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SHEARON HARRIS NUCLEAR POWER PLANT

1983 ANNUAL ENVIRONMENTAL MONITORING REPORT

Prepared by:

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BIOLOGY UNIT

ENVIRONMENTAL SERVICES SECTION

CAROLINA POWER & LIGHT COMPANY
NEW HILL, NORTH CAROLINA

December 1984

Reviewed and Approved by:

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This report was prepared under my supervision and direction, and I accept full responsibility for its content.

Manager
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This copy of this report is not a controlled document as detailed in Environmental Services Section Procedures. Any changes made to the original of this report subsequent to the date of issuance can be obtained from:

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Acknowledgments

The help of many people associated with the Biology Unit, Analytical Chemistry Laboratory, and Data Management Unit of the CP&L Environmental Services Section is greatly appreciated. All of the tasks ultimately resulting in this report could not have been accomplished without their contributions and support.

Special thanks are given to Ms. Sandra Price, Ms. Belinda Palladino, and members of the Word Processing Subunit at the Shearon Harris Energy & Environmental Center.

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Metric-English Conversion Table

Length

1 micron (μm) = 4.0×10^{-5} inch
1 millimeter (mm) = 1000 μm = 0.04 inch
1 centimeter (cm) = 10 mm = 0.4 inch
1 meter (m) = 100 cm = 3.28 feet
1 kilometer (km) = 1000 m = 0.62 mile

Area

1 square meter (m^2) = 10.76 square feet
1 hectare = 10,000 m^2 = 2.47 acres

Weight

1 microgram (μg) = 10^{-3} mg or 10^{-6} g = 3.5×10^{-8} ounce
1 milligram (mg) = 3.5×10^{-5} ounce
1 gram (g) = 1000 mg = 0.035 ounce
1 kilogram (kg) = 1000 g = 2.2 pounds
1 metric ton = 1000 kg = 1.1 tons
1 kilogram/hectare = 0.89 pounds/acre

Volume

1 milliliter (ml) = 0.034 fluid ounce
1 liter = 1000 ml = 0.26 gallons

Temperature

Degrees centrigrade (°C) = 5/9 (°F - 32)

Executive Summary

A comprehensive environmental sampling program was conducted at Carolina Power & Light Company's (CP&L) Shearon Harris Nuclear Power Plant (SHNPP) site during 1983 as required by the U.S. Nuclear Regulatory Commission. The program included aquatic (water quality and chemistry, plankton, benthos, vegetation, and fish) and terrestrial (vertebrates and vegetation) studies. This report presents and discusses the data from these studies.

Harris Lake reached its normal operational level of 67.1 m (220 ft) msl in January 1983. Water quality data indicated that Harris Lake and the auxiliary reservoir were thermally stratified throughout the summer. Low oxygen conditions which existed throughout substantial portions of the water column were primarily attributed to the decomposition of flooded terrestrial vegetation. Specific conductance and pH variations were primarily a function of watershed dynamics (e.g., precipitation, leaching of soils and overland runoff), whereas temperature and dissolved oxygen concentrations were mainly influenced by meteorological phenomena.

Water chemistry data indicated that the lake and auxiliary reservoir conditions closely paralleled conditions that existed in 1982. Generally, concentrations of chemical constituents were highest in the river and lowest in the main lake. Geologic factors (e.g., surface weathering and erosion) controlled these concentrations in the main lake and auxiliary reservoir, while anthropogenic factors (e.g., industrial discharges and farmland runoff) appeared to control those in the river. Most trace element concentrations in Harris Lake and the auxiliary reservoir were low and frequently below the 1983 analytical detection limits. However, about 75% of the copper and about 35% of the lead and nickel samples were at or above detection limits during 1983, but none exceeded the state of North Carolina or U.S. Environmental Protection Agency water quality standards or water quality criteria.

Phytoplankton density in Harris Lake in 1983 was low to moderate and was apparently regulated by nutrient availability and zooplankton grazing. Taxa richness was high (dominant classes were the Chlorophyceae and the Bacillariophyceae), while primary productivity and biomass were relatively low. These trends reflected the low nutrient levels in the lake.

The zooplankton community was in a transitory state with low to moderate total densities and high species diversity and richness. The numerically dominant taxa groups were rotifers, copepods, cladocerans, and protozoans. The major factor controlling the distribution of zooplankton appeared to be the presence of the decomposing inundated vegetation which influenced the nutrient availability and, in turn, the phytoplankton populations.

The Harris Lake benthic community continued to reflect the early phase of reservoir succession. This phase was related to the decomposition of flooded terrestrial vegetation and an increase in submerged aquatic macrophytes. Benthic macroinvertebrate diversities and densities were high providing an adequate food source for the expanding fish population. No Asiatic clams (*Corbicula fluminea*) were collected in 1983.

Fisheries sampling in 1983 indicated good species diversity and moderate to high reproduction. Sunfish species (*Lepomis* spp.) were the most abundant group of larval fish sampled, while gizzard shad, largemouth bass, bluegill, and brown bullhead accounted for the majority of the adult fish collected. Overall, sampling indicated that the fish community at Harris Lake continued a normal development during 1983.

Terrestrial vertebrate populations at the SHNPP site in 1983 showed no substantial changes in diversity or density from previous years. The lake and surrounding lands were utilized by all classes of vertebrates, and waterfowl use of the newly impounded lake increased over 1982. There were 7 observations of a bald eagle(s) at Harris Lake during 1983.

Terrestrial vegetation around the lake did not change from the previous year except for a shift to aquatic emergent species in a narrow zone at the edge of the lake. In the lake the major changes were the death of flooded terrestrial vegetation and the establishment of submerged aquatic species such as pondweed and bladderwort. No exotic species were observed.

In conclusion, these studies indicated that a diverse, normal aquatic system continued to develop in Harris Lake. Decomposition of terrestrial vegetation flooded by Harris Lake was a factor in causing low oxygen concentrations in deeper areas of the lake during the summer months as well as influencing the standing crops and diversities of planktonic and benthic macroinvertebrates. A good diversity of all classes of terrestrial vertebrates utilized the site and/or the lake.

1.0 INTRODUCTION

The Shearon Harris Nuclear Power Plant (SHNPP) nonradiological environmental monitoring program, required by the U.S. Nuclear Regulatory Commission, continued during 1983. This program included investigations of the water quality and chemistry of Harris Lake and the SHNPP auxiliary reservoir as well as studies of the plankton, benthic macroinvertebrates, fish, vegetation, and terrestrial vertebrates inhabiting the site. An outline of the 1983 SHNPP study plan is presented in Table 1.1; and the locations of sampling stations, areas, and routes are shown in Figure 1.1.

The purpose of this report is to present the results of the studies conducted during 1983 to further document preoperational environmental conditions in and around Harris Lake and the auxiliary reservoir. Harris Lake, which began filling in December 1980, reached its normal operating level of 67.1 m (220 ft) above mean sea level in January 1983 (Figure 1.2). The auxiliary reservoir filled to its normal operating level of 76.2 m (250 ft) above mean sea level in March 1983. When the SHNPP begins operation, Harris Lake will provide cooling tower makeup water while the auxiliary reservoir will be the source of emergency service water. SHNPP Unit 1 is presently scheduled for fuel loading in March 1986 and for commercial operation in September 1986. Units 2, 3, and 4 have been cancelled.

Data from the studies described in this report, together with the results of prior studies (Aquatic Control, Inc., 1973, 1975, 1976; CP&L 1978a, 1978b, 1979, 1981, 1982, 1983, 1984), are essential to assure adequate environmental assessments of potential operational effects of the SHNPP. These environmental assessments are required to support the SHNPP operating license proceedings and future NPDES permit renewals.

Table 1.1 Shearon Harris Nuclear Power Plant nonradiological environmental monitoring program for 1983.

Program	Frequency	Location
Water Quality		
Temperature, DO, pH, specific conductance, Secchi disk depth	Monthly	E2, H2, P2, S2, V3, and Z1 (every meter)[1] BK2 and D2 (surface only)
Water Chemistry		
Regular parameters	Monthly	E2, H2, P2, S2, V3, and Z1 (surface and bottom) BK2 and D2 (surface)
Special nutrient study	Monthly	E2 (surface to bottom at 1-meter intervals)
Phytoplankton		
Taxonomic study	Monthly	E2, H2, and P2 (composite sample from surface, 1 x Secchi, and 2 x Secchi)
Primary productivity (^{14}C)	Quarterly (Feb, May, Aug, and Nov)	E2, H2, and P2 (surface, 1/2 m, 1 m, and 2 m)
Chlorophyll a	Quarterly (Feb, May, Aug, and Nov)	E2, H2, and P2 (surface, 1 m, and 2 m)
Zooplankton		
Taxonomic study	Monthly	E2, H2, and P2 (vertical tows with #10 and #20 nets)
Benthic Macroinvertebrates		
Ponar grabs	Quarterly (Feb, May, Aug, and Nov)	E1, H1, P1, V3, and Z1 (3 reps at 2 m and 4 m)
Fish		
Gill nets and boat electrofishing	Quarterly (Feb, May, Aug, and Nov)	E1, E3, H1, H3, P1, P3, S1, S3, V1, and V3
Gill nets and boat electrofishing	Annually (Aug)	Z1, Z3, Z4, and Z5

[1]Secchi disk readings were taken at each lake station (i.e., E2, H2, P2, S2, V3, and Z1). pH and specific conductance were recorded only at the surface and bottom (lake stations) in Jan, Mar, May, Nov, and Dec.

Table 1.1 (continued)

Program	Frequency	Location
Fish (continued)		
Fyke nets	Quarterly (Feb, May, Aug, and Nov)	E1, H3, P3, S1, and V3
Fyke nets	Annually (Aug)	Z1 and Z5
Larval tows (night)	Biweekly (Apr-Aug) and monthly (Feb, Mar, Sep, Oct, and Nov)	E1, H3, P3, S1, and V3
Botany		
Aquatic vegetation	Spring, summer, and fall	Harris Lake and auxiliary reservoir
Terrestrial vegetation	Summer	SA5, SA6, SA7, and SA8
Terrestrial Vertebrates		
Amphibians and Reptiles		
Timed-area searches	Monthly (Apr and Jun)	SA5, SA6, SA7, and SA8
Evening call	Monthly (Feb through Jun)	Various points around the lake
Birds		
Woodland bird surveys	Spring and winter	SA5, SA6, SA7, SA8, and other project areas
Roadside bird survey	Quarterly	Merry Oaks-Buckhorn Dam route
Waterfowl surveys	Biweekly (Jan-Mar and Oct-Dec)	Various points around the lake
Wild turkey survey	Weekly (Mar and Apr)	Throughout project area
Mammals		
Scent station track survey	Fall and spring	Various roadside routes throughout project area

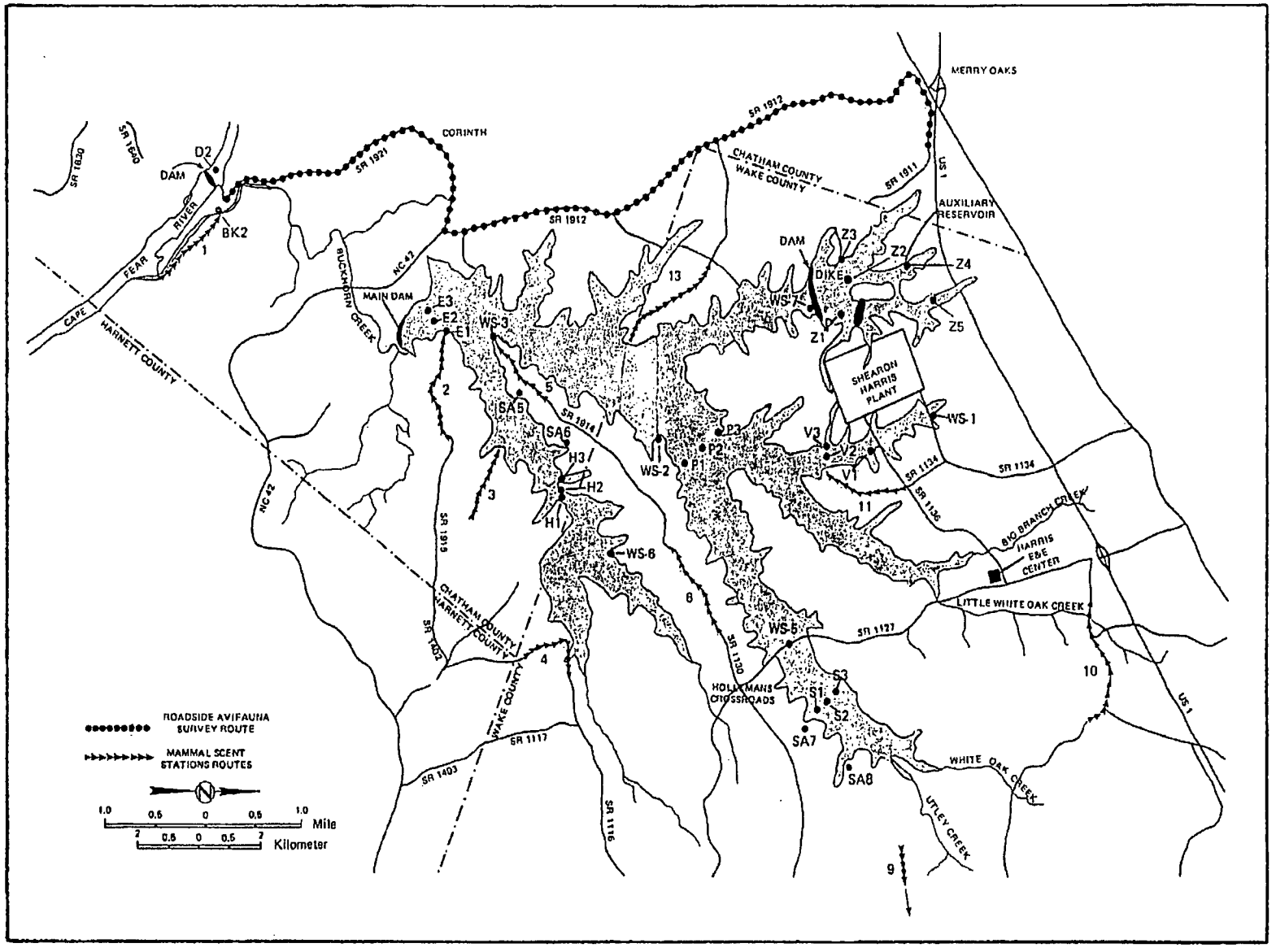

Figure 1.1 Shearon Harris Nuclear Power Plant site sampling stations for 1983.

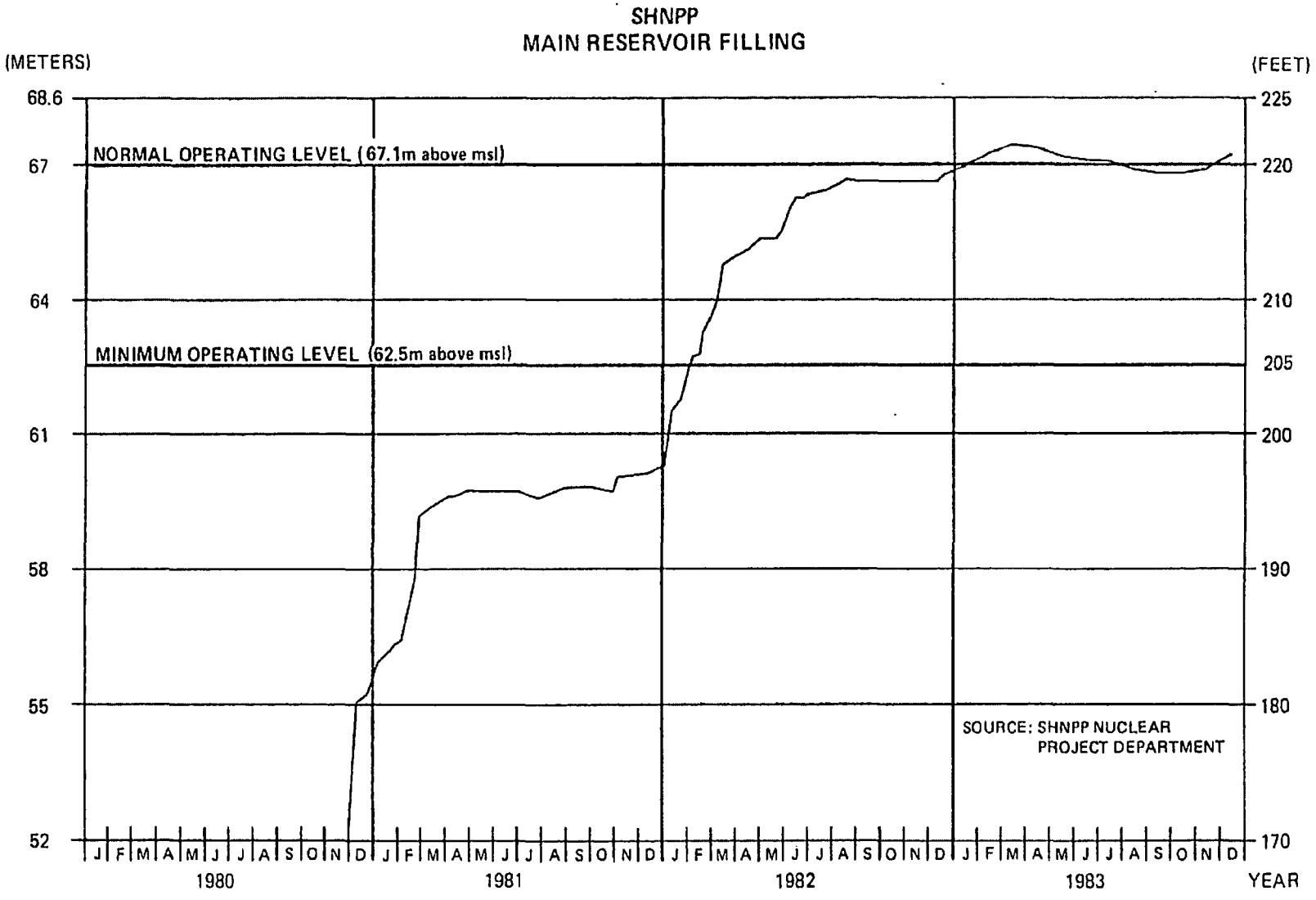

Figure 1.2 Harris Lake water level from December 1980 through December 1983.

2.0 WATER QUALITY

2.1 Introduction

As of January 1983, Harris Lake reached its normal operational elevation of 67.1 m msl. Therefore, the 1983 water quality monitoring program represented the first effort to monitor this newly impounded system over a complete calendar year. Previous environmental reports described the Harris Lake watershed as it existed in a preimpoundment state (CP&L 1979, 1981, 1982) and during the interim filling (CP&L 1983, 1984).

2.2 Methods

Temperature, dissolved oxygen (DO), hydrogen-ion activity (pH), and specific conductance were field recorded monthly during 1983 at the water quality stations listed in Table 1.1 and illustrated in Figure 1.1. Of the eight stations sampled, five were located in the lake itself (E2, H2, P2, S2, and V3), while one (Z1) was situated in the auxiliary reservoir. Two nonreservoir stations, BK2 and D2, represented sample points within Buckhorn Creek (downstream of Harris Dam) and the Cape Fear River, respectively. At lake and auxiliary reservoir stations, temperature and DO were recorded at the surface and 1-meter depth intervals. Specific conductance and pH values were also recorded in a similar spatial manner during February, April, and June through October. During the remaining months, the latter two parameters were measured only at the surface and bottom. Nonreservoir stations were monitored at the surface only due to the well-mixed nature of these lotic areas. Water quality values were primarily obtained with a Hydrolab System 8000 instrument.

Isopleths were computer produced for all water quality variables by using a grid-interpolation technique. Temperature and DO isopleths were representative of the entire year sampled, whereas pH and specific conductance isopleths were only developed for June through October 1983. Interpretation of the water quality data base was accomplished with the Statistical Analysis System (SAS). An agglomerative hierarchical cluster analysis which utilizes a squared Euclidian distance methodology as a measure of sample dissimilarity (Gauch 1982) was used to detect possible temporal (monthly) differences for all water quality parameters and areal

differences for pH and specific conductance during 1983. One-way analysis of variance (ANOVA) and Duncan's multiple range (DMR) tests were similarly used to examine variable means. When DMR test results appear in the written text, the underscores indicate similarity and values decrease from left to right. Paired t-tests were employed to determine differences between lake surface and bottom values of pH and specific conductance and also between lake and auxiliary reservoir water quality data. Unless otherwise noted, all descriptive statistics used in the interpretive analysis were determined to be "significant" at the $P = 0.05$ level of significance.

The "stability" of Harris Lake waters was also calculated on a monthly basis throughout 1983. Based on a computation developed by Symons and Robeck (1966), stability is defined as the energy required to lift the weight of the entire body of water the vertical distance between the center of gravity when the body of water is in a given state of stratification and the center of gravity when the water body is isothermal. For the purpose of this report, stability is viewed as an arbitrary yet quantifiable measurement of the intensity of thermal stratification measured in kilowatt-hour energy units.

2.3 Results and Discussion

Monthly data and summary statistics for temperature, DO, pH, and specific conductance are located in Appendix A.

2.3.1 Temperature and Dissolved Oxygen

The 1983 mean surface temperatures for Harris Lake and the auxiliary reservoir were 17.5° and 17.8°C, respectively. Lake surface temperatures ranged from 30.5°C at Station V3 in June and July to 4.3°C at Station S2 in January. Similarly, auxiliary reservoir temperatures (Z1) fluctuated from 29.6°C in July to 5.2°C in January.

Mean surface DO values were 8.3 mg/liter within the lake and 8.7 mg/liter in the auxiliary reservoir. Harris Lake DO levels ranged from 10.4 mg/liter at Station P2 in February to 5.4 mg/liter at Station H2 in July, whereas auxiliary reservoir (Z1) DO values ranged slightly higher for the same months (11.1 and 6.1 mg/liter, respectively).

Significant spatial differences were noted among lake station surface temperatures during 1983. Temperatures at Stations V3 and E2 were statistically dissimilar but were not significantly different from other lake station (H2, P2, and S2) temperatures. No significant areal differences were noted for either lake station DO values or between Harris Lake and auxiliary reservoir (Z1) temperature and DO values.

Monthly surface temperature and dissolved oxygen levels within the lake appeared to be influenced by ambient air temperatures as evidenced by the DMR test results that appear below and the hierarchical classification diagram of Figure 2.1.

Parameter	Month (1983)											
Temperature	7	6	8	9	5	10	11	4	3	12	1	2
Dissolved oxygen	2	3	6	1	11	4	5	10	12	9	8	7

In Figure 2.1 the second cluster level essentially divided the calendar year into a winter and summer period. This model accounted for 84% and 61% of the seasonal variance in the temperature and DO data, respectively.

Temperature isopleths (Figures 2.2-2.5) revealed a moderately pronounced thermal stratification from May through September. During this time interval, the top of the thermocline was positioned 6 m below surface waters. The metalimnetic stratum was approximately 2 m in thickness and was characterized by a 7°C decline in temperature from top to bottom. This temperature-induced stratification peaked in July when the mean stability of the lake equaled 761.6 kilowatt-hours (Figure 2.6). During the remaining months (January-April and October-December), the lake waters exhibited near isothermal conditions and relatively low stability values. It was interesting to note that January's stability value was -2.42 kilowatt-hours. This negative value was obtained when the cooling rate of surface and subsurface water layers located above the lake's isothermal center of gravity (theoretically, 3.7 m below the water surface at 4°C) exceeded the cooling rate of water layers located below the center of

gravity. In short, the lake waters became top heavy due to a density imbalance within the water column. Undoubtedly, the sinking and subsequent mixing of the denser top water layers with the less dense bottom strata quickly brought this system back to thermal equilibrium.

Station Z1 remained isothermal throughout 1983 primarily due to the shallow water conditions (< 4 m) which characterized this region of the auxiliary reservoir. However, summer stratification probably occurred within deeper waters (~ 10 m) located immediately upstream of the auxiliary reservoir dam.

