2000-2001

BEAR LAKE MONITORING DATA SUMMARY

Prepared for:

BEAR LAKE REGIONAL COMMISSION
Fish Haven, Idaho

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November 2001

INTRODUCTION

Water quality conditions were monitored in a single mid-lake station on Bear Lake during 2000-2001. 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 September 6, 2000 and June 18, 2001. 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 September 2000 to June 2001. This monitoring season was the first season in which the sampling schedule was adjusted from 12 to six sampling events. Bear Lake was sampled twice during both summer stratification and spring turnover and once during both fall and 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 40 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 in this analysis. During the 1999 and 2000 sampling period, the average surface total phosphorus concentrations in Bear Lake ranged from 2.5 to 6.5 µg/liter. Bottom concentrations ranged from to 2.5 to 12.8 µg/liter. February 2001 exhibited the highest concentrations throughout the lake, while the end of April brought levels which were less than detection at all depths. This pattern is similar to other years in which winter elevations of phosphorus tend to be higher and spring runoff brings the levels down. However, the 2000-2001 monitoring year results contain slightly lower overall concentrations of phosphorus than the previous year.

Average surface and bottom orthophosphorous (OP) concentrations were similar during the 2000-2001 monitoring program (Figure 2), ranging from 0.5 to 3.1 µg/liter in the epilimnion and 0.5 to 3.4 µg/liter in the hypolimnion. Less than detection results (<1 µg/L) accounted for 26 percent of the samples. The highest concentration of OP was observed in February 2001, but only for the hypolimnion. June 2001 had the lowest concentrations in which all depths were less than detection.

Surface total inorganic nitrogen (TIN) concentrations continued to exhibit the most dramatic change of any parameter monitored since the spring of 1997 (Figure 3). Concentrations have nearly returned to pre-1997 levels. During spring runoff in 1997, large quantities of total inorganic nitrogen (NH_3+NO_3+NO_2) were flushed into Bear Lake from the Bear Lake marsh. Levels have remained elevated for nearly four years, with nitrate-nitrogen contributing the most (Figure 4). Average nitrate-nitrogen decreased dramatically during the 2000-2001 monitoring season. Average surface concentrations ranged from 1.4 µg/liter in December to a high of 9.7 µg/liter at the end of April. Compared to the historical dataset, this peak was not significant (Figure 5; top).

Average surface ammonia ranged from 15.0 to 24.9 μg/liter (Figure 5: bottom). Thirty percent of the samples were below detection limit and half the value (15 μg/L) was used in the analysis. The hypolimnion experienced generally higher concentrations of ammonia than the epilimnion, a pattern that has been developing for the past two years. Concentrations increased throughout the spring season and gradually decreased during the summer. The peak concentration of 89.9 μg/liter on April 10, 2001 was last seen January 2000.

Water transparency, measured with a secchi disk, ranged from 8.45 meters on April 10, 2001 to a minimum of 3.0 meters in December 2000 (Figure 6: top). During this monitoring season, the secchi disk had transparencies greater than five meters 67 percent of the time. Chlorophyll-*a* concentrations followed transparency patterns during this monitoring period, exhibiting a slight increase during the spring of 2001, but averaging between 0.70 to 1.15 μg/liter for all lake layers (Figure 6: bottom).

Average surface and bottom pH levels were similar to the previous monitoring years (1996-1998), ranging from a low of 8.07 and 8.16 (epilimnion and hypolimion, respectively) to a high of 8.46 pH units in both layers (Figure 7). Hypolimnetic pH levels reached their lowest levels during the most mixed periods of the lake (February and April 2001).

Bottom temperatures during the entire monitoring period did not exceed 4.8˚C, and the highest temperature in the epilimnion was 18.5˚C, recorded on September 6, 2000 (Figure 8). Compared to the data collected since 1996, this monitoring period showed a decrease in the overall temperature of both the hypolimnion and the epilimnion, much like the pattern shown during 1996. 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 5.9 to 9.0 mg/liter during the monitoring period (Figure 10). Epilimnetic concentrations of dissolved oxygen ranged from 7.6 to 10.2 mg/liter. With the exception of lower concentrations of oxygen in the hypolimnion during the spring sampling events, the year was similar to the last monitoring season (1999-2000). These lower concentrations (6.0 and 5.9 mg/L during February and early April's sampling events, respectively), correspond to the decrease seen in pH and the increase in total inorganic nitrogen.

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 2000-2001 monitoring season, total phosphorus continued the trend toward declining levels, ranging from below detection (<5 μg/L) to 8.9 μg/liter. The lake averaged 5.6 μg/liter for the entire monitoring season. Orthophosphorus remained low as well, ranging from below detection (<1 μg/L) to 3.1 μg/liter, and averaging 2.0 μg/liter for the entire monitoring season. Total inorganic nitrogen continued to decrease throughout 2000 and 2001 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. An increase in hypolimnetic ammonia levels was observed during spring runoff in 2001, but returned to low levels by summer stratification.

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. Sampling of the marsh sites (Causeway, Lifton, Stewart Dam and the Outlet) was discontinued in July 1998. Additional funding should be found in order that this program can monitor both the lake and marsh sample sites. Annual nutrient loading for Bear lake needs to be determined. (See 4 below)

3. 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. In addition, the response of the other trophic levels (Zooplankton and fish should be investigated to determine the impacts to these organisms (both positive and/or negative)

4. 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.

5. New environmental studies (Ruzycki et al. 2001) have 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.

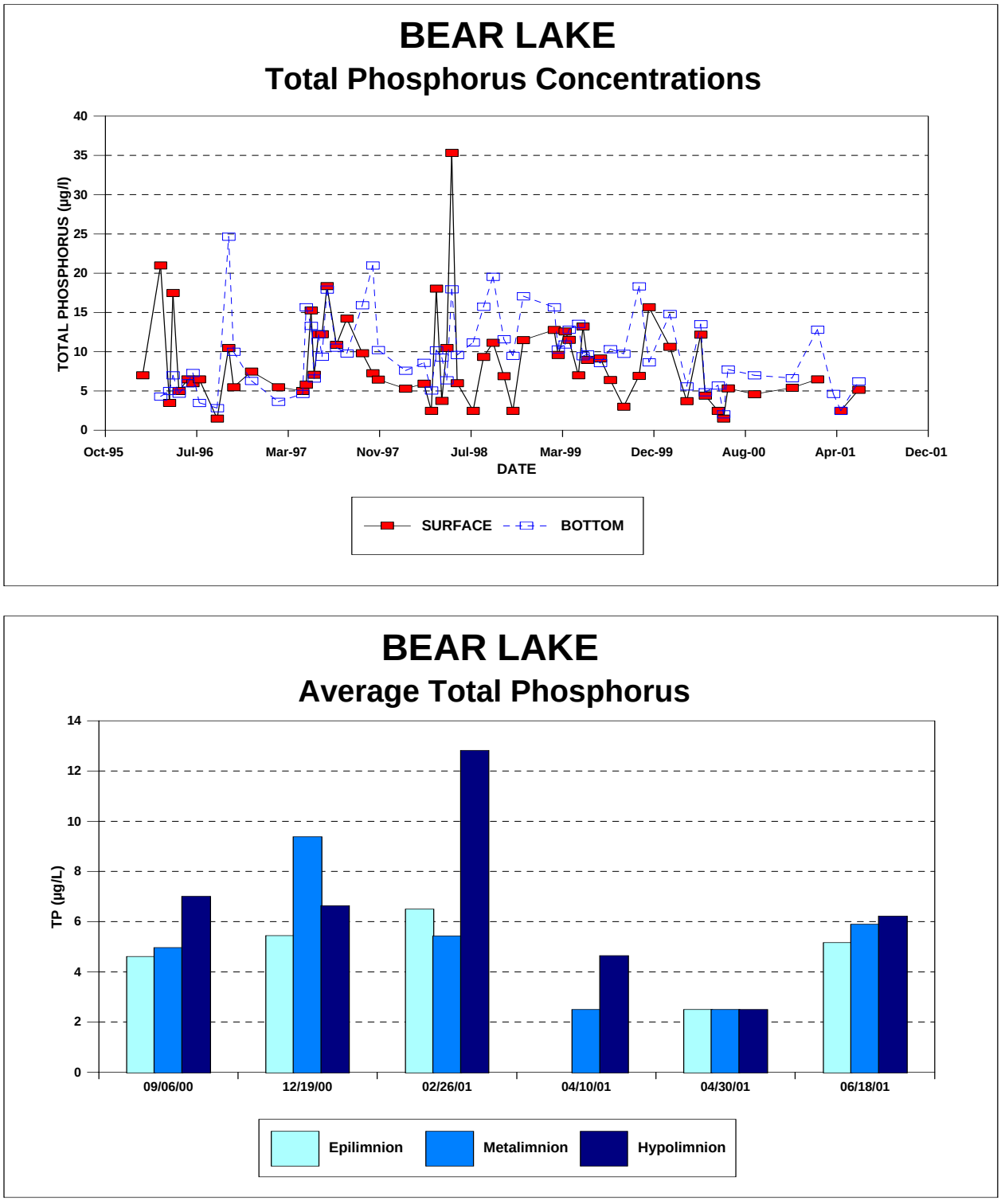


Figure 1. Concentrations of total phosphorus in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

