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Subject: McGuire Nuclear Station
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Please find attached a copy of the annual "Lake Norman Maintenance Monitoring Program: 2001 Summary," as required by the National Pollutant Discharge Elimination System (NPDES) permit NC0024392. The report includes detailed results and data comparable to that of previous years. The report was submitted to the North Carolina Department of Environment and Natural Resources on January 31, 2003.

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LAKE NORMAN

MAINTENANCE MONITORING PROGRAM:

2001 SUMMARY

McGuire Nuclear Station: NPDES No. NC0024392

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January 2003

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EXECUTIVE SUMMARY

As required by the National Pollutant Discharge Elimination System (NPDES) permit number NC0024392 for McGuire Nuclear Station (MNS), the following annual report has been prepared. This report summarizes environmental monitoring of Lake Norman conducted during 2001.

McGUIRE NUCLEAR STATION OPERATION

The monthly average capacity factor for MNS was 96.8 %, 101.3 %, and 102.0 % during July, August, and September of 2001, respectively (Table 1-1). These are the months when conservation of cool water and discharge temperatures are most critical and the thermal limit for MNS increases from a monthly average of 95.0°F (35.0°C) to 99.0°F (37.2°C). The average monthly discharge temperature was 96.2°F (35.7°C) for July, 98.0°F (36.7°C) for August, and 94.7°F (34.8°C) for September 2001. The volume of cool water in Lake Norman was tracked throughout the year to ensure that an adequate volume was available to comply with both the Nuclear Regulatory Commission Technical Specification requirements and the NPDES discharge water temperature limits.

WATER CHEMISTRY

Temporal and spatial trends in water temperature and DO data collected in 2001 were similar to those observed historically. Temperature and DO data collected in 2001 were within the range of previously measured values.

Reservoir-wide isotherm and isopleth information for 2001, coupled with heat content and hypolimnetic oxygen data, illustrated that Lake Norman exhibited thermal and oxygen dynamics characteristic of historical conditions and similar to other Southeastern reservoirs of comparable size, depth, flow conditions, and trophic status.

Availability of suitable pelagic habitat for adult striped bass in Lake Norman in 2001 was generally similar to historical conditions. All chemical parameters measured in 2001 were within the concentration ranges previously reported for the lake during both MNS preoperational and operational years. As has been observed historically, manganese concentrations in the bottom waters in the summer and fall of 2001 often exceeded the NC

water quality standard. This is characteristic of waterbodies that experience hypolimnetic deoxygenation during the summer.

PHYTOPLANKTON

Lake Norman continues to support highly variable and diverse phytoplankton communities. No obvious short term or long term impacts of station operations were observed.

In 2001 lake-wide mean chlorophyll *a* concentrations were all within ranges of those observed during previous years of the Program. Lake Norman continues to be classified as oligo-mesotrophic based on long term, annual mean chlorophyll concentrations. In most cases, total phytoplankton densities and biovolumes observed in 2001 were lower than those observed during 2000, and standing crops were within ranges established over previous years.

The proportions of ash-free dry weights to dry weights in 2001 were slightly lower than those of 2000, indicating little change in organic/inorganic inputs into Lake Norman. Diversity, or numbers of taxa, of phytoplankton had decreased since 2000, and the total number of individual taxa was within ranges of previous years. The phytopkankton index (Myxophycean) tended to confirm the characterization of Lake Norman as oligo-mesotrophic. The annual index for 2001 was lower than that of 2000, and was at the very low end of the intermediate range.

One indication of "balanced indigenous populations" in a reservoir is the diversity, or number of taxa observed over time. Nine classes comprising 64 genera and 118 species, varieties, and forms of phytoplankton were identified in samples collected during 2001, as compared to 81 genera and 172 lower taxa identified in 2000. Two taxa previously unrecorded during the Maintenance Monitoring Program were identified during 2001.

ZOOPLANKTON

Lake Norman continues to support a highly diverse and viable zooplankton community. Long term and seasonal changes observed over the course of the study, as well seasonal and spatial variability observed during 2001, were likely due to environmental factors and appear not to be related to plant operations.

Epilimnetic zooplankton densities during all but May of 2001 were within ranges of those observed in previous years. The epilimnetic density at Location 15.9 in May 2001 was the highest recorded during the Program, and may have represented an ongoing lag response to comparatively high phytoplankton standing crops uplake at that time.

One hundred and eight zooplankton taxa have been recorded from Lake Norman since the Program began in 1987 (forty-six were identified during 2001). No previously unreported taxa were identified during 2001.

FISHERIES

In accordance with the Lake Norman Maintenance Monitoring Program for the NPDES permit for MNS, specific fish monitoring programs were coordinated with the NCWRC and continued during 2001. General monitoring of Lake Norman and specific monitoring of the MNS mixing zone for striped bass mortalities during the summer of 2001, yielded nine mortalities within the mixing zone and nine mortalities in the main channel outside the mixing zone.

Spring shoreline electrofishing of Lake Norman yielded variable catches for the three areas sampled; the MNS mixing zone area, a mid-lake reference area, and the MSS mixing zone area. The total number of taxa collected was the same for the MSS and MNS mixing zone areas and slightly lower for the mid-lake reference area.

September 2001 forage fish densities ranged from a low of 3,173 fish/ha (Zone 6) to a high of 11,513 fish/ha (Zone 2). The estimated forage population was approximately 78 million fish. Purse seine sampling indicated that these fish were 76.47% threadfin shad, 23.52% alewives, and 0.01% gizzard shad.

During December 2001, forage fish densities in the six zones of Lake Norman ranged from 1,451 to 8,647 fish/ha. There appeared to be fewer fish in the downlake zones. The estimated forage population was approximately 47 million fish. Purse seine sampling indicated that these fish were 82.66% threadfin shad, 16.46% alewives and 0.88% gizzard shad.

Fisheries data to date indicate that the Lake Norman fishery is consistent with the trophic status and productivity of the reservoir. However, one aspect of the Lake Norman fishery that warrants close monitoring in the future is the composition of forage populations. The introduction of alewives by fishermen over the past several years could have a dramatic impact on lake-wide forage populations and game species.

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CHAPTER 1
McGUIRE NUCLEAR STATION OPERATION

INTRODUCTION

As required by the National Pollutant Discharge Elimination System (NPDES) permit number NC0024392 for McGuire Nuclear Station (MNS) issued by the North Carolina Department of Environment and Natural Resources (NC DENR), the following annual report has been prepared. This report summarizes environmental monitoring of Lake Norman conducted during 2001.

OPERATIONAL DATA FOR 2001

The monthly average capacity factor for MNS was 96.8 %, 101.3 %, and 102.0 % during July, August, and September of 2001, respectively (Table 1-1). These are the months when conservation of cool water and discharge temperatures are most critical and the thermal limit for MNS increases from a monthly average of 95.0°F (35.0°C) to 99.0°F (37.2°C). The average monthly discharge temperature was 96.2°F (35.7°C) for July, 98.0°F (36.7°C) for August, and 94.7°F (34.8°C) for September 2001. The volume of cool water in Lake Norman was tracked throughout the year to ensure that an adequate volume was available to comply with both the Nuclear Regulatory Commission Technical Specification requirements and the NPDES discharge water temperature limits.

Table 1-1. Average monthly capacity factors (%) calculated from daily unit capacity factors [Net Generation (Mwe per unit day) x 100 / 24 h per day x 1129 mw per unit] and monthly average discharge water temperatures for McGuire Nuclear Station during 2001.

Month	CAPACITY FACTOR (%)			NPDES DISCHARGE TEMPERATURE	
	Unit 1 Average	Unit 2 Average	Station Average	Monthly Average °F	Monthly Average °C
January	83.9	104.5	94.2	63.7	17.6
February	103.7	105.1	104.4	67.9	19.9
March	26.7	104.7	65.7	70.8	21.6
April	41.8	104.5	73.2	72.3	22.4
May	104.3	104.0	104.2	83.7	28.7
June	102.8	102.7	102.8	91.9	33.3
July	101.7	92.0	96.8	96.2	35.7
August	101.4	101.1	101.3	98.0	36.7
September	102.4	101.6	102.0	94.7	34.8
October	104.0	103.4	103.7	85.3	29.6
November	104.6	104.0	104.3	79.5	26.4
December	105.0	102.7	103.8	76.3	24.6

CHAPTER 2
WATER CHEMISTRY

INTRODUCTION

The objectives of the water chemistry portion of the McGuire Nuclear Station (MNS) NPDES Maintenance Monitoring Program are to:

1. maintain continuity in Lake Norman's chemical data base so as to allow detection of any significant station-induced and/or natural change in the physicochemical structure of the lake; and
2. compare, where appropriate, these physicochemical data to similar data in other hydropower reservoirs and cooling impoundments in the Southeast.

This year's report focuses primarily on 2000 and 2001. Where appropriate, reference to pre-2000 data will be made by citing reports previously submitted to the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR).

METHODS AND MATERIALS

The complete water chemistry monitoring program for 2001, including specific variables, locations, depths, and frequencies is outlined in Table 2-1. Sampling locations are identified in Figure 2-1, whereas specific chemical methodologies, along with the appropriate references are presented in Table 2-2. Data were analyzed using two approaches, both of which were consistent with earlier studies (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). The first method involved partitioning the reservoir into mixing, background, and discharge zones, and making comparisons among zones and years. In this report, the discharge includes only Location 4; the mixing zone encompasses Locations 1 and 5; the background zone includes Locations 8, 11, and 15. The second approach emphasized a much broader lake-wide investigation and encompassed the plotting of monthly isotherms and isopleths, and summer-time striped bass habitat. Several quantitative calculations were also performed; these included the calculation of the areal hypolimnetic oxygen deficit (AHOD), maximum whole-water column and hypolimnion oxygen content,

maximum whole-water column and hypolimnion heat content, mean epilimnion and hypolimnion heating rates over the stratified period, and the Birgean heat budget.

Heat (Kcal/cm^2) and oxygen content (mg/cm^2) and mean concentration (mg/L) of the reservoir were calculated according to Hutchinson (1957), using the following equation:

$$Lt = A_0^{-1} \bullet \int TO \bullet Az \bullet dz$$

where;

Lt = reservoir heat (Kcal/cm^2) or oxygen (mg/cm^2) content
Ao = surface area of reservoir (cm^2)
TO = mean temperature (° C) or oxygen content of layer z
Az = area (cm^2) at depth z
dz = depth interval (cm)
zo = surface
zm = maximum depth

RESULTS AND DISCUSSION

Precipitation Amount

Total annual precipitation in the vicinity of MNS in 2001 totaled 32.71 inches (Figure 2-2); this was similar to that observed in 2000 (33.68 inches), but appreciably less than the long-term precipitation average for this area (46.3 inches). The highest total monthly rainfall in 2001 occurred in March with a value of 6.14 inches.

Temperature and Dissolved Oxygen

Water temperatures measured in 2001 illustrated similar temporal and spatial trends in the background and mixing zones (Figures 2-3, 2-4). This similarity in temperature patterns between zones has been a dominant feature of the thermal regime in Lake Norman since MNS began operations in 1983. Water temperatures in the winter of 2001 were generally similar to corresponding measurements in 2000, except in early January

when year 2001 temperatures ranged from 2 to 6 C cooler throughout the entire water column in both zones than observed in 2000 (Figure 2-3, 2-4). Interannual variability in water temperatures during the spring, summer, and fall months was observed in both the mixing and background zones, but these conditions were well within the observed historical variability and were not considered of biological significance (DPC 1985, 1989, 1991, 1993. 1994, 1995, 1996, 1997, 1998, 1999, 2000). The major temperature differences between year 2000 and 2001 were observed in early winter (December) when year 2001 temperatures ranged from 2.5 to 6.2 C warmer than measured in 2000. These differences can be traced to the cooler than average meteorological conditions observed during the winter of 2000/2001.

Temperature data at the discharge location in 2001 were generally similar to 2000 (Figure 2-5) and historically (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). The warmest discharge temperature of 2001 occurred in September and measured 35.8°C, or 2.58 °C cooler than measured in August, 1999 (DPC 2000).

Seasonal and spatial patterns of DO in 2001 were reflective of the patterns exhibited for temperature, i. e., generally similar in both the mixing and background zones (Figures 2-6 and 2-7). Winter and early-spring DO values in 2001 were generally equal to or higher than measured in 2000, and appeared to be related predominantly to the cooler water column temperatures measured in 2001 versus 2000. The cooler water would be expected to exhibit a higher oxygen content because of the direct effect of temperature on oxygen solubility, which is an inverse relationship, and indirectly via an enhanced convective mixing regime which would promote reaeration.

Spring and summer DO values in 2001 were highly variable throughout the water column in both the mixing and background zones ranging from highs of 6 to 8 mg/L in the surface waters to lows of 0 to 2 mg/L in the bottom waters. This pattern is similar to that measured in 2000 and earlier years (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1998, 1999, 2000, 2001). Hypolimnetic DO values during the spring and summer of 2001 generally ranged from 0.1mg/L - 2.0 mg/L greater than measured in 2000; the lone exception to this was observed in September when DO values were considerably lower (by as much as 6.0 mg/L) than measured in 2000. All dissolved oxygen values recorded in 2001 were well within the historical range (DPC 1985, 1987, 1988a, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001).

Considerable differences were observed between 2001 and 2000 fall and early-winter DO values in both the mixing and background zones, especially in the metalimnion and hypolimnion during November (Figures 2-6 and 2-7). These interannual differences in fall DO levels are common in Catawba River reservoirs and can be explained by the effects of variable weather patterns on water column cooling and mixing. Warmer air temperatures would delay water column cooling (Figure 2-3, 2-4) which, in turn, would delay the onset of convective mixing of the water column and the resultant reaeration of the metalimnion and hypolimnion. Conversely, cooler air temperatures would promote the rate and magnitude of this process resulting in higher DO values sooner in the year. Interannual differences in DO are common in Southeastern reservoirs, particularly during the stratified period, and can reflect yearly differences in hydrological, meteorological, and limnological forcing variables (Cole and Hannon 1985; Petts, 1984).

The seasonal pattern of DO in 2001 at the discharge location was similar to that measured historically, with the highest values observed during the winter and lowest observed in the summer and early-fall (Figure 2-5). The lowest DO concentration measured at the discharge location in 2001 (5.5 mg/L) occurred in August, and was similar to DO levels measured in August 2000 (5.4 mg/L). Low DO values measured at the discharge location during the summer and early fall occurred concurrently with hypolimnetic water usage at MNS for condenser cooling water needs.

Reservoir-wide Temperature and Dissolved Oxygen

The monthly reservoir-wide temperature and dissolved oxygen data for 2001 are presented in Figures 2-8 and 2-9. These data are similar to that observed in previous years and are characteristic of cooling impoundments and hydropower reservoirs in the Southeast (Cole and Hannon, 1985; Hannon et. al., 1979; Petts, 1984). For a detailed discussion on the seasonal and spatial dynamics of temperature and dissolved oxygen during both the cooling and heating periods in Lake Norman, the reader is referred to earlier reports (DPC 1992, 1993, 1994, 1995, 1996).

The seasonal heat content of both the entire water column and the hypolimnion for Lake Norman in 2001 are presented in Figure 2-10a; additional information on the thermal regime in the reservoir for the years 2000 and 2001 are found in Table 2-3. Annual minimum heat content for the entire water column in 2001 (7.45 Kcal/cm^2; 7.5 °C)

occurred in early January, whereas the maximum heat content (27.96 Kcal/cm^2; 27.57 °C) occurred in mid-August. Heat content of the hypolimnion exhibited a somewhat different temporal trend as that observed for the entire water column. Annual minimum hypolimnetic heat content occurred in early January and measured 4.4 Kcal/cm^2 (6.98 °C), whereas the maximum occurred in early September and measured 15.17 Kcal/cm^2 (23.48 °C). Heating of both the entire water column and the hypolimnion occurred at approximately a linear rate from minimum to maximum heat content. The mean heating rate of the entire water column equalled 0.090 Kcal/cm^2/day versus 0.043 Kcal/cm^2/day for the hypolimnion. The 2001 heat content and heating rate data were slightly lower than measured in 1999 and 2000, but similar to earlier years (DPC 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000).

The seasonal oxygen content and percent saturation of the whole water column, and the hypolimnion, are depicted for 2001 in Figure 2-10b. Additional oxygen data can be found in Table 2-4 which presents the 2000 AHOD for Lake Norman and similar estimates for 18 TVA reservoirs. Reservoir oxygen content was greatest in mid-winter when DO content measured 10.6 mg/L for both the whole water and the hypolimnion. Percent saturation values at this time approached 94.5 % for the entire water column and 90% for the hypolimnion. Beginning in early spring, oxygen content began to decline precipitously in both the whole water column and the hypolimnion, and continued to do so in a linear fashion until reaching a minimum in mid-summer. Minimum summer volume-weighted DO values for the entire water column measured 4.33 mg/L (57 % saturation), whereas the minimum for the hypolimnion was 0.33 mg/L (3.9 % saturation). The mean rate of DO decline in the hypolimnion over the stratified period, i.e., the AHOD, was 0.030 mg/cm^2/day (0.047 mg/L/day) (Figure 2-10b), and is similar to that measured in 2000 (DPC 2001).

Hutchinson (1938, 1957) proposed that the decrease of dissolved oxygen in the hypolimnion of a waterbody should be related to the productivity of the trophogenic zone. Mortimer (1941) adopted a similar perspective and proposed the following criteria for AHOD associated with various trophic states; oligotrophic - $\leq$ 0.025 mg/cm^2 /day, mesotrophic - 0.026 mg/cm^2/day to 0.054 mg/cm^2/day, and eutrophic - $\geq$ 0.055 mg/cm^2/day. Employing these limits, Lake Norman should be classified as mesotrophic based on the calculated AHOD value of 0.030 mg/cm^2/day for 2001. The oxygen based mesotrophic classification agrees well with the mesotrophic classification based on chlorophyll *a* levels (Chapter 3). The 2001 AHOD value is also similar to that

found in other Southeastern reservoirs of comparable depth, chlorophyll *a* status, and secchi depth (Table 2-4).

Striped Bass Habitat

Suitable pelagic habitat for adult striped bass, defined as that layer of water with temperatures ≤ 26 °C and DO levels ≥ 2.0 mg/L, was found lake-wide from October 2000 through mid-June 2001. Beginning in late-June 2001, habitat reduction proceeded rapidly throughout the reservoir both as a result of deepening of the 26 °C isotherm and metalimnetic and hypolimnetic deoxygenation (Figure 2-11). Habitat reduction was most severe from mid July through early September when no suitable habitat was observed in the reservoir except for a small zone of refuge in the upper, riverine portion of the reservoir, near the confluence of Lyles Creek with Lake Norman. Habitat measured in the upper reaches of the reservoir at this time appeared to be influenced by both inflow from Lyles Creek and discharges from Lookout Shoals Hydroelectric facility, which were somewhat cooler than ambient conditions in Lake Norman. Upon entering Lake Norman, this water apparently mixes and then proceeds as a subsurface underflow (Ford 1985) as it migrates downriver.

Physicochemical habitat was observed to have expanded appreciably by mid-September, primarily as a result of epilimnion cooling and deepening, and in response to changing meteorological conditions. The temporal and spatial pattern of striped bass habitat expansion and reduction observed in 2001 was similar to that previously reported in Lake Norman and many other Southeastern reservoirs (Coutant 1985, Matthews 1985, DPC 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001).

Turbidity and Specific Conductance

Surface turbidity values were generally low at the MNS discharge, mixing zone, and mid-lake background locations during 2001, ranging from 1.04 to 2.3 NTUs (Table 2-5). Bottom turbidity values were also relatively low over the study period, ranging from 1.22 to 12.5 NTUs (Table 2-5). These values were similar to those measured in 2000 (Table 2-5), and well within the historic range (DPC 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001).

Specific conductance in Lake Norman in 2000 ranged from 48.9 to 108 umho/cm, and was similar to that observed in 2000 (Table 2-5), and historically (DPC 1989, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Specific conductance values in surface and bottom waters were generally similar throughout the year except during the period of intense thermal stratification. These increases in bottom conductance values appeared to be related primarily to the release of soluble iron and manganese from the lake bottom under anoxic conditions (Table 2-5). This phenomenon is common in both natural lakes and reservoirs that exhibit hypolimnetic oxygen depletion (Hutchinson 1957, Wetzel 1975).

pH and Alkalinity

During 2000, pH and alkalinity values were similar among MNS discharge, mixing and background zones (Table 2-5); they were also similar to values measured in 2000 (Table 2-5) and historically (DPC 1989, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Individual pH values in 2001 ranged from 6.3 to 8.1, whereas alkalinity ranged from 14.0 to 35.0 mg/L of $CaCO_3$.

Major Cations and Anions

The concentrations (mg/L) of major ionic species in the MNS discharge, mixing, and mid-lake background zones are provided in Table 2-5. The overall ionic composition of Lake Norman during 2001 was similar to that reported for 1999 (Table 2-5) and previously (DPC 1989, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Lake-wide, the major cations were sodium, calcium, magnesium, and potassium, whereas the major anions were bicarbonate, sulfate, and chloride.

Nutrients

Nutrient concentrations in the discharge, mixing, and mid-lake background zones of Lake Norman for 2000 and 2001 are provided in Table 2-5. Overall, nitrogen and phosphorus levels in 2001 were similar to those measured in 2000 and historically (DPC 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Total phosphorus concentrations in 2001, however, averaged about one-third to one-half of the values measured in 2000 for each of the zones investigated, but were well within the historical

range (DPC 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001) (Table 2-5).

Metals

Metal concentrations in the discharge, mixing, and mid-lake background zones of Lake Norman for 2001 were similar to that measured in 2000 (Table 2-5) and historically (DPC 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Iron concentrations near the surface were generally low (≤ 0.1 mg/L) during 2001, whereas iron levels near the bottom were slightly higher during the stratified period. Similarly, manganese concentrations in the surface and bottom waters were generally low (≤ 0.1 mg/L) in both 2000 and 2001, except during the summer and fall when bottom waters were anoxic (Table 2-5). This phenomenon, i.e., the release of iron and manganese from bottom sediments because of increased solubility induced by low redox conditions (low oxygen levels), is common in stratified waterbodies (Wetzel 1975). Manganese concentrations near the bottom rose above the NC water quality standard (0.5 mg/L) at various locations throughout the lake in summer and fall of both years, and is characteristic of historical conditions (DPC 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Heavy metal concentrations in Lake Norman never approached NC water quality standards, and there were no appreciable differences between 2000 and 2001.

FUTURE STUDIES

No changes are planned for the Water Chemistry portion of the Lake Norman maintenance monitoring program during 2002.

SUMMARY

Temporal and spatial trends in water temperature and DO data collected in 2001 were similar to those observed historically. Temperature and DO data collected in 2001 were within the range of previously measured values.

Reservoir-wide isotherm and isopleth information for 2001, coupled with heat content and hypolimnetic oxygen data, illustrated that Lake Norman exhibited thermal and oxygen dynamics characteristic of historical conditions and similar to other Southeastern reservoirs of comparable size, depth, flow conditions, and trophic status.

Availability of suitable pelagic habitat for adult striped bass in Lake Norman in 2001 was generally similar to historical conditions. All chemical parameters measured in 2001 were within the concentration ranges previously reported for the lake during both MNS preoperational and operational years. As has been observed historically, manganese concentrations in the bottom waters in the summer and fall of 2001 often exceeded the NC water quality standard. This is characteristic of waterbodies that experience hypolimnetic deoxygenation during the summer.

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Table 2-1. Water chemistry program for the McGuire Nuclear station NPDES long-term monitoring on Lake Norman.

2002 McGUIRE NPDES SAMPLING PROGRAM

PARAMETERS	LOCATIONS	10	20	40	50	80	95	110	130	140	150	159	620	690	720	800	160
	DEPTH (m)	33	33	5	20	32	23	27	21	10	23	23	15	7	5	4	3
	SAM CODE	IN-SITU ANALYSIS															
Temperature	Hydrolab	In-situ measurements are collected monthly at the above locations at 1m intervals from 0 3m to 1m above bottom															
Dissolved Oxygen	Hydrolab	Measurements are taken weekly from July-August for striped bass habitat.															
pH	Hydrolab																
Conductivity	Hydrolab																
		NUTRIENT ANALYSES															
Ammonia	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Nitrate+Nitrite	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Orthophosphate	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Total Phosphorus	AA-TP,DG-P	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Silica	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Cl	AA-Nut	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
TKN	AA-TKN	Q/T,B															
		ELEMENTAL ANALYSES															
Aluminum	ICP-24	Q/T,B	S/T,B	S/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Calcium	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Iron	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Magnesium	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Manganese	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Potassium	306-K	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Sodium	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Zinc	ICP-24	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Cadmium	HGA-CD		S/T,B	S/T		S/T,B	S/T,B			S/T		S/T,B					S/T
Copper	HGA-CU		S/T,B	S/T		S/T,B	S/T,B			S/T		S/T,B					S/T
Lead	HGA-PB		S/T,B	S/T		S/T,B	S/T,B			S/T		S/T,B					S/T
		ADDITIONAL ANALYSES															
Alkalinity	T-ALKT	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Turbidity	F-TURB	Q/T,B	Q/T,B	Q/T	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T,B	Q/T		Q/T,B		Q/T,B			S/T
Sulfate	UV_SO4		S/T,B	S/T		S/T,B				S/T		S/T,B					S/T
Total Solids	S-TSE		S/T,B	S/T		S/T,B				S/T		S/T,B					S/T
Total Suspended Solid·	S-TSSE		S/T,B	S/T		S/T,B				S/T		S/T,B					S/T

CODES. Frequency Q = Quarterly (Feb, May, Aug, Nov) S = Semi-annually (Feb,Aug)
T = Top (0 3m) B = Bottom (1m above bottom)

Table 2-2. Water chemistry methods and analyte detection limits for the McGuire Nuclear Station NPDES long-term maintenance program for Lake Norman.

