Limnological Survey of Lake Kemp, Texas: 1997

Gene R. Wilde
Department of Range, Wildlife, and Fisheries Management
Texas Tech University
Lubbock, TX 79409-4125

Submitted to:

U.S. Army Corps of Engineers
Tulsa District
1654 S. 101 E. Avenue
Tulsa, OK 74128-4629

12 April 1999

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

List of Tables

List of Figures

List of Figures (continued)

List of Figures (continued)

Acknowledgments

I am grateful to Mr. Stephen L. Nolen, US Army Corps of Engineers, Tulsa District for his assistance with all aspects of this study. I also wish to thank Ken Ostrand for overseeing laboratory analyses performed at Texas Tech University and Jenny Barham for organizing field supplies, labeling bottles, etc., in preparation for sampling trips. I also wish to acknowledge Jenny Barham, Matt Hyatt, Ken Ostrand, Bill Redell, and Gene R. Wilde, III, for their help in the field. Finally, I wish to thank Dr. Robert Albin, Associate Dean, College of Agricultural Sciences and Natural Resources, Texas Tech University, for providing funds with which to purchase project-related equipment

Introduction

The upper reaches of the Red River drainage basin, in southwest Oklahoma and north-central Texas, drain an area underlain by extensive marine evaporite deposits (Sonnenfeld 1984), formed by subsidence of inland seas during the Permian. As a result of spring seepage and dissolution of exposed deposits, tributaries of the Red River deliver a high load of dissolved solids, particularly sodium chloride, into the Red River, limiting its usefulness as a water supply for agricultural, industrial, and municipal uses.

The Tulsa District, U.S. Army Corps of Engineers has proposed constructing a number of chloride control facilities to intercept and dispose of these saline inflows to the Red River and its tributaries (USACOE 1994). This proposed project, the Red River Chloride Control Project, would intercept saline flows using a combination of dikes, inflatable weirs, and pumps, and dispose of these saline flows by export to brine disposal lakes and by deep-well injection into deep, porous strata. Operation of these control structures is expected to considerably reduce salinity in the Red River and affected tributaries: the ten naturally occurring sources of chloride loading into the Red River and its tributaries targeted by the Red River Chloride Control Project contribute a daily average of 3,208 metric tons of chloride to the river.

The Wichita River, a tributary of the Red River, drains arid and semiarid lands in north-central Texas. The river is formed by union of the North Wichita River, the Middle Wichita River, and the South Wichita River. The Red River Chloride Control Project proposes construction of three chloride control structures in the Wichita River basin: the Y Ranch low flow dam (North Wichita River), the Lowrance low flow dam (Middle

Wichita River), and the Bateman Low Flow Dam (South Wichita River). The Wichita River drainage area contains extensive deposits of sodium chloride and gypsum, of marine origin (Joerns 1961) and numerous springs and seeps deliver chlorides into the river (Lewis and Dalquest 1957; Joerns 1961). The USACOE (1972) indicates that brines in the Wichita River are primarily sodium chloride with a high sulfate concentration. Chloride concentrations in these springs and seeps range from 5000 to 30,000 mg/l, but chloride concentrations in deep aquifers exceed 100,000 mg/l (Garza 1983).

Construction of chloride control structures on the South Wichita River was authorized in 1974 and construction began in the fall of 1976. These structures include a low flow dam (Bateman low flow dam) with an inflatable weir to collect brine flows emitting from the South Wichita River drainage, and a pump station and pipeline to deliver collected brines to Truscott Brine Lake. The low flow dam is located at South Wichita River km 135, in King County, Texas. Under low flow conditions, when chloride concentrations are greatest in the river, the dam is inflated and impounds the river. These impounded brines are exported to Truscott Brine Lake. During periods of high flow, the dam deflates, allowing passage of waters with lower chloride concentrations. The Bateman low flow dam went into operation in May 1987

The Wichita River is impounded at river km 228 to form Lake Kemp. Construction and operation of chloride control structures on the Wichita River also is expected to reduce chloride loading into Lake Kemp. Historically, the average chloride load into Lake Kemp was about 408 metric tons per day.

Baldys et al. (1996) examined concentrations of total dissolved solids and chloride at several sites on the South Wichita and Wichita rivers. They reported that operation of the Bateman chloride control facility had significantly reduced chloride and dissolved solids concentrations at all sites studied.

A preliminary study of the effects of the Bateman chloride control facility on water quality in Lake Kemp (Baldys et al. 1996) was inconclusive. Baldys et al. (1996) found weak evidence of a decrease in chloride and dissolved solids concentrations in Lake Kemp and strong evidence of a decrease in these parameters in the Wichita River downstream from the lake. However, high runoff early in their study led them to question whether these decreases were due to chloride control or dilution. The purposes of this study are to provide an initial description of the physical, chemical, and biological limnology of Lake Kemp, provide baseline data for future monitoring efforts, and to assess potential effects of the chloride control structures on Lake Kemp water quality and productivity.

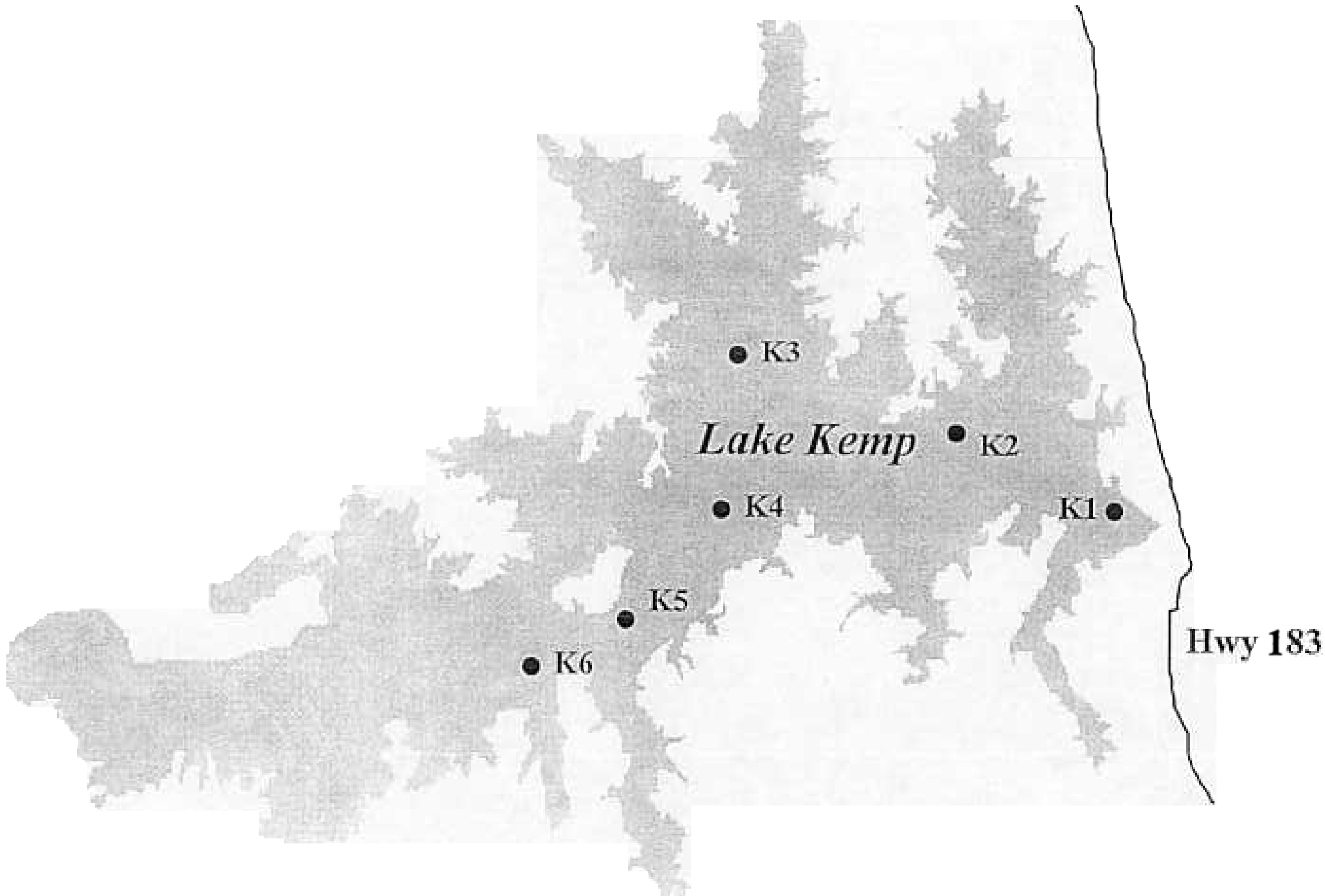
Description of the Study Area

Lake Kemp is a moderately large impoundment of the Wichita River located in north-central Baylor County, Texas, at river km 228. Lake Kemp is approximately 13 km north of Seymour, TX, and 64 km southwest of Wichita Falls, TX. The lake was impounded in October 1922, but the dam was not completed until August 1923. The height of the dam was increased by approximately 5 m in 1973. The dam now is 2710 m long and rises 35.1 m above the bed of the Wichita River. The spillway is located at an elevation of 360.6 m above sea level. At top of the conservation pool, the water level is at an elevation of 348.7 m. Lake Kemp has a surface area of 6,314 ha (15,590 acres), a volume of 0.432 km^3 (268,000 acre-feet), and mean and maximum depths of 9.6 (Ground and Groeger 1994) and 17 m (this study), respectively.

Lake Kemp was impounded for flood control and irrigation. The lake is operated by the City of Wichita Falls and the Wichita County Water Improvement District No. 2. Waters from the lake currently are used for irrigation in the Wichita River Valley, for oil field operations, and municipal and industrial uses. Flood storage in Lake Kemp is managed by the U.S. Army Corps of Engineers.

The drainage area of Lake Kemp is 5,403 km^2 (2,086 square miles) and is composed primarily of range (86.7%) and cropland (13.3%). Compared with other Texas river basins, the Wichita River drainage basin is highly erosible (Greiner 1982). Most erosion (71%) in the basin is sheet and rill erosion, which are associated with overland runoff following rain events.

Baylor County has a mild climate with a 214 day (frost free) growing season (Ramos 1995). The mean annual air temperature is 17°C; mean air temperatures in July (summer) and January (winter) are 36 and -3°C, respectively. Annual rainfall is 69 cm per year (Ramos 1995) and the evaporation rate is 152 cm per year (Joerns 1961). Winds are highly variable. Prevailing winds are out of the south in spring and summer, and out of the north in winter.



igure Map of Lake Kemp, Texas, showing sampling sites. Coordinates of sampling tes are K1 (33 07.8769"N, 99°0 .0067"W), K2 (33°46'02.2543"N, 99°10'02.2807"W), K3 (33 .6767"N, 99° 711"W), K4 (33°45'02.0317"N, 99°12'1 7.7930"W), K5 (33°44 98"N, 99° 601"W), and K6 (33°44'16.6801"N, 99° 716"W).

Methods

In general, sampling was conducted in accordance with the monitoring plan developed by Burks (1996). Sampling was conducted from April through December 1997 at six locations on Lake Kemp (Figure 1). These sites were chosen to include two locations (K1 and K2) representative of limnetic conditions, two locations (K3 and K4) that were transitional between riverine and limnetic conditions, and two locations (K5 and K6) that were riverine in nature. The Wichita River has deposited an extensive, shallow (< 1 m) delta in much of the upper reaches of Lake Kemp, therefore, sites K5 and K6 may not represent truly riverine conditions, but both sites are strongly influenced by the river.

On each sampling date, vertical profiles of water temperature, pH, dissolved oxygen, and conductivity were collected with a Hydrolab Reporter multiprobe water analyzer. Measurements were made from the surface to within 0.5 m of the bottom, in 1 m depth increments, at each station. Transparency was measured with a Secchi disc. Photosynthetically active radiation (PAR) was measured with a LI-COR model LI-192SA underwater Quantum Sensor. PAR was measured at the surface and at 1 m depth increments until ≤ 1% of incident surface radiation was detected. PAR readings were log transformed and linear regression was used to estimate extinction coefficients ($\varepsilon\lambda$) using the formula:

$$\ln(I_Z) = \ln(I_O) - \varepsilon\lambda z$$

where I_Z is the intensity of light at depth z, I_O is the intensity of light penetrating the surface, z is the path length (depth, m), and $\varepsilon\lambda$ is the extinction coefficient (Horne and Goldman 1994).

Water samples for alkalinity, turbidity, total dissolved solids, total suspended solids, nutrients, and ion analyses were collected at depths of 0.5 m and at 0.5 m above the lake bottom using a pump sampler. Three replicate samples were taken, surface and bottom, at each sampling site, except that 10 replicate samples were taken for turbidity and chlorophyll-*a* at sites K1, K4, and K6. Samples were preserved on ice or, in the case of nitrate samples were preserved with hydrochloric acid.

Samples for measurements of alkalinity, turbidity, total dissolved solids, total suspended solids and chlorophyll-*a* were maintained in controlled rooms, under chain-of-custody, until analyses were completed at Texas Tech University. Turbidity was measured with a LaMotte turbidity meter following NPDES method 180. (U.S. EPA 1993). Alkalinity, total dissolved solids (filterable residue), and total suspended solids (non-filterable residue) were measured following NPDES methods 310.1, 160.1, and 160.2 (U.S. EPA 1983), respectively.

Samples for chlorophyll-*a* and phytoplankton cell counts were collected from a depth of 0.5 m. Three replicate samples were taken at each sampling site, except that 10 replicate samples were taken for chlorophyll-*a* at sites K1, K4, and K6. Chlorophyll-*a* samples were held on ice and phytoplankton samples were preserved with Lugol's solution (Lind 1979). Chlorophyll-*a* was measured with a Turner model 10-AU fluorometer following Standard Method 10200 H. Chlorophyll (American Public Health

Association 1996), for fluorometric analysis of chlorophyll-*a*. Chlorophyll-*a* concentrations were corrected for phaeophytin as described by this method. Phytoplankton samples were counted, a using settling chambers and an inverted microscope as described by Wetzel and Likens (1991). All organisms in each field were identified to genus and enumerated. Counts were used to estimate phytoplankton densities as the number of cells per ml.

Zooplankton samples were collected with three replicate vertical tows of a Wisconsin plankton net, from 3 x Secchi depth to the surface. Zooplankton samples were preserved with a 5%-sucrose formalin solution. Sample volumes were adjusted to yield counts greater than 100 for common organisms. Three replicate 1 ml subsamples were drawn from each zooplankton sample with a calibrated pipette and placed in Sedgwick-Rafter cells. Zooplankton were counted under a compound microscope, at 40x magnification. All organisms in each subsample were identified to genus or species and enumerated. Counts were used to estimate zooplankton densities as the number of individuals per liter.

Samples for nutrient and ion analyses were maintained in controlled rooms, under chain-of-custody, until they were delivered to a contract lab (TraceAnalysis, Lubbock, Texas) for analysis. Total phosphorus (NPDES method 365.2), total nitrogen (= Keldahl nitrogen [NPDES method 351] + nitrate + nitrite), and hardness (NPDES method 130) were analyzed according to methods described in U.S. EPA (1983). Cations (calcium, potassium, magnesium, and sodium) were analyzed by inductively-coupled plasma spectrophotometry. Anions (chloride, sulfate, nitrite, nitrate, and phosphate) were analyzed by ion chromatography.

At the conclusion of sampling on each sampling date, 20 l of de-ionized water were pumped through the water sampling device. Water samples were collected from the effluent stream, preserved as field blank samples, and analyzed by the contract lab for nutrients, anions, and cations. Results for these field blanks are presented in Appendix D.

Results

Thermal Structure

Lake Kemp was well mixed at all sites during April with water temperatures ranging between 14 and 18°C (Figures 2 and 3). In May, water temperatures ranged from 18 to 24°C and by the end of the month slight vertical differences in temperature were evident at K1-K3 (Figure 2). Sites K4-K6 were isothermal through May.

Surface water temperatures increased to 26°C throughout the lake in June. Vertical heterogeneity in water temperature profiles at sites K1 and K2 increased, with the beginnings of a thermocline evident at a depth of 8 to 10m. Sites K3-K6 appeared to remain mixed. Although temperatures varied by 2 to 4°C throughout the water column at sites K4-K6, this variation may result from solar heating of surface waters and probably did not persist overnight.

During July and August, surface water temperatures ranged from 26 to 28°C throughout the lake. Thermal stratification became more pronounced at sites K1 and K2, with the establishment of a thermocline at a depth of 10m, along the 26°C isocline. Below the thermocline, temperatures decreased to a minimum of 18°C at the lake bottom.

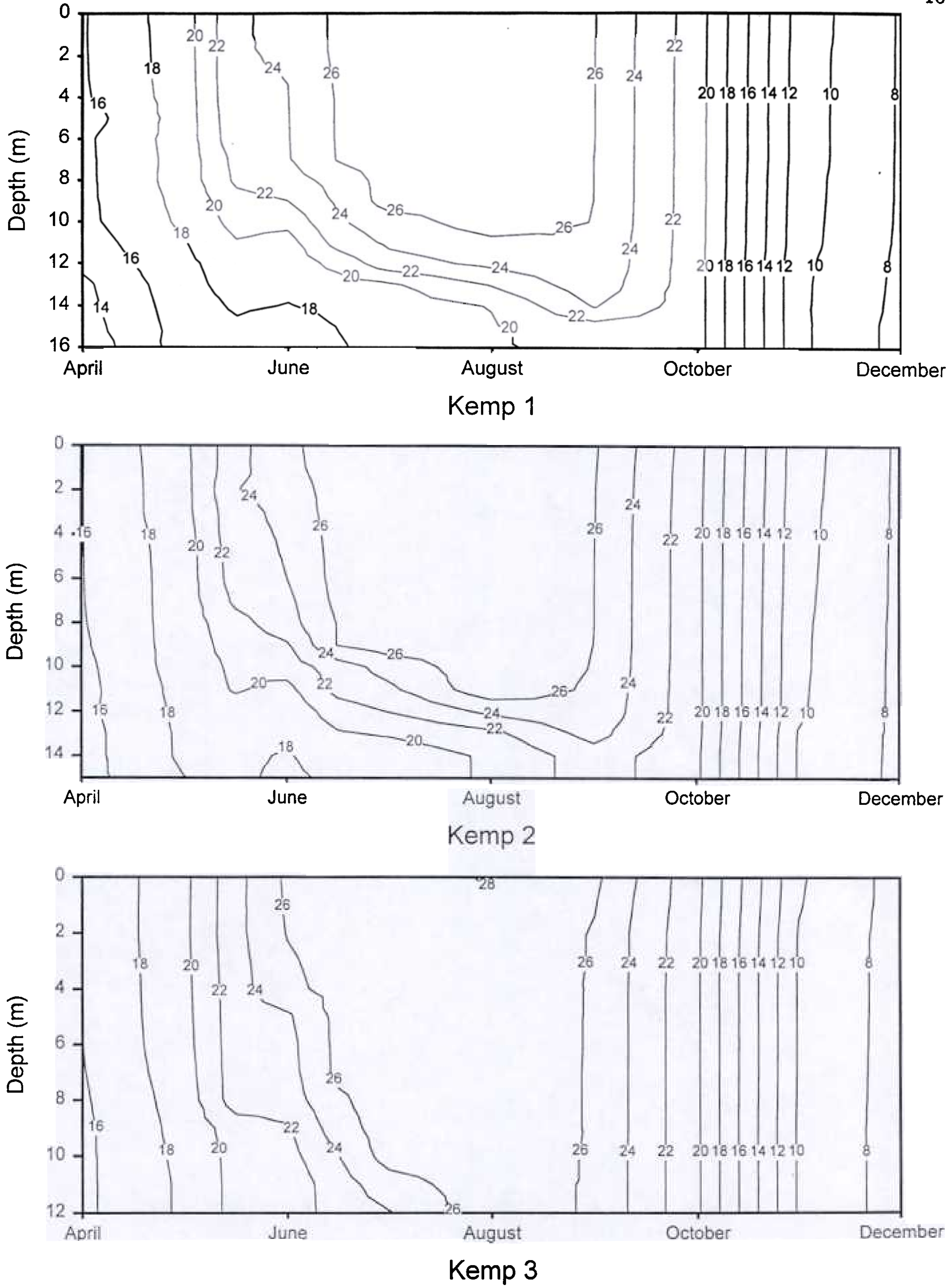


Figure 2. Temperature (°C) isoclines at sites K1-K3 in Lake Kemp, Texas, April through December 1997.

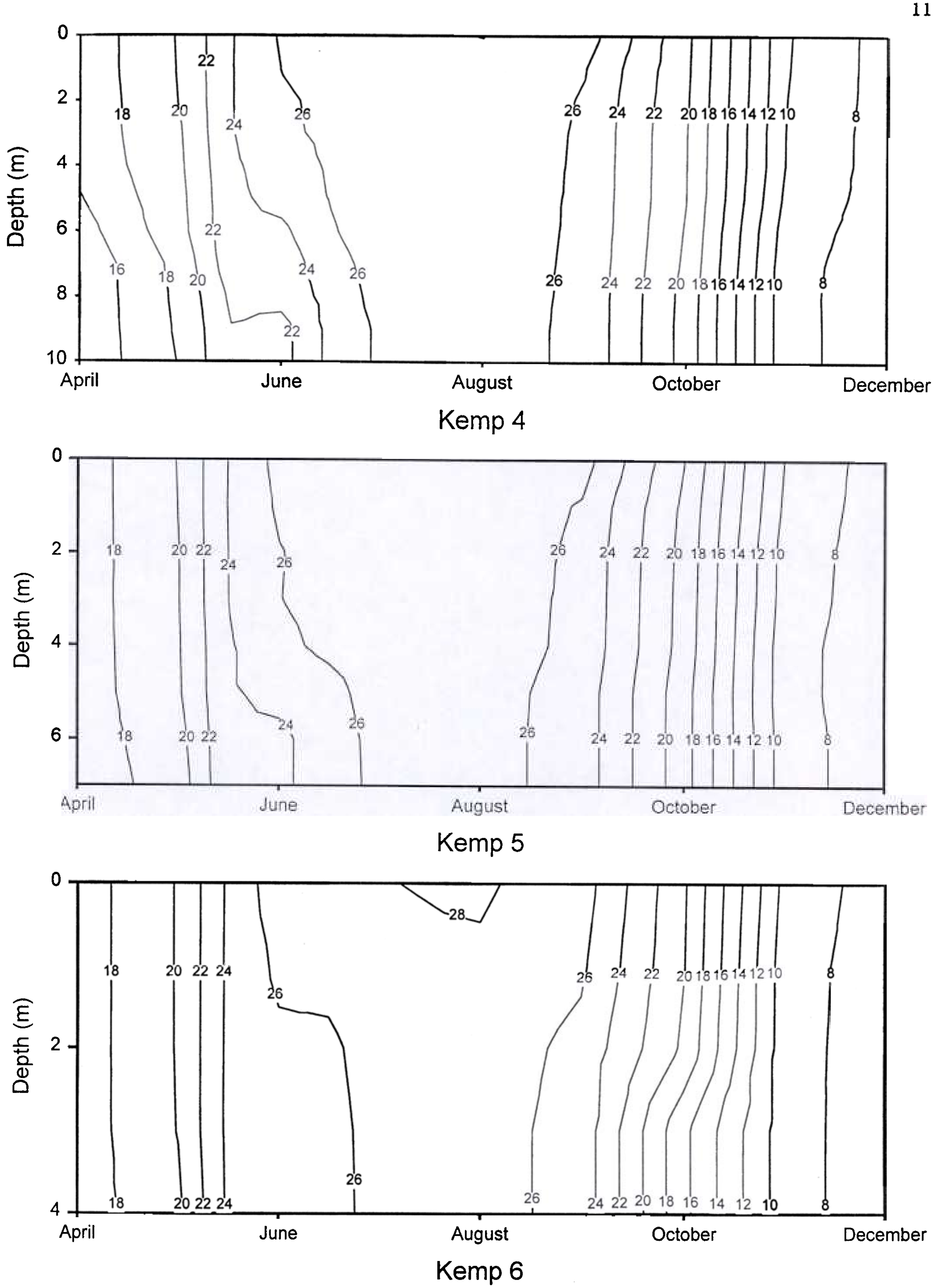


Figure 3. Temperature (°C) isoclines at sites K4-K6 in Lake Kemp, Texas, April through December 1997.

Thermal stratification, and location of the thermocline at 10m, at sites K1 and K2 persisted through the summer. Although minor vertical heterogeneity in temperature profiles occurred periodically at sites K3-K6, these sites remained unstratified throughout the summer.

Surface water temperatures cooled to 24°C in September and, by this time, thermal stratification had broken down at sites K1 and K2. From September through December, all study sites were isothermal. Throughout the water column, temperatures decreased to 20°C in October, 10 to 12°C in November, and 8°C in December.

Except for the development of thermal stratification at sites K1 and K2, during May through August, there was little spatial heterogeneity in water temperatures in Lake Kemp.

Conductivity

Conductivity was vertically and spatially uniform throughout Lake Kemp in April (4900 μS) (Figures 4 and 5). In early May, conductivity decreased to (4700 μS) at K1 and showed little vertical heterogeneity. At all other sites (K2-K6), however, an overflow of relatively "fresh" waters along the lake surface lowered conductivity near the surface and created considerable vertical heterogeneity in conductivity. During this period, conductivity was 4050 μS throughout the water column at Site K6 and from surface to nearly the bottom at sites K5 and K6. Surface conductivity was less than 4300 to 4400 μS at sites K3 and K4, and 4400 to 4600 μS at sites K1 and K2. At each of these sites (K1-K4), conductivity generally increased toward the lake bottom.

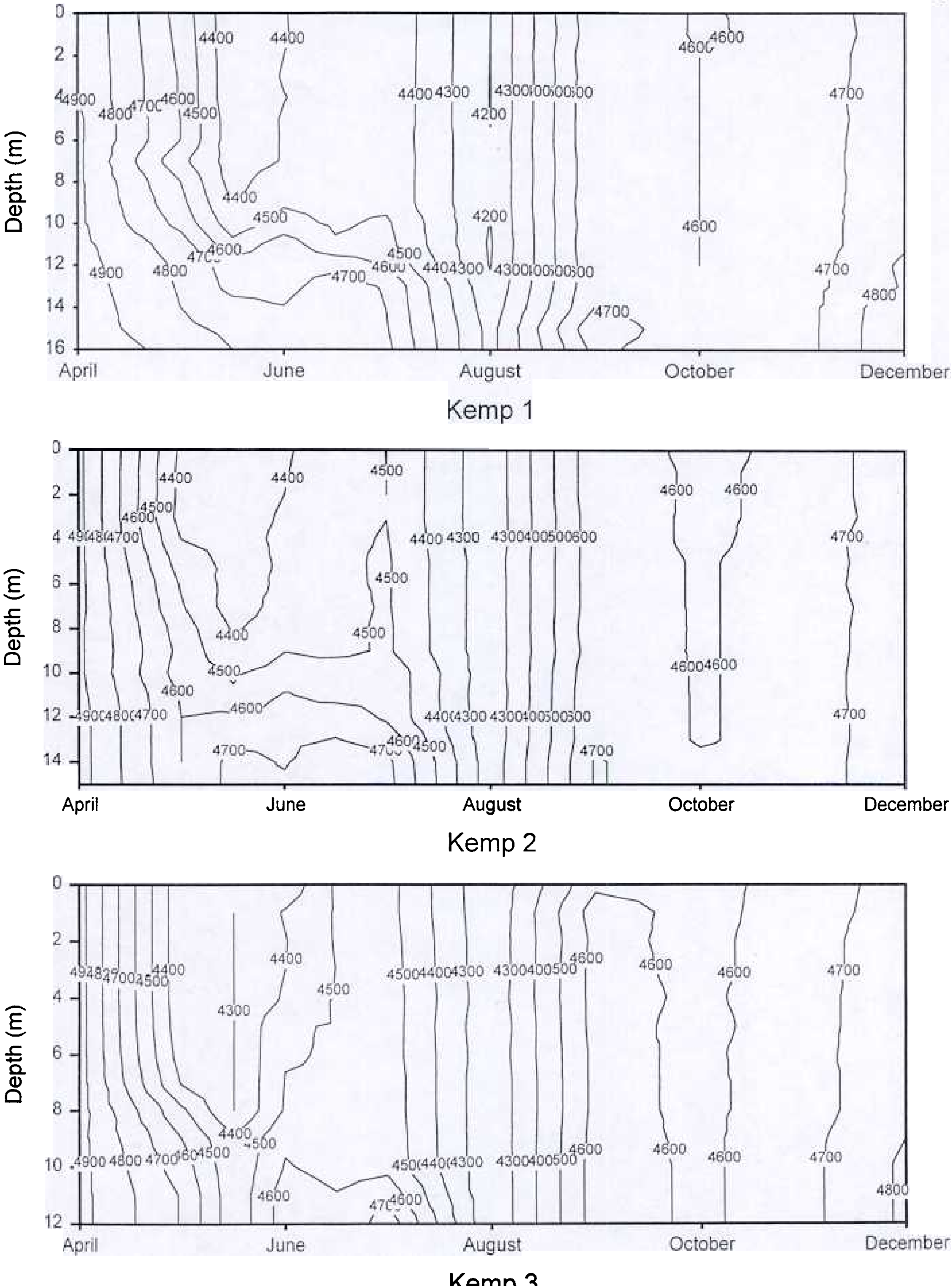


Figure 4. Conductivity (µS) isoclines at sites K1-K3 in Lake Kemp, Texas, April through December 1997.

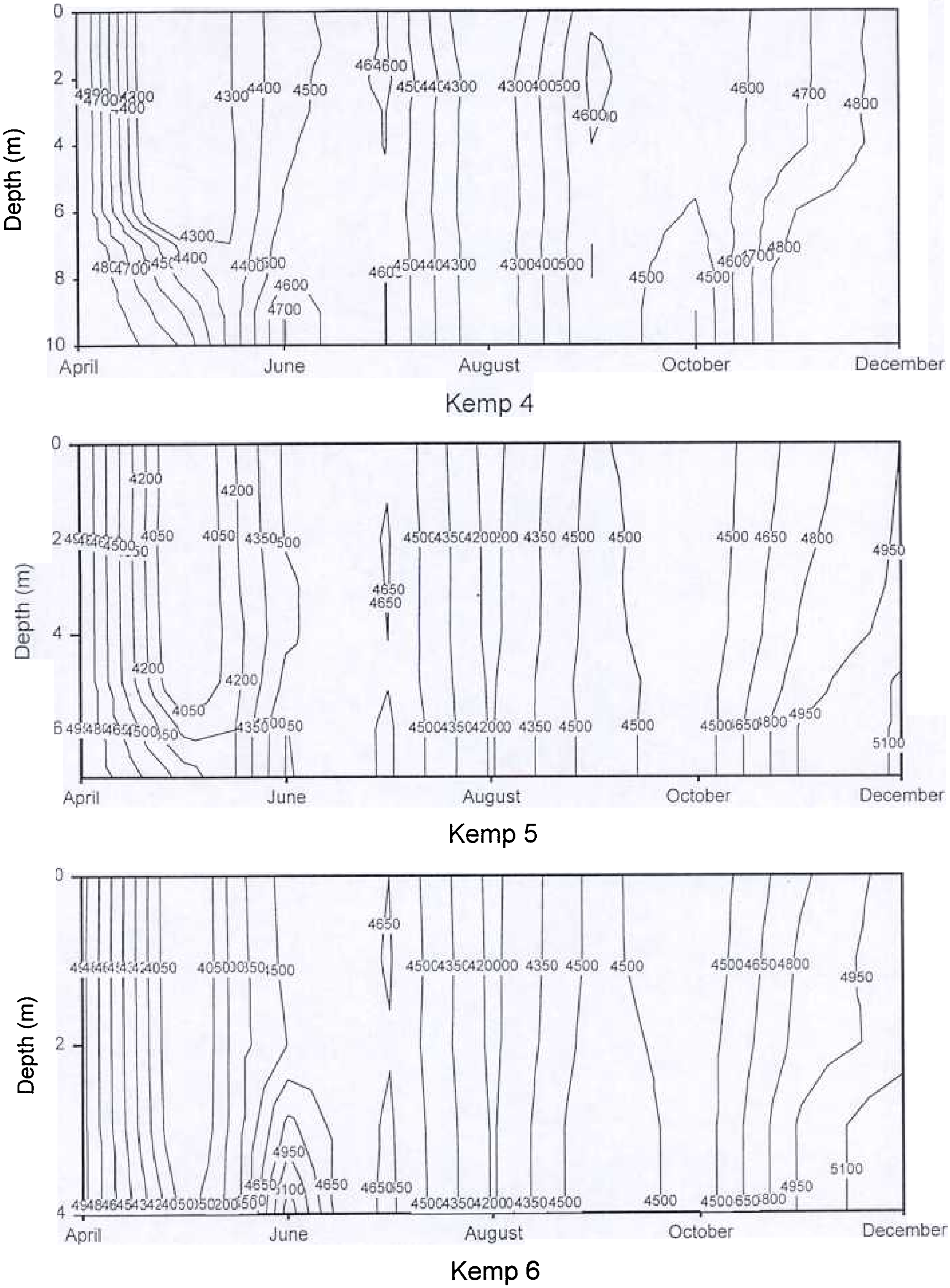


Figure 5. Conductivity (µS) isoclines at sites K4-K6 in Lake Kemp, Texas, April through December 1997.

