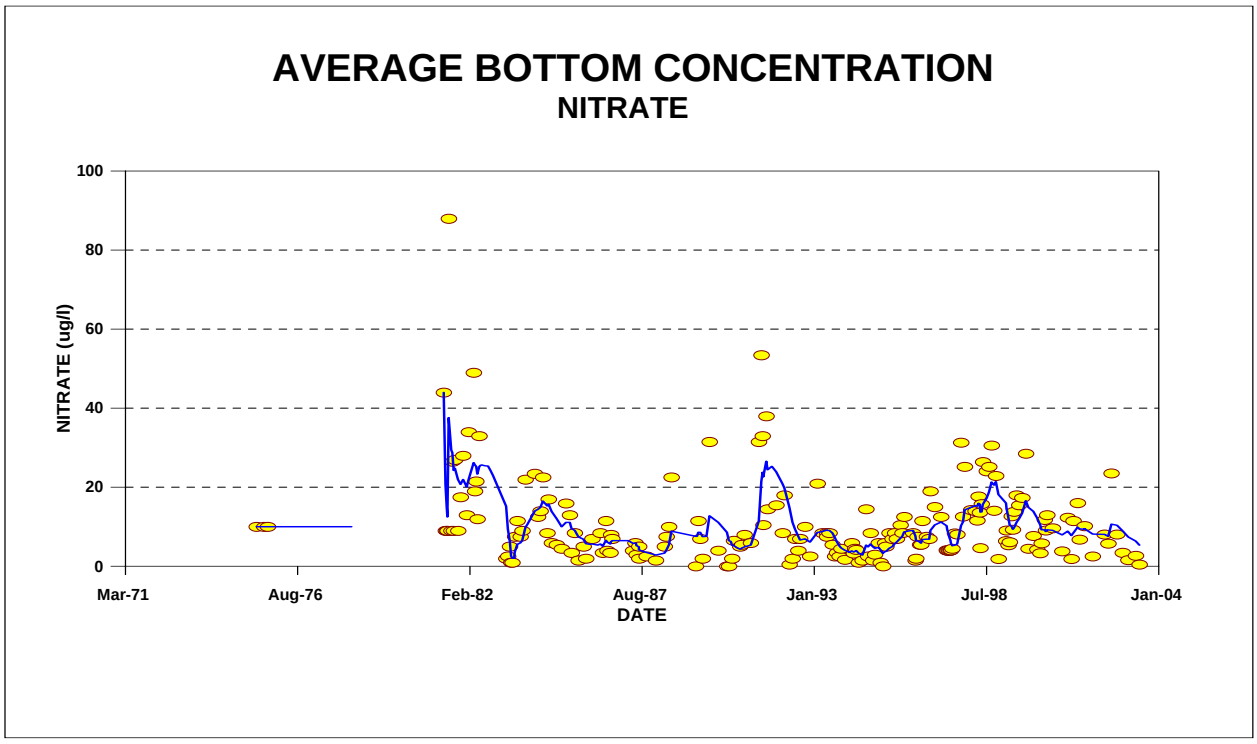
AVERAGE BOTTOM CONCENTRATION
ORTHOPHOSPHORUS



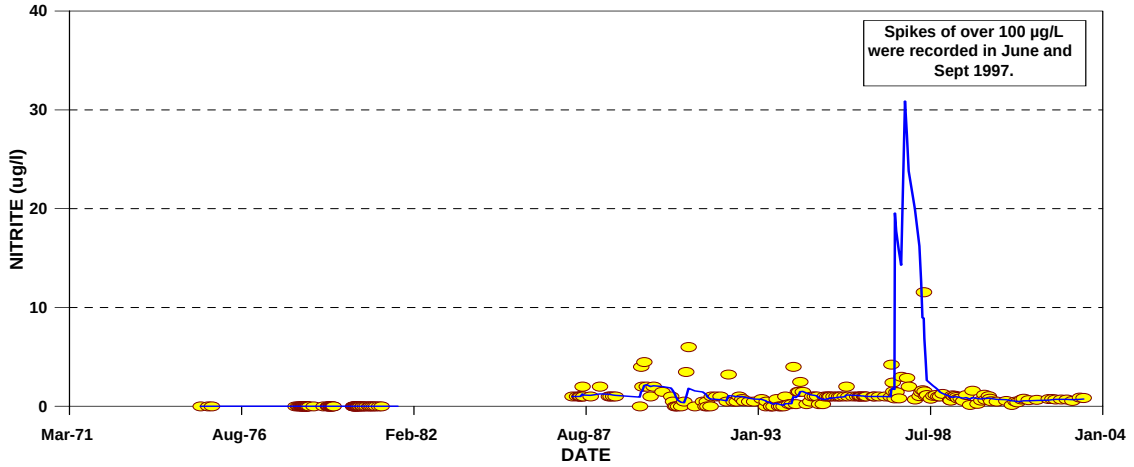

AVERAGE SURFACE CONCENTRATION
AMMONIA
AMMONIA (ug/l)
140
120
100
80
60
40
20
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE


AVERAGE BOTTOM CONCENTRATION
AMMONIA
AMMONIA (ug/l)
120
100
80
60
40
20