Variables	Method	Preservation	Detection Limit
Alkalinity, total	Electrometric titration to a pH of 5.1[2]	4°C	1mg-CaCO3·l^{-1} *
Aluminum	Atomic emission/ICP-direct injecition[2]	0.5% HNO_3	0.3 mg ·l^{-1}
Ammonium	Automated phenate[1]	4°C	0.050 mg ·l^{-1}
Cadmium	Atomic absorption/graphite furnace-direct injection[2]	0.5% HNO_3	0.1 µg·l^{-1}
Calcium	Atomic emission/ICP-direct injecition[2]	0.5% HNO_3	0.04 mg ·l^{-1}
Chloride	Automated ferricyanide[1]	4°C	1.0 mg ·l^{-1}
Conductance, specific	Temperature compensated nickel electrode[1]	In-situ	1µmho·cm^{-1} *
Copper	Atomic absorption/graphite furnace-direct injection[2]	0.5% HNO_3	0.5 µg·l^{-1}
Fluoride	Potentiometric[2]	4°C	0.10 mg ·l^{-1}
Iron	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.1 mg ·l^{-1}
Lead	Atomic absorption/graphite furnace-direct injection[2]	0.5% HNO_3	2.0 µg·l^{-1}
Magnesium	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.001 mg ·l^{-1}
Manganese	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.003 mg ·l^{-1}
Nitrite-Nitrate	Automated cadmium reduction[1]	4°C	0.050 mg ·l^{-1}
Orthophosphate	Automated ascorbic acid reduction[1]	4°C	0.005 mg ·l^{-1}
Oxygen, dissolved	Temperature compensated polarographic cell[1]	In-situ	0.1 mg ·l^{-1}
pH	Temperature compensated glass electrode[1]	In-situ	0.1 std. units*
Phosphorus, total	Persulfate digestion followed by automated ascorbic acid reduction[1]	4°C	0.005 mg ·l^{-1} ** 0.015 mg ·l^{-1} **
Potassium	Atomic absorption/graphite furnace-direct injection[2]	0.5% HNO_3	0.1 mg ·l^{-1}
Silica	Automated molydosilicate[1]	4°C	0.5 mg ·l^{-1}
Sodium	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	0.3 mg ·l^{-1}
Sulfate	Turbidimetric, using a spectrophotometer[3]	4°C	1.0 mg ·l^{-1}
Temperature	Thermistor/thermometer[1]	In-situ	0.1°C*
Turbidity	Nephelometric turbidity[1]	4°C	1 NTU*
Zinc	Atomic emission/ICP-direct injection[2]	0.5% HNO_3	4 µg·l^{-1}

[1]United States Environmental Protection Agency 1979. Methods for chemical analysis of water and wastes. Environmental Monitoring and Support Laboratory. Cincinnati, OH.
[2]USEPA. 1982
[3]USEPA. 1984
*Instrument sensitivity used instead of detection limit.
**Detection limit changed during 1989.

Table 2-3. Heat content calculations for the thermal regime in Lake Norman for 2000 and 2001.

	2001	2000
Maximum areal heat content (g cal/cm^2)	27,964	27,434
Minimum areal heat content (g cal/cm^2)	7451	8066
Maximum hypolimnetic (below 11.5 m) areal heat content (g cal/cm^2)	15,173	15,459
Birgean heat budget (g cal/cm^2)	20,513	19,368
Epilimnion (above 11.5 m) heating rate (°C /day)	0.094	0.106
Hypolimnion (below 11.5 m) heating rate (°C /day)	0.062	0.082

Table 2-4. A comparison of areal hypolimnetic oxygen deficits (AHOD), summer chlorophyll a (chl a), secchi depth (SD), and mean depth of Lake Norman and 18 TVA reservoirs.

Reservoir	AHOD ($mg/cm^2/day$)	Summer Chl a (ug/L)	Secchi Depth (m)	Mean Depth (m)
Lake Norman (2001)	0.030	5.9	2.03	10.3
TVA [a]				
Mainstem				
Kentucky	0.012	9.1	1.0	5.0
Pickwick	0.010	3.9	0.9	6.5
Wilson	0.028	5.9	1.4	12.3
Wheelee	0.012	4.4		5.3
Guntersville	0.007	4.8	1.1	5.3
Nickajack	0.016	2.8	1.1	6.8
Chickamauga	0.008	3.0	1.1	5.0
Watts Bar	0.012	6.2	1.0	7.3
Fort London	0.023	5.9	0.9	7.3
Tributary				
Chatuge	0.041	5.5	2.7	9.5
Cherokee	0.078	10.9	1.7	13.9
Douglas	0.046	6.3	1.6	10.7
Fontana	0.113	4.1	2.6	37.8
Hiwassee	0.061	5.0	2.4	20.2
Norris	0.058	2.1	3.9	16.3
South Holston	0.070	6.5	2.6	23.4
Tims Ford	0.059	6.1	2.4	14.9
Watauga	0.066	2.9	2.7	24.5

[a] Data from Higgins et al. (1980), and Higgins and Kim (1981)

Table 2-5 Quarterly surface (0.3 m) and bottom (bottom minus 1 m) water chemistry for the MNS discharge, mixing zone, and background locations on Lake Norman during 2000 and 2001. Values less than detection were assumed to be the detection limit for calculating a mean.

LOCATION	Mixing Zone 1.0				Mixing Zone 2				MNS Discharge 4.0		Mixing Zone 5.0				Background 8.0				Background 11.0			
DEPTH	Surface		Bottom		Surface		Bottom		Surface		Surface		Bottom		Surface		Bottom		Surface		Bottom	
PARAMETERS / YEAR	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Turbidity (ntu)																						
Feb	3.27	2.01	4.53	3.76	3.13	1.61	3.00	2.65	3.47	1.58	1.68	1.30	3.96	1.50	3.62	1.14	33.4	1.41	3.15	1.40	4.08	2.17
May	1.22	1.55	1.22	1.37	0.98	1.24	0.93	1.22	0.95	1.52	0.88	1.27	1.16	1.82	0.75	1.36	1.82	2.57	0.97	1.48	2.49	2.53
Aug	1.04	1.65	3.47	2.52	1.33	1.75	2.24	2.46	0.88	1.74	1.57	1.69	9.23	4.08	1.55	1.52	4.92	2.30	1.61	1.58	5.9	4.01
Nov	0.97	1.92	6.9	2.75	1.04	1.93	7.36	4.62	1.53	1.43	1.04	2.30	3.77	4.62	1.07	1.04	8.32	8.98	1.60	1.99	2.87	12.50
Annual Mean	1.63	1.78	4.02	2.6	1.62	1.6	3.38	2.7	1.71	1.6	1.29	1.6	4.53	3.0	1.75	1.3	12.12	3.8	1.83	1.6	3.84	5.3
Specific Conductance (umho/cm)																						
Feb	57.1	57	57.0	56	57.1	56	56.9	56	58.1	58	57.8	57	57.0	56	57.2	56	56.7	56	60.4	58	59.5	59
May	58.5	49	58.7	48.9	60.2	49.3	59.3	49	60.6	50	60.3	50	59.8	49.2	61.7	49.3	61.3	49.5	60.7	49.6	62.9	50.8
Aug	64.0	67.1	74.0	76.5	64.0	67.4	77.0	73.1	65.0	67.6	64.0	NS	75.0	NS	64.0	67.2	70.0	72	63.0	67.1	74.0	72.5
Nov	64.0	73.1	107.6	108	64.2	73	105.1	98	66.7	74.7	66.6	73.8	67.4	74	65.6	72.8	92.3	73	66.5	72.2	73.3	71.9
Annual Mean	60.9	74.3	74.3	72.3	61.4	61.3	74.6	68.9	62.6	62.6	62.2	60.3	64.8	59.7	62.1	61.3	70.1	62.7	62.7	61.7	67.4	63.6
pH (units)																						
Feb	6.5	7.1	6.6	7.1	7.0	7.2	6.7	7.1	7.2	7.3	7.0	7.2	6.6	7.0	7.0	7.2	6.8	7.0	7.0	7.2	6.8	7.0
May	6.9	7.2	6.1	6.9	6.8	7.5	6.1	6.9	6.9	7.2	7.1	7.3	6.3	6.8	6.9	7.3	6.2	6.9	7.1	7.2	6.2	6.7
Aug	7.2	7.5	6.2	6.4	7.4	7.6	6.3	6.3	6.8	7.4	7.0	NS	6.4	NS	7.1	7.9	6.2	6.4	6.6	8.1	6.2	6.4
Nov	7.0	7.6	6.8	6.9	7.1	7.4	6.8	6.8	7.1	7.5	7.1	7.6	6.6	7.1	7.2	7.6	6.7	7.0	7.0	7.6	6.6	6.9
Annual Mean	6.91	6.43	6.43	6.84	7.07	7.42	6.48	6.79	6.99	7.32	7.04	7.37	6.46	6.99	7.04	7.49	6.46	6.82	6.92	7.52	6.47	6.75
Alkalinity (mg CaCO3/l)																						
Feb	15.5	16.5	16.0	16.5	16.5	16.0	15.5	16.5	16.0	16.5	16.0	16.5	15.5	16.5	16.0	17.0	15.5	16.5	15.5	16.5	15.5	16.5
May	15.5	15.5	15.5	16.0	15.0	16.0	15.5	16.0	15.0	16.0	15.5	16.0	15.5	16.0	15.0	16.0	15.0	16.0	15.0	15.5	15.5	16.0
Aug	16.5	17.0	17.0	17.5	16.5	17.0	17.5	17.0	16.0	17.0	17.0	17.5	23.5	21.0	16.5	16.5	20.0	14.0	16.5	16.5	22.0	18.0
Nov	17.0	18.0	32.0	35.0	17.0	18.5	34.5	19.5	17.0	18.5	17.0	19.0	17.0	18.5	17.0	18.5	30.0	18.5	16.5	18.5	18.5	18.5
Annual Mean	16.14	16.76	20.14	21.26	16.26	16.88	20.77	17.26	16.01	17.01	16.39	17.26	17.89	18.01	16.14	17.01	20.14	16.26	15.89	16.76	17.89	17.26
Chloride (mg/l)																						
Feb	5.5	6.1	5.6	6.2	5.6	6.1	5.5	6.2	5.7	6.1	5.6	6.0	5.5	6.1	5.8	6.1	5.7	6.1	6.1	6.2	5.8	6.3
May	5.8	5.5	5.7	5.2	5.6	5.5	5.8	5.3	5.8	5.4	5.8	5.5	5.8	5.5	5.7	5.7	5.7	5.4	5.6	5.4	5.7	5.1
Aug	5.7	6.8	5.9	6.7	5.6	6.7	5.8	6.7	5.7	6.7	5.6	7.1	5.6	7.4	5.7	6.8	5.7	7.1	5.7	6.6	6.0	6.7
Nov	5.6	6.5	5.9	5.9	5.7	6.1	6.0	6.3	5.7	6.2	5.8	NS	5.7	6.0	5.6	6.2	5.8	6.2	5.6	6.3	5.6	6.2
Annual Mean	5.65	6.23	5.78	6.00	5.63	6.10	5.78	6.13	5.73	6.10	5.70	6.20	5.65	6.25	5.70	6.20	5.73	6.20	5.75	6.13	5.78	6.08
Sulfate (mg/l)																						
Feb	5.45	NS	5.76	NS	5.46	6.2	5.46	6.6	5.48	6.3	5.48	NS	5.44	NS	5.53	6.2	5.46	6.1	5.97	NS	5.88	NS
May	5.94	NS	5.98	NS	6.03	6.7	5.96	6.5	6.21	6.6	6.04	NS	5.95	NS	6.80	6.7	5.92	6.7	6.13	NS	5.96	NS
Aug	6.22	NS	5.95	NS	6.24	6.7	5.75	6.6	6.22	7.0	6.22	6.9	5.31	6.5	7.50	6.9	5.59	6.6	6.23	NS	5.47	NS
Nov	6.15	NS	3.78	NS	6.14	6.0	16.5	6.5	6.13	6.7	6.06	NS	6.01	NS	7.00	6.7	3.96	6.2	6.23	NS	6.13	NS
Annual Mean	5.94	NS	5.37	NS	5.97	6.38	8.43	6.53	6.01	6.66	5.95	6.91	5.68	6.51	6.71	6.64	5.23	6.40	6.14		5.86	
Calcium (mg/l)																						
Feb	2.83	3.20	2.79	3.34	2.95	3.71	3.01	3.21	2.86	3.31	2.88	2.96	2.95	3.22	2.79	3.14	2.89	2.98	2.69	2.90	2.91	3.03
May	3.05	3.17	3.09	3.39	2.91	3.25	2.89	3.09	2.93	3.11	2.99	3.21	3.03	3.41	2.62	3.46	3.05	3.30	3.06	3.54	3.20	3.13
Aug	3.15	3.33	3.37	3.44	3.14	3.35	3.46	3.49	3.16	3.37	3.12	3.38	3.57	3.37	3.11	3.34	3.40	3.58	3.21	3.36	3.65	3.60
Nov	3.29	3.47	4.03	4.37	3.21	4.36	4.11	3.96	3.22	3.78	3.22	3.79	3.25	3.64	3.22	3.88	4.02	3.52	3.19	3.35	3.07	3.28
Annual Mean	3.08	3.32	3.32	3.64	3.05	3.67	3.37	3.44	3.04	3.39	3.05	3.34	3.20	3.41	2.94	3.45	3.34	3.35	3.04	3.28	3.21	3.26
Magnesium (mg/l)																						
Feb	1.43	1.53	1.42	1.62	1.46	1.72	1.51	1.59	1.44	1.62	1.45	1.52	1.48	1.57	1.41	1.55	1.44	1.52	1.38	1.50	1.48	1.56
May	1.52	1.51	1.53	1.64	1.45	1.61	1.45	1.55	1.46	1.61	1.46	1.60	1.51	1.67	1.33	1.68	1.49	1.58	1.43	1.70	1.51	1.50
Aug	1.54	1.60	1.57	1.65	1.53	1.63	1.62	1.66	1.53	1.61	1.52	1.62	1.65	1.72	1.52	1.62	1.54	1.70	1.51	1.61	1.62	1.69
Nov	1.62	1.66	1.76	1.88	1.59	2.00	1.78	1.87	1.59	1.86	1.60	1.87	1.60	1.81	1.59	1.89	1.76	1.75	1.59	1.69	1.57	1.67
Annual Mean	1.53	1.57	1.57	1.70	1.51	1.74	1.59	1.67	1.50	1.67	1.51	1.65	1.56	1.69	1.46	1.68	1.56	1.64	1.48	1.63	1.55	1.61

NS = Not Sampled

Table 2-5 (Continued)

LOCATION	Mixing Zone 1 0				Mixing Zone 2				MNS Discharge 4.0		Mixing Zone 5 0				Background 8 0				Background 11 0			
DEPTH	Surface		Bottom		Surface		Bottom		Surface		Surface		Bottom		Surface		Bottom		Surface		Bottom	
PARAMETERS YEAR	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Potassium (mg/l)																						
Feb	1 67	1 83	1 67	1.84	1 75	1.79	1.82	1 83	1.72	1 82	1 72	1 87	1 78	1.78	1 66	1.79	1 65	1.76	1.63	1 86	1 82	1 83
May	1 91	1 84	1 85	1 82	1.76	1.77	1 74	1.75	1.77	1 81	1 95	1 78	1.82	1.75	1 59	1 82	1 88	1.72	1 73	1.82	1 86	1 82
Aug	1.71	1 83	1 79	1.85	1.82	1 87	1.74	1 92	1.76	1 88	1.73	1 86	1 86	1 87	1 83	1 85	1.65	1 85	1.73	1 82	1 80	1 84
Nov	1 85	1 96	1 92	2 02	1 82	2 01	1 99	1.97	1 84	1 94	1 85	1 98	1 82	1 99	1 80	1 95	1 91	1 93	1 85	1 95	1 84	1 87
Annual Mean	1 79	1 81	1 81	1 88	1.79	1 86	1 82	1 87	1 77	1 86	1 81	1 87	1 82	1 85	1.72	1 85	1 77	1 82	1 74	1 86	1 83	1 84
Sodium (mg/l)																						
Feb	6 43	6 78	6 27	7 25	7.33	6 80	6 99	6 92	6 57	7 22	6 34	7 06	6 52	6 87	6 40	6 87	6 55	7.14	7.16	7 48	7 41	7.29
May	6 72	6 89	6 79	6 98	6 37	7.13	6 31	6 95	6 58	7 39	6 45	6 88	6 36	6 94	5 82	6 94	6 69	7 09	6 08	7 21	6.57	6 96
Aug	7.12	7 09	6 43	6 35	6 84	6.70	7 30	6 74	6 93	6 40	7.12	6 68	6.76	7.17	7.19	6 89	6 76	6 95	7 06	6 57	6 72	6.76
Nov	6 46	7 38	6 19	7 46	6 61	8 17	6 26	7 66	6 40	7 85	6 40	8 23	6 37	8 02	6 46	7 82	6 06	7 50	6 50	7 50	6 67	7 55
Annual Mean	6 68	6 42	6 42	7 01	6 79	7 20	6 72	7 07	6 62	7 22	6 58	7 21	6 50	7 25	6 47	7 13	6 52	7.17	6 70	7.19	6 84	7.14
Aluminum (mg/l)																						
Feb	0 118	0 050	0.125	0 061	0 127	0 050	0 134	0 057	0 129	0 051	0 148	0 050	0 121	0 060	0.14	0 050	0 236	0 064	0 124	0 050	0 159	0 080
May	0 083	0 050	0 068	0 050	0 061	0 050	0.061	0 050	0 081	0 050	0 077	0 050	0 076	0 050	0 068	0 050	0 086	0 050	0 086	0 052	0 112	0 084
Aug	0 062	0 050	0 113	0 050	0 094	0 050	0 131	0 050	0 087	0 050	0 100	0 050	0 150	0 050	0 109	0 050	0 118	0 050	0 098	0 050	0 147	0 094
Nov	0 050	0 050	0 079	0 050	0 050	0 050	0 077	0 053	0 050	0 050	0 050	0 050	0 050	0 050	0 05	0 050	0 06	0 074	0 05	0 050	0 05	0 054
Annual Mean	0 08	0 05	0 096	0 05	0 083	0 05	0.101	0 05	0 087	0 05	0 094	0 05	0 099	0 05	0 092	0 05	0 124	0 06	0 09	0 05	0 117	0 08
Iron (mg/l)																						
Feb	0 019	0 028	0 026	0 033	0 021	0 029	0 037	0 032	0 021	0 027	0 020	0 020	0 027	0 034	0 020	0 023	0 211	0 032	0 024	0 026	0 069	0 050
May	0 027	0 015	0 040	0.010	0 019	0 013	0 020	0 010	0 017	0 014	0 022	0 013	0 051	0 010	0 010	0 019	0 027	0 017	0 024	0 027	0 063	0 047
Aug	0 030	0 029	0 068	0 057	0 028	0 034	0 055	0 047	0 030	0 028	0 023	0 028	0 756	0.010	0 033	0 024	0 265	0 068	0 029	0 034	0 450	0 155
Nov	0 033	0 018	1 281	0 537	0 039	0 024	3 218	0 044	0 052	0 015	0 041	0 013	0 129	0 030	0 029	0 011	1 960	0 070	0 053	0 010	0 161	0 067
Annual Mean	0 027	0 023	0 354	0 159	0 027	0 025	0 833	0 033	0 030	0 021	0 027	0 019	0 241	0 021	0 023	0 019	0 616	0 047	0 033	0 024	0 186	0 080
Manganese (mg/l)																						
Feb	0 01	0 01	0 02	0 02	0 01	0 01	0 01	0 02	0 01	0 01	0 01	0 01	0 02	0 02	0 01	0 01	0 06	0 01	0 01	0 02	0 02	0 03
May	0 01	0 01	0 02	0 02	0 01	0 00	0 01	0 01	0 01	0 01	0 01	0 01	0 02	0 03	0 01	0 00	0 01	0 01	0 01	0 00	0 04	0 04
Aug	0 02	0 02	0 31	0 72	0 02	0 02	1.18	0 54	0 02	0 02	0 02	0 02	2 47	0 22	0 02	0 02	0 87	0 94	0 01	0 01	2 20	1.14
Nov	0 04	NS	5 18	NS	0 05	NS	5 15	NS	0 07	NS	0 07	NS	0 42	NS	0 03	NS	3 72	NS	0 07	NS	1.19	NS
Annual Mean	0 02	0 01	1 38	0 25	0 02	0 01	1 59	0 19	0 03	0 01	0 03	0 01	0 73	0 09	0 01	0 01	1.17	0 32	0 02	0 01	0 86	0 40
Cadmium (ug/l)																						
Feb	0 5	NS	0 5	NS	0 5	0 5	0 5	0 5	0 5	0 5	0.5	NS	0.5	NS	0.5	0 5	0 5	0 5	0 5	NS	0 5	NS
May	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Aug	0 5	NS	0 5	NS	0 5	0 5	0 5	0 5	0 5	0 5	0 5	NS	0 5	NS	0 5	0 5	0 5	0 5	0 5	NS	0 5	NS
Nov	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS	0 5	NS
Annual Mean	0 5		0 5		0 5		0 5	0 5	0 5	0 5	0 5		0 5		0 5	0 5	0 5	0 5	0 5		0 5	
Copper (ug/l)																						
Feb	2 00	NS	2	NS	2	2 0	2	2 0	2	2 0	2	NS	2	NS	2	2 0	4 89	2 0	2 83	NS	2 58	NS
May	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Aug	2 0	NS	5 0	NS	2 3	2 0	2.1	2 0	2 0	2 0	2.0	NS	2.0	NS	2 0	2 0	2 0	2 0	2 0	NS	2.0	NS
Nov	2 1	NS	2 2	NS	2 0	NS	2 0	NS	2 0	NS	2 0	NS	2 3	NS	2 0	NS	2 0	NS	3 1	NS	2 1	NS
Annual Mean	2 0		3 1		2.1	2 0	2 0	2 0	2 0	2 0	2 0		2 1		2 0	2 0	3 0	2 0	2 7		2 2	
Lead (ug/l)																						
Feb	2	NS	2	NS	2	2	2	2	2	2	2	NS	2	NS	2	2	2	2	2	NS	2	NS
May	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Aug	2	NS	2	NS	2	2	2	2	2	2	2	NS	2	NS	2	2	2	2	2	NS	2	NS
Nov	2	NS	2	NS	2	NS	2	NS	2	NS	2	NS	2	NS	2	NS	2	NS	2	NS	2	NS
Annual Mean	2		2		2	2	2	2	2	2	2		2		2	2	2	2	2		2	

NS = Not sampled

Table 2-5. (Continued)

LOCATION	Mixing Zone 1.0				Mixing Zone 2				MNS Discharge 4.0		Mixing Zone 5.0				Background 8.0				Background 11.0			
DEPTH	Surface		Bottom		Surface		Bottom		Surface		Surface		Bottom		Surface		Bottom		Surface		Bottom	
PARAMETERS / YEAR	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Zinc (ug/l)																						
Feb	5	5	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5
May	5	5	5	5	5	5	5	5	5	5	9	5	5	5	5	5	5	5	5	5	5	5
Aug	5	5	12	9	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Nov	5	6	9	7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Annual Mean	5.0	5.3	8.5	6.5	5.0	5.0	5.0	5.3	5.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.3	5.0
Nitrate (ug/l)																						
Feb	100	110	100	120	100	120	100	120	100	110	100	110	100	120	100	110	90	110	160	150	150	160
May	160	130	240	150	160	130	240	150	160	140	160	130	220	150	160	130	220	170	190	640	260	140
Aug	20	30	290	260	20	30	240	270	60	30	40	30	30	170	30	30	180	1460	20	20	140	260
Nov	70	690	20	710	70	820	20	50	70	20	80	50	180	50	60	40	20	100	120	90	210	100
Annual Mean	87.5	240.0	162.5	310.0	87.5	275.0	150.0	147.5	97.5	75.0	95.0	80.0	132.5	122.5	87.5	77.5	127.5	460.0	122.5	225.0	190.0	165.0
Ammonia (ug/l)																						
Feb	20	20	20	40	20	20	20	30	20	20	20	20	20	30	20	20	20	20	40	30	40	40
May	20	20	20	60	20	20	20	50	20	30	20	20	20	50	20	20	20	60	20	20	20	90
Aug	20	20	20	70	20	20	50	50	20	20	20	10	180	60	20	20	60	20	20	20	100	20
Nov	20	30	560	600	20	20	730	90	20	20	20	20	20	70	20	30	610	80	70	120	80	210
Annual Mean	20.0	22.5	155.0	192.5	20.0	20.0	205.0	55.0	20.0	22.5	20.0	17.5	60.0	52.5	20.0	22.5	177.5	45.0	37.5	47.5	60.0	90.0
Total Phosphorous (ug/l)																						
Feb	7	4	7	5	6	4	8	5	26	4	31	4	6	4	17	63	7	4	9	7	7	8
May	9	6	11	5	7	16	6	8	6	5	8	7	8	6	7	7	7	5	10	8	10	6
Aug	23	10	16	10	18	10	9	10	26	10	10	10	20	10	10	10	11	10	18	10	29	17
Nov	13	10	14	10	8	10	14	10	9	10	159	10	11	10	10	10	24	18	17	11	26	11
Annual Mean	13.0	7.5	12.0	7.5	9.8	10.0	9.3	8.3	16.8	7.3	52.0	7.8	11.3	7.5	11.0	22.5	12.3	9.3	13.5	9.0	18.0	10.5
Orthophosphate (ug/l)																						
Feb	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2
May	5	2	5	2	5	2	5	2	5	2	6	2	6	2	14	2	5	2	5	2	6	2
Aug	5	5	5	8	5	5	5	5	5	5	5	7	5	7	5	5	5	7	5	7	5	7
Nov	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Annual Mean	5.0	3.5	5.0	4.3	5.0	3.5	5.3	4	5.0	4	5.3	4	5.3	4	7.3	4	5.0	4	5.0	4.0	5.3	4
Silica (mg/l)																						
Feb	3.3	2.9	3.2	3.0	3.2	3.0	3.3	3.0	3.2	3.0	3.2	2.9	3.2	3.0	3.3	2.9	3.1	2.8	4.1	3.6	4.0	3.7
May	3.4	2.9	4.0	3.2	3.5	2.9	4.0	3.1	3.6	2.9	3.5	2.9	3.9	3.2	3.5	3.0	3.9	3.3	3.4	2.9	4.3	3.5
Aug	2.0	2.4	4.5	4.0	2.0	2.7	4.6	4.1	2.2	2.7	2.1	2.7	4.2	4.1	2.0	2.6	4.2	4.0	2.1	2.7	4.5	4.2
Nov	2.7	3.4	5.3	4.7	2.7	3.2	5.6	3.4	2.7	3.2	2.7	3.3	3.2	3.4	2.6	3.1	5.1	4.3	3.3	3.5	4.4	4.5
Annual Mean	2.9	2.9	4.3	3.7	2.9	3.0	4.4	3.4	2.9	3.0	2.9	3.0	3.6	3.4	2.9	2.9	4.1	3.6	3.2	3.2	4.3	4.0