Dissolved oxygen isopleths presented in Figures 2.7 through 2.10 illustrate the severe hypolimnetic anoxia that occurred within the lake below 5 m from mid-May to mid-September 1983. Depleted DO levels (DO < 1.0 mg/liter) were apparent in 3.13×10^7 m^3 or roughly 35% of the entire lake volume. The formation of a clinograde oxygen distribution is typically attributed to a high degree of bacterial respiration acting in concert with an increased resistance to boundary layer mixing during summer stratification (Wetzel 1975). Cole (1979) noted that quantities of dead and dying organic matter severely deplete the oxygen in hypolimnetic waters. Once established, hypolimnetic oxygen depletion usually persists throughout the summer season as was the case in Harris Lake. During the remaining months of the year (January-April and October-December), Harris Lake exhibited near uniform DO levels throughout the water column. The auxiliary reservoir station (Z1) also displayed uniform water column DO levels throughout 1983.

2.3.2 pH and Specific Conductance

The mean annual reservoir and auxiliary reservoir surface pH values for 1983 were 6.6 and 6.8, respectively. Reservoir pH values ranged from 8.3 at Station H2 in June to 5.7 at Station S2 in February and April, while auxiliary reservoir (Z1) pH fluctuated from 7.3 in May to 6.2 in January.

Mean specific conductance values were 82 µmhos/cm in the lake and 106 µmhos/cm in the auxiliary reservoir. Harris Lake specific conductance levels ranged from 190 at Stations H2 and P2 in February to 10 µmhos/cm at Station S2 in April. In contrast, recognized extremes in specific conductance were recorded within the auxiliary reservoir in November (208 µmhos/cm) and March (55 µmhos/cm).

The ANOVA model did not reveal any significant spatial variation in surface pH or specific conductance among lake stations sampled during 1983. Similarly, ordination of all water quality sampling locations yielded few if any areal trends for pH; however, a distinct pattern was noted for specific conductance (Figure 2.11). The fourth cluster level which accounted for 90% of the model variance segregated Harris Lake Stations S2, P2, H2, E2, and V3 from auxiliary reservoir (Z1) and lotic (D2, BK2) stations. This ordination technique, when applied to the 1983 specific conductance data set, was more successful in differentiating between different water bodies.

No spatial differences existed between the lake and auxiliary reservoir for either parameter during 1983.

Temporal differences were more evident for surface pH and specific conductance means when DMR tests (seen below) and hierarchical classification techniques (Figure 2.1) were utilized for lake stations only.

Parameter	Month (1983)											
pH	6	12	5	7	3	10	1	8	9	11	2	4
Specific conductance	2	11	10	1	8	9	7	5	6	12	3	4

Both parameters appeared to be influenced by precipitation events, watershed dynamics, and stratification/destratification processes. The higher specific conductance means for October and November most likely reflected "fall-turnover," while the months of January and February probably represented increased rainfall patterns and a subsequent increase in basin runoff that led to a higher concentration of dissolved solids in the lake water column.

Specific conductance and pH isopleths for selected stations are presented in Figures 2.12 through 2.19. Paired t-tests did not detect any significant differences between surface and bottom specific conductance and pH annual means for Harris Lake stations; however, the respective water quality isopleths showed a substantial degree of surface to bottom variability during the summer months.

2.4 Summary

Harris Lake surface temperatures ranged from 30.5° to 4.3°C during 1983. The reservoir was strongly stratified throughout the summer months, and anoxic conditions persisted throughout a substantial portion of the water column. Specific conductance and pH values varied little areally but exhibited distinct monthly differences. It appeared that pH and specific conductance variability were primarily a function of watershed dynamics and stratification/destratification processes occurring within the lake, whereas both temperature and dissolved oxygen levels displayed a relatively high degree of seasonality and appeared to be primarily regulated by meteorological patterns. In summer hypolimnetic waters, dissolved oxygen levels were further influenced by biological decomposition processes. Auxiliary reservoir water quality values did not significantly differ from Harris Lake values.

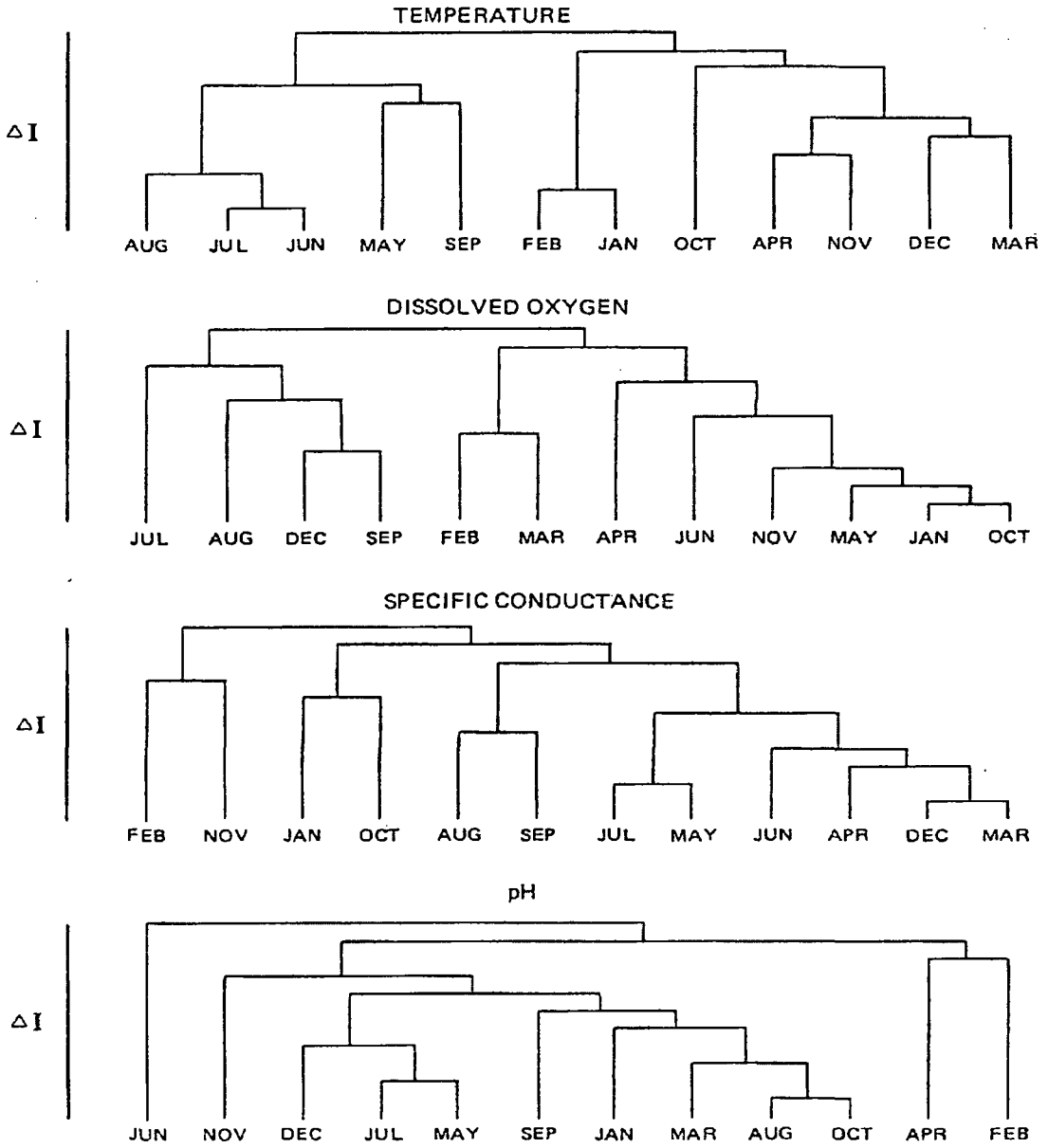

Figure 2.1 Hierarchical classification of temperature, dissolved oxygen, specific conductance, and pH data from Harris Lake for 1983. (The vertical axis (ΔI) represents sample dissimilarity.)

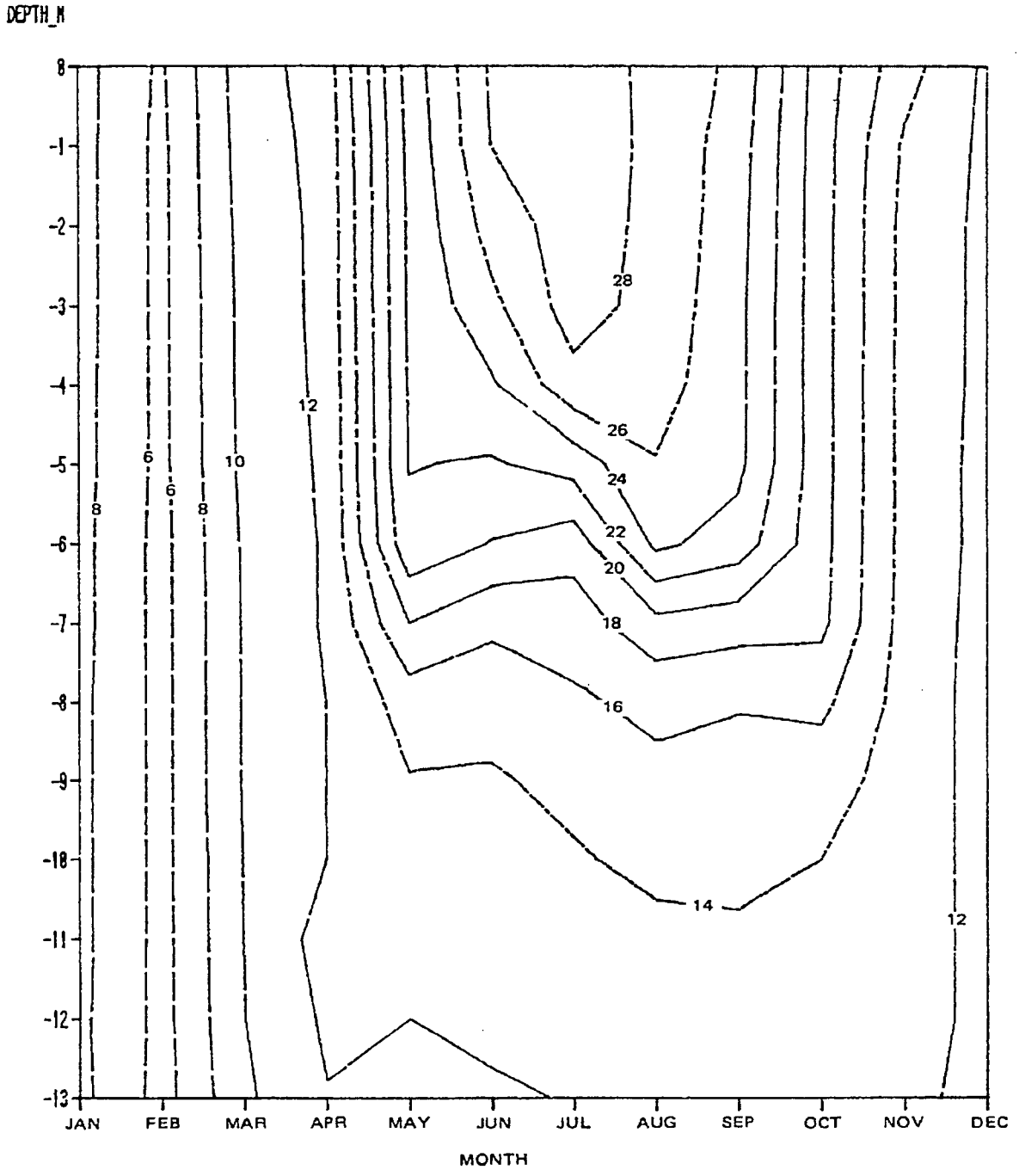

Figure 2.2 Temperature isopleths (^{o}C) of Station E2 at Harris Lake for 1983.

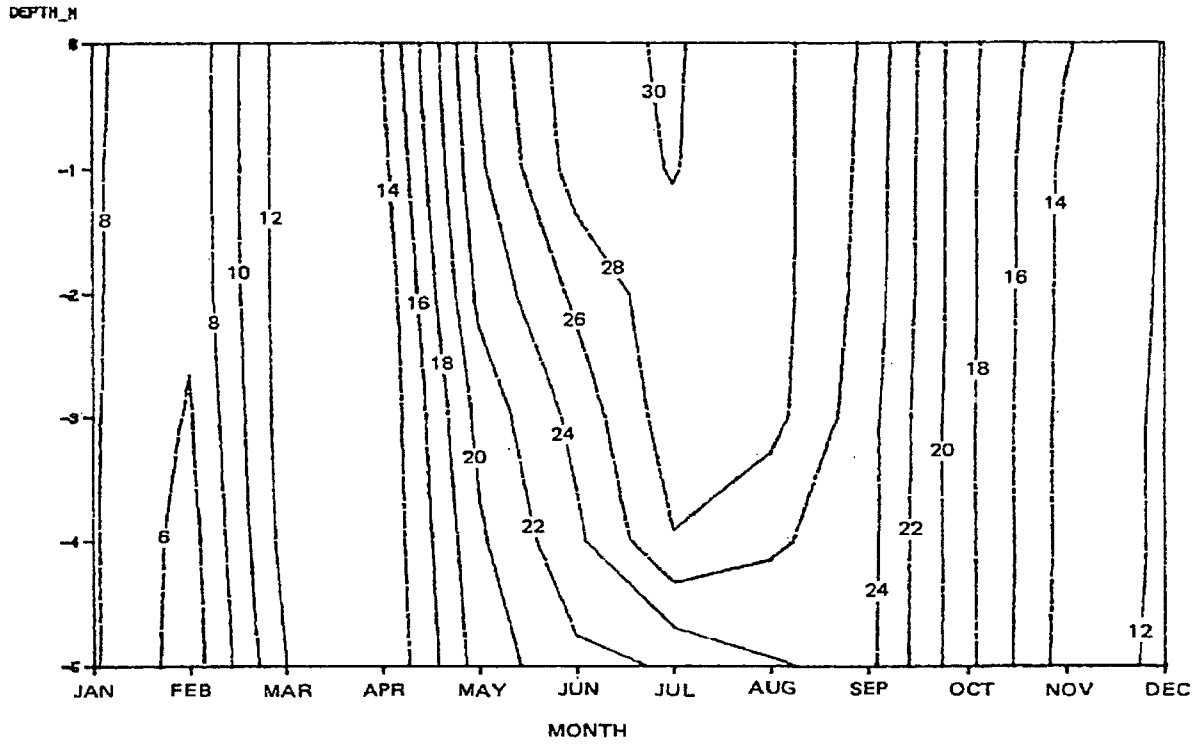

Figure 2.3 Temperature isopleths (^{o}C) of Station H2 at Harris Lake for 1983.

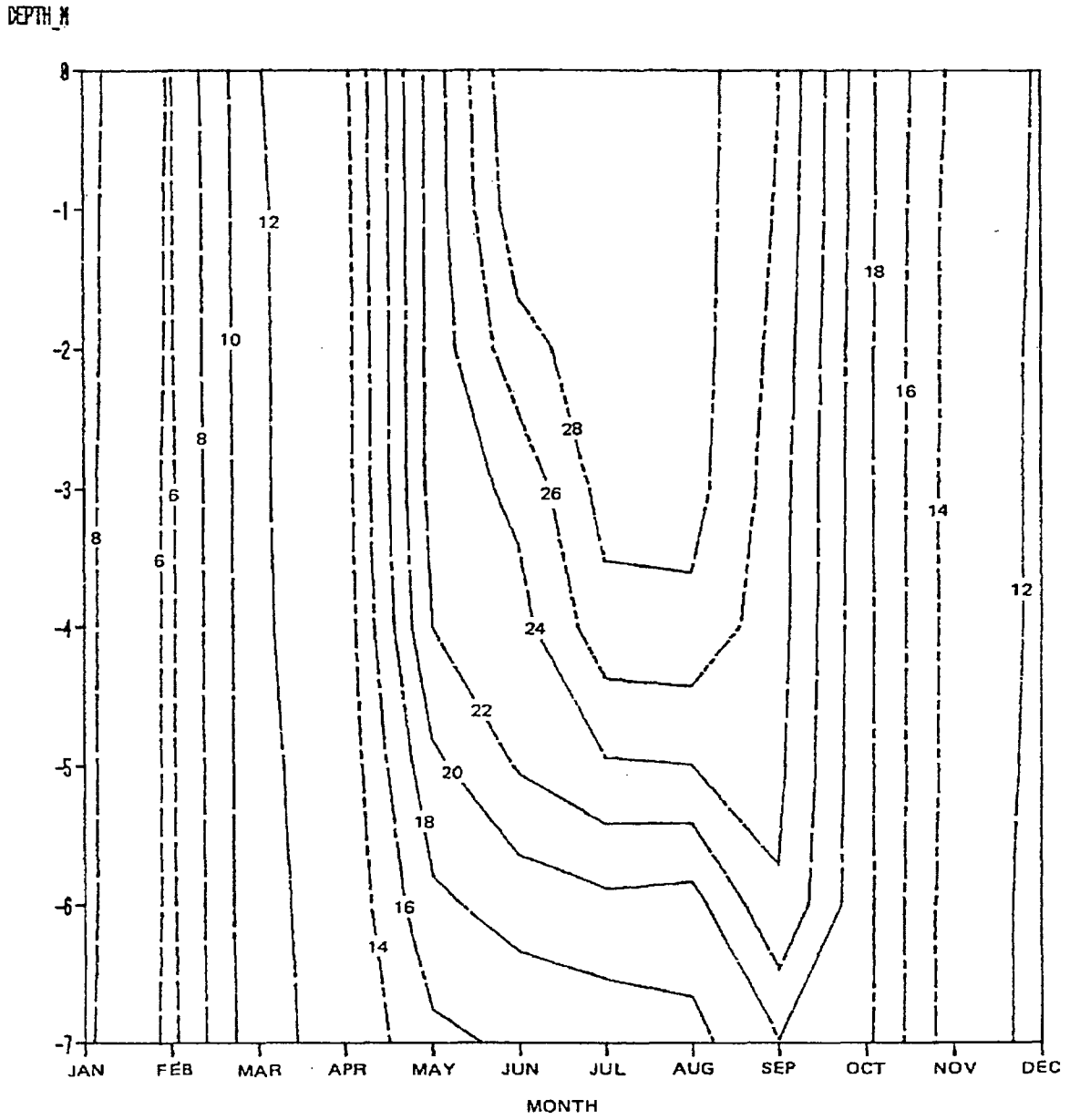

Figure 2.4 Temperature isopleths (^{o}C) of Station P2 at Harris Lake for 1983.

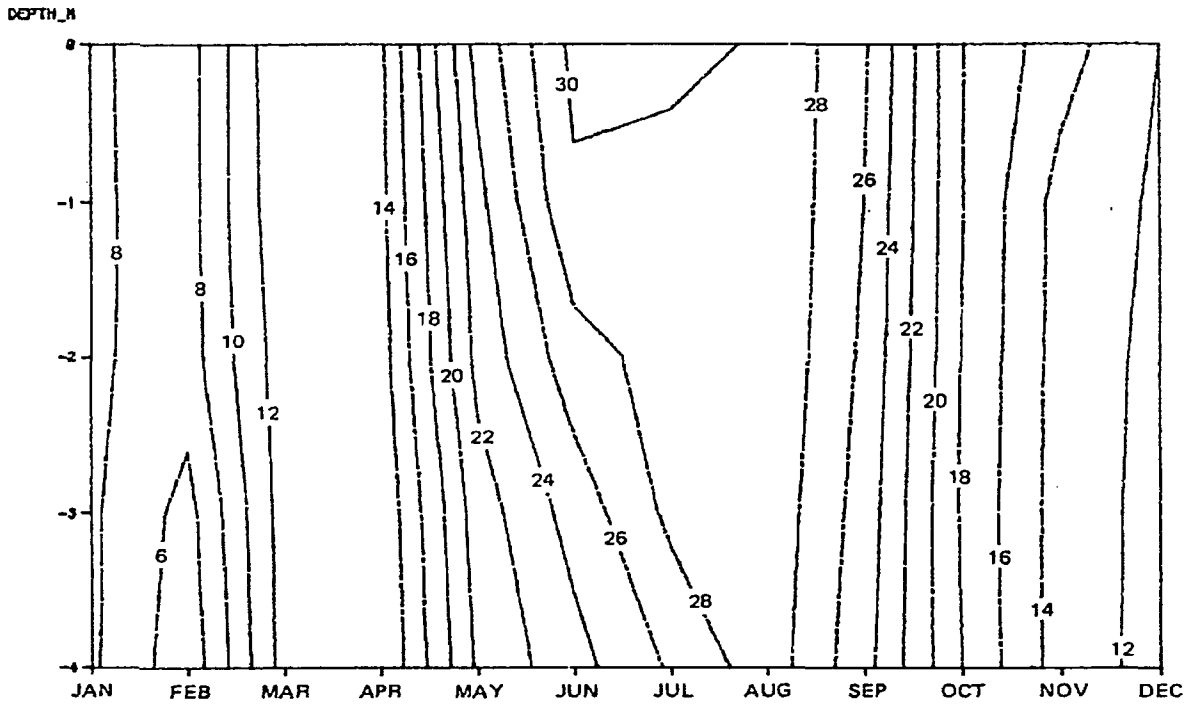

Figure 2.5 Temperature isopleths (^{o}C) of Station V3 at Harris Lake for 1983.

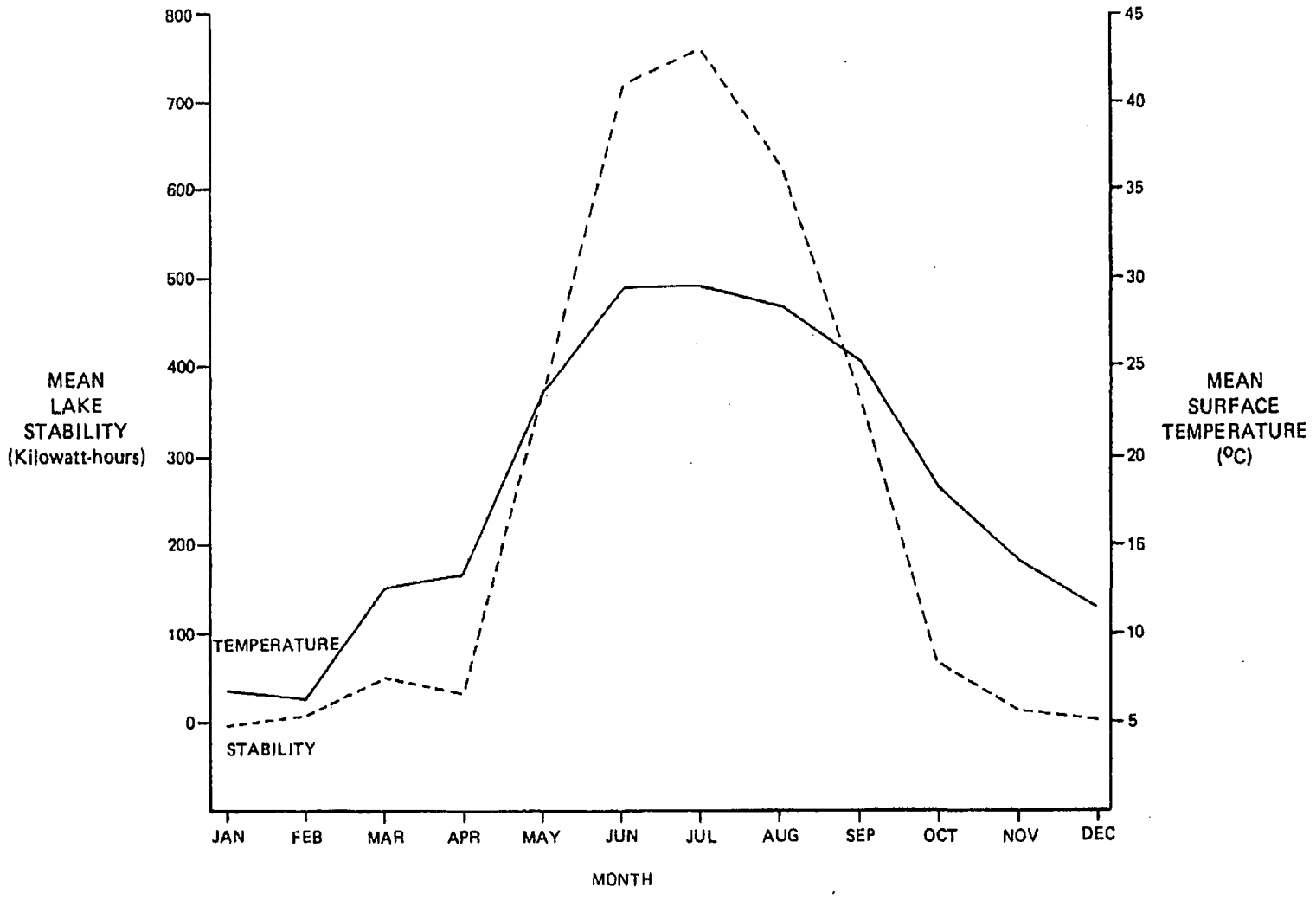

Figure 2.6 Monthly mean surface temperature and stability values at Harris Lake for 1983.