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE

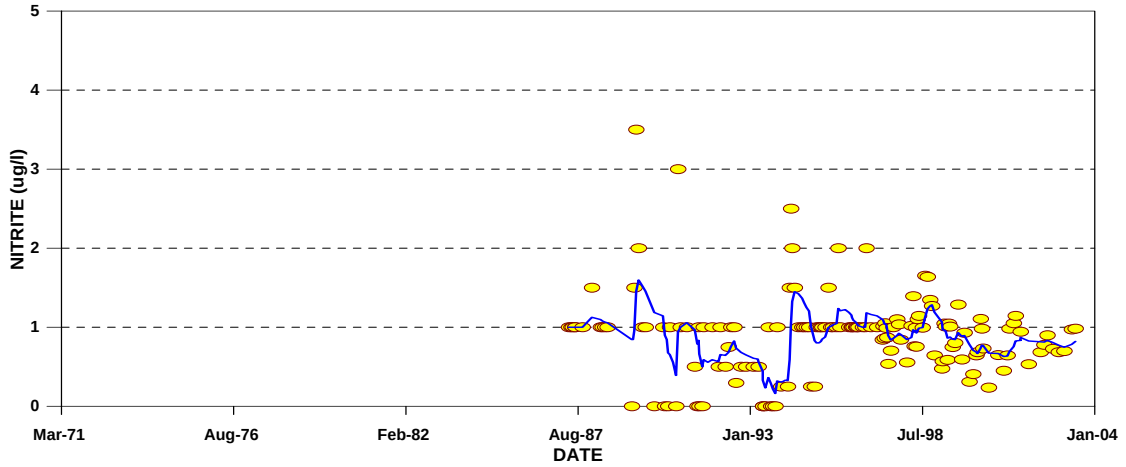

AVERAGE SURFACE CONCENTRATION
NITRATE
NITRATE (ug/l)
400
300
200
100
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE


AVERAGE BOTTOM CONCENTRATION
NITRATE
NITRATE (ug/l)
100
80
60
40
20
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE

