AN EVALUATION OF CHANGES IN WATER QUALITY OF MURIEL LAKE

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EXECUTIVE SUMMARY

Staff of Water Sciences Branch were requested by Northeast Boreal Region to provide a short report on the status of water quality in Muriel Lake. Only a limited data base is available.

Total dissolved solids, conductivity and major ions have increased over time in Muriel Lake and that increase is linked to the drop in lake levels and the concentration of dissolved substances in the water. The salinity of the Muriel Lake has increased, although it still qualifies as a slightly saline water body.

Phosphorus and chlorophyll *a* have increased slightly, but the database is insufficient to determine whether these changes are related to the decline in water levels or simply reflective of year-to-year variability. The lake has remained mesotrophic.

Low winter dissolved oxygen levels, recorded under ice in recent years, are a concern for fisheries in Muriel Lake.

ACKNOWLEDGEMENTS

W. G. (Wes) English, Fisheries Management, Cold Lake, shared recent dissolved oxygen and temperature profile data for Muriel Lake.

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Bridgette Halbig, Water Quality Section, provided technical assistance in data analysis and report preparation.

Dave Trew, Head, Water Quality Section, and Sal Figliuzzi, Head, Water Sciences Branch, reviewed the manuscript.

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1.0 BACKGROUND

Muriel Lake is located about 13 km south of the town of Bonnyville in the Municipal District of Bonnyville. The lake is described as shallow and moderately productive (i.e., mesotrophic) in the Atlas of Alberta Lakes (Mitchell and Prepas, 1990).

Lake levels have been monitored since 1967. The lake reached its maximum recorded level (560.43 m above sea level) in 1974, a very wet year. Since 1974 water levels have declined steadily and reached 557 m in 2000 (Figure 1). The drop in lake level of nearly 3 m has greatly reduced the surface area of the lake. In 1962, the average lake depth was 6.6 m (Prepas and Mitchell 1990); in 2000 it had dropped to an estimated 5.1 m. As a result of the drop in lake levels, shoreline width has increased considerably. There are also concerns that the decline in water levels is resulting in a deterioration of lake water quality.

The objective of this document is to review the existing water quality data base for Muriel Lake and to describe changes in water quality, if any, that have occurred over time. The existing information does not allow the detailed description of changes in the distribution of submerged or emergent vegetation, or fish habitat.

2.0 DATA

Alberta Environment sampled Muriel Lake water quality in 1978 (August), 1988 (monthly from May to October inclusive), 1989 (March), 1990 (March), 1993 (July), 1994 (September) and 1997 (monthly from May to October inclusive).

The data include information on nutrients such as phosphorus, chlorophyll *a*, Secchi transparency, major ions, conductivity and total dissolved solids.

The lake was sampled at several locations over its entire surface area to describe its general water quality (euphotic zone composite sampling) and at its deepest point to describe changes in water quality with depth (profile sampling).

3.0 RESULTS AND DISCUSSION

General water quality changes that may be associated with a drop in lake levels could include increases in dissolved substances (such as major ions) and indicators of major ion concentrations such as conductivity and total dissolved solids. As water evaporates, these ions may become more concentrated in the lake water, subject to solubility and chemical equilibria limitations. The concentration of some major ions in water (sulphate, bicarbonate and carbonate) can also be influenced by biological activity and air-water/sediment-water interactions.

Phosphorus, a major nutrient for plant growth, may also become more concentrated as the lake volume declines. However, changes in lake phosphorus levels are also mediated by sediment-water interactions and not simply by dilution or concentration resulting from changes in water volume.

Depending on the relative changes in major ion and phosphorus concentrations, there could also be changes in the density of algae and in the transparency of the lake. Typically, increases in phosphorus concentrations would enhance the growth of algae, resulting in increased chlorophyll *a* levels and decreased water transparency. However, as major ion concentrations and salinity of the water increase, algal responses to increased phosphorus levels are often reduced.

Data for major ions, conductivity and total dissolved solids are shown in Figure 2 and summarized in Table 1. Each graph shows a gradual increase in levels recorded from 1978 to 1997 inclusive. Compared to 1978, concentrations of sodium in 1997 have increased by about 80%, sulphate by about 50% and bicarbonate by about 30%. TDS and conductivity have increased by about 50 and 40%, respectively. If one assumes that the mass of major ions has remained unchanged since 1978 (i.e., no external inputs), then the reduction in lake volume alone would explain most of the increase in concentrations (Table 2). Sodium and chloride appear to have increased more than expected from lake volume changes alone. Sodium chloride rich ground water has been recorded just east of Muriel Lake (Ozoray et al. 1980) and inputs of groundwater may contribute to the levels of chloride and sodium recorded in the lake. Muriel lake was described as slightly saline by Mitchell and Prepas (1990) based on 1988 data; it still falls into that class, although its salinity has increased notably.

Phosphorus, chlorophyll and Secchi transparency can exhibit considerable changes over the seasons and among years as a result of variability in climatic conditions. Because of these natural fluctuations, several years of data are needed to determine the existence of trends and it is preferable to compare means for the open-water season rather than values for a given month. The only years with seasonal data are 1988 and 1997. Phosphorus and chlorophyll *a* concentrations are slightly higher and Secchi transparency slightly lower in 1997 than in 1998 (Figure 3, and Table 1). While the differences may be real, there are not enough data to determine if they are indicative of changes related to water level fluctuations or year-to-year variability. Based on chlorophyll and phosphorus content, Muriel Lake was classified as a mesotrophic lake with 1988 data (Mitchell and Prepas 1990); that classification applies to 1997 data as well.