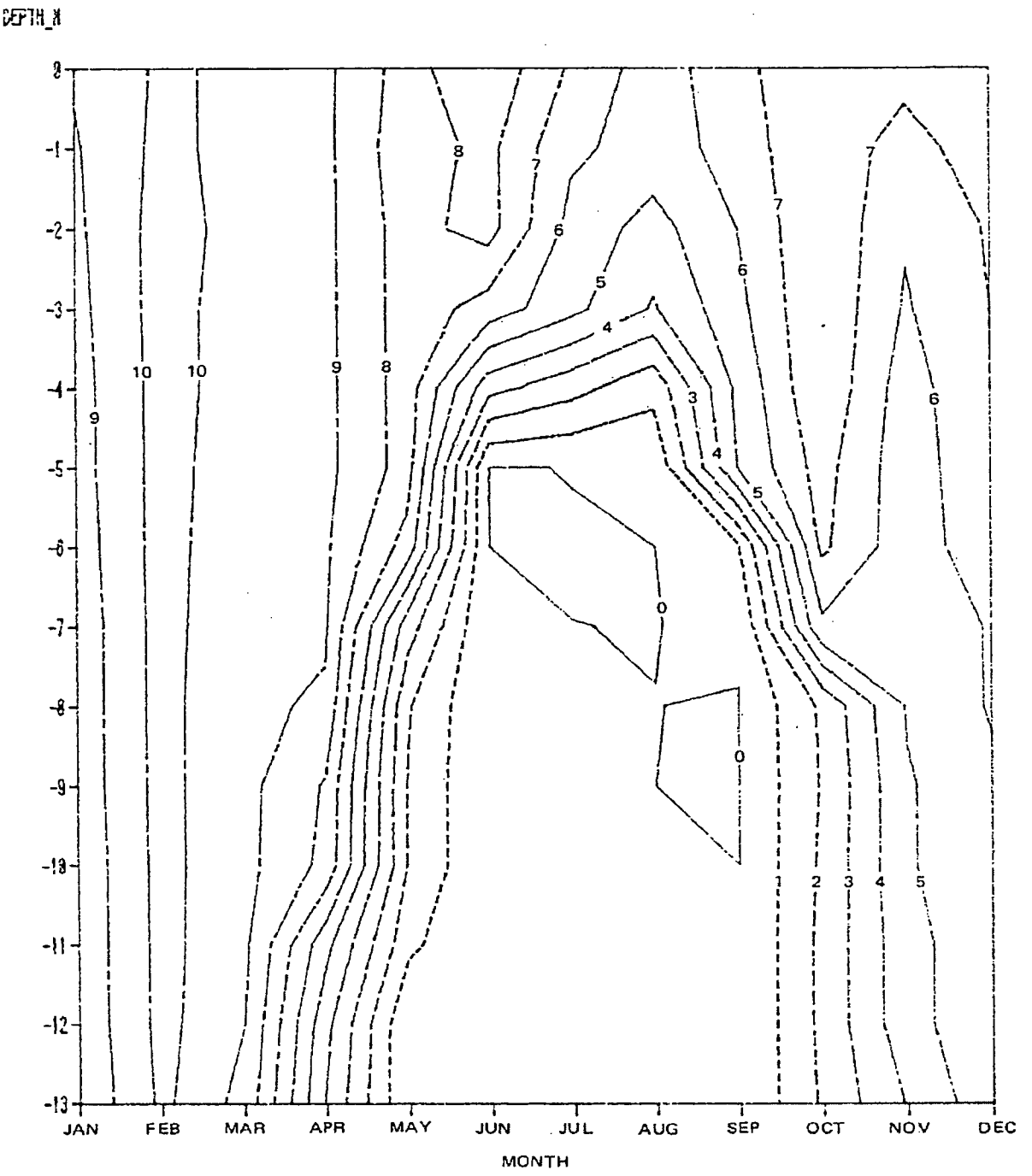

Figure 2.7 Dissolved oxygen isopleths (mg/liter) of Station E2 at Harris Lake for 1983.

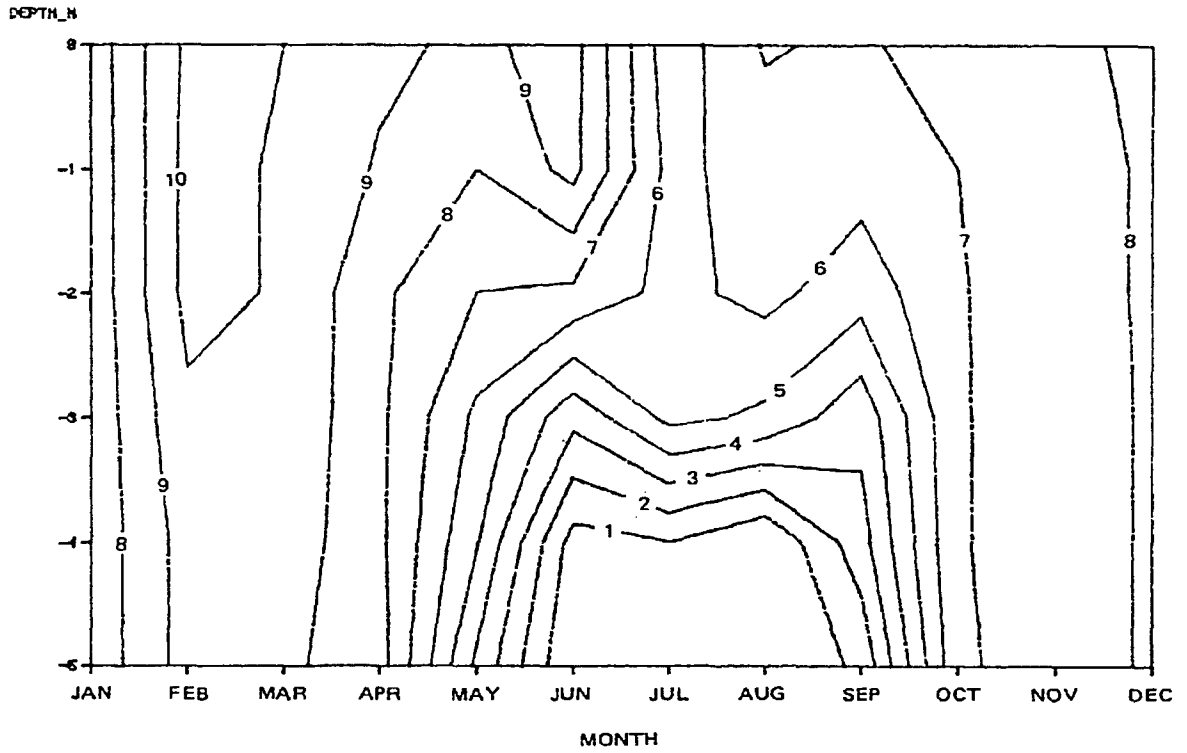

Figure 2.8 Dissolved oxygen isopleths (mg/liter) of Station H2 at Harris Lake for 1983.

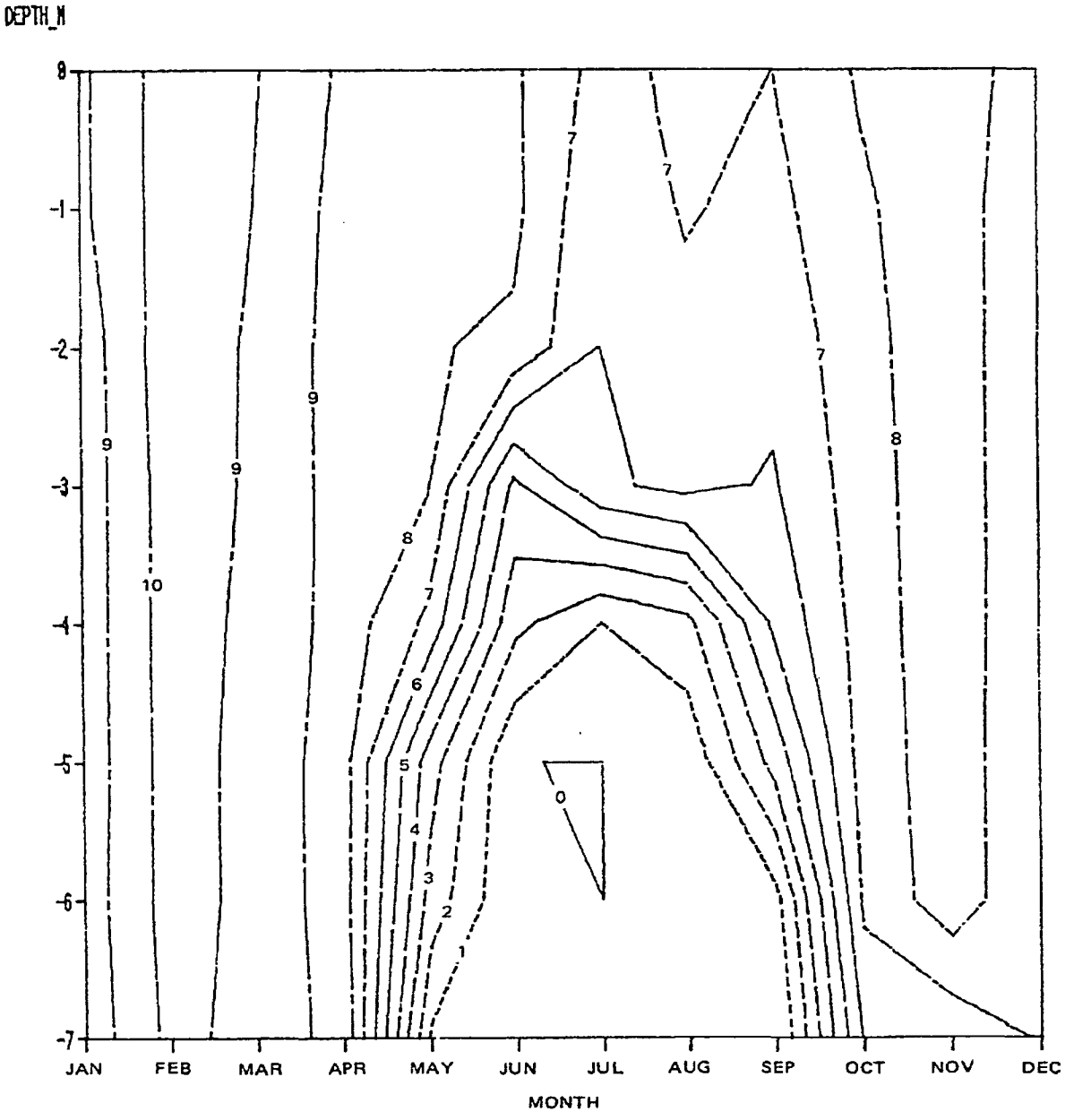

Figure 2.9 Dissolved oxygen isopleths (mg/liter) of Station P2 at Harris Lake for 1983.

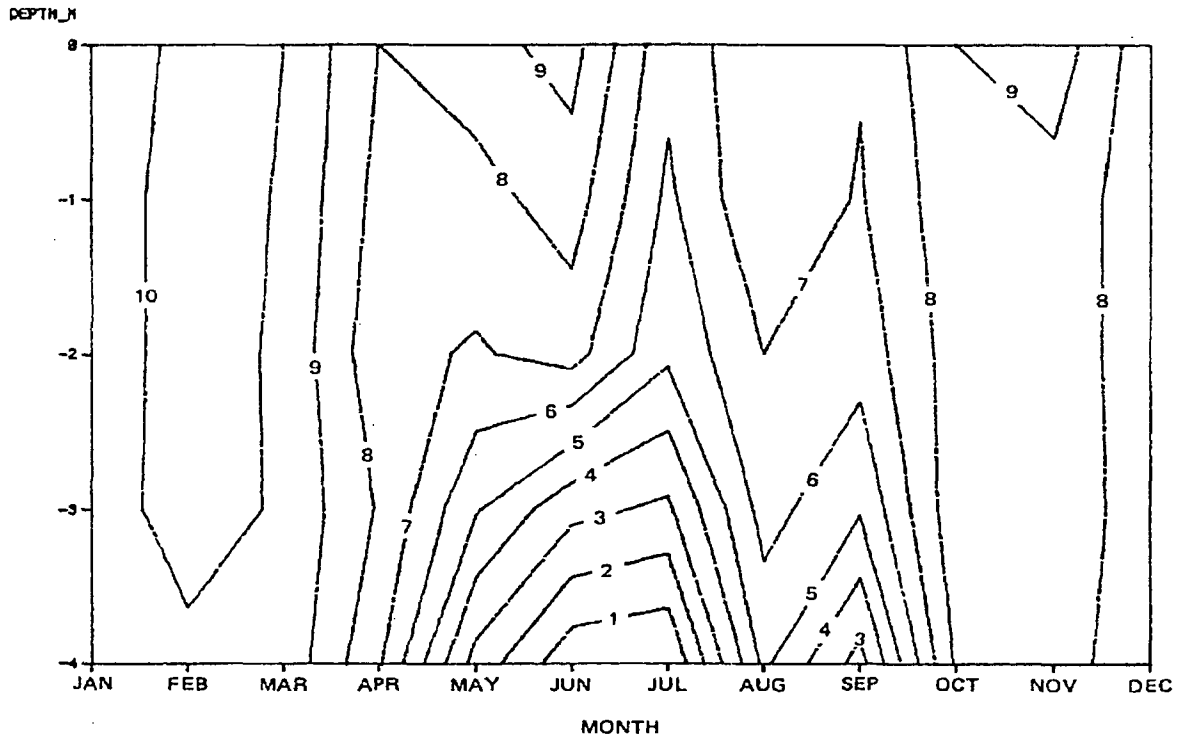

Figure 2.10 Dissolved oxygen isopleths (mg/liter) of Station V3 at Harris Lake for 1983.

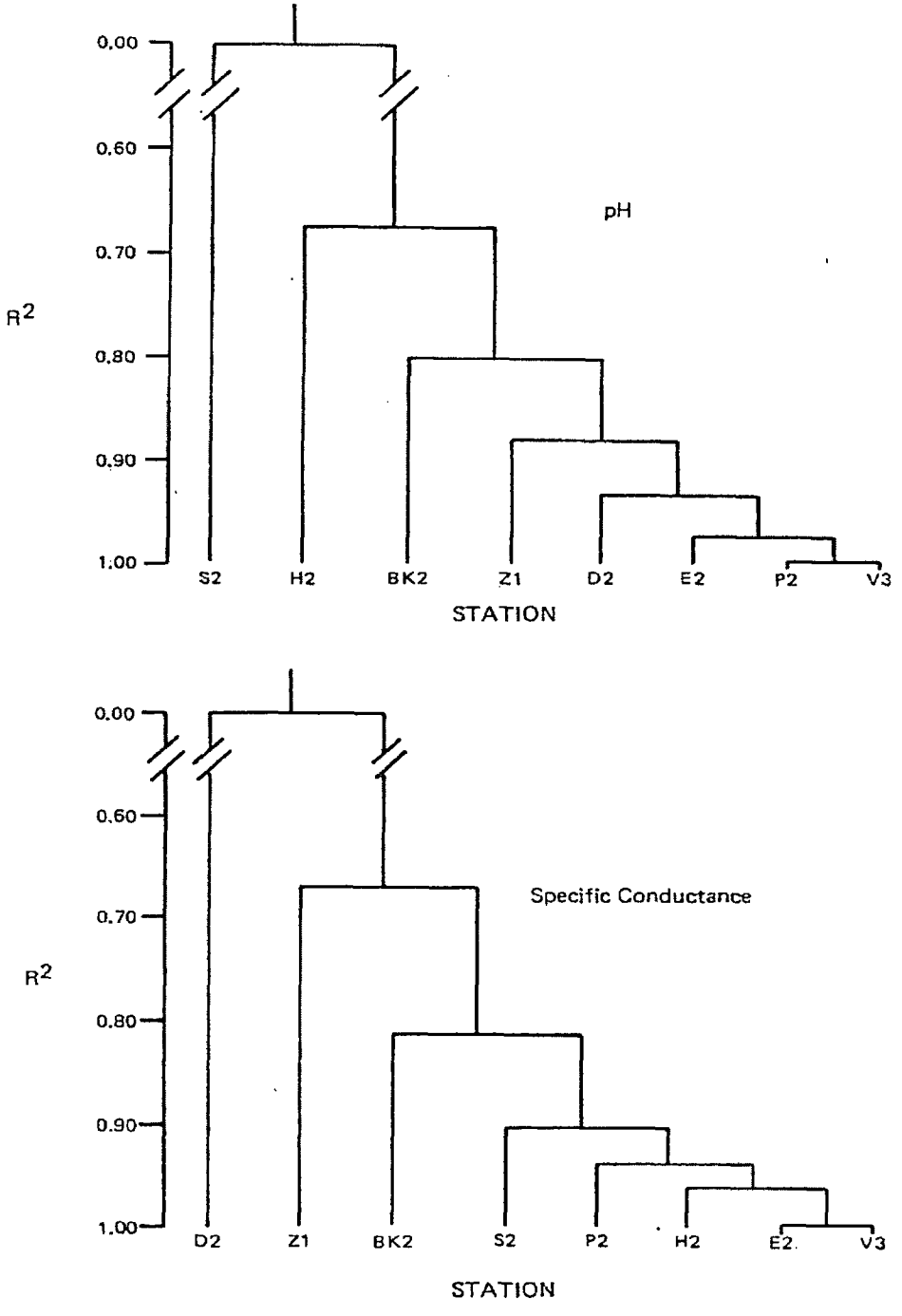

Figure 2.11 Area classification of pH and specific conductance for 1983 Harris Lake sampling locations.

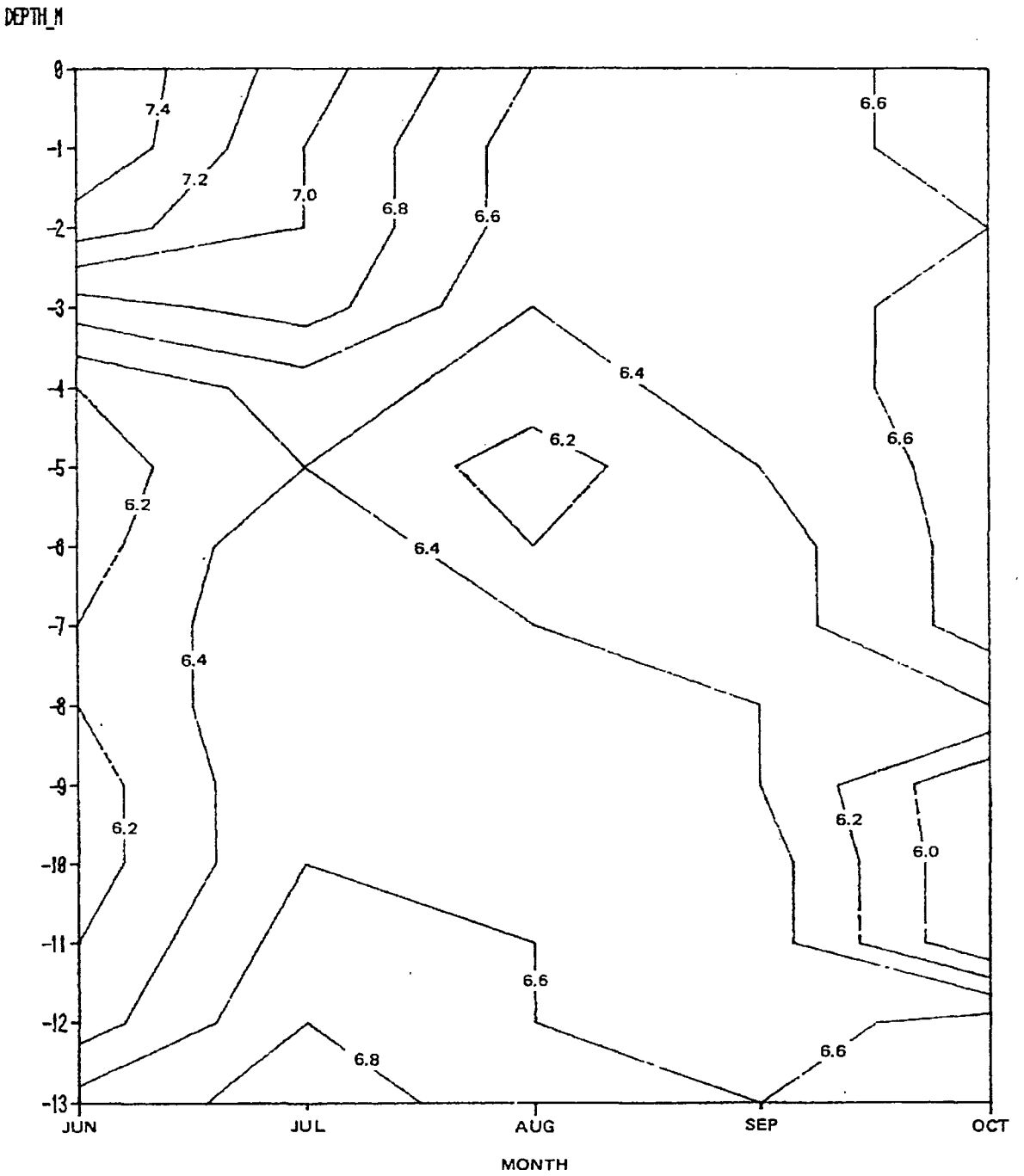

Figure 2.12 pH isopleths (standard units) of Station E2 at Harris Lake for June-October 1983.

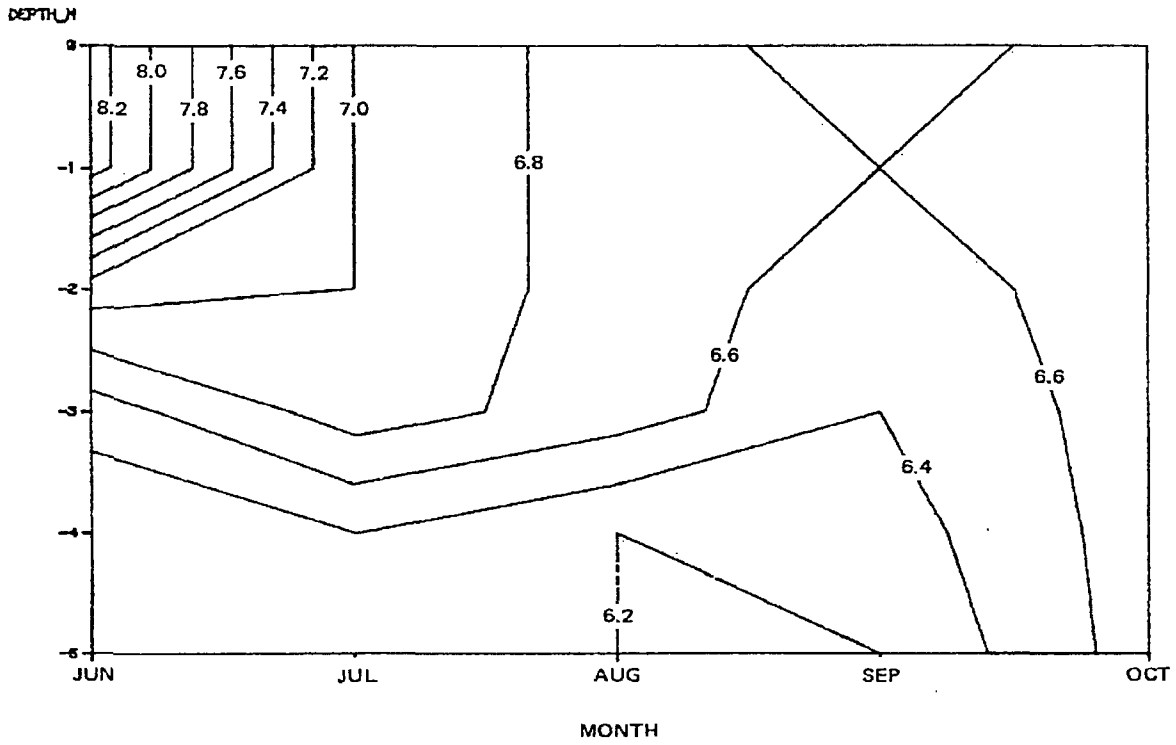

Figure 2.13 pH isopleths (standard units) of Station H2 at Harris Lake for June-October 1983.