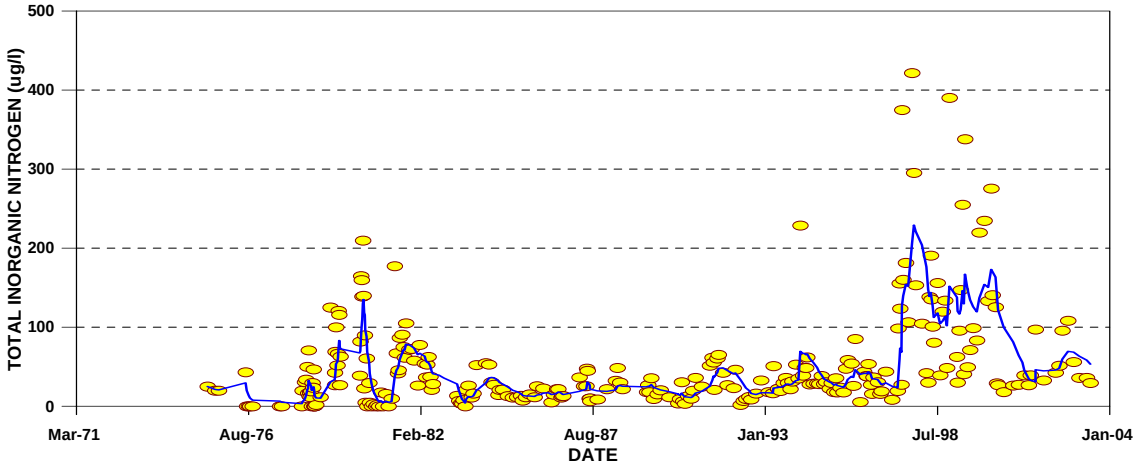
AVERAGE SURFACE CONCENTRATION
NITRITE



AVERAGE BOTTOM CONCENTRATION
NITRITE



AVERAGE SURFACE CONCENTRATION
TOTAL INORGANIC NITROGEN