Profile samples for temperature, dissolved oxygen and phosphorus indicate that the lake is generally well-mixed during the open-water season, with relatively small differences in the water sampled near the bottom or near the surface of the lake (Figures 4 to 8). Lake temperature in July and August 1997 (Figures 5 and 6) are higher than in 1988 or 1993, probably as a result of year-to-year differences in climatic conditions (air temperature records at the Cold Lake weather station indicate that mean daily temperatures in July and August 1997 were approximately 2^{o}C higher than in 1988 or 1993).

In the winter (Figure 8), temperature is a few degrees higher and dissolved oxygen a few mg/L lower near the bottom than near the top. This is a common occurrence in shallow lakes. Overall, winter profiles for 1986, 1989 and 1990 are similar. In 1990, the lake was slightly cooler and somewhat richer in dissolved oxygen than in 1989 or 1986. This may be due to the shallower depth of the lake or, more likely, to the specific conditions at the time of sampling (e.g., thickness of snow pack and ice). Much lower dissolved oxygen levels were recorded in the water column in February 1997 and a rapid decline in dissolved oxygen concentrations was measured below 3 m depth in March 2000 (Figure 9). Low winter dissolved oxygen levels may become a significant concern for fish survival in Muriel Lake.

4.0 CONCLUSIONS

Total dissolved solids, conductivity and major ions have increased over time in Muriel Lake and that increase is probably linked to the drop in lake levels and the concentration of dissolved substances in the water. The salinity of the Muriel Lake has increased, although it still qualifies as a slightly saline water body.

Phosphorus and chlorophyll *a* have increased slightly, but the data base is insufficient to determine whether these changes are related to the decline in water levels or simply reflective of year-to-year variability. The lake has remained mesotrophic.

Low winter dissolved oxygen levels recorded under ice in recent years, are a concern for fisheries in Muriel Lake.

5.0 LITERATURE CITED

Mitchell, P.A. and E.E. Prepas (Eds). 1990. The Atlas of Alberta Lakes. The University of Alberta Press, Edmonton. 675 pp.

Ozoray, G., E.I. Wallick, A.T. Lytviak. 1980. Hydrogeology of the Sand River Area, Alberta. Earth Sciences Report 79-1. Alberta Research Council. Alberta Research Council Library, Edmonton, Alberta. 11 pp. + map.

Table 1. Summary of water quality data for Muriel Lake.

Variables (*)	**8/3/1978 (one sample)**	**Average 1988**	**7/22/1993 (one sample)**	**Average 1997**
Total Dissolved Phosphorus		0.012	L0.001	0.016
Total Phosphorus		0.036	0.032	0.042
Total Dissolved Solids	596	714	853	918
Secchi Disk Transparency (m)		2.2		1.9
Chlorophyll *a* (mg/m^3)		6.70		6.75
Total Alkalinity	449	556	667	701
Conductivity (uS/cm)	955	1143	1350	1335
Chloride	11	17	19.9	23
Sodium	90	118	140	160
Bicarbonate	482	535	703	632
Calcium	26	11	7	7
Sulphate	105	116	143	156
Hardness	372	427	491	540

* Concentrations in mg/L unless specified otherwise

Table 2. Change in concentrations of selected water quality attributes predicted from changes in lake volume.

Variable	Year 1978	1988	1993	1997
Lake Volume (dam^3)	**459,600**	**391,700**	**336,100**	**321,000**
TDS (mg/L)				
Observed	596	714	853	918
Predicted from drop in lake volume		699	815	853
% explained by change in volume		***98***	***96***	***93***
Conductivity (uS/cm)				
Observed	955	1143	1350	1335
Predicted from drop in lake volume		1121	1306	1367
% explained by change in volume		***98***	***97***	***102***
Total Alkalinity (mg/L)				
Observed	449	556	667	701
Predicted from drop in lake volume		527	614	643
% explained by change in volume		***95***	***92***	***92***
Hardness (mg/L)				
Observed	372	427	491	540
Predicted from drop in lake volume		436	509	533
% explained by change in volume		***102***	***104***	***99***
Sodium (mg/L)				
Observed	90	118	140	160
Predicted from drop in lake volume		106	123	129
% explained by change in volume		***89***	***88***	***81***
Chloride (mg/L)				
Observed	11	17	19.9	23
Predicted from drop in lake volume		13	15	16
% explained by change in volume		***76***	***76***	***68***
Bicarbonate (mg/L)				
Observed	482	535	703	632
Predicted from drop in lake volume		566	659	690
% explained by change in volume		***106***	***94***	***109***