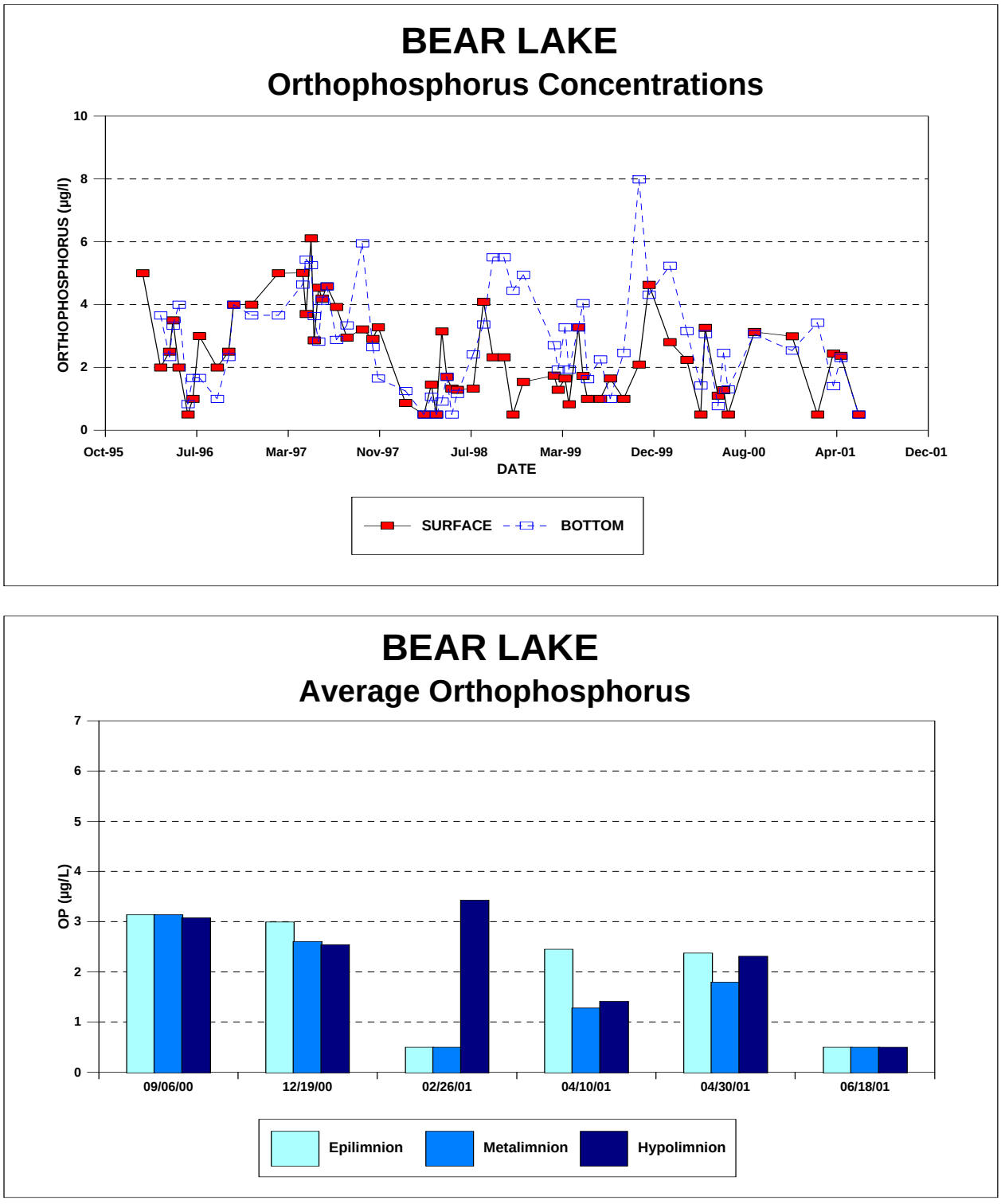


Figure 2. Concentrations of orthophosphorus in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

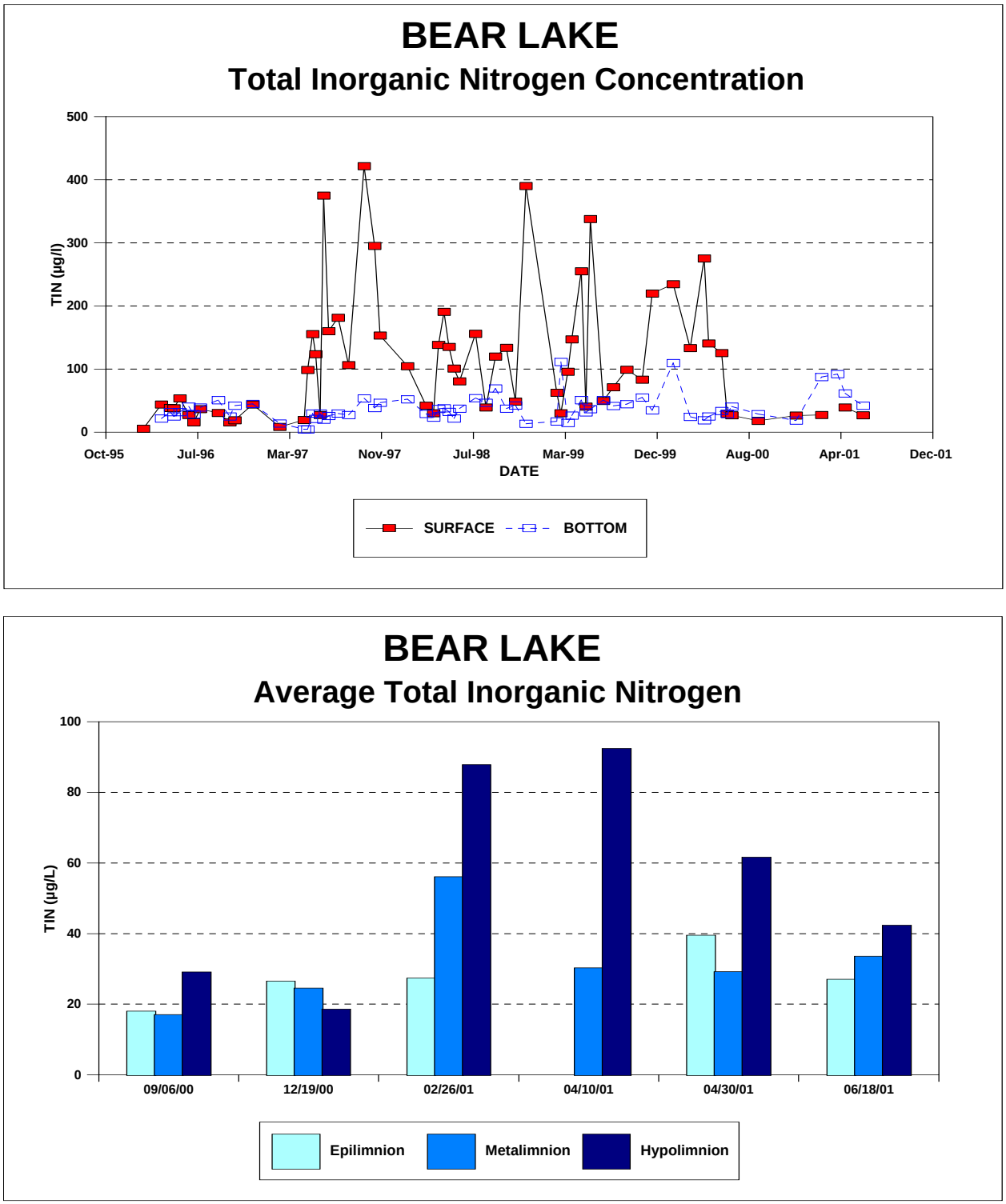


Figure 3. Concentrations of total inorganic nitrogen (NH_3+NO_3+NO_2) in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

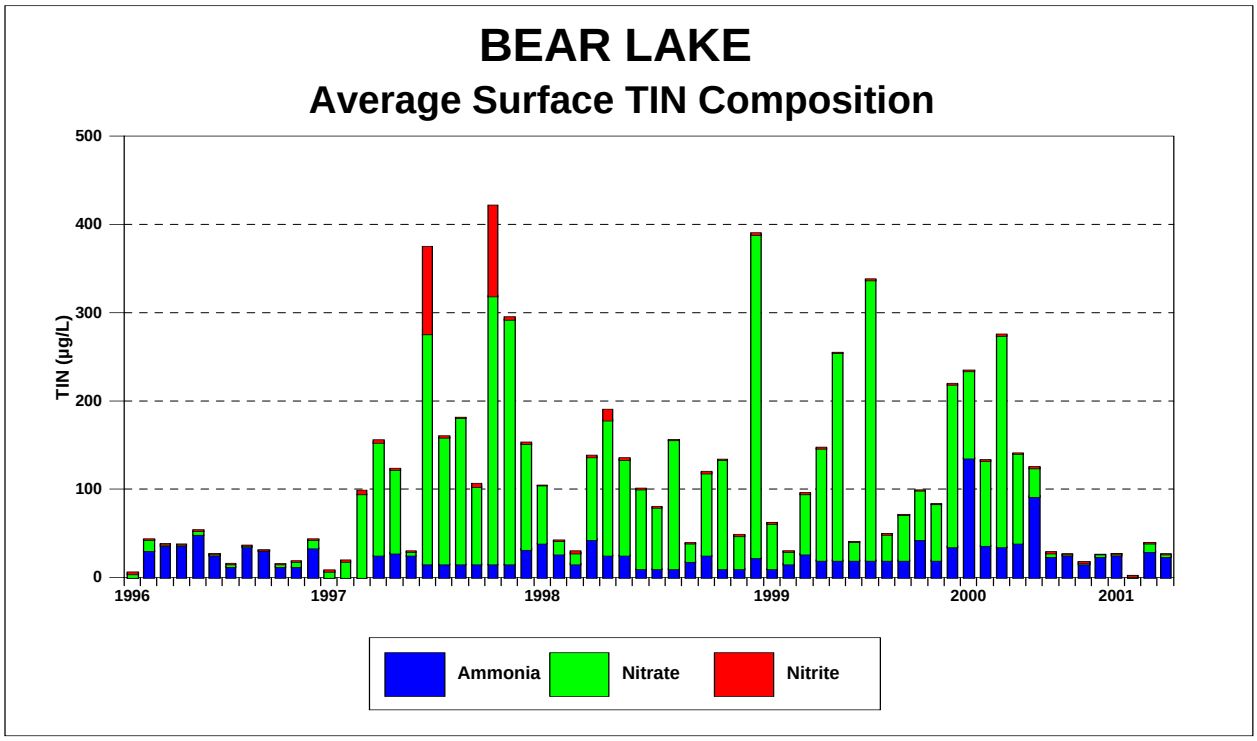


Figure 4. Total inorganic nitrogen composition of the epilimnion in Bear Lake since 1996.