The overflow progressed downlake from K6 to K1 during late May through early June. Dilution of the overflow as it moved downlake is indicated by comparison of minimum surface conductivity at sites K6 and K5 in early May, 4050 µS, with those at sites K1 and K2 in late May and June, 4400 µS.

From June through July, surface conductivity varied from 4400 to 4650 µS throughout the lake. Generally, surface conductivity was greater at uplake sites (K5 and K6) than at sites located further downlake (sites K1-K4). At sites K1-K3, conductivity increased from surface to bottom, with the greatest changes occurring at 10m, the depth of the thermocline at these sites (Figure 2). Vertical heterogeneity in conductivity was less evident at sites K4-K6, except for the presence of an underflow along the lake bottom.

Conductivity increased at all sites, from July though December, and generally was uniform from surface to bottom. Conductivity consistently was lowest at sites K1-K3 and was greatest at sites K5 and K6. In December, conductivity at sites K1-K3 was 4700 to 4800 µS, whereas conductivity at sites K5 and K6 was 4950 to 5000 µS.

Dissolved Oxygen

In April and early May, dissolved oxygen concentrations were generally greater than 8.0 ppm at all sites and there was little vertical heterogeneity in oxygen profiles (Figures 6 and 7). However, by late May, dissolved oxygen profiles showed considerable vertical heterogeneity at sites K1-K3. Reduced oxygen concentrations towards the bottom at these sites coincided with the early stages of thermal stratification at sites K1

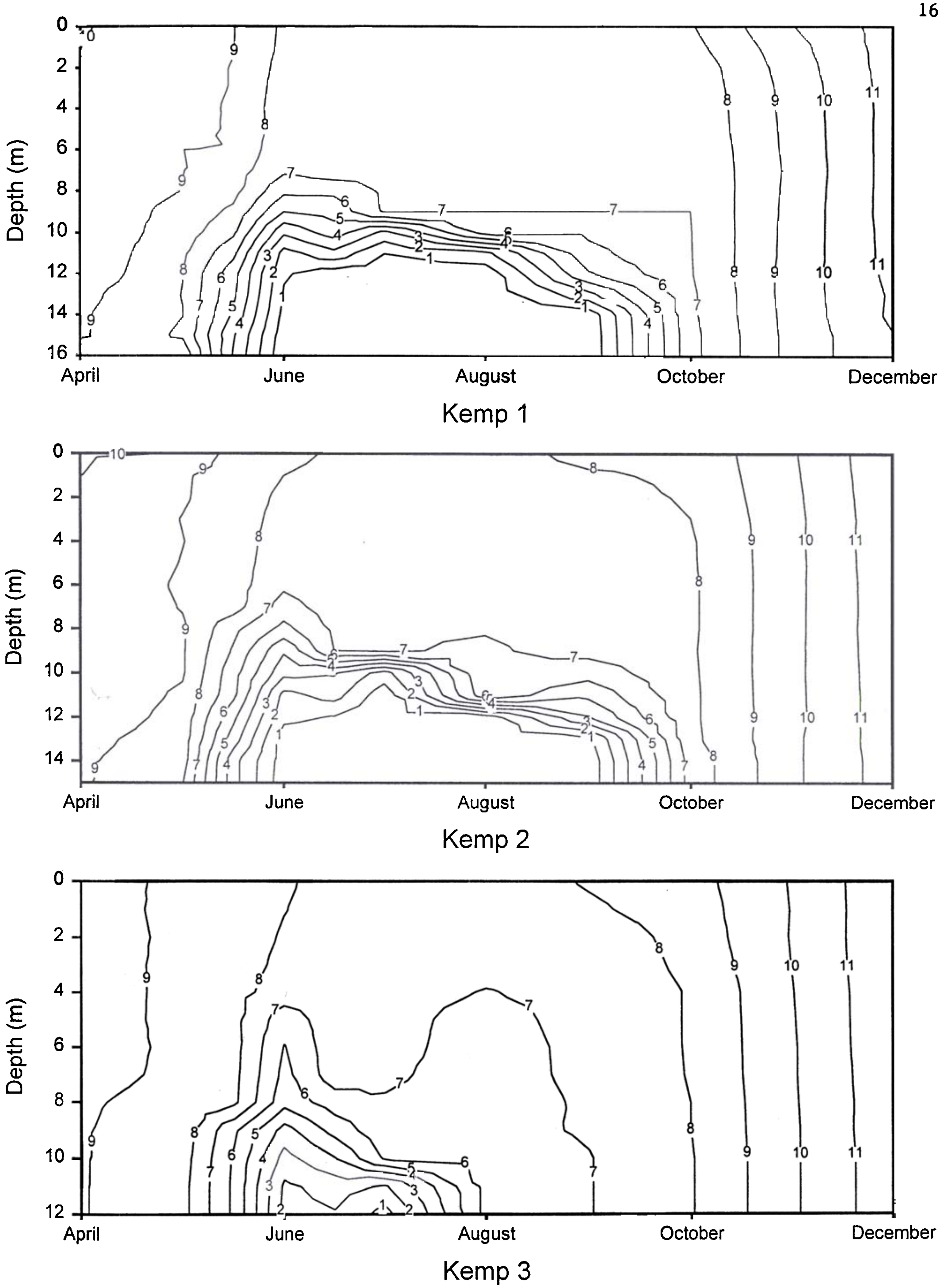


Figure 6. Dissolved oxygen (ppm) isoclines at sites K4-K6 in Lake Kemp, Texas, April through December 1997.

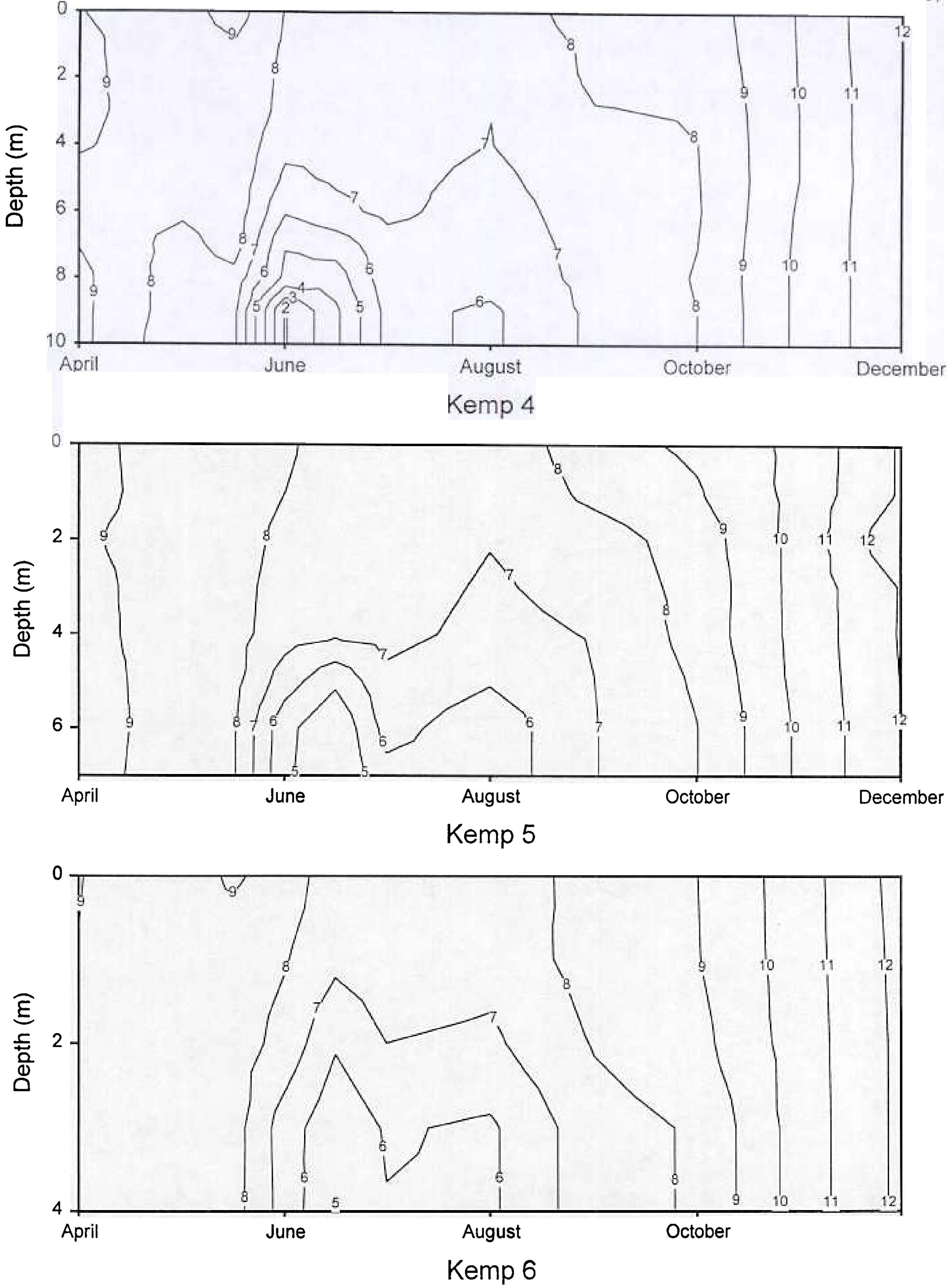


Figure 7. Dissolved oxygen (ppm) isoclines at sites K4-K6 in Lake Kemp, Texas, April through December 1997.

and K2 and with the "freshwater" overflow. Oxygen profiles showed little vertical heterogeneity at sites K4-K6 through late May.

Surface and midwater oxygen concentrations remained at 7.0 ppm, or greater, during June through August. Depletion of metalimnetic and hypolimnetic oxygen resulted in anoxic conditions in the lower 3 to 4 m at sites K1 and K2, and along the lake bottom at site K3. Oxygen concentrations decreased from surface to bottom at sites K4-K6, but did not fall below 2.0 ppm at K4, or below 5.0 ppm at sites K5 and K6.

Thermal stratification was disrupted beginning in September, however, hypolimnetic dissolved oxygen concentrations were still reduced at sites K1 and K2. At sites K3-K6, oxygen concentrations (7.0 to 8.0 ppm) were uniform throughout the water column. By October, dissolved oxygen concentrations were uniform throughout the water column at all sites. Dissolved oxygen concentrations increased from 8.0 ppm in October to 11.0 to 12.0 in December throughout the lake.

pH

During April and early May, pH ranged from 8.0 to 8.2 throughout the water column at all sites (Figures 8 and 9). From late May through August, at sites K1-K3, pH was greater than 8.0 from the surface to the thermocline, which was located at a depth of 10m. Below this depth, pH generally decreased toward the lake bottom.

At sites K4-K6, pH of surface waters was greater than 8.2 and, during June, pH decreased toward the bottom, possibly reflecting differences in water quality between the

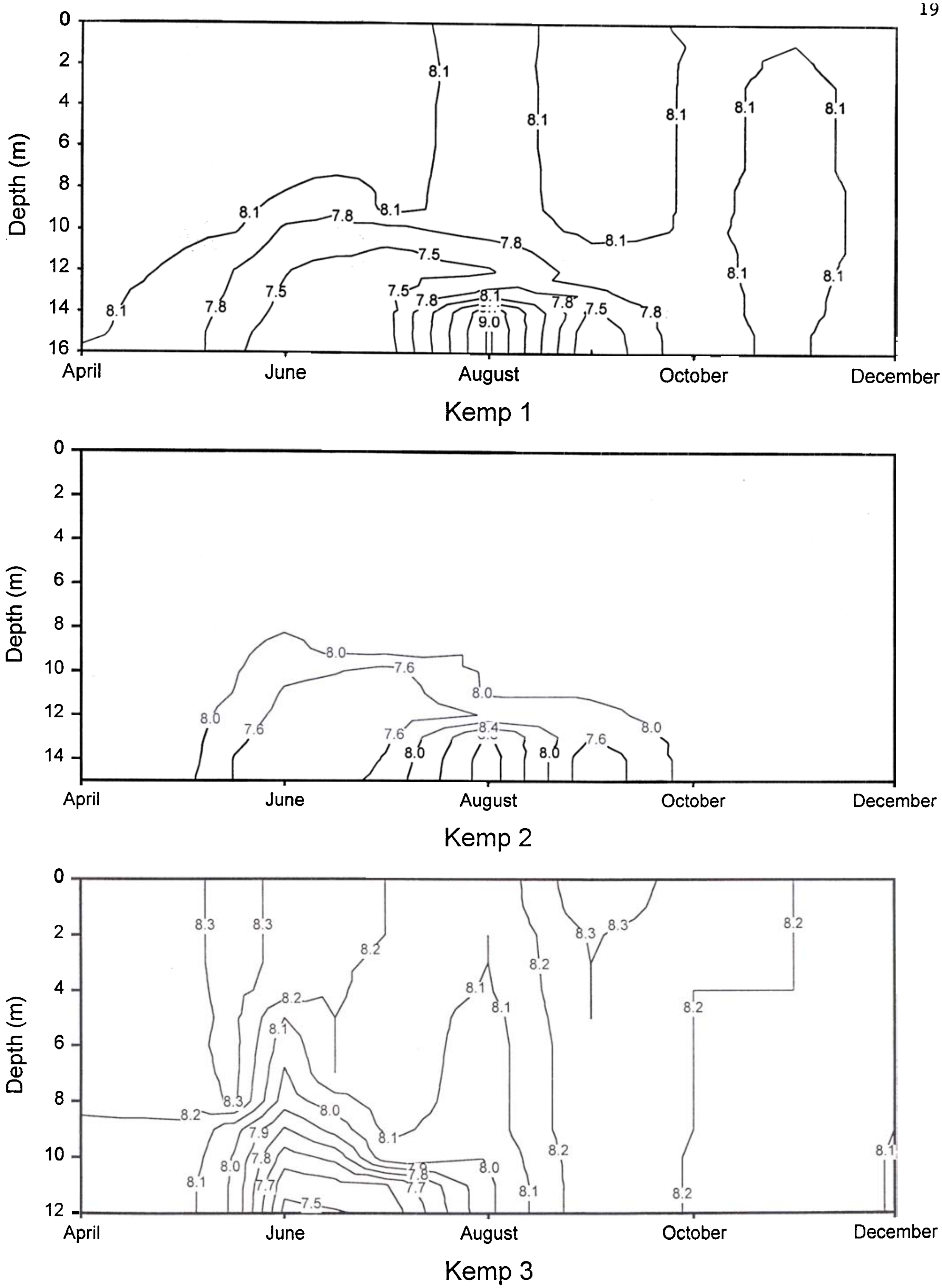


Figure 8. pH isoclines at sites K1-K3 in Lake Kemp, Texas, April through December 1997.

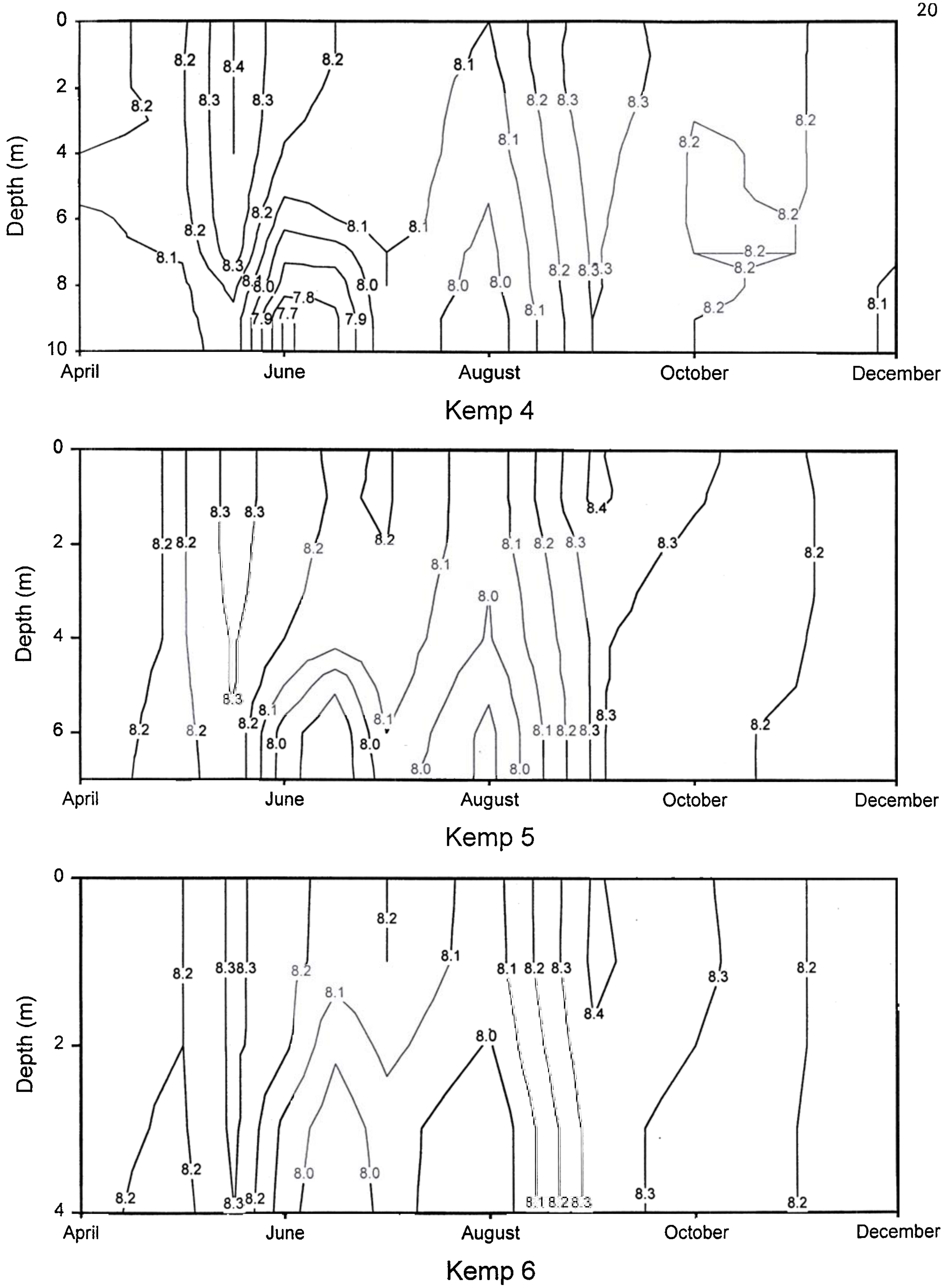


Figure 9. pH isoclines at sites K4-K6 in Lake Kemp, Texas, April through December 1997.

lake and the underflow that was present at these sites at this time. From July through August, there was no vertical variation in pH at sites K4-K6.

Following the breakdown of thermal stratification at sites K1-K3, pH was almost uniform throughout the lake, ranging from 8.1 to 8.3, from September through December.

Photosythetically Active Radiation

Light extinction coefficients $\varepsilon\lambda$ varied among sites and dates by a factor of five throughout the study period (Table 1). A minimum extinction coefficient of 0.5664 was observed at site K6 in April and a maximum of 2.6433 was observed at site K6 in late May. An extinction coefficient of 0.693 indicates a 50% extinction per meter; a coefficient of 2.3 indicates a 90% extinction per meter.

Extinction coefficients progressively decreased downlake from an average of 1.7639 at K6 to 0.7838 at K1 There was little seasonal pattern evident in light extinction; however, light extinction coefficients were generally greatest throughout the lake in November and were lowest in December, during periods of relatively low phytoplankton (i.e., chlorophyll-*a*) abundance.

Using the extinction coefficients in Table 1, the depth of the euphotic zone in Lake Kemp can be determined (Figure 10). Depth of the euphotic zone was greatest at site K1 and decreased progressively uplake to site K6. The euphotic zone generally was between 4 and 7+ m at sites K1 and K2, between 3 and 5 m at sites K3 and K4, and between 2 and 4 m at sites K5 and K6. Seasonal variation in depth of the euphotic zone was the same as that described for light extinction above.

Table 1. Light extinction coefficients (ελ) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Date	K1	K2	K3	K4	K5	K6
23 April 1997	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13 May 1997	0.7079	0.7579	0.9582	1.3351	1.5171	1.6435
27 May 1997	0.7159	1.0594	1.1253	1.0918	1.4685	2.6433
15 June 1997	0.9103	1.0351	1.2147	1.7143	2.0379	1.8612
29 June 1997	0.7523	0.8068	0.9096	1.0905	1.4446	1.5908
13 July 1997	0.6451	0.7744	1.0035	1.1180	1.3927	1.5799
16 August 1997	0.6607	0.7056	1.0385	1.1627	1.5679	1.7800
14 September 1997	0.7226	0.8044	1.0776	0.9986	1.2909	1.6455
20 October 1997	1.2062	1.1075	1.3798	1.5253	1.5985	1.9047
19 November 1997	1.0784	0.8461	1.0535	0.8819	0.9624	1.2194
18 December 1997	0.6558	0.7467	0.8505	0.7301	0.8191	1.4634

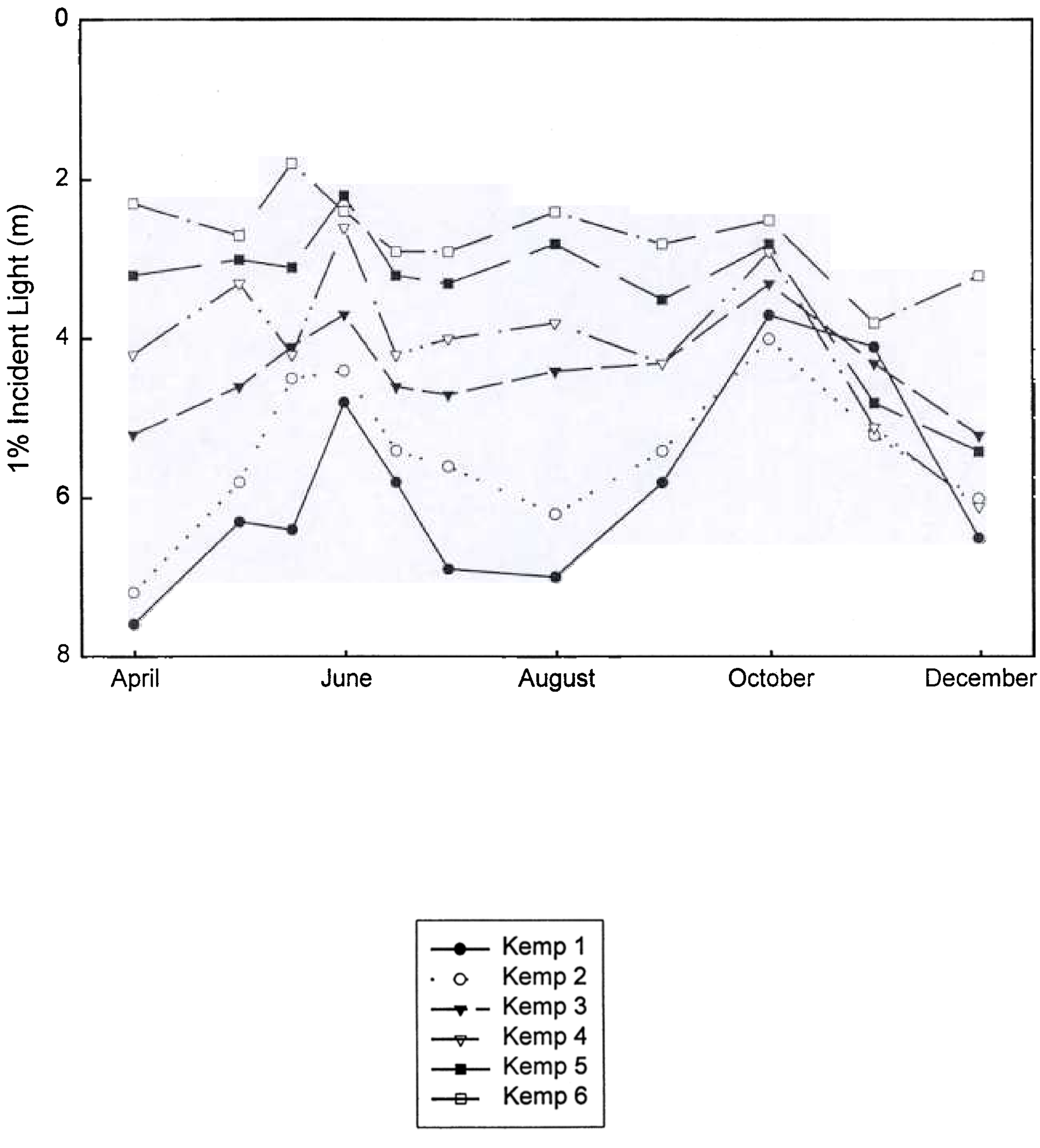


Figure 10. Euphotic zone, based on 1% penetration of incident light (photosynthetically active radiation), at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Transparency

Secchi depth varied among sites and dates by less than 1.5 m throughout the study period (Figure 11). A minimum Secchi depth of 0.27 m was observed at site K6 in August and a maximum Secchi depth of 1.66 m was observed at site K1 in April.

In general, Secchi depth progressively increased downlake from an average of 0.63 m at K6 to .22 m at K1. There was little seasonal pattern evident in Secchi depth, most temporal variation may be the result of the variation in the intensity and duration of winds, which induced suspension of bottom sediments. Nevertheless, two observations seem warranted. First, the surface overflow that occurred in late May and early June, associated with a large rain event, did not appear to appreciably affect Secchi depth, except perhaps at sites K1 and K2. Second, Secchi depth at sites K5 and K6 was seasonally greatest in November and December, during periods of relatively low phytoplankton (i.e., chlorophyll-*a*) abundance.

The depth of the euphotic zone is sometimes approximated as 3x Secchi depth. This approximation is inadequate in Lake Kemp (Figure 12). The euphotic zone, based on light extinction, was consistently greater, by a factor of about 1.5, than that approximated by 3x Secchi depth.

Turbidity

Surface turbidity ranged from a minimum of 3.14 NTUs to a maximum of 26.95 NTUs throughout the study period (Figure 13). Bottom turbidity ranged from a minimum of 10.71 NTUs to a maximum of 77.87 NTUs. In general, turbidity progressively

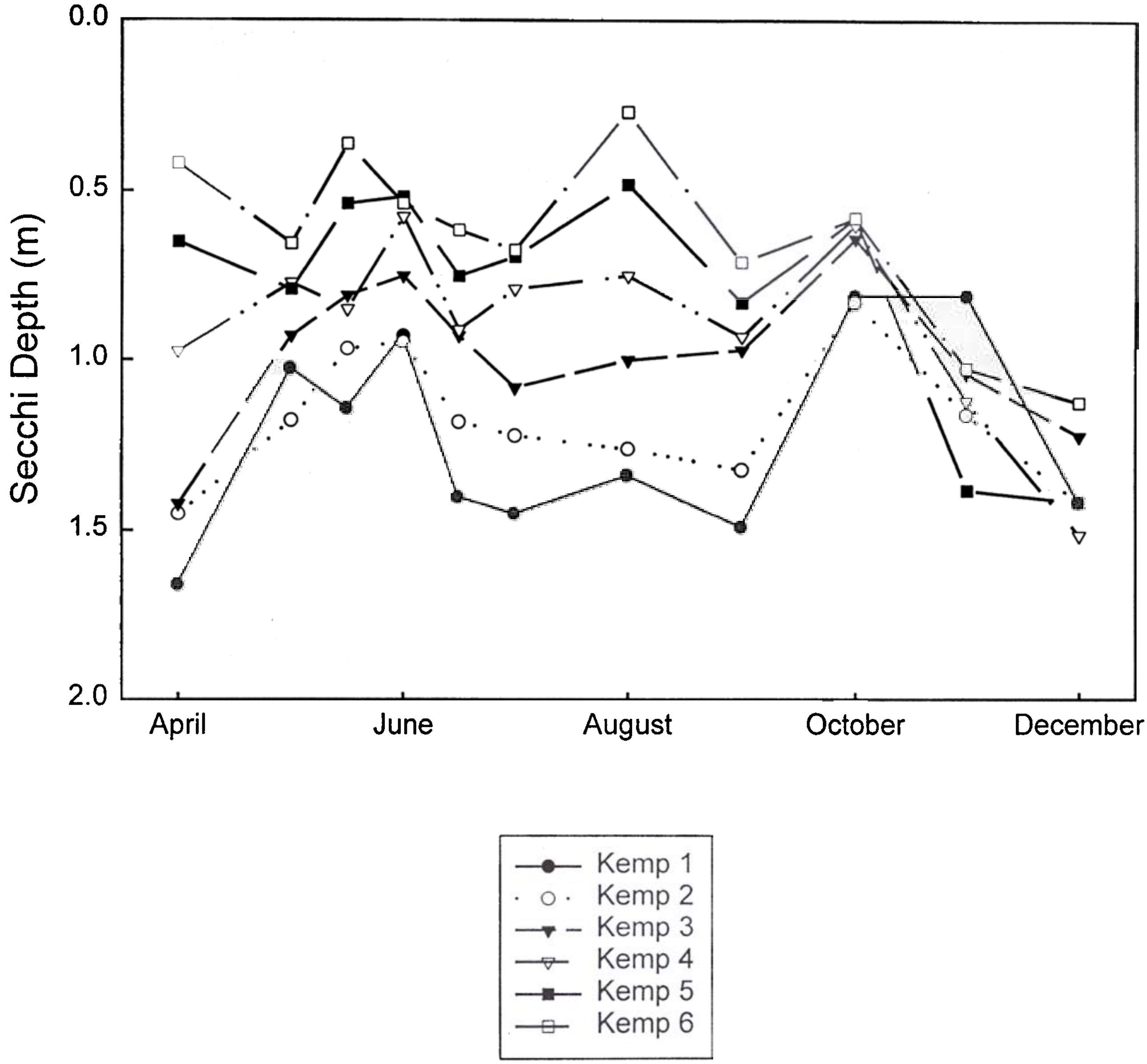


Figure 11. Secchi depth (m) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

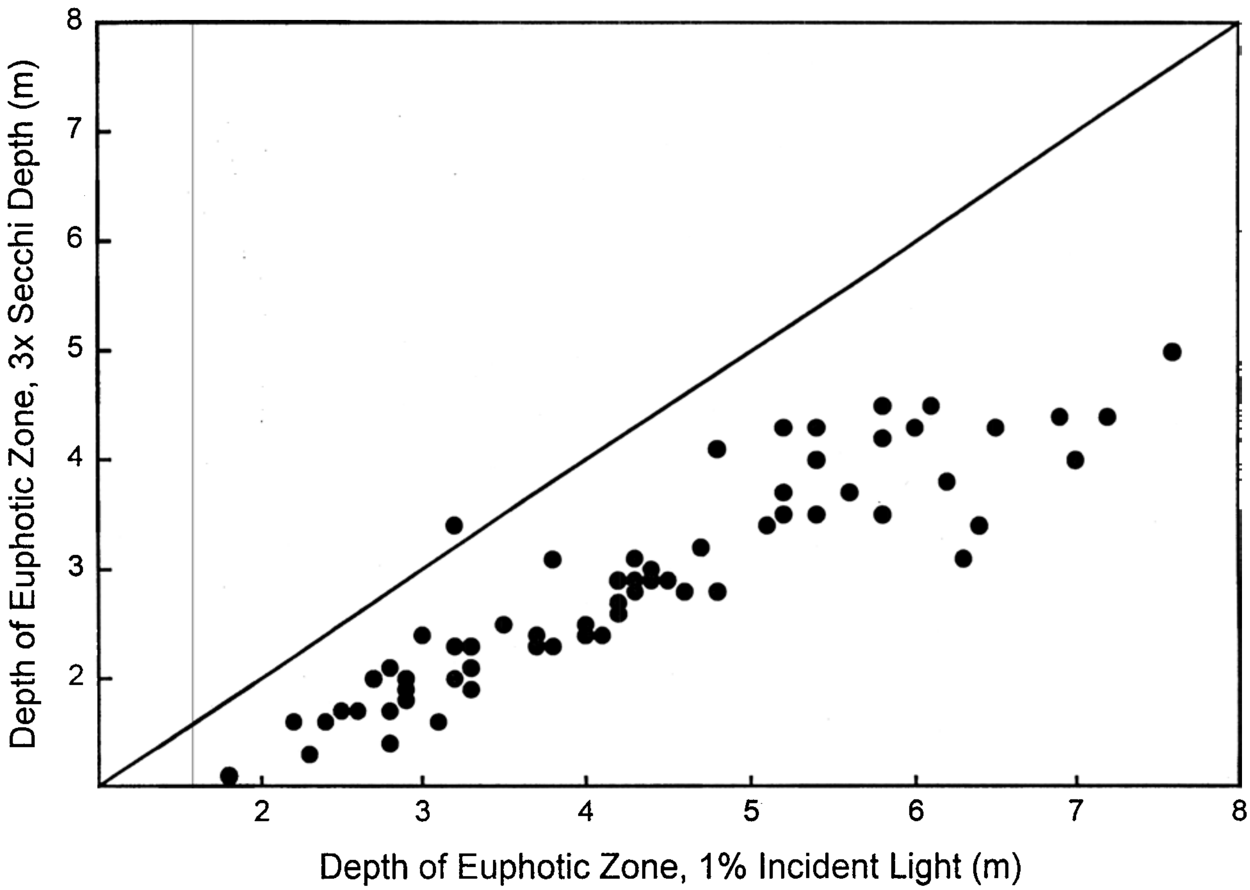


Figure 12. Comparison of euphotic zones based on 1% penetration of incident light (photosynthetically active radiation) and 3x Secchi depth, in Lake Kemp, Texas, April through December 1997. Diagonal line shows the expected 1:1 ratio between the two measures.