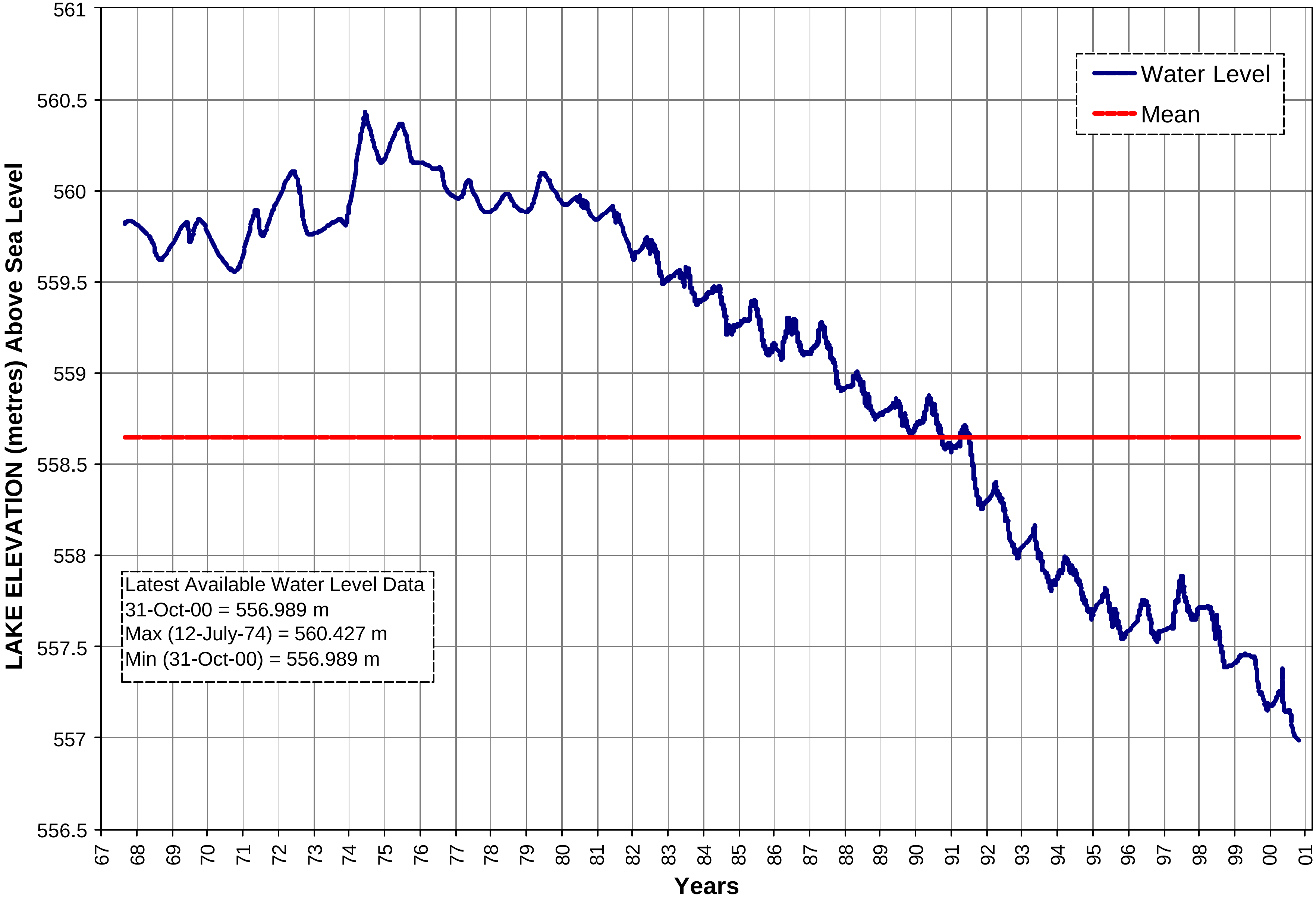

Figure 1. Historic water levels for Muriel Lake near Gurneyville (06AC912), 1967 to 2000.