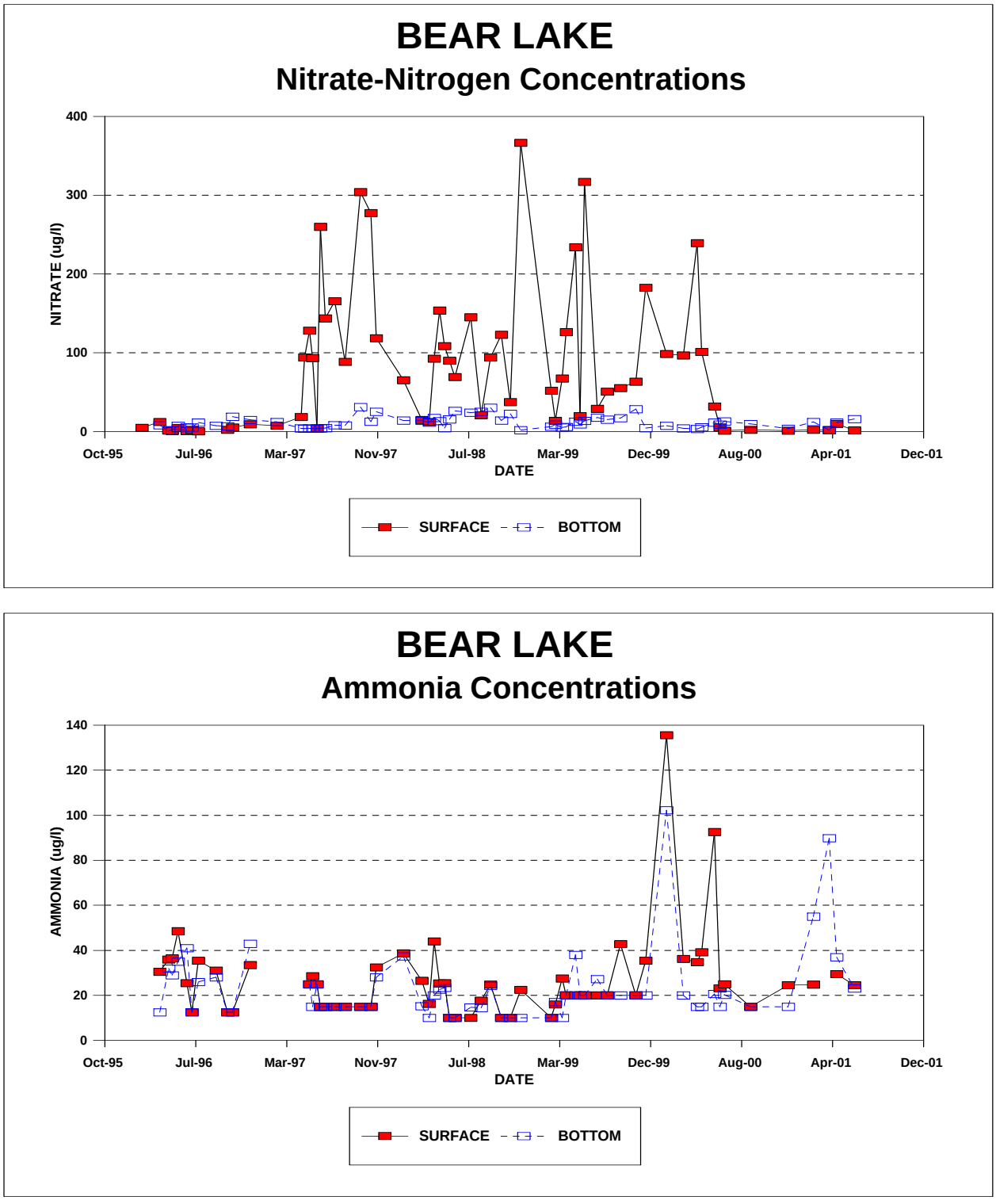


Figure 5. Concentrations of nitrate-nitrogen (above) and ammonia (below) in the surface and bottom waters of Bear Lake since 1996.

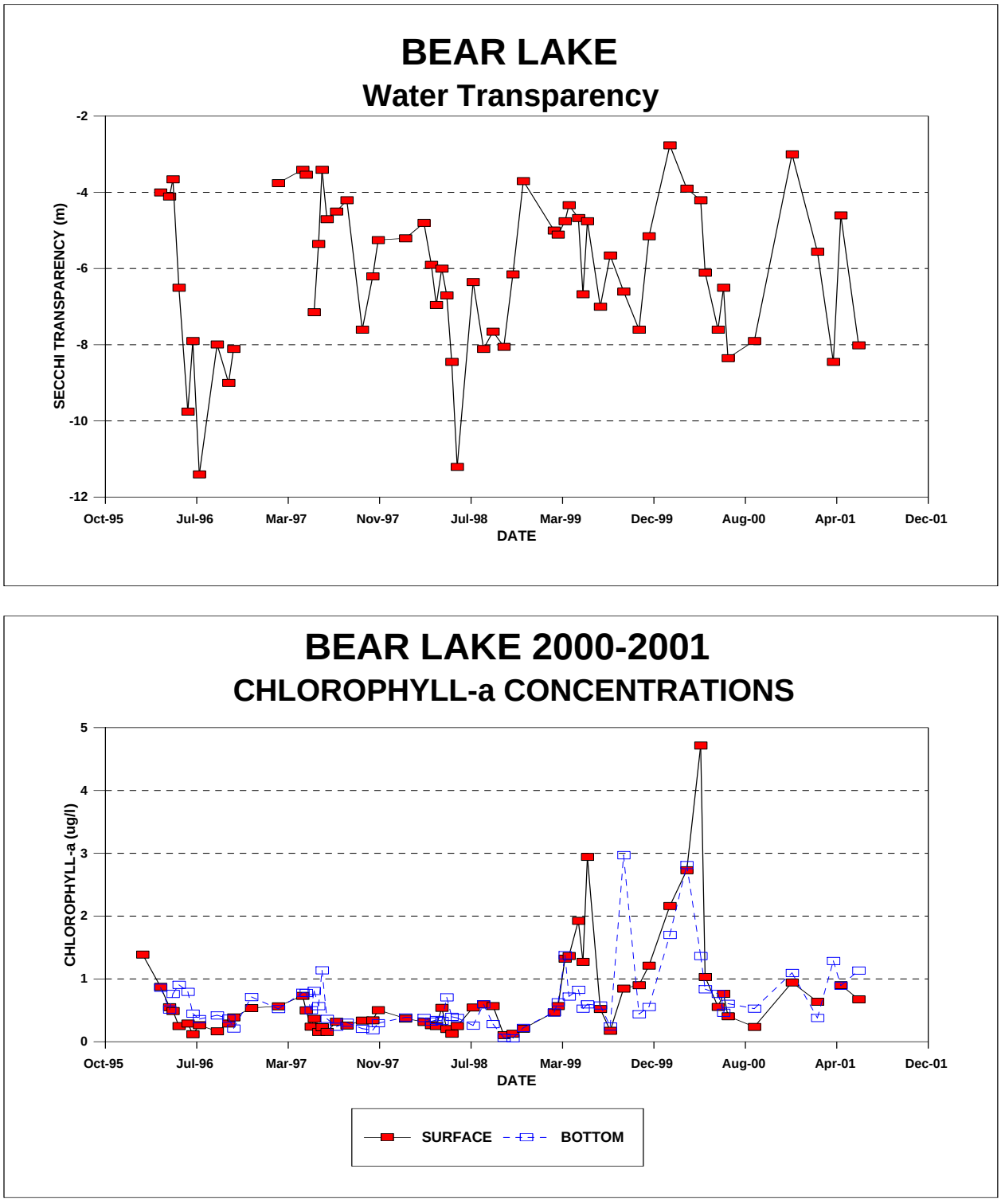


Figure 6. Water transparency (above) and surface and bottom chlorophyll-a concentrations in Bear Lake since 1996.

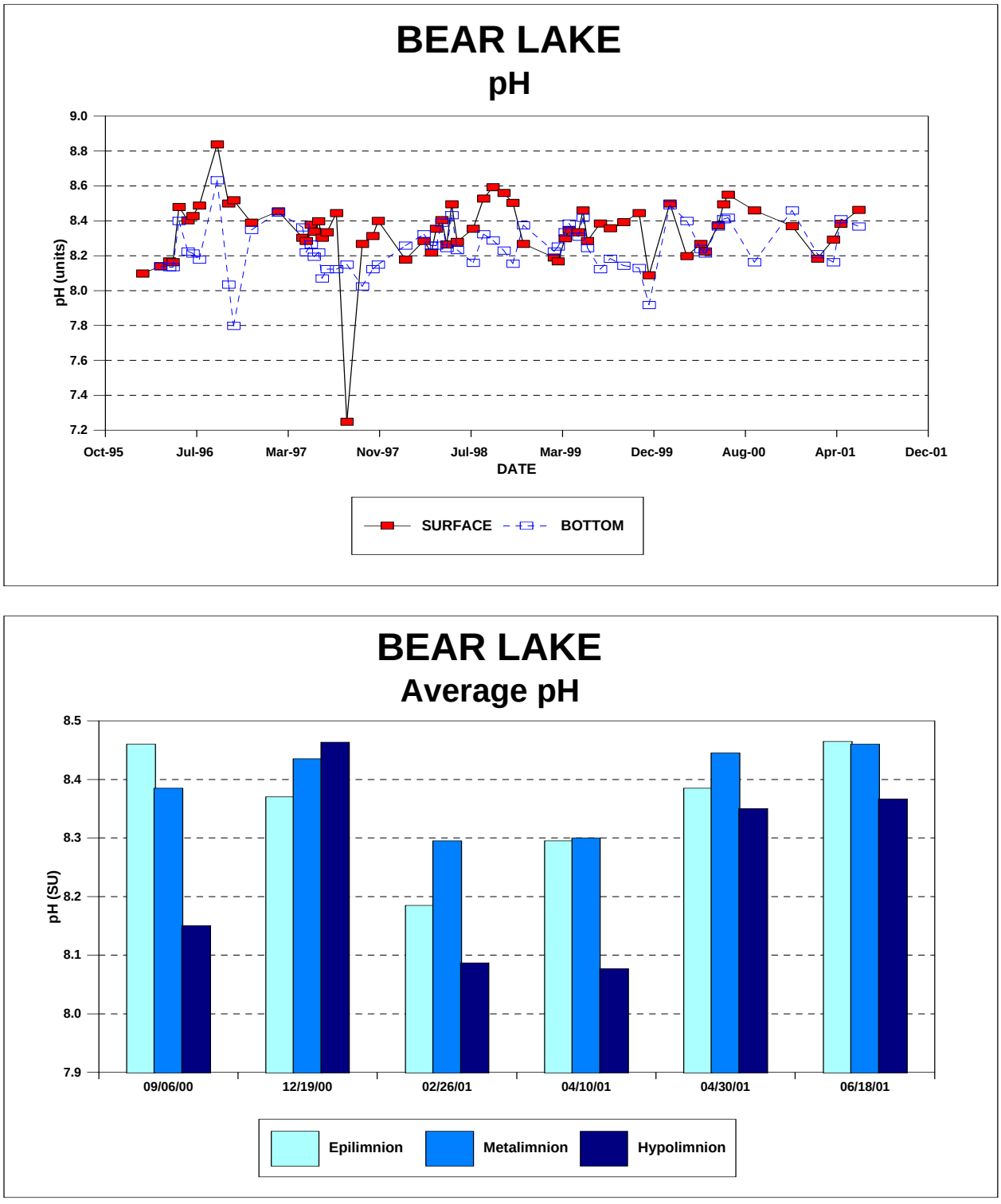


Figure 7. pH levels in the surface and bottom waters of Bear Lake since 1996 (above) and average levels within each layer of the lake for the monitoring period (below).