NS = Not Sampled

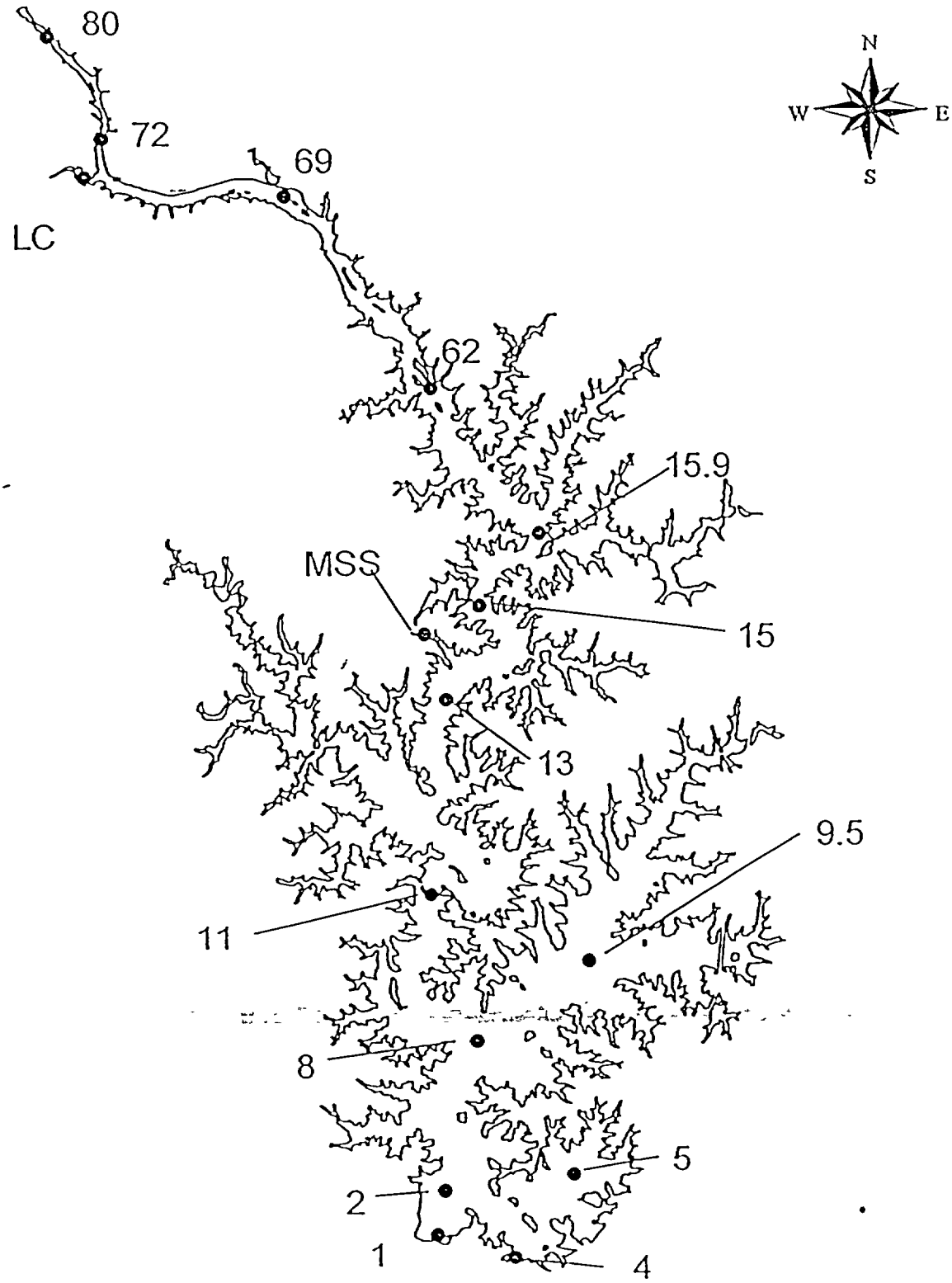


Figure 2-1. Water quality sampling locations for Lake Norman.

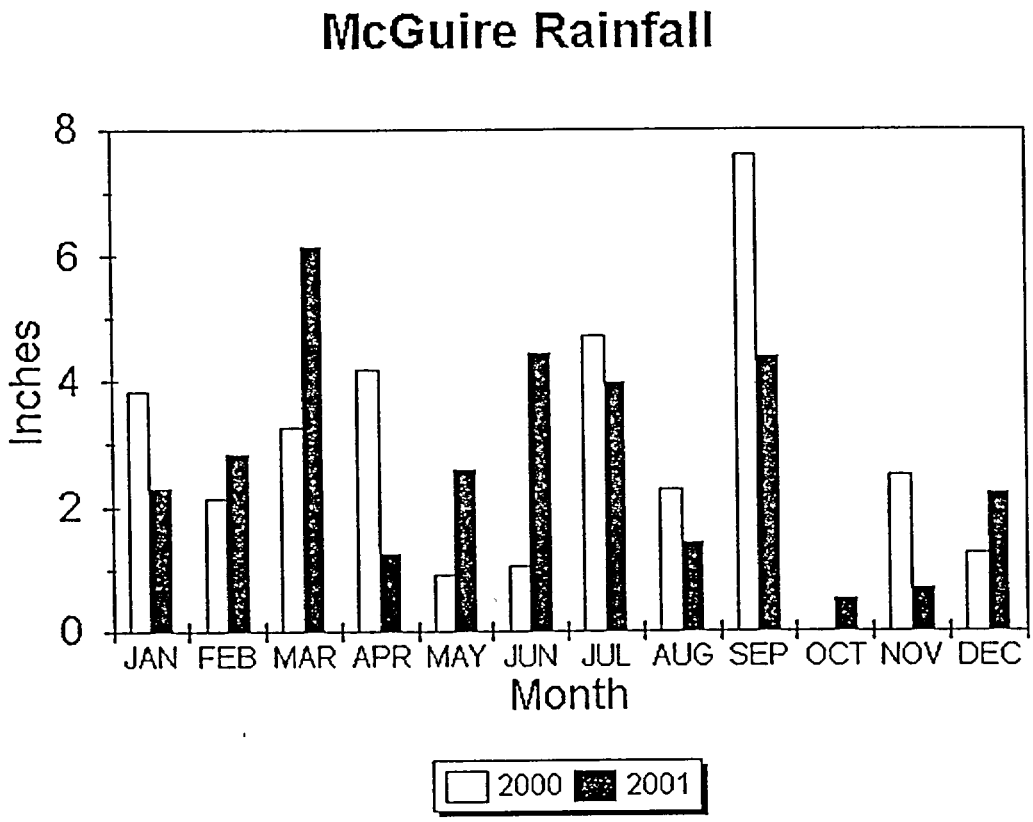


Figure 2-2. Monthly precipitation in the vicinity of McGuire Nuclear Station.

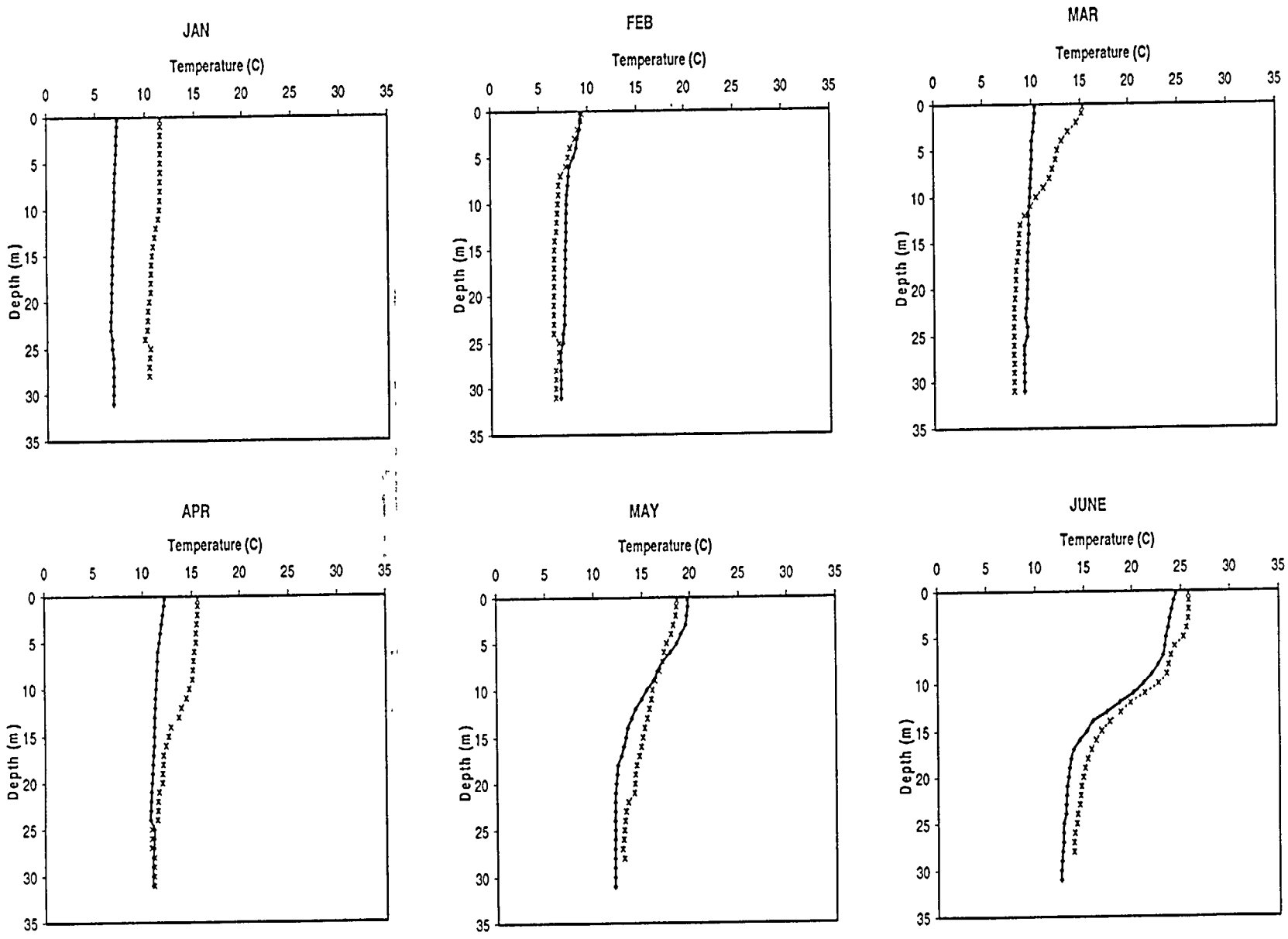


Figure 2-3. Monthly mean temperature profiles for the McGuire Nuclear Station background zone in 2000 (××) and 2001 (♦ ♦).

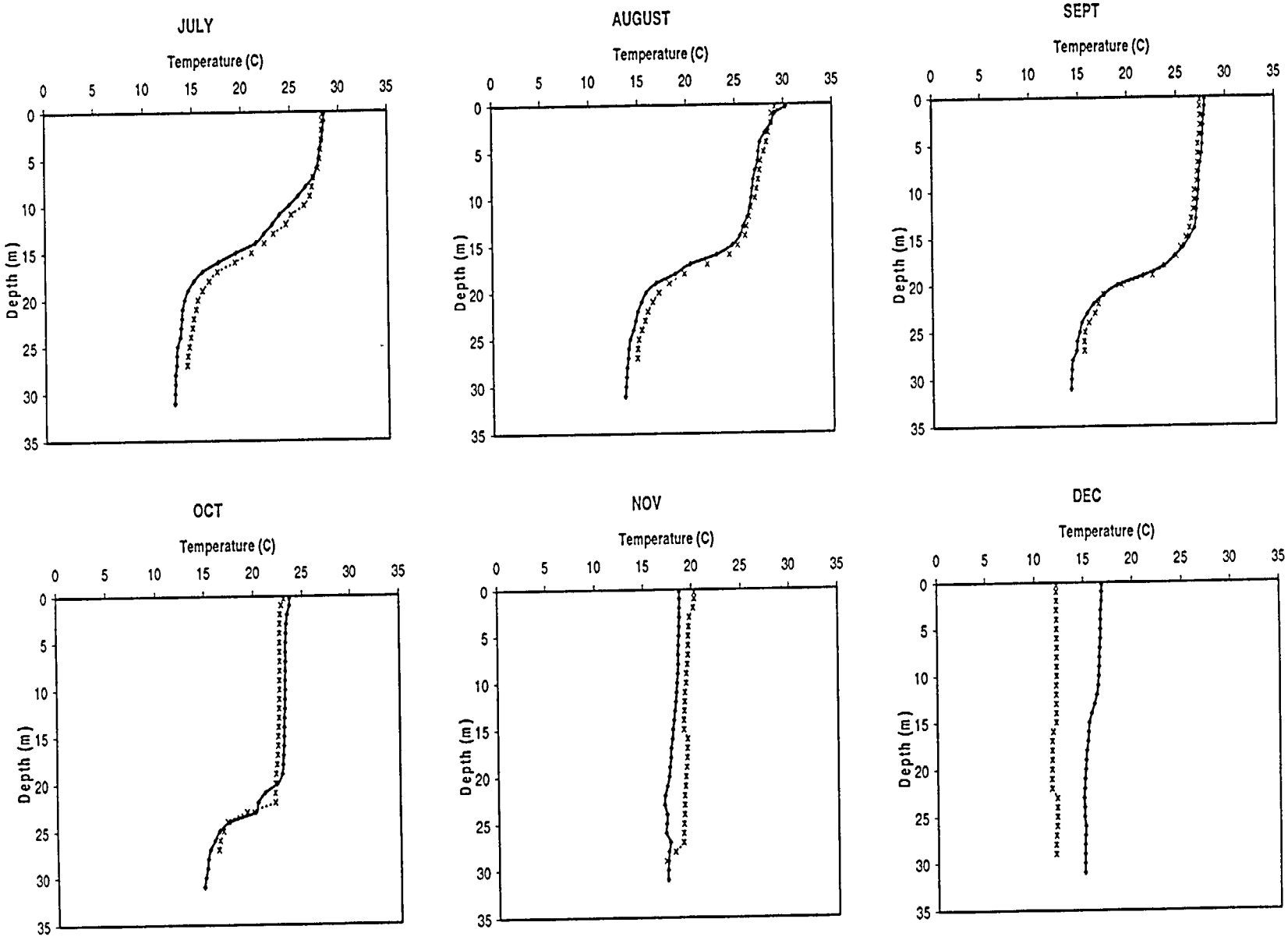


Figure 2-3. (con't).

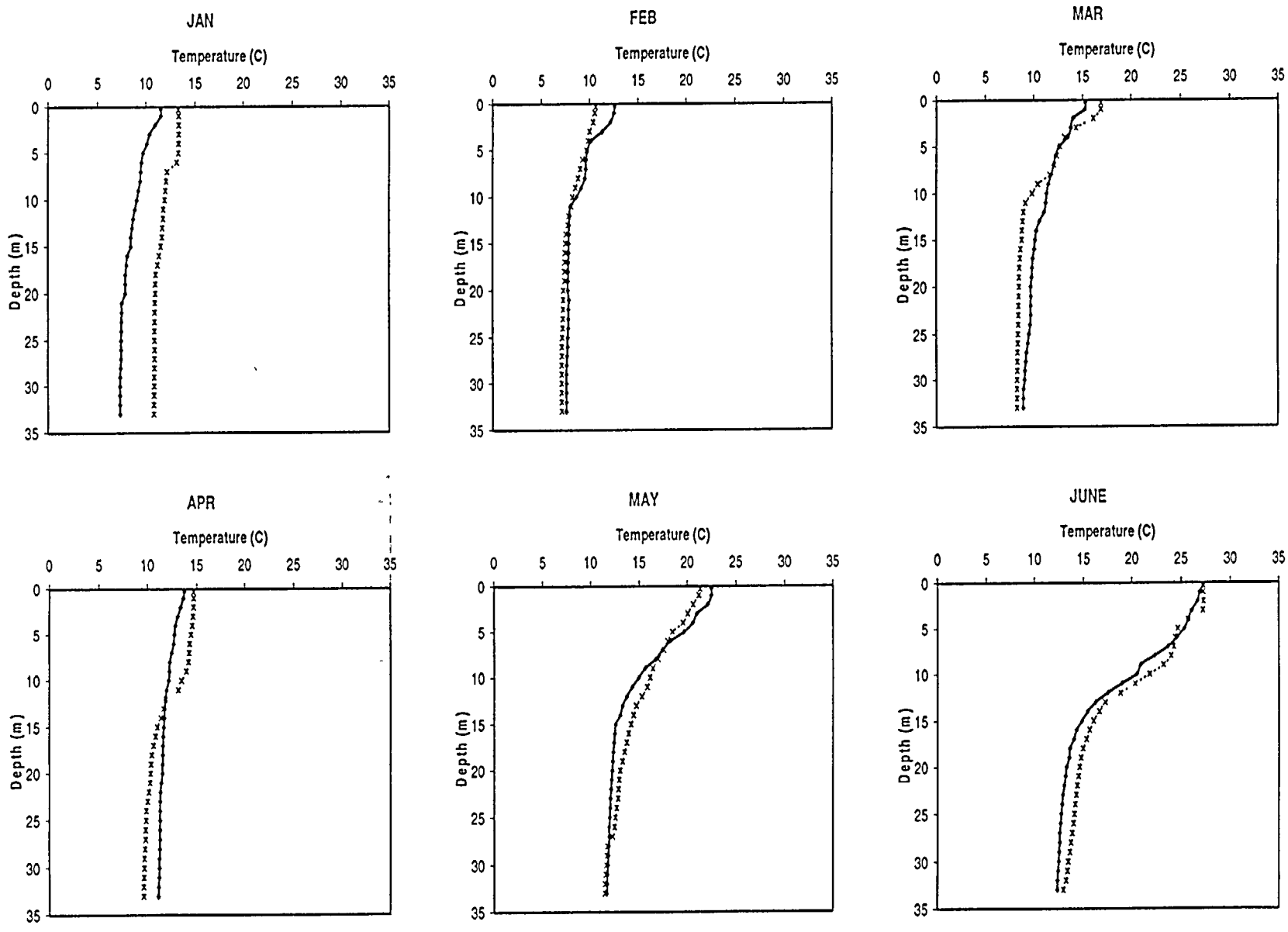


Figure 2-4. Monthly mean temperature profiles for the McGuire Nuclear Station mixing zone in 2000 (××) and 2001 (♦♦).

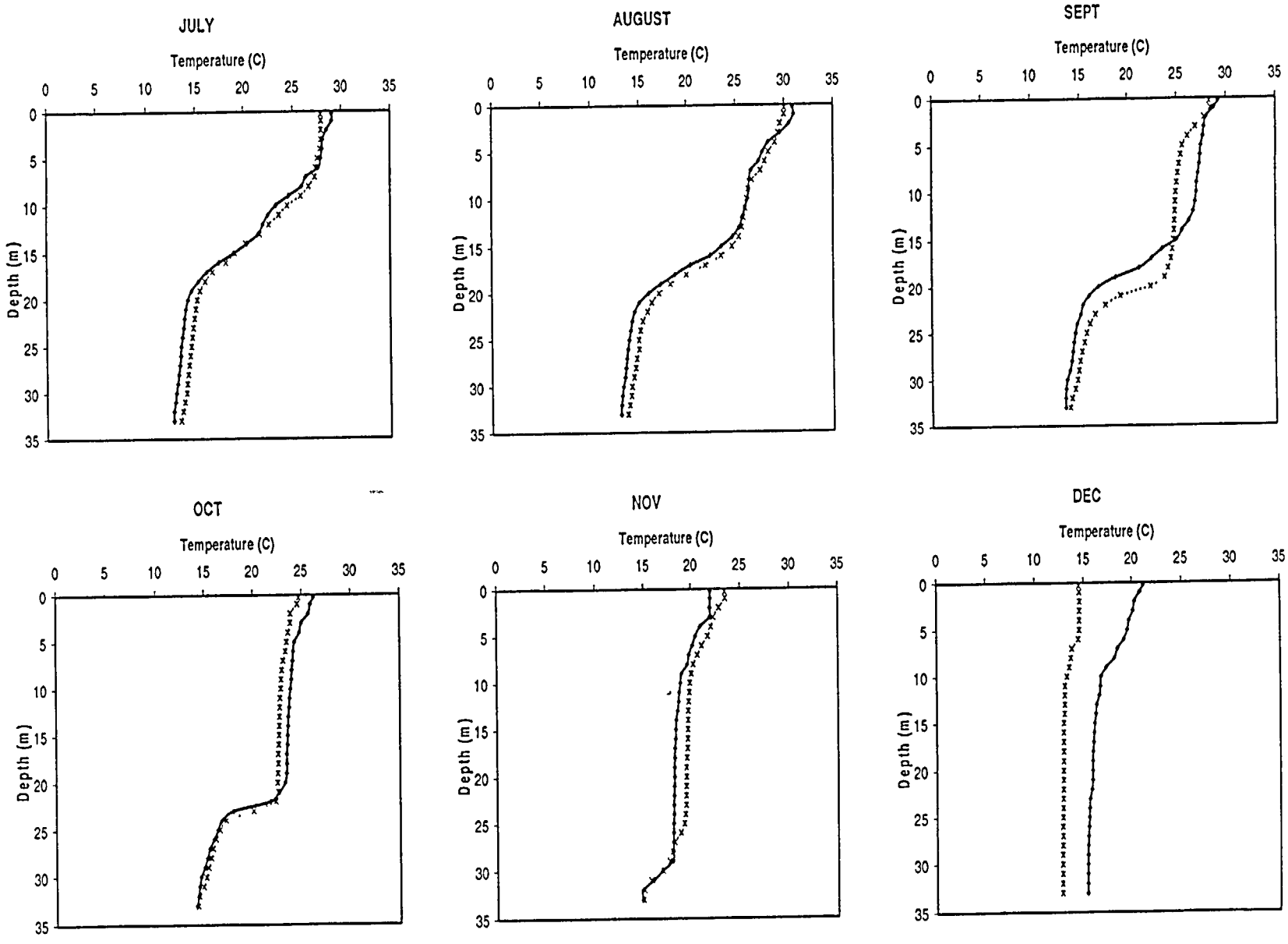


Figure 2-4. (con't).

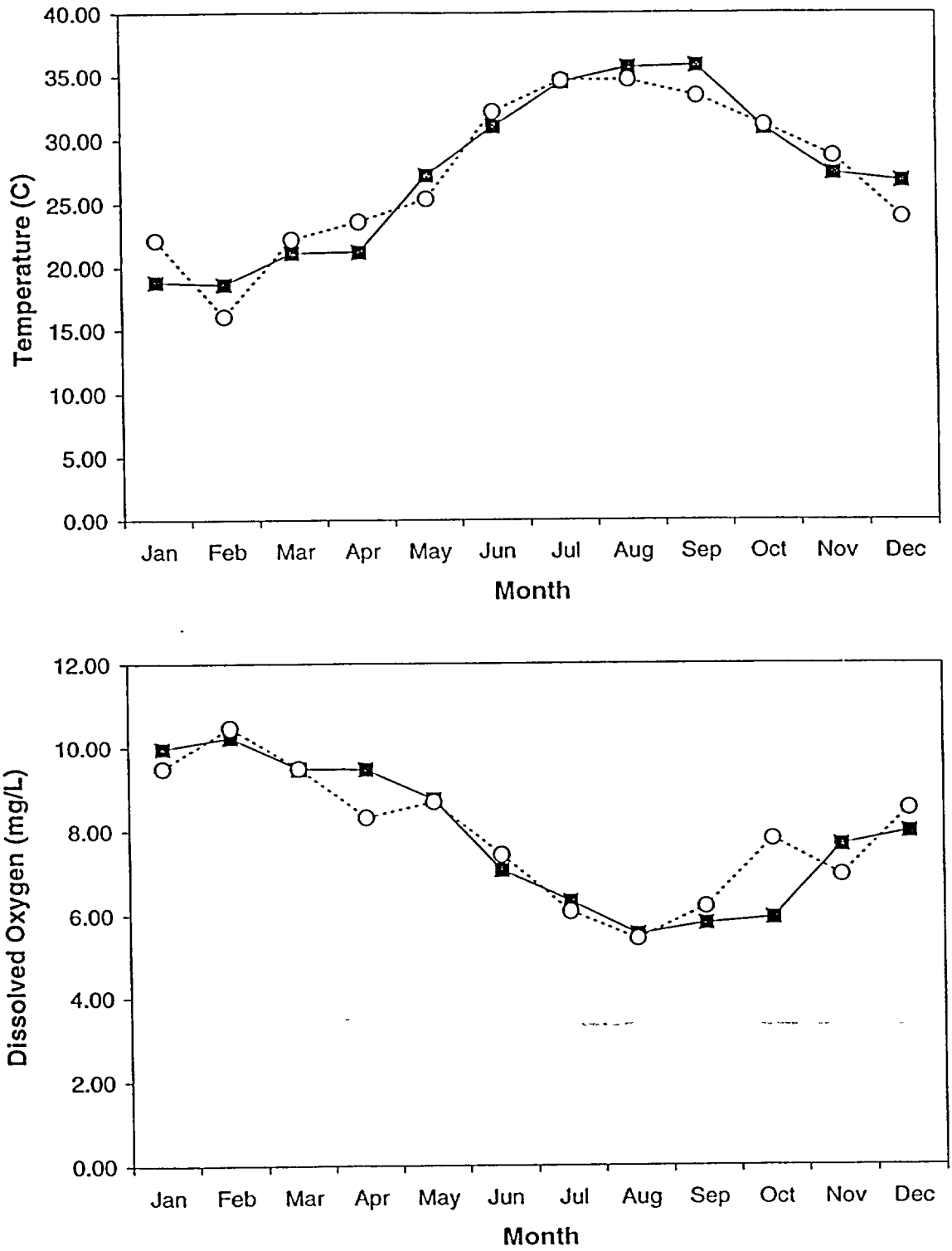


Figure 2-5. Monthly surface (0.3m) temperature and dissolved oxygen data at the discharge location (loc. 4.0) in 2000 (O) and 2001 (■).