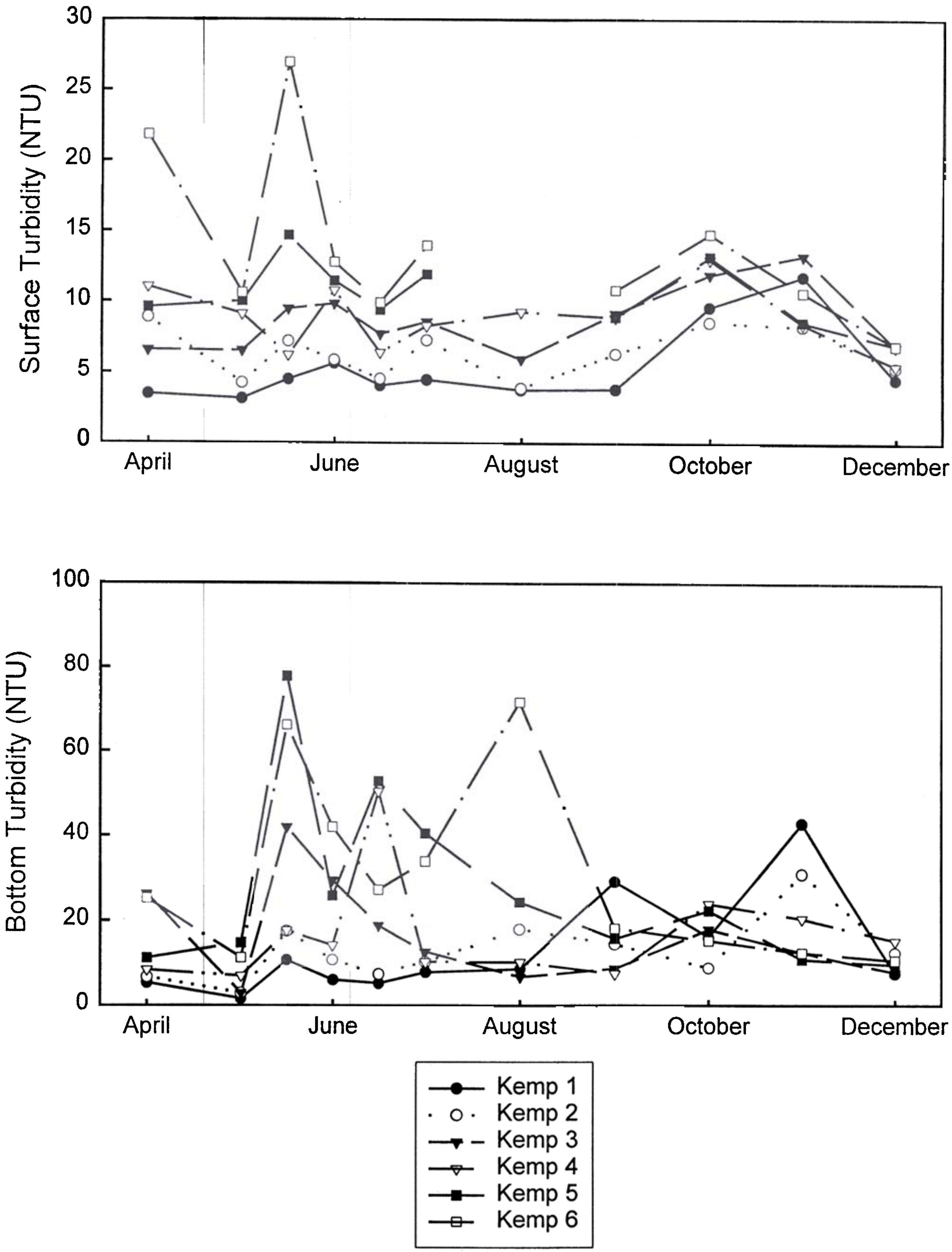


Figure 13. Mean turbidity (NTU) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

decreased downlake from site K6 (surface mean = 13.93 NTU; bottom mean = 30.43 NTU) to site K1 (surface mean = 5.34 NTU; bottom mean = 12.89 NTU).

There was little evident seasonal pattern in turbidity. At the surface, turbidity was variable and high in April through May, but then was generally low through September. Surface turbidity increased in October and November, but decreased in December.

Bottom turbidity was more variable than surface turbidity, especially at sites K5 and K6. However, no seasonal pattern in bottom turbidity was evident.

There was no relationship between sample standard deviations (SD) for turbidity and number of replicate samples collected. Ten replicate turbidity samples were taken, surface and bottom, at sites K1, K4, and K6. Mean standard deviations for these sites, were 1.53 (K1), 1.18 (K4), and 3.01 (K6). Mean standard deviations at sites K2, K3, and K5, at which only three replicate samples were collected, were 1.16 (K2), 1.48 (K3), and 1.00 (K5). There appears to be no increase in precision associated with increasing sample sizes for turbidity from three to ten. Higher standard deviations at sites K1, K4, and K6 generally were due to occasional samples containing one or more outliers.

Mean turbidity, across all sample sites, dates, and depths is presented in Appendix B. Mean turbidity, by site, is presented in Appendix C.

Total Suspended Solids

Total suspended solids (TSS) at the surface varied considerably among sample sites in early May (Figure 14). At sites K1-K3, TSS ranged from 3.3 to 10.3 mg/l and at sites K4-K6 TSS ranged from 30.7 to 57.3 mg/l. In late May, TSS increased at sites K1-

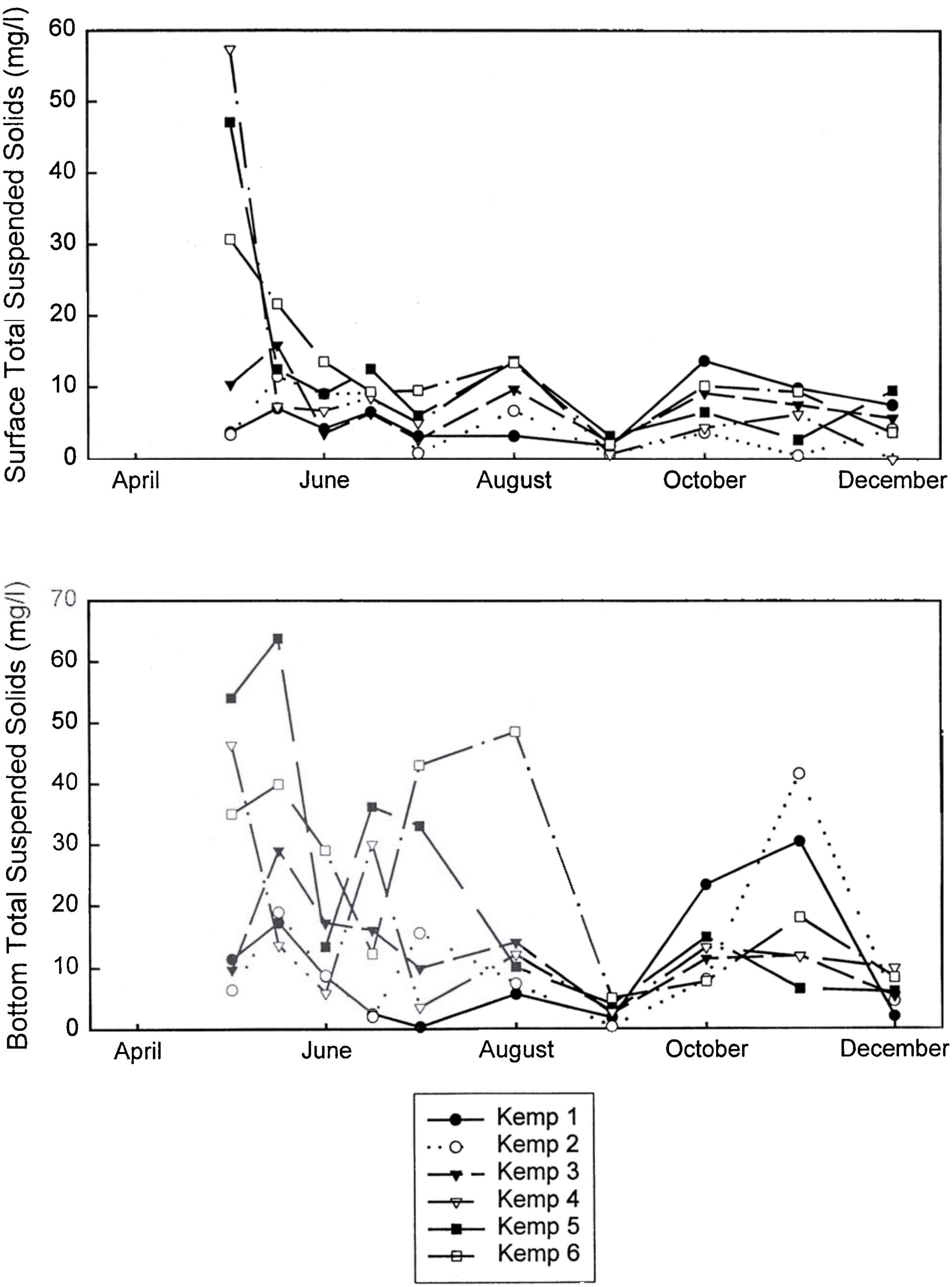


Figure 14. Mean total suspended solids (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

K3, ranging from 7.0 to 15.83 mg/l, but TSS decreased at sites K4-K6, ranging from 7.2 to 21.7 mg/l. From June through December, surface TSS ranged from 0.5 to 13.7 mg/l and showed no consistent pattern of variation among sites and dates.

TSS at the bottom ranged from 6.3 to 54.0 mg/l in early May; bottom TSS was considerably lower at sites K1-K3 (6.6 to 11.3 mg/l) than at sites K4-K6 (35.0 to 54.0 mg/l). Bottom TSS remained extremely variable (8.50 to 63.7 mg/l) in late May and June, with the highest concentrations at sites K4-K6. From July through December, TSS at the bottom generally was less than 20 mg/l, except for occasionally high concentrations at sites K1, K2, and K6.

Surface TSS usually was greatest at site K6 (mean = 12.3 mg/l) and decreased downlake to sites K2 (4.9 mg/l) and K1 (6.1 mg/l). Bottom TSS was greatest at site K6 (24.7 mg/l) and progressively decreased downlake to site K1 (10.3 mg/l).

Mean total suspended solids concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean total suspended solids concentrations, by site, are presented in Appendix C.

Total Dissolved Solids

Total dissolved solids (TDS) was relatively high, 3150 mg/l, at the surface at all sites in April (Figure 15). TDS decreased throughout the lake in May as a result of increased inflows into Lake Kemp. In early May, TDS ranged from 2322 to 2429 mg/l at sites K1-K3 and from 1959 to 2054 mg/l at sites K4-K6.

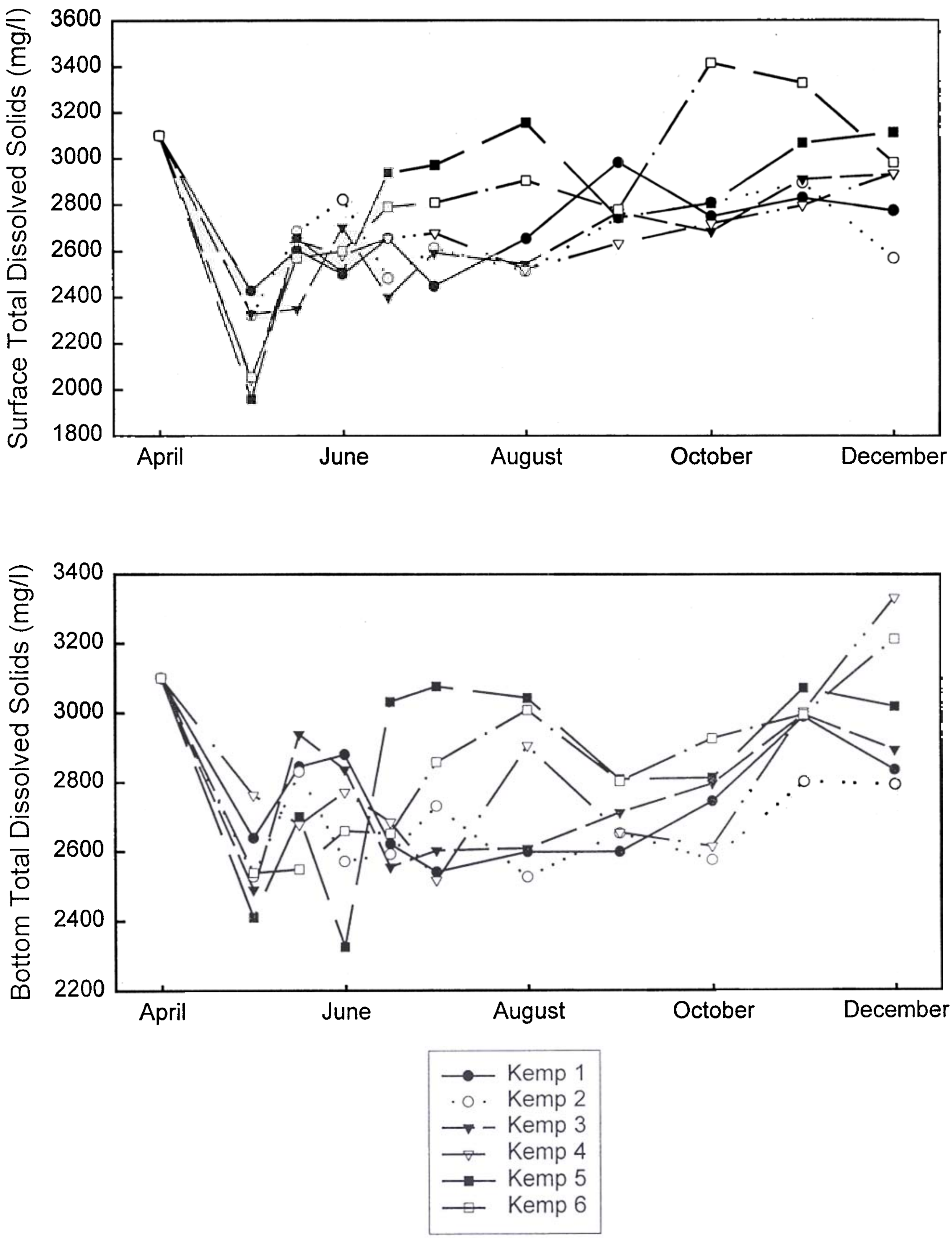


Figure 15. Mean total dissolved solids (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Although TDS varied among sites, it consistently increased from late May through December. There was little consistent pattern in variation in TDS among sites, except that TDS was generally greatest at sites K5 and K6.

Total dissolved solids (TDS) was 3150 mg/l at the bottom at all sites in April (Figure 15). TDS decreased slightly in early May and then gradually increased through the remainder of the study period, as it did at the surface.

Mean total dissolved solids concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean total dissolved solids concentrations, by site, are presented in Appendix C.

Total Alkalinity

In surface waters, total alkalinity ranged from 93.3 to 99.7 mg/l $CaCO_3$ in April (Figure 16). Total alkalinity increased sharply through May (106.6 to 116.7 mg/l $CaCO_3$) at all sites. Total alkalinity at the surface declined from late May through September, reaching a minimum of 92.9 to 95.4 mg/l $CaCO_3$. Total alkalinity increased from September through November (109.9 to 112.1 mg/l $CaCO_3$) and decreased slightly in December (107.9 to 111.2 mg/l $CaCO_3$). There was no evident spatial pattern to the variation observed in total alkalinity.

Total alkalinity at the bottom ranged from 92.9 to128.8 mg/l $CaCO_3$ in Lake Kemp. Seasonal variation in alkalinity mirrored that observed at the surface: alkalinity increased from April (95.5 to 101.0 mg/l $CaCO_3$) through late May (110.9 to 118.5 mg/l $CaCO_3$), before decreasing to a minimum (92.9 to 122.5 mg $CaCO_3$/l) in September.

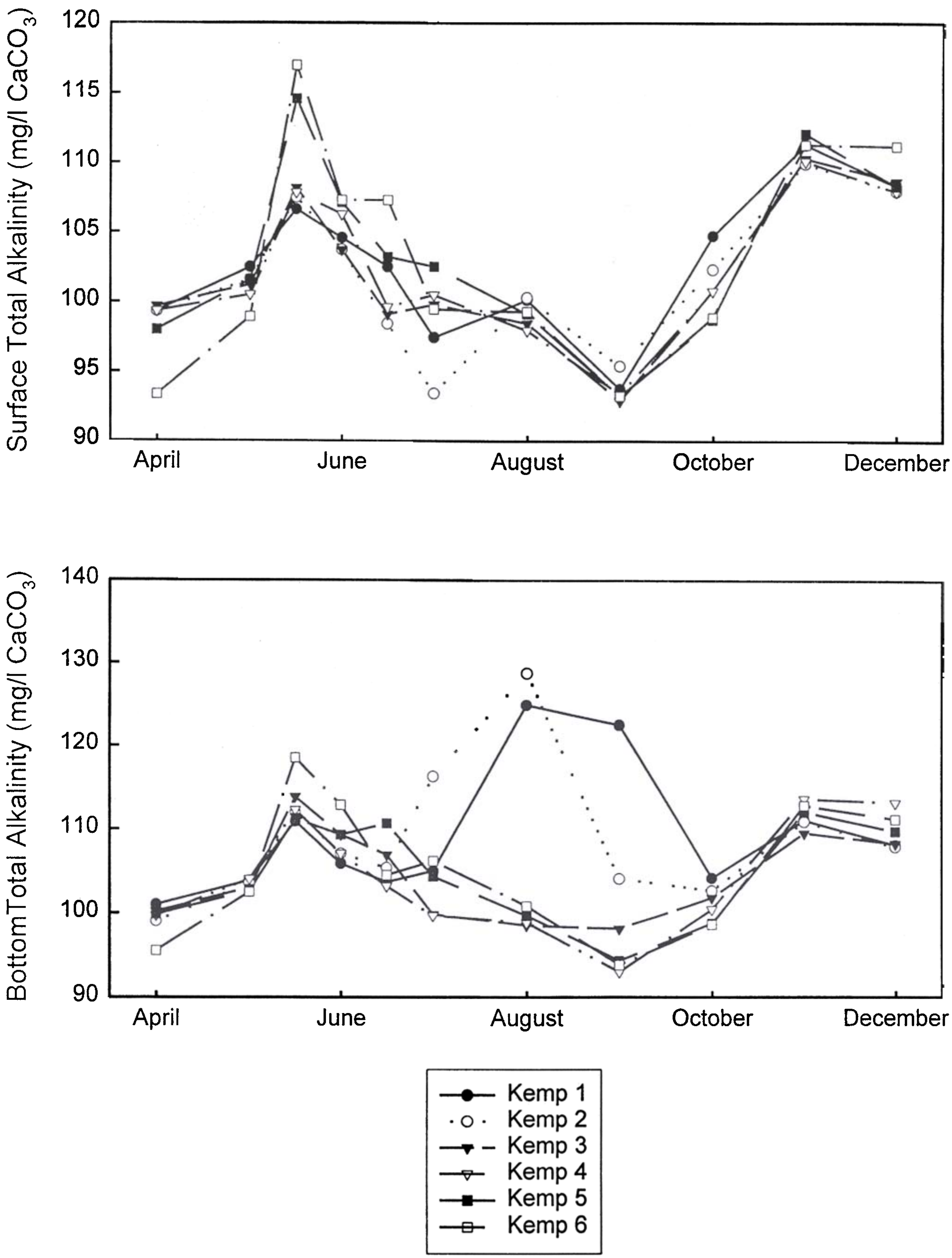


Figure 16. Mean total alkalinity (mg/l $CaCO_3$) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Total alkalinity at the bottom increased from September through December (107.9 to 113.2 mg/l $CaCO_3$). There was little pattern, among sites, in total alkalinity except that, in summer, alkalinity was consistently greatest at sites K1 and K2.

Mean alkalinity, across all sample sites, dates, and depths is presented in Appendix B. Mean alkalinity, by site, is presented in Appendix C.

Hardness

Hardness ranged from slightly over 600 to 1500 mg/l $CaCO_3$ in both surface and bottom samples (Figure 17). At the surface, hardness was high and variable in April (897 to 1500 mg/l $CaCO_3$). Hardness decreased at all sites in early May (870 to 1027 mg/l $CaCO_3$), but increased from late May (633 to 683 mg/l $CaCO_3$) through late June (957 to 993 mg/l $CaCO_3$). Hardness decreased through October (643 to 743 mg/l $CaCO_3$), increased in November (983 to 1103 mg/l $CaCO_3$), but decreased slightly in December (828 to 865 mg/l $CaCO_3$). Hardness in surface waters generally was greatest at site K3 (mean = 911 mg/l $CaCO_3$) and decreased progressively downlake to site K1 (mean = 873 mg/l $CaCO_3$) and uplake to site K6 (mean = 856 mg/l $CaCO_3$).

Temporal variation in hardness in bottom samples paralleled that in surface samples. Hardness was greatest in April (937 to 1467 mg/l $CaCO_3$) and decreased through late May (660 to 710 mg/l $CaCO_3$). Hardness increased from May through June (957 to 1027 mg/l $CaCO_3$), and then decreased through October (650 to 753 mg/l $CaCO_3$). Hardness increased in November (1010 to 1120 mg/l $CaCO_3$), but decreased slightly in December (821 to 922 mg/l $CaCO_3$). Hardness in bottom waters generally was

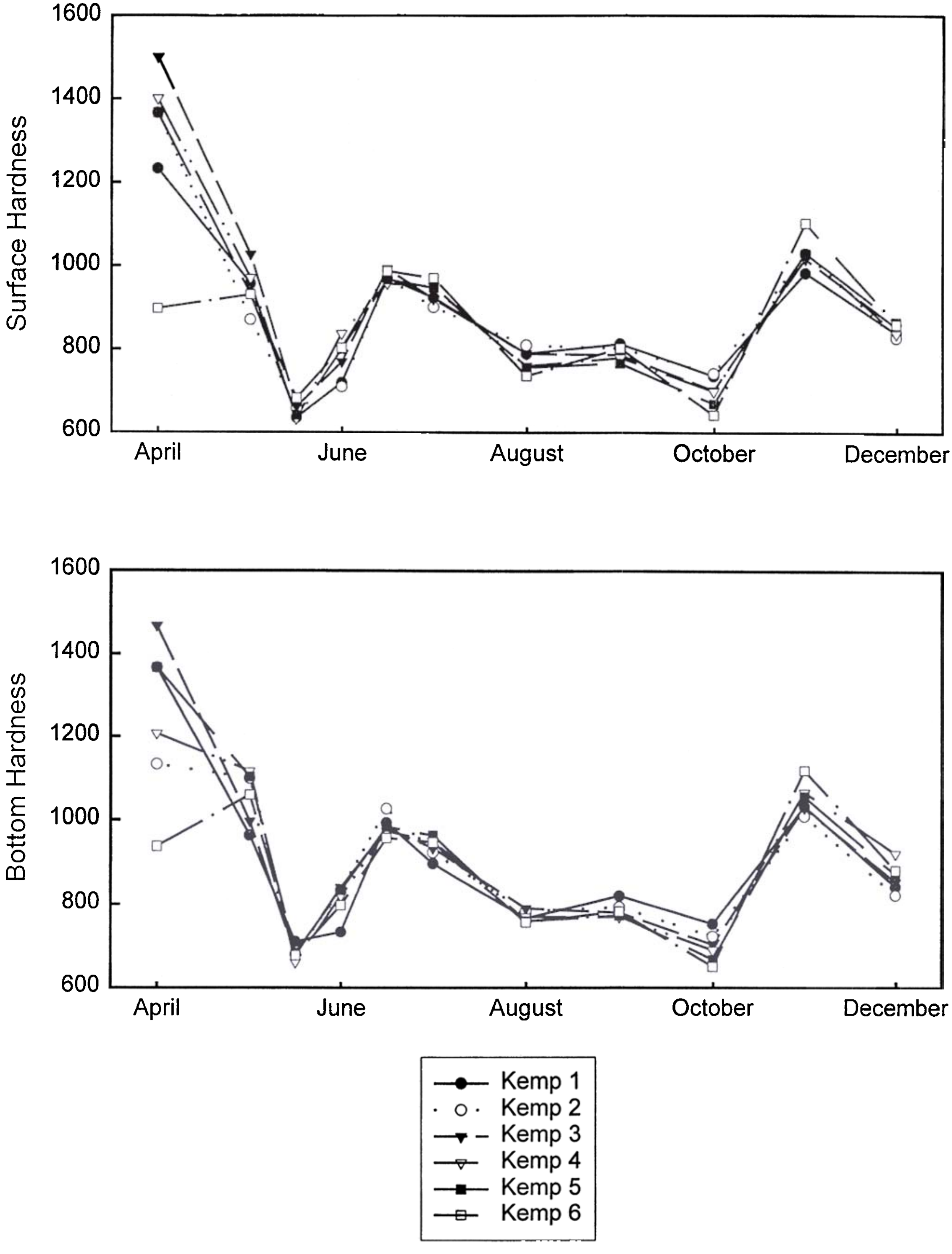


Figure 17. Mean hardness (mg/l $CaCO_3$) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

greatest at sites K3 (mean = 914 mg/l $CaCO_3$) and K5 (mean = 915 mg/l $CaCO_3$) and decreased progressively downlake to site K1 (mean = 898 mg/l $CaCO_3$) and uplake to site K6 (mean 869 mg/l $CaCO_3$).

Mean hardness, across all sample sites, dates, and depths is presented in Appendix B. Mean hardness, by site, is presented in Appendix C.

Calcium

Calcium concentrations showed similar ranges in both surface (163 to 497 mg/l) and bottom (170 to 480 mg/l) samples throughout the study period (Figure 18). Spatial and seasonal trends in calcium were nearly identical in surface and bottom samples and closely followed those described above for hardness. Except in April, when surface and bottom concentrations at site K6 (surface = 253 mg/l; bottom = 267 mg/l) were much lower than at other sites (surface range = 420 to 497 mg/l; bottom range = 370 to 480 mg/l), there was little spatial variation in calcium concentrations.

Temporal variation in calcium concentrations in both surface and bottom waters resulted from a decrease in calcium concentrations, throughout the lake, from April (surface range = 253 to 497 mg/l; bottom range = 266 to 480 mg/l) through late May (surface range = 163 to 173 mg/l; bottom range = 170 to 187 mg/l), that coincided with the increased inflows from the Wichita River. Calcium concentrations increased through late June (surface range = 257 to 267 mg/l; bottom range = 260 to 283 mg/l), and showed little evident pattern through the remainder of the study period, varying from 190 to 280 mg/l in surface samples and from 180 to 303 mg/l in bottom samples.

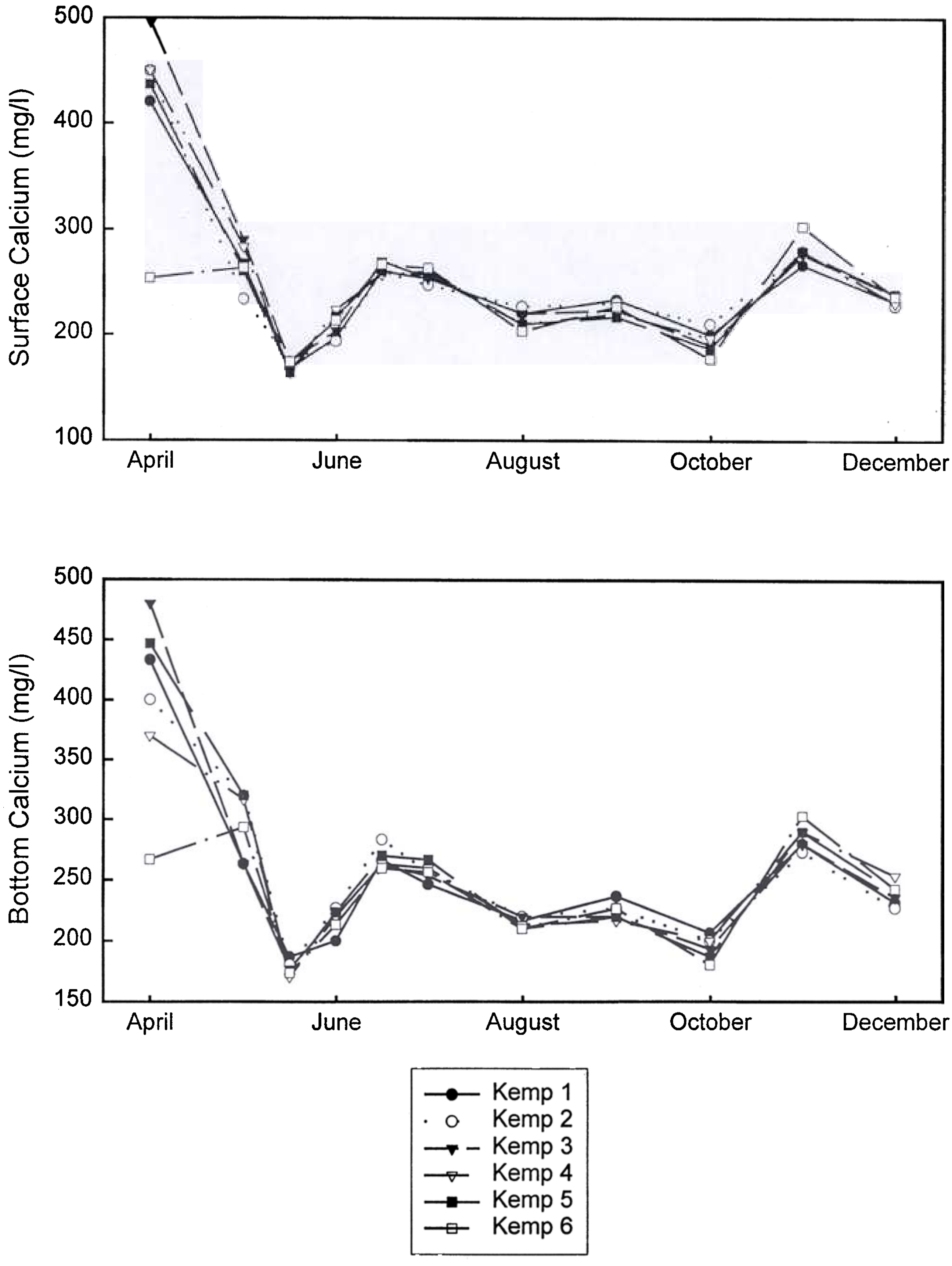


Figure 18. Mean calcium concentrations (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Mean calcium concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean calcium concentrations, by site, are presented in Appendix C.

Magnesium

Magnesium concentrations showed similar ranges in both surface (range = 48.0 to 85.0 mg/l) and bottom samples (31 to 87 mg/l) throughout the study period (Figure 19). There was generally little difference among sites, on any given date, in magnesium concentrations, with the sole exception occurring in April, when magnesium concentrations at sites K1 (surface) and K2 (surface and bottom) were much lower than at other sites.

In both surface and bottom samples, magnesium concentrations were variable from April through June, reflecting changes in water quality associated with inflows from the Wichita River. In late June, surface (75.0 to 79.0 mg/l) and bottom (75.3 to 78.0 mg/l) magnesium concentrations were relatively high, but then decreased to a minimum in October (surface range = 49.3 to 55.3 mg/l; bottom range = 48.0 to 55.0 mg/l). Magnesium concentrations increased sharply throughout the lake in November (surface range = 78.0 to 84.7 mg/l; bottom range = 79.3 to 87.3 mg/l) and then decreased in December (surface range = 63.0 to 65.5 mg/l; bottom range = 61.9 to 66.8 mg/l).

Mean magnesium concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean magnesium concentrations, by site, are presented in Appendix C.