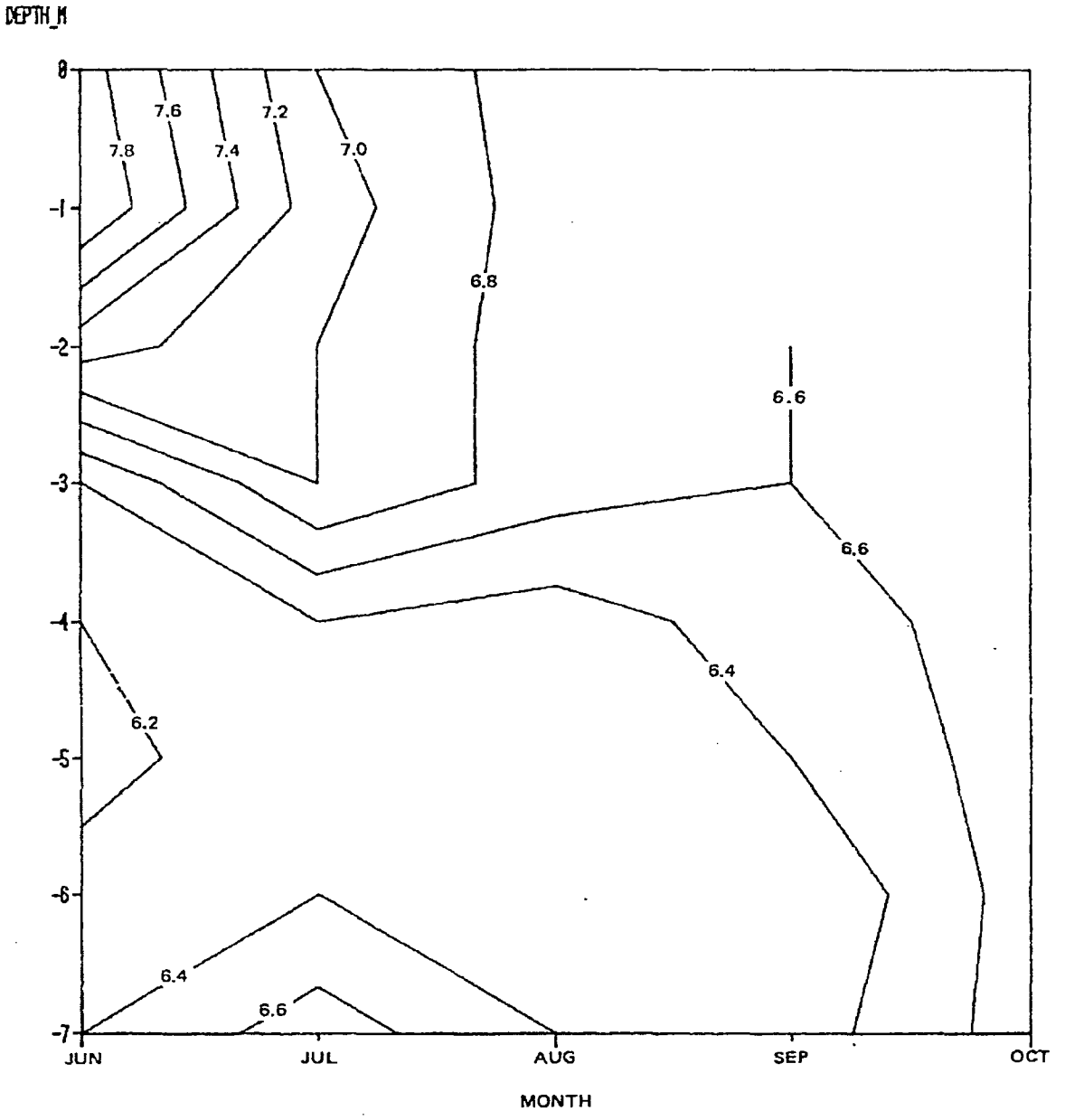

Figure 2.14 pH isopleths (standard units) of Station P2 at Harris Lake for June-October 1983.

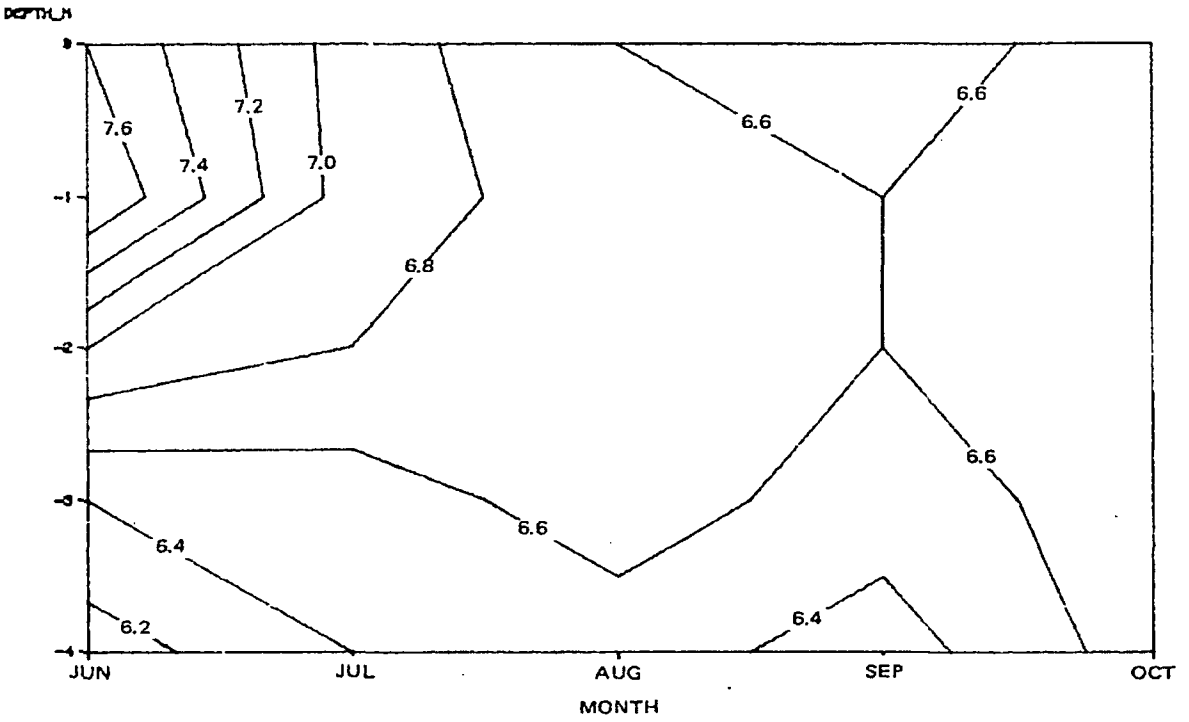

Figure 2.15 pH isopleths (standard units) of Station V3 at Harris Lake for June-October 1983.

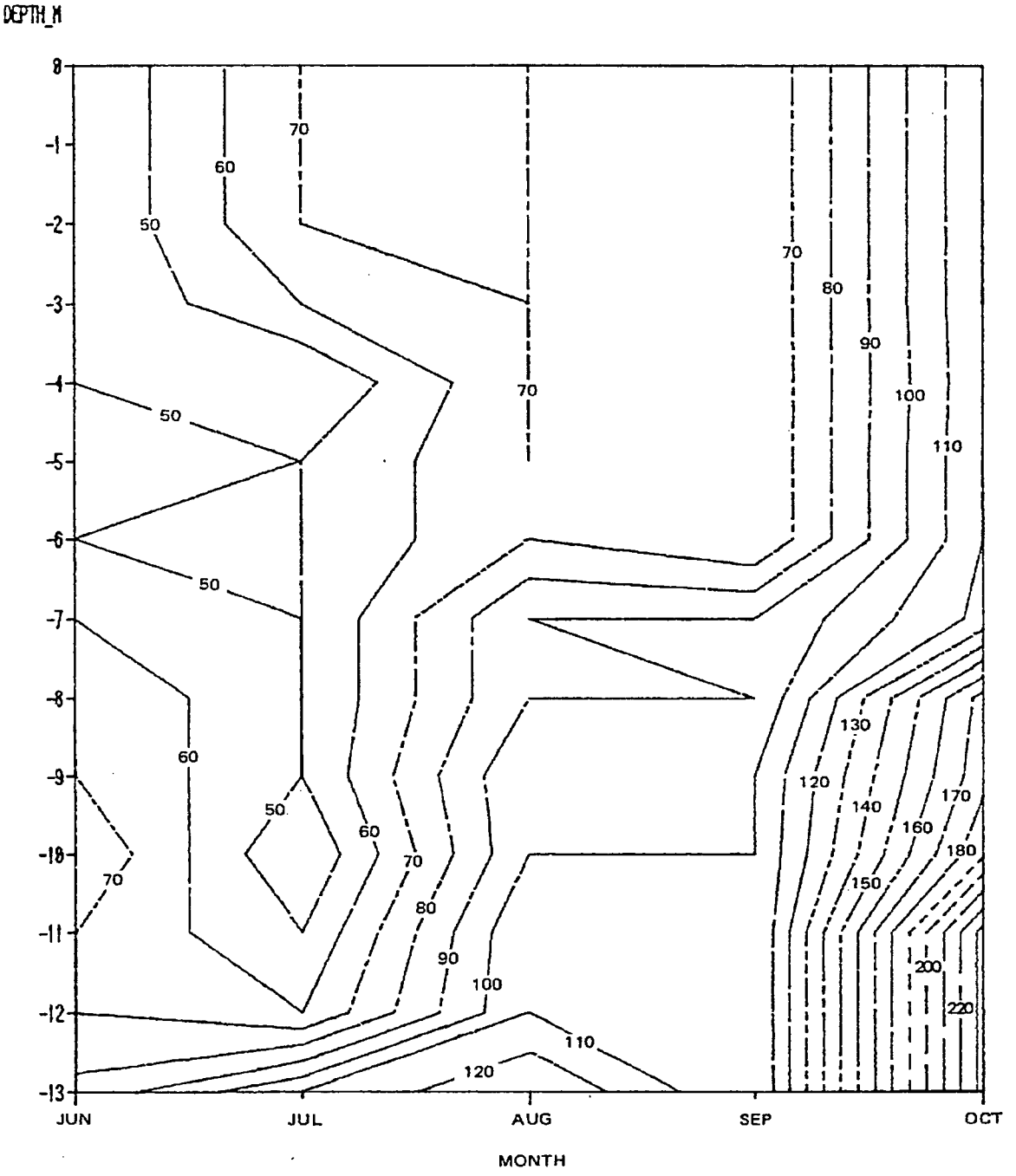

Figure 2.16 Specific conductance isopleths (μmhos/cm) of Station E2 at Harris Lake for June-October 1983.

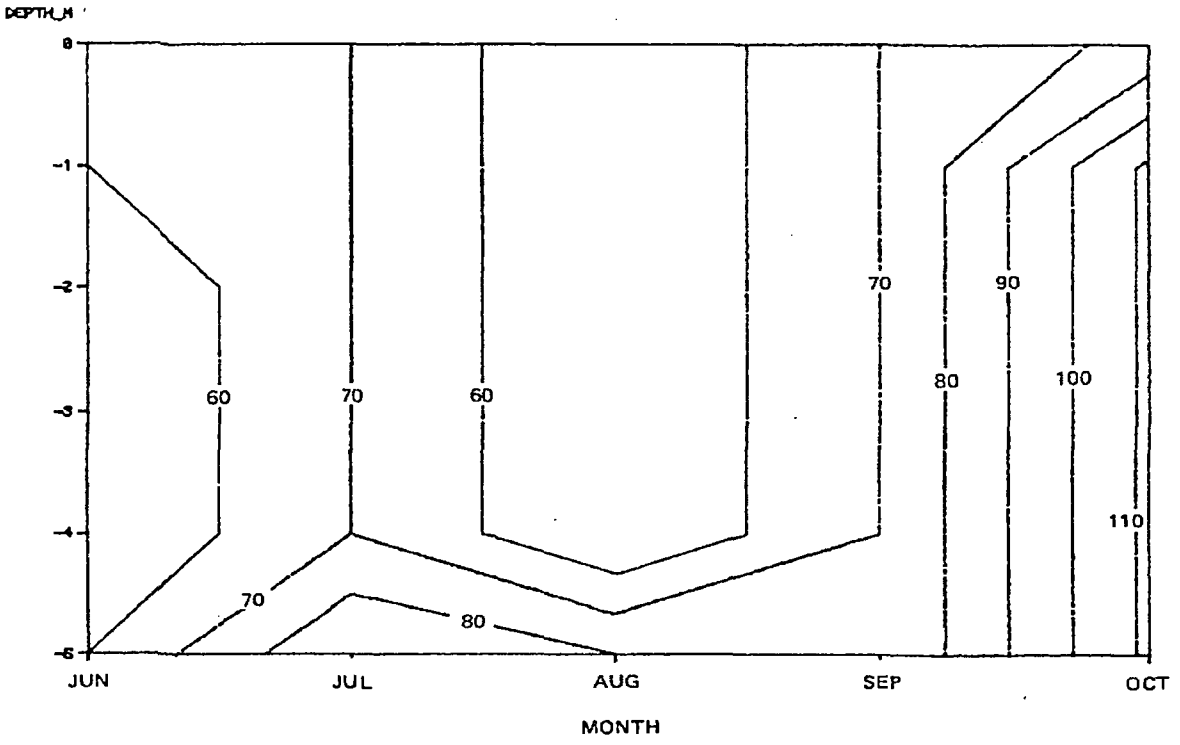

Figure 2.17 Specific conductance isopleths (μmhos/cm) of Station H2 at Harris Lake for June-October 1983.

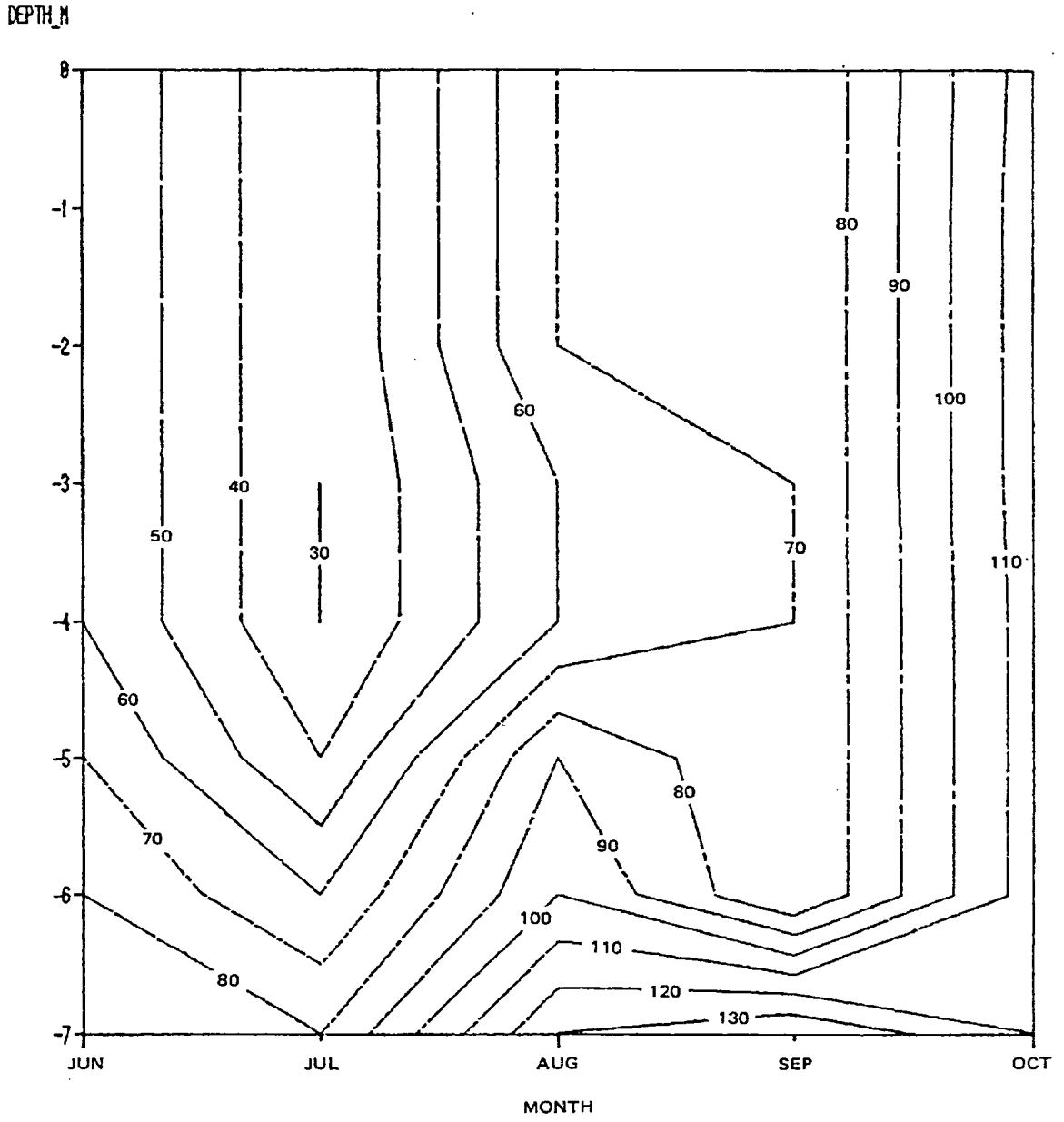

Figure 2.18 Specific conductance isopleths (μmhos/cm) of Station P2 at Harris Lake for June-October 1983.

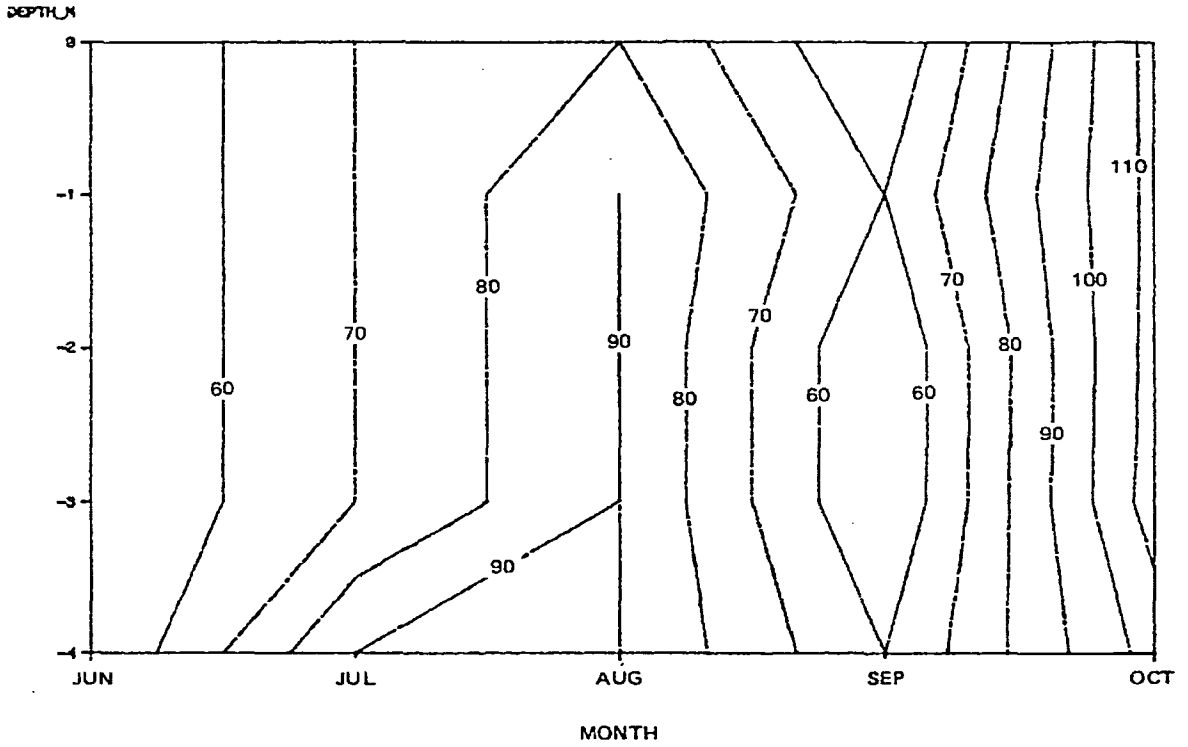

Figure 2.19 Specific conductance isopleths (μmhos/cm) of Station V3 at Harris Lake for June-October 1983.

3.0 WATER CHEMISTRY

3.1 Introduction

Water chemistry monitoring of the SHNPP site was initiated in 1972 and has progressed through three distinct phases. The first phase (1972-1977) surveyed the major creeks of the Buckhorn Creek watershed and the nearby Cape Fear River. This phase was designed to provide a comparative baseline chemical data base during the preconstruction period of the SHNPP project. The second phase (1978-1982) continued the initial survey into the SHNPP construction period to evaluate potential effects on the water chemistry of the site. Because Harris Lake was impounded in December 1980, this phase also documented the initial water chemistry characteristics of the reservoir as it filled. The third phase began in January 1983 when Harris Lake reached its normal operating level. This section of the report evaluates the results of the 1983 Harris Lake monitoring program which provides a basis for future assessment of potential SHNPP operational effects on the lake's water chemistry.

3.2 Methods

Monthly water samples were collected from the surface of the Cape Fear River (D2) and Buckhorn Creek (BK2) stations, the surface and bottom of Harris Lake (E2, H2, P2, S2, V3), and the auxiliary (Z1) reservoir stations. Methodologies used in the collection, preservation, and transport of water samples paralleled previous studies (see CP&L 1979, 1981, 1982, 1983, 1984). Chemical analyses performed by the CP&L Analytical Chemistry Laboratory were in accordance with currently accepted USEPA (1979) or APHA (1981) methodologies. In addition, a number of other analyte concentrations were calculated by difference from two analytically determined fractions. These included total particulate phosphorus [TPP] (the difference between total phosphorus [TP] and total dissolved phosphorus [TDP]), dissolved organic phosphorus [DOP] (the difference between total dissolved phosphorus [TDP] and dissolved molybdate reactive phosphorus [DMRP]), and the particulate fraction for selected metals and metalloids (the difference between the total and dissolved fractions).

All statistical analyses and data reduction were carried out using standard statistical methods. Analysis of variance (ANOVA), Duncan's multiple range test, and paired t-tests were performed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS). Two-way ANOVA was performed for selected water chemistry variables; the main effect was station blocked on months. Unless otherwise noted, a significant effect is denoted at the 5% level of significance.