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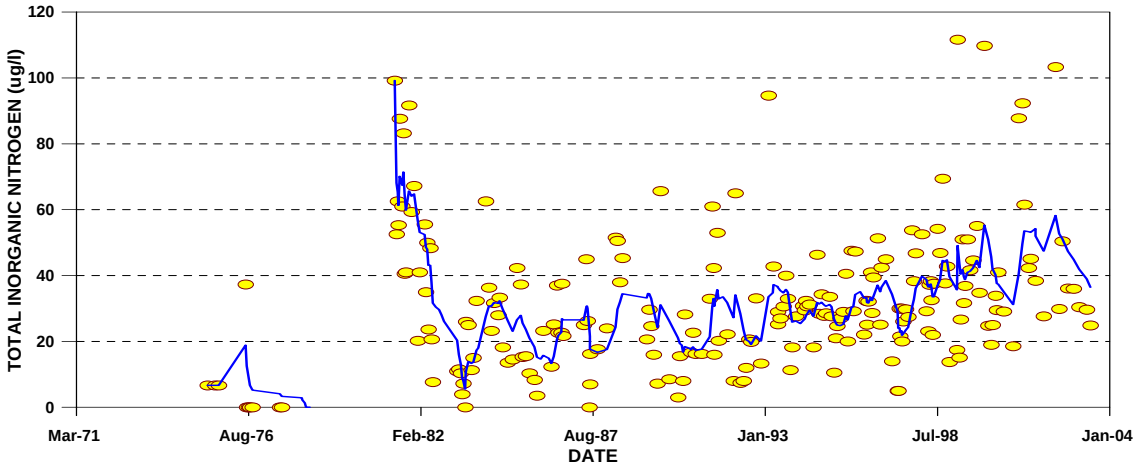
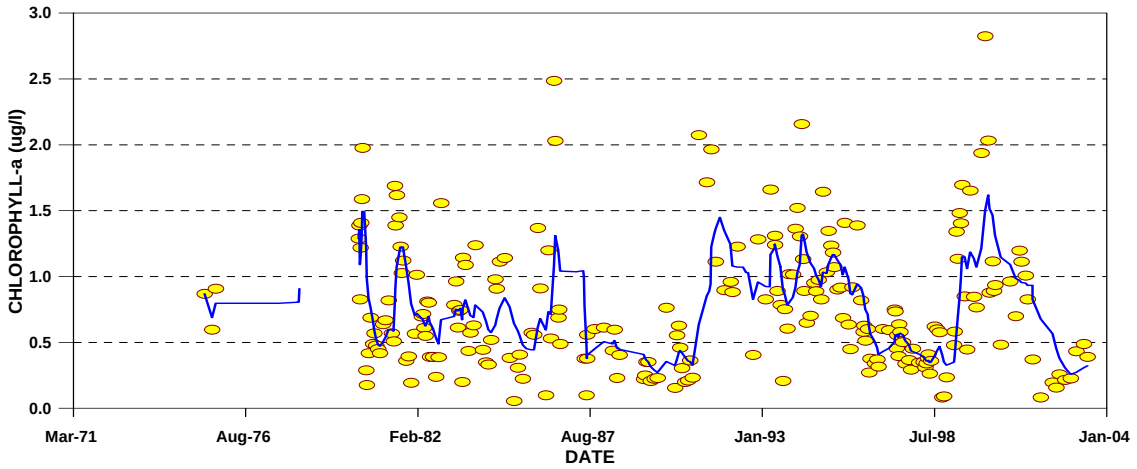
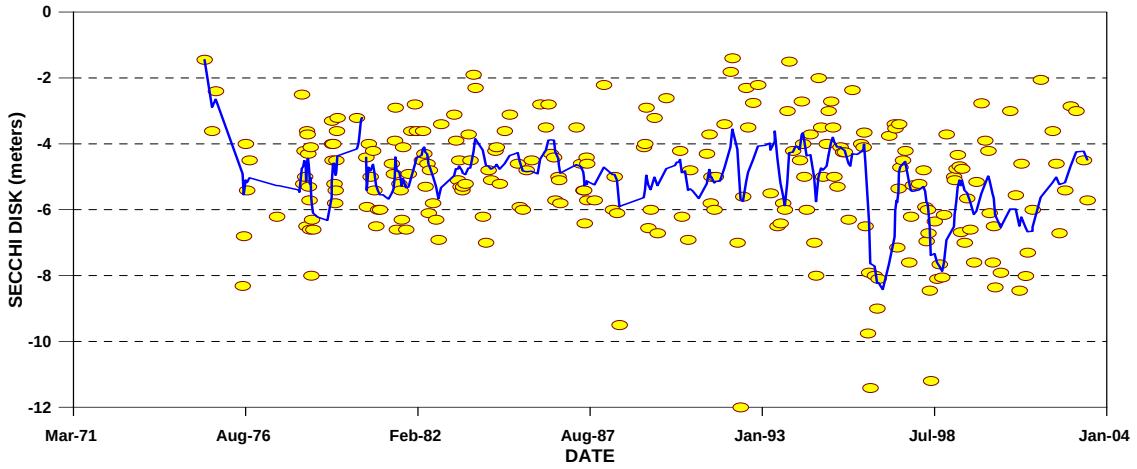
TOTAL INORGANIC NITROGEN