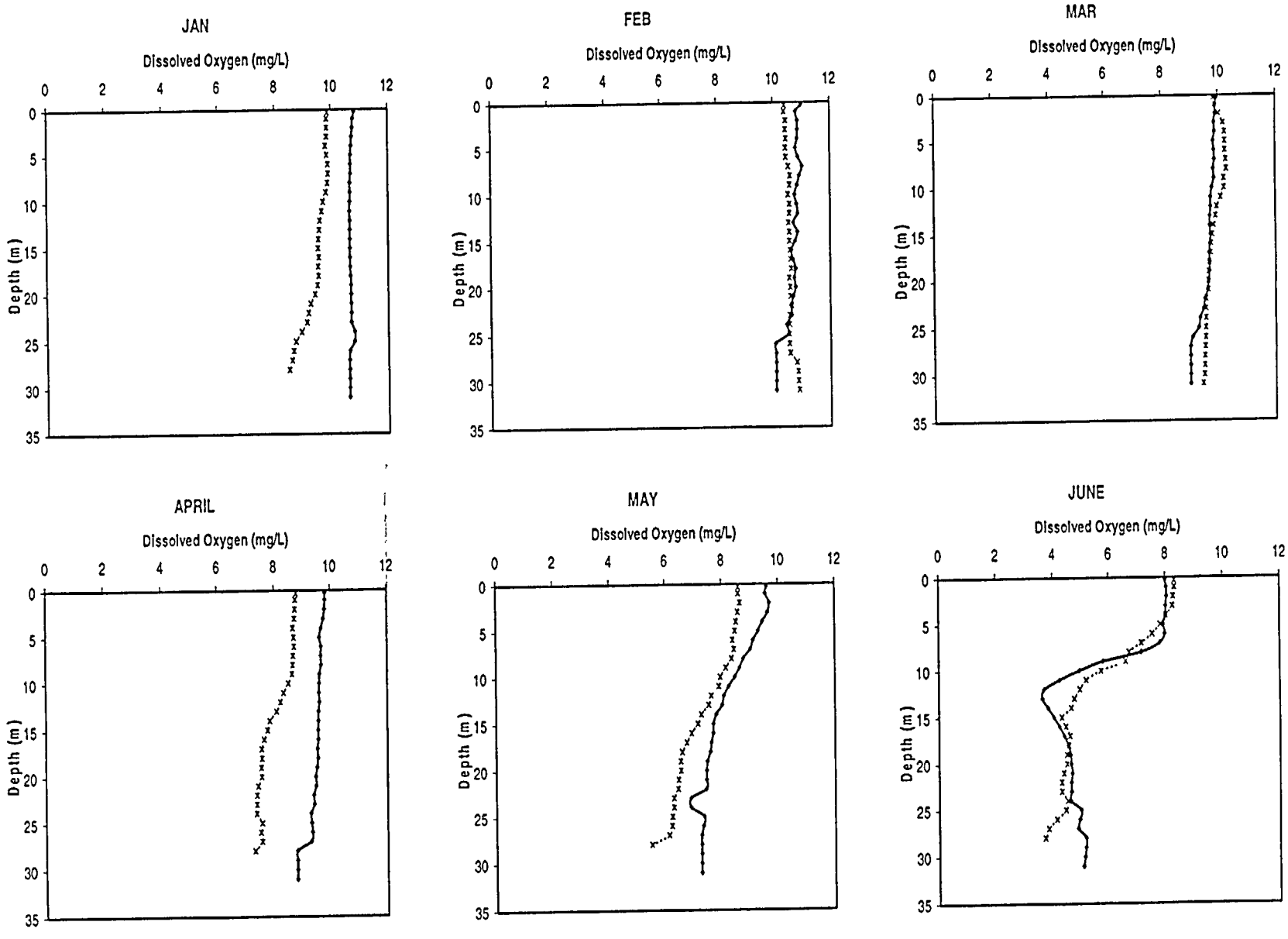


Figure 2-6. Monthly mean dissolved oxygen profiles for the McGuire Nuclear Station background zone in 2000 (××) and 2001 (♦ ♦).

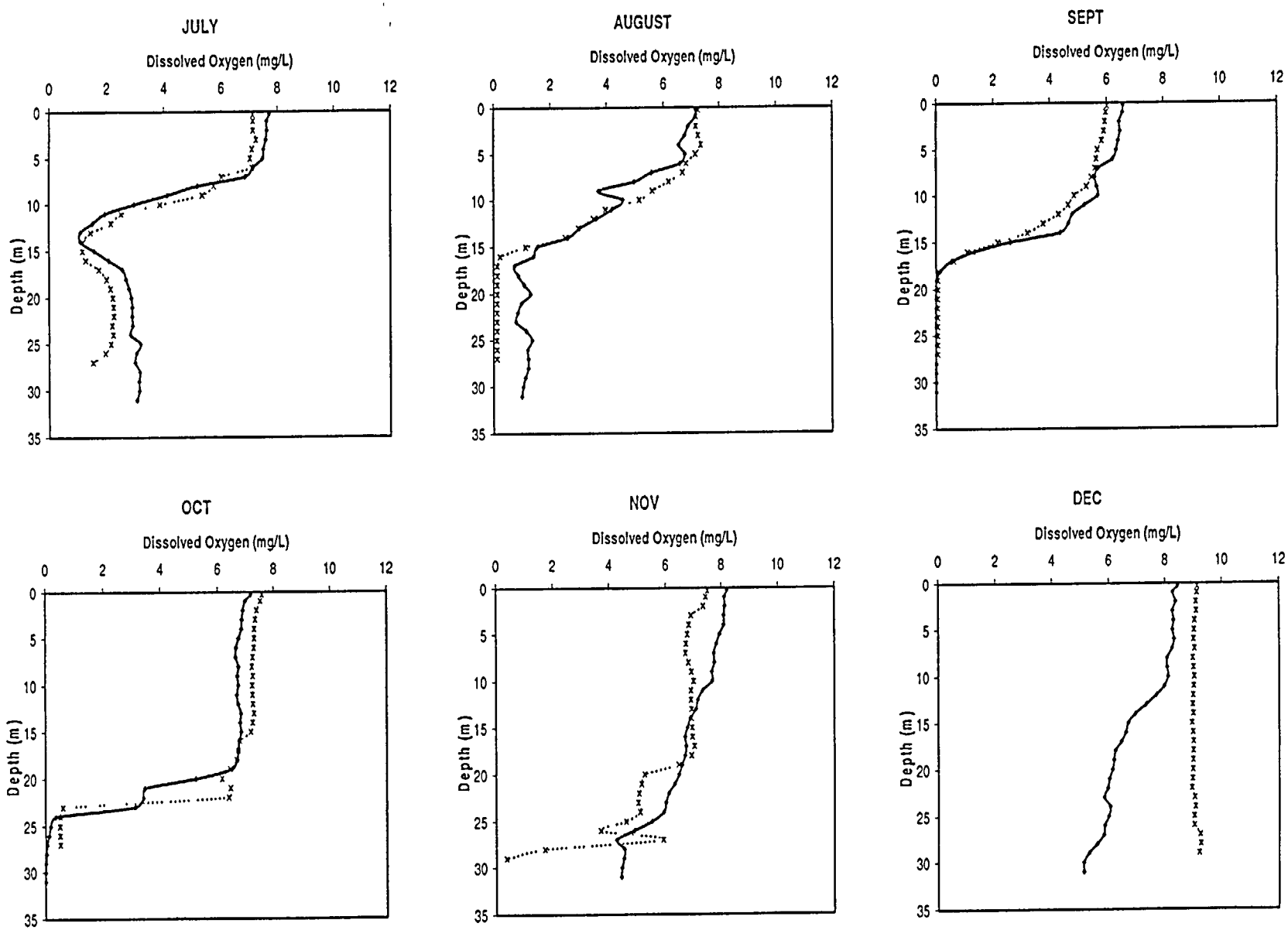


Figure 2-6. (con't).

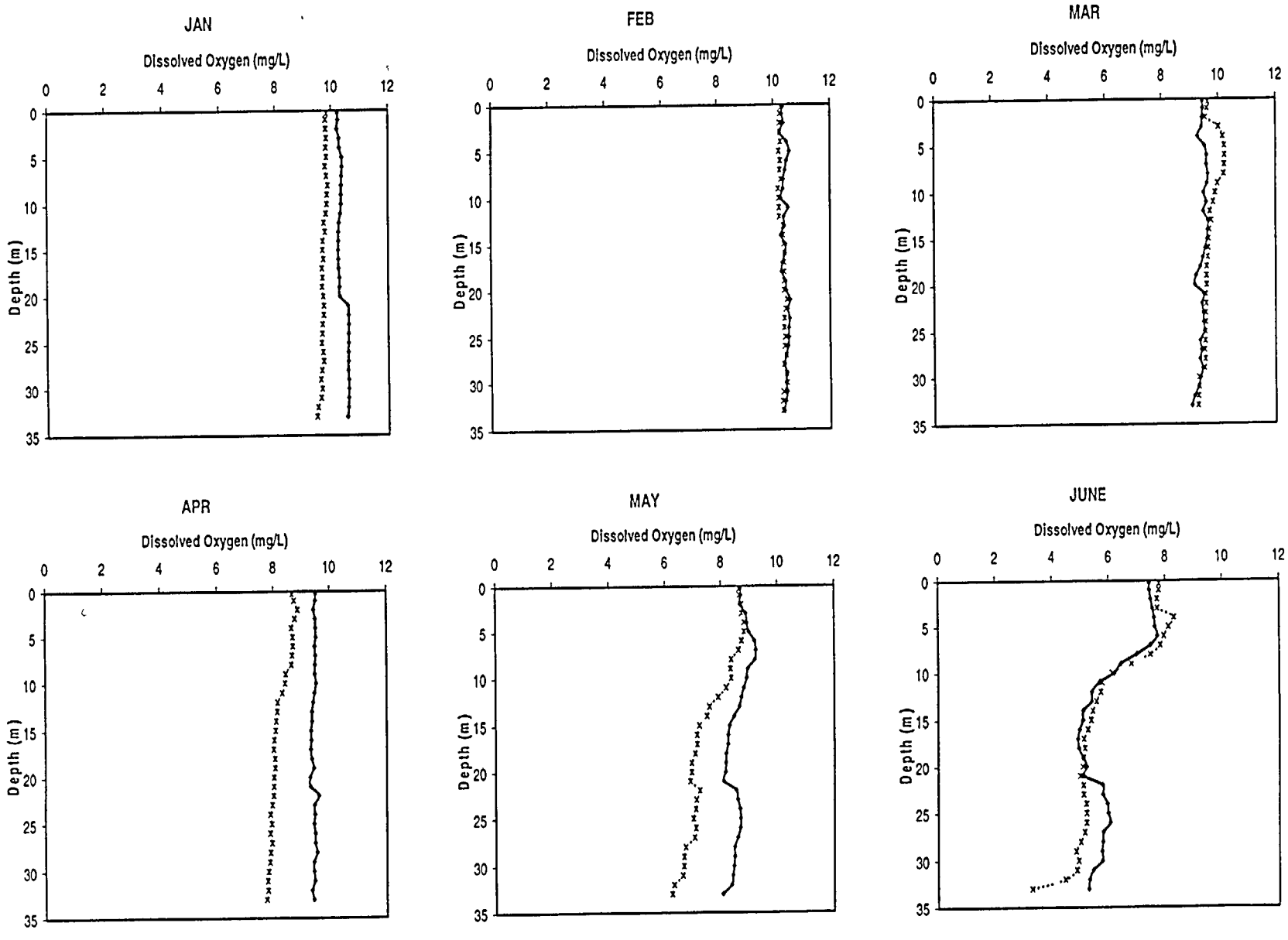


Figure 2-7. Monthly mean dissolved oxygen profiles for the McGuire Nuclear Station mixing zone in 2000 (××) and 2001 (♦ ♦).

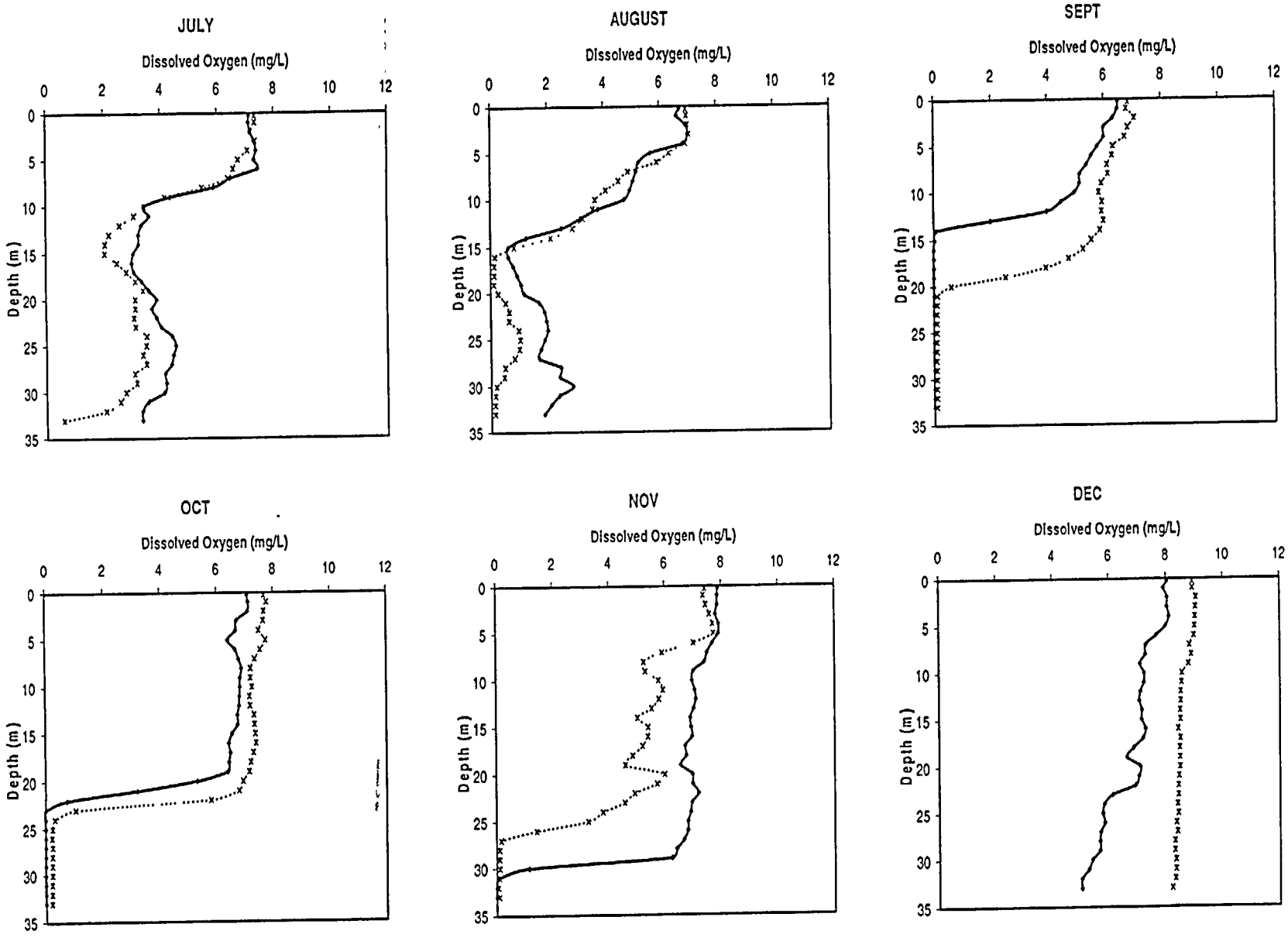


Figure 2-7. (con't).

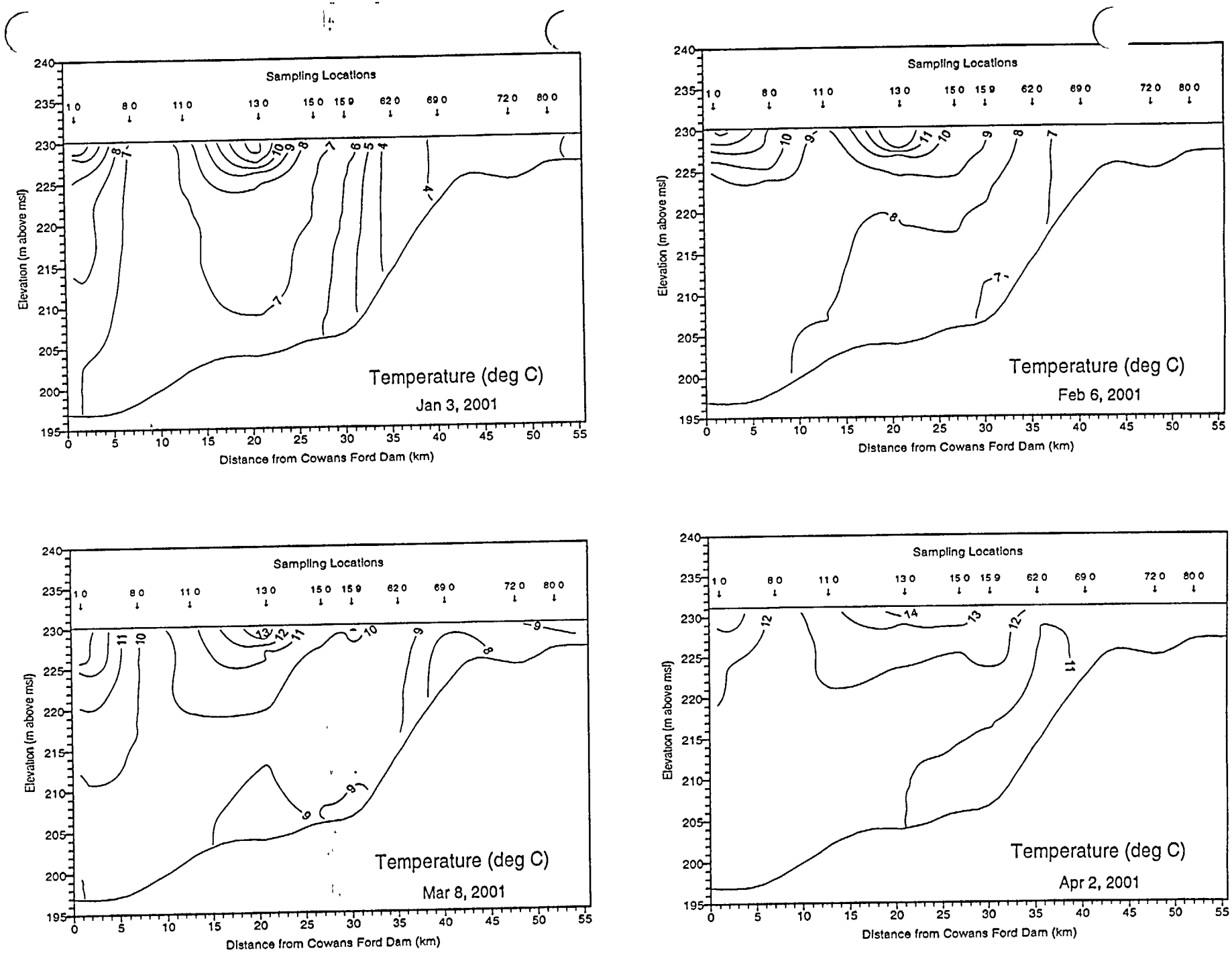


Figure 2-8. Monthly reservoir-wide temperature isotherms for Lake Norman in 2001.

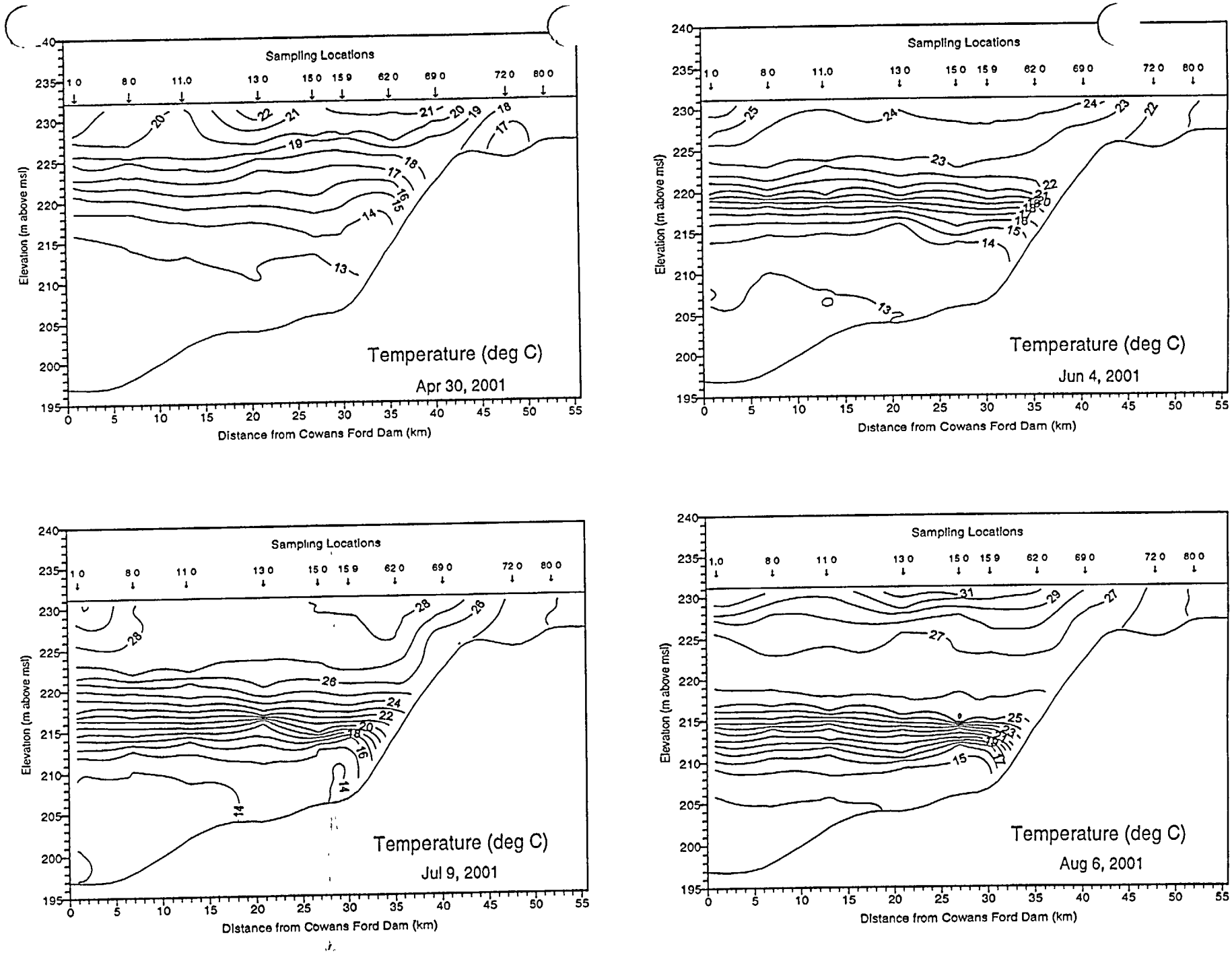


Figure 2-8. Continued.

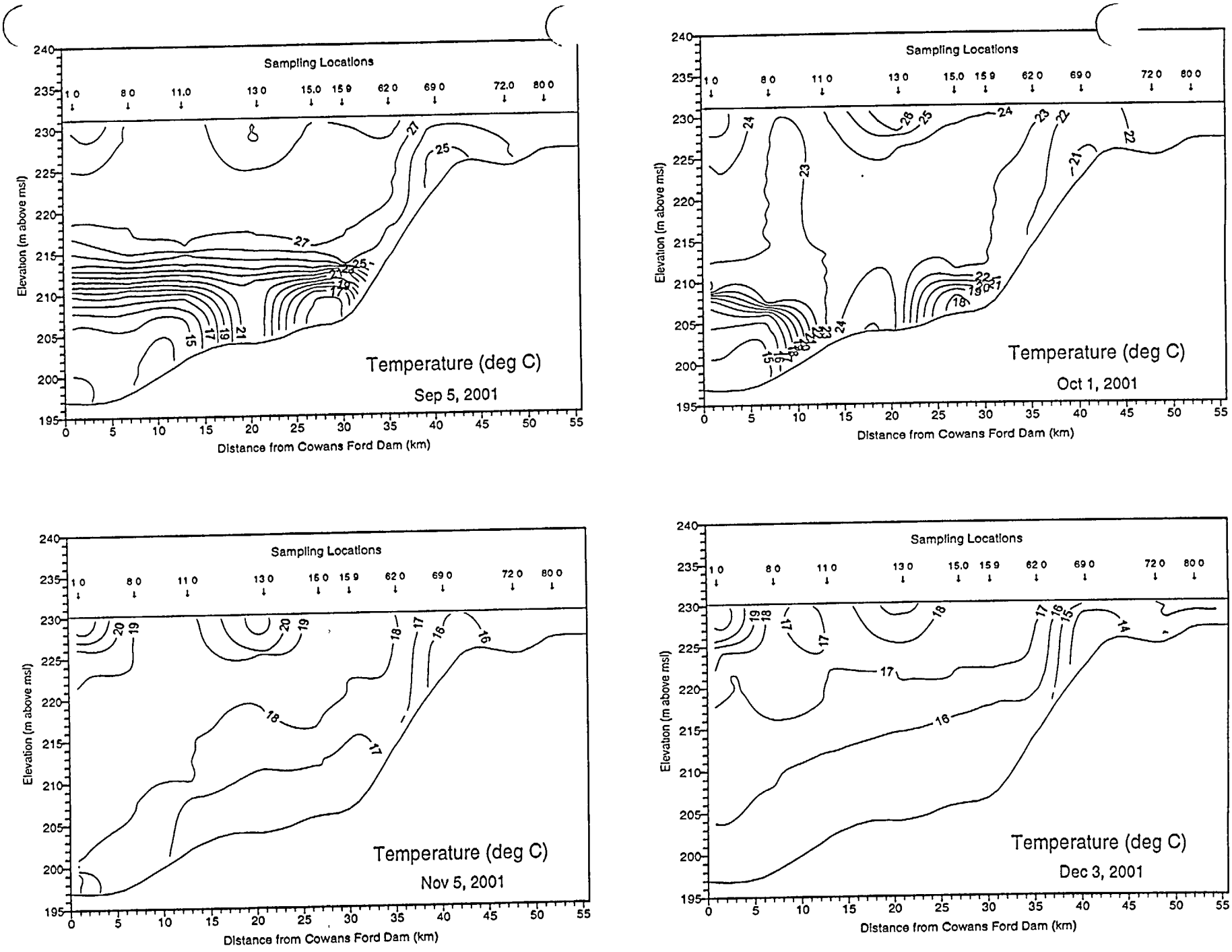


Figure 2-8. Continued.