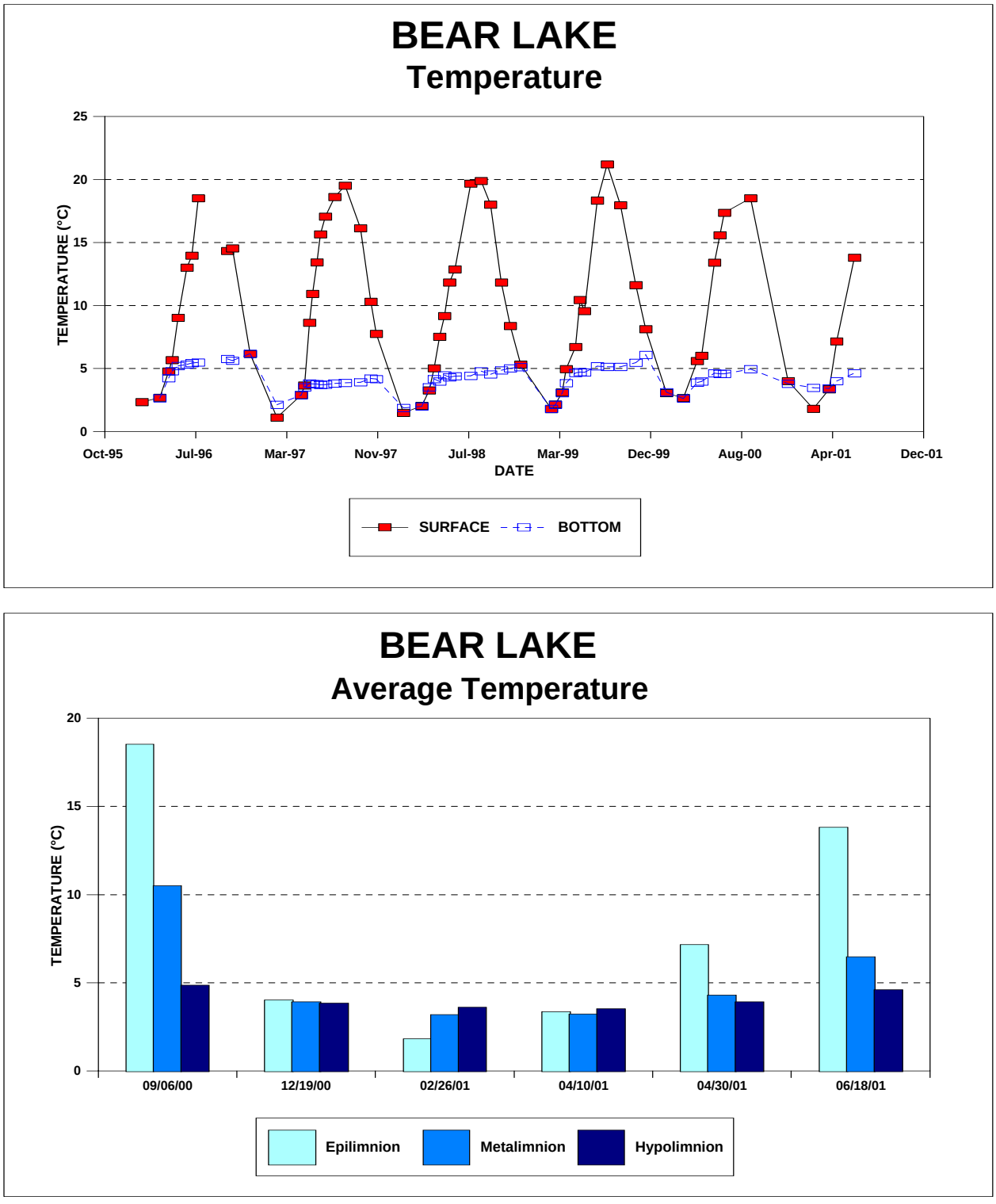


Figure 8. Temperature of the surface and bottom waters of Bear Lake since 1996 (above) and average temperature within each layer of the lake for the monitoring period (below).

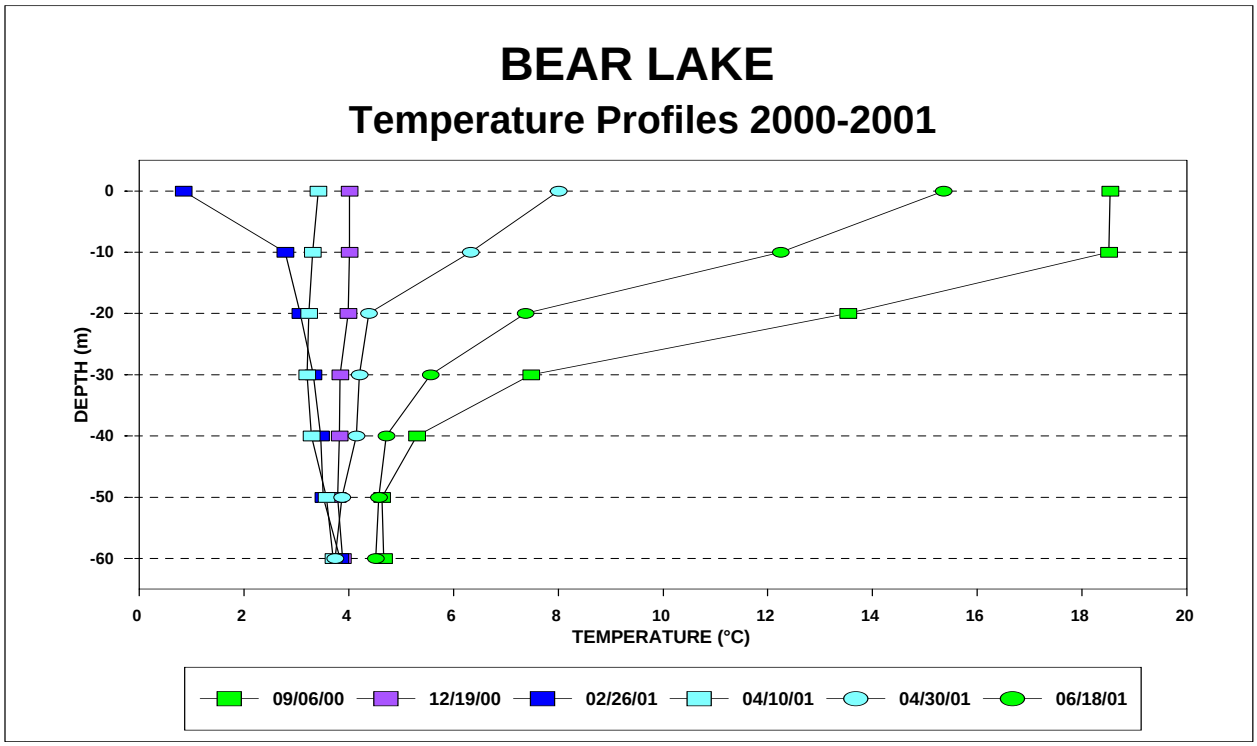


Figure 9. Temperature profiles of Bear Lake for each sampling event during the monitoring period. Green indicates summer stratification, cyan is spring turnover, purple and blue are fall and winter conditions, respectively.