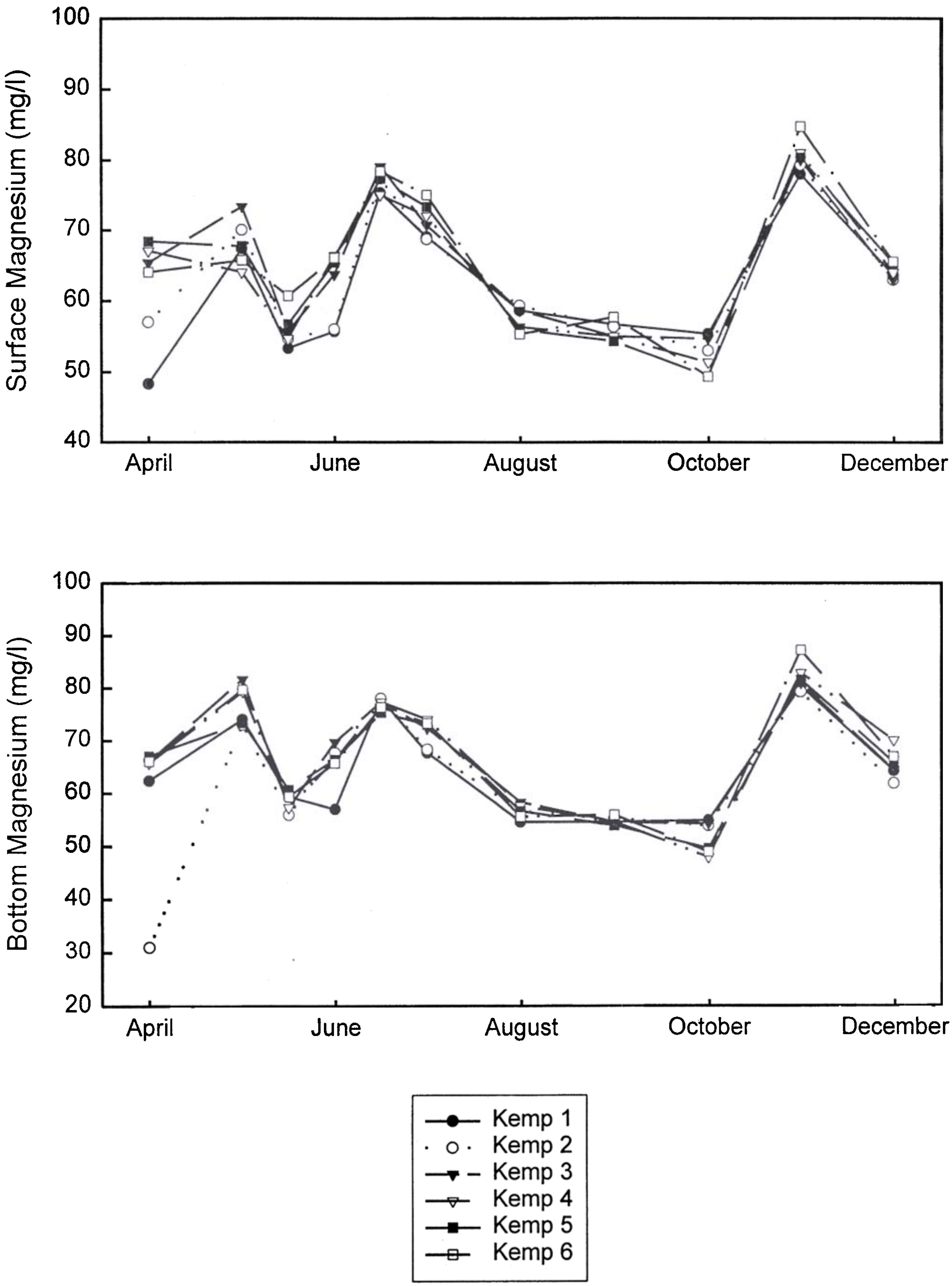


Figure 19. Mean magnesium concentrations (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Sodium

Sodium concentrations generally were greater in surface samples (range = 433.3 to 796.7 mg/l) than in bottom samples (306.7 to 846.7 mg/l) during the study period (Figure 20). Although sodium concentrations varied throughout the study period, there was no consistent seasonal or spatial pattern in either surface or bottom samples.

Sodium concentrations were extremely variable in April (surface range = 443.3 to 646.7 mg/l; bottom range = 306.7 to 686.7 mg/l). Sodium concentrations generally increased through early May (surface range = 560.0 to 710.0 mg/l; bottom range = 710.0 to 846.7 mg/l) and decreased in late May and early June (surface range = 560.0 to 626.7 mg/l; bottom range = 600.0 to 686.7 mg/l). Sodium concentrations increased in late June and reached a summer maximum in July (surface range = 710.0 to 796.7 mg/l; bottom range = 736.7 to 776.7 mg/l), before decreasing in August (surface range = 523.3 to 576.7 mg/l; bottom range = 520.0 to 553.3 mg/l). Sodium concentrations increased throughout the lake from August through December (surface range = 637.0 to 684.0 mg/l; bottom range = 624.0 to 762.0 mg/l).

Mean sodium concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean sodium concentrations, by site, are presented in Appendix C.

Potassium

Potassium concentrations ranged from 5.6 to 16.0 mg/l in both surface and bottom samples throughout the study period (Figure 21). In both surface and bottom samples,

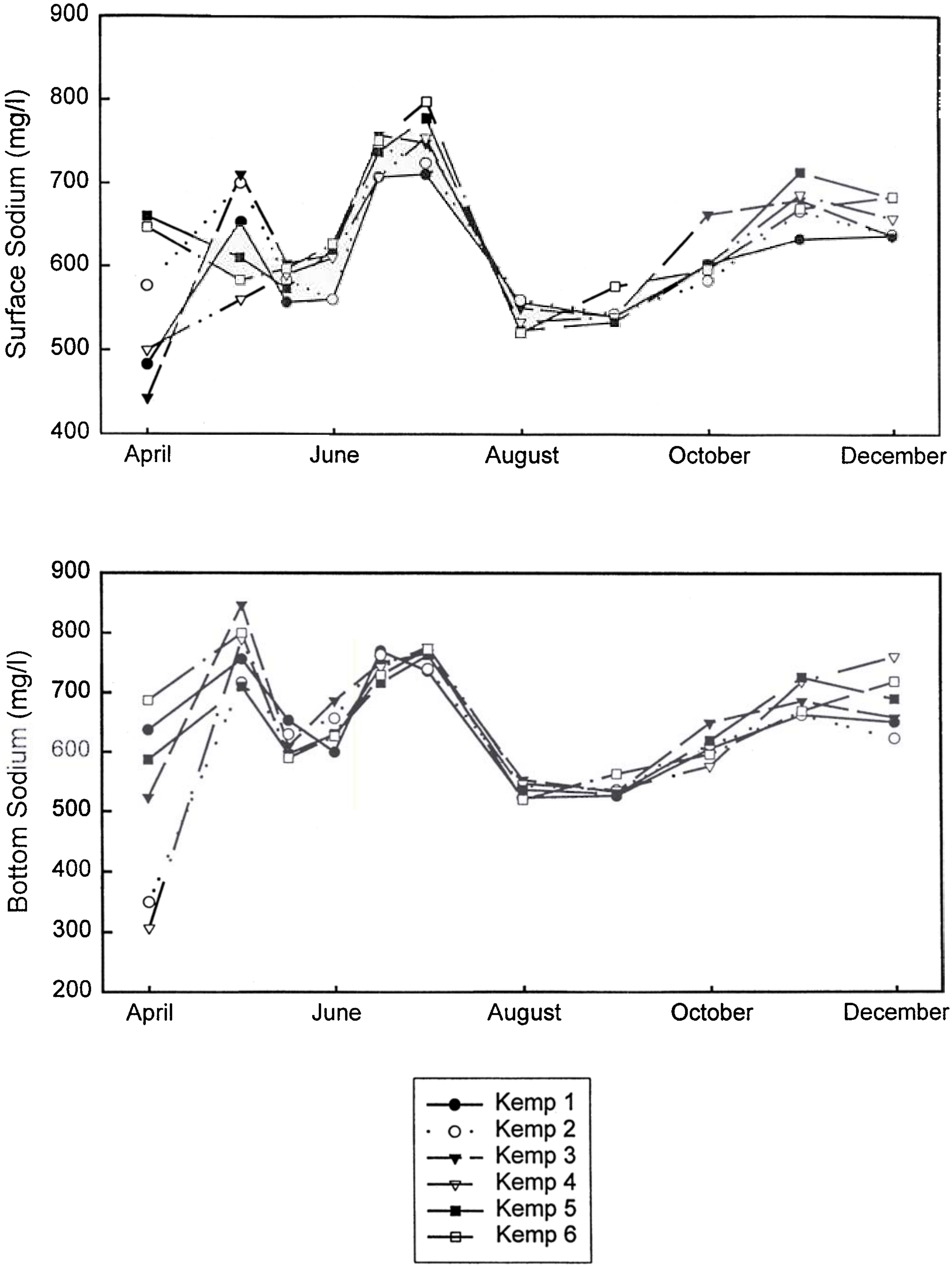


Figure 20. Mean sodium concentrations (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

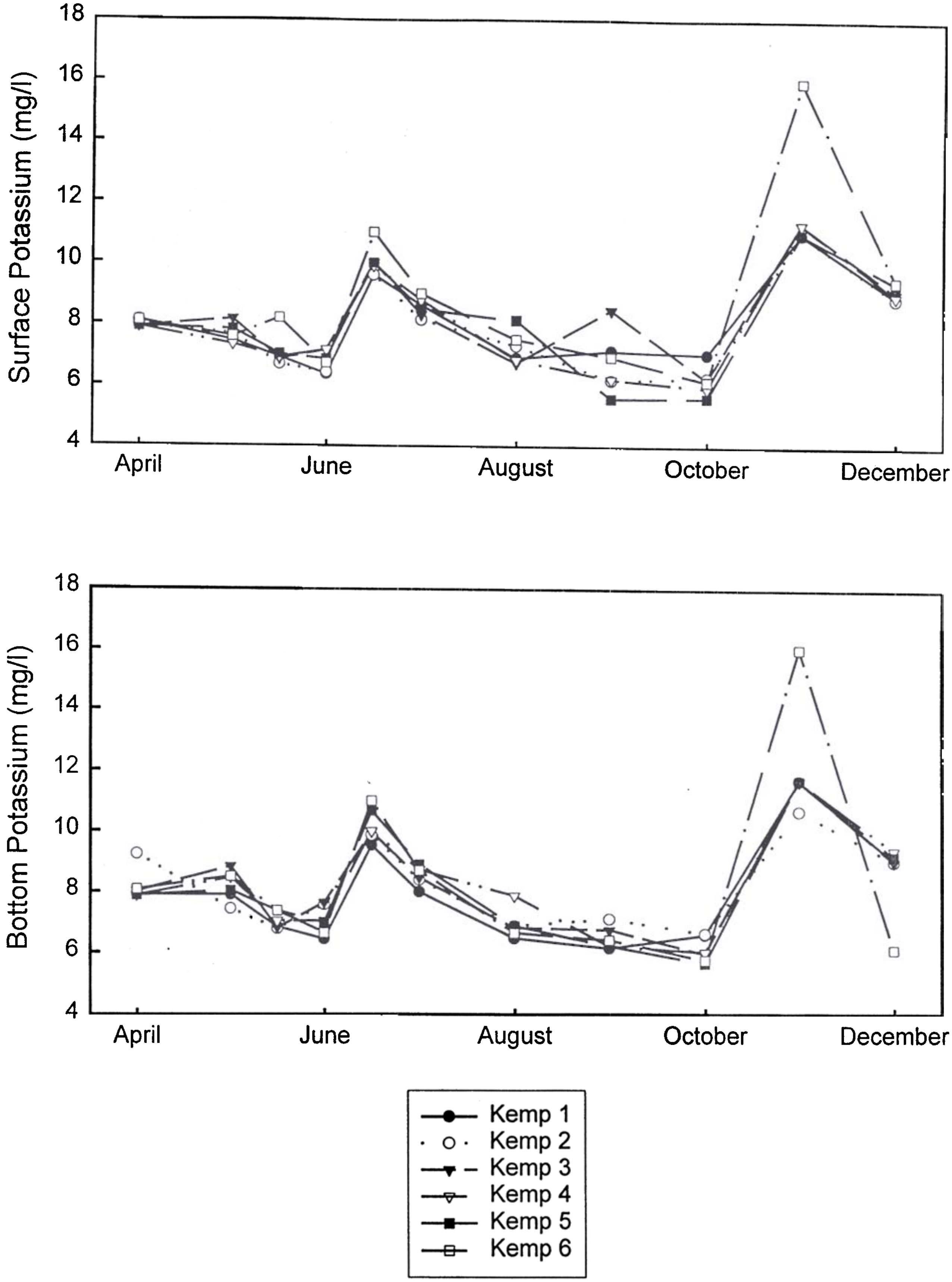


Figure 21. Mean potassium concentrations (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

potassium concentrations generally were greatest at K6 (surface mean = 8.8 mg/l; bottom mean = 8.28 mg/l). There were no consistent differences in potassium concentrations among sites K1-K5 (range of surface means = 7.8 to 8.2; range of bottom means = 7.9 to 8.2 mg/l).

Potassium concentrations in Lake Kemp generally decreased from April (surface range = 7.9 to 8.1 mg/l; bottom range = 7.9 to 9.2 mg/l) through early June (surface range = 66.4 to 7.2 mg/l; bottom range = 6.4 to 7.6 mg/l), before reaching a peak in late June (surface range = 9.6 to 11.0 mg/l; bottom range = 9.5 to 11.0 mg/l). Potassium concentrations decreased from late June through October (surface range = 5.6 to 7.1 mg/l; bottom range = 5.6 to 6.6 mg/l). Potassium concentrations increased sharply throughout Lake Kemp in November (surface range = 11.0 to 16.0 mg/l; bottom range = 10.7 to 16.0 mg/l), but then decreased in December (surface range = 8.9 to 9.5 mg/l; bottom range = 6.1 to 9.4 mg/l).

Mean potassium concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean potassium concentrations, by site, are presented in Appendix C.

Chloride

Chloride concentrations showed similar ranges in both surface (530 to 1367 mg/l) and bottom (587 to 480 mg/l) samples throughout the study period (Figure 22). Mean chloride concentrations in surface and bottom samples were 1000 and 1042 mg/l, respectively. Spatial and seasonal trends in chloride concentrations were nearly identical in surface and bottom samples. Chloride concentrations showed no pronounced spatial

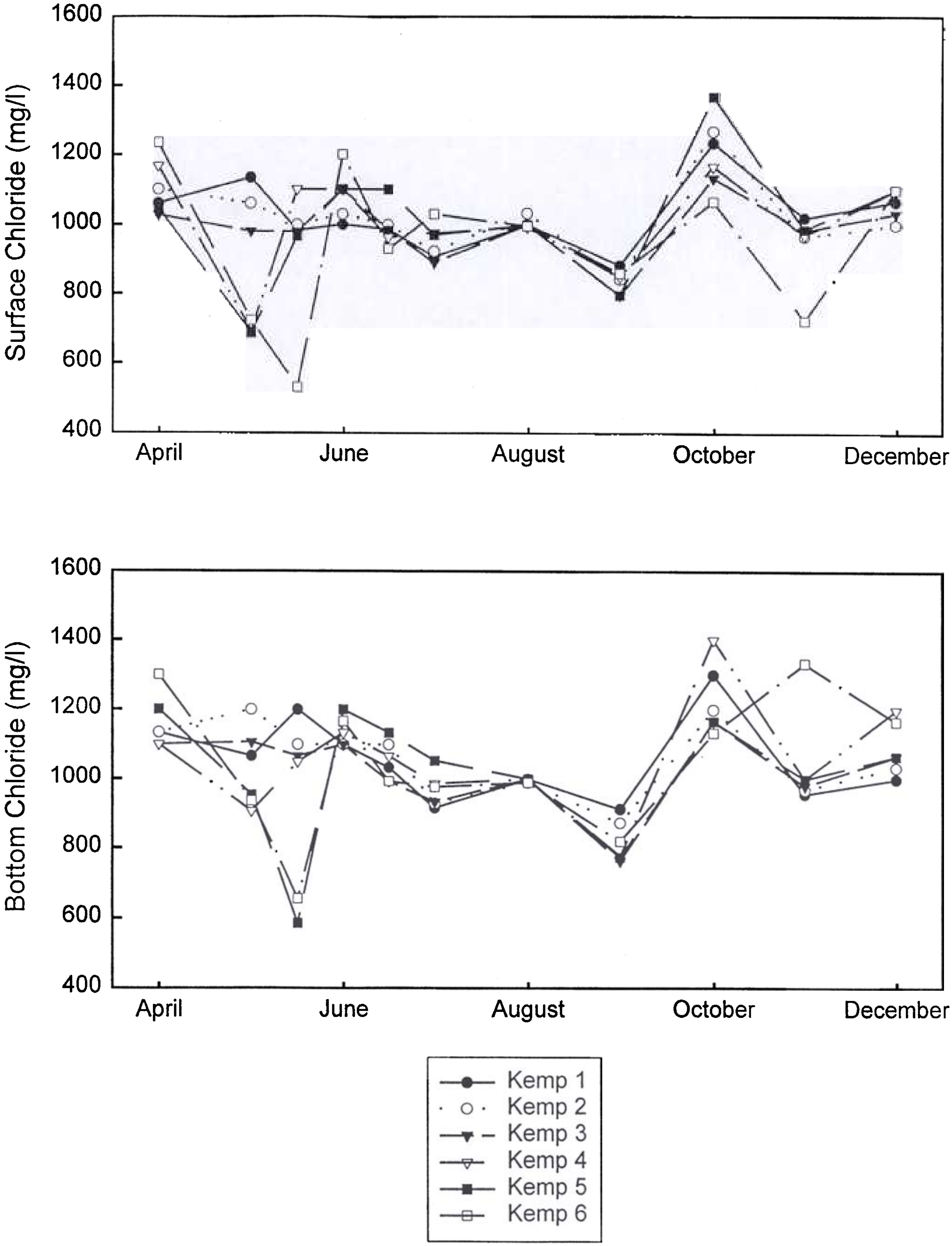


Figure 22. Mean chloride concentrations (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

pattern of variation except during May when concentrations at the uplake sites K5-K6 were lower than those at sites K1-K4 because of freshwater inflows from the Wichita River.

Temporal variation in chloride concentrations in both surface and bottom waters resulted from a decrease in chloride concentrations, throughout the lake, from April (surface range = 1027 to 1233 mg/l; bottom range = 1100 to 1300 mg/l) through September (surface range = 797 to 883 mg/l; bottom range = 763 to 913 mg/l). Chloride concentrations increased in October (surface range = 1067 to 1367 mg/l; bottom range = 1133 to 1400 mg/l) and showed little evident pattern through the remainder of the study period, varying from 723 to 1100 mg/l in surface samples and from 957 to 1200 mg/l in bottom samples.

Mean chloride concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean chloride concentrations, by site, are presented in Appendix C.

Sulfate

Sulfate concentrations showed similar ranges in both surface (433 to 1047 mg/l) and bottom (460 to 1100 mg/l) samples throughout the study period (Figure 23). Mean sulfate concentrations in surface and bottom samples were 786 and 795 mg/l, respectively. Spatial and seasonal trends in sulfate concentrations were nearly identical in surface and bottom samples. Sulfate concentrations showed no pronounced spatial pattern of variation except during May when concentrations at the uplake sites K5-K6

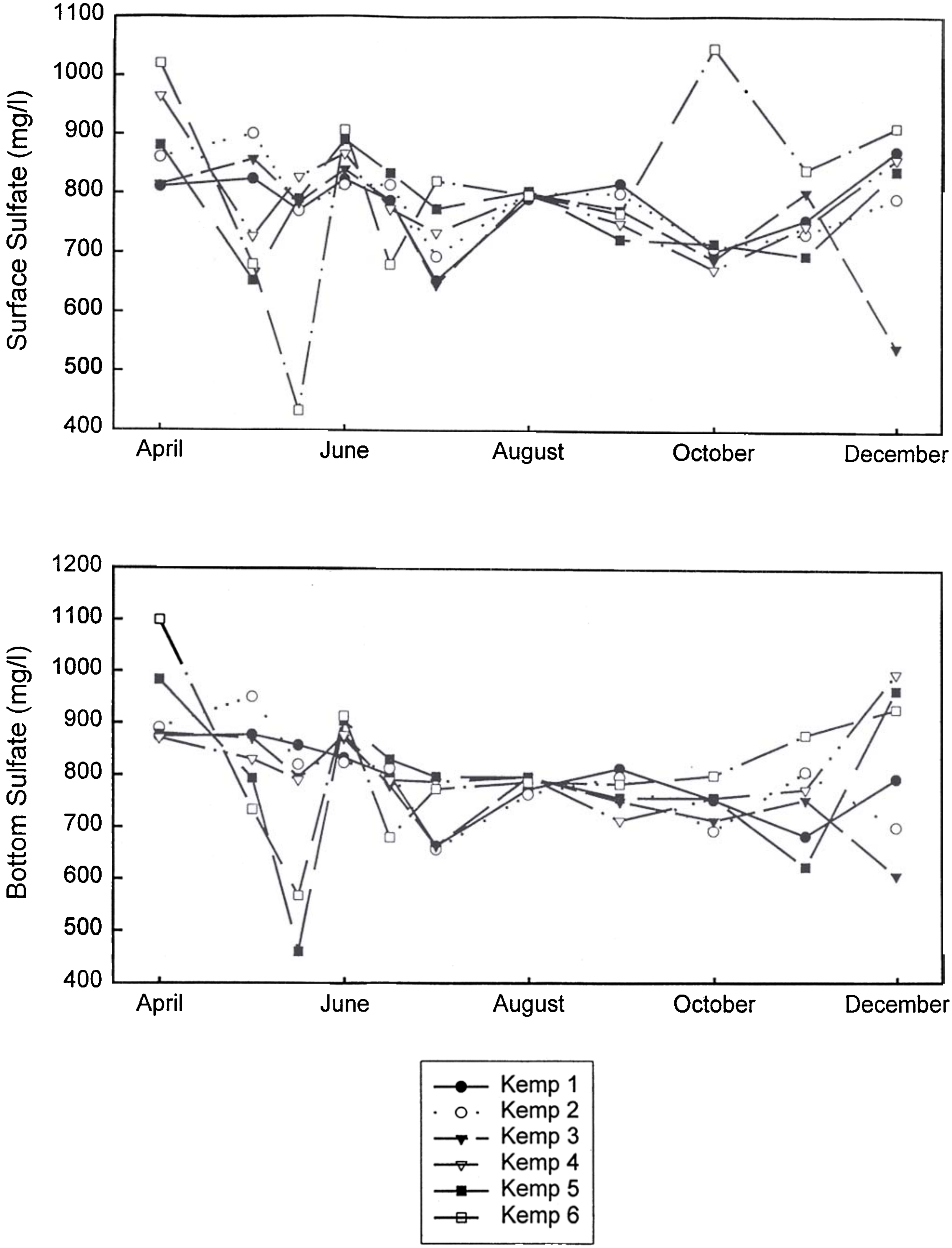


Figure 23. Mean sulfate concentrations (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

were lower than those at sites K1-K4 because of freshwater inflows from the Wichita River.

Temporal variation in sulfate concentrations in both surface and bottom waters resulted from a general decrease in sulfate concentrations, throughout the lake, from April (surface range = 810 to 1020 mg/l; bottom range = 870 to 1100 mg/l) through October (surface range = 673 to 1047 mg/l; bottom range = 713 to 813 mg/l). Sulfate concentrations generally increased through December (surface range = 543 to 913 mg/l bottom range = 700 to 997 mg/l).

Mean sulfate concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean sulfate concentrations, by site, are presented in Appendix C

Nutrient Concentrations

Concentrations of nitrate nitrogen (NO_2), nitrate nitrogen (NO_3), total nitrogen, soluble phosphorus, and total phosphorous in Lake Kemp generally were below laboratory detection limits. Laboratory detection limits were elevated in part because of interference from high total dissolved solids concentrations in Lake Kemp, which required dilution of samples.

Nitrite concentrations were < 0.1 mg/l in April and early May and < 1.0 through the remainder of the study (Table 2). Nitrate concentrations were < 1.0 mg/l throughout much of the study (Table 3). Surface and bottom nitrate concentrations ranging from

Table 2. Mean nitrite nitrogen (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Date	Depth	K1	K2	K3	K4	K5	K6
23 April 1997	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13 May 1997	Surface	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Bottom	0.03	<0.01	<0.01	<0.01	<0.01	<0.01
27 May 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
15 June 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
29 June 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
13 July 1997	Surface	0.72	0.73	<1.0	<1.0	<1.0	<1.0
	Bottom	0.73	1.88	<1.0	<1.0	<1.0	<1.0
16 August 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	0.3
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
14 September 1997	Surface	2.6	5.0	<1.0	4.9	<1.0	2.5
	Bottom	<1.0	2.4	2.7	<1.0	7.3	<1.0
20 October 1997	Surface	6.7	<1.0	6.0	6.0	<1.0	<1.0
	Bottom	3.2	4.0	<1.0	<1.0	<1.0	<1.0
19 November 1997	Surface	<1.0	<1.0	<1.0	1.7	<6.0	<6.0
	Bottom	<1.0	<1.0	2.6	<1.0	<6.0	<6.0
18 December 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0

Table 3. Mean nitrate nitrogen (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Date	Depth	K1	K2	K3	K4	K5	K6
23 April 1997	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13 May 1997	Surface	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Bottom	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27 May 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
15 June 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
29 June 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
13 July 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
16 August 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
14 September 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
20 October 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
19 November 1997	Surface	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0
18 December 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0

0.72 to 6.7 mg/l occurred infrequently from July through November, with no discernible spatial or seasonal pattern. Total nitrogen was < 10.0 mg/l throughout the study (Table 4).

Soluble phosphorus was less than 1.0 mg/l throughout the study (Table 5), except at site K1 in November (1.1 mg/l surface; 1.3 mg/l bottom). Total phosphorus was usually less than elevated laboratory detection limits (Table 6), but when measured, ranged from 0.01 to 0.11 mg/l. Because of elevated laboratory detection limits, there was no discernible spatial or seasonal pattern in soluble phosphorus and total phosphorus.

Chlorophyll-a

Chlorophyll-*a* concentrations ranged from 5.6 to 9.3 μg/l in April and increased through late May (range = 11.1 to 14.2 μg/l) (Figure 24). Chlorophyll-*a* concentrations decreased in June to 5.2 to 7.6 μg/l, but then increased through August (range = 6.7 to 11.7 μg/l). Chlorophyll-*a* concentrations generally increased from August through October (range = 6.6 to 15.7 μg/l), before declining in November (range = 2.6 to 3.2 μg/l) and December (range = 1.9 to 4.0 μg/l).

The was a fairly consistent spatial pattern in chlorophyll-*a* concentrations, which generally decreased downlake from site K6 (mean = 9.0 μg/l) to site K1 (mean = 7.0 μg/l).

Ten replicate chlorophyll-*a* samples were taken at sites K1, K4, and K6. Mean standard deviations for these sites, were 1.10 (K1), 1.65 (K4), and 1.74 (K6). Mean standard deviations at sites K2, K3, and K5, at which only three replicate samples were collected, were 0.54 (K2), 1.37 (K3), and 1.41 (K5). Thus, there appears to be no

Table 4. Mean total nitrogen (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Date	Depth	K1	K2	K3	K4	K5	K6
13 May 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
27 May 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
15 June 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
29 June 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
13 July 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
16 August 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
14 September 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
20 October 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
19 November 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
18 December 1997	Surface	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
	Bottom	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0

Table 5. Mean soluble phosphorous (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Date	Depth	K1	K2	K3	K4	K5	K6
13 May 1997	Surface	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Bottom	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
27 May 1997	Surface	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
	Bottom	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
15 June 1997	Surface	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Bottom	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
29 June 1997	Surface	1.5	0.7	0.6	0.5	0.17	<0.8
	Bottom	0.7	0.6	0.6	0.3	0.30	<0.8
13 July 1997	Surface	<0.8	0.6	<0.5	<0.5	<0.5	0.4
	Bottom	<0.8	<0.8	<0.5	<0.5	0.2	0.5
16 August 1997	Surface	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Bottom	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
14 September 1997	Surface	<1.0	<1.0	<1.0	<1.0	<0.5	<0.5
	Bottom	<1.0	<1.0	<1.0	<0.5	<0.5	<0.5
20 October 1997	Surface	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Bottom	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
19 November 1997	Surface	1.1	1.3	<0.5	0.60	0.96	0.81
	Bottom	1.3	0.7	0.19	0.87	0.86	0.81
18 December 1997	Surface	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Bottom	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 6. Mean total phosphorous (mg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Date	Depth	K1	K2	K3	K4	K5	K6
23 April 1997	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13 May 1997	Surface	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Bottom	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27 May 1997	Surface	0.04	0.02	0.02	0.02	0.02	0.04
	Bottom	0.04	0.05	0.04	0.02	0.11	0.07
15 June 1997	Surface	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Bottom	<0.05	<0.05	0.05	<0.05	0.06	0.04
29 June 1997	Surface	<0.01	<0.01	0.01	<0.01	<0.01	0.01
	Bottom	<0.01	<0.01	0.01	0.07	0.07	0.03
13 July 1997	Surface	<0.01	<0.01	0.01	0.01	0.01	0.01
	Bottom	<0.01	<0.01	0.01	<0.01	0.02	0.02
16 August 1997	Surface	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Bottom	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
14 September 1997	Surface	0.02	0.03	0.01	<0.01	0.02	0.01
	Bottom	0.03	0.01	0.01	0.01	0.02	0.02
20 October 1997	Surface	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
	Bottom	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
19 November 1997	Surface	<1.5	<1.5	<0.5	<1.0	0.01	0.01
	Bottom	<1.5	<1.5	<0.5	<1.0	0.01	0.01
18 December 1997	Surface	0.003	0.02	0.01	<0.001	0.01	0.01
	Bottom	0.002	0.01	0.03	<0.001	0.01	0.02

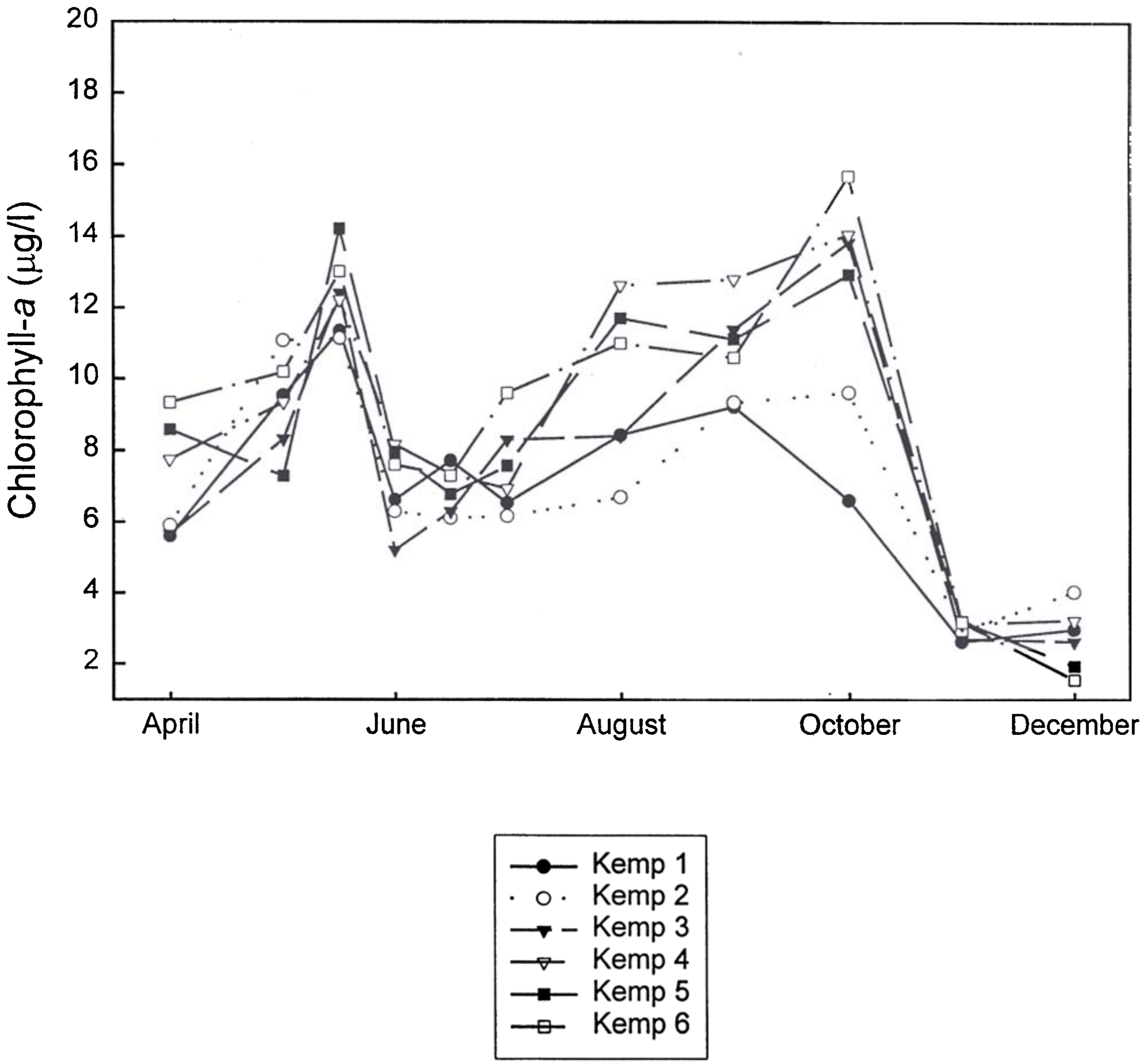


Figure 24. Mean chlorophyll-*a* concentrations (µg/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

increase in precision associated with increasing sample sizes for chlorophyll-*a* from three to ten. As with turbidity, higher standard deviations at sites K1, K4, and K6 generally were due to occasional samples containing one or more outliers.