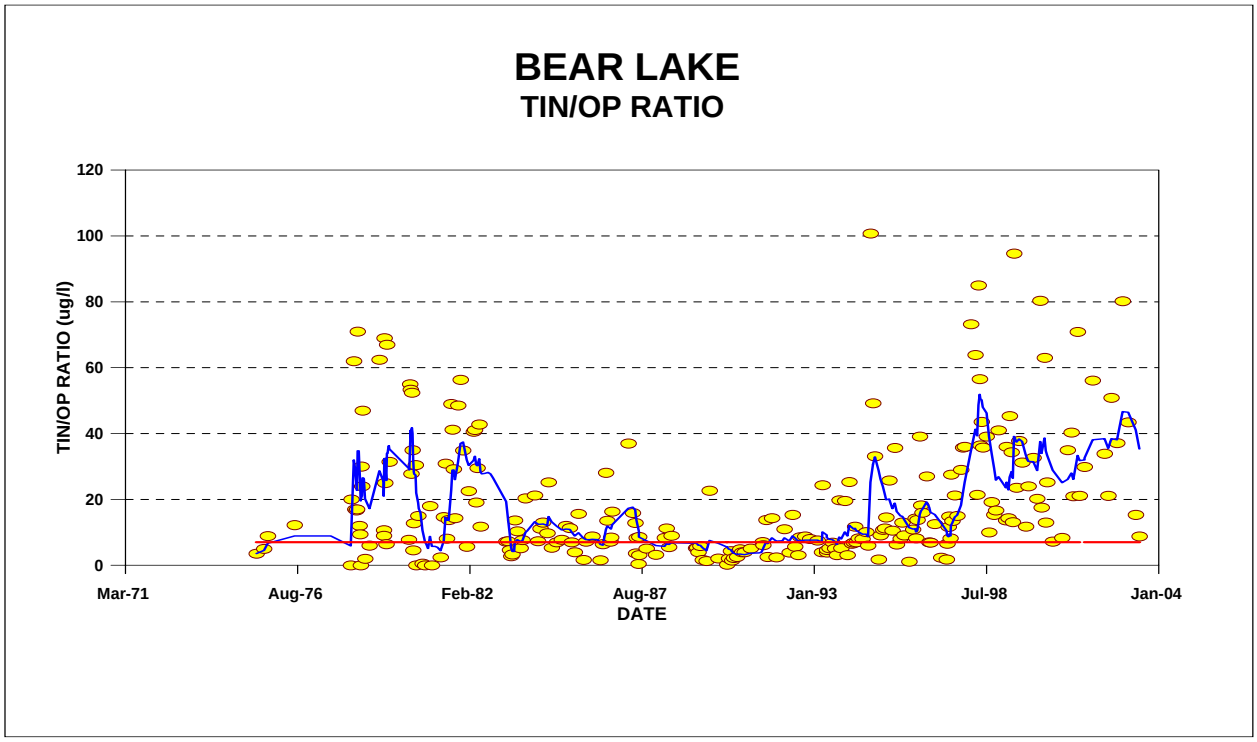


AVERAGE CONCENTRATIONS
CHLOROPHYLL-a

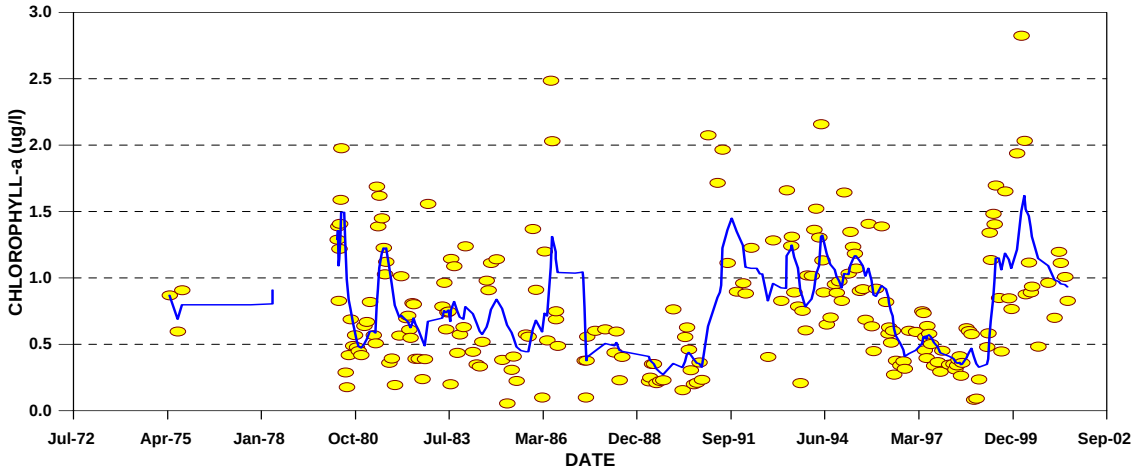


AVERAGE WATER TRANSPARENCY
SECCHI DISK

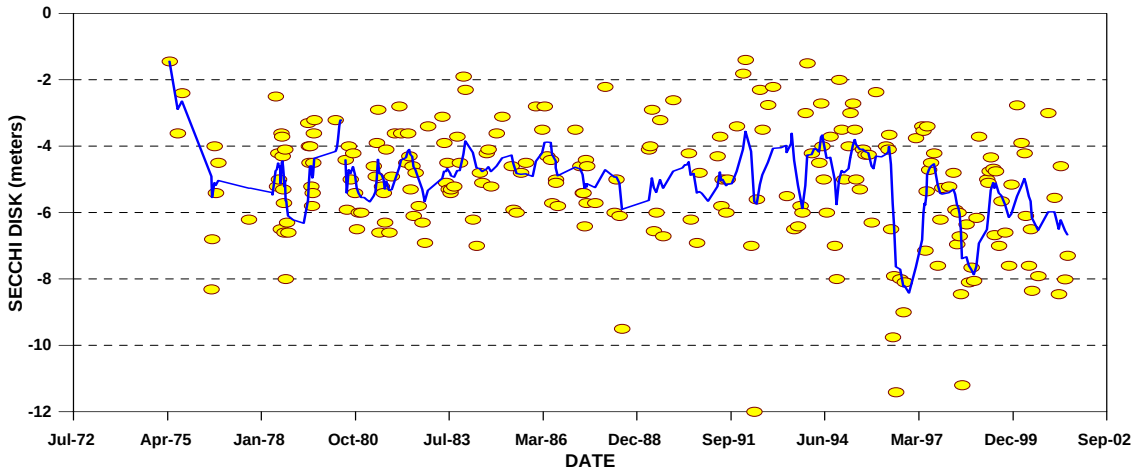


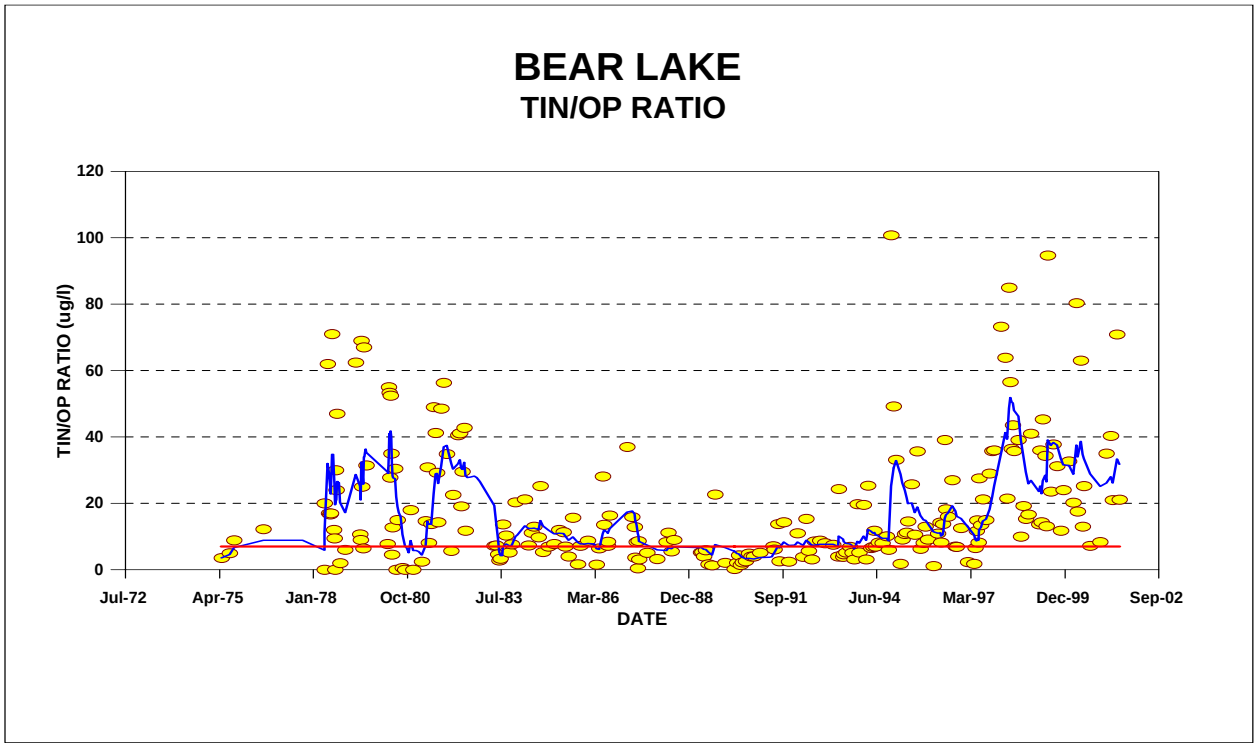

BEAR LAKE
TIN/OP RATIO
TIN/OP RATIO (ug/l)
120
100
80
60
40
20
0
Mar-71
Aug-76
Feb-82
Aug-87
Jan-93
Jul-98
Jan-04
DATE

AVERAGE CONCENTRATIONS
CHLOROPHYLL-a



AVERAGE WATER TRANSPARENCY
SECCHI DISK




BEAR LAKE
TIN/OP RATIO
TIN/OP RATIO (ug/l)
120
100
80
60
40
20
0
Jul-72
Apr-75
Jan-78
Oct-80
Jul-83
Mar-86
Dec-88
Sep-91
Jun-94
Mar-97
Dec-99
Sep-02
DATE

APPENDIX B

Raw Data

	DEPTH (meters)						
	0	**10**	**20**	**30**	**40**	**50**	**60**