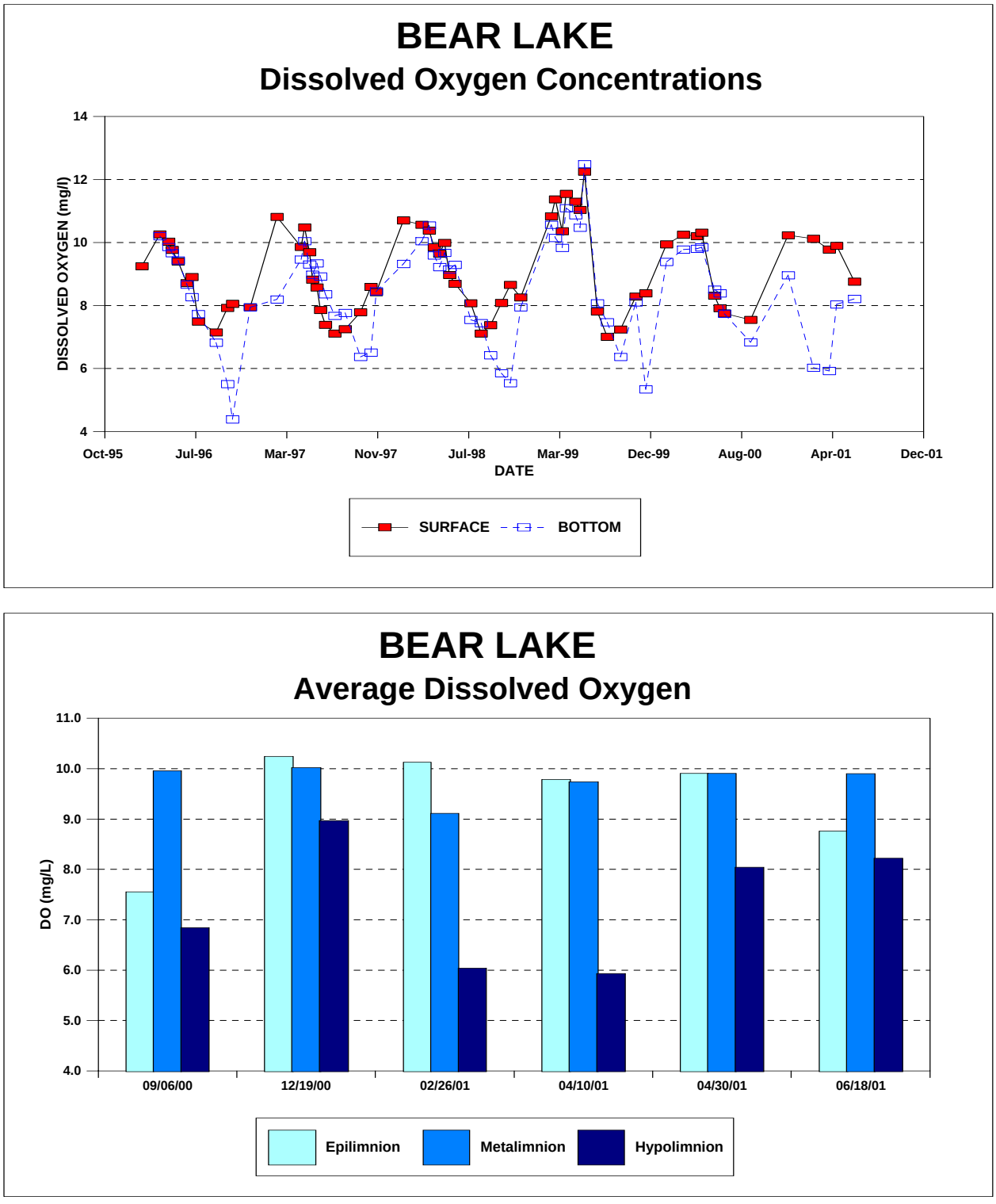
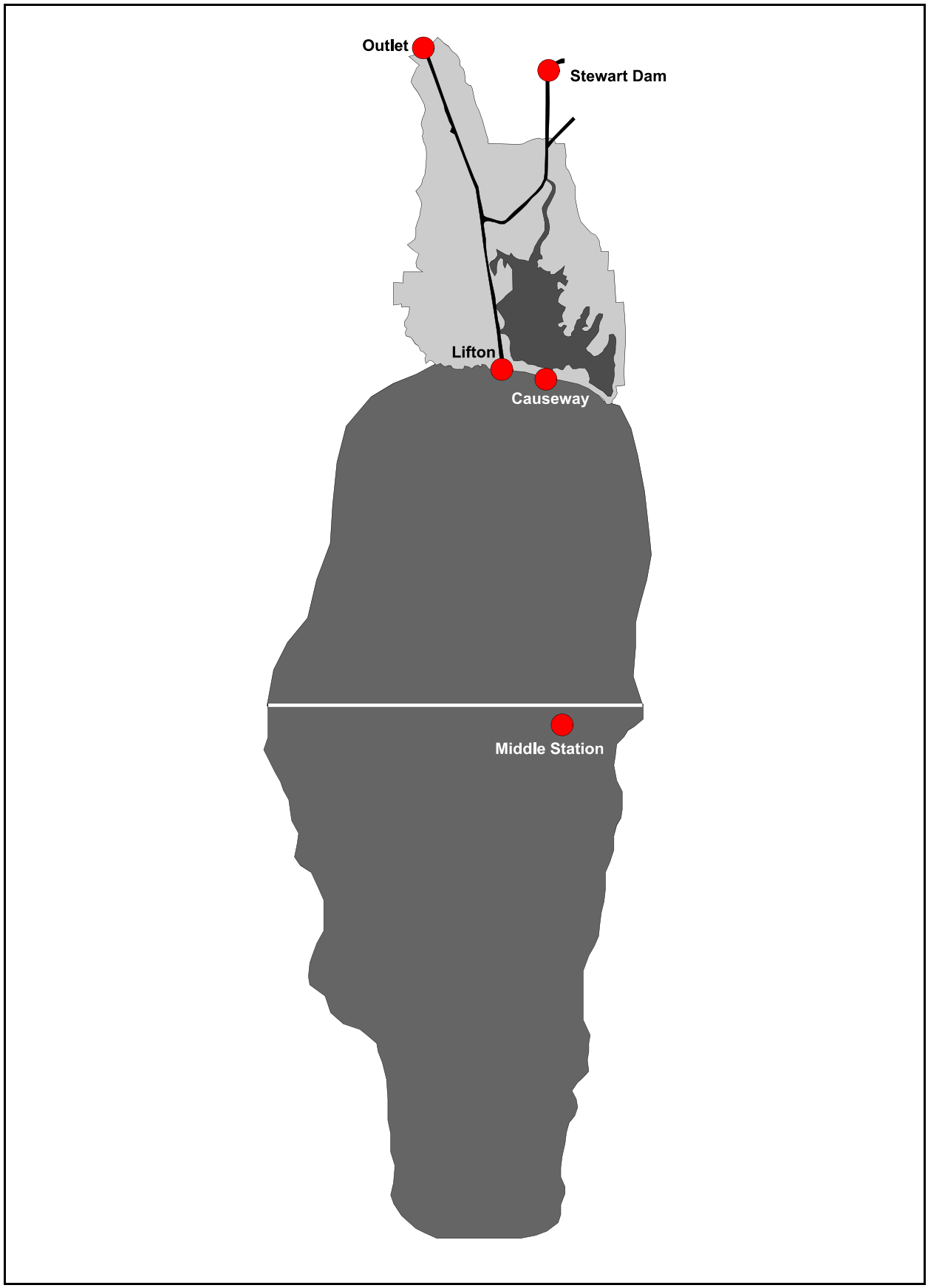


Figure 10. Dissolved oxygen concentrations in the surface and bottom waters of Bear Lake since 1996 (above) and average concentrations within each layer of the lake for the monitoring period (below).