3.3 Results and Discussion

Analytical results of the 1983 monthly water chemistry monitoring of Harris Lake are presented in Appendix B. Summary statistics for each station and depth are listed in Appendix C. For purposes of discussion, Stations E2, H2, P2, S2, and V3 will be referred to collectively as the main lake; Station Z1 as the auxiliary reservoir; Station D2 as the Cape Fear River; and Station BK2 as Buckhorn Creek. The reader should be aware of the differences in sampling and analytical protocol (i.e., sampling locations, elemental analyses, and analytical precision) between 1982 and 1983, as these variations will preclude and/or invalidate direct comparisons. Indeed, any temporal contrasts will be of limited value and should be interpreted in the general sense. In most cases these limitations will become obvious to the reader because the 1983 program emphasized metal partitioning and distribution, nutrient fractionation with respect to vertical and horizontal zonation, and increased elemental accuracy. These aspects were ill-defined or simply not considered in the 1982 studies.

In 1982, the major findings were (1) the waters of Harris Lake were typically low in dissolved salts and buffering capacity with a slightly acid pH (pH ~ 6.8); (2) the nutrient concentrations were moderately low with the N:P suggestive of P as the limiting nutrient; (3) spatial variations (i.e., horizontal partitioning) within Harris Lake were minimal; and (4) the elemental concentrations in the Cape Fear River were, in general, significantly greater than those in Harris Lake.

Results of the 1983 studies are summarized in Tables 3.1-3.7 and Figures 3.1-3.4. Mean annual concentrations for selected chemical constituents in the Cape Fear River, Harris Lake, and the auxiliary reservoir are presented in Table 3.1. The 1983 results closely paralleled those of the prior year with the annual average concentration variation within $\pm$ 20%. Distribution of the cationic and anionic constituents followed the pattern $Ca^{2+} \approx Na^{+} > K^{+} > Mg^{2+}$, and $HCO_3^- >> SO_4^{2-} > Cl^-$, respectively. This cationic pattern is atypical of most piedmont systems but represents a characteristic distribution for the watershed (Simmons and Heath 1979). Absolute mean annual concentrations for the alkali (Na^+ = 4.6 mg/liter, K^+ = 2.1 mg/liter) and alkaline earth (Ca^{2+} = 4.6 mg/liter, Mg^{2+} = 1.8 mg/liter) metals, as well as the halide (Cl^- = 5.1 mg/liter), carbonate (HCO_3^- = 16 mg/liter), and sulfur (SO_4^{2-} = 6.0 mg/liter) species were characteristic of waters in the Southeast. Mean annual concentrations in the Cape Fear River were generally a factor of 2 or 3 greater than those in the main lake (Table 3.1). Of considerable interest was the finding that the average values in the auxiliary reservoir were consistently above those in the main lake, but the anomalous concentrations may have simply reflected variation differences about the annual means. That is, the larger number of stations in the main lake (five) as compared to the auxiliary reservoir (one) would have resulted in a larger main lake spatial variation. Regardless, the range of values was comparable between the two locations (Table 3.1), and it seems reasonable to assume that the differences reflected a mathematical phenomenon rather than true geological variation.

On the basis of the foregoing, it is clearly evident that the spatial variation was quite pronounced, but of principal interest was the sharp chemical definition between the three areas (i.e., Cape Fear River, Harris Lake, and the auxiliary reservoir). Results of the ANOVA are illustrated in Table 3.2 and show that, with the exception of ammonia, total and dissolved Ni and Mn, and dissolved Fe, significant spatial differences existed for the remaining variables. Because of the rather distinct spatial partitioning among the stations, the results were categorized (via Duncan's multiple range test) into three defining classes with the concentrations in (1) the Cape Fear River > all other stations, (2) the Cape

Fear River > auxiliary reservoir > main lake, or (3) the Cape Fear River = auxiliary reservoir > main lake. For the most part there were few, if any, spatial differences within the main lake (i.e., E2, H2, P2, S2, V3). Variables in the first class included the transition (i.e., Fe, Cu) and A-type (i.e., Al, K) metal cations, nutrient (i.e., total N and P, total dissolved P, NO_3-NO_2, and DMRP) and solids (total, dissolved, and suspended solids; turbidity) fractions, and sulfate. The degree of mineralization (i.e., conductivity) and associated ionic indications (i.e., Na, Mg, Cl) were components of the second class, while the buffering (i.e., HCO_3) and hardness (i.e., Ca) qualities comprised the third class. Collectively, these findings are significant and illustrate three fundamental points regarding the partitioning sequence. First, absolute concentrations in the main lake adequately describe ambient background levels and thus signify the nonimpacted nature of the system. Second, the auxiliary reservoir is a more highly mineralized and, to a slight degree, a more buffered system than the main lake. From a practical and/or biological standpoint, however, these differences can be viewed as insignificant. Finally, elemental concentrations in the Cape Fear River are substantially different from the Harris system and represent significant anthropogenic influence.

Results of the surface and bottom comparisons for selected water chemistry parameters showed the vertical zonation to be both variable and site-specific. The presence or absence of chemical stratification was determined by testing (via t-test) both biologically and chemically reactive elements (i.e., N, P, S, C, Fe, Mn) and nonreactive elements (i.e., Na, Cl, K). In this way a relative measure of the sampling effectiveness could be assessed by examining the observed flux of nonreactive elements. The results are presented in Table 3.3 for the main lake and auxiliary reservoir stations. In the case of the reactive elements, the results clearly show marked vertical differences. Spatial differences were distinct between the surface and bottom waters and could simply relate to the spatial variability in redox potentials. Evidence to support this theory is generally lacking, but it can be concluded on the basis of bottom water concentrations for Fe, Mn, and P that measurable fluxes of redox-sensitive elements do occur during periods of anoxia (see Appendix B). On the other

hand, these spatial differences may reflect variations in sampling efficiency by artificially creating apparent differences. The significantly higher concentrations of Na (Stations E2, S2, V3) and Cl (Station P2) in the bottom waters suggests the latter to have been a process. These elements are considered inactive with respect to redox cycling, and the elevated bottom water concentrations are suggestive of sampling errors (e.g., collection of bottom sediments). If this were the case, one would think that Fe, a large component in the sediment matrix, would consistently be elevated in the bottom waters. This phenomenon was not observed, and it is likely that the two processes collectively interact to create the observed variability.

Because of the predicted potential for accelerated eutrophication in Harris Lake (see CP&L 1983, 1984), nutrient concentrations (primarily phosphorus) have been a concern for some period of time. This eutrophication was contingent largely upon the proposed use of the Cape Fear River which, under the existing nutrient conditions, would have contributed approximately 30% of the total areal phosphorus load. Cancellation of Unit 2 (December 1983) meant that use of the makeup system was unnecessary, resulting in diminished concern in the eutrophication potential. However, the character of the 1983 chemical monitoring program reflected, to a large extent, these initial beliefs (i.e., eutrophication), and the resultant efforts focused on two separate aspects of the eutrophication issue. These included a more complete characterization of the defined phosphorus fractions coupled with a limited assessment of sedimentary nutrient fluxes. Results from these studies are presented in Tables 3.4-3.5 and Figures 3.1-3.4.

A generalized distribution of selected nitrogen and phosphorus fractions in the Cape Fear River, Harris Lake, and auxiliary reservoir is presented in Table 3.4. Consistent with past results (CP&L 1983, 1984) was the characteristic order of magnitude difference in the various phosphorus fraction concentrations between the Cape Fear River and Harris Lake. The Cape Fear River phosphorus concentrations were exceptionally high, particularly the dissolved labile form (i.e., DMRP). Also noteworthy was the

differential distribution in the organic form between the river and the main lake. Similar partitioning (as determined by Duncan's multiple range test) of the phosphorus fractions (i.e., spatially) was observed in both the main lake and the auxiliary reservoir. The labile nitrogen species (i.e., NO_3-NO_2, NH_3) followed a pattern similar to the phosphorus counterparts with elevated concentrations in the Cape Fear River. The relative magnitude of the spatial divergence (i.e., between the river and the main lake) was not as pronounced.

The temporal distribution for the labile nitrogen compounds was well defined (see Figure 3.1), but no discernable labile phosphorus (i.e., DMRP) pattern was detected. The typical seasonal pattern for NO_3-NO_2 and NH_3 in the main lake was a winter/spring maximum and a summer minimum corresponding with comparatively low and high biological uptake (primary production), respectively. Of principal interest, however, was the very marked difference in removal between the two forms. The profiles in Figure 3.1 show that NH_3 decreased through May and was below the limit of detection (0.02 mg/liter) from June-August. Conversely, depletion of NO_3-NO_2 began in June, the month in which NH_3 supplies became exhausted. These data, then, suggest that "significant" biological depletion of the NO_3-NO_2 species occurs only after the NH_3 reservoir has been depleted. While the observed relationship may be fortuitous, the significance of this finding is that the distribution of these two nutrients differs in detail reflecting selective biotic uptake/assimilation. Discrimination between the available nitrogen forms during incorporation has been previously reported with the results showing preferential assimilation of NH_3 over NO_3-NO_2. This finding is consistent with the theory that organisms (plankton) will preferentially select the lowest available oxidation state (i.e., NH_3), since fewer energy-consuming metabolic steps are required to reduce and incorporate inorganic forms into amino acids.

The distribution of phosphorus between the defined phases is presented in Table 3.5. As expected, the total particulate phosphorus (TPP) fraction accounted for the greatest percentage of the total phosphorus pool, ranging from 57%-68% in the main lake and averaging 52% and 56% in the Cape Fear River and Buckhorn Creek, respectively. In the case of the

dissolved phosphorus pool, the dissolved organic phosphorus (DOP) was the dominant fraction in the main lake (range 66%-75%), while the inorganic form (i.e., dissolved molybdate reactive phosphorus, DMRP) predominated in the lotic systems (range 70%-87%). While availability of the organophosphorus compounds is open to speculation (i.e., labile or refractory compounds), the distribution differences (i.e., inorganic and organic phosphorus) between the main lake and creek/river system clearly suggest two different processes controlling the phosphorus incorporation and regeneration cycles. Relative to the stream (BK2) and river (D2) stations, the elevated DOP fraction in the main lake can probably be viewed as the biologically recycled phosphorus resulting from both active planktonic excretion and oxidative decomposition of planktonic tissues. Similarly, the lower DMRP (relative to the lotic system) fraction in the main lake may reflect active uptake/incorporation into biological compartments in addition to rapid cycling among the more abundant plankton. Conversely, the higher DMRP fraction and lower DOP percent in the lotic systems is perhaps a function of the lower standing stock of plankton (i.e., decreased DMRP uptake) and subsequent regeneration (i.e., production of DOP) of the phosphorus compounds. While data are certainly limiting in support of these observations, these data are of fundamental value in, at the very minimum, describing and delineating phosphorus partitioning in lotic and lentic waters.

Monthly depth profiles of NH_3, total nitrogen (TN), NO_3-NO_2, DMRP, and total, dissolved, and particulate phosphorus at Station E2 in Harris Lake are presented in Figures 3.2-3.4. The profiles for NH_3 (Figure 3.2) generally showed concentrations to be depth invariant from January-June. Also apparent was a significant concentration decline throughout the entire water column during the same time interval. From July-October, the upper water column (0-6 m) concentrations remained depleted, while concentrations below this zone rose sharply to a deep-water maximum in the oxygen minimum. This trend was most strongly developed during October when a concentration of 930 µg/liter (~ 12 m) was observed. Development of the NH_3 flux clearly intensified during the course of the latter time interval, but the zone/thickness of NH_3 production varied considerably. Uniform NH_3 concentrations with respect to depth were observed during November and December (i.e., following fall turnover).

The profiles for TN somewhat paralleled the NH_3 data set, but the vertical variability was far more pronounced (Figure 3.2). The TN profiles displayed an inconsistent array of both shallow and deep-water minima and maxima regions from January through June. The regions during some months were additionally characterized by sharp and/or abrupt zones (e.g., May and June), in contrast to broadly diffuse areas (e.g., April). Consistent with the NH_3 trend, however, the TN profiles showed typical deep-water fluxes from August through October and relatively uniform concentrations during November and December.

The NO_3-NO_2 profiles (Figure 3.3) showed tendencies of a deep-water maximum, but sampling depth variations precluded a direct identification. This observation was particularly evident during May and June when a broadly defined and a sharp increase occurred, respectively, at the 10-13 m interval. A midwater NO_3-NO_2 maximum (~ 8 m) was observed during March; but in the absence of more detailed information, the factor of 2 concentration flux (i.e., relative to the water column) cannot be explained. The remaining NO_3-NO_2 depth profiles tended to exhibit rather linear responses.

Depth profiles for the various phosphorus fractions are illustrated in Figures 3.3 and 3.4. In general, the behavior was quite different from the nitrogen profiles with the depth and time variability more highly pronounced. In the case of DMRP, the most notable finding was the demonstration of DMRP regeneration in the anoxic bottom waters (July-September). Total phosphorus (TP) exhibited a similar pattern, but the flux was confined to May and September. The vertical profiles of TP also demonstrate, or at least suggest, the summertime abundance and concentration of phosphorus just above the thermocline boundary (Figure 3.4, July). The distribution of total particulate phosphorus (TPP), which may be a good indicator of organic material, showed a series of depth profiles paralleling the TP fraction.

The overall pattern of the profiles presented in Figures 3.2-3.4 shows a distribution typical of nutrients, with removal in surface waters and regeneration with depth. The distribution of the nitrogen species

(predominantly NH_3 and TN) is representative of particulate material which, as it falls through the water column, undergoes a slow, non-oxidative dissolution. Conversely, the distribution of phosphorus is representative of shallow oxidative decomposition (i.e., of nonsilicate materials), leading to intermittently defined maxima and minima throughout the water column. The implications from these results suggest that the material phases for N and P vertical transport are different, and thus regeneration processes play an important role in the final observed profile distribution.

Trace element concentrations were measured routinely in the Harris environmental program, but 1983 represented, as previously noted, the first full year of impoundment. Because 1982 represented a transition year (i.e., filling stages), trace element measurements were viewed unrepresentative and were not analyzed (see CP&L 1984). Thus, trace element concentrations measured during 1983 reflected ambient background levels and initial measurements of a fully impounded reservoir.

As expected, trace element concentrations were typically low and frequently fell below the current detection limits. The latter are presented in Table 3.6 as the frequency of nonreportable total element concentrations expressed as a percent below the detection limit. The table shows that with detection limits of 0.0001 mg/liter for Hg; 0.01 mg/liter for Cr; 0.001 mg/liter for As, Cd, and Se; and 0.02 mg/liter for Zn, these elements were present in only minor amounts in the surface waters of Harris Lake and, further, were infrequently detected within the limits of the method. The trend for the Cape Fear River and Buckhorn Creek, as well as the Harris Lake bottom waters, was generally similar for the latter elements. The remaining trace elements, including Cu, and to a lesser extent Pb and Ni, were frequently reported with detection limits of 0.001, 0.002, and 0.01 mg/liter, respectively (Table 3.6). On the average, 75% of the Cu and ~ 35% of the Pb and Ni concentrations were above their respective detection limits during 1983. Typical background levels for Cu in Harris Lake appear to be on the order of 0.002-0.003 mg/liter (see Appendix C). Background concentrations for Pb and Ni were undefined, as the annual mean concentrations were below the relative detection limits.

Partitioning of elements between the dissolved and particulate phase is presented in Table 3.7. Elements for which insufficient data existed (see footnote in Table 3.7) for calculation of the distribution included Cr, Cd, and Se. Because of the limited number of observations used to calculate the partitioning for As and Zn, the observed distribution should be viewed as preliminary. In short, the partitioning data were exceedingly variable, much more so than originally anticipated. For example, the alkaline earth metals would have been predicted to exist almost exclusively in the dissolved aquated phase (particularly at the ambient Harris pH of ~ 7), but Table 3.7 illustrates that upwards of 30% of the Ca and 65% of the Mg were present in the particulate form during certain times. The adsorption behavior for the transition elements was expected with the particulate fraction accounting for a large part of the total element concentration. Calculations for the element distribution coefficients (K_D) were limited by resolution of the particulate fraction (i.e., particulate = total-dissolved); but the estimates, given limitations of the data, agreed reasonably well with documented literature values. Based on the general principles of surface adsorption and coordination chemistry, the observed partitioning of metals in Harris Lake was generally typical for a freshwater system.

3.4 Summary

Results of the 1983 Harris Lake water chemistry monitoring program were evaluated. In general, results of the 1983 studies paralleled those of the prior year with the distribution and absolute concentrations for the major cations and anions patterned after the 1982 results.

The spatial variability was highly pronounced but was clearly partitioned into three defining categories. For the most part, there were few, if any, spatial differences within the main lake while the spatial effects signified differences between the Cape Fear River, Harris Lake (main lake), and auxiliary reservoir. Results of the surface-to-bottom comparisons showed significant vertical zonation, but the differences were highly spatially oriented. The marked differences in the spatial flux were attributed to redox potential variations coupled with differences in sampling efficiency.

The temporal distribution for the available nitrogen forms (i.e., NO_3-NO_2 and NH_3) showed a typical seasonal pattern for southeastern reservoirs with depletion in the summer and regeneration during the winter months. The results also showed selective discrimination by plankton of the reactive nitrogen species with sequential depletion of NH_3 and NO_3-NO_2.

A spatial distribution of the phosphorus classes was defined between the main lake and creek/river systems and suggested that the processes controlling the regeneration cycles functioned independently. Results from the vertical distribution of the nutrient fractions showed the profiles to be representative of nutrient behavior with depletion in the surface waters and regeneration with depth. The results further suggested that material phases for nitrogen and phosphorus transport were different, and thus regenerative mechanisms played an important part in the resultant profile distribution.

Results of the trace element analyses showed that the concentrations were typically low and generally below current detection limits. Copper concentrations were the exception, with background levels on the order of 0.002-0.003 mg/liter.

Table 3.1. Comparison of selected water chemistry constituents[1] in the Cape Fear River, Harris Lake, and auxiliary reservoir during 1983.

Parameter[2]	Location					
	Cape Fear River (D2)		Auxiliary Reservoir (Z1)		Harris Lake (E2, H2, P2, S2, V3)	
Total Ca	6.4	(3.7-9.7)	6.4	(5.3-8.1)	4.6	(2.4-5.6)
Total Mg	2.8	(1.9-3.7)	2.3	(1.7-2.8)	1.8	(1.2-2.5)
Total Na	12.7	(3.8-28)	7.5	(6.7-8.2)	4.6	(3.6-5.5)
Dissolved K	2.6	(0.48-4.7)	1.9	(1.1-2.6)	2.1	(0.72-2.8)
Total Fe	1.62	(0.53-4.3)	0.58	(0.15-0.90)	0.66	(0.08-2.0)
Total Al	0.43	(0.09-0.89)	0.20	(0.02-0.68)	0.10	(< 0.01-0.45)
Total Cu	0.006	(0.002-0.026)	0.003	(< 0.001-0.006)	0.002	(< 0.001-0.007)
Hardness[3]	25	(13-38)	24	(16-33)	18	(7.8-24)
Conductivity	113	(55-200)	84	(73-96)	63	(41-76)
Turbidity	71	(8.5-410)	20	(1.2-79)	11	(1.4-96)
TSS	30	(7-83)	10	(< 1-43)	8	(< 1-26)
TDS	98	(51-135)	52	(< 1-70)	43	(< 1-77)
Sulfate	14	(7.3-31)	8	(5.2-9.4)	6	(2.4-8.8)
Total Alkalinity	25	(7.6-50)	22	(16-28)	16	(3.2-36)
Chloride	9.8	(3.8-21)	7.2	(6.6-8.4)	5.1	(3.7-6.2)

[1]Values reflect mean annual surface concentrations; range enclosed in parentheses.

[2]All concentrations except conductivity (μmhos/cm) and turbidity (NTU) expressed in mg/liter.

[3]Hardness concentrations were calculated empirically.

Table 3.2. Results of analysis of variance (station effects blocked on months) for selected water chemistry variables in Harris Lake during 1983.

Dependent Variable	Station Effects F Value	Dependent Variable	Station Effects F Value
Total Alkalinity	7.14*	Total Ca	17.98*
Chloride	8.85*	Dissolved Ca	11.99*
Sulfate	11.27*	Total Mg	18.51*
Conductivity	14.45*	Dissolved Mg	15.61*
Total Solids	37.10*	Total Na	12.53*
Total Suspended Solids	7.43*	Dissolved Na	11.18*
Total Dissolved Solids	22.74*	Dissolved K	3.65*
Turbidity	4.51*	Total Al	11.41*
Hardness	13.79*	Dissolved Al	3.09*
Total N	3.46*	Total Cu	3.31*
Nitrate-Nitrite	25.84*	Dissolved Cu	6.23*
Ammonia	0.96^{NS}	Total Ni	0.92^{NS}
Total P	48.30*	Dissolved Ni	1.13^{NS}
Total Dissolved P	20.41*	Total Fe	5.02*
DMRP	20.65*	Dissolved Fe	1.83^{NS}
TOC	3.41*	Total Mn	1.52^{NS}
DOC	2.94*	Dissolved Mn	0.82^{NS}

*Significance $P \leq 0.05$.

^{NS}Not Significant.

Table 3.3. Results of paired t-tests for surface and bottom comparison of selected water chemistry variables for Harris Lake and auxiliary reservoir during 1983.

Variable	Station					
	E2	H2	P2	S2	V3	Z1
Total Alkalinity	-	-	*	-	-	-
Chloride	-	-	*	-	-	-
Conductivity	*	-	*	-	-	-
Ammonia	-	-	*	-	-	-
Total N	-	-	-	-	-	-
TOC	-	-	*	*	-	-
Total P	*	-	-	*	*	*
Total Dissolved P	-	-	-	-	-	-
Total Mn	*	-	-	-	-	-
Dissolved Mn	*	-	-	-	-	-
Total Fe	-	-	*	-	*	-
Dissolved Fe	-	-	-	-	-	-
Sulfate	-	-	-	-	-	*
Turbidity	-	-	*	*	*	-
Total Solids	*	-	*	-	*	-
Particulate Mn	-	-	-	*	*	-
Particulate Fe	-	-	-	-	*	-
Nitrate-Nitrite	-	-	-	-	-	-
Total Cu	-	-	-	-	-	-
Dissolved Cu	-	-	-	-	-	-
Total Na	-	-	-	-	*	-
Dissolved Na	*	-	-	*	*	-
Dissolved K	-	-	-	-	-	-
Total Ni	-	-	-	-	-	-
Dissolved Ni	-	-	-	-	-	-
DMRP	*	-	-	-	-	-

-Represents no significant difference between surface and bottom.

*Indicates bottom concentration significantly ($P < 0.05$) greater than surface.

Table 3.4. Mean annual nutrient concentrations (± 1 standard deviation) in the Cape Fear River, Harris Lake, and auxiliary reservoir for 1983.

Nutrient[1]	Location		
	Cape Fear River	Harris Lake	Auxiliary Reservoir
Total P	0.167 ± 0.061 (N = 11)	0.019 ± 0.014 (N = 60)	0.020 ± 0.017 (N = 12)
Total Dissolved P	0.076 ± 0.046 (N = 11)	0.007 ± 0.006 (N = 59)	0.009 ± 0.013 (N = 12)
Dissolved Molybdate Reactive P	0.067 ± 0.058 (N = 11)	0.002 ± 0.002 (N = 60)	0.002 ± 0.002 (N = 12)
Ammonia	0.141 ± 0.172 (N = 11)	0.116 ± 0.112 (N = 55)	0.056 ± 0.046 (N = 11)
Nitrate-Nitrite	0.530 ± 0.240 (N = 11)	0.111 ± 0.105 (N = 60)	0.048 ± 0.040 (N = 11)

[1]Concentrations expressed as mg/liter.

Table 3.5. Distribution of phosphorus (mg/liter) between the defined phases in Harris Lake during 1983.

Station	TP[1]	Phosphorus Fraction			
		TDP[2,6]	TPP[3,6]	DOP[4,7]	DMRP[5,7]
BK2	0.023	0.010 (46%)	0.013 (56%)	0.003 (30%)	0.008 (70%)
D2	0.159	0.076 (48%)	0.083 (52%)	0.010 (13%)	0.067 (87%)
E2	0.012	0.004 (33%)	0.008 (67%)	0.003 (75%)	0.001 (25%)
H2	0.019	0.007 (37%)	0.012 (63%)	0.005 (71%)	0.002 (29%)
P2	0.014	0.006 (43%)	0.008 (57%)	0.004 (66%)	0.002 (34%)
S2	0.022	0.007 (32%)	0.015 (68%)	0.005 (71%)	0.003 (29%)
V3	0.029	0.010 (34%)	0.018 (66%)	0.007 (70%)	0.003 (30%)
Z1	0.019	0.009 (47%)	0.010 (53%)	0.007 (78%)	0.002 (22%)

[1]TP represents Total Phosphorus.