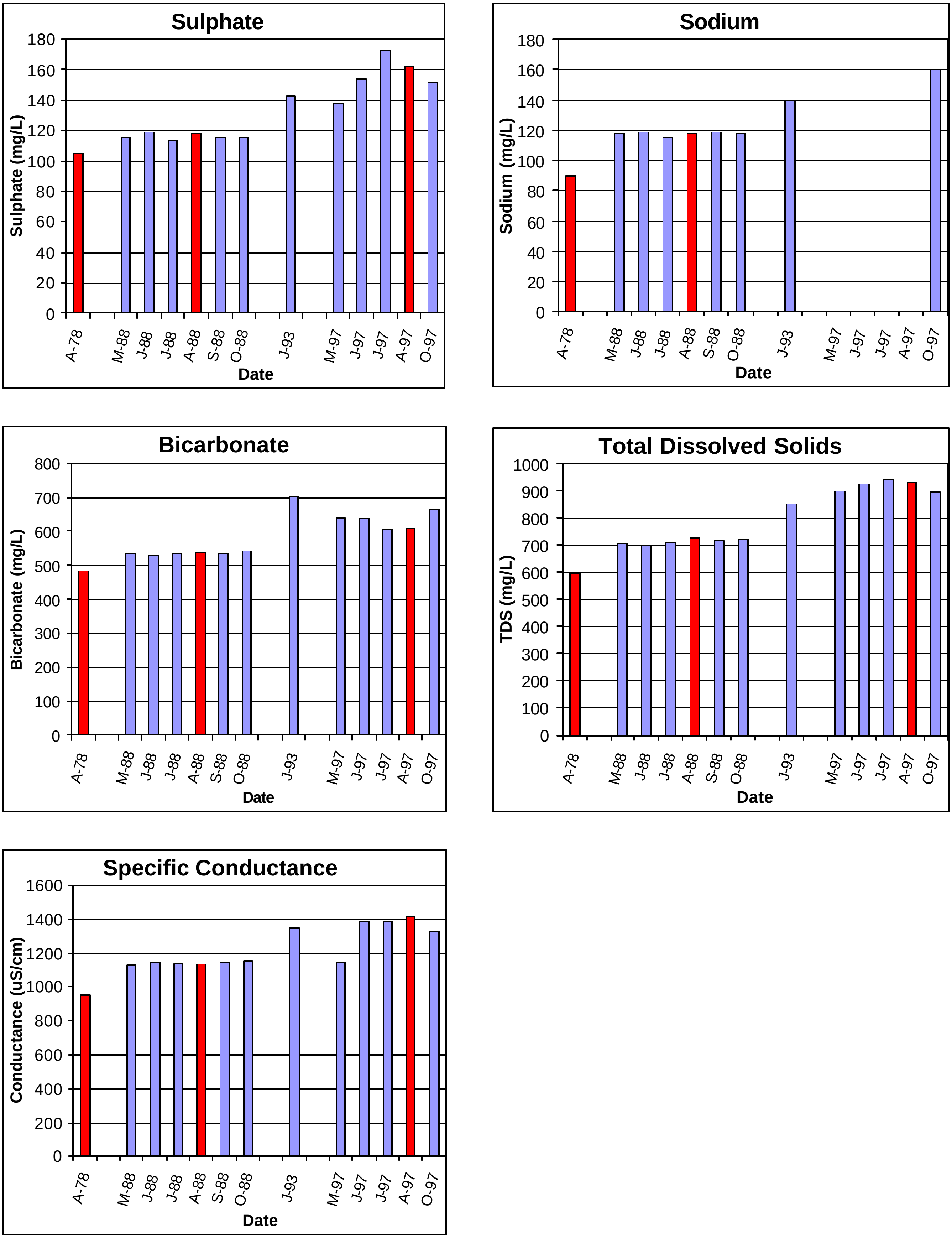

Figure 2. Selected major ions, TDS and conductivity in Muriel Lake.

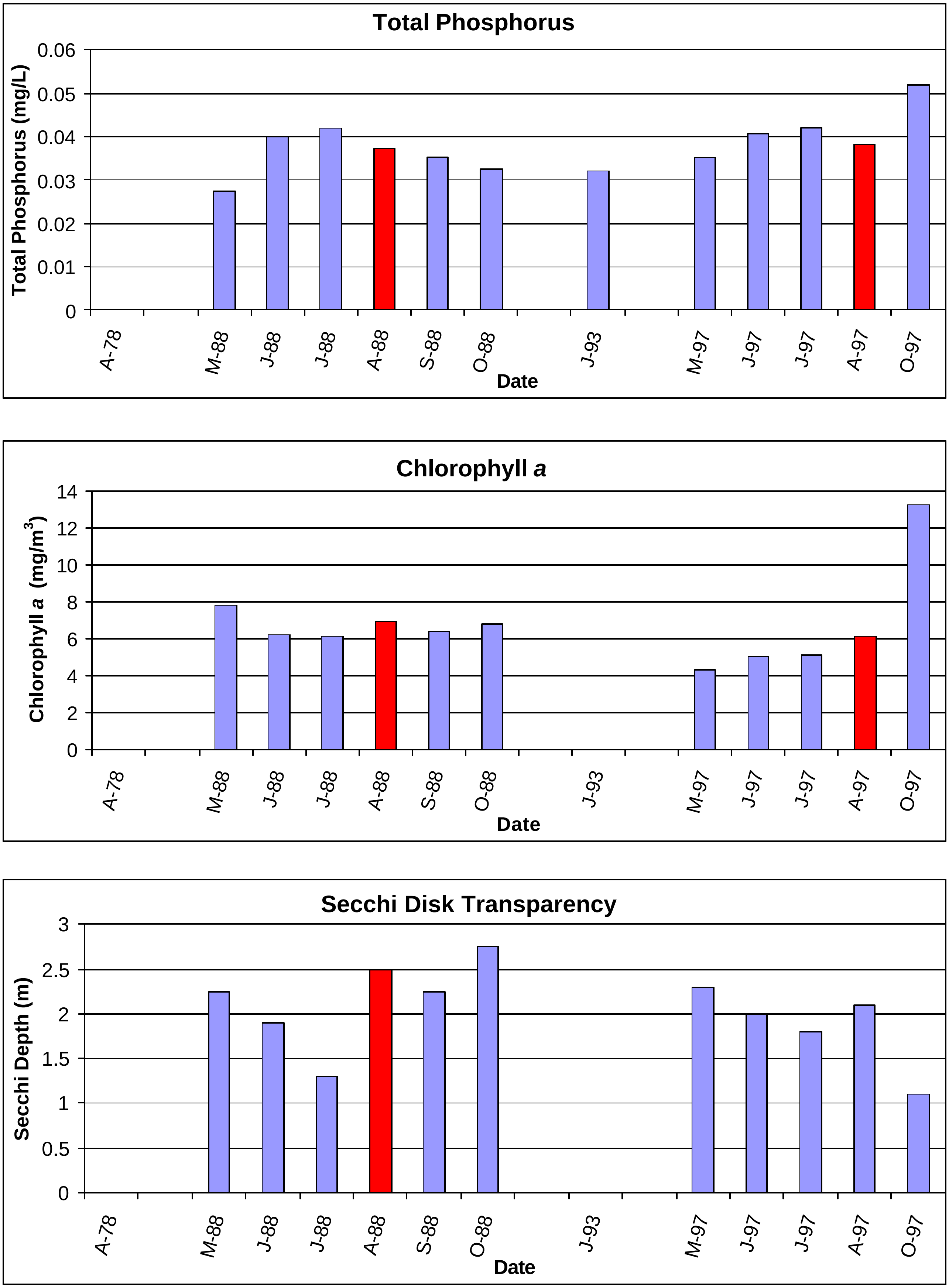

Figure 3. Total phosphorus, chlorophyll *a* and transparency in Muriel Lake.