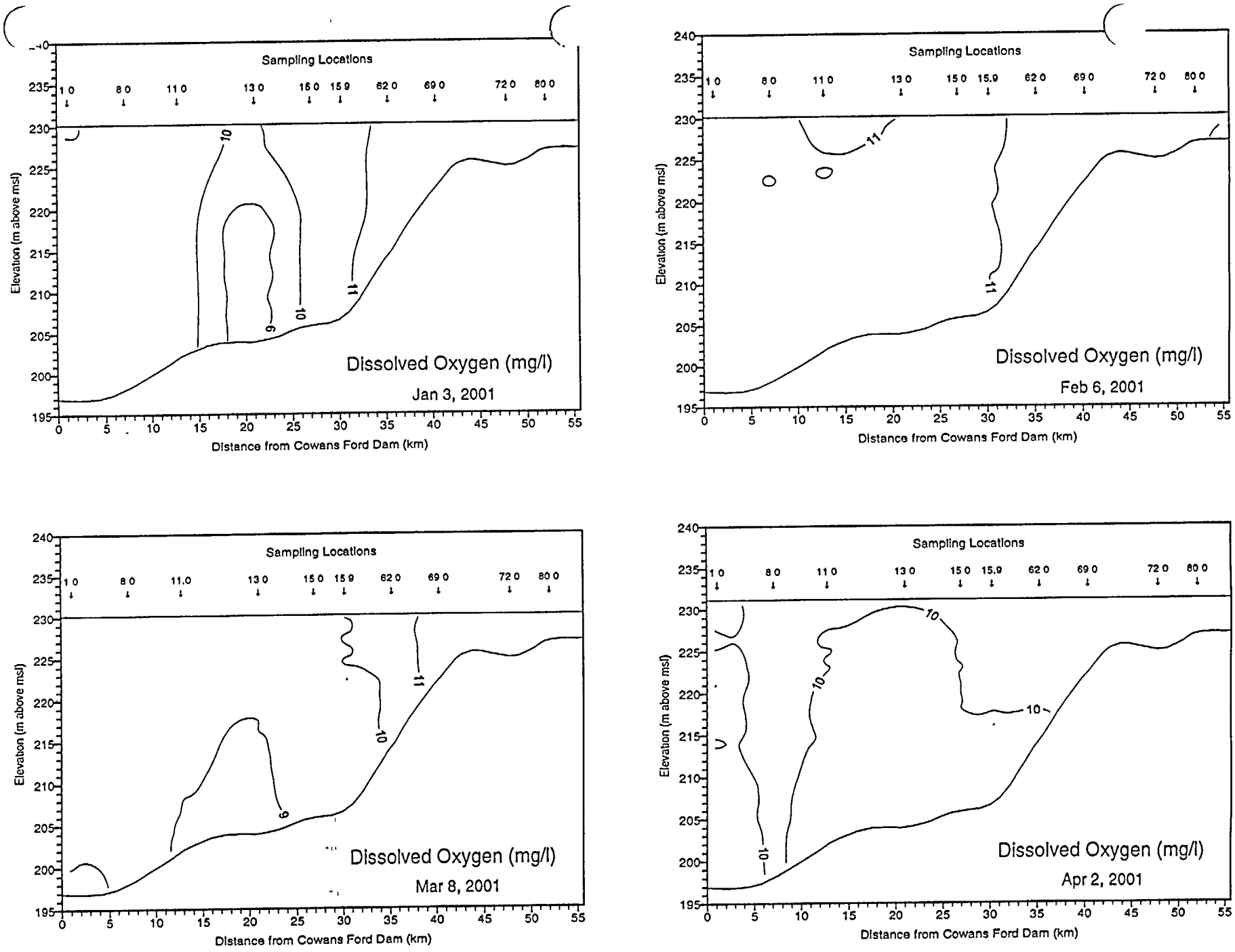


Figure 2-9. Monthly reservoir-wide dissolved oxygen isopleths for Lake Norman in 2001.

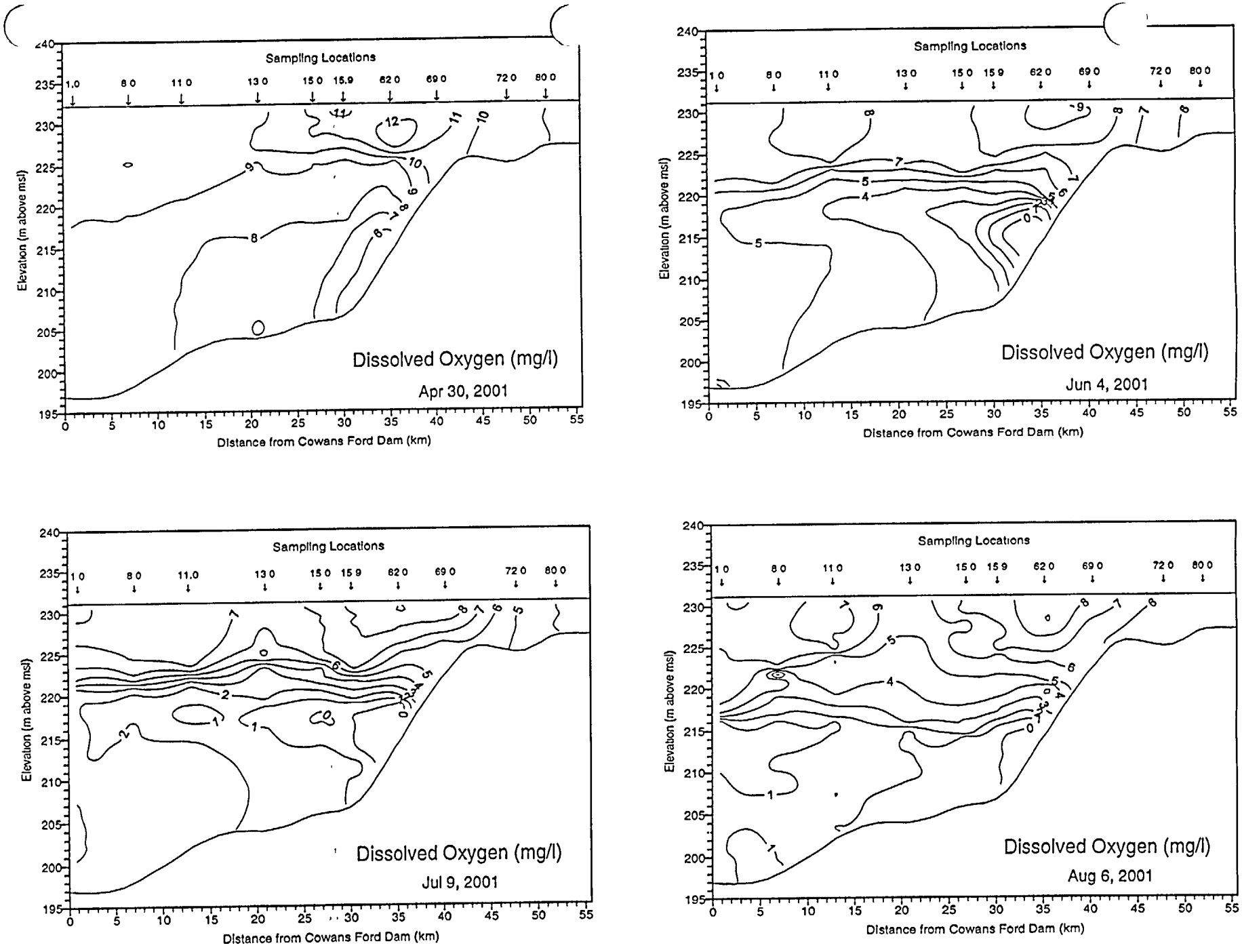


Figure 2-9. Continued.

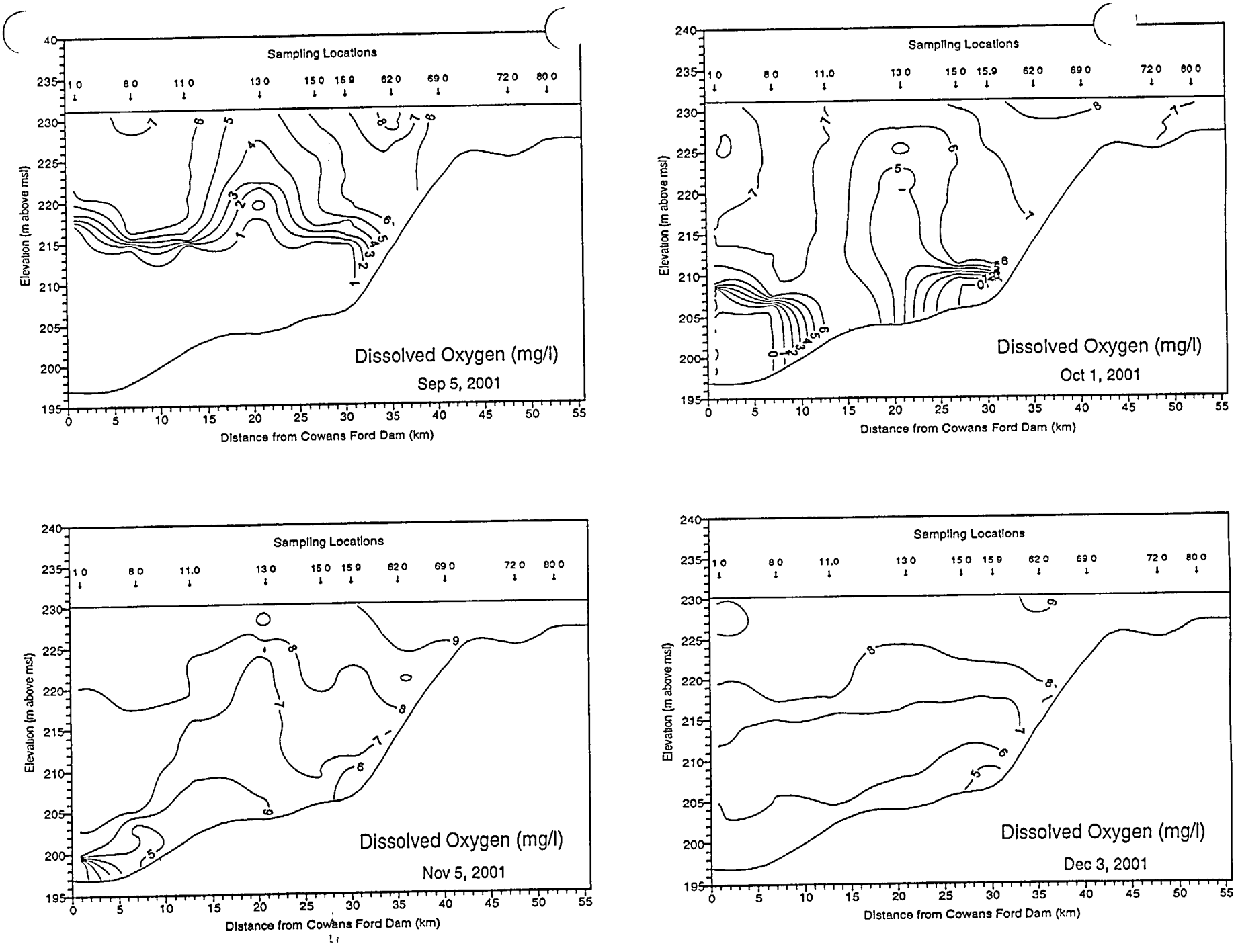


Figure 2-9. Continued.

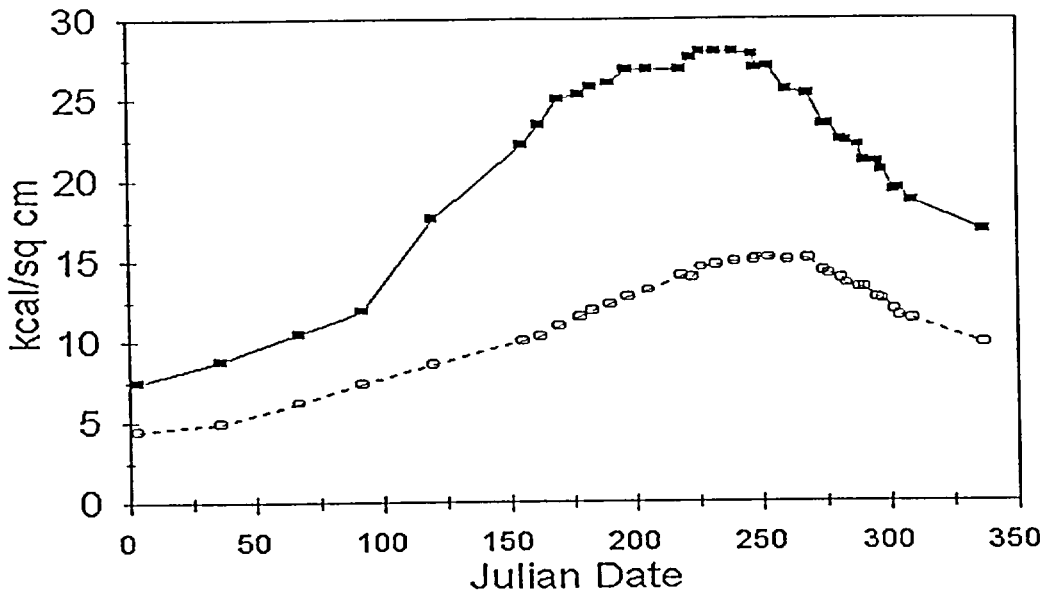


Figure 2-10a. Heat content of the entire water column (■) and the hypolimnion (O) in Lake Norman in 2001.

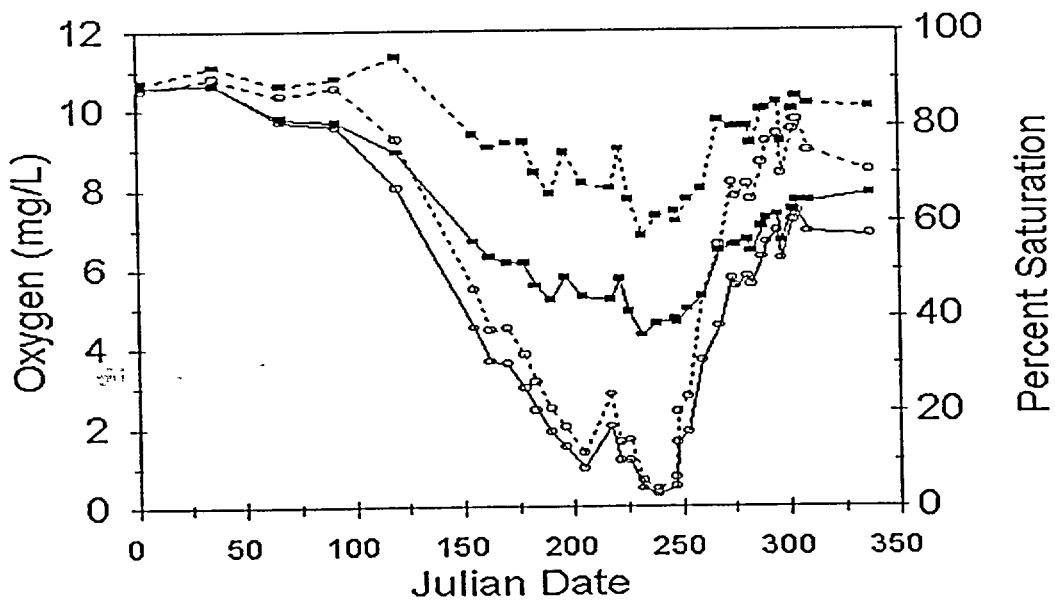


Figure 2-10b. Dissolved oxygen content (–) and percent saturation (---) of the entire water column (■) and the hypolimnion (O) of Lake Norman in 2001.

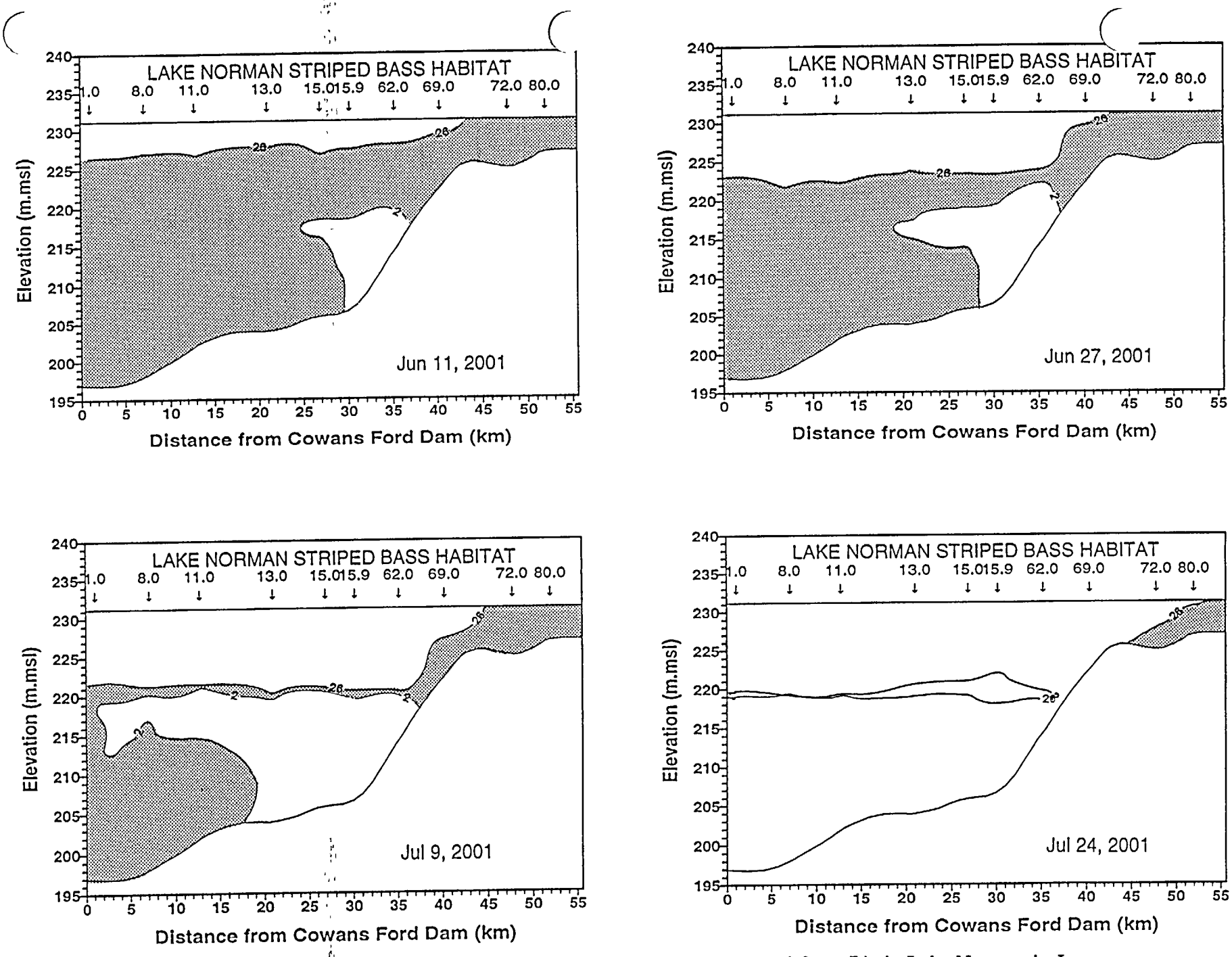
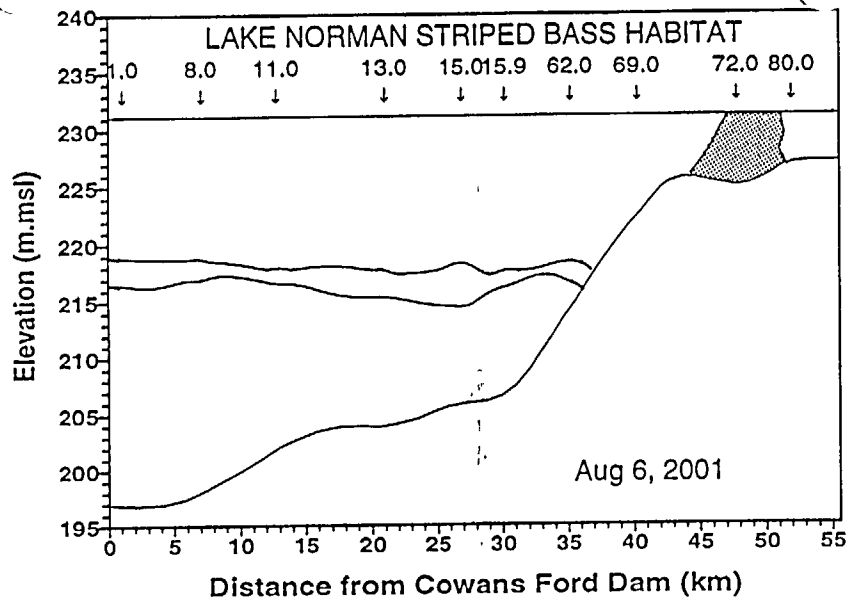
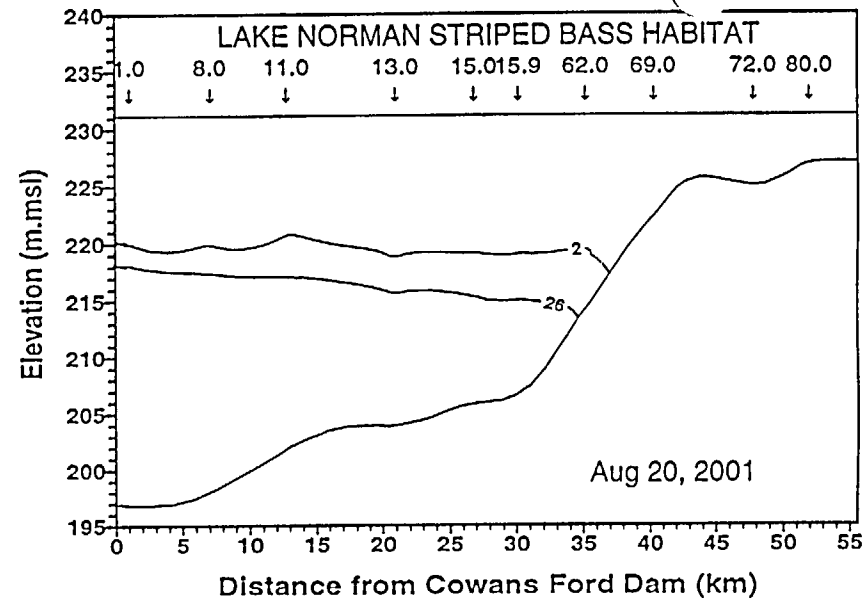
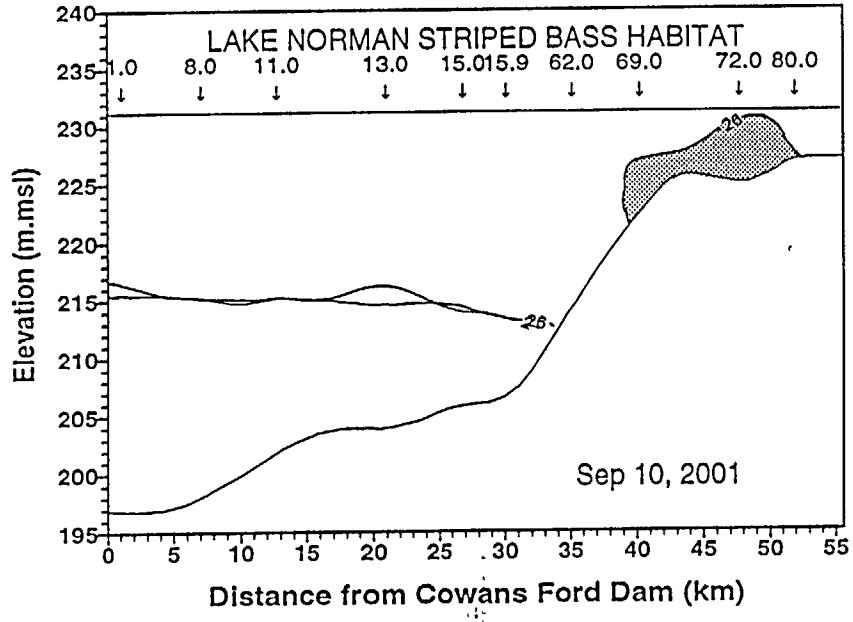


Figure 2-11. Striped bass habitat (temperatures ≤ 26 ° C and dissolved oxygen ≥ 2.0 mg/L) in Lake Norman in June, July, August, and September 2001.