Mean chlorophyll-*a* concentrations, across all sample sites, dates, and depths are presented in Appendix B. Mean chlorophyll-*a* concentrations, by site, are presented in Appendix C.

Phytoplankton Cell Counts

Phytoplankton concentrations varied widely among sampling sites in April, ranging from 1230 to 2997 cells/ml (Figure 25). Phytoplankton concentrations increased slightly in early May (range = 1842 to 2155 cells/ml) and late May (range = 1845 to 2520 cells/ml) and showed only a slight decrease through early June (range = 1671 to 2109 cells/ml) In late June, phytoplankton concentrations deceased (range = 892 to 1749 cells/ml) and then showed a slight increase through August (range = 1135 to 1514 cells/ml). Phytoplankton concentrations increased throughout the lake in September (range = 1569 to 2438 cells/ml) and then decreased through December (range = 298 to 610 cells/ml).

Phytoplankton concentrations decreased progressively downlake from site K6 (mean = 1625 cells/ml) to site K1 (mean = 1279 cells/ml).

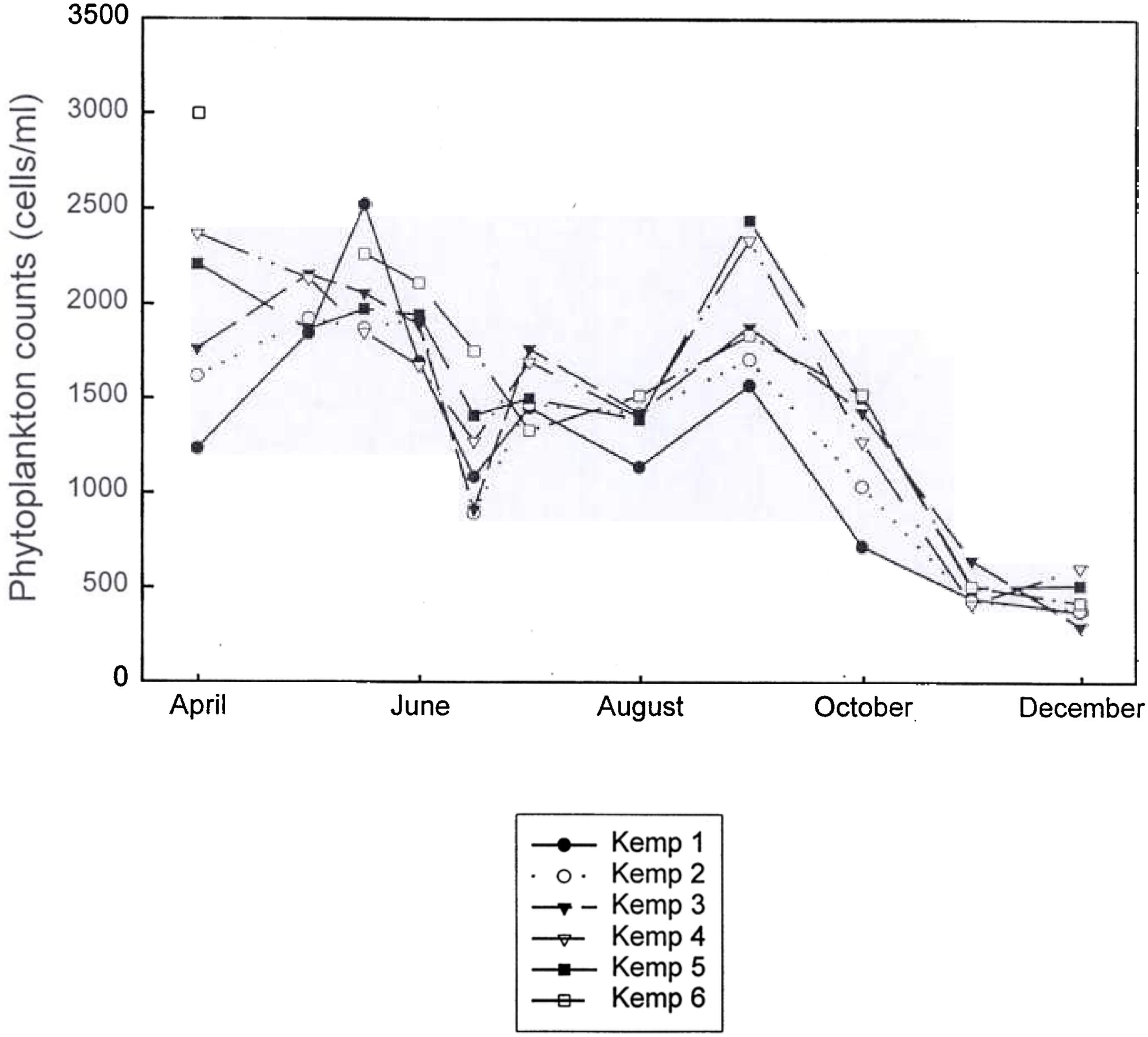


Figure 25. Mean phytoplankton cell counts (cells/ml) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Phytoplankton Assemblage

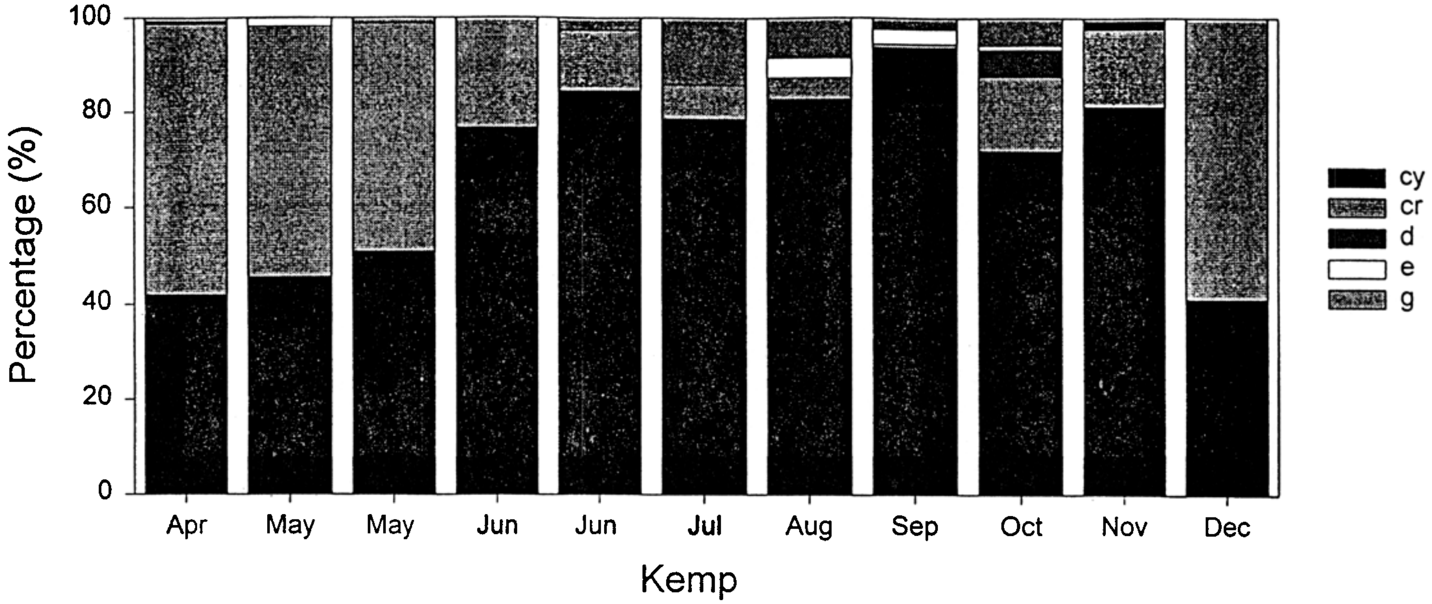
Throughout the year, the phytoplankton assemblage in Lake Kemp was dominated by cyanobacteria (bluegreen algae) (Figures 26 and 27). Generally, cyanobacteria represented at least 50%, by number, of the phytoplankton, with the only exceptions occurring in April (sites K1 and K5) and December (sites K1-K6). Cyanobacteria comprised 40 to 60% of the phytoplankton assemblage in April and May, 60 to 80% from June through October, and then 20 to 80% in November and December. The most common cyanobacteria genera in Lake Kemp were Aphanocapsa, Aphanothece, Chroococcus, Gloecapsa, Lyngbya, Oscillatoria, Spirulina, and Synechococcus).

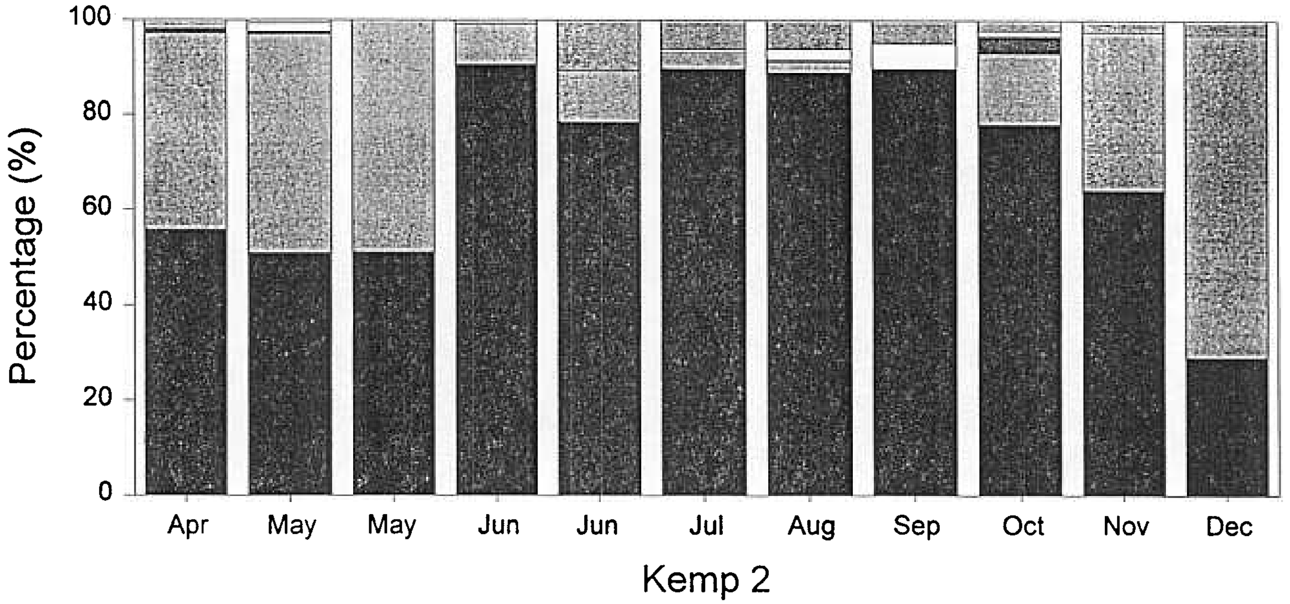
Chrysophytes, primarily Chroomonas and Cryptomonas, were the second most dominant algal group in Lake Kemp and comprised 30 to 40% of the phytoplankton assemblage in April through May. Chrysophytes were most dominant in November and December when they comprised 30 to 70% of the phytoplankton assemblage.

Other phytoplankton groups including diatoms (primarily Navicula and Fragillaria), euglenoids (primarily Trachelmonas and Lepocinclis), and green algae (Lagerheima, Tetrahedron, and Crucigenia) were minor constituents of the Lake Kemp phytoplankton assemblage.

There was no apparent spatial variation in the composition of the Lake Kemp phytoplankton assemblage.

Figure 26. Relative abundance (%) of major phytoplankton groups at sites K1-K3 in Lake Kemp, Texas, April through December 1997.


Percentage (%)
100
80
60
40
20
0
Apr
May
May
Jun
Jun
Jul
Aug
Sep
Oct
Nov
Dec
cy
cr
d
e
g
Kemp


Percentage (%)
100
80
60
40
20
0
Apr
May
May
Jun
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Kemp 2

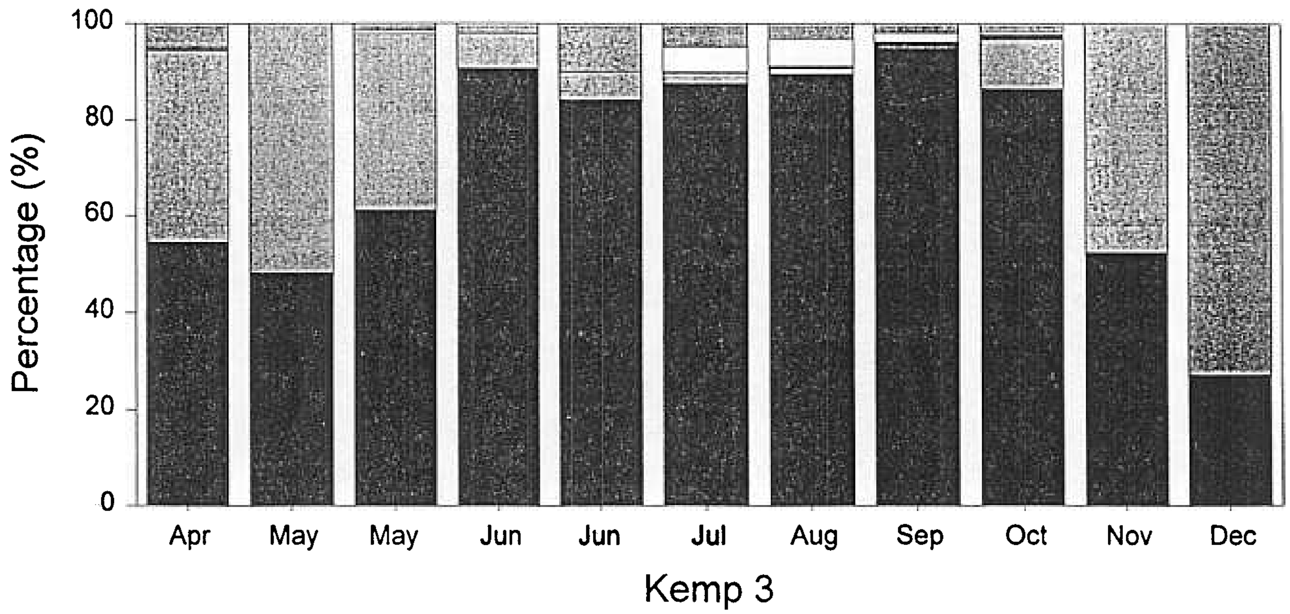
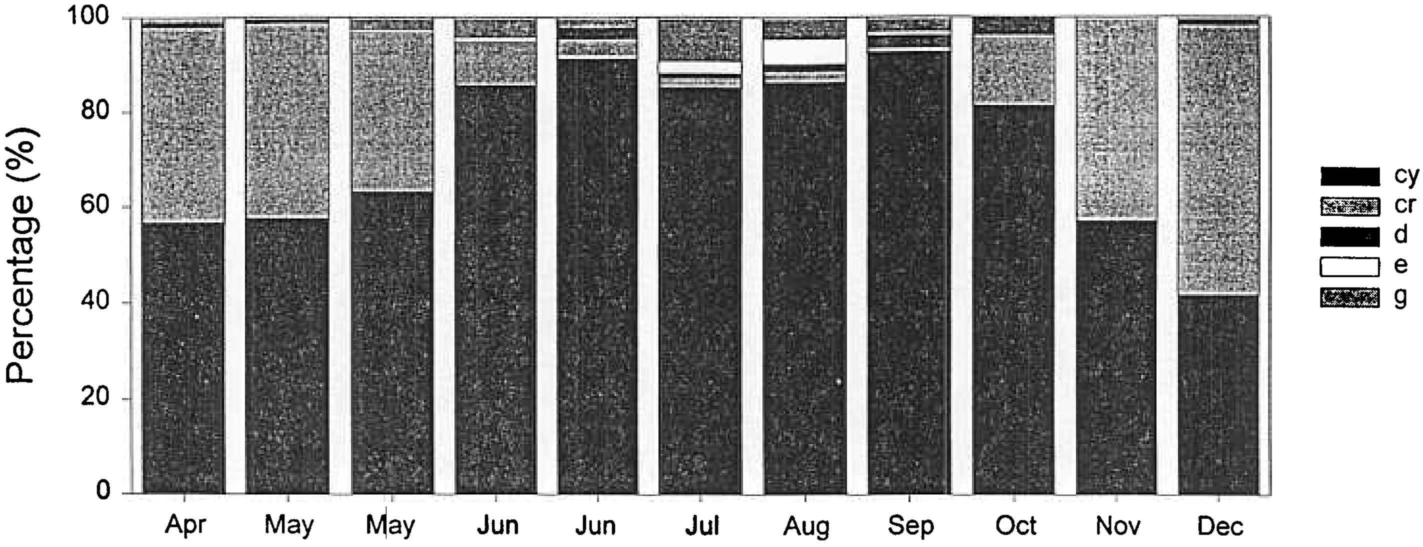
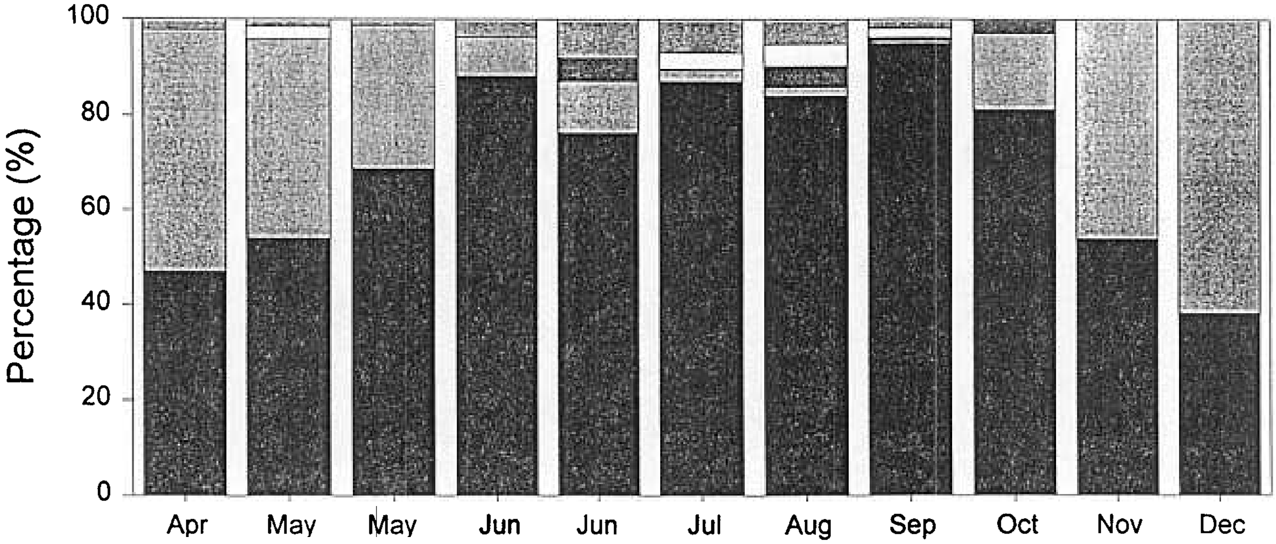

Percentage (%)
100
80
60
40
20
0
Apr
May
May
Jun
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Kemp 3

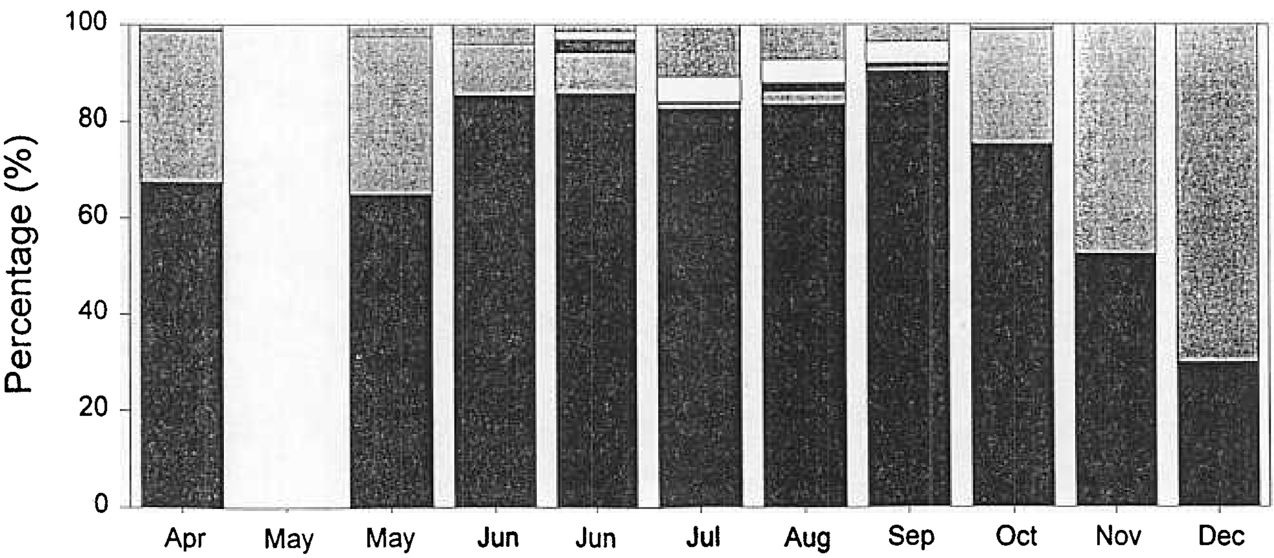
Figure 27. Relative abundance (%) of major phytoplankton groups at sites K4-K6 in Lake Kemp, Texas, April through December 1997.



Kemp 4



Kemp 5



Kemp 6

Zooplankton Counts

Zooplankton densities ranged from 97 to 717 individuals/l in April (Figure 28). Zooplankton densities increased in early May (range = 263 to 527 individuals/l) and reached annual maxima in late May (range = 607 to 1884 individuals/l). Zooplankton densities decreased sharply in early June (range 66 to 191 individuals/l) and remained low through September (range individuals/l = 104 to 322). Zooplankton densities increased in October (range = 404 to 649 individuals/l) and decrease slightly in November (range = 174 to 394 individuals/l) and December (range = 206 to 438 individuals/l). Zooplankton densities showed no obvious spatial pattern.

Zooplankton Assemblage

Throughout most of the year, the zooplankton assemblage in Lake Kemp was dominated by copepods, especially nauplii (Figures 29 and 30). Copepod nauplii represented 22 to 83% of the zooplankton, but generally represented 30 to 60% of the zooplankton. Nauplii were proportionally most abundant in April through June. Copepod copepodites and adults (Cyclops sp., Eurytemora affinis, and Mesocyclops edax) made up 0 to 50% of the zooplankton, but, on average, represented 20% of the zooplankton assemblage. Copepodite and adult copepods were most abundant in April through May and September through October.

Cladocerans (primarily Bosmina longirostris, Daphnia ambigua, D. parvula, and D. pulex) were a small part of the Lake Kemp zooplankton assemblage, representing 0 to

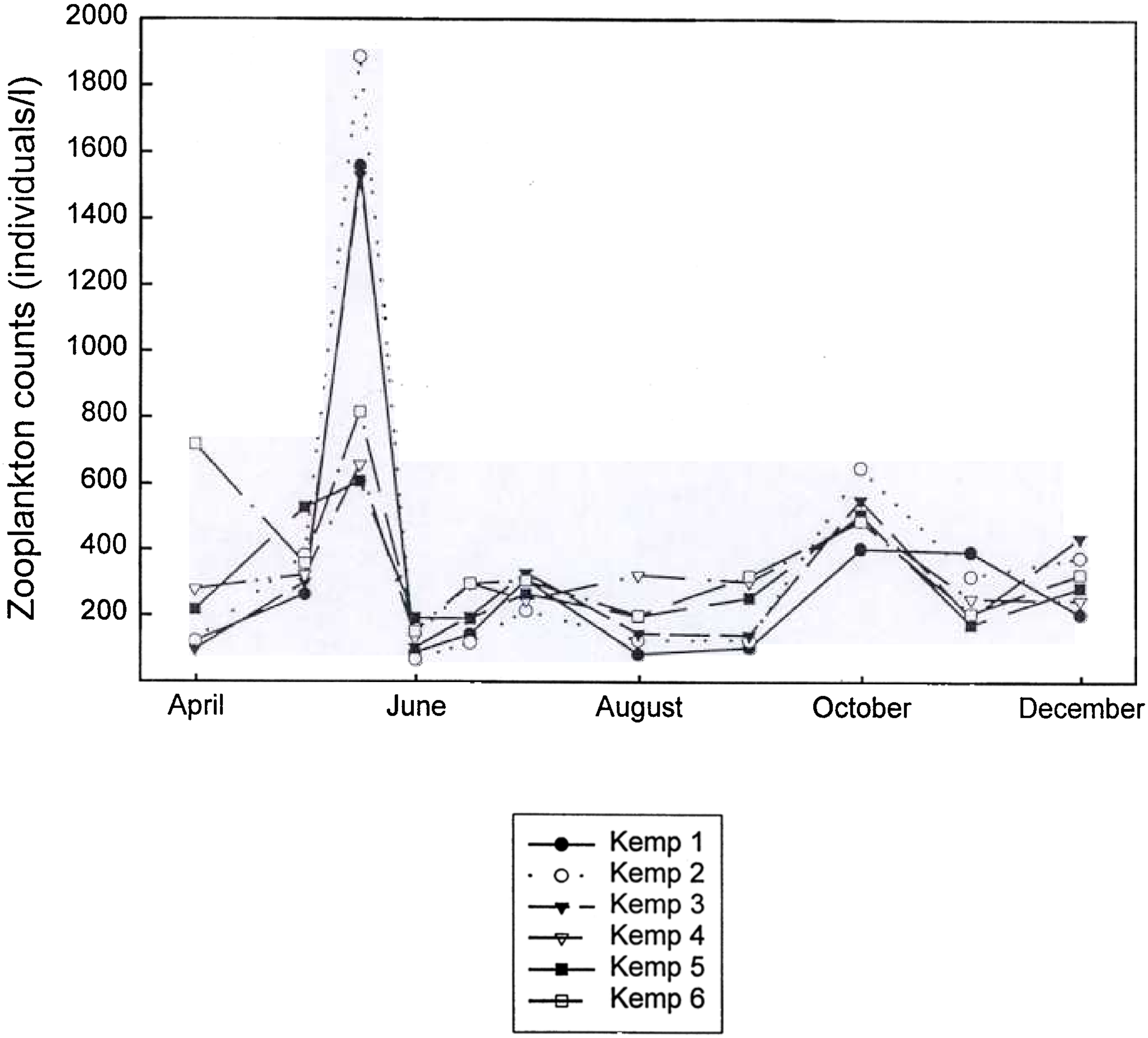
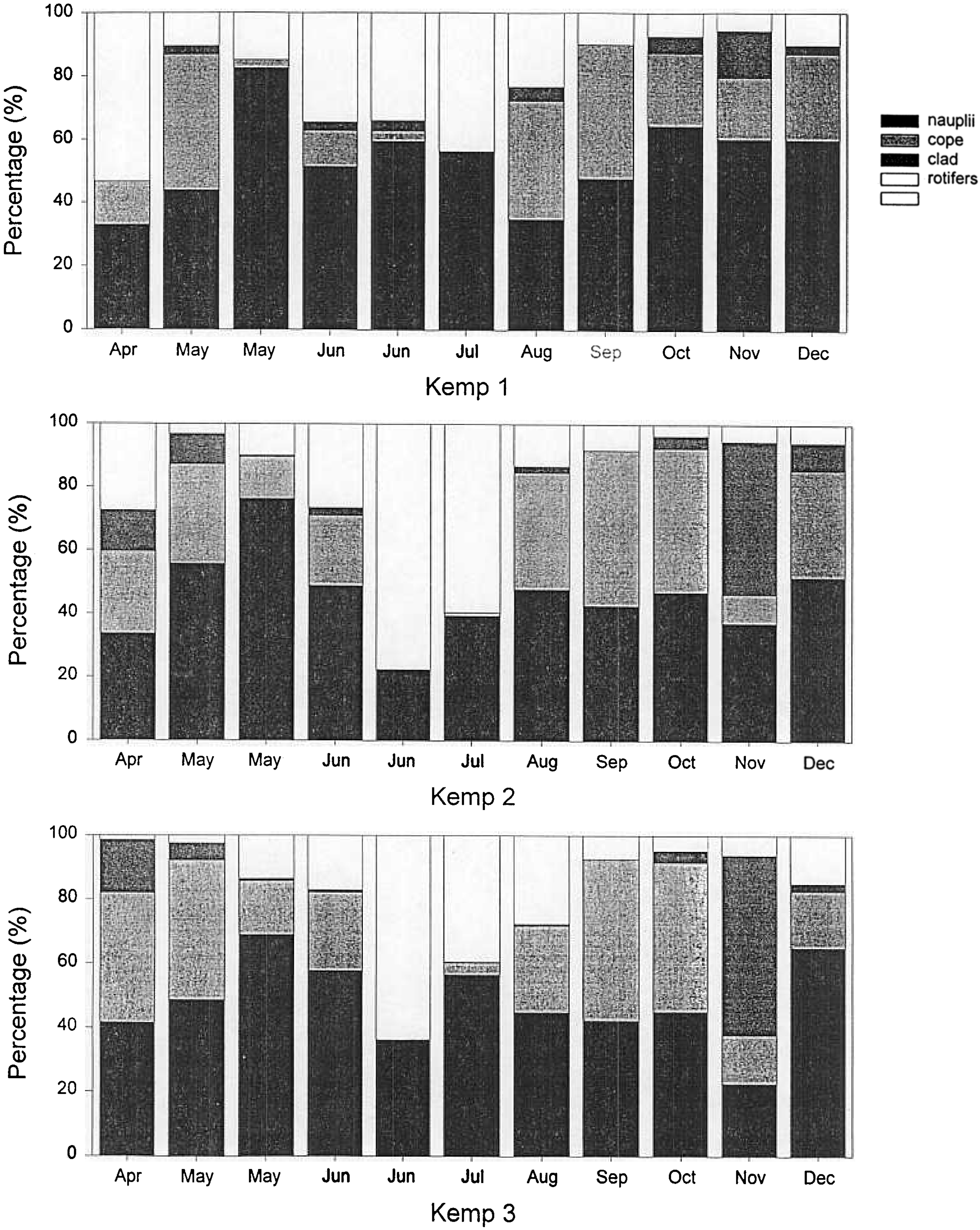


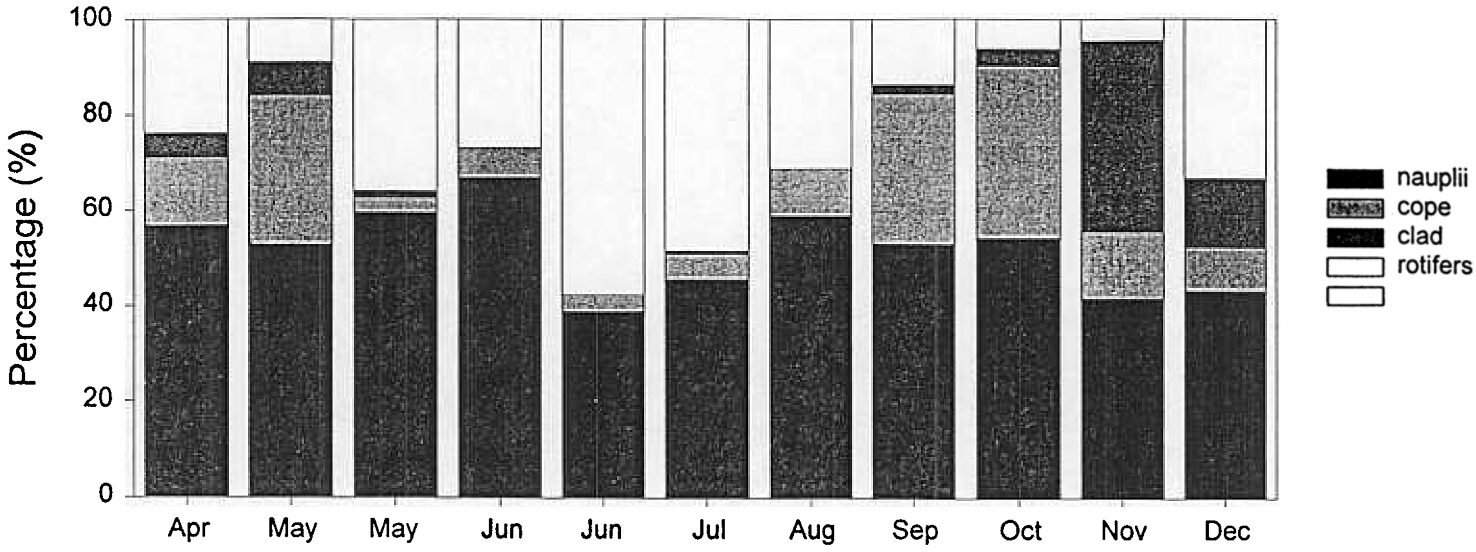
Figure 28. Mean zooplankton densities (individuals/l) at sites K1-K6 in Lake Kemp, Texas, April through December 1997.