[2]TDP represents Total Dissolved Phosphorus.

[3]TPP represents Total Particulate Phosphorus (i.e., TP-TDP).

[4]DOP represents Dissolved Organic Phosphorus (i.e., TDP-DMRP).

[5]DMRP represents Dissolved Molybdate Reactive Phosphorus.

[6]Number in parentheses represents percent of the total fraction.

[7]Number in parentheses represents percent of the dissolved phase.

Table 3.6. Frequency of nonreportable total element concentrations expressed as a percent below the detection limit[1] for all stations and depths[2] sampled in the 1983 Harris Lake water chemistry monitoring program.

Station	Element								
	As	Cr	Cd	Hg	Cu	Pb	Ni	Se	Zn
BK2[3]	75	100	92	92	8	67	83	100	83
D2[4]	42	100	92	83	0	33	33	100	75
E2 (s)	92	100	100	75	25	67	75	92	83
E2 (b)	75	100	92	83	16	83	67	100	92
H2 (s)	100	100	100	92	25	83	58	100	100
H2 (b)	83	100	92	92	25	75	67	92	92
P2 (s)	100	100	92	92	33	83	67	100	92
P2 (b)	75	100	92	75	33	83	67	100	100
S2 (s)	100	100	92	100	17	67	58	92	75
S2 (b)	67	100	83	100	8	50	67	100	83
V3 (s)	67	100	92	83	25	42	58	100	100
V3 (b)	33	100	100	100	25	42	33	100	67
Z1 (s)	83	100	100	100	17	67	75	100	83
Z1 (b)	66	100	100	100	36	54	72	100	82
Lake Surface Mean[5]	90	100	93	90	24	65	62	99	86
Lake Bottom Mean[5]	65	100	96	92	24	68	65	97	89

[1]The detection (reporting) limit is defined as the blank concentration plus three standard deviations of the blank with detection limits for the elements as follows: 0.001 mg/liter for As, Cd, Cu, and Se; 0.002 mg/liter for Pb; 0.005 mg/liter for Cr; 0.01 mg/liter for Ni; 0.02 mg/liter for Zn; and 0.0001 mg/liter for Hg.

[2]Surface and bottom are represented by (s) and (b), respectively.

[3]Buckhorn Creek Station below outfall of the Harris Reservoir main dam.

[4]Cape Fear River Station.

[5]Lake mean calculated using Stations E2, H2, P2, S2, and V3.

Table 3.7. Mean[1] annual distribution of the dissolved and particulate elemental fractions in Harris Lake for 1983.

Element	N[2]	Percent Dissolved		Percent Particulate[3]	
		Mean	Range	Mean	Range
As	1	100	-	0	-
Cr	0	-	-	-	-
Cd	0	-	-	-	-
Ca	46	90.7	69.5 - 100	9.3	0 - 30.4
Cu	18	60.3	28.5 - 100	39.7	0 - 71.4
Fe	53	34.1	8.0 - 66.7	65.8	33.3 - 92.0
Al	41	45.6	10.0 - 100	54.3	0 - 90.0
Pb	4	68.7	25.0 - 100	31.2	0 - 75.0
Mg	47	89.9	34.8 - 100	10.0	0 - 65.2
Mn	43	60.3	13.0 - 91.7	39.7	8.3 - 86.9
Ni	15	90.0	50.0 - 100	10.0	0 - 50.0
Se	0	-	-	-	-
Na	39	96.4	86.5 - 100	3.6	0 - 13.4
Zn	1	11.1	-	88.8	-

[1]The mean percentages were calculated using surface water concentrations from Stations E2, H2, P2, S2, and V3.

[2]Number of observations used to calculate the percent dissolved and particulate fractions. The calculations were performed only if the dissolved metal concentration was less than the total concentration and both fractions were greater than the detection limit. The detection (reporting) limit is defined as the blank concentration plus 3 standard deviations of the blank with detection limits for the elements as follows: 0.001 mg/liter for As, Cd, Cu, and Se; 0.002 mg/liter for Pb; 0.005 mg/liter for Cr; 0.01 mg/liter for Al and Ni; 0.02 mg/liter for Ca, Mg, Mn, and Zn; 0.05 mg/liter for Fe; 0.1 mg/liter for Na.

[3]Particulate fraction calculated as the difference between the total and dissolved fractions.

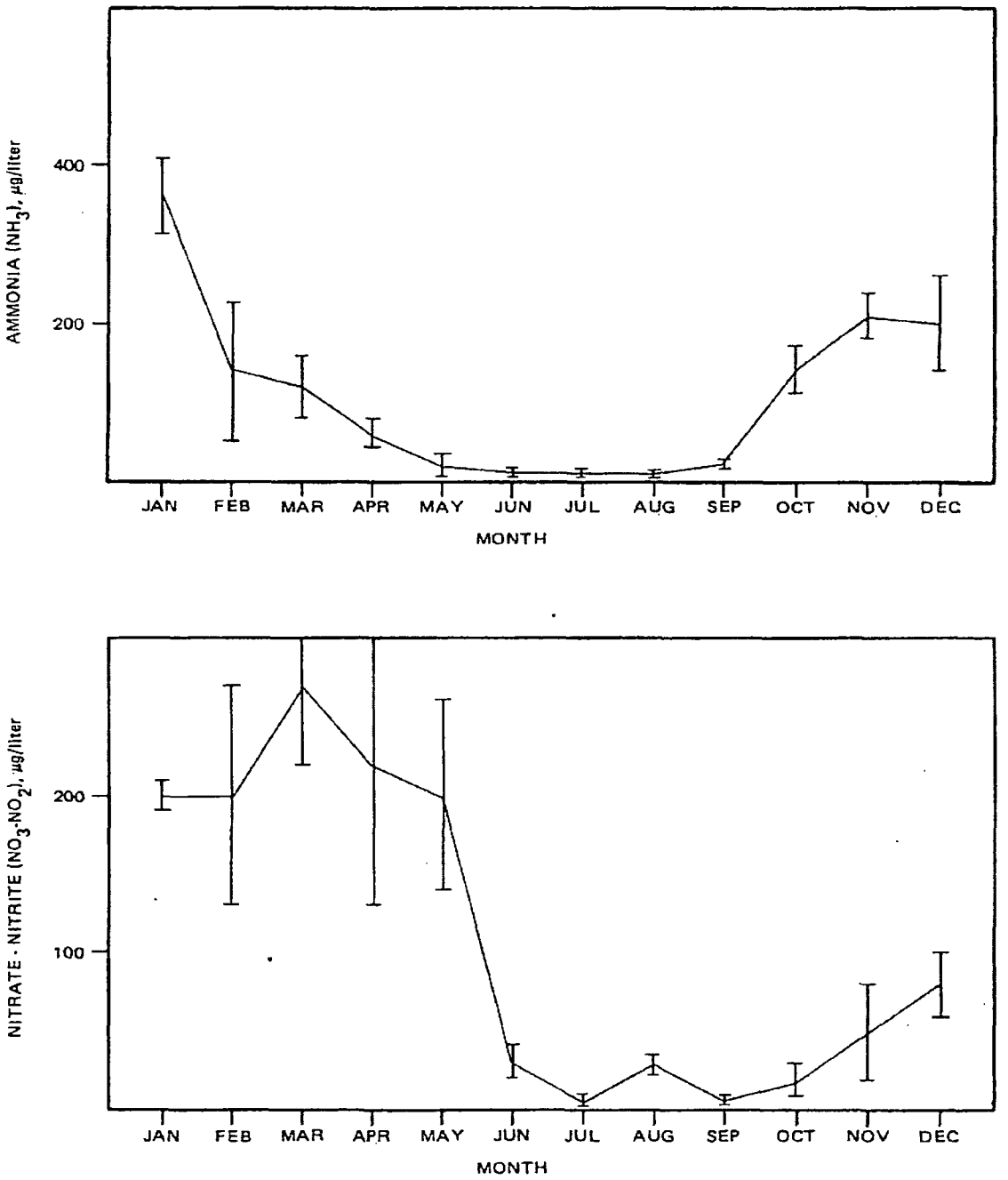

Figure 3.1 Temporal variations in ammonia and nitrate-nitrite concentrations in Harris Lake during 1983. Each data point represents a mean of five locations (ie E2, H2, P2, S2, V3) while the error bars represent ±1 standard deviation.

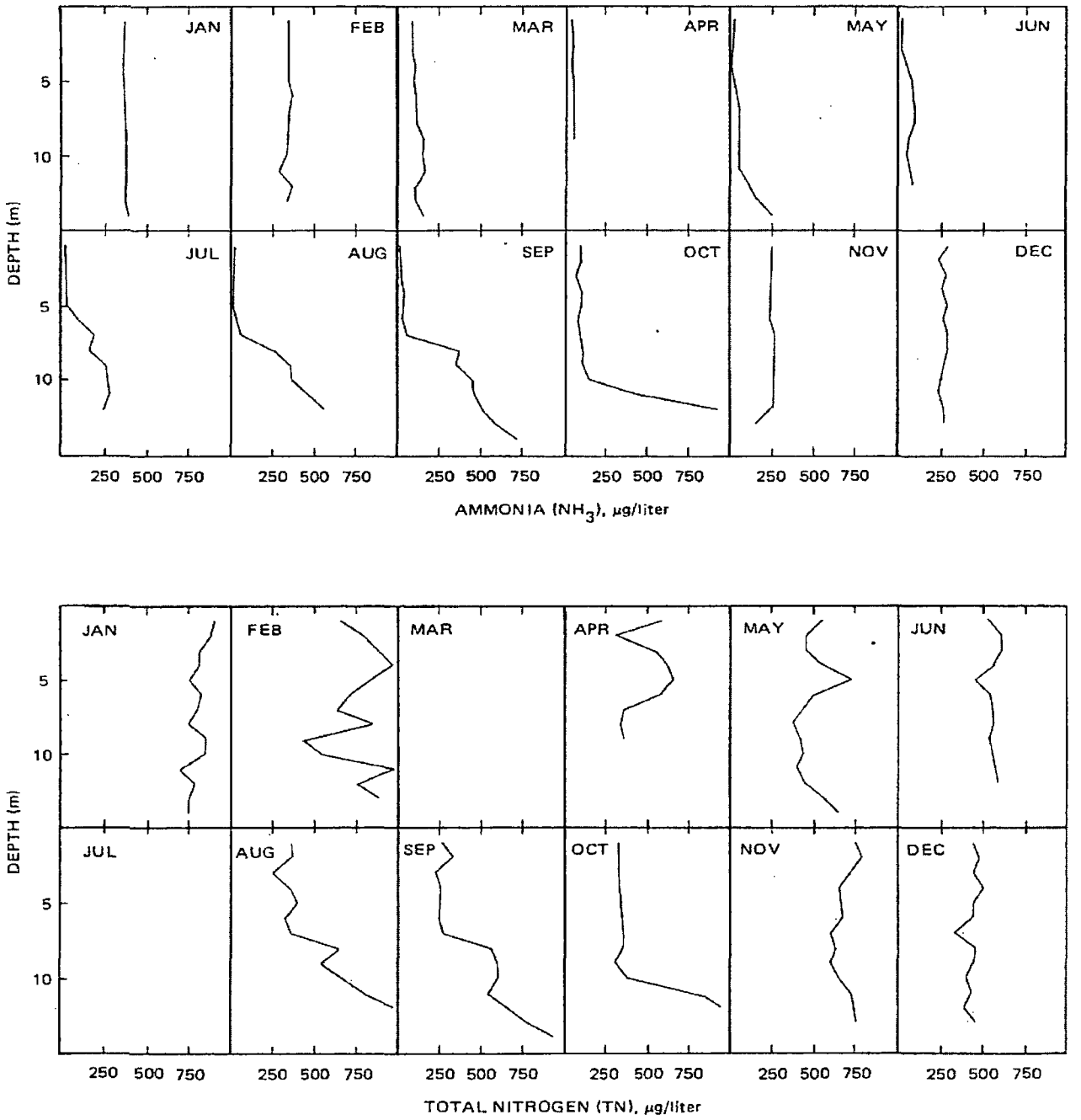

Figure 3.2 Profiles of ammonia and total nitrogen for Station E2 in Harris Lake for 1983. Total nitrogen samples were not analyzed during March and July because of instrumentation problems.

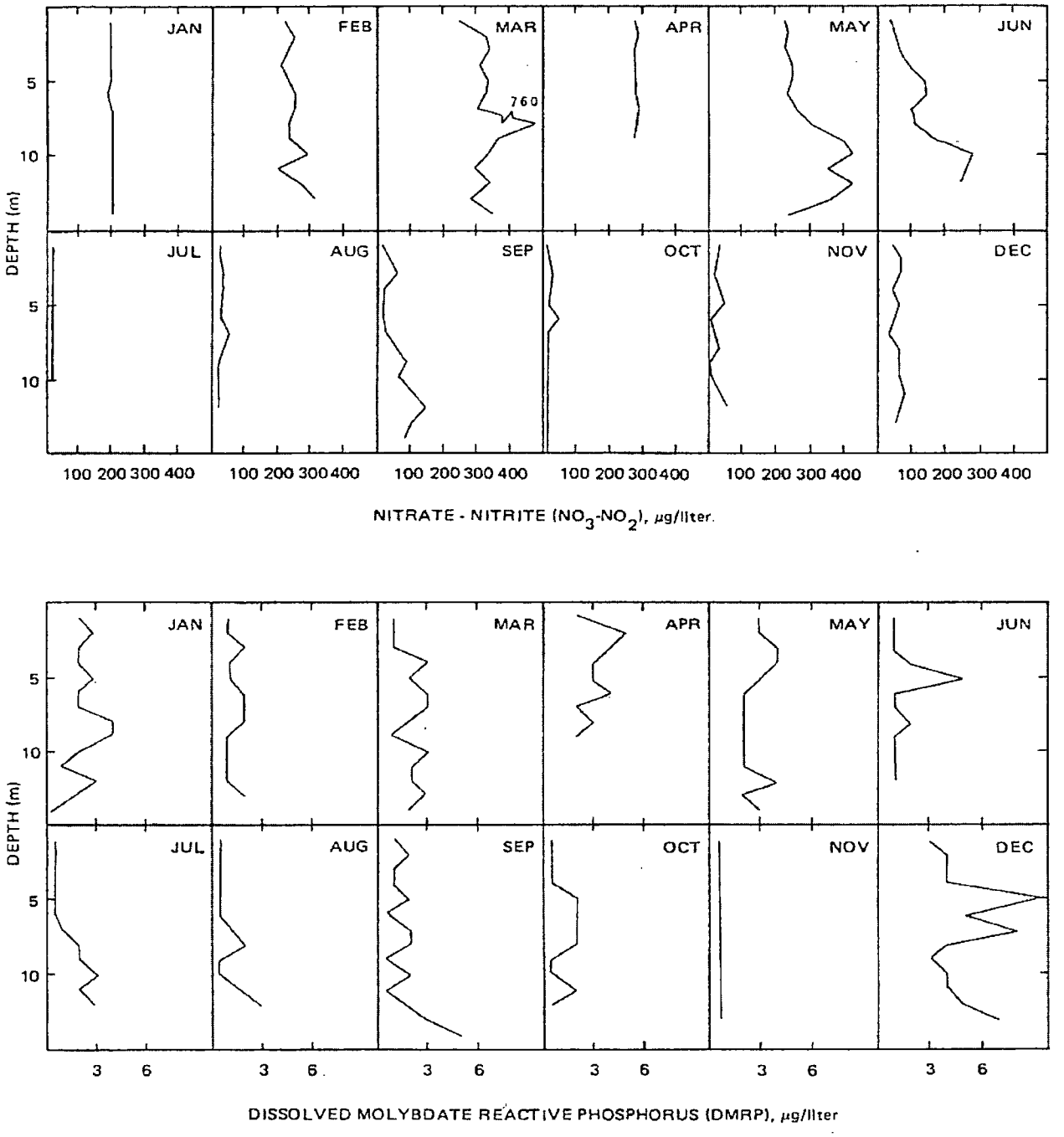

Figure 3.3 . Profiles of nitrate-nitrite and dissolved molybdate reactive phosphorus for Station E2 in Harris Lake for 1983.

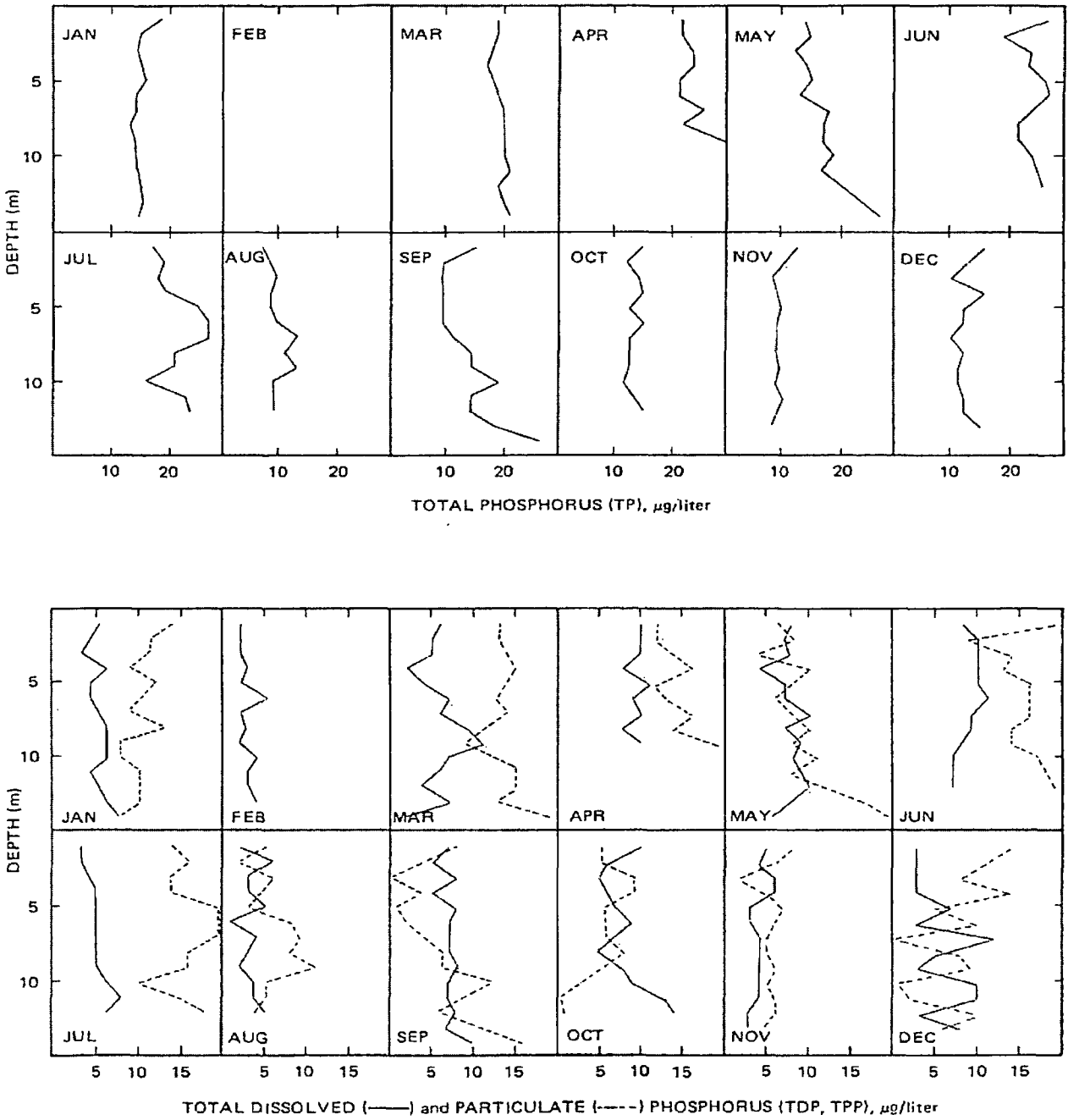

Figure 3.4 Profiles of total phosphorus, total dissolved phosphorus, and total particulate phosphorus for Station E2 in Harris Lake for 1983. Total phosphorus samples were contaminated during February.

4.0 PHYTOPLANKTON, PRIMARY PRODUCTIVITY, AND CHLOROPHYLL

4.1 Introduction

Phytoplankton form the base of the trophic pyramid in lacustrine systems (Hutchinson 1975). In Harris Lake, quarterly monitoring of the phytoplankton community during 1982 indicated moderate levels of primary production. In order to assess the status of producer populations, phytoplankton sampling frequency was increased to monthly in 1983. In addition, quarterly productivity and chlorophyll sampling allowed an assessment of the physiological state of the phytoplankton. No monitoring of phytoplankton was conducted in the auxiliary reservoir during 1983.

4.2 Methods

4.2.1 Phytoplankton

Phytoplankton samples were collected from Harris Lake during 1983 at Stations E2, H2, and P2 (Figure 1.1). The methods of sample collection, preservation, and processing were consistent with those employed during the previous year (CP&L 1984). Sampling frequency, however, was increased from quarterly to monthly.

4.2.2 Primary Productivity and Pigment Analyses

Primary productivity measurements were made *in situ* on a quarterly basis (February, May, August, November) at Stations E2, H2, and P2 using ^{14}C incubations. Chlorophyll *a* and phaeophytin concentrations were determined at the same times and locations.

Replicate samples for primary productivity were collected with a nonmetallic alpha bottle sampler and incubated (midday) in light bottles for approximately three hours at surface, 0.5-, 1-, and 2-meter depths. A zero-time control was used at each depth. After incubation, the samples were preserved with Lugol's iodine solution and returned to the laboratory. Three aliquots of 10 ml from each bottle were filtered

through 0.45 µm Millipore® filters, placed into scintillation vials, and counted in a Beckman® LS-233 liquid scintillation counter. Corrections for quenching and counter efficiency were made, and the zero-time control counts were subtracted from the light bottle counts. These data were used to calculate hourly uptake rates at each depth. Integration of these measurements and the use of local solar radiation data allowed calculation of a daily production rate for each station.

Pigment samples were collected with a nonmetallic alpha bottle sampler at surface, 1-, and 2-meter depths. Samples were put on ice and returned to the laboratory where approximately 200 to 500 ml were filtered and extracted in 90% acetone for 24 hours. The absorbance values at 665 and 750 nm were read on a spectrophotometer. All concentrations were corrected for phaeophytin (chlorophyll degradation product) by acidifying the extract. Chlorophyll *a* and phaeophytin concentrations are presented as individual depth concentrations (mg/m^3) and averages for each station.

4.2.3 Statistical Analyses

Analysis of variance (stations blocked on months) and Duncan's multiple range test were performed to assess spatial differences during 1983 of total phytoplankton densities, densities of dominant classes, biomass (chlorophyll) levels, production rates, Secchi disk depths, and surface water temperatures. A significance level of 5% was used.

4.3 Results and Discussion

4.3.1 Density Estimates

Phytoplankton density estimates in Harris Lake during 1983 were low to moderate, ranging from 701 units/ml (Station E2, March) to 4044 units/ml (Station H2, May) (Figure 4.1) with a mean annual density of 1996 units/ml. A comparison of the mean of quarterly data from Harris Lake in 1982 (4256 units/ml) with a mean calculated from the corresponding sample months in 1983 (2052 units/ml) indicated an overall decline in phytoplankton densities. Patterns similar to this often occur in newly

impounded reservoirs. As land is flooded to form reservoirs, nutrients are leached into the water and stimulate production, a process often referred to as a "trophic upsurge" (Ostrofsky and Duthie 1980). In subsequent years, internal nutrient loading declines and phytoplankton densities are lower. A similar pattern is hypothesized for Harris Lake.