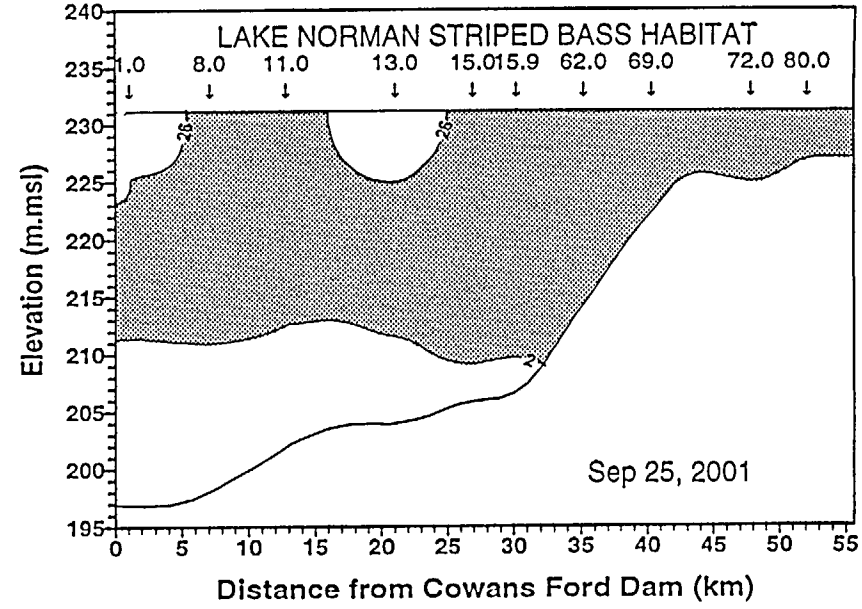


Figure 2-11. Continued.

CHAPTER 3
PHYTOPLANKTON

INTRODUCTION

Phytoplankton standing crop parameters were monitored in 2001 in accordance with the NPDES permit for McGuire Nuclear Station (MNS). The objectives of the phytoplankton section for the Lake Norman Maintenance Monitoring Program are to:

1. Describe quarterly patterns of phytoplankton standing crop and species composition throughout Lake Norman; and
2. Compare phytoplankton data collected during this study (February, May, August, November 2001) with historical data collected in other years during these months.

In previous studies on Lake Norman considerable spatial and temporal variability in phytoplankton standing crops and taxonomic composition have been reported (Duke Power Company 1976, 1985; Menhinick and Jensen 1974; Rodriguez 1982). Rodriguez (1982) classified the lake as oligo-mesotrophic based on phytoplankton abundance, distribution, and taxonomic composition. Past Maintenance Monitoring Program studies have tended to confirm this classification.

METHODS AND MATERIALS

Quarterly sampling was conducted at Locations 2.0, 5.0 (Mixing Zone), 8.0, 9.5, 11.0, 13.0, 15.9, and 69.0 in Lake Norman (see map of locations in Chapter 2, Figure 2-1). Duplicate grabs from 0.3, 4.0, and 8.0 m (i.e., the estimated euphotic zone) were taken and then composited at all but Location 69.0, where grabs were taken at 0.3, 3.0, and 6.0 m due to the shallow depth. Sampling was conducted on 9 February, 1 May, 6 August, and 5 November 2001. Phytoplankton density, biovolume and taxonomic composition were determined for samples collected at Locations 2.0, 5.0, 9.5, 11.0, and 15.9; chlorophyll *a* concentrations and seston dry and ash-free dry weights were determined for samples from all locations. Chlorophyll *a* and total phytoplankton densities and biovolumes were used in determining phytoplankton standing crop. Field sampling and laboratory methods used for chlorophyll *a*, seston dry weights and population identification and enumeration were identical to those

used by Rodriguez (1982). Data collected in 2001 were compared with corresponding data from quarterly monitoring beginning in August 1987.

A one way ANOVA was performed on chlorophyll *a* concentrations, phytoplankton densities and seston dry and ash free dry weights by quarter. This was followed by a Duncan's Multiple Range Test to determine which location means were significantly different.

RESULTS AND DISCUSSION

Standing Crop

Chlorophyll *a*

Chlorophyll *a* concentrations (mean of two replicate composites) ranged from a low of 1.42 ug/l at Location 2.0 in February, to a high of 32.57 ug/l at Location 69.0 in August (Table 3-1, Figure 3-1). All values were below the North Carolina water quality standard of 40 ug/l (NCDEHNR 1991). Lake-wide mean chlorophyll concentrations were within ranges of those recorded in previous years (Figure 3-2). The seasonal trend in 2001 of minimum values in February, increasing slightly in May, achieving maximum values in August, then declining to the second highest levels in November, has never been observed during the course of the Lake Norman Maintenance Monitoring Study. Based on quarterly mean chlorophyll concentrations, Lake Norman was in the mesotrophic range during 2001, although a number of individual values were less than 4 ug/l (oligotrophic) and greater than 12 ug/l (eutrophic). Lake-wide quarterly mean concentrations of below 4 ug/l have been recorded on eight previous occasions, while concentrations of greater than 12 ug/l were only recorded during May 1997, and May 2000.

During 2001 chlorophyll *a* concentrations showed somewhat less spatial variability than in 2000. Maximum concentrations were observed at Location 69.0 during all quarters, while minimum concentrations occurred at Location 2.0 in all but August (Table 3-2). The trend of increasing chlorophyll concentrations from down-lake to up-lake, which had been observed during most quarters of 2000, was apparent in varying degrees during all quarters of 2001 (Table 3-1, Figure 3-1). Locations 15.9 (uplake, above Plant Marshall) and 69.0 (the uppermost riverine locations) had significantly higher chlorophyll values than Mixing Zone locations during all sample periods (Table 3-2). Flow in the riverine zone of a reservoir is subject to wide fluctuations depending, ultimately, on meteorological conditions (Thornton,

et al. 1990), although influences may be moderated due to upstream dams. During periods of high flow, algal production and standing crop would be depressed, due in great part, to washout. Conversely, production and standing crop would increase during periods of low flow and high retention time. Over long periods of low flow, production and standing crop would gradually decline once more. These conditions result in the high variability in chlorophyll concentrations observed between Locations 15.9 and 69.0 throughout the year, as opposed to Locations 2.0 and 5.0 which were very similar during each sampling period.

Average quarterly chlorophyll concentrations during the period of record (August 1987 – November 2001) have varied considerably. During February 2001, Locations 2.0 through 13.0 had chlorophyll concentrations in the low range, and the value at Location 5.0 was the lowest yet recorded for February (Figure 3-3). The chlorophyll concentration at Location 15.9 was in the intermediate range, while the value at Location 69.0 was the highest February chlorophyll yet observed. Long term February peaks at locations 2.0 through 9.5 occurred in 1996; while long term February peaks at Locations 11.0 through 15.9 were observed in 1991. As stated above, the highest February value at location 69.0 occurred in 2001. Locations 2.0 through 9.5 had lower chlorophyll concentrations in February 2001 than in February 2000, while concentrations at Locations 11.0 through 69.0 were higher than in February 2000.

During May 2001 chlorophyll concentrations at Locations 2.0 through 11.0 were in the low range, in fact the concentrations at Locations 5.0 through 11.0 were the lowest recorded for May. Location 13.0 was in the intermediate range for May, while the value at 15.9 was in the high range. Once again, Location 69.0 demonstrated a record high value for May (Figure 3-3). Long term May peaks at Locations 2.0 and 9.5 occurred in 1992; at location 5.0 in 1991; at Locations 8.0, 11.0, and 13.0 in 1997; and at Location 69.0 in 2001. All but Locations 69.0 had lower chlorophyll concentrations in May 2001 than during this period in 2000.

August 2001 chlorophyll concentrations at most locations were in the intermediate range. The concentration at Location 69.0 was the highest August concentration yet observed at this location (Figure 3-3). Long term August peaks in the Mixing Zone were observed in 1998; while year-to-year maxima at Locations 8.0 and 9.5 occurred in 1993. Long term August peaks at Locations 11.0 and 13.0 were observed in 1991 and 1993, respectively. The highest August chlorophyll concentration from Location 15.9 was observed in 1998, while Location 69.0 experienced its long term August peak in 2001. Locations 2.0 through 13.0, and 69.0

had higher August concentrations in 2001 than in 2000, while concentrations at all other locations were lower than the previous year.

In November 2001, chlorophyll concentrations were in the low range at Locations 2.0 through 9.5. At Locations 11.0 through 69.0, November 2001 chlorophyll concentrations were in the intermediate range (Figure 3-3). Long term November peaks at Locations 5.0, 8.0, and 11.0 through 15.9 occurred in 1996; while November maxima at Locations 2.0 and 9.5 were observed in 1997. The highest November chlorophyll concentration at location 69.0 occurred in 1991. All but Location 15.9 had higher November values in 2001 than in 2000.

Total Abundance

Density and biovolume are measurements of phytoplankton abundance. The lowest density during 2001 occurred at Location 2.0 in February (669 units/ml), and the lowest biovolume (208 mm^3/m^3) occurred at Location 5.0 during May (Table 3-3, Figure 3-1). The maximum density (6,430 units/ml) and biovolume (4,468 mm^3/m^3) were observed at Location 15.9 in May. Phytoplankton standing crops during February and November 2001 were generally higher than those of February and November 2000, while May 2001 standing crops were lower than in May 2000 (Duke Power Company 2001). August 2001 densities were generally higher than those of August 2000, while biovolumes during August 2001 were most often lower than those of August 2000. Phytoplankton densities and biovolumes during 2001 never exceeded the NC guidelines 10,000 units/ml density, and 5,000 mm^3/m^3 biovolume (NCDEHNR 1991). Densities and biovolumes in excess of NC guidelines were recorded in 1987, 1989, 1997, 1998, and 2000 (Duke Power Company 1988, 1990, 1998, 1999, 2001).

Total densities at locations in the Mixing Zone during 2001 were within the same statistical ranges during all sampling periods but February (Table 3-4). In all sampling periods except August, Location 15.9 had significantly higher densities than both Mixing Zone locations. During August, Location 9.5 had the maximum density, and was in the same statistical range as Location 15.9 and Mixing Zone locations. During all but August, phytoplankton densities showed a spatial trend similar to that of chlorophyll, that is lower values at down-lake locations versus up-lake locations.

Seston

Seston dry weights represent a combination of algal matter, and other organic and inorganic material. Dry weights during 2001 were most often lower than those of 2000. Location 69.0, the uppermost riverine location, had the highest seston dry weights during all sample periods (Table 3-5). A pattern of increasing values from down-lake to up-lake was observed in all quarters to some extent (Figure 3-1). Statistically, Location 69.0 had significantly higher values than other locations during all quarters of 2001. From 1995 through 1997 seston dry weights had been increasing (Duke Power Company 1998). Values since 1998 represented a reversal of this trend, and were in the low range at most locations during 1999 through 2001 (Duke Power Company 2001). Low dry weights over the past four years were likely a result of prolonged drought conditions.

Seston ash-free dry weights represent organic material and may reflect trends of algal standing crops. In some cases, this relationship held true in 2001; most notably at Location 69.0, which had the highest ash-free dry weights, as well as maximum chlorophyll values during all quarters of 2001 (Tables 3-1, 3-2, and 3-5). Location 15.9, which had comparatively high ash-free dry weights in February, May, and November, also had seasonal maximum density values during these periods (Tables 3-4 and 3-5). During all sampling periods, the only significant statistical difference was that Location 69.0 was in a higher range than other locations. The proportions of ash free dry weights to dry weights during 2001 were slightly lower than in 2000, and similar to those of 1999, indicating very little change in inorganic inputs during those three years. Between 1994 and 1997 a trend of declining organic/inorganic ratios was observed (Duke Power Company 1995, 1996, 1997, 1998, 2001).

Secchi Depths

Secchi depth is a measure of light penetration. Secchi depths were often the inverse of suspended sediment (seston dry weight), with the shallowest depths at Locations 13.0 through 69.0 and deepest from Locations 9.5 through 2.0 down-lake. Depths ranged from 1.10 m at Location 69.0 in May, to 3.50 m at Location 11.0, also in May (Table 3-1). The lake-wide mean secchi depth during 2001 was the second highest recorded since measurements were first reported in 1992. The highest lake-wide mean secchi depth was recorded for 1999 (Duke Power Company 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). Again, high secchi depths were likely due to low rainfall over the past few years.

Community Composition

One indication of "balanced indigenous populations" in a reservoir is the diversity, or number of taxa observed over time. Lake Norman typically supports a rich community of phytoplankton species, this was also true in 2001. Nine classes comprising 64 genera and 118 species, varieties, and forms of phytoplankton were identified in samples collected during 2001, as compared to 81 genera and 172 lower taxa identified in 2000 (Table 3-6). The 2001 total represented an average number of individual taxa based on monitoring since 1987. Two taxa previously unrecorded during the Maintenance Monitoring Program were identified during 2001.

Species Composition and Seasonal Succession

The phytoplankton community in Lake Norman varies both seasonally and spatially within the reservoir. In addition, considerable variation occurs between years for the same months sampled.

Diatoms (Bacillariophyceae) dominated densities at all locations in February 2001 (Table 3-7, Figures 3-4 through 3-8). In May, cryptophytes (Cryptophyceae) were dominant at all but Location 15.9, where diatoms were predominant. During most previous years, cryptophytes, and occasionally diatoms, dominated February phytoplankton samples in Lake Norman. Diatoms have typically been the predominant forms in May samples of previous years; however, cryptophytes dominated May samples in 1988, and were co-dominants with diatoms in May 1990, 1992, 1993, and 1994 (Duke power Company 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001). The most abundant diatoms during February were *Tabellaria fenestrata* (Locations 2.0 through 11.0), and *Melosira distans* (Location 15.9). During May, the most abundant cryptophyte was the small flagellate, *Rhodomonas minuta*, which was dominant at all but Location 15.9, where the diatom *Fragillaria crotonensis* was most abundant (Table 3-7). All of these species have been common and abundant at various times throughout the course of the Program. *Rhodomonas minuta* has been one of the most common and abundant forms observed in Lake Norman samples since monitoring began in 1987. Cryptophytes are characterized as light limited, often found deeper in the water column, or near surface under low light conditions, which are common during winter (Lee 1989). In addition, *R. minuta*'s small size and high surface to

volume ratio would allow for more efficient nutrient uptake during periods of limited nutrient availability (Harris 1978).

During August 2001 diatoms dominated densities at all but Location 15.9, where green algae, primarily the small desmid *Cosmarium asphearosporum* var. *strigosum*, were dominant (Figures 3-4 through 3-8). The most abundant diatom in August was the small pennate, *Anomoeoneis vitrea* (Table 3-7). This same pattern was observed in August 1999 and August 2000. During August periods of the Lake Norman study prior to 1999, green algae (Chlorophyceaea), with blue-green algae (Myxophyceae) as occasional dominants or co-dominants, were the primary constituents of summer phytoplankton assemblages. This pattern of diatom dominance in August periods of 1999 through 2001 was generally lake-wide. *A. vitrea* was described as a major contributor to periphyton communities on natural substrates during studies conducted from 1974 through 1977 (Derwort 1982). The possible causes of this significant shift in summer taxonomic composition were discussed in the 1999 report, and included deeper light penetration (the three deepest lake-wide secchi depths were recorded from 1999 through 2001), extended periods of low water due to draw-down, shifts in nutrient inputs and concentrations, and macrophyte control procedures upstream (Duke Power Company 2000). Whatever the cause, the phenomenon was lake-wide, and not localized near MNS or Marshall Steam Station (MSS); therefore, it was most likely due to a combination of environmental factors, and not station operations.

During November 2001, densities at all but Location 2.0 were dominated by diatoms, while cryptophytes were most abundant at Location 2.0 (Figures 3-4 through 3-8). The dominant species at Locations 5.0, 11.0, and 15.9 was *T. fenestrate*. The dominant taxa at Locations 2.0 and 9.5 were the cryptophyte *R. minuta*, and the centrate diatom *Cyclotella comta* (Table 3-7). During previous years diatoms have been dominant on most occasions, with occasional dominance by cryptophytes.

Blue-green algae (Myxophyceae), which are often implicated in nuisance blooms, were never abundant in 2001 samples. Their overall contribution to phytoplankton densities was lower in 2001 than in 2000 and 1999. Densities of blue-greens seldom exceeded 2% of totals. The highest percent composition of Myxophyceae (2.5%) during all sampling periods in 2001 occurred at Location 15.9 in August. Prior to 1991, blue-green algae were often dominant at up-lake locations during the summer (Duke Power Company 1988, 1989, 1990, 1991, 1992).

Phytoplankton index

Phytoplankton indexes have been used with varying degrees of success ever since the concept was formalized by Kolkwitz and Marsson in 1902 (Hutchinson 1967). Nygaard (1949) proposed a series of indexes based on the number of species in certain taxonomic categories (Divisions, Classes, and Orders). The Myxophycean index was selected to help determine long term changes in the trophic status of Lake Norman. This index is a ratio of the number of blue-green algae taxa to desmid taxa, and was designed to reflect the "potential" trophic status as opposed to chlorophyll, which gives an "instantaneous" view of phytoplankton concentrations. The index was calculated on an annual basis for the entire lake, for each sampling period, and for each location during 2001 (Figure 3-9).

For the most part, the long term annual Myxophycean index values confirmed that Lake Norman has been in the oligo-mesotrophic (low to intermediate) range since 1988 (Figure 3-9). Values were in the high, or eutrophic, range in 1989, 1990, and 1992; in the intermediate, or mesotrophic, range in 1991, 1993, 1994, 1996, 1998, and 2000; and in the low, or oligotrophic, range in 1988, 1995, 1997, and 1999. The index for 2001 was lower than that of 2000, and fell in the very low mesotrophic range.

The highest index value among sample periods of 2001 was observed in November, and the lowest index value occurred in February (Figure 3-9). The highest lake-wide chlorophyll was in August, with the minimum in February, therefore, the index did not completely reflect chlorophyll concentrations observed throughout the lake during 2001. The index values for locations during 2001 showed low values at Locations 2.0 through 9.5, with values in the high range at Locations 11.0 and 15.9. This tended to reflect the pattern of increasing algae concentrations from down-lake to up-lake locations observed during most quarters of 2001. During 2000, this pattern of increasing trophic state from down-lake to up-lake locations was also observed during most sampling periods (Duke Power Company 2001).

FUTURE STUDIES

No changes are planned for the phytoplankton portion of the Lake Norman Maintenance Monitoring program during 2002.

SUMMARY

In 2001 lake-wide mean chlorophyll *a* concentrations were all within ranges of those observed during previous years of the Program. Lake Norman continues to be classified as oligo-mesotrophic based on long term, annual mean chlorophyll concentrations. The lake-wide mean chlorophyll in February represented the annual minimum. The lake-wide mean increased slightly during May, then increased to the annual maximum in August. The lake-wide mean declined to the second highest value in November. This seasonal pattern had never been recorded during the Maintenance Monitoring Study. Some spatial variability was observed in 2001; however, maximum chlorophyll concentrations were most often observed up-lake, while comparatively low chlorophyll concentrations were recorded from Mixing Zone locations. Location 69.0, the furthest upstream location, demonstrated long term maximum chlorophyll concentrations in February, May, and August of 2001. The highest chlorophyll value recorded in 2001, 32.57 ug/l, was below the NC State Water Quality standard of 40 ug/l.

In most cases, total phytoplankton densities and biovolumes observed in 2001 were lower than those observed during 2000, and standing crops were within ranges established over previous years. Phytoplankton densities and biovolumes during 2001 never exceeded the NC guidelines for algae blooms. Standing crop values in excess of bloom guidelines have been recorded during five previous years of the program. As in past years, high standing crops were usually observed at up-lake locations; while comparatively low values were noted down-lake.

Seston dry and ash free dry weights were generally lower in 2001 than in 2000, and down-lake to up-lake differences were apparent most of the time. Maximum dry and ash-free dry weights were most often observed at Location 69.0, while low values were most often noted at Locations 2.0 through 11.0. The proportions of ash-free dry weights to dry weights in 2001 were slightly lower than those of 2000, indicating little change in organic/inorganic inputs into Lake Norman.

Secchi depths reflected suspended solids, with shallow depths related to high dry weights. The lake-wide mean secchi depth in 2001 was the second deepest recorded since measurements were first reported in 1992. The greatest annual mean lake-wide secchi depth was recorded for 1999. High secchi depths over the last few years were likely due to low rainfall.

Diversity, or numbers of taxa, of phytoplankton had decreased since 2000, and the total number of individual taxa was within ranges of previous years. The taxononic composition of phytoplankton communities during February, May, and November were similar to those of certain previous years. Diatoms were dominant at most locations during all sampling periods except May, when cryptophytes were most often dominant. A shift in community composition was first observed in August 1999 when diatoms, primarily the periphytic form *Anomoeonies vitrea*, dominated phytoplankton assemblages at Lake Norman locations. This pattern was again observed during August periods of 2000 and 2001. During most previous August periods, green algae (and occasionally blue-green algae) dominated the phytoplankton. This shift was likely the result of a variety of environmental factors, and not related to station operations. Blue-green algae were less abundant during 2001 than during 2000, and their contribution to total densities seldom exceeded 2%.

The most abundant alga, on an annual basis, was the cryptophyte *Rhodomonas minuta*. Common and abundant diatoms were *Tabellaria fenestrata* in February and November; and *Anomoeneis vitrea* during August. Other diatoms, *Melosira ditans, Fragillaria crotonensis,* and *Cyclotella comta*; as well as small desmids, were occasionally dominant. All of these taxa, except *A. vitrea*, have been common and abundant throughout the Maintenance Monitoring Program. *A. vitrea* was found to be a major contributor to periphyton communities on natural substrates during studies conducted from 1974 through 1977.

The phytoplankton index (Myxophycean) tended to confirm the characterization of Lake Norman as oligo-mesotrophic. The annual index for 2001 was lower than that of 2000, and was at the very low end of the intermediate range. Quarterly index values increased from February to May, declined in August, then increased in November. Quarterly values did not completely reflect seasonal changes in phytoplankton standing crops. Location values tended to reflect increases in phytoplankton standing crops from down-lake to up-lake.

Lake Norman continues to support highly variable and diverse phytoplankton communities. No obvious short term or long term impacts of station operations were observed.

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Table 3-1. Mean chlorophyll *a* concentrations (ug/l) in composite samples and secchi depths (m) observed in Lake Norman, NC, in 2001.

Chlorophyll *a*

Location	FEB	MAY	AUG	NOV
2.0	1.85	1.42	6.40	3.34
5.0	2.27	1.53	6.73	3.46
8.0	2.29	1.70	7.37	4.71
9.5	2.62	1.44	7.66	4.47
11.0	3.78	1.98	6.00	8.21
13.0	5.42	6.80	5.69	5.72
15.9	7.08	12.82	8.30	8.10
69.0	12.47	14.15	32.57	9.54

Secchi depths

Location	FEB	MAY	AUG	NOV
2.0	2.56	3.15	2.42	2.36
5.0	2.45	2.98	1.58	1.52
8.0	2.66	3.44	3.00	2.10
9.5	2.40	2.97	2.06	2.30
11.0	2.60	3.50	2.28	2.01
13.0	1.79	1.84	1.50	2.00
15.9	1.78	1.76	1.30	1.59
69.0	1.20	1.10	1.25	1.35

Table 3-2. Duncan's multiple Range Test on chlorophyll *a* concentrations in Lake Norman, NC, during 2001.

February	Location	**2.0**	**5.0**	**8.0**	**9.5**	**11.0**	**13.0**	**15.9**	**69.0**
	Mean	1.85	2.27	2.29	2.62	3.78	5.42	7.08	12.47
May	Location	**2.0**	**9.5**	**5.0**	**8.0**	**11.0**	**13.0**	**15.9**	**69.0**
	Mean	1.42	1.44	1.53	1.70	1.98	6.80	12.82	14.15
August	Location	**13.0**	**11.0**	**2.0**	**5.0**	**8.0**	**9.5**	**15.9**	**69.0**
	Mean	5.69	6.00	6.40	6.73	7.37	7.66	8.30	32.57
November	Location	**2.0**	**5.0**	**9.5**	**8.0**	**13.0**	**15.9**	**11.0**	**69.0**
	Mean	3.34	3.46	4.47	4.71	5.72	8.10	8.21	9.54

Table 3-3. Total mean phytoplankton densities and biovolumes from samples collected in Lake Norman, NC, during 2001.

Density (units/ml)

	Locations					
Month	2.0	5.0	9.5	11.0	15.9	Mean
FEB	669	962	1106	1262	3275	1455
MAY	877	929	1202	1450	6430	2178
AUG	2957	3059	3221	2764	3155	3031
NOV	1286	1422	1611	2494	2873	1937

Biovolume (mm^3/m^3)

	Locations					
Month	2.0	5.0	9.5	11.0	15.9	Mean
FEB	484	868	1258	1104	2786	1300
MAY	310	208	270	277	4468	1107
AUG	1474	1649	1706	1278	2975	1816
NOV	964	1180	1514	2680	2730	1814

Table 3-4. Duncan's multiple Range Test on phytoplankton densities in Lake Norman, NC, during 2001.

February	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	669	962	1106	1262	3275
May	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	877	929	1202	1450	6430
August	Location	**11.0**	**2.0**	**5.0**	**15.9**	**9.5**
	Mean	2764	2957	3059	3155	3221
November	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	1286	1422	1611	2494	2873

Table 3-5. Duncan's multiple Range Test on dry and ash free dry weights (mg/l) in Lake Norman, NC during 2001.

DRY WEIGHT

February	Location	**5.0**	**11.0**	**2.0**	**8.0**	**9.5**	**13.0**	**15.9**	**69.0**
	Mean	0.50	0.92	0.98	1.12	1.18	1.56	2.75	7.61
May	Location	**8.0**	**9.5**	**11.0**	**5.0**	**2.0**	**13.0**	**15.9**	**69.0**
	Mean	0.58	0.78	0.78	0.87	0.90	1.96	2.52	5.53
August	Location	**11.0**	**13.0**	**2.0**	**9.5**	**8.0**	**5.0**	**15.9**	**69.0**
	Mean	1.45	1.67	2.04	2.07	2.18	2.32	2.39	7.43
November	Location	**8.0**	**9.5**	**2.0**	**15.9**	**11.0**	**5.0**	**13.0**	**69.0**
	Mean	1.39	1.58	1.60	1.93	2.36	2.87	2.96	7.20

ASH FREE DRY WEIGHT

February	Location	**5.0**	**8.0**	**9.5**	**11.0**	**13.0**	**2.0**	**15.9**	**69.0**
	Mean	0.48	0.59	0.63	0.70	0.85	0.93	1.09	1.98
May	Location	**9.5**	**2.0**	**8.0**	**11.0**	**5.0**	**13.0**	**15.9**	**69.0**
	Mean	0.49	0.53	0.55	0.78	0.82	0.96	1.11	2.10
August	Location	**13.0**	**11.0**	**15.9**	**8.0**	**2.0**	**5.0**	**9.5**	**69.0**
	Mean	0.88	1.06	1.31	1.56	1.58	1.67	1.80	3.11
November	Location	**8.0**	**9.5**	**13.0**	**2.0**	**11.0**	**15.9**	**5.0**	**69.0**
	Mean	0.82	0.86	0.87	0.88	0.91	1.00	1.17	1.74

Table 3-6. Phytoplankton taxa identified in quarterly samples collected in Lake Norman from February 1988 to November 2001.