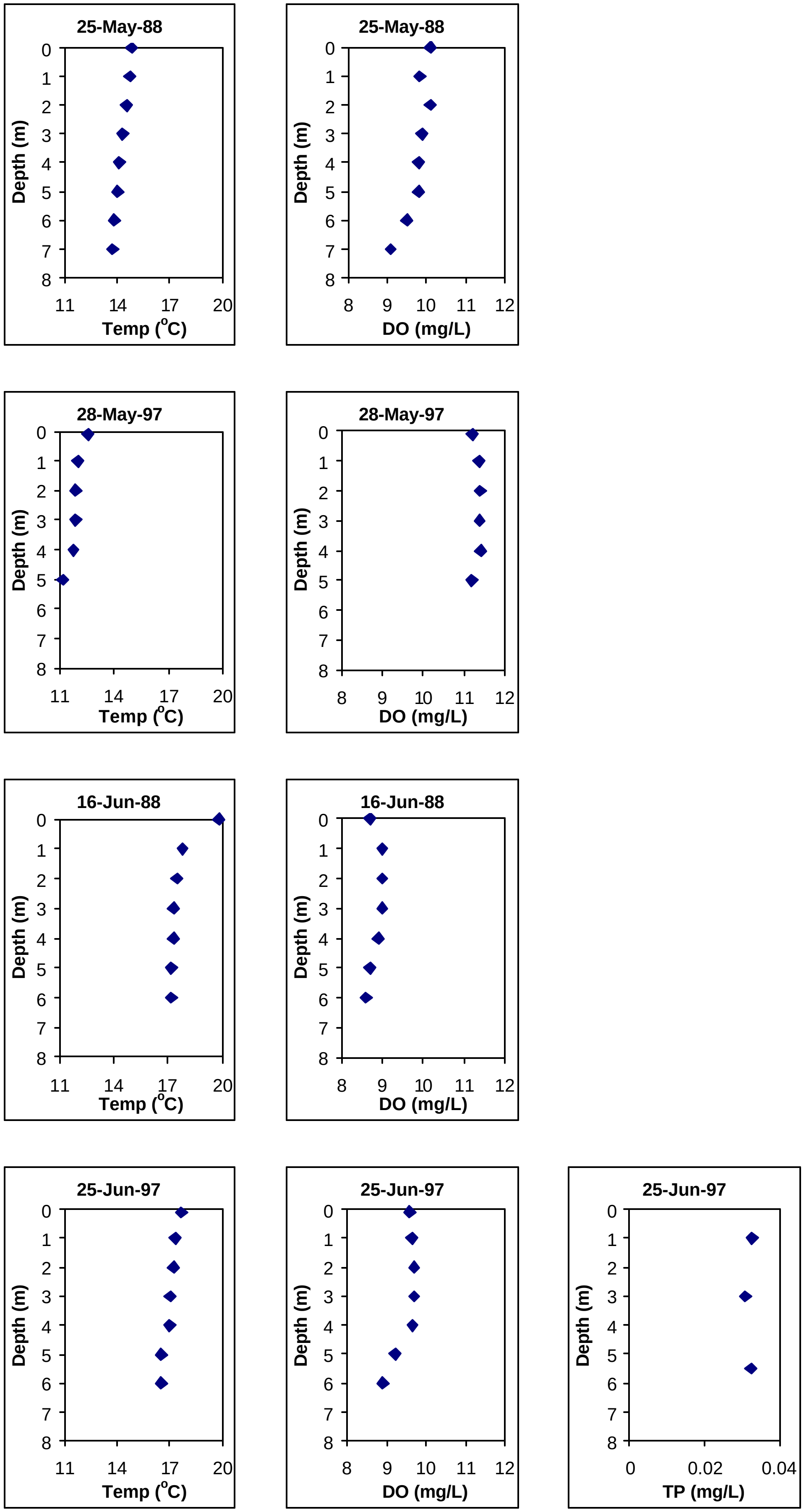

Figure 4. Vertical profiles for Muriel Lake, May and June, 1988 and 1997.