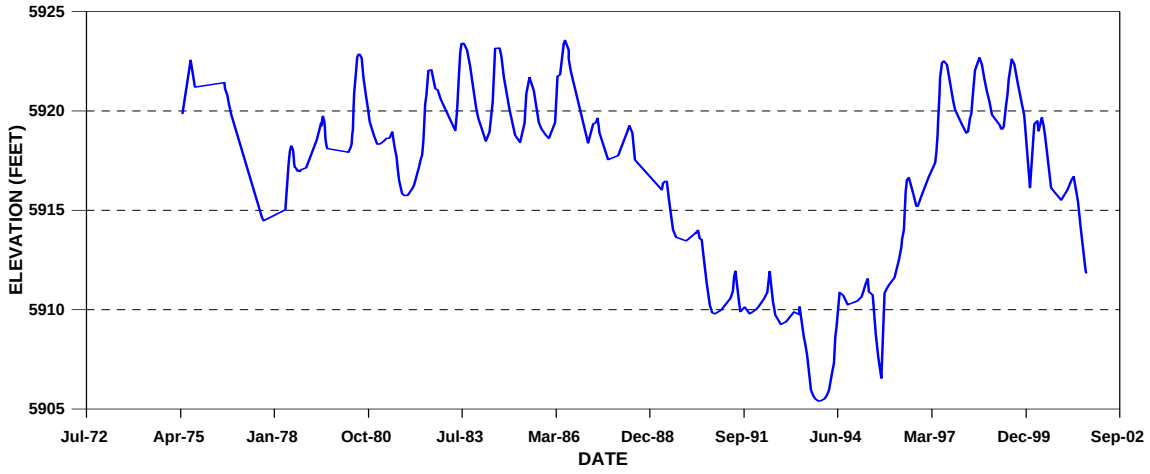
APPENDIX A

Graphs of Long-term Water Quality Data Monitoring Locations

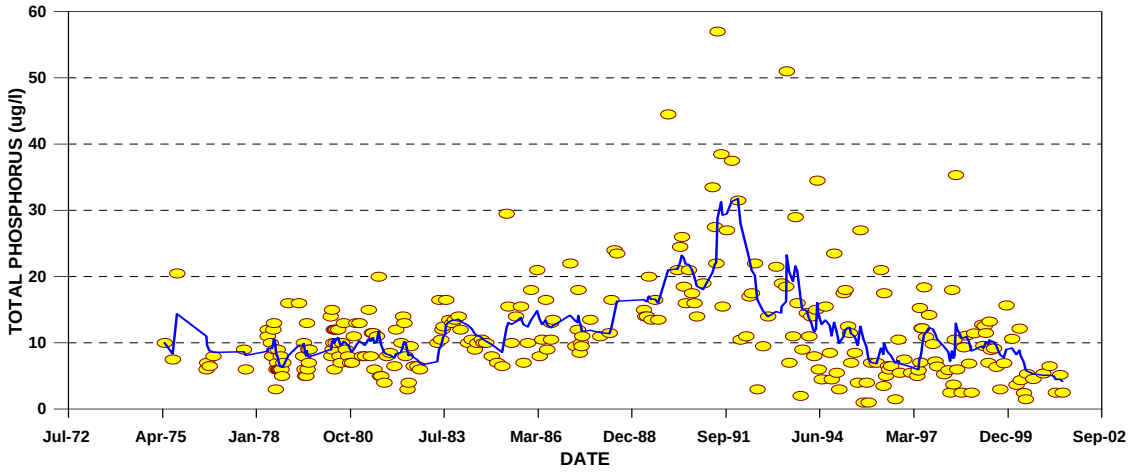

Outlet
Stewart Dam
Lifton
Causeway
Middle Station

BEAR LAKE

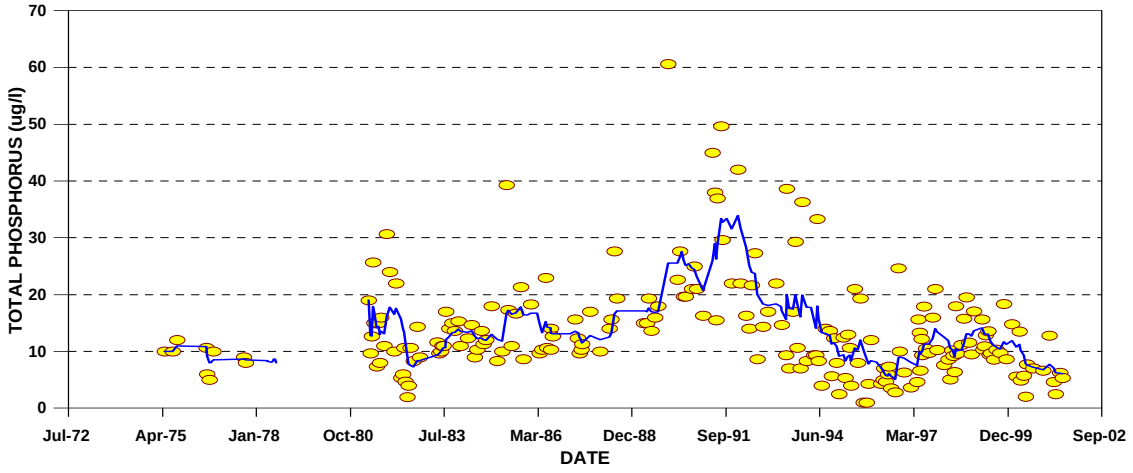
SURFACE ELEVATIONS



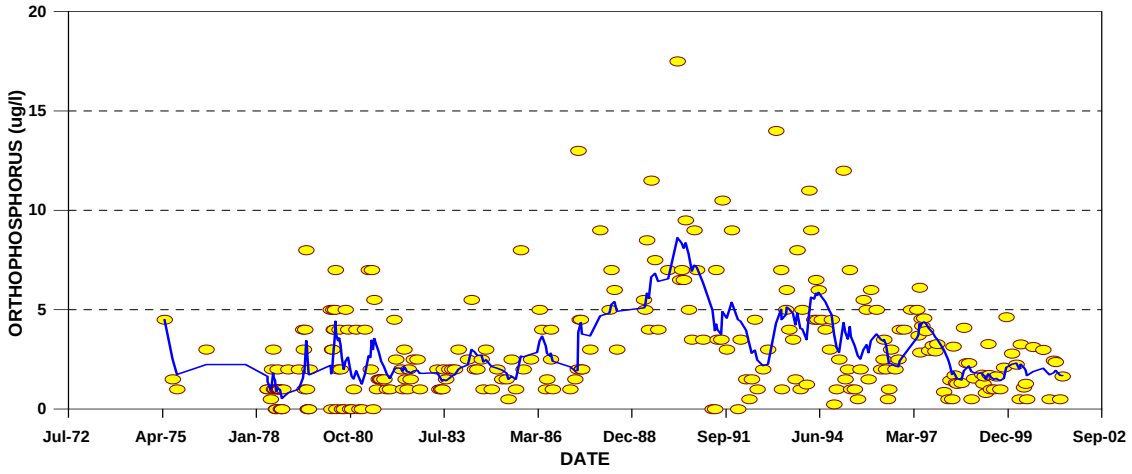
AVERAGE SURFACE CONCENTRATION
TOTAL PHOSPHORUS



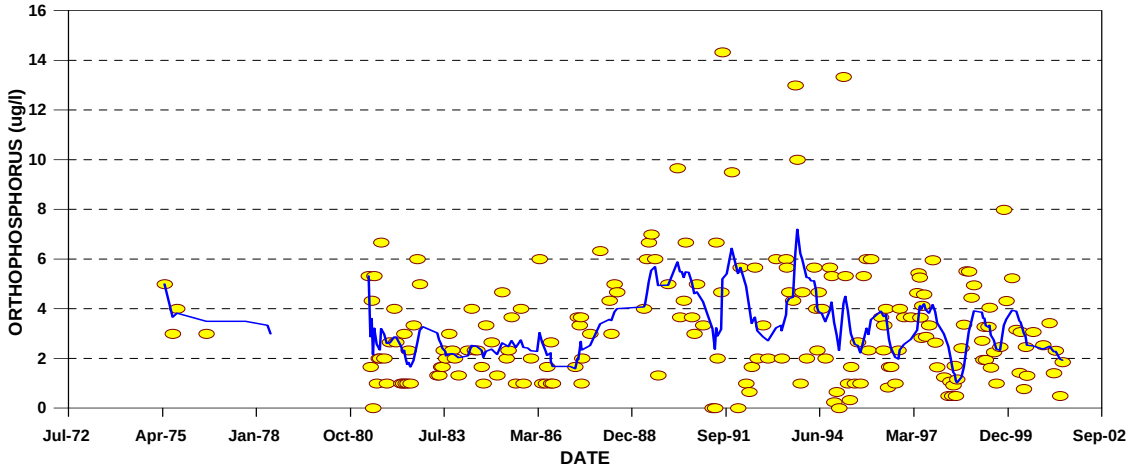
AVERAGE BOTTOM CONCENTRATION
TOTAL PHOSPHORUS



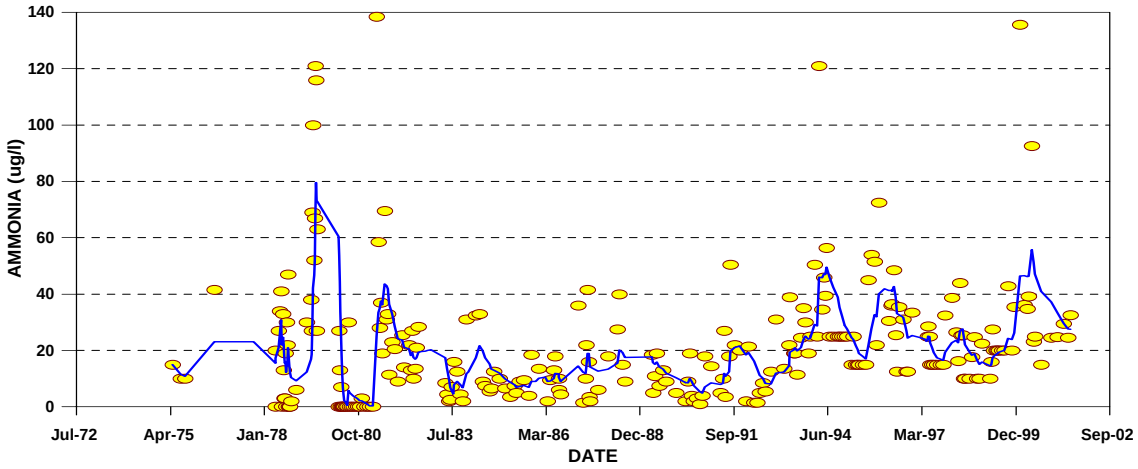
AVERAGE SURFACE CONCENTRATION
ORTHOPHOSPHORUS



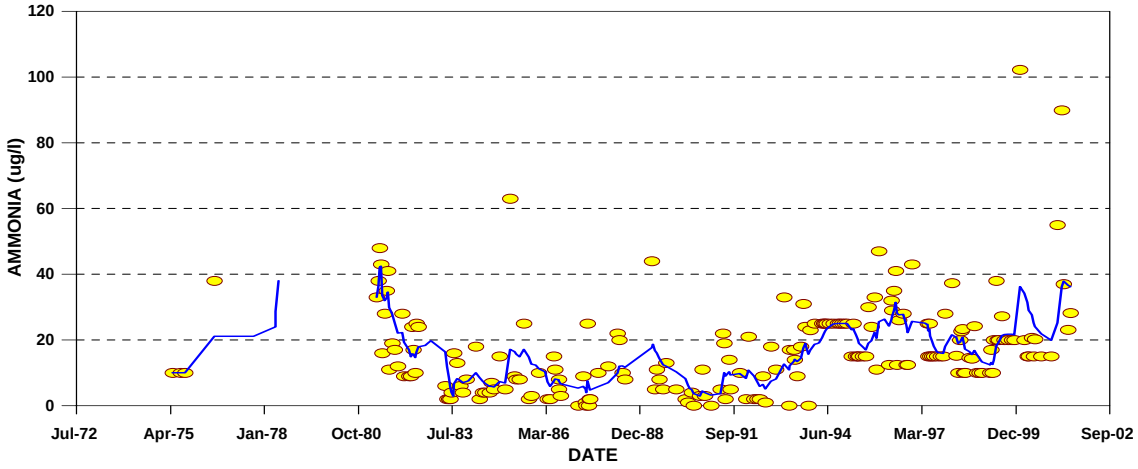
AVERAGE BOTTOM CONCENTRATION
ORTHOPHOSPHORUS