Dissolved Oxygen (mg/L)							
07/16/02	6.79	8.15	9.62	8.56	8.33	7.32	6.69
09/17/02	7.73	7.81	9.64	8.31	7.29	5.35	4.74
11/25/02	8.9	8.97	8.4	8.86	8.76	8.14	4.4
01/29/03	10.02	10.02	9.87	9.56	9.44	9.08	8.07
04/24/03	10.46	10.39	9.8	10	9.82	9.7	7.62
06/10/03	8.06	10.02	10.07	9.66	9.01	8.65	6.9
Temperature (°C)							
07/16/02	22.78	14.58	7.77	5.57	5.05	4.91	4.9
09/17/02	17.74	17.74	7.91	5.81	5.24	4.99	4.99
11/25/02	6.66	6.62	6.43	6.62	6.62	6.6	5.39
01/29/03	3.19	3.07	3.06	3.1	3.13	3.26	3.37
04/24/03	7.47	5.3	5.21	4.8	4.27	4.01	3.98
06/10/03	16.37	9.24	7.44	5.66	4.94	4.48	4.36
pH (SU)							
07/16/02	8.13	8.22	8.27	8.24	8.2	8.16	8.14
09/17/02	8.07	8.22	8.3	8.25	8.21	8.16	8.12
11/25/02	8.28	8.42	8.46	8.56	8.56	8.55	8.33
01/29/03	8.25	8.37	8.38	8.54	8.54	8.55	8.54
04/24/03	8.2	8.22	8.24	8.26	8.29	8.3	8.32
06/10/03	7.85	7.93	7.96	7.98	7.99	7.99	7.99
Conductivity (µmho/cm)							
07/16/02	705	689	681	682	681	683	683
09/17/02	747	748	730	732	732	737	737
11/25/02	697	697	697	697	698	698	703
01/29/03	692	694	695	697	696	697	697
04/24/03	706	703	704	703	704	703	704
06/10/03	721	713	710	709	708	708	709
Turbidity (NTU)							
07/16/02	0.4	0.4	1	1	1.5	2.5	15
09/17/02	0.4	0.35	0.5	0.7	0.65	3.7	11
11/25/02	1.5	1.5	1.4	1.4	1.5	6.6	1.4
01/29/03	1.3	1	1	1.1	1	2.2	8.3
04/24/03	0.8	1	1	1	1.1	2.6	4.3
06/10/03	0.85	0.9	0.85	0.95	0.9	1.7	2.8