TAXON	88	89	90	91	92	93	94	95	96	97	98	99	00	01
CLASS: CHLOROPHYCEAE														
Acanthosphaera zachariasi Lemm.			X	X		X								
Actidesmium hookeri Reinsch						X								
Actinastrum hantzchii Lagerheim	X		X	X	X	X	X							
Ankistrodesmus braunii (Naeg) Brunn								X	X	X	X	X	X	X
A. convolutus Corda													X	
A. falcatus (Corda) Ralfs	X	X	X	X	X	X	X	X	X	X	X	X	X	X
A. fusiformis Corda sensu Korsch.		X	X	X	X	X	X							
A. nannoselene Skuja													X	
A. spiralis (Turner) Lemm.	X	X	X	X		X				X				
A. spp. Corda				X		X								
Arthrodesmus convergens Ehrenberg								X						
A. incus (Breb.) Hassall	X			X				X			X			X
A. subulatus Kutzing									X	X	X		X	X
A. spp. Ehrenberg						X	X							
Asterococcus limneticus G. M. Smith			X	X	X	X	X					X		
Botryococcus braunii Kutzing				X	X									
Carteria frtzschii Takeda	X												X	
C. spp. Diesing	X		X		X	X				X				
Characium spp. Braun		X												
Chlamydomonas spp. Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chlorella vulgaris Beyerink										X				
Chlorogonium euchlorum Ehrenberg			X						X	X			X	
C. spirale Scherffel & Pascher							X	X						
Closteriopsis longissima West & West	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Closterium cornu Ehrenberg												X		
C. gracile Brebisson									X					
C. incurvum Brebisson	X						X	X	X	X	X	X	X	X
C. tumidum Johnson													X	
C. spp. Nitzsch		X	X	X		X								
Coccomonas orbicularis Stein											X			
Coelastrum cambricum Archer	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C. microporum Nageli								X	X		X		X	
C reticulatum (Dang.) Sinn												X		
C sphaericum Nageli			X	X			X		X			X	X	X
C. proboscideum Bohlin				X										
C. spp. Nageli			X	X										
Cosmarium angulosum v. *concinnum* (Rab) W&W													X	
C. asphaerosporum v. *strigosum* Nord.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
C. contractum Kirchner				X			X	X	X	X	X	X	X	X
C. moniliforme (Turp.) Ralfs													X	
C. phaseolus f. *minor* Boldt.										X	X		X	
C. pokornyanum (Grun.) W. & G.S. West											X			
C. polygonum (Nag.) Archer								X	X	X	X	X	X	X
C. regnellii Wille						X			X	X	X	X	X	X
C. regnesi Schmidle				X	X	X								
C. tenue Archer	X							X	X	X	X	X	X	X
C. tinctum Ralfs	X					X	X	X	X	X	X	X	X	X
C. tinctum v. *subretusum* Messik.													X	
C. tinctum v. *tumidum* Borge.										X		X	X	X
C. spp. Corda	X	X	X	X	X	X	X							
Crucigenia crucifera (Wolle) Collins	X		X	X				X	X	X	X	X	X	X
C. fenestrata Schmidle				X										
C. irregularis Wille	X				X	X	X		X		X		X	
C. rectangularis (A. Braun) Gay											X			
C. tetrapedia (Kirch.) West & West	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dictyospaerium ehrenbergianum Nageli	X												X	
D. pulchellum Wood	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dimorphococcus spp. Braun			X											
Elakatothrix gelatinosa Wille	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Euastrum denticulatum (Kirch.) Gay								X	X	X	X	X	X	X
E. spp. Ehrenberg	X		X		X	X								
Eudorina elegans Ehrenberg	X								X					
Franceia droescheri (Lemm.) G. M. Smith	X							X	X	X	X	X	X	X
F. ovalis (France) Lemm.	X	X	X	X	X	X	X						X	
Gloeocystis botryoides (Kutz.) Nageli													X	
G. gigas Kutzing	X	X							X	X	X	X	X	X
G. major Gerneck *ex.* Lemmermann											X			
G. planktonica (West & West) Lemm.		X	X	X	X	X	X	X	X	X	X	X	X	X
G. vesciculosa Naegeli											X			
G. spp. Nageli	X	X	X	X	X	X	X							
Golenkinia paucispina West & West	X													
G radiata Chodat	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gonium pectorale Mueller											X			
G. sociale (Duj.) Warming	X							X			X	X		
Kirchneriella contorta (Schmidle) Bohlin	X	X	X	X	X	X	X				X			
K. elongata G.M. Smith													X	
K. lunaris (Kirch.) Mobius	X	X		X										
K. lunaris v. *dianae* Bohlin		X								X			X	
K. lunaris v. *irregularis* G.M Smith													X	
K obesa W. West	X	X	X	X	X	X	X							

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
K subsolitaria G. S. West	X							X	X	X	X	X	X	
K. spp. Schmidle	X							X	X	X				
Lagerheimia ciliata (Lag.) Chodat														
L. citriformis (Snow) G. M. Smith										X				
L. longiseta (Lemmermann) Printz														
L. quadriseta (Lemm.) G. M. Smith		X	X	X	X									
L. subsala Lemmerman	X		X	X	X	X	X		X	X	X		X	
Mesostigma viride Lauterborne	X							X	X	X	X	X	X	
Micractinium pusillum Fresen.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Monoraphidium contortum Thuret	X	X		X	X	X	X							
M. pusillum Printz	X	X		X	X	X	X							
Mougeitia elegantula Whittrock	X							X	X	X	X	X	X	X
M. spp. Agardh	X				X	X	X							
Nephrocytium agardhianum Nageli	X			X										
N. limneticum (G.M. Smith) G.M. Smith	X											X		
Oocystis borgii Snow											X	X	X	
O. ellyptica W. West	X										X			
O. lacustris Chodat	X													
O. parva West & West	X	X	X					X	X	X	X	X	X	X
O. pusilla Hansgirg		X	X			X	X	X	X	X	X	X	X	X
O. pyriformis Prescott											X			
O. spp. Nageli			X											
Pandorina charkowiensis Kprshikov														
P. morum Bory		X	X		X	X								
Pediastrum biradiatum Meyen														
P. duplex Meyen	X		X	X		X		X	X	X		X	X	X
P. duplex v. *gracillimum* West and West										X	X			
P. tetras v. *tetroadon* (Corda) Rabenhorst	X	X	X	X	X	X	X	X	X	X	X	X	X	X
P. spp. Meyen			X	X										
Planktosphaeria gelatinosa G. M. Smith	X							X						
Quadrigula closterioides (Bohlin) Printz				X					X	X				X
Q lacustris (Chodat) G. M. Smith	X													
Scenedesmus abundans (Kirchner) Chodat	X	X	X											
S abundans v. *asymetrica* (Schr.) G. Sm.	X	X	X	X	X	X	X		X	X			X	
S abundans v. *brevicauda* G. M. Smith								X						
S. acuminatus (Lagerheim) Chodat					X	X	X	X	X		X	X	X	X
S. armatus v. *bicaudatus* (Gug.-Prin.)Chod	X		X	X	X	X	X	X	X	X	X	X	X	X
S. bijuga (Turp.) Lagerheim	X	X	X			X	X	X	X	X	X	X	X	X
S. bijuga v. *alterans* (Reinsch) Hansg.														
S. brasiliensis Bohlin								X	X	X	X	X	X	X
S denticulatus Lagerheim	X	X	X	X	X	X	X	X	X		X	X	X	X

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
S. dimorphus (Turp.) Kutzing			X		X	X	X			X	X	X	X	
S. incrassulatus G. M. Smith														
S. quadricauda (Turp.) Brebisson	X	X	X	X	X	X	X	X	X	X	X	X	X	X
S smithii Teiling									X					
S. spp. Meyen		X	X	X	X	X	X							
Schizochlamys compacta Prescott									X		X		X	
S. gelatinosa A. Braun													X	
Schoederia setigera (Schroed.) Lemm.	X			X										
Selenastrum gracile Reinsch				X					X					
S. minutum (Nageli) Collins	X	X	X	X	X	X	X	X	X	X	X	X	X	X
S. westii G. M. Smith	X				X			X	X		X	X		
Sorastrum americanum (Bohlin) Schmidle										X				
Sphaerocystis schoeteri Chodat	X		X					X			X	X	X	
Sphaerozosma granulatum Roy & Bliss	X													
Stauastrum americanum (W&W) G. Sm.	X							X	X	X	X	X	X	X
S. apiculatum Brebisson										X	X	X	X	X
S brachiatum Ralfs										X	X	X		
S brevispinum Brebisson											X			
S. chaetocerus (Schoed.) G. M. Smith					X	X	X							
S curvatum W. West			X	X	X	X	X	X	X	X	X	X	X	X
S. cuspidatum Brebisson										X	X	X	X	X
S. dejectum Brebisson	X	X	X	X	X		X						X	
S dickeii v. *maximum* West & West	X													
S gladiosum Turner						X								
S leptocladum v. *sinuatum* Wolle				X										
S. manfeldtii v. *fluminense* Schumacher	X		X	X			X	X		X	X		X	
S megacanthum Lundell	X					X	X							
S ophiura v. *cambricum* (Lund) W. & W.													X	
S. orbiculare Ralfs							X							
S. paradoxum Meyen		X	X	X	X	X	X				X	X		
S paradoxum v. *cingulum* West & West														
S paradoxum v. *parvum* W. West											X			
S. subcruciatum Cook & Wille								X		X	X	X	X	
S tetracerum Ralfs	X	X	X	X	X	X	X	X	X	X	X	X	X	X
S turgescens de Not.	X													
S. spp. Meyen		X	X	X	X		X							
Stigeoclonium spp. Kutzing														X
Tetraedron bifurcatum v. *minor* Prescott									X					
T. caudatum (Corda) Hansgirg	X	X	X		X		X		X	X	X	X	X	X
T. limneticum Borge					X									
T. lobulatum (Naeg.) Hansgirg													X	
T. lobulatum v. *crassum* Prescott						X								

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
T. minmum (Braun) Hansgirg	X	X	X				X	X	X		X	X	X	X
T. muticum (Braun) Hansgirg	X			X	X	X	X	X	X		X			
T. obesum (W & W) Wille *ex* Brunnthaler									X					
T. planktonicum G. M. Smith											X		X	
T. pentaedricum West & West		X					X							
T. regulare Kutzing				X	X	X	X							
T. regulare v. *bifurcatum* Wille											X			
T. regulare v. *incus* Teiling	X	X				X								
T. trigonum (Nageli) Hansgirg	X		X	X		X			X	X	X		X	X
T. trigonum v. *gracile* (Reinsch) DeToni					X				X				X	
T. spp. Kutzing	X		X			X								
Tetrallantos lagerheimii														X
Tetraspora lamellosa Prescott													X	
T. spp. Link						X	X							
Tetrastrum heteracanthum (Nordst.) Chod.			X											
Treubaria setigerum (Archer) G. M. Smith	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Westella botryoides (West & West) Wilde.											X		X	
W. linearis G. M. Smith	X										X		X	
Xanthidium spp. Ehrenberg							X							
CLASS: BACILLARIOPHYCEAE														
Achnanthes microcephala Kutzing		X	X					X	X	X	X	X	X	X
A spp. Bory	X	X	X	X	X	X	X		X					
Anomoeoneis vitrea (Grunow) Ross	X		X				X	X	X		X	X	X	X
A. spp. Pfitzer							X							
Asterionella formosa Hassall	X	X	X	X	X	X	X	X	X	X	X		X	X
Attheya zachariasi J. Brun	X	X	X	X		X	X	X	X	X	X	X	X	X
Cocconeis placentula Ehrenberg	X										X	X		
C. spp. Ehrenberg							X							
Cyclotella comta (Ehrenberg) Kutzing		X					X	X	X	X	X	X	X	X
C glomerata Bachmann								X	X	X	X	X		
C. meneghiniana Kutzing	X	X					X	X	X	X	X	X	X	
C. pseudostelligera Hustedt +														
C. stelligera Cleve & Grunow	X		X	X	X	X	X	X	X	X	X	X	X	X
C. spp. Kutzing	X	X	X											
Cymbella affinis Kutzing													X	
C. minuta (Bliesch & Rabn.) Reim.			X		X	X		X	X		X	X		
C tumida (Breb.) van Huerck							X							
C. turgida (Gregory) Cleve	X													
C. spp. Agardh	X			X										
Denticula thermalis Kutzing											X			
Diploneis spp. Ehrenberg			X											

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
Eunotia flexuosa v. *eurycephala* Grun.													X	
E. zasuminensis (Cab.) Koerner		X	X	X	X	X	X	X	X	X	X	X	X	X
Fragilaria crotonensis Kitton	X		X	X	X	X	X	X	X	X	X	X	X	X
Frustulia rhomboides (Ehr.) de Toni	X													
Gomphonema spp. Agardh				X			X							
Melosira ambigua (Grun.) O. Muller	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. distans (Ehr.) Kutzing	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. granulata (Ehr.) Ralfs	X		X	X		X								
M. granulata v. *angustissima* O. Muller	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. italica (Ehr.) Kutzing	X													
M. varians Agardh					X	X					X			
M. spp. Agardh	X	X	X	X	X	X	X		X			X		X
Navicula cryptocephala Kutzing			X						X	X				
N. exigua (Gregory) O. Muller								X						
N. exigua v. *capitata* Patrick									X					
N. subtilissima Cleve								X					X	
N. spp. Bory		X	X	X	X	X	X							
Nitzschia acicularis W. Smith	X		X	X	X	X			X	X	X	X	X	X
N. agnita Hustedt	X	X	X	X	X	X	X	X	X	X	X	X	X	X
N. holsatica Hustedt	X	X	X	X				X		X	X	X	X	X
N. linearis W. Smith													X	
N. palea (Kutzing) W. Smith	X						X	X	X	X	X			
N. sublinearis Hustedt									X		X			X
N. spp. Hassall	X	X	X	X	X	X	X							
Pinnularia spp. Ehrenberg						X								
Rhizosolenia spp. Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Skeletonema potemos (Weber) Hilse	X					X		X	X		X	X	X	
Stephanodiscus spp. Ehrenberg	X	X	X	X	X	X	X	X	X	X	X			
Surirella linearis v. *constricta* (Ehr.) Grun.											X			
Synedra actinastroides Lemmerman							X							
S acus Kutzing	X					X	X			X	X		X	
S. delicatissima Lewis					X	X	X							
S filiformis v. *exilis* Cleve-Euler											X		X	X
S. planktonica Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
S rumpens Kutzing	X							X	X	X	X	X	X	X
S rumpens v. *fragilarioides* Grunow	X													
S rumpens v. *scotica* Grunow	X													
S. ulna (Nitzsch) Ehrenberg	X			X				X	X	X	X	X	X	
S spp. Ehrenberg	X	X	X	X	X	X	X							
Tabellaria fenestrata (Lyngb) Kutzing	X	X	X	X	X	X	X	X	X	X	X	X	X	X
T. flocculosa (Roth.) Kutzing	X		X				X						X	

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
CLASS: CHRYSOPHYCEAE														
Aulomonas purdyii Lackey	X						X	X	X	X	X	X	X	
Bicoeca petiolatum (Stien) Pringsheim										X	X			
Calycomonas pascheri (Van Goor) Lund								X					X	
Chromulina spp. Chien.	X										X			
Chrysosphaerella solitaria Lauterb.				X	X	X	X	X	X	X	X	X	X	X
Codomonas annulata Lackey									X	X	X	X	X	X
Dinobryon bavaricum Imhof	X	X	X	X	X	X	X	X	X	X	X	X	X	X
D. cylindricum Imhof			X	X	X	X	X		X		X			
D. divergens Imhof		X	X		X	X	X	X	X			X		
D. sertularia Ehrenberg	X							X					X	
D. spp. Ehrenberg	X	X	X	X				X	X	X	X	X	X	X
Domatomococcus cylindricum Lackey											X	X		
Erkinia subaequicilliata Skuja	X	X	X				X	X	X	X	X	X	X	X
Kephyrion littorale Lund											X			
K. rubi-claustri Conrad	X													
K. skujae Ettl	X													
K. spp. Pascher		X	X	X	X	X	X	X	X	X	X	X	X	X
Mallomonas acaroides Perty							X							
M. akrokomos (Naumann) Krieger			X								X	X	X	
M. alpina Pascher											X		X	
M. caudata Conrad		X	X	X	X	X	X	X				X	X	X
M. globosa Schiller			X								X		X	X
M. producta Iwanoff													X	
M pseudocoronata Prescott	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. tonsurata Teiling	X	X	X	X	X	X	X	X	X	X	X	X	X	X
M. spp. Perty	X	X	X	X	X	X	X						X	
Ochromonas granularis Doflein											X	X	X	X
O. mutabilis Klebs													X	
O. spp. Wyss	X	X					X	X	X	X	X	X	X	X
Pseudokephyrion schilleri Conrad											X	X		X
P. tintinabulum Conrad											X			
Rhizochrisis polymorpha Naumann												X	X	X
R. spp. Pascher	X			X										
Salpingoeca frequentissima (Zachary) Lemm.											X	X	X	
Stelexomonas dichotoma Lackey	X	X	X	X	X	X	X	X	X	X	X		X	
Stokesiella epipyxis Pascher										X	X	X		
Synura spinosa Korschikov	X		X					X	X	X	X	X	X	X
S. uvella Ehrenberg	X	X	X	X		X	X							X
S spp. Ehrenberg		X	X	X	X	X	X							
Uroglenopsis americana (Caulk.) Lemm.	X							X	X	X		X		

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
CLASS: HAPTOPHYCEAE														
Chrysochromulina parva Lackey	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CLASS: XANTHOPHYCEAE														
Characiopsis dubia Pascher								X	X		X	X	X	X
Dichotomococcus curvata Korschikov														
Ophiocytium caoitatum v. *longisp.* (M) Lem						X	X							
CLASS: CRYPTOPHYCEAE														
Cryptomonas erosa Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C. erosa v. *reflexa* Marsson			X								X	X	X	X
C. gracilia Skuja													X	
C. marsonii Skuja		X	X	X	X	X	X							
C. ovata Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C. phaseolus Skuja		X	X	X	X	X	X							
C. reflexa Skuja	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C. spp. Ehrenberg		X	X	X	X	X	X							
Rhodomonas minuta Skuja	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CLASS: MYXOPHYCEAE														
Agmenellum quadriduplicatum Brebisson					X	X	X	X		X	X	X	X	X
Anabaena catenula (Kutzing) Born.	X									X	X			
A. inaequalis (Kutz.) Born.													X	
A. scheremetievi Elenkin										X	X	X		X
A. wisconsinense Prescott	X							X	X	X	X	X	X	X
A. spp. Bory	X	X	X	X	X	X	X		X			X		X
Anacystis incerta (Lemm.) Druet & Daily		X	X	X	X	X	X				X		X	X
A spp. Meneghini														
Chroococcus dispersus (Keissl) Lemm.											X		X	
C. limneticus Lemmermann	X		X							X	X	X	X	X
C. minor Kutzing														
C. turgidus (Kutz.) Lemmermann				X		X								
C. spp. Nageli		X	X	X	X	X	X	X	X	X	X	X	X	X
Coelosphaerium kuetzingiana Nageli			X											
Dactylococcopsis irregularis Hansgirg			X	X			X							
D. rupestris Hansgirg													X	
D. smithii Chodat and Chodat										X	X		X	
D. spp. Hansgirg													X	
Gomphospaeria lacustris Chodat	X	X	X	X	X	X	X							
Lyngbya contorta Lemmermann				X	X									
L limnetica Lemmermann		X	X	X	X	X	X							

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
L. ochracea (Kutz.) Thuret													X	
L. subtilis W. West		X	X	X	X		X							
L. spp. Agardh	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Merismopedia tenuissima Lemmermann											X			
Microcystis aeruginosa Kutz. *emend* Elen.		X	X	X	X	X	X	X	X		X	X	X	X
Oscillatoria geminata Meneghini	X		X					X	X	X	X	X	X	X
O. limnetica Lemmermann	X							X	X	X	X	X	X	X
O. splendida Greville								X	X		X			
O. subtilissima Kutz.													X	X
O. spp. Vaucher	X	X					X							X
Phormidium angustissimum West & West		X	X	X			X							
P. spp. Kutzing	X	X	X			X	X							
Raphidiopsis curvata Fritsch & Rich	X				X		X	X	X	X	X	X	X	
R. mediterranea Skuja												X		
Rhabdoderma sigmoidea Schm. & Lautrb.		X												
Synecococcus lineare (Sch. & Laut.) Kom.			X	X	X	X	X	X	X		X	X	X	X
CLASS: EUGLENOPHYCEAE														
Euglena acus Ehrenberg			X									X		
E. minuta Prescott		X											X	
E. polymorpha Dangeard									X					X
E. spp. Ehrenberg	X	X	X	X		X	X	X	X		X	X		X
Lepocinclus ovum (Ehr.) Lemm													X	
L spp. Perty	X										X			
Phacus cuvicauda Swirenko													X	
P. longicauda (Ehr.) Dujardin													X	
P. orbicularis Hubner					X									
P. tortus (Lemm) Skvortzow		X	X		X									
P. spp. Dujardin		X												
Trachelomonas acanthostoma (Stok.) Defl.	X													X
T. hispida (Perty) Stein						X		X				X		X
T. pulcherrima Playfair	X													
T. volvocina Ehrenberg	X							X				X		X
T. spp Ehrenberg			X	X			X							
CLASS: DINOPHYCEAE														
Ceratium hirundinella (OFM) Schrank	X	X	X		X		X	X		X	X	X	X	
Glenodinium borgei (Lemm.) Schiller	X								X					
G. gymnodinium Penard		X	X	X	X	X				X				
G. palustre (Lemm.) Schiller														
G. penardiforme (Inde.) Schiller												X	X	

Table 3-6 (continued)

	88	89	90	91	92	93	94	95	96	97	98	99	00	01
G. quadridens (Stein) Schiller			X				X							
G. spp. (Ehrenberg) Stein				X			X							
Gymnodinium aeruginosum Stein											X	X	X	
G. spp. (Stein) Kofoid & Swezy			X	X	X	X	X	X		X	X		X	X
Peridinium aciculiferum Lemmermann	X													
P. inconspicuum Lemmermann	X	X	X	X	X	X	X	X	X	X	X	X	X	X
P. intermedium Playfair											X	X	X	X
P. pusillum (Lenard) Lemmermann	X	X	X	X	X	X	X	X	X	X	X	X	X	X
P. umbonatum Stein					X	X	X							
P. wisconsinense Eddy	X		X	X	X	X	X	X	X	X	X	X	X	X
P. spp. Ehrenberg			X	X	X	X	X							
CLASS: CHLOROMONADOPHYCEAE														
Gonyostomum depresseum Lauterborne	X							X			X	X		
G. semen (Ehrenberg) Diesing			X											
G. spp. Diesing	X		X				X							

Table 3-7. Dominant classes and species, and their percent composition (in parenthesis) at Lake Norman locations during each sampling period of 2001.