Densities varied both spatially and seasonally. Mean annual densities at Stations H2 and P2 were similar (approximately 2100 units/ml). The mean annual density at Station E2 was lower (approximately 1700 units/ml). Analysis of variance indicated that significant differences occurred only between density means at P2 and E2 (Table 4.1). Densities at Stations E2 and P2 did not reach the spring peak typical of temperate lakes but did reach the expected summer peak (Figure 4.1). Densities at Station H2 followed a typical bimodal pattern, attaining peaks in May and August-September. A comparison of phytoplankton with zooplankton data (Figure 5.5) suggested that autotroph density patterns were influenced in some locations by fluctuating grazer populations. Grazing pressure at Stations E2 and P2 probably did not fluctuate greatly during the year because zooplankton densities remained relatively constant. However, wide fluctuations in zooplankton numbers occurred at Station H2. The May peak in phytoplankton densities at that station was followed by a June increase and July peak in zooplankton densities, suggesting that grazing may have played a role in the phytoplankton decline. Phytoplankton numbers again increased in August when zooplankton numbers at Station H2 were low. Autotroph densities remained high in September as zooplankton numbers increased and then both communities declined through the fall.

4.3.2 Community Composition

The dominant classes of phytoplankton in Harris Lake during 1983 included Chlorophyceae, Bacillariophyceae, Myxophyceae, Xanthophyceae, Cryptophyceae, and Chrysophyceae. The class Chlorophyceae dominated during most sampling periods (February, March, and May-December), while the class Bacillariophyceae was dominant during the remainder of the year (January and April) (Figure 4.2). A direct comparison between 1982 data

(quarterly) and 1983 data (monthly) was difficult but suggested that the abundance of Myxophyceae (blue-green algae) was greater in 1982. This trend is consistent with the "trophic upsurge" hypothesized for the period following reservoir filling as nutrient levels in 1982 would be expected to favor blue-green algae.

The class Chlorophyceae was represented by nine dominant taxa in 1983 (Table 4.2). The spring and fall periods were dominated by several genera including *Nannochloris, Chlorella, Ankistrodesmus, Selenastrum,* and *Crucigenia.* All are small cells or colonies with relatively rapid growth rates that are favored by balanced nutrient conditions. Summer dominants included the genera *Chlorella* and *Sphaerocystis. Chlorella* has been shown to be unpalateable to zooplankton (Porter 1977), while *Sphaerocystis* often dominates when grazing pressure is high because its gelatinous sheath prevents its assimilation by zooplankton (Porter 1976). There were no significant spatial differences among means of the Chlorophyceae (Table 4.1).

Phytoplankton of the class Bacillariophyceae were most abundant in the winter and spring monthly samples and were dominated by *Cyclotella glomerata* and *Melosira varians. C. meneghiniana* and *C. stelligera* dominated in July. No significant spatial differences were detected (Table 4.1).

The class Myxophyceae was present in significant numbers only from July through October and was dominated by *Chroococcus minimus, Merismopedia punctata,* and *M. major.* It is typical for blue-green algae to dominate during the summer when light levels and temperatures are high and stratification occurs (Prescott 1968). The absence of dominant nitrogen-fixing blue-green algae indicated that nitrogen did not become a limiting nutrient (relative to phosphorus) to phytoplankton during 1983. No significant spatial differences were detected (Table 4.1).

The class Xanthophyceae was dominated by one species, *Chlorochromonas minuta,* which was abundant during most months of the year. Densities of the class Cryptophyceae, represented by the genera *Chroomonas, Cryptomonas,* and *Rhodomonas,* were greatest in spring and fall

(Table 4.2). Lastly, the Chrysophyceae was represented by the minute *Erkenia subaequiciliata* (April), two species of *Dinobryon* (May and December) and *Ochromonas* sp. (April).

Overall, the phytoplankton community appeared to be reflective of limited nutrient availability during 1983.

4.3.3 Taxa Richness and Diversity

Taxa richness values (the number of taxa identified in each sample) were moderate to high, ranging from 13 to 44 taxa (Table 4.3). Taxa richness was greatest in August and September and lowest in January and February. This trend was similar to density trends. The range of 1983 richness values was similar to those in 1982 (13-39).

Shannon-Wiener diversity index values were high, ranging from 2.8 to 4.9 at Stations E2, H2, and P2 (Table 4.4) while lake diversities ranged from 3.6 to 5.0. Both individual station and whole lake diversity values were highest in September and lowest in January. Diversity values in 1983 were similar to those in 1982.

4.3.4 Quarterly Primary Productivity and Chlorophyll

Quarterly areal productivity measurements were low, ranging from 2.2 mg C/m^2/day to 112.8 mg C/m^2/day (Table 4.5). Primary productivity was greatest at Station H2 followed by P2 and E2 (Table 4.1). Phytoplankton biomass levels, as indicated by chlorophyll *a* concentrations, followed similar temporal and spatial patterns and ranged from approximately 2 to 7 µg/l (Table 4.5). The most notable difference between productivity and biomass levels occurred in May when relatively greater biomass levels coincided with low production rates (Table 4.5). Poor physiological quality of the phytoplankton, as indicated by increased phaeophytin levels, may have contributed to the seasonal difference noted in May although the reason is not known.

Depth profiles of productivity, chlorophyll, and phaeophytin levels are presented in Figure 4.3. Productivity was low and fairly uniform throughout the water column, except during August at Station H2 and P2. Wetzel (1975) indicated that this type of profile was typical of oligotrophic systems where low nutrient levels prevent the accumulation of plankton at the surface which would, in turn, shade out deeper plankton layers. He further noted that high levels of inorganic particulate and colloidal substances typically reduced the maximal levels of photosynthesis. The resultant profiles, like those in Harris Lake, were relatively uniform vertically and low in terms of production rates.

The profiles observed in August at Stations H2 and P2 were more typical of mesotrophic systems (Wetzel 1975), both because productivity was more stratified overall and levels were greater. When the lake was thermally stratified, oxygen depletion in the hypolimnion (Section 3.0) would result in increased dissolved nutrient levels there. If this were followed by a mixing event, epilimnetic nutrient levels and productivity rates may have briefly increased. Internal nutrient recycling may be greater in shallow systems (Oglesby 1977) and the shallow nature of Stations H2 and P2 may have contributed to greater summer primary productivity than at Station E2. In addition, Stations H2 and P2 are in closer proximity to the headwaters which are potential nutrient sources due to runoff inputs.

Overall, the quarterly primary productivity and chlorophyll levels indicate that Harris Lake is an oligotrophic (i.e., nutrient limited) system (Wetzel 1975). However, quarterly sampling may have missed greater peaks in production during the summer months which might have revised this assessment.

4.4 Summary

Phytoplankton density estimates in Harris Lake during 1983 ranged from 701 units/ml to 4044 units/ml with a mean annual density of approximately 2000 units/ml. Densities at Station P2 were greatest followed by H2 and E2. Significant spatial differences were detected only between Stations P2 and E2.

The Chlorophyceae was the dominant class during most months. The Bacillariophyceae dominated in January and April. Myxophyceae appeared to have declined from 1982 to 1983 and the community overall was indicative of oligotrophic nutrient conditions.

Productivity and biomass levels were relatively low in all four quarters, presumably due to nutrient limitation. Increased production at Stations H2 and P2 in August may have been related to internal nutrient cycling or watershed nutrient inputs.

Table 4.1 Results of Duncan's multiple range test for selected[1] phytoplankton and water quality parameters indicating significant spatial differences in Harris Lake for 1983[2].

Variable	Station		
Total phytoplankton density	P2	H2	E2
Mean water column chlorophyll *a* concentration	H2	P2	E2
Daily primary productivity	H2	P2	E2
Surface water temperature	H2	P2	E2

[1]Analysis of variance did not indicate significant station effects for densities of the classes Bacillariophyceae, Chlorophyceae, Myxophyceae, or for Secchi disk depth.

[2]Ranking of stations (left to right) indicates decreasing mean values. Underscores indicate that means were not significantly different ($P \leq 0.05$).

Table 4.2 Phytoplankton taxa which comprised greater than 10% of total density estimate in a particular sample indicating the month and station of abundance in Harris Lake during 1983.

Taxon	Station E2	Station H2	Station P2
Bacillariophyceae			
Cyclotella meneghiniana	Jul		
C. stelligera		Jul	Jul
C. glomerata	Jan, Feb	Jan, Feb, Apr	Jan-Apr
Melosira varians		Dec	
Xanthophyceae			
Chlorochromanas minuta	Jan, Feb, Apr, Jan, Aug	Jan, Apr, May, Dec	Jan, Mar-May, Nov
Chrysophyceae			
Erkenia subaequiciliata		Apr	
Dinobryon bavaricum	May		
D. sertularia			Dec
Ochromonas sp.		Apr	
Chlorophyceae			
Sphaerocyotis schroeteri	Jul, Aug, Nov	Jul	Jul, Aug
Nannochloris bacillaris	Apr, Nov	Mar	Aug
Nannochloris sp.	Jan	Apr, May	
Chlorella vulgaris	Mar, May, Aug, Oct	Feb, Aug	Jan, Jul
Ankistrodesmus falcatus	Nov		
Selenastrum minutum	Feb, Jun, Oct	May, Oct	Feb, May
Crucigenia tetrapedia	Feb, Mar	Jan	
C. rectangulliaris			Oct
C. quadrata		Sep	
Cryptophyceae			
Chroomonas nordstedii	Dec		
Cryptomonas erosa	Dec	Mar, Oct, Nov	Feb, Nov, Dec
C. ovata			May
Rhodomonas minuta		Feb	Feb
Myxophyceae			
Chroococcus minimus	Jul	Jul	
Merismopedia punctata	Sep, Oct	Sep	Jul, Aug, Sep
M. major			Oct

Table 4.3 Taxa richness values of phytoplankton samples collected from Harris Lake during 1983.

	Month												
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
E2	14	13	14	14	24	20	21	30	24	26	16	19	20
H2	20	15	22	17	27	25	22	37	44	25	27	17	25
P2	14	15	20	21	18	28	23	31	30	27	19	20	22
Mean	16	14	19	17	23	24	22	33	33	26	21	19	22

Table 4.4 Phytoplankton Shannon-Wiener diversity index values of samples collected from Harris Lake during 1983.

	Month											
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E2	3.0	3.4	3.5	3.1	4.0	3.7	3.3	4.0	4.1	4.0	3.7	4.0
H2	3.8	3.6	4.1	3.6	4.1	4.3	3.2	4.4	4.9	4.3	4.3	3.4
P2	2.8	3.4	3.7	3.4	3.6	3.4	3.7	4.2	4.4	4.2	3.9	3.6
Whole Lake	3.6	4.0	4.5	4.0	4.4	4.5	3.9	4.7	5.0	4.7	4.5	4.4

Table 4.5 Daily primary productivity rates, chlorophyll *a*, and phaeophytin levels in Harris Lake during 1983.

Station	Month	Daily Productivity ($mgC/m^2/day$)	Chlorophyll *a* (µg/liter)	Phaeophytin (µg/liter)
E2	Feb	14.7	2.3	2.9
	May	9.5	4.2	3.2
	Aug	63.3	2.2	4.1
	Nov	2.2	2.4	0.8
	Mean	22.4	2.8	2.8
H2	Feb	34.1	3.4	1.6
	May	19.4	7.1	4.3
	Aug	112.8	4.3	3.7
	Nov	2.9	2.3	0.7
	Mean	42.3	4.3	2.6
P2	Feb	22.4	2.8	1.6
	May	11.3	4.2	4.4
	Aug	100.0	1.7	2.5
	Nov	2.4	3.4	0.7
	Mean	34.0	3.0	2.3

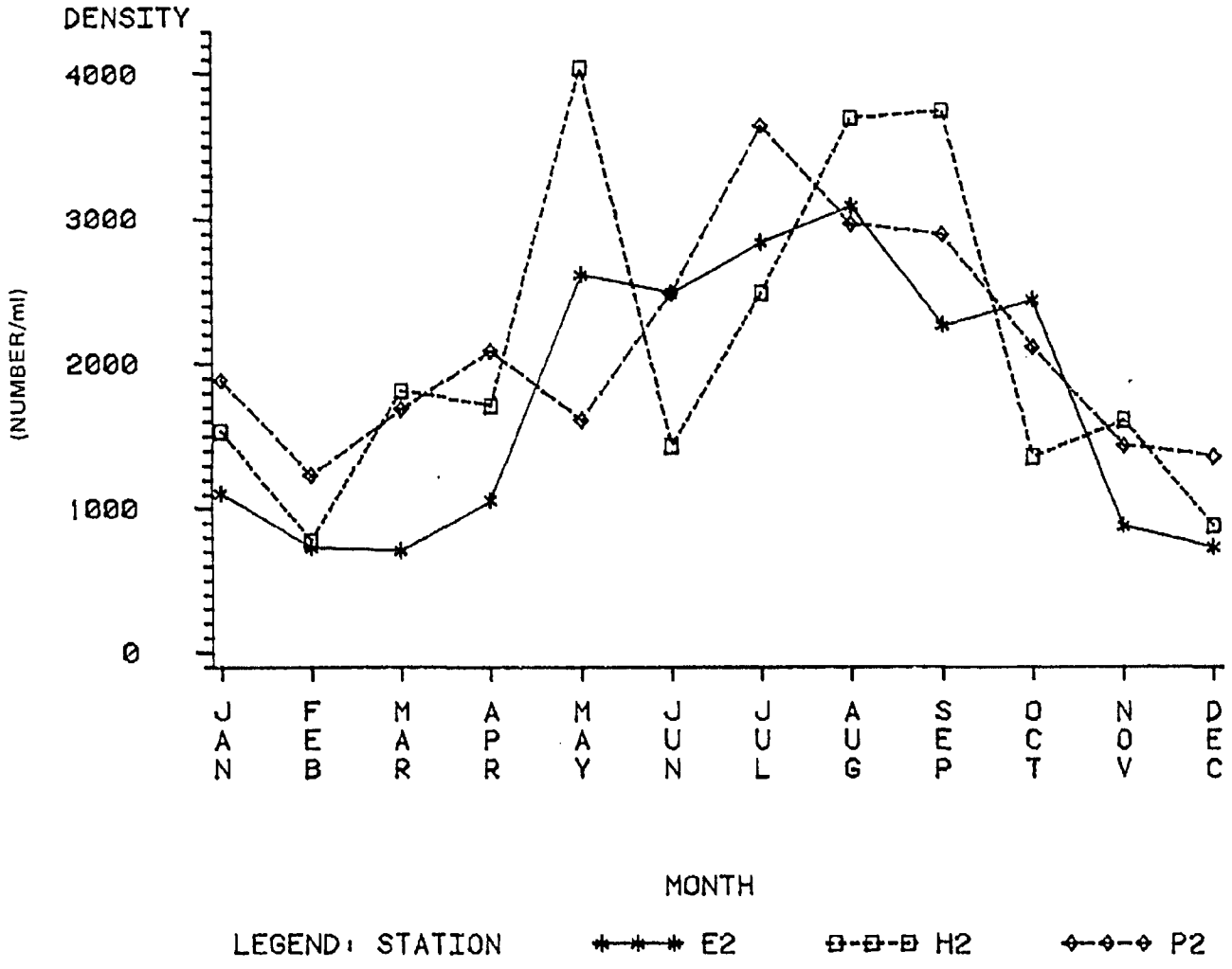

Figure 4.1 Phytoplankton density estimates (number/ml) by station in Harris Lake during 1983.

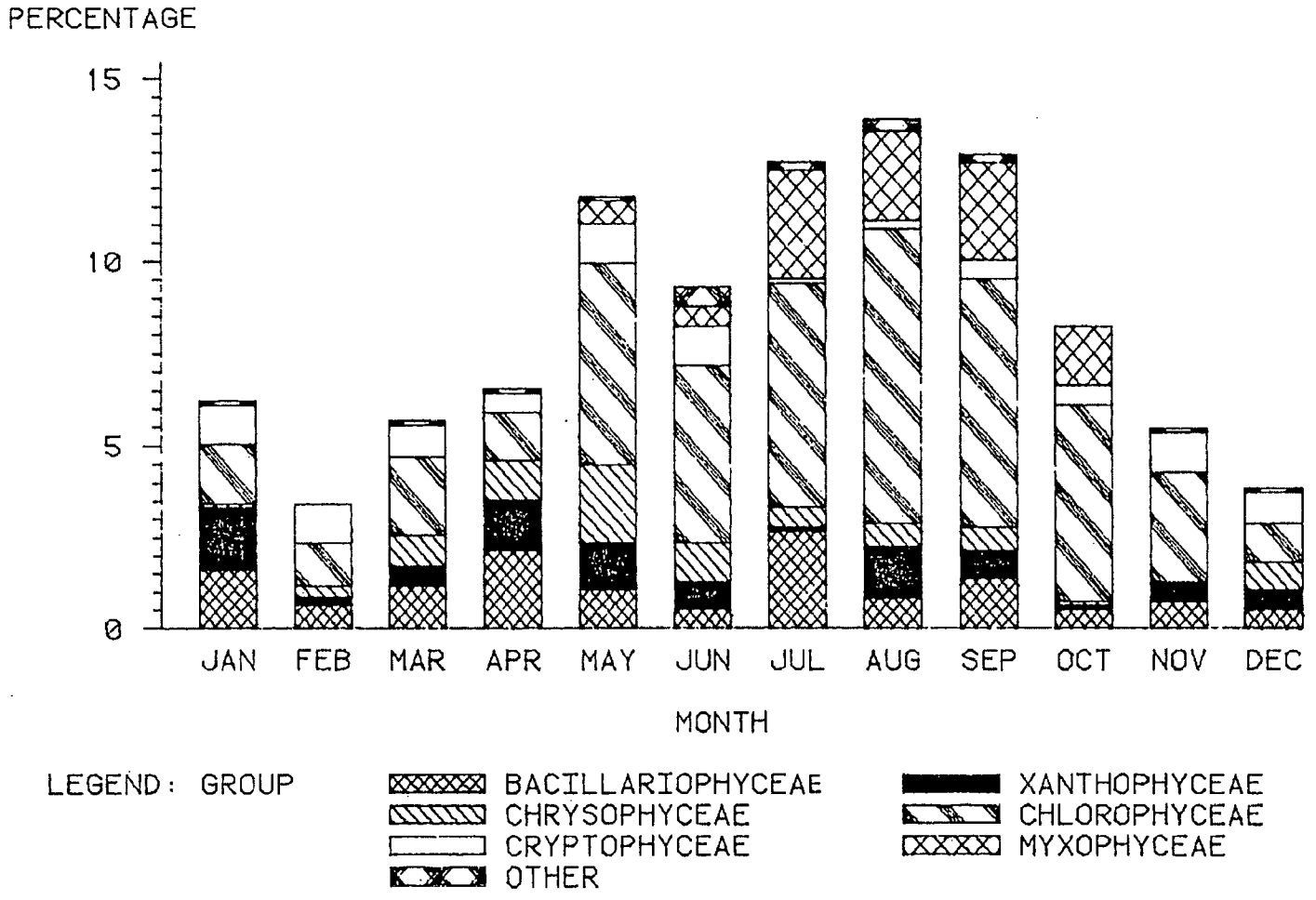

Figure 4.2 Phytoplankton classes as percentage of the total annual density in Harris Lake during 1983.

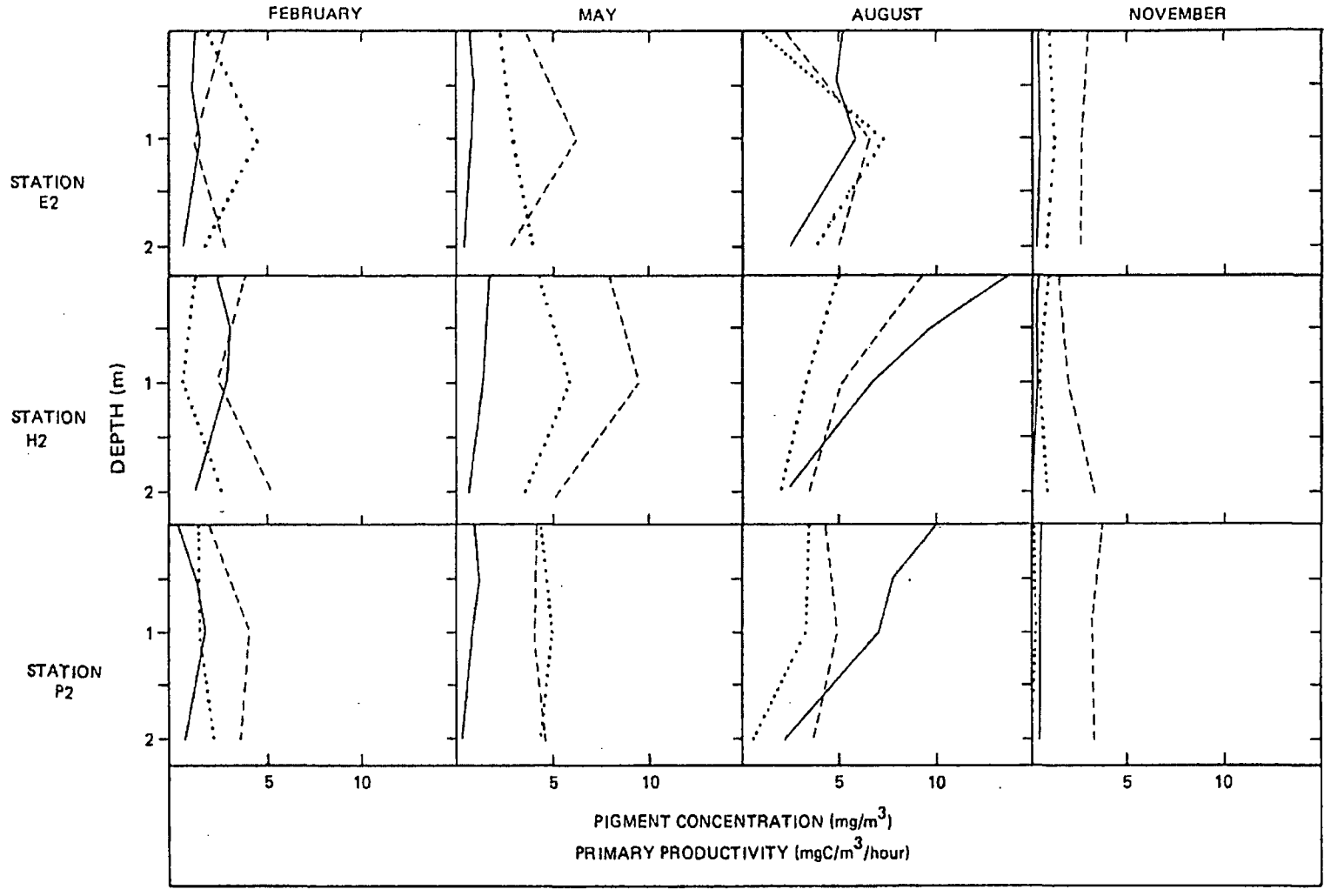

Figure 4.3 Vertical profiles of chlorophyll *a* (--------), phaeophytin (··········), and primary productivity (————) from Stations E2, H2, and P2 in Harris Lake during 1983.

5.0 ZOOPLANKTON

5.1 Introduction

Zooplankton data collected during 1983 at Harris Lake represent a community expected to be in an unstable, transitory state due to the newness of the impoundment. This condition may persist for about three years (Munro and Baily 1980). Species richness and diversity, especially among herbivores was expected to be high (Potter and Meyer 1982). Data acquired during this early period will provide baseline material to compare with the system when it stabilizes.

5.2 Methods

Bottom-to-surface vertical tows were used to collect zooplankton at Stations E2, H2, and P2 (Figure 1.1). No zooplankton sampling was conducted on the auxiliary reservoir in 1983. Tows were taken monthly using a # 10 mesh-sized net (0.156 mm) to collect adult copepods and cladocerans and a # 20 mesh-sized net (0.076 mm) to collect rotifers and copepod nauplii. Samples were preserved in the field with formalin to 2% of volume and returned to the laboratory for analysis. In the laboratory the samples were mixed, and an aliquot containing at least 100 organisms was withdrawn and placed in a circular zooplankton counting wheel. The organisms were examined using a dissecting stereoscope with difficult identifications aided by the use of a compound microscope.