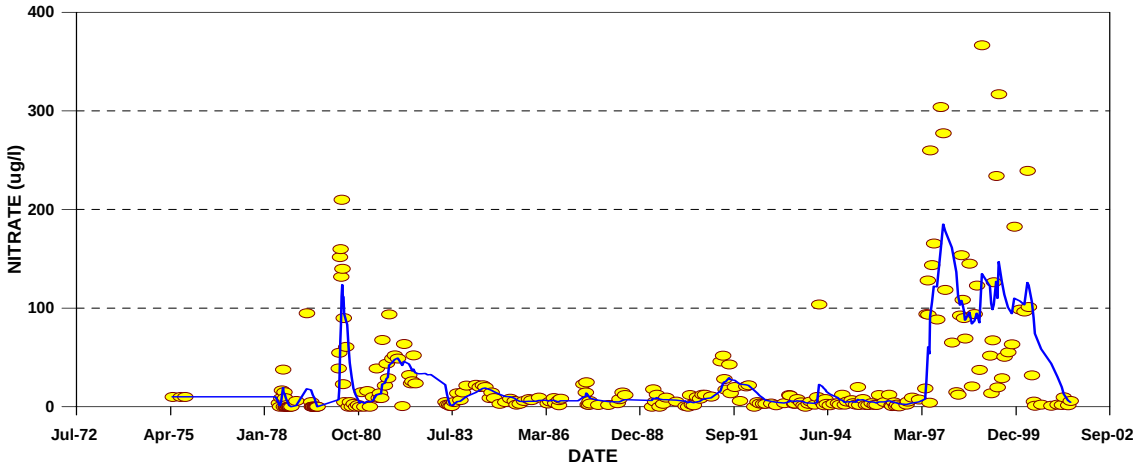
AVERAGE SURFACE CONCENTRATION
AMMONIA



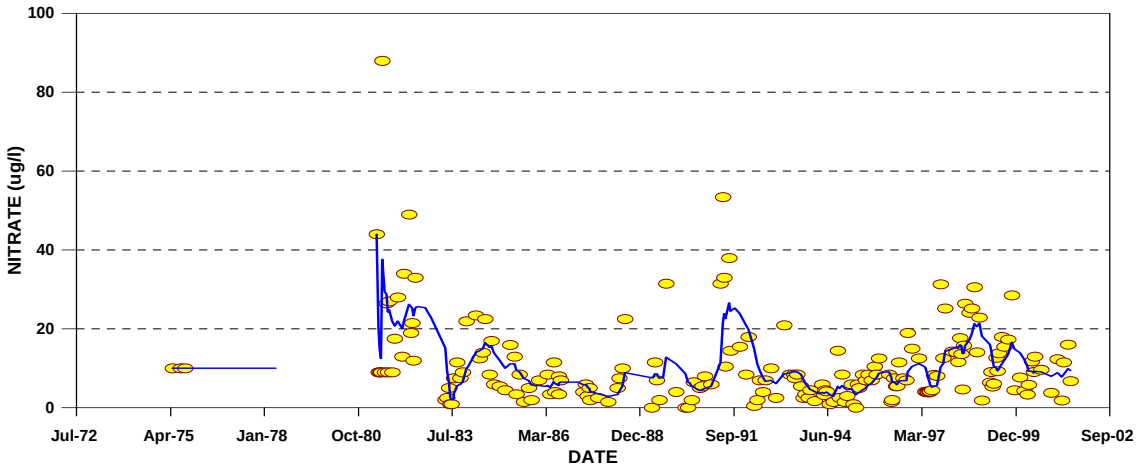
AVERAGE BOTTOM CONCENTRATION
AMMONIA



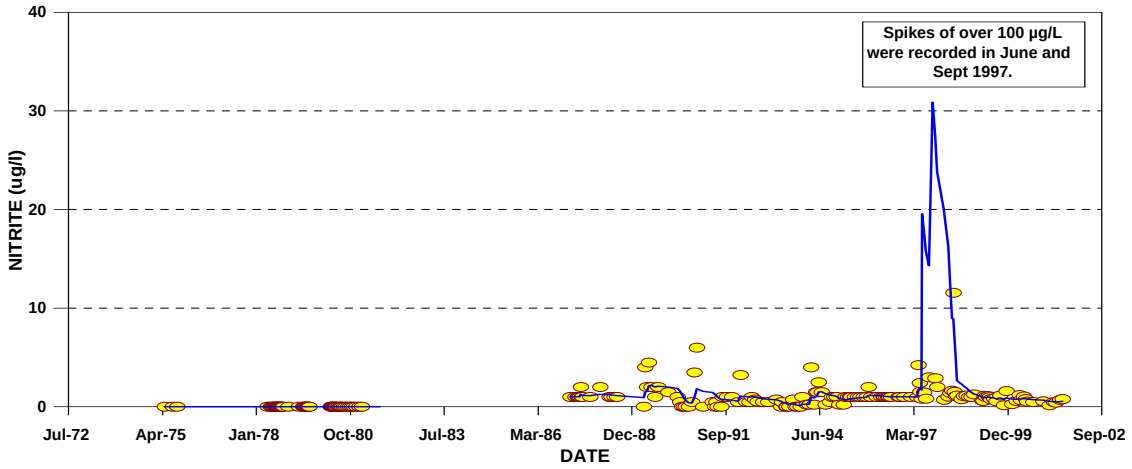
AVERAGE SURFACE CONCENTRATION
NITRATE



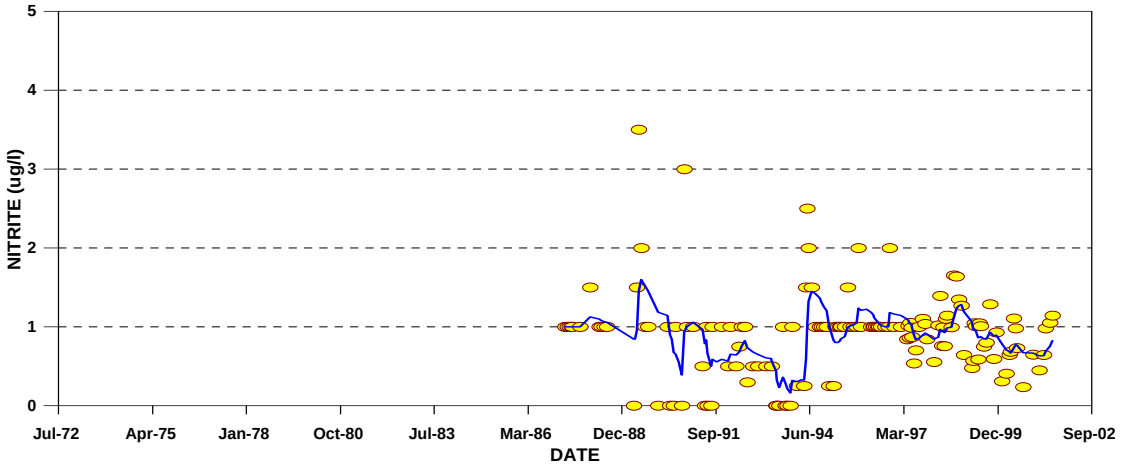
AVERAGE BOTTOM CONCENTRATION
NITRATE



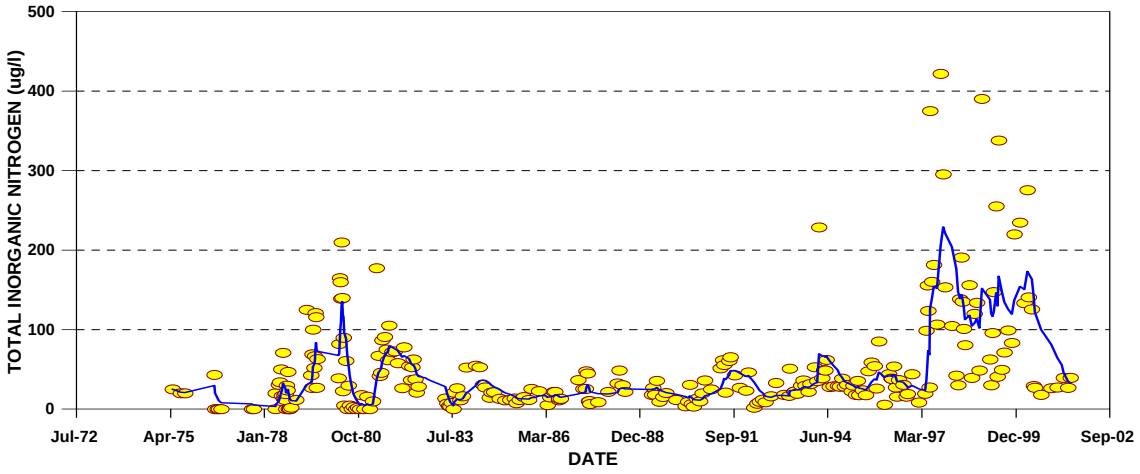
AVERAGE SURFACE CONCENTRATION
NITRITE



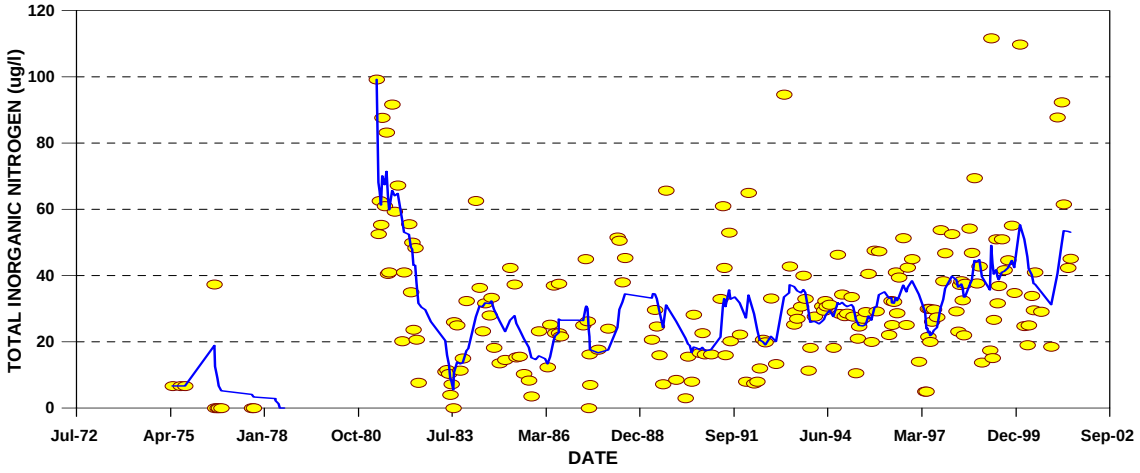
AVERAGE BOTTOM CONCENTRATION
NITRITE



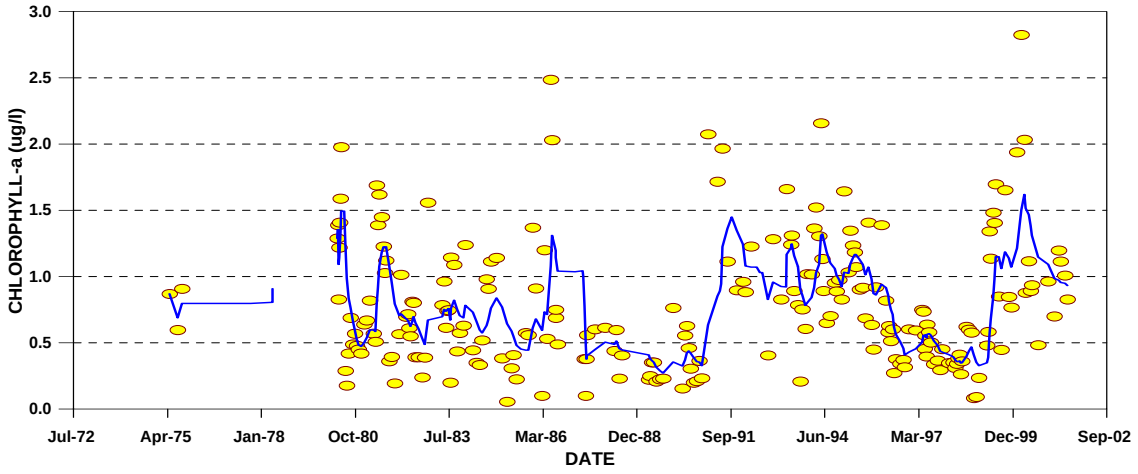
AVERAGE SURFACE CONCENTRATION
TOTAL INORGANIC NITROGEN



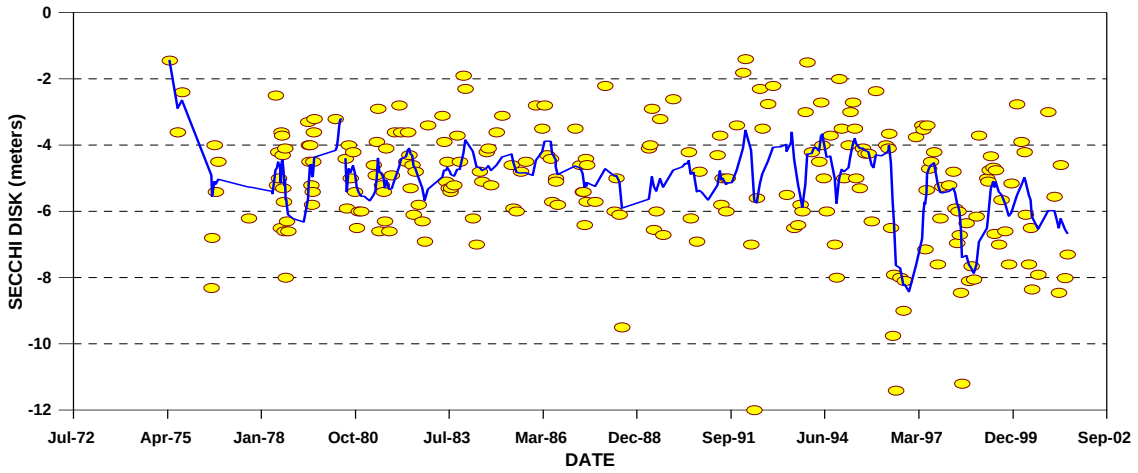
AVERAGE BOTTOM CONCENTRATION
TOTAL INORGANIC NITROGEN



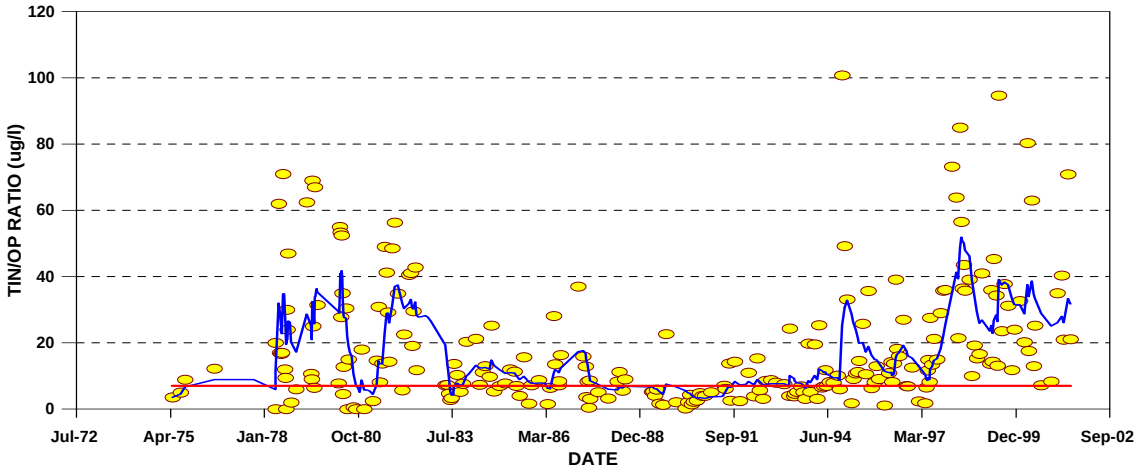
AVERAGE CONCENTRATIONS
CHLOROPHYLL-a



AVERAGE WATER TRANSPARENCY
SECCHI DISK



BEAR LAKE
TIN/OP RATIO



APPENDIX B

Raw Data

	DEPTH (meters)							AVERAGES			
	0	10	20	30	40	50	60	Epilimnion	Metalimnion	Hypolimnion	ALL
Dissolved Oxygen (mg/liter)											
09/06/00	7.57	7.54	10.3	9.61	7.82	6.63	6.07	7.56	9.96	6.84	7.93
12/19/00	10.11	10.37	10.19	9.85	9.53	9.37	8	10.24	10.02	8.97	9.63
02/26/01	10.5	9.75	9.43	8.8	7.8	7.05	3.26	10.13	9.12	6.04	8.08
04/10/01	9.62	9.95	9.78	9.7	8.71	5.61	3.48	9.79	9.74	5.93	8.12
04/30/01	9.9	9.91	9.96	9.85	9.74	8.32	6.06	9.91	9.91	8.04	9.11
06/18/01	8.25	9.27	10.05	9.75	8.45	8.3	7.91	8.76	9.90	8.22	8.85
Temperature (℃)											
09/06/00	18.53	18.51	13.53	7.48	5.3	4.63	4.67	18.52	10.51	4.87	10.38
12/19/00	4.02	4.01	3.99	3.84	3.82	3.79	3.88	4.02	3.92	3.83	3.91
02/26/01	0.85	2.79	3.07	3.32	3.47	3.51	3.83	1.82	3.20	3.60	2.98
04/10/01	3.42	3.31	3.24	3.21	3.29	3.57	3.7	3.37	3.23	3.52	3.39
04/30/01	8.01	6.33	4.38	4.21	4.15	3.87	3.74	7.17	4.30	3.92	4.96
06/18/01	15.36	12.25	7.37	5.56	4.72	4.58	4.51	13.81	6.47	4.60	7.76
pH (SU)											
09/06/00	8.46	8.46	8.43	8.34	8.2	8.13	8.12	8.46	8.39	8.15	8.31
12/19/00	8.33	8.41	8.43	8.44	8.46	8.46	8.47	8.37	8.44	8.46	8.43
02/26/01	8.1	8.27	8.29	8.3	8.24	8.18	7.84	8.19	8.30	8.09	8.17
04/10/01	8.34	8.25	8.3	8.3	8.26	8.07	7.9	8.30	8.30	8.08	8.20
04/30/01	8.35	8.42	8.45	8.44	8.44	8.38	8.23	8.39	8.45	8.35	8.39
06/18/01	8.46	8.47	8.47	8.45	8.37	8.37	8.36	8.47	8.46	8.37	8.42
Conductivity (μmho/cm)											
09/06/00	739	741	727	724	727	727	724	740	726	726	730
12/19/00	689	690	690	691	690	691	691	690	691	691	690
02/26/01	699	681	684	683	688	692	713	690	684	698	691
04/10/01	676	678	678	681	688	705	716	677	680	703	689
04/30/01	685	683	682	681	682	689	697	684	682	689	686
06/18/01	706	701	695	694	697	696	696	704	695	696	698
Secchi disk transparency (meters)											
09/06/00	-7.9										
12/19/00	-3										
02/26/01	-5.55										
04/10/01	-8.45										
04/30/01	-4.6										
06/18/01	-8.01										

	DEPTH (meters)							AVERAGES			
	0	10	20	30	40	50	60	Epilimnion	Metalimnion	Hypolimnion	ALL
Turbidity (ntu)											
09/06/00	0.7	0.8	0.85	0.95	0.8	1.9	11	0.75	0.90	4.57	2.43
12/19/00	1.5	1.8	1.5	1.2	2	1.5	2.3	1.65	1.35	1.93	1.69
02/26/01	0.05	0.06	0.06	0.06	0.11	2	24	0.06	0.06	8.70	3.76
04/10/01	0.09	0.4	0.35	0.4	0.45	1.5	8	0.25	0.38	3.32	1.60