Figure 29. Relative abundance (%) of major zooplankton groups at sites K1-K3 in Lake Kemp, Texas, April through December 1997.

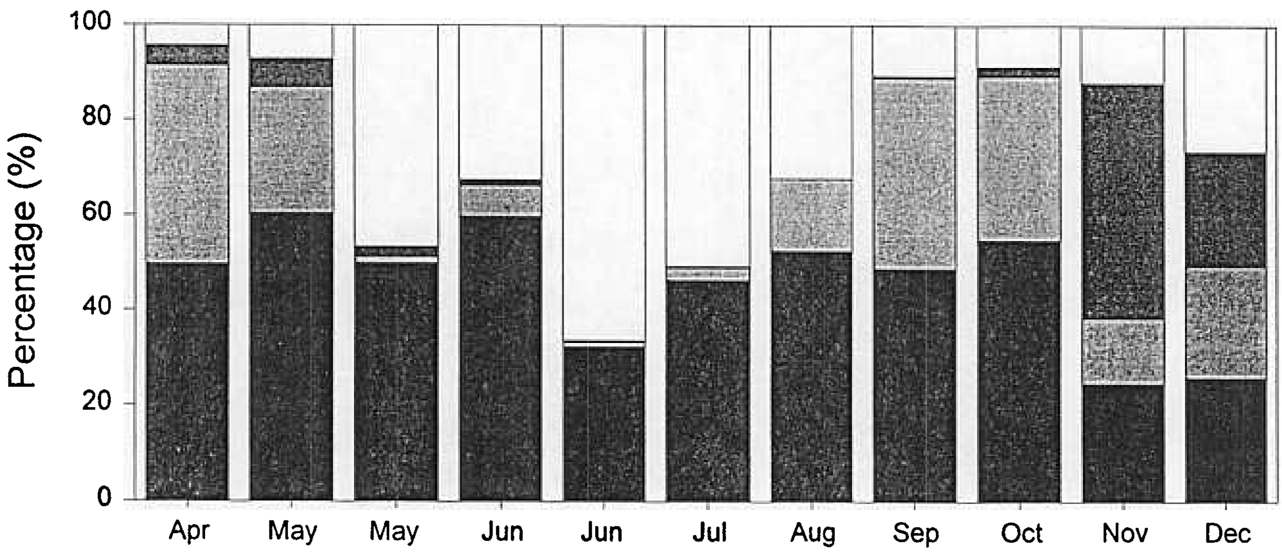


Percentage (%)
Apr
May
May
Jun
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Kemp 1
nauplii
cope
clad
rotifers
Kemp 2
Kemp 3

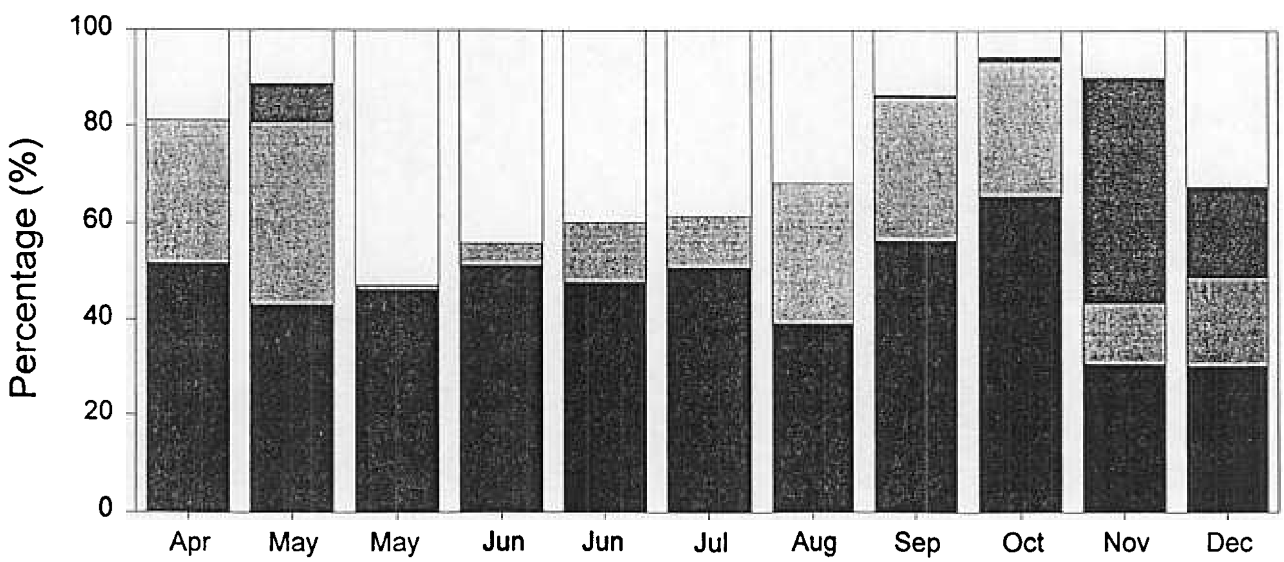
Figure 30. Relative abundance (%) of major zooplankton groups at sites K4-K6 in Lake Kemp, Texas, April through December 1997.



Kemp 4



Kemp 5



Kemp 6

56% (mean = 7%) of the zooplankton. Cladocerans were proportionately most abundant in November and December.

Rotifers (primarily Brachionus spp., Hexarthra sp., Keratella cochlearis, K. quadrata, and Syncheata sp.) composed 1 to 66% (mean = 24%) of the Lake Kemp zooplankton assemblage. Among these species, Syncheata was by far the most abundant rotifer, representing 35% of the rotifer assemblage. Rotifers were proportionately most abundant in June through August and were least abundant in October through December. In general, rotifers were proportionally most abundant at sites K6 and K5 and decreased in relative abundance downlake to site K1

Lake Elevation

The surface elevation of Lake Kemp ranged from 347.2 m to 349.3 m above sea level during 1996 (Figure 31). Lake elevation was less than 347.5 m in January and February, but increased to 347.8 m in March and to nearly 348.1 m in April. Lake surface elevation increased further, to 349.0 m, in May. This latter increase was associated with occurrence of a relatively freshwater overflow that spread across most of the lake in May. Lake surface elevation generally declined through the remainder of the year, with occasional, small increases in elevation occurring after localized rains in the Wichita River watershed.

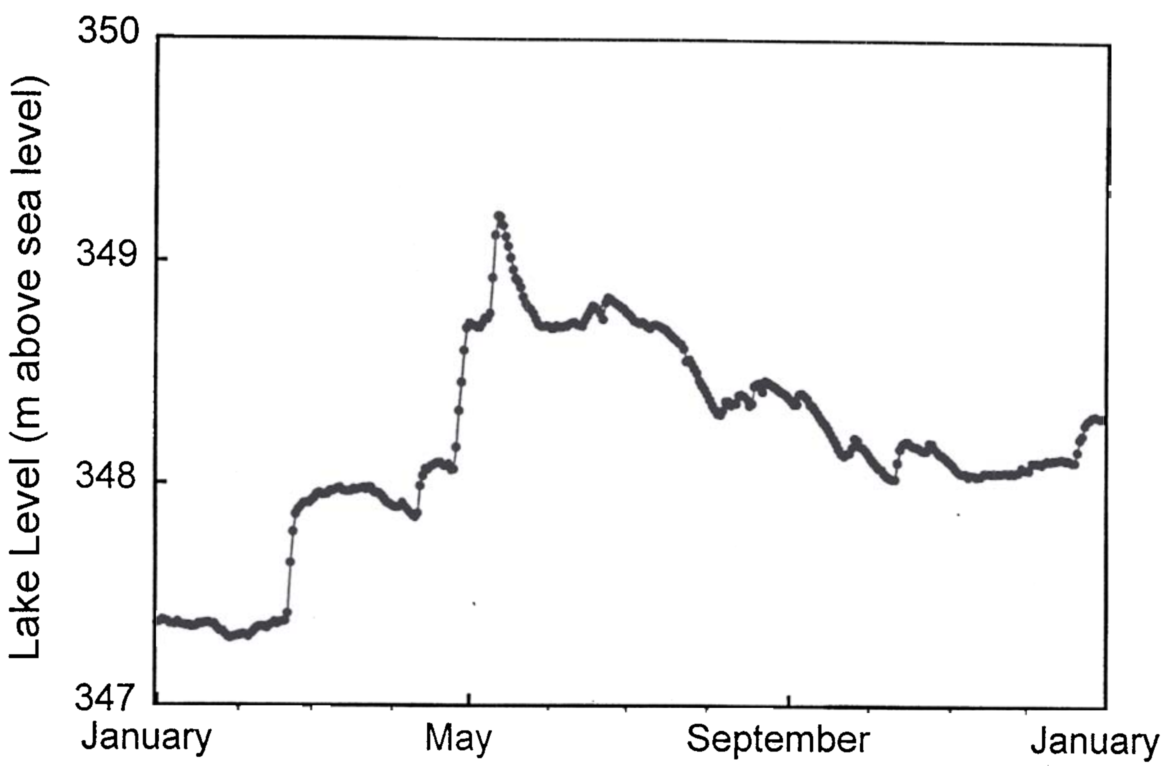


Figure 31. Lake Kemp, Texas, lake level elevation (m above sea level), January through December 1997.

Discussion

Physical Limnology of Lake Kemp

Lake Kemp can be characterized as a warm monomictic lake and is similar in limnology to other moderately large, north-central Texas reservoirs (Harris and Silvey 1940; Sterner 1994). The lake is just deep enough to develop a stable thermocline, at a depth of 10 m, that resisted wind mixing through the summer. Stratification was initiated in Lake Kemp in June and persisted through August, with turnover occurring in September. The development, depth, and persistence of thermal stratification usually are consistent from year to year (Horne and Goldman 1994); however, these characteristics are relatively more variable in reservoirs than in natural lakes (Wetzel 1983). It is possible that Lake Kemp does not stratify every year or may not remain stratified for as long a period as observed in 1997. Interannual differences in inflow, duration and intensity of winds, and lake level may be important in determining whether stratification occurs in any given year.

Water level fluctuations in Lake Kemp were relatively small during 1997. Lake elevation increased from a minimum of 346.6 m above sea level in January to a maximum of 349.3 m in May and then slowly decreased to 348.1 m in December. Increases in lake elevation are due to inflows from the Wichita River and decreases are due to irrigation releases from the dam and evaporation. The general increase in TDS throughout Lake Kemp during summer and fall suggests concentration of dissolved solids through evaporation.

The greatest change in lake level occurred in May due to high runoff from the Wichita River. During this period, the river displaced, or thoroughly mixed with, lake water at site K6 and then progressed downstream as an overflow. This overflow is best documented by conductivity profiles, which showed considerably reduced conductivity at K6 and low conductivity waters overlaying lake waters with higher conductivity at other sites in early May, compared with April. Density flows such as this can be established based on differences in temperature, suspended solids (silt), and dissolved solids between inflow and lake waters (Ford 1990). Temperature isopleths for Lake Kemp show no evidence of an overflow, and both turbidity and TSS decreased between April and early May. TDS decreased considerably in surface waters between April and early May, confirming the characterization of the overflow as comprising relatively "fresh" waters.

At 25°C, 330 mg/l of TDS is required to establish a density difference comparable to that associated with a temperature difference of 1°C (Ford 1990). The decrease in surface TDS between April (3150 mg/l) and early May at most stations (2000 to 2400 mg/l) suggests a establishment of a considerable density difference between inflow and lake waters. The remnants of this overflow were observable in late May at sites K1-K3 indicating this overflow, although diluted, had spread out (Ford 1990) and completely covered the lake.

Conductivity profiles also suggest the presence of an underflow at sites K2-K6 during June and July. However, there was weak evidence of this density flow at site K1 The occurrence of this underflow in June and July, at approximately the same time that thermal stratification developed at sites K1-K3, may indicate that the underflow contributed to the development of stratification by intensifying density differences between metalimnetic and hypolimnetic waters (Wunderlich and Elder 1967).

One of the most notable features of the limnology of Lake Kemp is the rapidity with which oxygen was consumed in the hypolimnion. Thermal stratification began to develop at sites K1-K3 in late May and was poorly developed in early June. Near-bottom oxygen concentrations decreased at these sites in late May and by early June, oxygen concentrations below 10 m were reduced and were less than mg/l below 12 m at sites K1 and K2. Cole and Hannon (1990) proposed a conceptual model for the development and spread of anoxic conditions in the hypolimnia of reservoirs. They suggested the anoxic zone first develops in the thalweg at the downlake end of the active sedimentation zone and then progresses both uplake and downlake from that zone. Development and spread of this anoxic zone continues throughout the period of summer stagnation, until it extends from the free-flowing river at one end of the reservoir to the dam at the other. At the same time, the anoxic zone develops outward and laterally from the thalweg. Cole and Hannon (1990) suggested that development and spread of the anoxic zone could be completed in a matter of days in shallow eutrophic lakes. This model is consistent with the development of the anoxic hypolimnetic zone in Lake Kemp.

According to the model of Cole and Hannon (1990), anoxic conditions first develop at, and propagate outward from, the downlake end of the zone of active sedimentation because decomposition of allochthonous organic matter consumes more oxygen than is produced by photosynthesis. Development and spread of anoxic conditions in Lake Kemp appeared to be related to high runoff from the Wichita River in May, which resulted in a rapid increase in lake level (Figure 31). It is likely that increased runoff into Lake Kemp, from the Wichita River drainage basin, transported a considerable amount of organic material into the lake. Thus, although Cole and

Hannon's (1990) model may explain development and propagation of anoxic conditions in Lake Kemp, whether and when such a zone develops in Lake Kemp may be closely tied to runoff from the Wichita River.

Chemical Limnology of Lake Kemp

The chemical limnology of reservoirs is largely influenced by the chemistry of their inflows (Blaxter 1977), which is in turn influenced by the geology of their watersheds (Wetzel 1983; Jones and Knowlton 1993; Riera et al. 1992). The relative concentration of major ions in fresh waters generally is $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$, and the relative concentrations of major anions is $CO_3^{--} > SO_4^{--} > Cl^{-}$ (Wetzel 1983). In Lake Kemp, the relative concentration of these ions, based on lakewide averages during 1997, is Na^{+} (636 mg/l) > Ca^{++} (250 mg/l) > Mg^{++} (65 mg/l) > K^{+} (8 mg/l) for cations and Cl^{-} (1021 mg/l) > SO_4^{--} (791 mg/l) > CO_3^{--} for anions. The relative concentrations of these ions reflects several processes. First, the predominance of sodium and chloride in Lake Kemp results from the dissolution of halides in the Wichita River drainage and their import into the lake. Second, the relatively high concentration of sulfates in Lake Kemp is due to dissolution of gypsum ($CaSO_4{\cdot}2H_20$) deposits, which are common in West Texas (Sonnefeld 1984) including the Wichita River basin (Joerns 1961). Third, the relatively low concentration of calcium, which is less than 1/3 that of sulfates, likely results from precipitation of $CaCO_3$, which begins to reach supersaturation and precipitate when alkalinity exceeds 100 to 125 mg/l $CaCO_3$ (Gorham et al. 1983; Kilham 1990) as it generally does in Lake Kemp. Precipitation of calcium, as $CaCO_3$, may be increased in Lake Kemp as a result of the high chloride concentrations in the lake (e.g., Strumm and

Morgan 1996). Fourth, the relatively high concentration of magnesium in Lake Kemp is a result of dissolution of dolomitic limestones ($CaMg(CO_3)_2$) in the Wichita River drainage basin (Joerns 1961).

Ground and Groeger (1994) classified 80 Texas reservoirs based on a number of morphometric and chemical characteristics. They found consistent differences among reservoirs in several characteristics based on their geographic location: eastern, central, and western. In general, western reservoirs, including Lake Kemp, had a high conductivity and alkalinity, and high concentrations of dissolved solids including calcium, sodium, chloride, and sulfate. My results are consistent with this characterization of Lake Kemp.

The nutrient status of Lake Kemp is, unfortunately, inadequately described by my results. High levels of total dissolved solids in Lake Kemp water interfered with nutrient analyses, limiting instrument sensitivity, so that most analytical results were at or below elevated laboratory detection limits. Nitrite- and nitrate-nitrogen concentrations generally were less than 0.1 and 1.0 mg/l, respectively, and soluble and total phosphorus generally were less 0.4 and 0.01 mg/l, respectively. In particular, the phosphorus concentrations are quite low; however, Ground and Groeger (1996) reported an average total phosphate concentration for Lake Kemp, based on analyses conducted by the Texas Water Commission (1988), of 18 μg/l. However, my inspection of the Texas Water Commission's data suggests that Ground and Groeger (1996) made an error in their calculations and that the correct concentration is 9 μg/l. Based on these results, Lake Kemp would appear to be mesotrophic (Likens 1975; Walker 1990)

Samples from Lake Kemp collected from 1983 to 1997, and analyzed by the Texas Natural Resource Conservation Commission, show the average concentration of nitrates and ammonia to be 0.059 mg/l (21 samples) and 0.038 mg/l (13 samples), respectively, and the concentration of total phosphorus to be 0.028 mg/l (21 samples). These results yield a N:P ratio of approximately 3.5:1, indicating potential nitrogen limitation in Lake Kemp (Horne and Goldman 1994). However, given the relatively low concentrations of both nitrogen and phosphorus in Lake Kemp, both are likely to limit phytoplankton growth (Elster et al. 1990). The N:P ratio suggests, though, that nitrogen is the more limiting nutrient.

Based on chlorophyll-*a* concentrations, which ranged from 1.5 to 15.7 µg/l throughout the study, Lake Kemp can be characterized as meso-eutrophic according to the criteria of Likens (1975), Carlson (1977), and Walker (1990). Ground and Groeger (1996) reported a mean growing season (May through October) chlorophyll-*a* concentration of 9.6 µg/l near the dam at Lake Kemp. Mean growing season chlorophyll-*a* concentrations in 1997 were 9.5 µg/l throughout the lake and 8.3 µg/l at site K1, near the dam. Ground and Groeger's results are limited, but suggest there has been no recent change in phytoplankton biomass in Lake Kemp. In contrast, the Texas Natural Conservation Commission (1998) suggested that chlorophyll-*a* concentrations in Lake Kemp have decreased in recent years. This is based on a 10-year running average, based on 13 measurements. However, seven of these measurements, over a four-year period, indicated the sample chlorophyll-*a* concentration was < .0 µg/l. These results have to be considered suspect. Excluding these results, a mean chlorophyll-*a* concentration of 7.4 is indicated, which agrees well with the overall mean chlorophyll-*a* concentration I observed at site K1 (7.0 μg/l).

The trophic status of Lake Kemp also can be characterized based on transparency (Secchi depth). Secchi depth in Lake Kemp ranged from 0.27 to 1.66 m during 1997. Based on criteria presented by Carlson (1977) and Walker (1990), Lake Kemp can be considered as eutrophic. However, trophic classification, based on Secchi depth, is unreliable in lakes with a substantial concentration of nonliving suspended particles (Carlson 1977; Canfield and Bachman 1981). This appears to be the case with Lake Kemp. Carlson (1977) presented a relationship between Secchi depth (m) and chlorophyll-a concentration (μg/l):

$$\text{Secchi depth (m)} = 7.7 * \text{Chlorophyll-}a^{-0.68}$$

Using this relationship and the lakewide growing season mean chlorophyll-a concentration for Lake Kemp (9.5 μg/l), the growing season Secchi depth should be 0.87 m. This is approximately 50% less than the observed mean growing season Secchi depth (1.7 m) in Lake Kemp. This suggests that nonliving suspended particles are responsible for a substantial portion of the light absorption in the lake.

Overall, the best trophic characterization of Lake Kemp appears to be that based on chlorophyll-*a* concentration. This suggests that the lake is meso-eutrophic.

Biological Limnology of Lake Kemp

Marzolf (1984) and Kimmel and Groeger (1986) presented conceptual models for spatial (uplake-downlake) changes in various physical, chemical, and biological charactersitics in reservoirs. Generally, these models divide reservoirs into three zones, which include an uplake, riverine zone, a river-reservoir transition zone, and a downlake, lacustrine zone. The riverine zone is characterized by relatively high flow, high nutrient concentrations, light limitation due to high suspended particle concentrations, and moderately low phytoplankton and zooplankton abundances. The transition zone has reduced flow, moderately high nutrient concentrations, and reduced concentrations of suspended particles due to sedimentation. This zone typically has high phytoplankton and zooplankton abundances, because of adequate nutrient availability and increased light penetration. The lacustrine zone has low flow, light light penetration, and depends on nutrient supply by internal recycling, so it is commonly nutrient limited. Consequently, phytoplankton and zooplankton abundances are reduced compared with the transition zone.

According to this model, one would expect the greatest chlorophyll-*a* concentrations, phytoplankton cell counts, and zooplankton densities to occur at sites K3 and K4. Instead, each of these measures reaches peak density at site K6 and progressively decreases downlake to site K1. This suggests that sites K5 and K6 may not adequately represent riverine conditions in Lake Kemp. Other than this, conditions in Lake Kemp are generally consistent with the conceptual models of Marzolf (1984) and Kimmel and Groeger (1986). Turbidity and and extinction coefficients progressively decrease downlake from site K6 to K1, and transparency (Secchi depth) increases from site K6 to K1

Phytoplankton genera found in Lake Kemp are typical constituents of the plankton of mesotrophic and eutrophic lakes in North America (Wetzel 1983; Horne and Goldman 1994). Chrysophytes were common in the early spring (April and May) in Lake Kemp, often accounting for the greatest portion of the phytoplankton. They were replaced in June by cyanobacteria, which remained numerically dominant through the summer and fall. In November and December, chrysophytes again succeeded cyanobacteria as the most abundant constituents of the phytoplankton. Throughout the year, green algae and diatoms were relatively small constituents of the Lake Kemp phytoplankton. However, in the absence of samples from January through March, it is possible that these groups were seasonally abundant. This pattern of seasonal succession differs from the pattern generally observed in North American lakes, which includes an early spring bloom of diatoms, followed by late spring blooms of chrysophytes and green algae, which are replaced in summer by cyanobacteria, followed by a second bloom of diatoms in fall, following turnover.

The cyanobacteria genera common in Lake Kemp are common dominant and subdominant constituents of mesotrophic and eutrophic lakes (Pearl 1988) and at least two of these genera, Lyngbya and Oscillatoria are known to be nitrogen fixers. The low N:P ratio in Lake Kemp, suggestive of nitrogen limitation, may explain the dominance of cyanobacteria during much of the year in Lake Kemp. Alternatively, because many cyanobacteria rise to the surface during the day (Pearl 1988) they may predominate in Lake Kemp because of the low transparency that is characteristic of the lake.

Potential Effects of Chloride Control Structures on the Limnology of Lake Kemp

To assess the potential effects of the Bateman low flow dam, Baldys et al. (1996) studied TDS and chloride concentrations from October 1982 through September 1992, at several sites on the South Wichita and Wichita rivers upstream from Lake Kemp, at the dam at Lake Kemp, and in the Wichita River downstream from the lake. They found evidence of a highly significant ($\underline{P} < 0.0001$) decrease in TDS and chloride concentrations in the South Wichita and Wichita rivers upstream from Lake Kemp. They found suggestive evidence of decreases in TDS ($\underline{P} = 0.108$) and chloride ($\underline{P} = 0.083$) in Lake Kemp and strong evidence for decreases in both TDS and chloride ($\underline{P} < 0.0001$) downstream from Lake Kemp. However, Baldys et al. (1996) believed the evidence for a decrease in chloride concentrations in Lake Kemp and the Wichita River downstream were inconclusive.

My results allow a qualitative assessment of potential changes in chloride concentrations in Lake Kemp. Baldys et al. (1996) sampled Lake Kemp on ten occasions between August 1989 and August 1992. The mean volume-weighted concentration of TDS in their samples was 2562 mg/l and the mean volume-weighted chloride concentration was 1512 mg/l. Mean surface TDS in 1997, calculated across all samples, (mean = 2732 mg/l, range = 1959 to 3414 mg/l) and bottom TDS (mean = 2793 mg/l, range = 2325 to 3332 mg/l) was slightly higher than that observed by Baldys et al (1996). However, chloride concentrations (surface mean = 1000 mg/l; range = 530 to 1367 mg/l) and bottom TDS (mean = 1042 mg/l; range = 587 to 1400 mg/l) were substantially lower in 1997 than reported by Baldys et al. (1996). These results suggest that chloride concentrations decreased approximately 33% in Lake Kemp between 1992 and 1997. However, Baldys et al.'s (1996) results were volume weighted, whereas mine were not- this weighting may affect my assessment, which should be considered as tentative. Additional monitoring of chloride concentrations in the Wichiata River and a better understanding of the chemical limnology of Lake Kemp may strengthen this assessment.

Baldys et al. (1996) believed that their results showing decreases in TDS and chloride concentrations in Lake Kemp and in the Wichita River downstream were inconclusive, because the lake had been diluted by freshwater inflows from the Wichita River during the spring of 1988. USGS records indicate that Lake Kemp water level increased by 1.8 m, from 347.4 to 349.2 m above sea level, during May 1988. A similar increase in water level occurred in 1997. Lake Kemp water level increased 1.8 m, from 364.0 to 347.8 m above sea level, between January 1 and May 11, 1997, with most of this increase occurring in May. A number of physical (conductivity) and chemical (TDS, calcium, chloride, etc.) measurements demonstrate that these inflows were substantially fresher than Lake Kemp. Therefore, on a gross level, my samples are comparable to those of Baldys et al. (1996) and support the suggestion that chloride concentrations have decreased in Lake Kemp.

The Texas Water Commission (now part of the Texas Natural Resource Conservation Commission) has sporadically measured chloride concentrations in Lake Kemp near the dam. The mean chloride concentration in Lake Kemp before operation of the Bateman chloride control structure was 1430 mg/l based on four measurements made between November 1983 and November 1985. The mean chloride concentration in Lake

Kemp after operation of the Bateman chloride control structure was 1093 mg/l based on 14 measurements made between May 1987 and April 1997. These results, especially for the pre-operation period, are quite limited.

Several lines of evidence suggest chloride concentrations in Lake Kemp have decreased since the mid-1980s; however, the evidence is still not conclusive at this time. Variation in sampling and analytical protocols, and seasonal and inflow (dilution) related variation in chloride concentrations may account for some of the observed temporal difference. Baldys et al. (1996) reported that the specific conductance in the North Wichita and South Wichita rivers is similar (see also Garza 1983), but that 60% of the longterm annual mean flow of the Wichita River upstream from Lake Kemp is contributed by the North Wichita River. Therefore, potential effects of chloride control structures on the South Wichita River may be masked by chloride loading from the North Wichita River. Continued monitoring of chloride concentrations at USGS gauging stations on the North and South Wichita rivers, or on the Wichita River upstream from Lake Kemp should be conducted in conjunction with future limnological surveys of Lake Kemp

Insufficient information is available to allow any assessment of potential changes in turbidity, nutrient concentrations, and phytoplankton productivity in Lake Kemp as a result of operation of the Bateman chloride control facility.

Literature Cited

American Public Health Association. 1996. Standard methods of the examination of water and wastewater, 24th edition. American Public Health Association, Inc. New York, NY.

Baldys, S., III, P. W. Bush, and C. C. Kidwell. 1996. Effects of low-flow diversions from the South Wichita River on downstream salinity of the South Wichita River, Lake Kemp, and the Wichita River, North Texas, October 1982-September 1992. US Geological Survey Water-Resources Investigations Report 95-4288.

Baxter, R. M. 1977. Environmental effects of dams and impoundments. Annual Reviews of Ecology and Systematics 8:255-283.

Burks, S. L. 1996. Development of a water quality monitoring plan for Lake Kemp, TX. Unpublished report prepared for Tulsa District, US Army Corps of Engineers.

Canfield, D. E., Jr., and R. W. Bachmann. 1981. Prediction of total phosphorus concentrations, chlorophyll *a*, and Secchi depths in natural and artificial lakes. Canadian Journal of Fisheries and Aquatic Science 38:414-423.

Carlson, R. E. 1977. A trophic state index for lakes. Limnology and Oceanography 22:361-369.

Cole, T. M., and H. H. Hannan. 1990. Dissolved oxygen dynamics. Pages 71-107 *in* K. W. Thornton, B. L. Kimmel, and F. E. Payne, editors. Reservoir limnology: ecological perspectives. Wiley. New York, NY.

Elster, J. J., E. R. Marzlof, and C. R. Goldman. 1990. Phosphorus and nitrogen limitation in the freshwaters of North America: a review and critique of \ experimental enrichments. Canadian Journal of Fisheries and Aquatic Sciences \ 47:1468-1477.

Ford, D. E. 1990. Reservoir transport systems. Pages 15-41 *in* K. W. Thornton, B. L. Kimmel, and F. E. Payne, editors. Reservoir limnology: ecological perspectives. Wiley. New York, NY.

Garza, S. 1983. Projected effects of proposed chloride-control projects on shallow ground water—preliminary results for the Wichita River Basin, Texas. U.S. Geological Survey, Water-Resources Investigations Report 83-4026. Austin, TX.

Gorham, E., W. E. Dean, and J. E. Sanger. 1983. The chemical composition of lakes in the north-central United States. Limnology and Oceanography 28:287-301.

Greiner, J. H., Jr. 1982. Erosion and sedimentation by water in Texas: average rates estimated in 1979. Texas Department of Water Resources Report No. 268. Austin, TX.

Ground, T. A., and A. W. Groeger. 1994. Chemical classification and trophic characteristics of Texas reservoirs. Lake and Reservoir Management 10: 189-201

Harris, B. B., and J. K. G. Silvey. 1940. Limnological investigations on Texas reservoir lakes. Ecological Monographs 10:111-143.

Horne, A. J., and C. R. Goldman. 1994. Limnology, 2nd edition. McGraw-Hill. New York, NY.

Joerns, J. O. 1961. Investigation of sources of natural pollution: Wichita River basin above Lake Kemp, Texas, 1951-1957. U.S. Geological Survey, Water Resources Division, Open File Release No. 62. Austin, TX.

Jones, J. R., and M. F. Knowlton. 1983. Limnology of Missouri reservoirs: an analysis of regional patterns. Lake and Reservoir Managment 8:17-30.

Kilham, P. 1960. Mechanisms controlling the chemical composition of lakes and rivers: data from Africa. Limnology and Oceanography 35:80-83

Kimmel, B. L., and A. W. Groeger. 1986. Limnological and ecological changes associated with reservoir aging. Pages 103-109 *in* G. E. Hall and M. J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80s. Reservoir Committee, American Fisheries Society. Bethesda, MD.

Kimmel, B. L. O. T. Lind, and L. J. Paulson. 1990. Reservoir primary production. Pages 133-198 *in* K. W. Thornton, B. L. Kimmel, and F. E. Payne, editors. Reservoir limnology: ecological perspectives. Wiley. New York, NY.

Lewis, L. D., and W. W. Dalquest. 1957. A fisheries survey of the Big Wichita River system. IF Report Series No. 2. Texas Parks and Wildlife Department, Austin, TX.

Likens, G. E. 1975. Primary productivity of inland aquatic ecosystems. Pages 185-202 *in* H. Lieth and R. H. Whittaker, editors. Primary productivity of the biosphere. Springer-Verlag. New York, NY.

Lind, O. T. 1979. Handbook of common methods in limnology, second edition. C. V. Mosby Company. St. Louis, MO.

Marzolf, G. R. 1984. Reservoirs in the Great Plains of North America. Pages 291-302 *in* F. B. Taub, editor. Ecosystems of the world 23, lakes and reservoirs. Elsevier. New York, NY.

Paerl, H. W. 1988. Growth and reproductive strategies of freshwater bluegreen algae (cyanobacteria). Pages 261-315 *in* C. D. Sangren, editor. Growth and reproductive strategies of freshwater phytoplankton. Cambridge University Press. Cambridge, England.

Ramos, M.G., editor. 1995. Texas almanac, 1996-1997. The Dallas Morning News, Dallas, TX.