The organisms were identified, counted, and densities were computed on a volumetric basis and reported as organisms/m^3. References used in organism identification included Pennak (1953), Brooks (1957, 1959), Voigt (1957), Edmondson (1959), and Wilson and Yeatman (1959).

Analysis of variance (blocking on months) followed by Duncan's multiple range test was used for determining density differences among stations. Comparisons were not made with 1982 data because only quarterly data are available from that year.

5.3 Results and Discussion

5.3.1 Community Composition and Density

The 1983 Harris zooplankton community was diverse with 6 copepod, 15 cladoceran, 21 rotifer, and 3 protozoan taxa found in the samples (Table 5.1). In addition to the normal pelagic component of the zooplankton community, a variety of littoral cladocerans was found (e.g. *Alona*, *Leydigia*, *Kurzia*, etc.); their presence was probably attributable to the large amount of inundated terrestrial vegetation in the new reservoir.

The community was well balanced among major taxa groups (Figure 5.1). The protozoan community found in this type of sampling gear was notable only in July and December.

Total zooplankton densities for the reservoir during 1983 were moderate to low (Figure 5.2) and remained fairly constant through June when a summer increase occurred. Densities dropped from September to a November minimum and were followed by a subsequent December increase. A description of temporal variation in individual taxa follows.

The calanoid copepods, *Diaptomas pallidus* and *Diaptomus reighardi*, displayed winter maxima and a spring minimum (Figure 5.3). The two species coexisted with *D. pallidus* somewhat more abundant than *D. reighardi*. The cyclopoid copepod, *Cyclops bicuspidatus thomasi*, showed moderate densities in winter and early spring and subsequently declined. Concurrent with the decline of *Cyclops*, two other cyclopoids *(Mesocyclops edax* and *Tropocyclops prasinus)* appeared and maintained moderate densities through late fall.

The cladoceran community was species rich and numerically abundant in 1983. This was likely because these are filter feeders, and the large amount of bacteria and detritus created by decomposition of the organic material in the bottom of the new reservoir provided an abundant food source for the herbivores. *Daphnia ambigua* and *Bosmina coregoni* dominated

the winter and early spring cladoceran community. In spring and summer, *Daphnia parvula*, *Ceriodaphnia reticulata*, *Bosmina longirostris*, *Diaphanosoma brachyurum*, and *Holopedium amazonicum* were prevalent with *D. ambigua* returning in winter (Figure 5.4).

Many rotifer taxa were numerically important in 1983 (Table 5.1). Again, this was likely due to the large amount of filterable material. Total densities were variable with numbers ranging from 5,738/m^3 in October to 33,038/m^3 in June. No real patterns of dominance developed as there were constantly several different taxa present in moderate abundances.

There were some significant areal differences in zooplankton densities among stations during 1983. Statistical analysis performed on a variety of zooplankton taxa group densities indicated that Station H2 had significantly greater densities of total zooplankton, total copepods, total rotifers, and total cyclopoid copepods than Station E2. Densities at Station P2 usually were intermediate to the other two stations (Figure 5.6). Increased densities at Station H2 were probably a result of the physical nature of that station. It is a shallower station containing a lot of vegetation which was inundated during flooding of the reservoir. As mentioned earlier, organic breakdown created much filterable food material for herbivores. Since predators such as cyclopoid copepods would have more food available in the form of herbivores, density increases at Station H2 were probably food-related.

5.3.2 Taxa Richness and Diversity

Taxa richness (number of individual taxa per sample) was generally high in Harris Lake (Table 5.2). Richness was highest in the upstream areas (Stations H2 and P2) as opposed to the dam area (Station E2). Higher taxa richness upstream was mainly caused by littoral and benthic taxa in the shallower waters feeding on the by-products of organic matter decomposition. Temporally, the only evident trend was reduced richness values in winter and early spring.

Shannon-Wiener diversity index values were also high (Table 5.3). Diversity was high at all three stations, and there were no evident temporal trends.

The high taxonomic richness and diversity were indicative of a new system, still in a state of flux, in which opportunistic species (r-selected) predominated (Baxter 1977). These species are organisms which will multiply under favorable conditions such as abundance of food. In time, stabilization should occur and there should be fewer herbivores and more predators (cyclopoid copepods).

5.4 Summary

During 1983 the Harris Lake zooplankton community remained in a transitory state. Total densities were low to moderate with filter-feeding organisms predominating. Species diversity and taxomonic richness were high probably as a result of organisms associated with vegetation inundated during reservoir filling. The major energy flow was probably through filterers (cladocerans and rotifers) from bacteria associated with decomposition. Upstream stations tended to have greater densities than the dam station, possibly because of shallower water and greater amounts of vegetation.

Table 5.1 Zooplankton taxa collected at Harris Lake by station during 1983

Taxa	Station E2	Station H2	Station P2	Abundance
Copepoda				
Diaptomus pallidus	X	X	X	**
D. reighardi	X	X	X	*
Cyclops vernalis	X	X	X	
C. bicuspidatus thomasi	X	X	X	*
Mesocyclops edax	X	X	X	*
Tropocylops prasinus	X	X	X	*
Unknown harpacticoid			X	
Cladocera				
Daphnia ambigua	X	X	X	**
D. parvula	X	X	X	*
Ceriodaphnia reticulata	X	X	X	**
Bosmina longirostris	X	X	X	
B. coregoni	X	X	X	*
Ilyocryptus spinifer		X		
Alona sp.		X		
A. quadrangularis	X			
Leydigia quadrangularis		X		
Chydorus sphaericus		X	X	
Pleuroxus striatus		X		
Kurzia latissima		X	X	
Sida crystallina	X			
Diaphanosoma brachyurum	X	X	X	*
Holopedium amazonicum	X	X	X	*
Rotifera				
Keratella americana	X	X	X	
K. cochlearis	X	X	X	**
K. crassa	X	X	X	*
Kellicottia bostoniensis	X	X	X	**

Table 5.1 (continued)

Taxa	Station E2	Station H2	Station P2	Abundance
Monostyla sp.		X		
Trichocerca longiseta	X	X	X	*
T. similis		X	X	
Ascomorpha sp.	X	X	X	*
Asplanchna priodonta	X	X		
Synchaeta spp.	X	X	X	**
Polyarthra spp.	X	X	X	*
P. euryptera	X	X	X	*
Filinia longiseta	X	X	X	
Pompholyx sulcata	X	X	X	*
Hexarthra sp.	X	X	X	
Conochilus unicornis	X	X	X	**
Conochiloides coenobasis	X	X	X	**
Ptygura sp.	X	X	X	*
Collotheca sp.	X	X	X	*
Bdelloid rotifer			X	
Unidentified rotifer		X		
Protozoa				
Difflugia sp.	X	X	X	
Codonella sp	X	X	X	*
Epistylus sp.	X	X	X	

*taxa comprised 1% to < 3% of total zooplankton density in lake
**taxa comprised ≥ 3% of total zooplankton density in lake

Table 5.2 Zooplankton taxa richness data for Harris Lake by month and station for 1983.

Station	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Mean
E2	12	15	10	22	17	21	17	18	15	19	18	17	16.7
H2	17	19	19	18	17	21	21	20	21	18	21	21	19.5
P2	16	16	15	21	19	21	17	22	18	20	16	20	18.4
Lake Mean	15.0	16.7	14.7	20.3	17.7	21.0	18.3	20.0	18.0	19.0	18.3	19.3	18.2

Table 5.3 Zooplankton Shannon-Wiener diversity index values for Harris Lake by month and station for 1983.

Station	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E2	2.6	3.2	2.6	3.6	2.8	3.8	3.1	3.6	3.0	3.4	3.6	4.2
H2	3.0	3.2	3.6	3.7	3.2	4.0	3.4	3.5	3.3	3.5	3.5	4.3
P2	2.7	2.5	3.2	3.5	3.1	3.9	3.4	3.7	3.3	3.7	3.4	4.2
Whole Lake	2.9	3.2	3.5	3.7	3.1	4.0	3.5	3.7	3.3	3.6	3.7	4.3

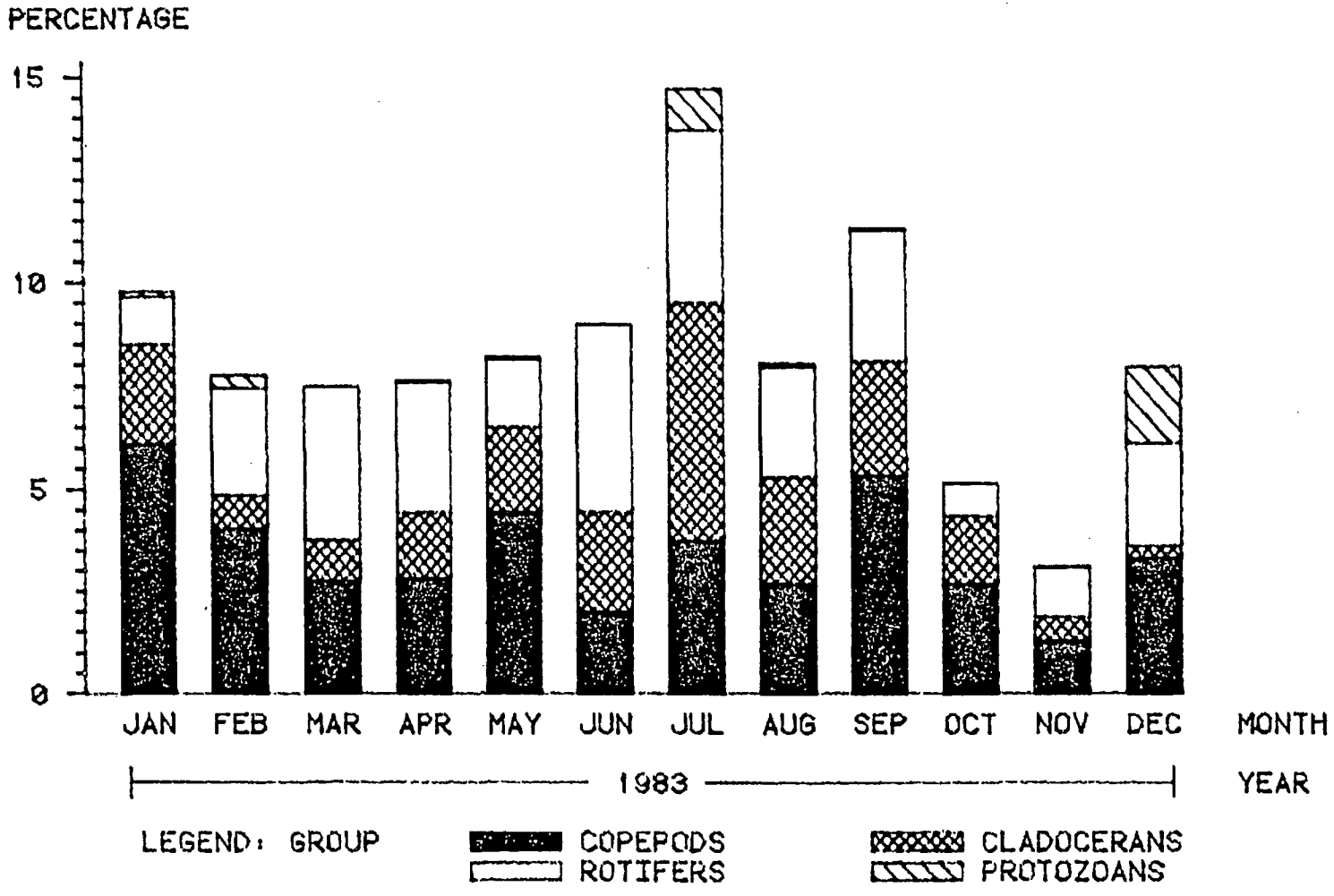

Figure 5.1 Percent of total zooplankton community by taxonomic group for Harris Lake during 1983.

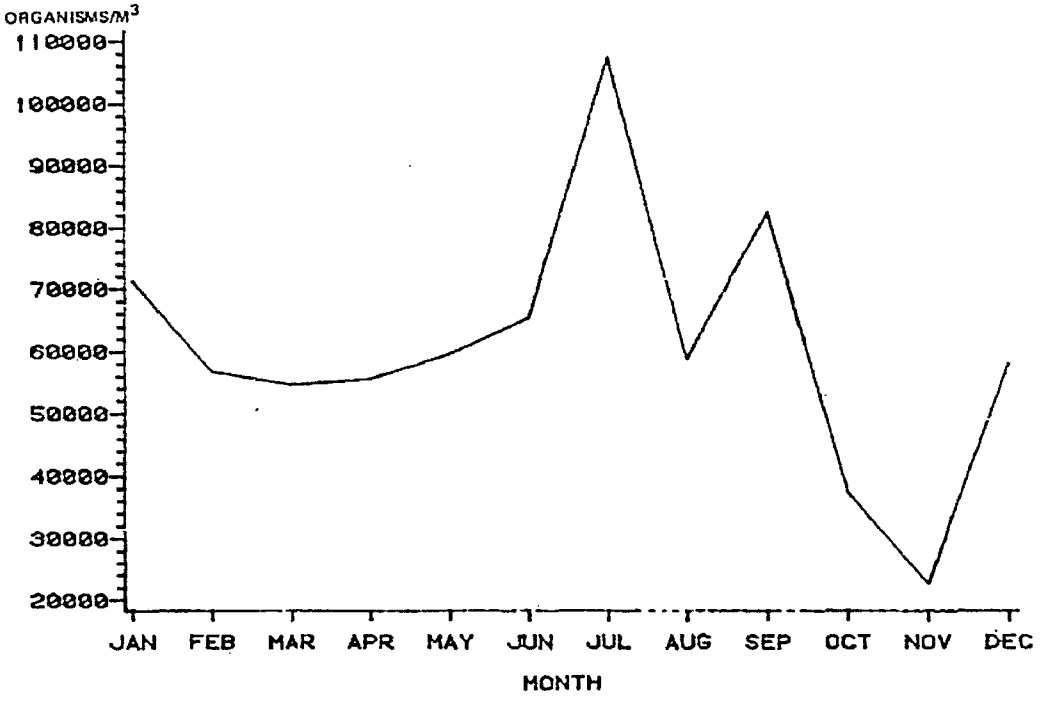

Figure 5.2 Mean total zooplankton densities for Harris Lake during 1983.

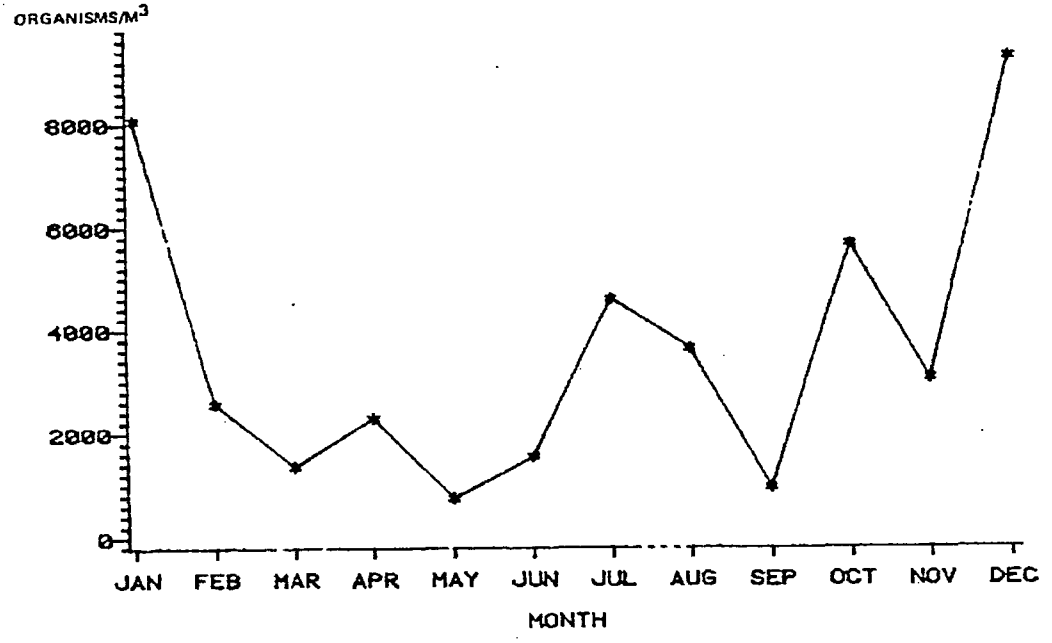

Figure 5.3 Monthly mean total *Diaptomus* spp. densities in Harris Lake during 1983.

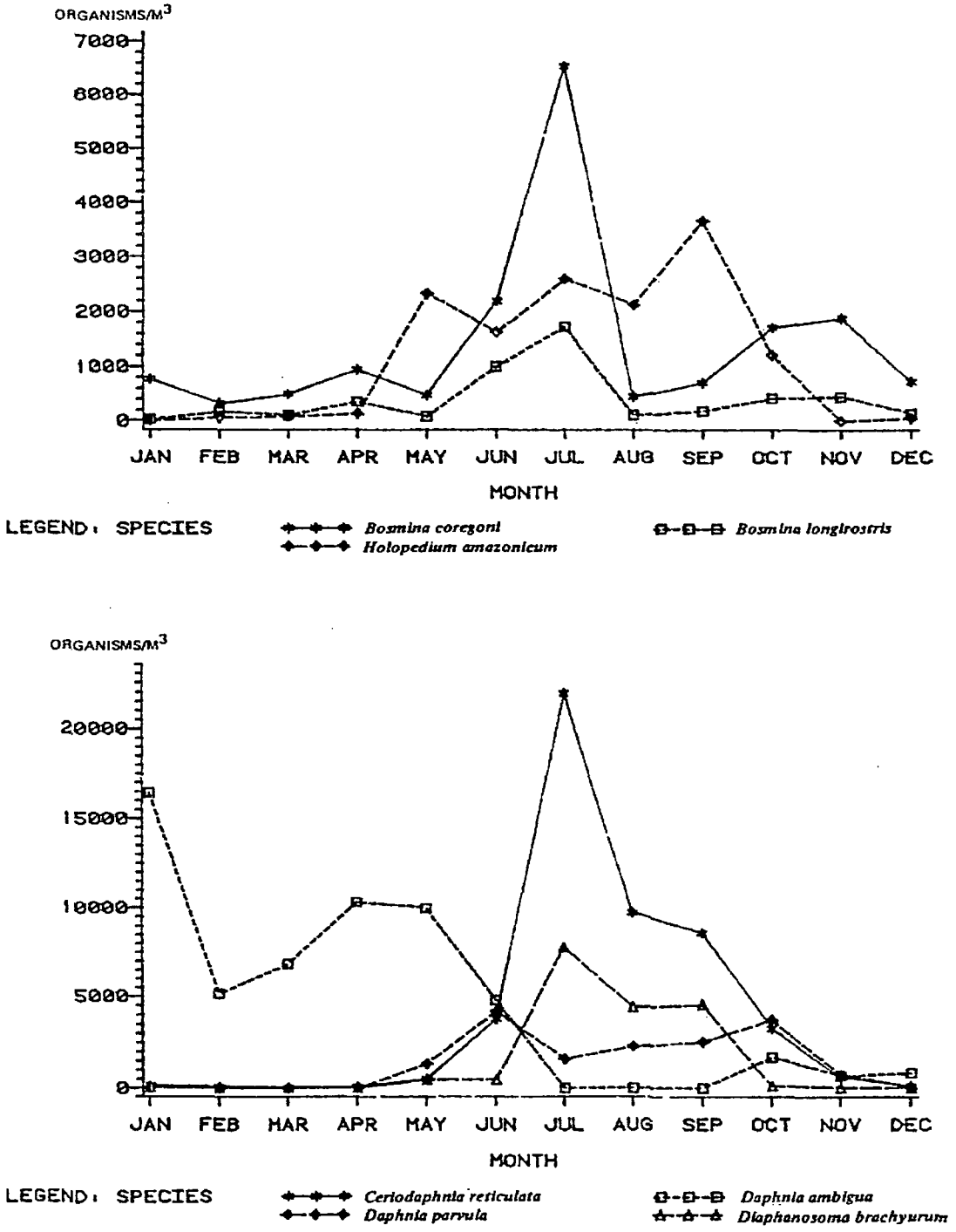

Figure 5.4 Monthly mean total densities of important cladoceran taxa in Harris Lake during 1983.

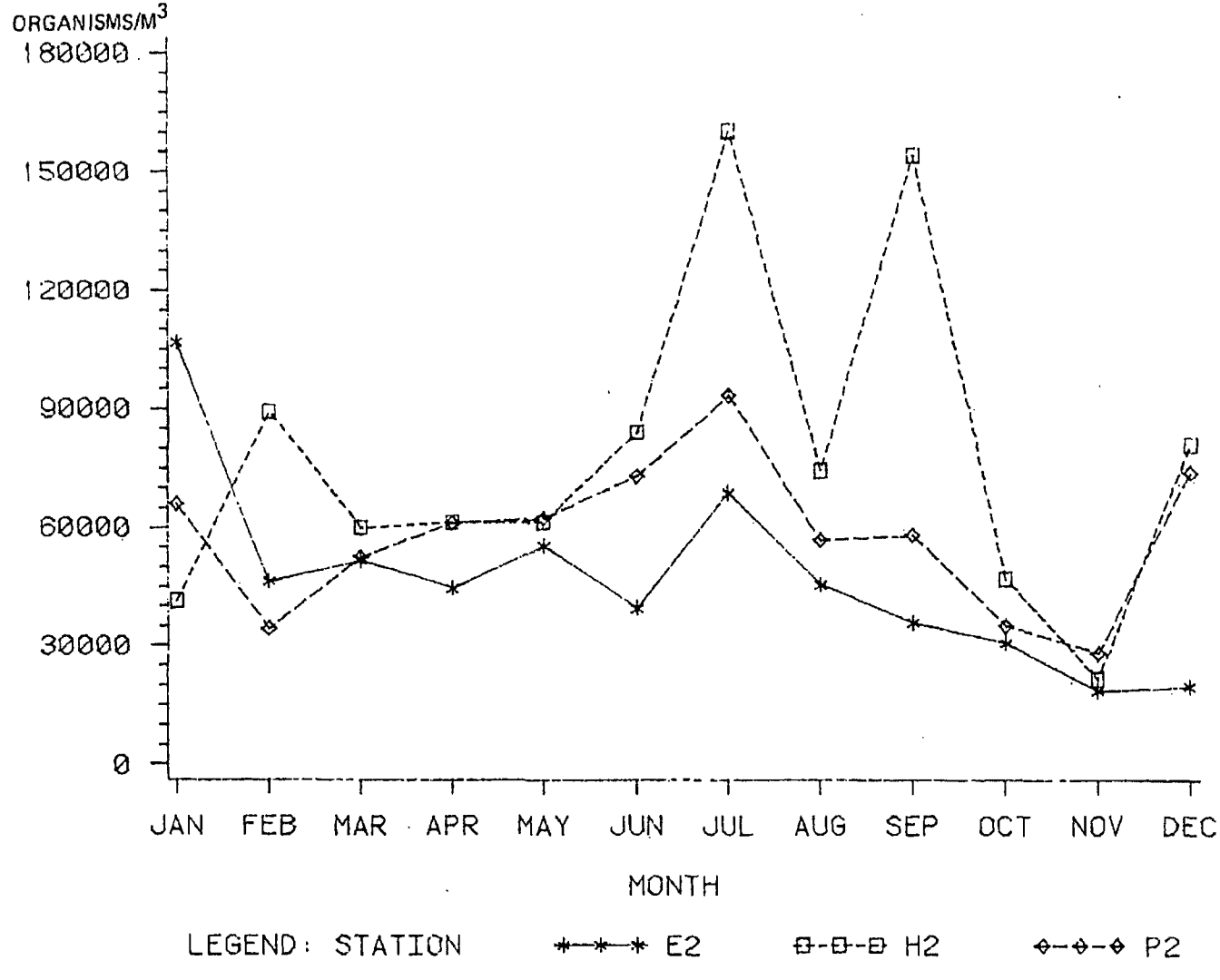

Figure 5.5 Monthly total zooplankton densities by station in Harris Lake during 1983.