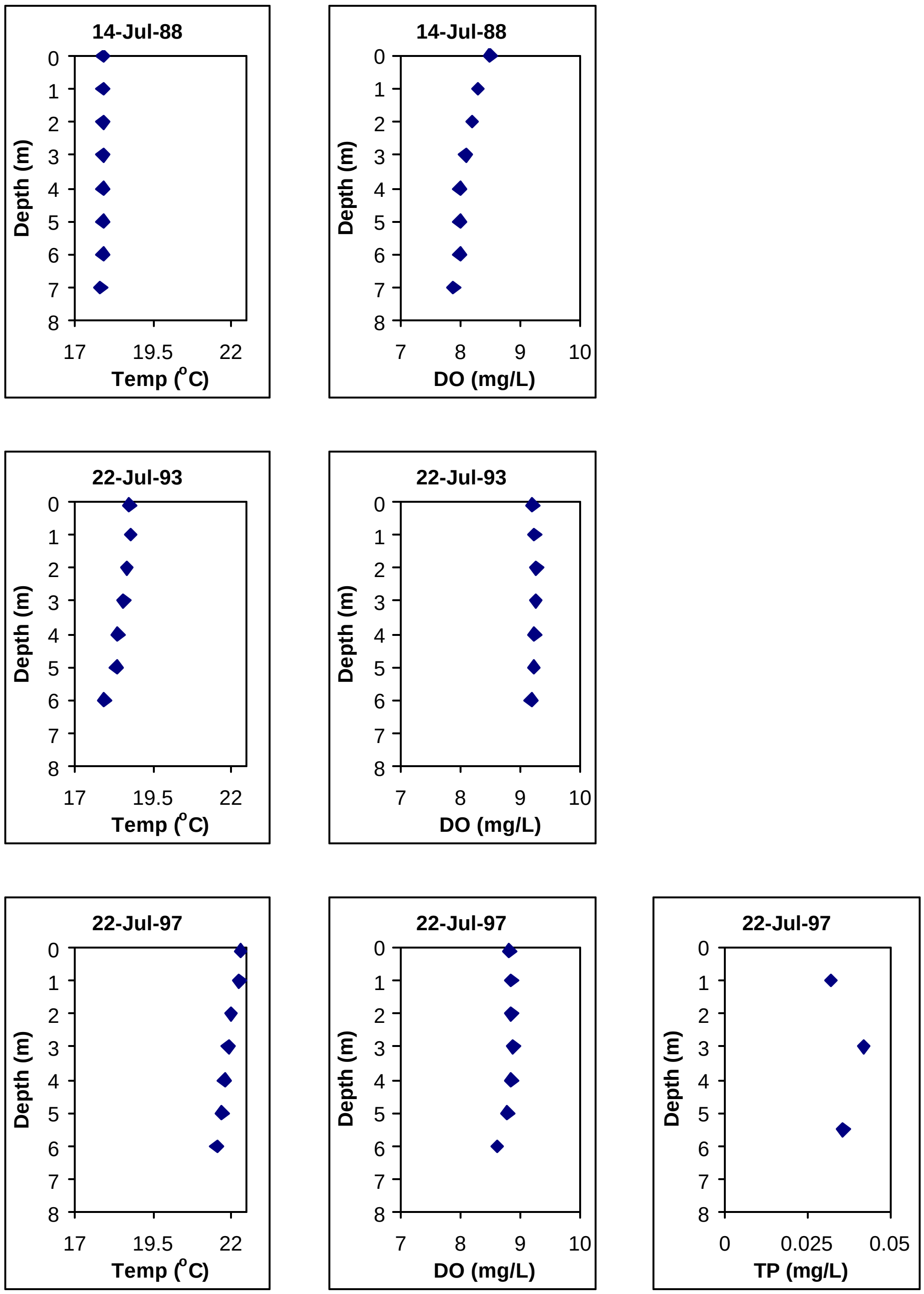

Figure 5. Vertical profiles for Muriel Lake, July, 1988, 1993 and 1997.

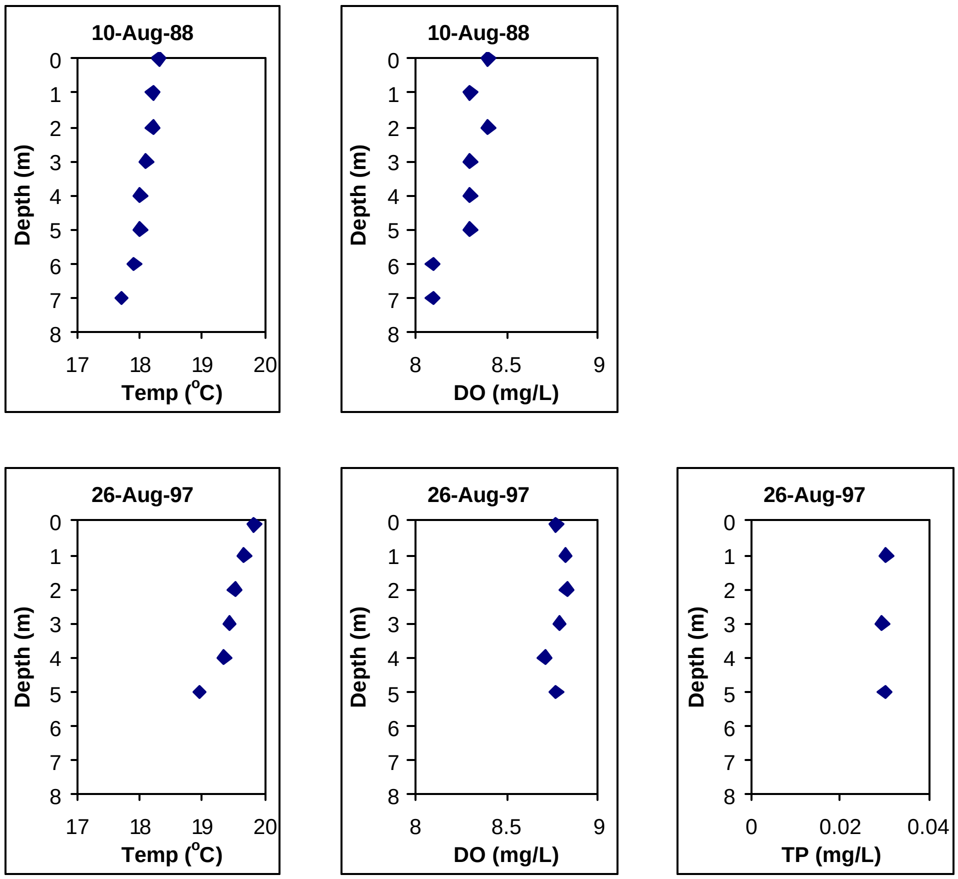

Figure 6. Vertical profiles for Muriel Lake, August, 1988 and 1997.