	DEPTH (meters)						
	0	**10**	**20**	**30**	**40**	**50**	**60**
Secchi (meters)							
07/16/02	-6.7						
09/17/02	-5.4						
11/25/02	-2.85						
01/29/03	-3						
04/24/03	-4.5						
06/10/03	-5.7						
Total Phosphorus (µg/L)							
07/16/02	<7	<7	<7	<7	<7	<7	72
09/17/02	<8	<8	<8	<8	<8	<8	12
11/25/02	9	<8	<8	<8	<8	<8	<8
01/29/03	<6	<6	<6	<6	<6	<6	9
04/24/03	<6	<6	<6	<6		<6	<6
06/10/03	<6	<6	<6	<6	<6	<6	<6
Orthophosphorus (µg/L)							
07/16/02	<1	1	<1	1	1	1	3
09/17/02	2	<1	2	2	<1	1	2
11/25/02	<1	<1	<1	<1	<1	<1	<1
01/29/03	<1	<1	1	4	1	<1	<1
04/24/03	1	2	1	6	2	1	2
06/10/03	<1	2	<1	<1	18	<1	<1
Total Suspended Solids (mg/L)							
07/16/02	1	1	1	1	1	3	
09/17/02	<1	1.7	1.1	<1	<1	6.2	14
11/25/02	1.6	1.6	1.5	1.9	2.2	8.6	1.7
01/29/03	<1	1	<1	1.2	1.5	2.6	12.6
04/24/03	<1	<1	<1	<1	<1	1.9	3.3
06/10/03	<1	1	1.1	<1	<1	1.1	2.2
Ammonia (µg/L)							
07/16/02	23	157	38	35	33	36	32
09/17/02	28	183	28	24	28	25	25
11/25/02	68	28	28	28	29	28	40
01/29/03	32	35	159	39	27	27	26
04/24/03	36	29	28	41	28	24	24
06/10/03	24	31	36	26	24	22	21

	DEPTH (meters)						
	0	**10**	**20**	**30**	**40**	**50**	**60**
Nitrate+Nitrite (μg/L)							
07/16/02	7	5	3	7		25	25
09/17/02	<3	4	<3	<3	<3	15	13
11/25/02	11	6	<3	3	4	5	3
01/29/03	<3	4	<3	4	<3	3	6
04/24/03	4	<4	4	<4	4	<4	5
06/10/03	<4	<4	<4	<4	<4	<4	5
Nitrite (μg/L)							
07/16/02	0.7	0.7	0.8	0.8	0.9	0.9	0.9
09/17/02	0.8	0.7	0.8	0.6	0.6	0.9	0.8
11/25/02	0.7	0.8	0.6	0.7	0.7	0.7	0.7
01/29/03	0.5	0.6	0.6	0.7	0.7	0.7	0.6
04/24/03	0.9	0.9	0.8	0.8	1	1	1
06/10/03	0.9	0.8	1	0.9	0.8	1.1	1.1
Chlorophyll-a (μg/L)							
07/16/02	0.05	0.08	0.18	0.34	0.12	0.51	0.53
09/17/02	0.13	0.12	0.2	0.49	0.18	0.16	0.25
11/25/02	0.23	0.24	0.22	0.24	0.24	0.21	0.22
01/29/03	0.41	0.48	0.51	0.43	0.42	0.37	0.43
04/24/03	0.26	0.41	0.41	0.65	0.57	0.57	0.57
06/10/03	0.21	0.28	0.41	0.81	0.28	0.41	0.35