Riera, J. L., D. Jaume, J. de Manuel, J. A. Morgui, and J. Armengol. 1992. Patterns of variation in the limnology of Spanish reservoirs: a regional study. Limnetica 8:111-123

Sonnenfeld, P. 1984. Brines and evaporites. Academic Press, Inc. Orlando, Florida.

Sterner, R. W. 1994. Seasonal and spatial patterns in macro- and micronutrient limitations in Joe Pool Lake, Texas. Limnology and Oceanography 39:535-550.

Strumm, W., and J. J. Morgan. 1996. Aquatic chemistry, third edition. Wiley. New York, NY.

Texas Natural Resource Conservation Commission (TNRCC). 1998. 1998 state of Texas reservoir water quality assessment. Texas Natural Resource Conservation Commission, Austin, TX.

Texas Water Commission. 1988. The state of Texas water quality inventory, 9th edition. Report LP 88-04. Texas Water Commission, Austin, TX.

U.S. Army Corps of Engineers. 1972. Chloride-control. Part I, Arkansas-Red River basins, Oklahoma, Kansas, and Texas. Tulsa District, U.S. Army Corps of Engineers, Tulsa, OK.

U.S. Army Corps of Engineers. 1994. Draft supplement I to the final environmental statement: Red River Chloride Control Project Texas and Oklahoma. Tulsa \ District, U.S. Army Corps of Engineers, Tulsa, OK.

U.S. Environmental Protection Agency (U.S. EPA). 1983. Methods for chemical analysis of water and wastes. EPA 600/4-79-020. Washington, D.C.

U.S. Environmental Protection Agency (U.S. EPA). 1993. Methods for the determination of inorganic substances in environmental samples. EPA 600/R-93-100. Washington, D.C.

Walker, W. W. 1990. Predicting lake water quality. 1990. Pages 69-91, *in* H. Olem and Flock, editors. Lake and reservoir restoration guidance manual, second edition. EPA 440/4-90-006. U.S. Environmental Protection Agency, Washington, D.C.

Wetzel, R. G. 1983. Limnology, second edition. Saunders College Publishing. Philadelphia, PA.

Wetzel, R. G., and G. E. Likens. 1991. Limnological analyses, second edition. Springer. New York, NY.

Wunderlich, W. O., and R. A. Elder. 1967. The mechanics of stratified flow in reservoirs. Pages 56-68 *in* Reservoir fisheries symposium. American Fisheries Society, Washington, D.C.

APPENDICES

APPENDIX A

Water Chemistry Summarized Across All Sampling Sites, Dates, and Depths

Appendix A: Water Chemistry Summarized Across All Sampling Sites and Depths

Parameter	Units	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	104.37	86.4	129.28	6.79	396
Hardness	mg/l CaCO3	891.32	535	1700	187.97	396
Total dissolved solids	mg/l	2781.55	1822	8466	420.51	396
Total suspended solids	mg/l	12.65	0	81	13.74	360
Turbidity	NTU	15.27	1.38	90.6	15.04	858
Chloride	mg/l	1020.78	500	1500	156.73	395
Sulfate	mg/l	790.52	280	1600	117.37	395
Calcium	mg/l	249.95	140	570	68.17	396
Magnesium	mg/l	64.82	18	89	10.37	396
Sodium	mg/l	635.47	220	860	97.1	396
Potassium	mg/l	8.13	0	16	1.91	396
Chlorophyll	ug/l	8.19	0	19.91	3.81	430

APPENDIX B

Water Chemistry Summaries by Site

Appendix B: Water Chemistry Summaries by Site

Parameter	Units	Sampling Site	Depth	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	K1	All depths combined	106.02	93.75	125.75	7.14	66
Alkalinity	mg/l CaCO3	K1	Surface	102.83	93.75	112.66	4.92	33
Alkalinity	mg/l CaCO3	K1	Bottom	109.21	100.5	125.75	7.64	33
Hardness	mg/l CaCO3	K1	All depths combined	885.5	535	1500	182.15	66
Hardness	mg/l CaCO3	K1	Surface	872.82	535	1400	178.97	33
Hardness	mg/l CaCO3	K1	Bottom	898.18	688	1500	187.16	33
Total dissolved solids	mg/l	K1	All depths combined	2737.67	2396	3518	240.54	66
Total dissolved solids	mg/l	K1	Surface	2708	2396	3518	263.87	33
Total dissolved solids	mg/l	K1	Bottom	2767.33	2400	3150	214.67	33
Total suspended solids	mg/l	K1	All depths combined	8.19	0	37	8.31	60
Total suspended solids	mg/l	K1	Surface	6.05	0	19	4.61	30
Total suspended solids	mg/l	K1	Bottom	10.32	0	37	10.49	30
Turbidity	NTU	K1	All depths combined	9.09	1.38	72.5	10.01	219
Turbidity	NTU	K1	Surface	5.35	2.46	13.07	2.74	110
Turbidity	NTU	K1	Bottom	12.86	1.38	72.5	12.89	109
Chloride	mg/l	K1	All depths combined	1040.61	860	1300	115.89	66
Chloride	mg/l	K1	Surface	1024.85	880	1300	105.24	33
Chloride	mg/l	K1	Bottom	1056.36	860	1300	125.27	33
Sulfate	mg/l	K1	All depths combined	787.58	630	1100	76.52	66
Sulfate	mg/l	K1	Surface	782.42	640	920	64.76	33
Sulfate	mg/l	K1	Bottom	792.73	630	1100	87.44	33
Calcium	mg/l	K1	All depths combined	249.21	140	480	66.6	66
Calcium	mg/l	K1	Surface	246.76	140	470	68.06	33
Calcium	mg/l	K1	Bottom	251.67	180	480	66.06	33
Magnesium	mg/l	K1	All depths combined	63.12	25	82	10.18	66
Magnesium	mg/l	K1	Surface	61.93	25	80	10.98	33
Magnesium	mg/l	K1	Bottom	64.3	52	82	9.33	33
Sodium	mg/l	K1	All depths combined	787.58	630	1100	76.52	66
Sodium	mg/l	K1	Surface	603.7	260	740	93.44	33
Sodium	mg/l	K1	Bottom	647.73	490	780	82.48	33
Potassium	mg/l	K1	All depths combined	7.94	5.3	12	1.56	66
Potassium	mg/l	K1	Surface	8.02	5.3	11	1.5	33
Potassium	mg/l	K1	Bottom	7.86	6	12	1.65	33
Chlorophyll	ug/l	K1	All depths combined	7.03	2.29	13.64	2.84	111
Chlorophyll	ug/l	K1	Surface	7.03	2.29	13.64	2.84	111

Appendix B: Water Chemistry Summaries by Site

Parameter	Units	Sampling Site	Depth	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	K2	All depths combined	105.35	92.42	129.28	7.7	66
Alkalinity	mg/l CaCO3	K2	Surface	101.81	92.42	110.33	5.11	33
Alkalinity	mg/l CaCO3	K2	Bottom	108.88	98.5	129.28	8.28	33
Hardness	mg/l CaCO3	K2	All depths combined	887.17	643	1500	185.26	66
Hardness	mg/l CaCO3	K2	Surface	880.85	643	1400	189.22	33
Hardness	mg/l CaCO3	K2	Bottom	893.48	647	1500	183.94	33
Total dissolved solids	mg/l	K2	All depths combined	2698.24	2198	3150	231.99	66
Total dissolved solids	mg/l	K2	Surface	2692.42	2260	3150	245.69	33
Total dissolved solids	mg/l	K2	Bottom	2704.06	2198	3150	221.12	33
Total suspended solids	mg/l	K2	All depths combined	8.13	0	54.5	10.88	60
Total suspended solids	mg/l	K2	Surface	4.94	0	21.5	5.04	30
Total suspended solids	mg/l	K2	Bottom	11.32	0	54.5	13.94	30
Turbidity	NTU	K2	All depths combined	9.61	2.79	32.7	6.35	66
Turbidity	NTU	K2	Surface	6.4	3.6	12.3	1.99	33
Turbidity	NTU	K2	Bottom	12.81	2.79	32.7	7.53	33
Chloride	mg/l	K2	All depths combined	1038.79	810	1300	108.11	66
Chloride	mg/l	K2	Surface	1020.3	810	1300	108.44	33
Chloride	mg/l	K2	Bottom	1057.27	860	1200	106.19	33
Sulfate	mg/l	K2	All depths combined	790.91	620	980	78.15	66
Sulfate	mg/l	K2	Surface	789.7	670	980	68.44	33
Sulfate	mg/l	K2	Bottom	792.12	620	960	87.85	33
Calcium	mg/l	K2	All depths combined	252.03	170	570	73.48	66
Calcium	mg/l	K2	Surface	248.27	170	490	71.41	33
Calcium	mg/l	K2	Bottom	255.79	170	570	76.4	33
Magnesium	mg/l	K2	All depths combined	62.54	18	81	11.8	66
Magnesium	mg/l	K2	Surface	63.15	41	80	9.69	33
Magnesium	mg/l	K2	Bottom	61.93	18	81	13.72	33
Sodium	mg/l	K2	All depths combined	790.91	620	980	78.15	66
Sodium	mg/l	K2	Surface	625.3	420	760	78.62	33
Sodium	mg/l	K2	Bottom	621.58	260	780	115.03	33
Potassium	mg/l	K2	All depths combined	7.99	6.1	11	1.46	66
Potassium	mg/l	K2	Surface	7.84	6.1	11	1.48	33
Potassium	mg/l	K2	Bottom	8.14	6.1	11	1.45	33
Chlorophyll	ug/l	K2	All depths combined	7.21	2.74	11.85	2.69	33
Chlorophyll	ug/l	K2	Surface	7.21	2.74	11.85	2.69	33

Parameter	Units	Sampling Site	Depth	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	K3	All depths combined	103.28	92.91	114.37	5.3	66
Alkalinity	mg/l CaCO3	K3	Surface	102.08	92.91	110.33	5.1	33
Alkalinity	mg/l CaCO3	K3	Bottom	104.48	96.35	114.37	5.3	33
Hardness	mg/l CaCO3	K3	All depths combined	912.42	647	1700	219.06	66
Hardness	mg/l CaCO3	K3	Surface	911.12	647	1700	229.44	33
Hardness	mg/l CaCO3	K3	Bottom	913.73	655	1500	211.73	33
Total dissolved solids	mg/l	K3	All depths combined	2724.64	2192	3500	270.19	66
Total dissolved solids	mg/l	K3	Surface	2669.76	2192	3150	271.79	33
Total dissolved solids	mg/l	K3	Bottom	2779.52	2334	3500	261.15	33
Total suspended solids	mg/l	K3	All depths combined	9.98	0.5	33.33	7.22	60
Total suspended solids	mg/l	K3	Surface	7.3	0.5	22	5.72	30
Total suspended solids	mg/l	K3	Bottom	12.67	1.5	33.33	7.64	30
Turbidity	NTU	K3	All depths combined	12.83	2.64	45.6	9.29	66
Turbidity	NTU	K3	Surface	8.72	5.7	13.83	2.39	33
Turbidity	NTU	K3	Bottom	16.93	2.64	45.6	11.61	33
Chloride	mg/l	K3	All depths combined	1008.48	740	1300	112.55	66
Chloride	mg/l	K3	Surface	991.82	780	1200	100.42	33
Chloride	mg/l	K3	Bottom	1025.15	740	1300	122.78	33
Sulfate	mg/l	K3	All depths combined	764.39	280	1000	108.95	66
Sulfate	mg/l	K3	Surface	757.88	470	960	103.04	33
Sulfate	mg/l	K3	Bottom	770.91	280	1000	115.8	33
Calcium	mg/l	K3	All depths combined	256.38	170	570	82.05	66
Calcium	mg/l	K3	Surface	257.7	170	570	86.46	33
Calcium	mg/l	K3	Bottom	255.06	170	500	78.72	33
Magnesium	mg/l	K3	All depths combined	66.19	53	83	9.5	66
Magnesium	mg/l	K3	Surface	65.36	54	81	9.08	33
Magnesium	mg/l	K3	Bottom	67.01	53	83	9.97	33
Sodium	mg/l	K3	All depths combined	764.39	280	1000	108.95	66
Sodium	mg/l	K3	Surface	631.24	310	770	98.48	33
Sodium	mg/l	K3	Bottom	660.52	300	860	111.25	33
Potassium	mg/l	K3	All depths combined	8.19	5.8	12	1.65	66
Potassium	mg/l	K3	Surface	8.22	6	12	1.66	33
Potassium	mg/l	K3	Bottom	8.17	5.8	12	1.67	33
Chlorophyll	ug/l	K3	All depths combined	7.76	0.73	14.95	3.86	34
Chlorophyll	ug/l	K3	Surface	7.76	0.73	14.95	3.86	34

Appendix B: Water Chemistry Summaries by Site

Parameter	Units	Sampling Site	Depth	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	K4	All depths combined	103.15	92.44	113.83	5.86	66
Alkalinity	mg/l CaCO3	K4	Surface	102.21	92.91	110.33	4.99	33
Alkalinity	mg/l CaCO3	K4	Bottom	104.09	92.44	113.83	6.57	33
Hardness	mg/l CaCO3	K4	All depths combined	900.02	618	1400	195.64	66
Hardness	mg/l CaCO3	K4	Surface	895.88	618	1400	201.66	33
Hardness	mg/l CaCO3	K4	Bottom	904.15	659	1400	192.47	33
Total dissolved solids	mg/l	K4	All depths combined	2836	1822	8466	763.8	66
Total dissolved solids	mg/l	K4	Surface	2670.24	1822	3150	285.4	33
Total dissolved solids	mg/l	K4	Bottom	3001.76	2318	8466	1023.17	33
Total suspended solids	mg/l	K4	All depths combined	12.92	0	81	15.81	60
Total suspended solids	mg/l	K4	Surface	10.97	0	81	17.18	30
Total suspended solids	mg/l	K4	Bottom	14.87	0	68	14.32	30
Turbidity	NTU	K4	All depths combined	12.84	4.68	57.6	9.55	220
Turbidity	NTU	K4	Surface	8.81	4.68	14.46	2.25	110
Turbidity	NTU	K4	Bottom	16.87	5	57.6	12.06	110
Chloride	mg/l	K4	All depths combined	1031.54	670	1500	159.48	65
Chloride	mg/l	K4	Surface	1007.27	690	1300	148.6	33
Chloride	mg/l	K4	Bottom	1056.56	670	1500	168.65	32
Sulfate	mg/l	K4	All depths combined	804.62	580	1100	100.05	65
Sulfate	mg/l	K4	Surface	792.42	580	1000	107.06	33
Sulfate	mg/l	K4	Bottom	817.19	680	1100	92.26	32
Calcium	mg/l	K4	All depths combined	252.15	160	470	68.28	66
Calcium	mg/l	K4	Surface	252.15	160	470	72.87	33
Calcium	mg/l	K4	Bottom	252.15	170	450	64.49	33
Magnesium	mg/l	K4	All depths combined	65.46	47	84	10.09	66
Magnesium	mg/l	K4	Surface	64.24	51	83	9.16	33
Magnesium	mg/l	K4	Bottom	66.68	47	84	10.95	33
Sodium	mg/l	K4	All depths combined	804.62	580	1100	100.05	65
Sodium	mg/l	K4	Surface	612.88	290	770	91.3	33
Sodium	mg/l	K4	Bottom	635.03	220	800	142.78	33
Potassium	mg/l	K4	All depths combined	8.08	5.7	12	1.66	66
Potassium	mg/l	K4	Surface	7.95	5.7	12	1.62	33
Potassium	mg/l	K4	Bottom	8.2	5.7	12	1.72	33
Chlorophyll	ug/l	K4	All depths combined	8.86	0	19.27	3.99	111
Chlorophyll	ug/l	K4	Surface	8.86	0	19.27	3.99	111

Appendix B: Water Chemistry Summaries by Site

Parameter	Units	Sampling Site	Depth	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	K	All depths combined	104.14	92.9	115.92	6.24	66
Alkalinity	mg/l CaCO3	K5	Surface	103.49	92.91	114.89	6.29	33
Alkalinity	mg/l CaCO3	K5	Bottom	104.78	93.91	115.92	6.21	33
Hardness	mg/l CaCO3	K5	All depths combined	900	626	1400	199.05	66
Hardness	mg/l CaCO3	K5	Surface	885.39	626	1400	196.93	33
Hardness	mg/l CaCO3	K5	Bottom	914.61	660	1400	203.13	33
Total dissolved solids	mg/l	K5	All depths combined	2841.48	1892	3704	344.35	66
Total dissolved solids	mg/l	K5	Surface	2824.61	1892	3414	367.3	33
Total dissolved solids	mg/l	K5	Bottom	2858.36	2240	3704	324.58	33
Total suspended solids	mg/l	K5	All depths combined	18.19	0	76.33	18.31	60
Total suspended solids	mg/l	K5	Surface	12.23	0.5	52	12.55	30
Total suspended solids	mg/l	K5	Bottom	24.15	0	76.33	21.24	30
Turbidity	NTU	K5	All depths combined	19.8	6.14	78.8	16.93	66
Turbidity	NTU	K5	Surface	11.74	6.14	25.3	4.69	33
Turbidity	NTU	K5	Bottom	27.87	8.89	78.8	20.64	33
Chloride	mg/l	K5	All depths combined	1011.52	570	1400	181.39	66
Chloride	mg/l	K5	Surface	1010.91	670	1400	172.74	33
Chloride	mg/l	K5	Bottom	1012.12	570	1400	192.33	33
Sulfate	mg/l	K5	All depths combined	784.7	440	1100	122.25	66
Sulfate	mg/l	K5	Surface	781.82	630	980	87.59	33
Sulfate	mg/l	K5	Bottom	787.58	440	1100	150.56	33
Calcium	mg/l	K5	All depths combined	253.29	160	460	71.66	66
Calcium	mg/l	K5	Surface	247.76	160	450	69.7	33
Calcium	mg/l	K5	Bottom	258.82	170	460	74.23	33
Magnesium	mg/l	K5	All depths combined	65.34	48	83	9.58	66
Magnesium	mg/l	K5	Surface	64.91	48	81	9.71	33
Magnesium	mg/l	K5	Bottom	65.77	49	83	9.57	33
Sodium	mg/l	K5	All depths combined	784.7	440	1100	122.25	66
Sodium	mg/l	K5	Surface	639.39	510	800	81.26	33
Sodium	mg/l	K5	Bottom	646.12	510	780	80.16	33
Potassium	mg/l	K5	All depths combined	8.06	5	12	1.78	66
Potassium	mg/l	K5	Surface	7.99	5	11	1.77	33
Potassium	mg/l	K5	Bottom	8.12	5.5	12	1.81	33
Chlorophyll	ug/l	K5	All depths combined	8.48	1.91	15.71	4.04	33
Chlorophyll	ug/l	K5	Surface	8.48	1.91	15.71	4.04	33

Appendix B: Water Chemistry Summaries by Site

Parameter	Units	Sampling Site	Depth	Mean	Minimum	Maximum	Standard Deviation	N
Alkalinity	mg/l CaCO3	K6	All depths combined	104.3	86.4	118.51	7.89	66
Alkalinity	mg/l CaCO3	K6	Surface	103.38	88.2	117.47	7.81	33
Alkalinity	mg/l CaCO3	K6	Bottom	105.21	86.4	118.51	7.98	33
Hardness	mg/l CaCO3	K6	All depths combined	862.8	630	1130	140.86	66
Hardness	mg/l CaCO3	K6	Surface	856.03	630	1130	135.76	33
Hardness	mg/l CaCO3	K6	Bottom	869.58	650	1120	147.57	33
Total dissolved solids	mg/l	K6	All depths combined	2851.24	2026	4898	405.06	66
Total dissolved solids	mg/l	K6	Surface	2852.85	2026	4898	517.95	33
Total dissolved solids	mg/l	K6	Bottom	2849.64	2424	3288	254.95	33
Total suspended solids	mg/l	K6	All depths combined	18.49	1	59	14.47	60
Total suspended solids	mg/l	K6	Surface	12.32	1	37	8.69	30
Total suspended solids	mg/l	K6	Bottom	24.66	1	59	16.48	30
Turbidity	NTU	K6	All depths combined	24.88	6.58	90.6	20.36	221
Turbidity	NTU	K6	Surface	19.19	6.58	90.6	17.96	110
Turbidity	NTU	K6	Bottom	30.53	7.09	90.6	21.1	111
Chloride	mg/l	K6	All depths combined	993.94	500	1500	226.59	66
Chloride	mg/l	K6	Surface	944.85	500	1300	236.51	33
Chloride	mg/l	K6	Bottom	1043.03	520	1500	208.29	33
Sulfate	mg/l	K6	All depths combined	811.14	410	1600	183.05	66
Sulfate	mg/l	K6	Surface	809.55	410	1600	213.55	33
Sulfate	mg/l	K6	Bottom	812.73	420	1100	149.84	33
Calcium	mg/l	K6	All depths combined	236.62	160	310	40.37	66
Calcium	mg/l	K6	Surface	234.52	160	310	39.59	33
Calcium	mg/l	K6	Bottom	238.73	170	310	41.65	33
Magnesium	mg/l	K6	All depths combined	66.25	48	89	10.65	66
Magnesium	mg/l	K6	Surface	65.65	49	87	10.11	33
Magnesium	mg/l	K6	Bottom	66.85	48	89	11.29	33
Sodium	mg/l	K6	All depths combined	811.14	410	1600	183.05	66
Sodium	mg/l	K6	Surface	640.67	510	800	78.99	33
Sodium	mg/l	K6	Bottom	661.52	510	810	88.41	33
Potassium	mg/l	K6	All depths combined	8.54	0	16	2.93	66
Potassium	mg/l	K6	Surface	8.8	5.8	16	2.7	33
Potassium	mg/l	K6	Bottom	8.28	0	16	3.17	33
Chlorophyll	ug/l	K6	All depths combined	9.04	1.29	19.91	4.35	108
Chlorophyll	ug/l	K6	Surface	9.04	1.29	19.91	4.35	108

APPENDIX C

Lake Kemp Physicochemical Profiles

Lake Kemp Physicochemical Profiles: 23-24 April 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K1	4/23/97	1145	16.4	1.66	0.0	15.83	8.30	10.10	4900	1898.00
K1	4/23/97	1145	16.4	1.66	1.0	15.85	8.31	10.01	4900	801.00
K1	4/23/97	1145	16.4	1.66	2.0	15.82	8.33	9.93	4900	462.10
K1	4/23/97	1145	16.4	1.66	3.0	15.80	8.32	9.91	4900	218.30
K1	4/23/97	1145	16.4	1.66	4.0	15.72	8.32	9.92	4900	134.00
K1	4/23/97	1145	16.4	1.66	5.0	15.01	8.31	9.89	4920	78.58
K1	4/23/97	1145	16.4	1.66	6.0	15.58	8.31	9.84	4920	43.96
K1	4/23/97	1145	16.4	1.66	7.0	15.55	8.31	9.82	4920	27.10
K1	4/23/97	1145	16.4	1.66	8.0	15.53	8.31	9.78	4920	14.76
K1	4/23/97	1145	16.4	1.66	9.0	15.51	8.31	9.75	4920	9.72
K1	4/23/97	1145	16.4	1.66	10.0	15.46	8.30	9.76	4920	5.70
K1	4/23/97	1145	16.4	1.66	11.0	14.99	8.29	9.82	4930	.
K1	4/23/97	1145	16.4	1.66	12.0	14.46	8.26	9.75	4940	.
K1	4/23/97	1145	16.4	1.66	13.0	13.57	8.18	9.30	4950	.
K1	4/23/97	1145	16.4	1.66	14.0	13.37	8.16	9.13	4960	.
K1	4/23/97	1145	16.4	1.66	15.0	13.12	8.15	9.12	4960	.
K1	4/23/97	1145	16.4	1.66	16.0	12.58	8.07	8.48	4980	.
K2	4/24/97	1045	13.0	1.45	0.0	15.92	8.24	9.85	4930	121.20
K2	4/24/97	1045	13.0	1.45	1.0	15.92	8.24	9.85	4930	50.40
K2	4/24/97	1045	13.0	1.45	2.0	15.93	8.24	9.86	4930	24.62
K2	4/24/97	1045	13.0	1.45	3.0	15.93	8.24	9.86	4930	13.19
K2	4/24/97	1045	13.0	1.45	4.0	15.93	8.24	9.88	4930	7.99
K2	4/24/97	1045	13.0	1.45	5.0	15.92	8.24	9.88	4930	4.60
K2	4/24/97	1045	13.0	1.45	6.0	15.92	8.23	9.89	4930	3.03
K2	4/24/97	1045	13.0	1.45	7.0	15.90	8.23	9.93	4930	1.78
K2	4/24/97	1045	13.0	1.45	8.0	15.83	8.23	10.10	4920	0.60
K2	4/24/97	1045	13.0	1.45	9.0	15.70	8.22	10.07	4920	.
K2	4/24/97	1045	13.0	1.45	10.0	15.46	8.20	10.01	4920	.
K2	4/24/97	1045	13.0	1.45	11.0	15.35	8.15	9.77	4930	.
K2	4/24/97	1045	13.0	1.45	12.0	15.45	8.19	10.05	4940	.
K2	4/24/97	1045	13.0	1.45	13.0	15.25	8.16	10.78	4940	.

Lake Kemp Physicochemical Profiles: 23-24 April 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	4/24/97	1130	10.0	1.42	0.0	16.05	8.23	9.47	4940	413.60
K3	4/24/97	1130	10.0	1.42	1.0	16.05	8.23	9.38	4940	167.00
K3	4/24/97	1130	10.0	1.42	2.0	16.05	8.23	9.42	4940	58.36
K3	4/24/97	1130	10.0	1.42	3.0	16.02	8.27	9.35	4940	22.63
K3	4/24/97	1130	10.0	1.42	4.0	16.02	8.23	9.36	4940	11.05
K3	4/24/97	1130	10.0	1.42	5.0	16.00	8.25	9.34	4940	4.28
K3	4/24/97	1130	10.0	1.42	6.0	15.98	8.23	9.42	4940	2.61
K3	4/24/97	1130	10.0	1.42	7.0	15.90	8.22	9.35	4940	.
K3	4/24/97	1130	10.0	1.42	8.0	15.75	8.21	9.12	4940	.
K3	4/24/97	1130	10.0	1.42	9.0	15.60	8.19	9.06	4930	.
K4	4/24/97	1305	8.4	0.98	0.0	16.64	8.22	9.02	4960	249.30
K4	4/24/97	1305	8.4	0.98	1.0	16.64	8.21	9.13	4960	119.85
K4	4/24/97	1305	8.4	0.98	2.0	16.54	8.21	9.15	4970	33.68
K4	4/24/97	1305	8.4	0.98	3.0	16.62	8.22	9.19	4970	9.89
K4	4/24/97	1305	8.4	0.98	4.0	16.47	8.20	9.11	4970	2.79
K4	4/24/97	1305	8.4	0.98	5.0	15.88	8.14	8.75	4960	1.11
K4	4/24/97	1305	8.4	0.98	6.0	15.13	8.07	8.75	4950	.
K4	4/24/97	1305	8.4	0.98	7.0	14.46	8.07	8.97	4960	.
K4	4/24/97	1305	8.4	0.98	8.0	14.46	8.08	9.25	4960	.
K5	4/24/97	1417	6.0	0.65	0.0	16.91	8.24	9.30	4960	444.20
K5	4/24/97	1417	6.0	0.65	1.0	16.91	8.24	9.34	4960	140.50
K5	4/24/97	1417	6.0	0.65	2.0	16.91	8.24	9.14	4960	29.37
K5	4/24/97	1417	6.0	0.65	3.0	16.93	8.24	9.28	4960	6.02
K5	4/24/97	1417	6.0	0.65	4.0	16.93	8.24	9.32	4960	1.43
K5	4/24/97	1417	6.0	0.65	5.0	16.91	8.24	9.47	4960	.
K5	4/24/97	1417	6.0	0.65	5.5	16.88	8.24	9.67	4960	.
K6	4/24/97	1200	3.0	0.42	0.0	16.94	8.22	9.02	5020	221.90
K6	4/24/97	1200	3.0	0.42	1.0	16.93	8.22	8.99	5000	29.14
K6	4/24/97	1200	3.0	0.42	2.0	16.94	8.22	8.98	5000	5.14
K6	4/24/97	1200	3.0	0.42	2.5	16.94	8.22	8.97	5000	1.03

APPENDICES

Lake Kemp Physicochemical Profiles: 13 July 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	7/13/97	1235	11.6	1.08	0.0	27.81	8.20	7.57	4537	2159.00
K3	7/13/97	1235	11.6	1.08	1.0	27.74	8.20	7.56	4536	838.60
K3	7/13/97	1235	11.6	1.08	2.0	27.76	8.20	7.48	4545	330.70
K3	7/13/97	1235	11.6	1.08	3.0	27.54	8.19	7.37	4549	132.50
K3	7/13/97	1235	11.6	1.08	4.0	27.27	8.17	7.18	4554	47.97
K3	7/13/97	1235	11.6	1.08	5.0	27.27	8.17	7.16	4553	12.23
K3	7/13/97	1235	11.6	1.08	6.0	27.22	8.17	7.15	4552	4.90
K3	7/13/97	1235	11.6	1.08	7.0	27.18	8.16	7.08	4561	2.38
K3	7/13/97	1235	11.6	1.08	8.0	27.14	8.15	6.96	4560	.
K3	7/13/97	1235	11.6	1.08	9.0	27.04	8.12	6.75	4567	.
K3	7/13/97	1235	11.6	1.08	10.0	26.89	8.07	6.12	4572	.
K3	7/13/97	1235	11.6	1.08	11.0	25.09	7.59	1.87	4663	.
K3	7/13/97	1235	11.6	1.08	11.5	23.90	7.52	0.61	4761	.
K4	7/13/97	1334	9.0	0.79	0.0	27.74	8.19	7.65	4614	2138.00
K4	7/13/97	1334	9.0	0.79	1.0	27.64	8.19	7.57	4612	678.30
K4	7/13/97	1334	9.0	0.79	2.0	27.54	8.19	7.66	4630	175.00
K4	7/13/97	1334	9.0	0.79	3.0	27.35	8.18	7.41	4604	54.68
K4	7/13/97	1334	9.0	0.79	4.0	27.31	8.17	7.34	4603	20.13
K4	7/13/97	1334	9.0	0.79	5.0	27.27	8.17	7.26	4593	8.89
K4	7/13/97	1334	9.0	0.79	6.0	27.24	8.17	7.22	4582	.
K4	7/13/97	1334	9.0	0.79	7.0	26.85	8.10	6.64	4593	.
K4	7/13/97	1334	9.0	0.79	8.0	26.78	8.10	6.64	4601	.
K4	7/13/97	1334	9.0	0.79	9.0	26.36	8.08	6.30	4601	.
K5	7/13/97	1433	6.5	0.69	0.0	27.97	8.21	7.92	4650	2133.00
K5	7/13/97	1433	6.5	0.69	1.0	27.83	8.21	7.75	4647	512.00
K5	7/13/97	1433	6.5	0.69	2.0	27.58	8.20	7.67	4660	114.80
K5	7/13/97	1433	6.5	0.69	3.0	27.39	8.19	7.49	4655	28.72
K5	7/13/97	1433	6.5	0.69	4.0	27.24	8.17	7.32	4651	9.53
K5	7/13/97	1433	6.5	0.69	5.0	27.04	8.15	6.74	4644	2.88
K5	7/13/97	1433	6.5	0.69	6.0	26.64	8.10	6.36	4676	0.35
K5	7/13/97	1433	6.5	0.69	6.5	26.55	8.06	5.67	4675	.
K6	7/13/97	1515	3.7	0.67	0.0	27.93	8.20	7.74	4650	1929.00
K6	7/13/97	1515	3.7	0.67	1.0	27.66	8.20	7.59	4662	337.30
K6	7/13/97	1515	3.7	0.67	2.0	26.87	8.13	7.00	4642	76.78
K6	7/13/97	1515	3.7	0.67	3.0	26.68	8.05	6.11	4667	16.31
K6	7/13/97	1515	3.7	0.67	3.5	26.66	8.04	5.94	4677	.