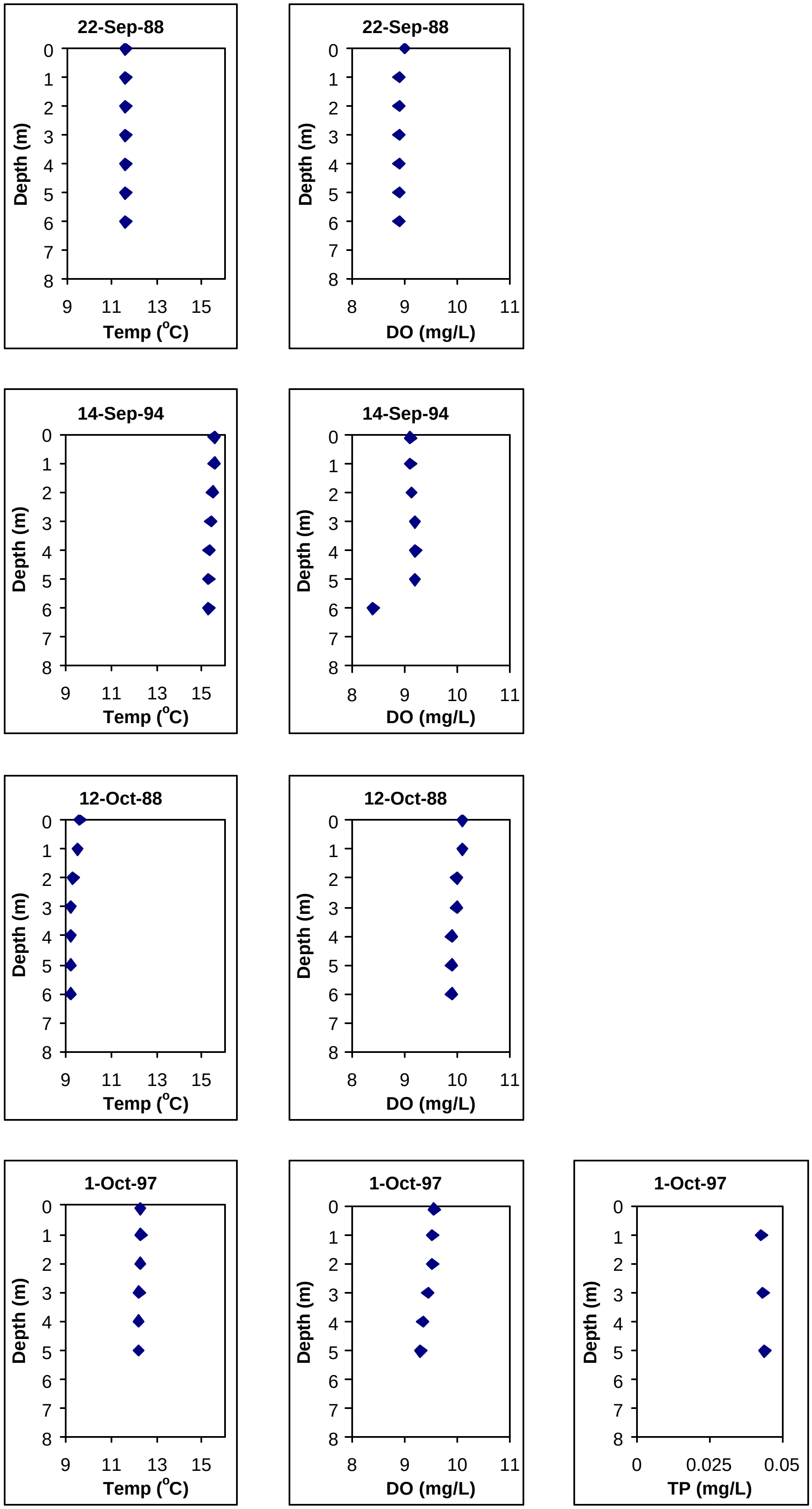

Figure 7 Vertical profiles for Muriel Lake, September and October, 1988, 1994 and 1997.