04/30/01	0.15	0.15	0.14	0.15	0.14	0.3	0.9	0.15	0.15	0.45	0.28
06/18/01	0.05	0.1	0.09	0.08	0.15	0.15	0.2	0.08	0.09	0.17	0.12
Ammonia (µg/liter)											
09/06/00	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.00	15.00	15.00	15.00
12/19/00	34.1	15.0	30.2	15.0	15.0	15.0	15.0	24.56	22.59	15.00	19.90
02/26/01	27.7	22.0	22.9	84.3	62.0	36.2	67.0	24.85	53.58	55.07	46.01
04/10/01			27.2	28.3	26.2	202.0	41.6		27.77	89.93	65.06
04/30/01	21.1	37.8	29.5	23.9	22.0	36.3	52.8	29.46	26.68	37.02	31.91
06/18/01	25.0	24.0	22.1	36.3	26.1	22.1	21.2	24.52	29.21	23.13	25.27
Nitrate (µg/liter)											
09/06/00	3.6	1.5	1.7	1.9	1.9	17.5	22.2	2.56	1.76	13.85	7.17
12/19/00	1.48	1.39	1.39	1.39	1.31	6.32	1.39	1.43	1.39	3.01	2.10
02/26/01	2.4	2.4	2.4	2.2	6.0	18.8	71.7	2.35	2.26	32.15	15.10
04/10/01		2.0	1.8	1.9	1.9	1.9	1.5		1.81	1.74	1.81
04/30/01	6.4	12.9	2.2	2.1	7.0	16.2	44.9	9.68	2.16	22.68	13.10
06/18/01	1.8	1.8	1.9	5.7	14.8	17.4	22.2	1.79	3.78	18.14	9.36
Nitrite (µg/liter)											
09/06/00	0.50	0.50	0.33	0.15	0.15	0.33	0.42	0.50	0.24	0.30	0.34
12/19/00	0.52	0.61	0.61	0.61	0.69	0.61	0.61	0.57	0.61	0.64	0.61
02/26/01	0.15	0.15	0.15	0.33	0.41	0.49	1.07	0.15	0.24	0.66	0.39
04/10/01	0.48	0.48	0.73	0.65	0.65	0.65	0.98	0.48	0.69	0.76	0.66
04/30/01	0.47	0.39	0.30	0.39	0.64	1.33	3.72	0.43	0.34	1.89	1.03
06/18/01	0.71	0.71	0.63	0.63	1.06	1.06	1.23	0.71	0.63	1.11	0.86
Total phosphorus (µg/liter)											
09/06/00	5.3	3.9	3.9	6.0	4.6	5.3	11.1	4.61	4.97	7.00	5.74
12/19/00	4.0	6.9	14.0	4.7	10.5	4.0	5.4	5.44	9.38	6.64	7.08
02/26/01	6.1	6.9	5.4	5.4	6.9	8.3	23.3	6.50	5.43	12.82	8.90
04/10/01			2.5	2.5	2.5	8.9	2.5		2.50	4.65	3.79
04/30/01	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.50	2.50	2.50	2.50
06/18/01	2.5	7.8	2.5	9.3	13.7	2.5	2.5	5.17	5.90	6.22	5.83

	DEPTH (meters)							AVERAGES			
	0	10	20	30	40	50	60	Epilimnion	Metalimnion	Hypolimnion	ALL
Orthophosphorus (µg/liter)											
09/06/00	3.3	2.9	3.3	2.9	2.5	2.9	3.7	3.14	3.14	3.07	3.11
12/19/00	3.2	2.8	2.4	2.8	2.8	2.4	2.4	3.00	2.60	2.54	2.69
02/26/01	0.5	0.5	0.5	0.5	1.3	1.3	7.6	0.50	0.50	3.43	1.76
04/10/01	1.3	3.6	1.3	1.3	1.7	1.3	1.3	2.45	1.28	1.41	1.67
04/30/01	3.0	1.8	1.8	1.8	3.0	2.2	1.8	2.38	1.79	2.31	2.18
06/18/01	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.50	0.50	0.50	0.50
Total suspended solids (mg/liter)											
09/06/00	0.5	0.5	0.5	1.1	0.5	0.5	11.4	0.50	0.79	4.13	2.14
12/19/00	2.2	2.2	2.4	2.7	2.6	2.5	3.4	2.20	2.56	2.87	2.59
02/26/01	0.5	0.5	0.5	0.5	0.5	1.4	17.3	0.50	0.50	6.40	3.03
04/10/01	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.50	0.50	0.50	0.50
04/30/01	0.5	1.1	0.5	0.5	0.5	1.3	3.9	0.78	0.50	1.90	1.18
06/18/01	0.5	0.5	0.5	0.5	0.5	0.5	4.3	0.50	0.50	1.77	1.04
Chlorophyll-a (µg/liter)											
09/06/00	0.29	0.19	0.45	0.98	0.66	0.40	0.42	0.24	0.71	0.49	0.48
12/19/00	0.92	0.97	1.08	0.61	1.02	1.18	0.97	0.95	0.84	1.06	0.97
02/26/01	0.72	0.56	1.33	0.56	0.36	0.41	0.97	0.64	0.95	0.58	0.70
04/10/01			1.50	1.19	1.18	1.40	0.72		1.34	1.10	1.20
04/30/01	0.69	1.13	1.76	1.47	1.29	0.49	0.98	0.91	1.62	0.92	1.12
06/18/01	0.59	0.77	1.04	1.74	1.11	1.16	0.66	0.68	1.39	0.98	1.01