Lake Kemp Physicochemical Profiles: 16 August 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K1	8/16/97	1043	15.0	1.34	0.0	27.48	8.02	7.28	4200	1300.00
K1	8/16/97	1043	15.0	1.34	1.0	27.46	8.02	7.31	4200	736.60
K1	8/16/97	1043	15.0	1.34	2.0	27.44	8.02	7.78	4199	346.10
K1	8/16/97	1043	15.0	1.34	3.0	27.40	8.02	7.27	4198	174.80
K1	8/16/97	1043	15.0	1.34	4.0	27.34	8.02	7.21	4197	83.21
K1	8/16/97	1043	15.0	1.34	5.0	27.32	8.02	7.17	4197	49.04
K1	8/16/97	1043	15.0	1.34	6.0	27.28	8.02	7.14	4205	24.01
K1	8/16/97	1043	15.0	1.34	7.0	27.26	8.01	7.14	4204	13.88
K1	8/16/97	1043	15.0	1.34	8.0	27.21	8.01	7.08	4203	
K1	8/16/97	1043	15.0	1.34	9.0	27.17	8.00	7.01	4202	
K1	8/16/97	1043	15.0	1.34	10.0	27.00	7.94	6.30	4198	
K1	8/16/97	1043	15.0	1.34	11.0	25.53	7.62	1.72	4189	
K1	8/16/97	1043	15.0	1.34	12.0	24.45	7.47	0.34	4195	
K1	8/16/97	1043	15.0	1.34	13.0	22.07	7.86	0.23	4218	
K1	8/16/97	1043	15.0	1.34	14.0	20.08	8.95	0.20	4240	
K1	8/16/97	1043	15.0	1.34	15.0	19.79	9.05	0.10	4265	
K2	8/16/97	1200	14.0	1.26	0.0	27.63	8.09	7.47	4230	1972.00
K2	8/16/97	1200	14.0	1.26	1.0	27.52	8.10	7.40	4229	841.40
K2	8/16/97	1200	14.0	1.26	2.0	27.55	8.11	7.33	4229	391.60
K2	8/16/97	1200	14.0	1.26	3.0	27.53	8.10	7.30	4228	128.40
K2	8/16/97	1200	14.0	1.26	4.0	27.53	8.10	7.27	4228	90.06
K2	8/16/97	1200	14.0	1.26	5.0	27.51	8.09	7.22	4238	44.37
K2	8/16/97	1200	14.0	1.26	6.0	27.49	8.09	7.17	4236	23.60
K2	8/16/97	1200	14.0	1.26	7.0	27.49	8.09	7.12	4236	11.01
K2	8/16/97	1200	14.0	1.26	8.0	27.42	8.08	7.05	4234	5.67
K2	8/16/97	1200	14.0	1.26	9.0	27.36	8.06	6.88	4233	3.00
K2	8/16/97	1200	14.0	1.26	10.0	27.36	8.06	6.90	4233	1.44
K2	8/16/97	1200	14.0	1.26	11.0	27.31	8.05	6.61	4224	
K2	8/16/97	1200	14.0	1.26	12.0	24.43	7.63	0.41	4230	
K2	8/16/97	1200	14.0	1.26	13.0	21.45	8.86	0.26	4231	
K2	8/16/97	1200	14.0	1.26	14.0	20.29	9.01	0.20	4241	

Lake Kemp Physicochemical Profiles: 16 August 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	8/16/97	1246	10.5	1.00	0.0	28.04	8.11	7.34	4215	2062.00
K3	8/16/97	1246	10.5	1.00	1.0	27.94	8.11	7.31	4220	686.20
K3	8/16/97	1246	10.5	1.00	2.0	27.78	8.10	7.20	4225	259.70
K3	8/16/97	1246	10.5	1.00	3.0	27.78	8.10	7.14	4224	82.35
K3	8/16/97	1246	10.5	1.00	4.0	27.67	8.09	6.98	4231	28.82
K3	8/16/97	1246	10.5	1.00	5.0	27.49	8.06	6.83	4218	9.17
K3	8/16/97	1246	10.5	1.00	6.0	27.48	8.05	6.79	4227	3.77
K3	8/16/97	1246	10.5	1.00	7.0	27.48	8.05	6.79	4218	1.60
K3	8/16/97	1246	10.5	1.00	8.0	27.48	8.05	6.77	4218	.
K3	8/16/97	1246	10.5	1.00	9.0	27.46	8.05	6.72	4217	.
K3	8/16/97	1246	10.5	1.00	10.0	27.28	8.01	6.50	4213	.
K3	8/16/97	1246	10.5	1.00	10.5	27.23	7.98	6.30	4212	.
K4	8/16/97	1326	8.7	0.75	0.0	28.02	8.10	7.43	4124	2045.00
K4	8/16/97	1326	8.7	0.75	1.0	27.75	8.08	7.33	4153	492.80
K4	8/16/97	1326	8.7	0.75	2.0	27.59	8.05	7.01	4185	150.90
K4	8/16/97	1326	8.7	0.75	3.0	27.49	8.04	7.01	4183	42.00
K4	8/16/97	1326	8.7	0.75	4.0	27.42	8.04	6.98	4181	14.46
K4	8/16/97	1326	8.7	0.75	5.0	27.25	8.01	6.78	4177	5.07
K4	8/16/97	1326	8.7	0.75	6.0	27.12	7.99	6.56	4176	1.83
K4	8/16/97	1326	8.7	0.75	7.0	27.09	7.97	6.42	4191	.
K4	8/16/97	1326	8.7	0.75	8.0	26.97	7.96	6.34	4179	.
K4	8/16/97	1326	8.7	0.75	8.5	26.87	7.93	5.83	4183	.
K5	8/16/97	1408	6.0	0.48	0.0	27.92	8.03	7.21	4142	2085.00
K5	8/16/97	1408	6.0	0.48	1.0	27.59	8.03	7.15	4150	272.40
K5	8/16/97	1408	6.0	0.48	2.0	27.44	8.03	7.05	4156	49.28
K5	8/16/97	1408	6.0	0.48	3.0	27.17	8.00	6.86	4158	14.42
K5	8/16/97	1408	6.0	0.48	4.0	27.13	7.99	6.67	4157	3.57
K5	8/16/97	1408	6.0	0.48	5.0	26.88	7.92	6.08	4178	.
K5	8/16/97	1408	6.0	0.48	6.0	26.79	7.87	5.35	4186	.
K6	8/16/97	1437	3.5	0.27	0.0	28.27	8.05	7.45	4157	1953.00
K6	8/16/97	1437	3.5	0.27	1.0	27.69	8.04	7.34	4164	127.60
K6	8/16/97	1437	3.5	0.27	2.0	27.13	7.99	6.81	4165	41.10
K6	8/16/97	1437	3.5	0.27	3.0	26.79	7.90	5.84	4185	7.55

Lake Kemp Physicochemical Profiles: 14 September 1997

Station	Date	Time	Maximum Depth (m)	Sec Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K1	9/14/97	1050	15.5		0.0	26.03	8.19	7.23	4680	410.80
K1	9/14/97	1050	15.5		1.0	26.03	8.19	7.21	4670	114.20
K1	9/14/97	1050	15.5		2.0	26.01	8.20	7.19	4690	57.31
K1	9/14/97	1050	15.5		3.0	26.01	8.19	7.14	4680	27.64
K1	9/14/97	1050	15.5		4.0	26.01	8.19	7.13	4690	13.98
K1	9/14/97	1050	15.5		5.0	26.01	8.19	7.11	4690	6.88
K1	9/14/97	1050	15.5		6.0	26.01	8.19	7.08	4690	3.49
K1	9/14/97	1050	15.5		7.0	25.99	8.19	7.06	4680	1.74
K1	9/14/97	1050	15.5		8.0	25.99	8.19	7.02	4680	0.88
K1	9/14/97	1050	15.5		9.0	25.99	8.19	7.00	4690	0.45
K1	9/14/97	1050	15.5		10.0	25.94	8.16	6.16	4680	0.21
K1	9/14/97	1050	15.5		11.0	25.75	8.05	5.70	4690	
K1	9/14/97	1050	15.5		12.0	25.65	7.95	4.87	4680	
K1	9/14/97	1050	15.5		13.0	25.24	7.73	2.63	4680	
K1	9/14/97	1050	15.5		14.0	24.10	7.42	0.27	4700	
K1	9/14/97	1050	15.5		15.0	21.14	7.23	0.18	4780	
K1	9/14/97	1050	15.5		15.5	20.58	7.19	0.16	4730	
K2	9/14/97	1200	14.4		0.0	26.24	8.30	8.34	4670	953.20
K2	9/14/97	1200	14.4		1.0	26.16	8.30	7.84	4670	313.90
K2	9/14/97	1200	14.4		2.0	26.10	8.29	7.58	4670	128.80
K2	9/14/97	1200	14.4		3.0	26.09	8.28	7.48	4660	66.14
K2	9/14/97	1200	14.4		4.0	26.05	8.29	7.48	4660	28.30
K2	9/14/97	1200	14.4		5.0	26.03	8.29	7.37	4660	14.22
K2	9/14/97	1200	14.4		6.0	26.03	8.29	7.41	4660	6.82
K2	9/14/97	1200	14.4		7.0	26.01	8.28	7.34	4660	
K2	9/14/97	1200	14.4		8.0	26.01	8.28	7.31	4670	
K2	9/14/97	1200	14.4		9.0	25.99	8.27	7.31	4660	
K2	9/14/97	1200	14.4		10.0	25.92	8.18	6.38	4680	
K2	9/14/97	1200	14.4		11.0	25.69	8.04	5.22	4690	
K2	9/14/97	1200	14.4		12.0	25.50	7.89	3.89	4690	
K2	9/14/97	1200	14.4		13.0	24.71	7.60	0.68	4690	
K2	9/14/97	1200	14.4		14.0	23.05	7.29	0.21	4710	

Lake Kemp Physicochemical Profiles: 14 September 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	9/14/97	1247		0.97	0.0	26.43	8.39	8.10	4580	2413.00
K3	9/14/97	1247		0.97	1.0	26.10	8.37	7.84	4650	879.80
K3	9/14/97	1247		0.97	2.0	25.86	8.31	7.32	4630	264.70
K3	9/14/97	1247		0.97	3.0	25.86	8.30	7.21	4640	90.79
K3	9/14/97	1247		0.97	4.0	25.80	8.30	7.14	4640	33.86
K3	9/14/97	1247		0.97	5.0	25.80	8.30	7.17	4640	11.18
K3	9/14/97	1247		0.97	6.0	25.80	8.29	7.13	4630	
K3	9/14/97	1247		0.97	7.0	25.78	8.29	7.12	4630	
K3	9/14/97	1247		0.97	8.0	25.78	8.29	7.07	4630	
K3	9/14/97	1247		0.97	9.0	25.78	8.29	7.09	4640	
K3	9/14/97	1247		0.97	10.0	25.71	8.28	6.96	4650	
K4	9/14/97	1325		0.93	0.0	26.96	8.37	8.45	4580	599.70
K4	9/14/97	1325		0.93	1.0	26.09	8.39	8.21	4610	118.80
K4	9/14/97	1325		0.93	2.0	25.82	8.39	8.17	4620	56.22
K4	9/14/97	1325		0.93	3.0	25.71	8.36	7.95	4610	21.47
K4	9/14/97	1325		0.93	4.0	25.67	8.34	7.66	4600	8.12
K4	9/14/97	1325		0.93	5.0	25.65	8.33	7.55	4590	3.35
K4	9/14/97	1325		0.93	6.0	25.64	8.32	7.47	4590	
K4	9/14/97	1325		0.93	7.0	25.58	8.31	7.35	4600	
K4	9/14/97	1325		0.93	8.0	25.58	8.31	7.29	4600	
K4	9/14/97	1325		0.93	8.5	25.56	8.30	7.22	4590	
K5	9/14/97	1400		0.83	0.0	26.82	8.41	8.65	4530	915.40
K5	9/14/97	1400		0.83	1.0	25.80	8.42	8.25	4550	219.40
K5	9/14/97	1400		0.83	2.0	25.54	8.35	7.52	4560	62.62
K5	9/14/97	1400		0.83	3.0	25.50	8.33	7.38	4550	20.01
K5	9/14/97	1400		0.83	4.0	25.45	8.31	7.06	4560	4.77
K5	9/14/97	1400		0.83	5.0	25.10	8.31	6.99	4580	
K5	9/14/97	1400		0.83	6.0	25.10	8.31	6.95	4570	
K6	9/14/97	1430		0.71	0.0	26.92	8.41	8.34	4550	729.80
K6	9/14/97	1430		0.71	1.0	26.33	8.42	8.42	4550	141.00
K6	9/14/97	1430		0.71	2.0	25.45	8.39	8.07	4580	28.98
K6	9/14/97	1430		0.71	3.0	25.28	8.35	7.61	4640	5.13

Lake Kemp Physicochemical Profiles: 19 October 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K1	10/19/97	1030	15.2	0.81	0.0	20.92	8.07	7.92	4590	1213.00
K1	10/19/97	1030	15.2	0.81	1.0	20.88	8.09	7.68	4590	314.90
K1	10/19/97	1030	15.2	0.81	2.0	20.86	8.08	7.38	4600	95.97
K1	10/19/97	1030	15.2	0.81	3.0	20.84	8.08	7.31	4600	29.34
K1	10/19/97	1030	15.2	0.81	4.0	20.84	8.08	7.22	4600	8.92
K1	10/19/97	1030	15.2	0.81	5.0	20.83	8.08	7.19	4600	2.81
K1	10/19/97	1030	15.2	0.81	6.0	20.84	8.08	7.10	4600	.
K1	10/19/97	1030	15.2	0.81	7.0	20.84	8.08	7.07	4600	.
K1	10/19/97	1030	15.2	0.81	8.0	20.82	8.08	7.02	4600	.
K1	10/19/97	1030	15.2	0.81	9.0	20.82	8.08	7.00	4600	.
K1	10/19/97	1030	15.2	0.81	10.0	20.80	8.08	6.96	4600	.
K1	10/19/97	1030	15.2	0.81	11.0	20.80	8.07	6.95	4600	.
K1	10/19/97	1030	15.2	0.81	12.0	20.77	8.07	6.93	4600	.
K1	10/19/97	1030	15.2	0.81	13.0	20.77	8.07	6.82	4610	.
K1	10/19/97	1030	15.2	0.81	14.0	20.79	8.07	6.81	4610	.
K1	10/19/97	1030	15.2	0.81	15.0	20.77	8.07	6.72	4610	.
K2	10/19/97	1111	14.4	0.83	0.0	20.84	8.19	8.28	4570	1378.00
K2	10/19/97	1111	14.4	0.83	1.0	20.75	8.19	8.19	4580	315.20
K2	10/19/97	1111	14.4	0.83	2.0	20.70	8.19	8.10	4580	120.40
K2	10/19/97	1111	14.4	0.83	3.0	20.65	8.18	7.99	4580	39.94
K2	10/19/97	1111	14.4	0.83	4.0	20.64	8.18	7.89	4580	14.07
K2	10/19/97	1111	14.4	0.83	5.0	20.64	8.18	7.88	4590	4.77
K2	10/19/97	1111	14.4	0.83	6.0	20.64	8.18	7.84	4590	.
K2	10/19/97	1111	14.4	0.83	7.0	20.64	8.18	7.84	4590	.
K2	10/19/97	1111	14.4	0.83	8.0	20.64	8.18	7.84	4590	.
K2	10/19/97	1111	14.4	0.83	9.0	20.64	8.18	7.87	4590	.
K2	10/19/97	1111	14.4	0.83	10.0	20.63	8.18	7.84	4590	.
K2	10/19/97	1111	14.4	0.83	11.0	20.64	8.18	7.81	4590	.
K2	10/19/97	1111	14.4	0.83	12.0	20.64	8.18	7.81	4590	.
K2	10/19/97	1111	14.4	0.83	13.0	20.60	8.18	7.76	4590	.
K2	10/19/97	1111	14.4	0.83	14.0	20.47	8.19	7.44	4620	.

Lake Kemp Physicochemical Profiles: 9 October 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	10/19/97	1147	9.5	0.64	0.0	20.54	8.25	8.62	4560	1549.00
K3	10/19/97	1147	9.5	0.64	1.0	20.49	8.24	8.51	4560	336.70
K3	10/19/97	1147	9.5	0.64	2.0	20.37	8.23	8.40	4570	81.34
K3	10/19/97	1147	9.5	0.64	3.0	20.34	8.22	8.26	4570	20.96
K3	10/19/97	1147	9.5	0.64	4.0	20.29	8.20	8.09	4580	5.76
K3	10/19/97	1147	9.5	0.64	5.0	20.28	8.20	8.09	4570	1.49
K3	10/19/97	1147	9.5	0.64	6.0	20.28	8.20	8.09	4580	.
K3	10/19/97	1147	9.5	0.64	7.0	20.28	8.20	8.07	4580	.
K3	10/19/97	1147	9.5	0.64	8.0	20.28	8.20	8.01	4580	.
K3	10/19/97	1147	9.5	0.64	9.0	20.28	8.20	8.01	4580	.
K3	10/19/97	1147	9.5	0.64	9.5	20.28	8.19	7.95	4580	.
K4	10/19/97	1216	8.5	0.60	0.0	20.44	8.23	8.43	4510	1498.00
K4	10/19/97	1216	8.5	0.60	1.0	20.32	8.23	8.33	4520	279.10
K4	10/19/97	1216	8.5	0.60	2.0	20.19	8.21	8.20	4520	56.53
K4	10/19/97	1216	8.5	0.60	3.0	20.07	8.20	8.06	4520	12.37
K4	10/19/97	1216	8.5	0.60	4.0	20.06	8.19	7.99	4520	2.87
K4	10/19/97	1216	8.5	0.60	5.0	20.04	8.19	7.95	4520	0.73
K4	10/19/97	1216	8.5	0.60	6.0	19.82	8.19	7.91	4490	.
K4	10/19/97	1216	8.5	0.60	7.0	19.62	8.20	7.99	4450	.
K4	10/19/97	1216	8.5	0.60	8.0	19.29	8.21	8.06	4410	.
K4	10/19/97	1216	8.5	0.60	8.5	19.22	8.20	8.00	4400	.
K5	10/19/97	1247	5.7	0.58	0.0	20.04	8.33	9.17	4360	1482.00
K5	10/19/97	1247	5.7	0.58	1.0	19.57	8.31	8.90	4360	304.70
K5	10/19/97	1247	5.7	0.58	2.0	19.38	8.28	8.46	4360	53.14
K5	10/19/97	1247	5.7	0.58	3.0	19.29	8.26	8.31	4370	7.34
K5	10/19/97	1247	5.7	0.58	4.0	19.25	8.26	8.36	4370	1.31
K5	10/19/97	1247	5.7	0.58	5.0	18.91	8.24	8.12	4400	0.80
K5	10/19/97	1247	5.7	0.58	5.5	18.89	8.23	7.97	4400	.
K6	10/19/97	1314	2.8	0.58	0.0	20.29	8.32	8.98	4360	1660.00
K6	10/19/97	1314	2.8	0.58	1.0	20.11	8.33	8.94	4370	277.30
K6	10/19/97	1314	2.8	0.58	2.0	19.65	8.30	8.69	4410	50.84
K6	10/19/97	1314	2.8	0.58	2.8	16.53	8.25	8.11	4410	7.30

Lake Kemp Physicochemical Profiles: 19 November 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K1	11/19/97	1008	15.4	0.81	0.0	11.12	8.08	9.95	4630	903.90
K1	11/19/97	1008	15.4	0.81	1.0	11.09	8.10	9.63	4620	254.40
K1	11/19/97	1008	15.4	0.81	2.0	10.99	8.11	9.46	4630	79.37
K1	11/19/97	1008	15.4	0.81	3.0	10.97	8.12	9.35	4630	25.72
K1	11/19/97	1008	15.4	0.81	4.0	10.96	8.12	9.33	4640	9.17
K1	11/19/97	1008	15.4	0.81	5.0	10.94	8.12	9.29	4640	3.48
K1	11/19/97	1008	15.4	0.81	6.0	10.94	8.12	9.26	4640	1.24
K1	11/19/97	1008	15.4	0.81	7.0	10.94	8.12	9.21	4650	0.43
K1	11/19/97	1008	15.4	0.81	8.0	10.83	8.13	9.25	4640	.
K1	11/19/97	1008	15.4	0.81	9.0	10.78	8.13	9.29	4650	.
K1	11/19/97	1008	15.4	0.81	10.0	10.73	8.14	9.32	4640	.
K1	11/19/97	1008	15.4	0.81	11.0	10.68	8.14	9.34	4640	.
K1	11/19/97	1008	15.4	0.81	12.0	10.43	8.14	9.41	4650	.
K1	11/19/97	1008	15.4	0.81	13.0	10.35	8.13	9.42	4660	.
K1	11/19/97	1008	15.4	0.81	14.0	10.33	8.13	9.37	4660	.
K1	11/19/97	1008	15.4	0.81	15.0	10.37	8.12	9.33	4660	.
K2	11/19/97	1040	14.5	1.16	0.0	10.89	8.17	9.87	4630	1293.00
K2	11/19/97	1040	14.5	1.16	1.0	10.84	8.17	9.81	4630	438.50
K2	11/19/97	1040	14.5	1.16	2.0	10.79	8.18	9.75	4630	164.50
K2	11/19/97	1040	14.5	1.16	3.0	10.70	8.17	9.70	4630	69.74
K2	11/19/97	1040	14.5	1.16	4.0	10.65	8.17	9.71	4640	31.16
K2	11/19/97	1040	14.5	1.16	5.0	10.61	8.17	9.69	4640	14.56
K2	11/19/97	1040	14.5	1.16	6.0	10.56	8.18	9.70	4640	6.66
K2	11/19/97	1040	14.5	1.16	7.0	10.50	8.18	9.71	4640	3.18
K2	11/19/97	1040	14.5	1.16	8.0	10.42	8.18	9.71	4640	.
K2	11/19/97	1040	14.5	1.16	9.0	10.38	8.18	9.72	4640	.
K2	11/19/97	1040	14.5	1.16	10.0	10.37	8.18	9.73	4640	.
K2	11/19/97	1040	14.5	1.16	11.0	10.30	8.18	9.72	4640	.
K2	11/19/97	1040	14.5	1.16	12.0	10.25	8.18	9.70	4640	.
K2	11/19/97	1040	14.5	1.16	13.0	9.92	8.18	9.78	4640	.
K2	11/19/97	1040	14.5	1.16	14.0	9.87	8.18	9.79	4640	.

Lake Kemp Physicochemical Profiles: 19 November 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	11/19/97	1113	9.0	1.04	0.0	10.24	8.20	10.07	4650	1287.00
K3	11/19/97	1113	9.0	1.04	1.0	10.12	8.20	10.03	4660	416.70
K3	11/19/97	1113	9.0	1.04	2.0	9.89	8.20	10.05	4660	130.60
K3	11/19/97	1113	9.0	1.04	3.0	9.81	8.20	10.01	4660	41.12
K3	11/19/97	1113	9.0	1.04	4.0	9.81	8.20	9.96	4660	17.61
K3	11/19/97	1113	9.0	1.04	5.0	9.79	8.19	9.93	4660	6.49
K3	11/19/97	1113	9.0	1.04	6.0	9.79	8.19	9.90	4660	2.16
K3	11/19/97	1113	9.0	1.04	7.0	9.78	8.19	9.90	4650	.
K3	11/19/97	1113	9.0	1.04	8.0	9.73	8.19	9.88	4650	.
K3	11/19/97	1113	9.0	1.04	9.0	9.66	8.19	9.85	4670	.
K4	11/19/97	1136	8.3	1.12	0.0	10.15	8.21	10.08	4670	1248.00
K4	11/19/97	1136	8.3	1.12	1.0	10.09	8.21	10.06	4670	483.90
K4	11/19/97	1136	8.3	1.12	2.0	9.99	8.21	10.04	4670	185.30
K4	11/19/97	1136	8.3	1.12	3.0	9.83	8.21	10.00	4680	72.89
K4	11/19/97	1136	8.3	1.12	4.0	9.81	8.21	9.99	4680	32.58
K4	11/19/97	1136	8.3	1.12	5.0	9.45	8.21	9.99	4740	15.43
K4	11/19/97	1136	8.3	1.12	6.0	8.92	8.20	10.11	4800	5.90
K4	11/19/97	1136	8.3	1.12	7.0	8.66	8.20	10.17	4840	.
K4	11/19/97	1136	8.3	1.12	8.0	8.59	8.19	10.20	4930	.
K4	11/19/97	1136	8.3	1.12	8.3	8.61	8.19	10.20	4930	.
K5	11/19/97	1203	5.5	1.38	0.0	9.94	8.21	10.26	4710	1264.00
K5	11/19/97	1203	5.5	1.38	1.0	9.61	8.22	10.30	4730	493.70
K5	11/19/97	1203	5.5	1.38	2.0	9.15	8.22	10.32	4760	181.30
K5	11/19/97	1203	5.5	1.38	3.0	9.09	8.22	10.32	4790	69.95
K5	11/19/97	1203	5.5	1.38	4.0	8.78	8.21	10.30	4810	25.21
K5	11/19/97	1203	5.5	1.38	5.0	8.78	8.20	10.25	4870	10.81
K5	11/19/97	1203	5.5	1.38	5.5	8.99	8.18	10.13	4960	.
K6	11/19/97	1226	2.5	1.03	0.0	9.38	8.21	10.51	4770	1413.00
K6	11/19/97	1226	2.5	1.03	1.0	8.89	8.21	10.49	4830	423.50
K6	11/19/97	1226	2.5	1.03	2.0	8.84	8.21	10.45	4860	123.30
K6	11/19/97	1226	2.5	1.03	2.5	8.87	8.20	10.42	4980	.

Lake Kemp Physicochemical Profiles: 18 December 1997

Station	Date	Time	Maximum Depth (m)	Secchi Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K1	12/18/97	1020	15.5	1.42	0.0	7.82	8.06	11.46	4770	1156.00
K1	12/18/97	1020	15.5	1.42	1.0	7.82	8.06	11.46	4770	397.90
K1	12/18/97	1020	15.5	1.42	2.0	7.81	8.06	11.45	4780	205.40
K1	12/18/97	1020	15.5	1.42	3.0	7.81	8.07	11.40	4780	98.37
K1	12/18/97	1020	15.5	1.42	4.0	7.81	8.07	11.38	4780	51.01
K1	12/18/97	1020	15.5	1.42	5.0	7.81	8.07	11.40	4770	31.28
K1	12/18/97	1020	15.5	1.42	6.0	7.81	8.07	11.40	4780	17.35
K1	12/18/97	1020	15.5	1.42	7.0	7.79	8.07	11.40	4770	10.19
K1	12/18/97	1020	15.5	1.42	8.0	7.79	8.07	11.40	4780	.
K1	12/18/97	1020	15.5	1.42	9.0	7.79	8.07	11.40	4770	.
K1	12/18/97	1020	15.5	1.42	10.0	7.77	8.06	11.35	4790	.
K1	12/18/97	1020	15.5	1.42	11.0	7.72	8.06	11.33	4790	.
K1	12/18/97	1020	15.5	1.42	12.0	7.64	8.04	11.24	4820	.
K1	12/18/97	1020	15.5	1.42	13.0	7.58	8.04	11.13	4810	.
K1	12/18/97	1020	15.5	1.42	14.0	7.51	8.03	11.16	4890	.
K1	12/18/97	1020	15.5	1.42	14.5	7.35	8.00	10.95	4900	.
K2	12/18/97	1100	14.7	1.42	0.0	7.72	8.11	11.80	4770	1208.00
K2	12/18/97	1100	14.7	1.42	1.0	7.72	8.10	11.77	4770	579.90
K2	12/18/97	1100	14.7	1.42	2.0	7.71	8.11	11.74	4770	208.80
K2	12/18/97	1100	14.7	1.42	3.0	7.72	8.11	11.71	4760	97.49
K2	12/18/97	1100	14.7	1.42	4.0	7.71	8.11	11.72	4780	44.86
K2	12/18/97	1100	14.7	1.42	5.0	7.69	8.11	11.70	4770	25.41
K2	12/18/97	1100	14.7	1.42	6.0	7.69	8.11	11.66	4780	12.46
K2	12/18/97	1100	14.7	1.42	7.0	7.69	8.11	11.64	4760	6.64
K2	12/18/97	1100	14.7	1.42	8.0	7.66	8.11	11.66	4770	.
K2	12/18/97	1100	14.7	1.42	9.0	7.66	8.11	11.63	4770	.
K2	12/18/97	1100	14.7	1.42	10.0	7.64	8.10	11.60	4780	.
K2	12/18/97	1100	14.7	1.42	11.0	7.64	8.10	11.58	4780	.
K2	12/18/97	1100	14.7	1.42	12.0	7.64	8.10	11.58	4770	.
K2	12/18/97	1100	14.7	1.42	13.0	7.64	8.10	11.56	4770	.
K2	12/18/97	1100	14.7	1.42	14.0	7.63	8.10	11.50	4780	.

Lake Kemp Physicochemical Profiles: 18 December 1997

Station	Date	Time	Maximum Depth (m)	Sec Depth (m)	Sample Depth (m)	Temp (C)	pH	DO (ppm)	Conductivity (microSiemens)	Light (microeinsteins)
K3	12/18/97	1135	10.5	1.22	0.0	7.25	8.10	11.81	4740	1174.00
K3	12/18/97	1135	10.5	1.22	1.0	7.25	8.10	11.81	4740	408.20
K3	12/18/97	1135	10.5	1.22	2.0	7.21	8.10	11.81	4760	168.50
K3	12/18/97	1135	10.5	1.22	3.0	7.20	8.10	11.80	4760	61.90
K3	12/18/97	1135	10.5	1.22	4.0	7.21	8.10	11.77	4770	26.95
K3	12/18/97	1135	10.5	1.22	5.0	7.20	8.10	11.78	4770	12.57
K3	12/18/97	1135	10.5	1.22	6.0	7.18	8.10	11.78	4780	7.86
K3	12/18/97	1135	10.5	1.22	7.0	7.16	8.10	11.73	4790	.
K3	12/18/97	1135	10.5	1.22	8.0	7.16	8.10	11.70	4790	.
K3	12/18/97	1135	10.5	1.22	9.0	7.15	8.10	11.73	4800	.
K3	12/18/97	1135	10.5	1.22	9.5	7.16	8.09	11.67	4820	.
K4	12/18/97	1207	8.9	1.51	0.0	7.16	8.13	12.02	4860	1357.00
K4	12/18/97	1207	8.9	1.51	1.0	7.15	8.11	12.00	4870	541.80
K4	12/18/97	1207	8.9	1.51	2.0	7.13	8.11	11.93	4860	253.20
K4	12/18/97	1207	8.9	1.51	3.0	7.08	8.11	11.94	4870	121.40
K4	12/18/97	1207	8.9	1.51	4.0	7.07	8.12	11.94	4860	57.71
K4	12/18/97	1207	8.9	1.51	5.0	7.07	8.12	11.90	4870	28.36
K4	12/18/97	1207	8.9	1.51	6.0	7.03	8.12	11.87	4870	15.16
K4	12/18/97	1207	8.9	1.51	7.0	6.93	8.11	11.83	4950	7.77
K4	12/18/97	1207	8.9	1.51	8.0	6.90	8.08	11.78	5220	.
K5	12/18/97	1255	5.8	1.42	0.0	6.88	8.11	12.11	4950	1288.00
K5	12/18/97	1255	5.8	1.42	1.0	6.85	8.11	12.11	4960	397.80
K5	12/18/97	1255	5.8	1.42	2.0	6.87	8.11	12.80	4970	179.20
K5	12/18/97	1255	5.8	1.42	3.0	6.80	8.11	12.05	4980	95.04
K5	12/18/97	1255	5.8	1.42	4.0	6.77	8.11	12.07	5010	36.07
K5	12/18/97	1255	5.8	1.42	5.0	6.75	8.10	12.02	5120	19.97
K6	12/18/97	1325	3.0	1.12	0.0	7.00	8.11	12.36	5030	1316.00
K6	12/18/97	1325	3.0	1.12	1.0	6.97	8.11	12.27	5050	325.70
K6	12/18/97	1325	3.0	1.12	2.0	6.87	8.11	12.22	5010	70.50
K6	12/18/97	1325	3.0	1.12	2.5	6.77	8.10	12.22	5250	.

APPENDIX D

Laboratory Results for Field Blank Samples

Appendix D: Laboratory Results for Field Blank Samples

Date	NO2 (mg/l)	NO3 (mg/l)	TKN (mg/l)	Soluble P (mg/l)	Total P (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)	Chloride (mg/l)	Sulfate (mg/l)	Hardness (mg/l CaCO3)
24 Apr 1997	<.1	<.1	<10	<.01	<.4	0.1	<.1	<0.2	<.1	17	5.9	<1
13 May 1997	0.01	<.01	<10	<.01	<.4	<.01	<.01	<.4	<.3	<1	760	<10
27 May 1997	<1	<1	<10	<.01	<.3	<.01	<.01	0.6	<3	63	40	<10
15 Jun 1997	<1	<1	<10	<.05	<1	<0.01	<0.01	1.1	<.3	38	28	<10
29 Jun 1997	<0.1	<0.1	<10	<.1	<1	0.12	0.16	<.3	1.7	<1	<1	0.9
13 Jul 1997	<1	<1	<10	0.02	<.05	1.02	0.23	0.5	<.3	35	4.3	3
17 Aug 1997	<1	<1	<10	<.01	<.5	0.3	0.17	<4	<3	160	110	1
14 Sep 1997	<1	<1	<10	<.01	<.5	0.09	<.01	<.4	0.14	<50	180	<10
19 Oct 1997	<1	<1	<10	<20	<.5	0.46	<.8	0.8	<.3	92	98	1.8
19 Nov 1997	<2	<6	<10	<.001	0.52	<1	<1	6.1	9.6	85	20	<10
18 Dec 1997	<1	<1	<10	0.01	<.1	1.3	0.79	3	2.4	<5	<5	6