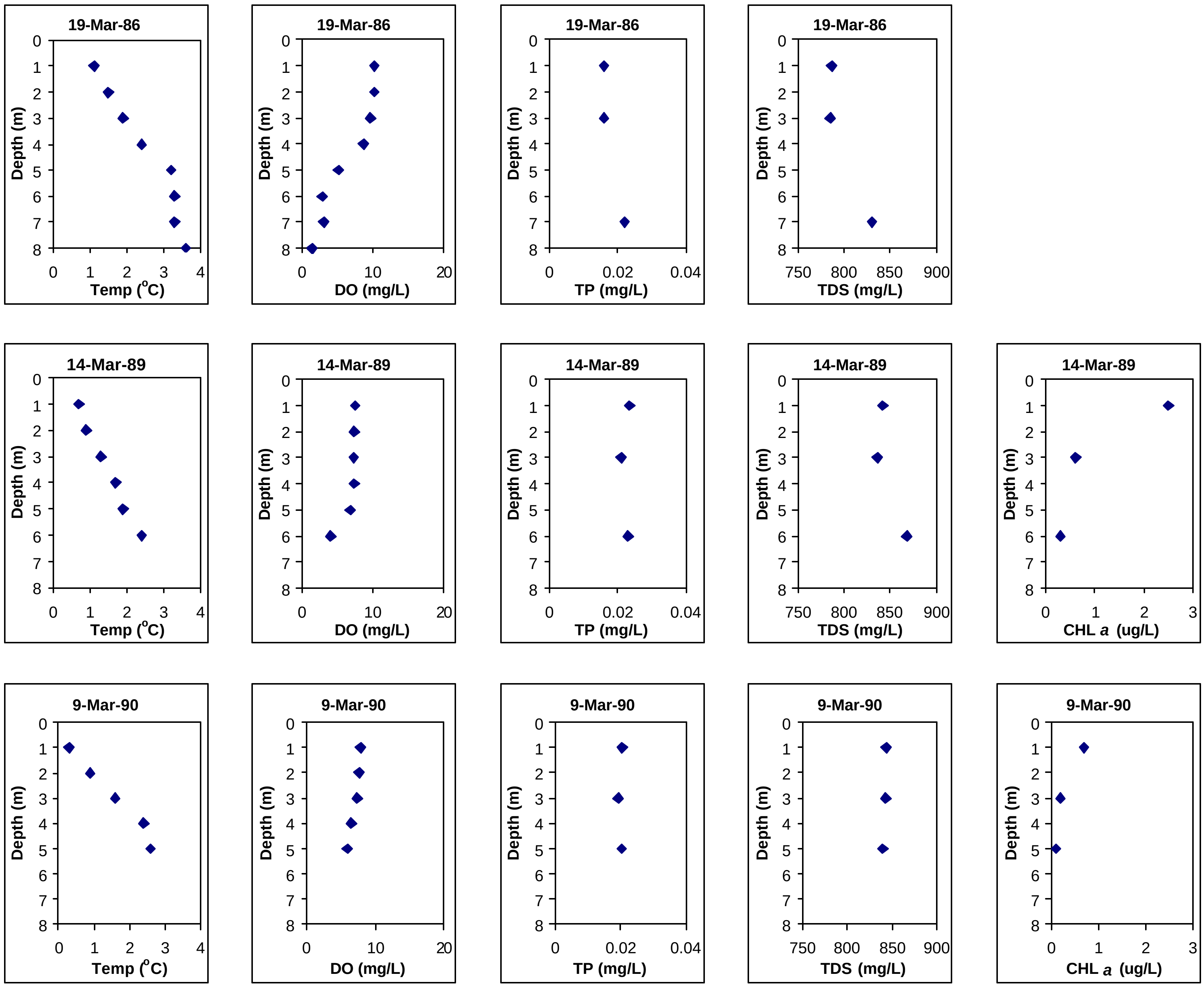

Figure 8. Vertical profiles for Muriel Lake, March, 1986, 1989 and 1990.

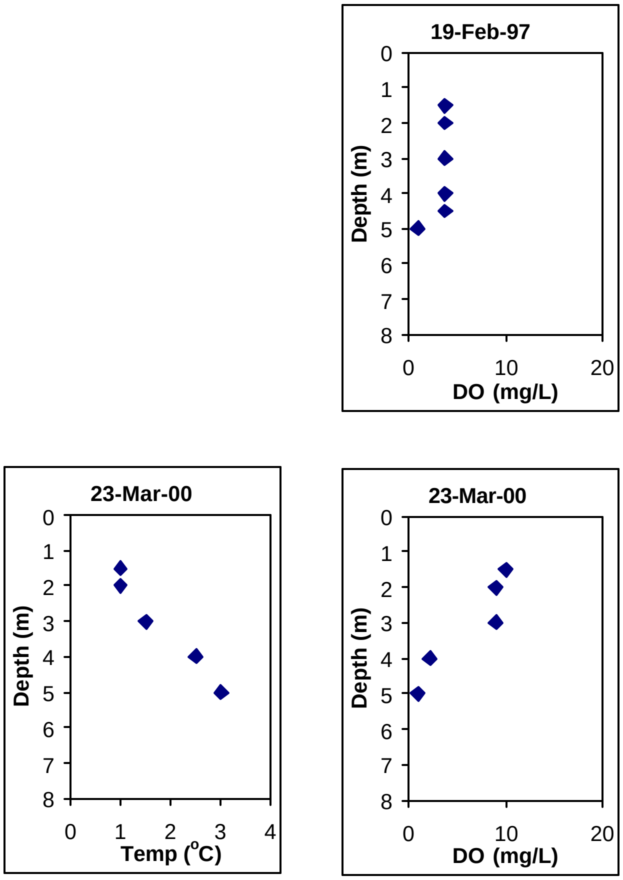

Figure 9. Vertical profiles for Muriel Lake, winter, 1997 and 2000.