LOC	FEBRUARY	MAY
2.0	BACILLARIOPHYCEAE (70.1) *Taballaria fenestrata* (20.4)	CRYPTOPHYCEAE (51.1) *Rhodomonas minuta* (50.2)
5.0	BACILLARIOPHYCEAE (49.6) *T. fenestrata* (24.2)	CRYPTOPHYCEAE (59.5) *R. minuta* (57.8)
9.5	BACILLARIOPHYCEAE (50.0) *T. fenestrata* (28.6)	CRYPTOPHYCEAE (59.0) *R. minuta* (56.7)
11.0	BACILLARIOPHYCEAE (53.0) *T. fenestrata* (27.0)	CRYPTOPHYCEAE (63.3) *R. minuta* (59.7)
15.9	BACILLARIOPHYCEAE (75.0) *Melosira distans* (38.9)	BACILLARIOPHYCEAE (65.3) *Fragillaria crotonensis* (54.8)
	AUGUST	NOVEMBER
2.0	BACILLARIOPHYCEAE (43.3) *Anomoeoneis vitrea* (29.3)	CRYPTOPHYCEAE (43.3) *R. minuta* (28.0)
5.0	BACILLARIOPHYCEAE (40.3) *A. vitrea* (28.9)	BACILLARIOPHYCEAE (39.4) *T. fenestrata* (11.8)
9.5	BACILLARIOPHYCEAE (41.4) *A. vitrea* (26.9)	BACILLARIOPHYCEAE (36.1) *Cyclotella comta* (10.4)
11.0	BACILLARIOPHYCEAE (36.3) *A. vitrea* (25.2)	BACILLARIOPHYCEAE (52.0) *T. fenetrata* (28.2)
15.9	CHLOROPHYCEAE (36.6) *Cosmarium asphear. strig.* (13.0)	BACILLARIOPHYCEAE (43.5) *T. fenestrata* (25.3)

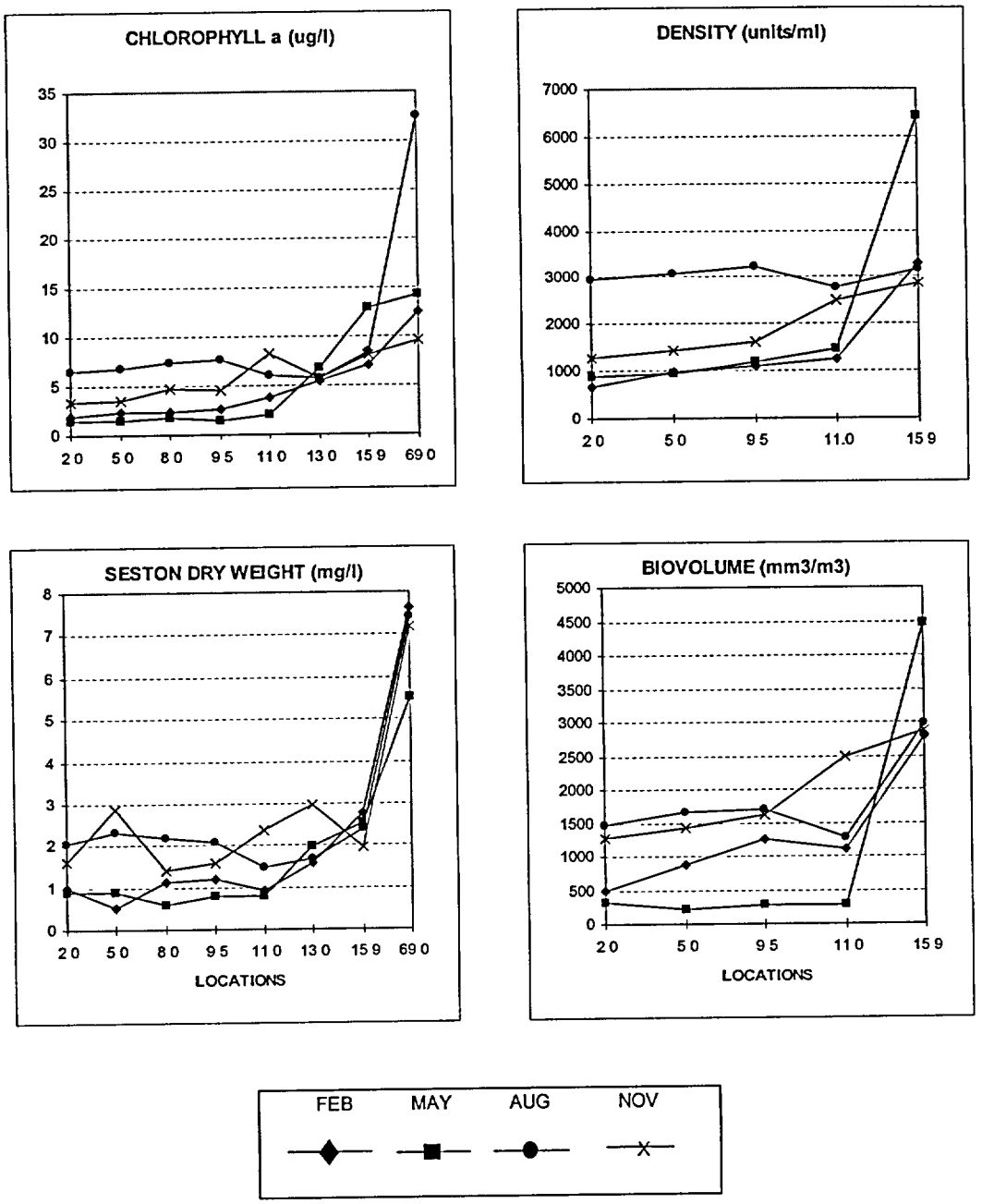

Figure 3-1. Phytoplankton chlorophyll *a*, densities, and biovolumes; and seston weights at locations in Lake Norman, NC, in February, May, August, and November 2001.

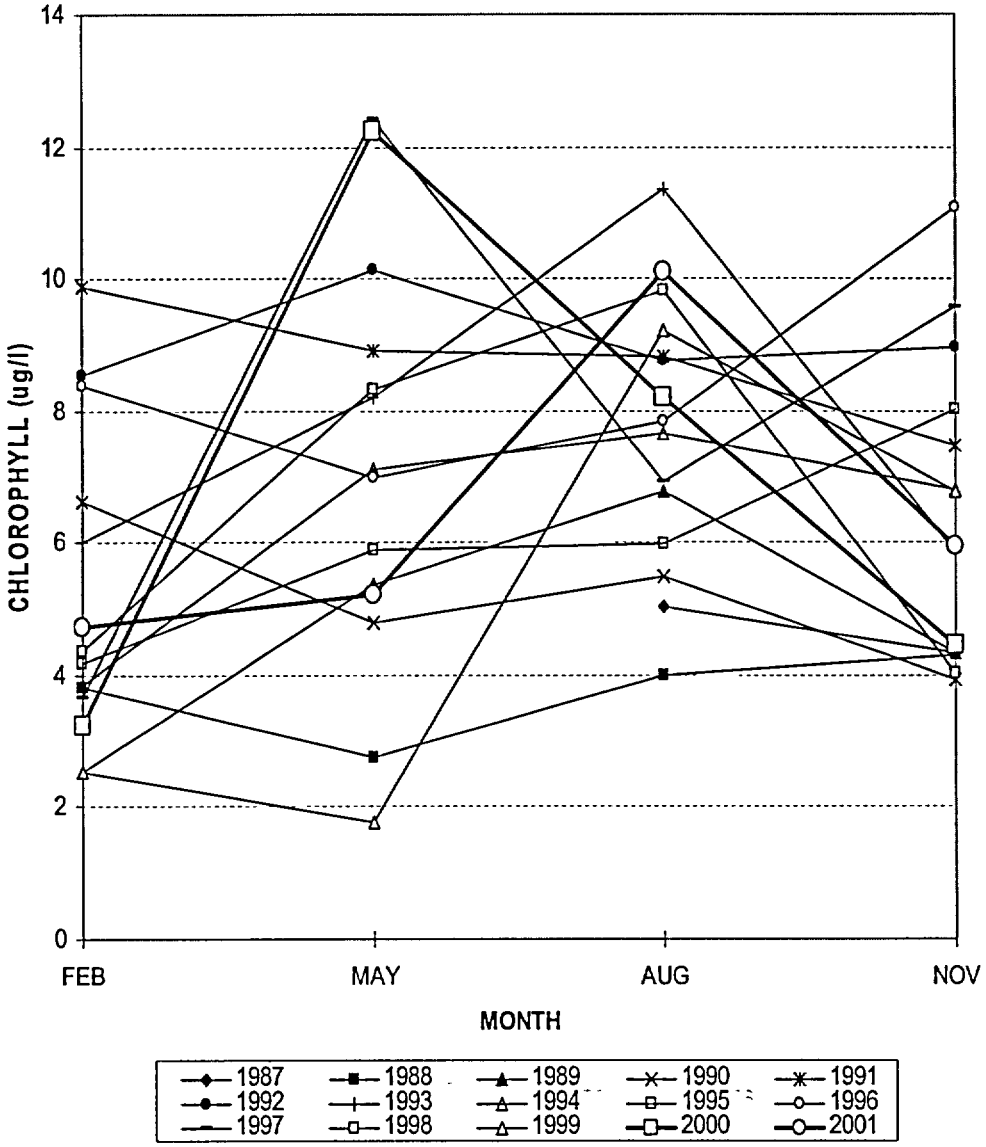

Figure 3-2. Phytoplankton chlorophyll *a* annual lake means from all locations in Lake Norman, NC, for each quarter since August 1987.

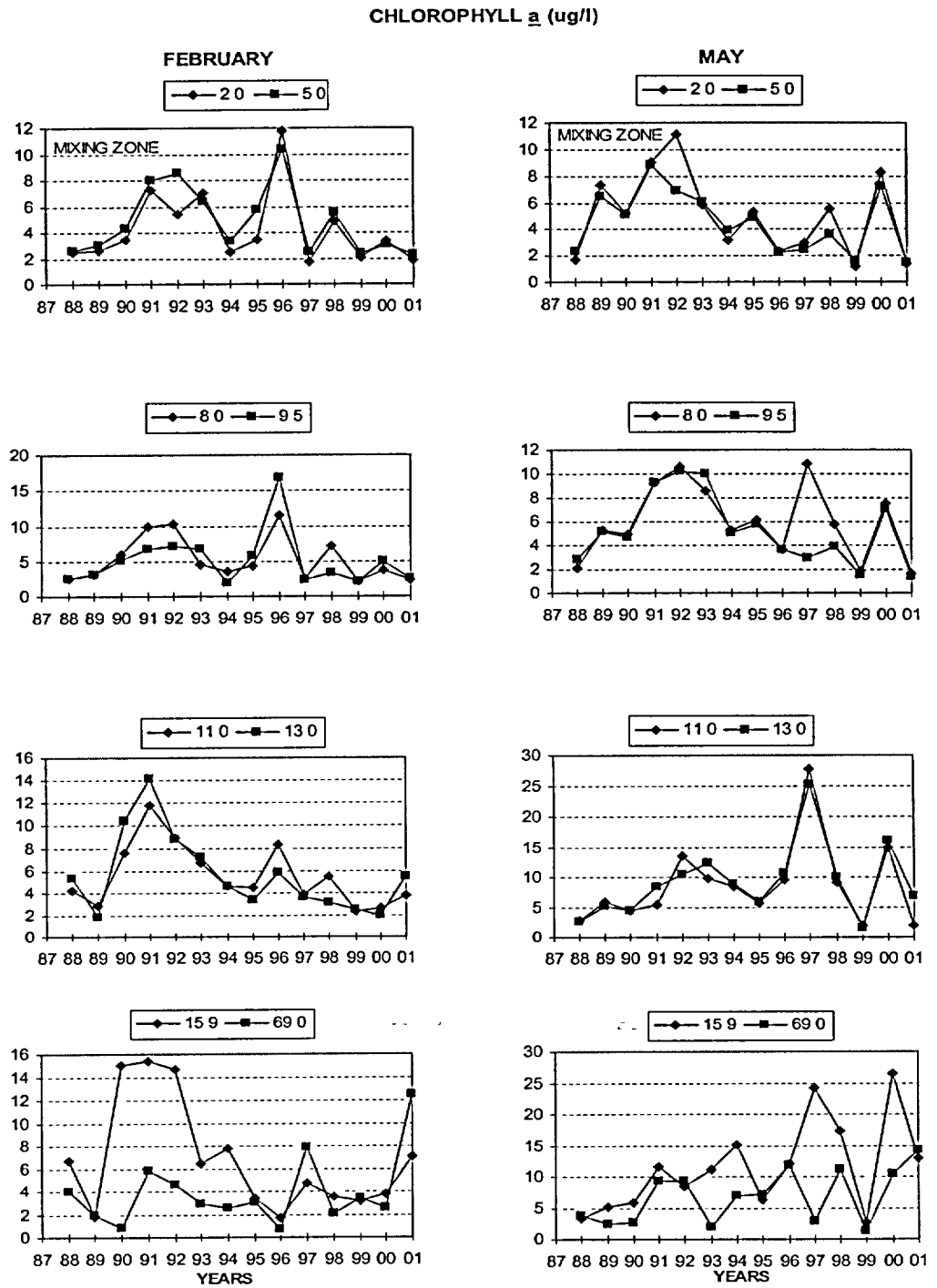

Figure 3-3. Phytoplankton chlorophyll *a* concentrations by location for samples collected in Lake Norman, NC, from August 1987 through November 2001.

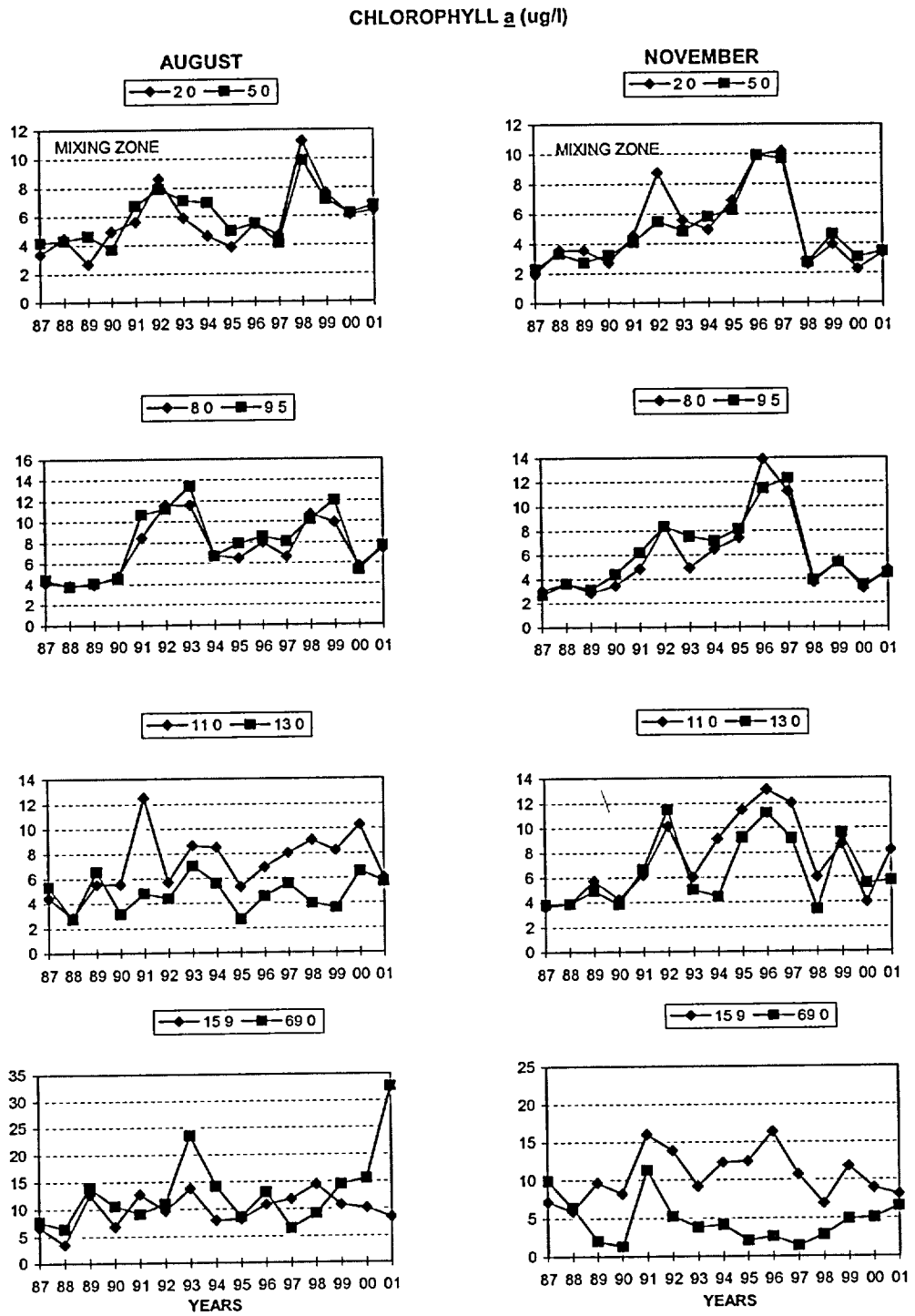

Figure 3-3 (continued).

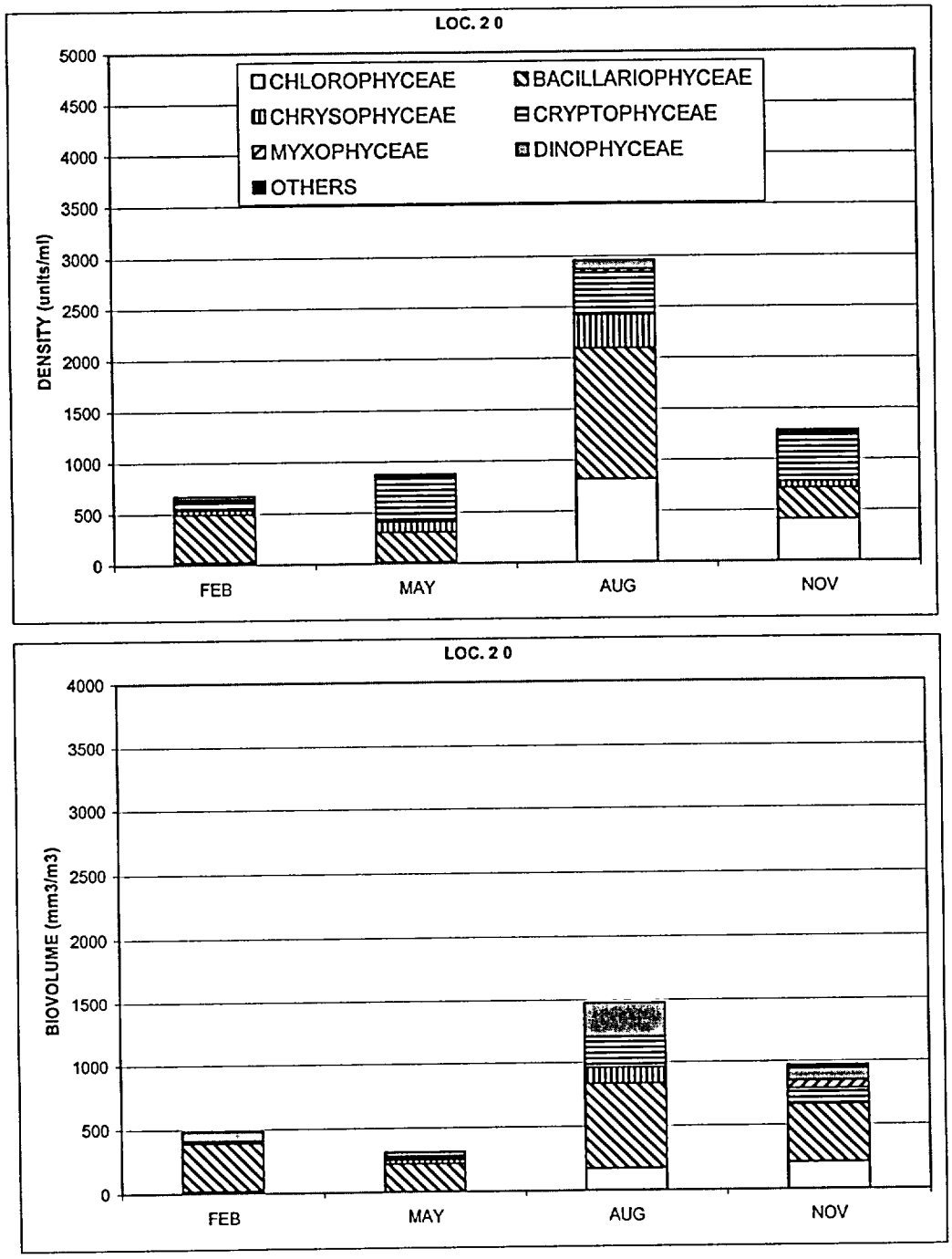

Figure 3-4. Class composition (mean density and biovolume) of phytoplankton from euphotic zone samples collected at Location 2.0 in Lake Norman, NC, during 2001.

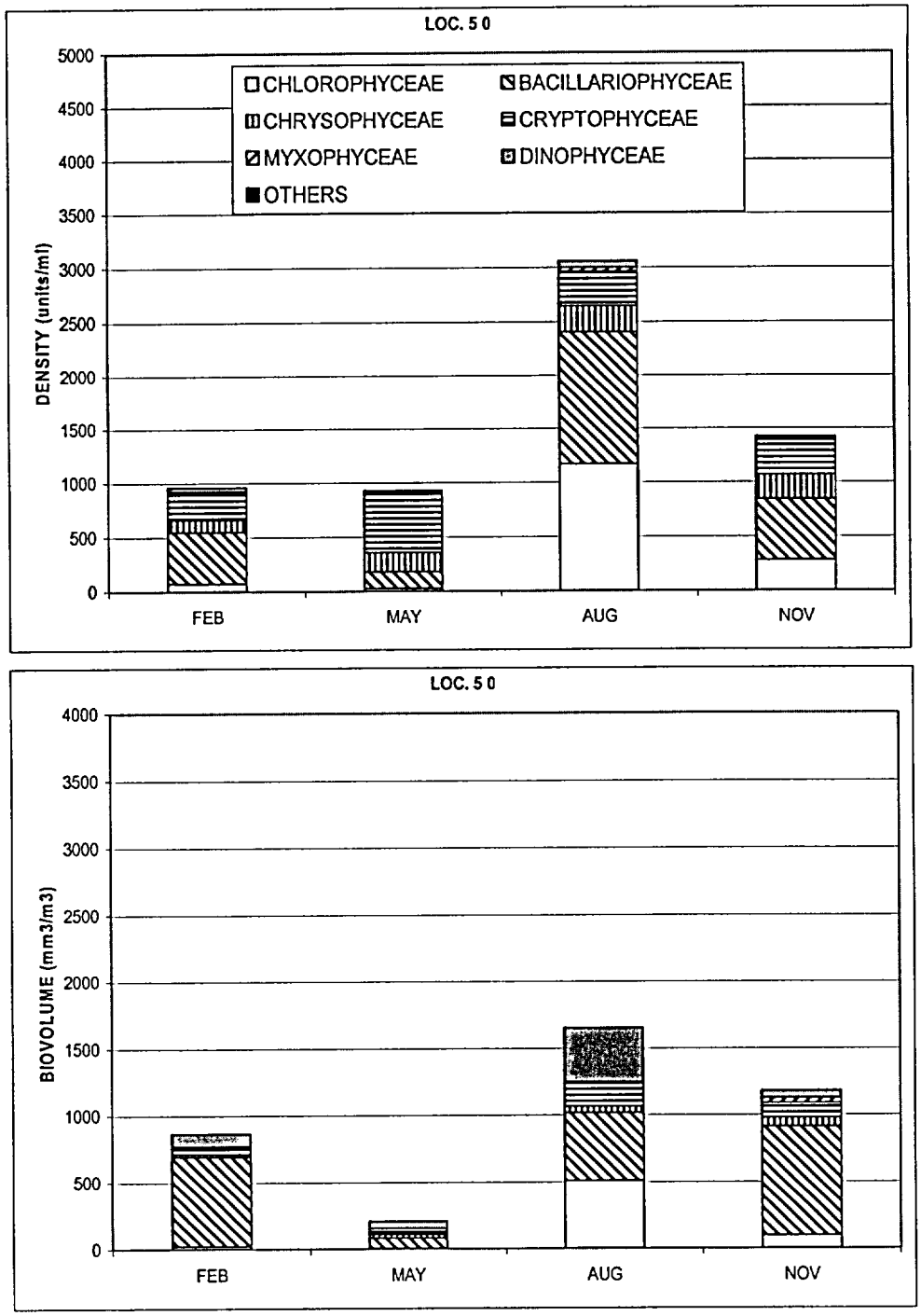

Figure 3-5. Class composition (mean density and biovolume) of phytoplankton from euphotic zone samples collected at Location 5.0 in Lake Norman, NC, during 2001.

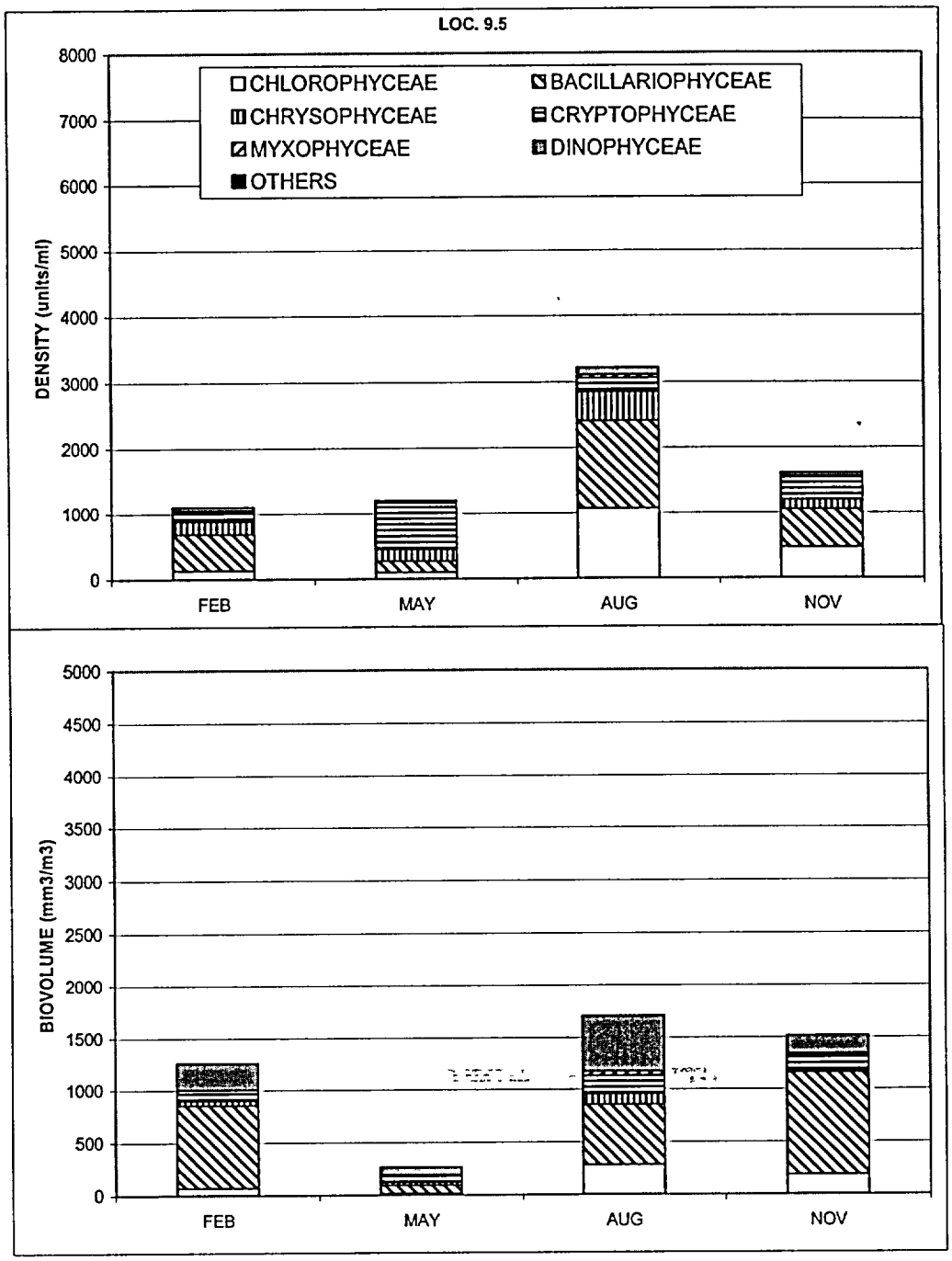

Figure 3-6. Class composition (mean density and biovolume) of phytoplankton from euphotic zone samples collected at Location 9.5 in Lake Norman, NC, during 2001.

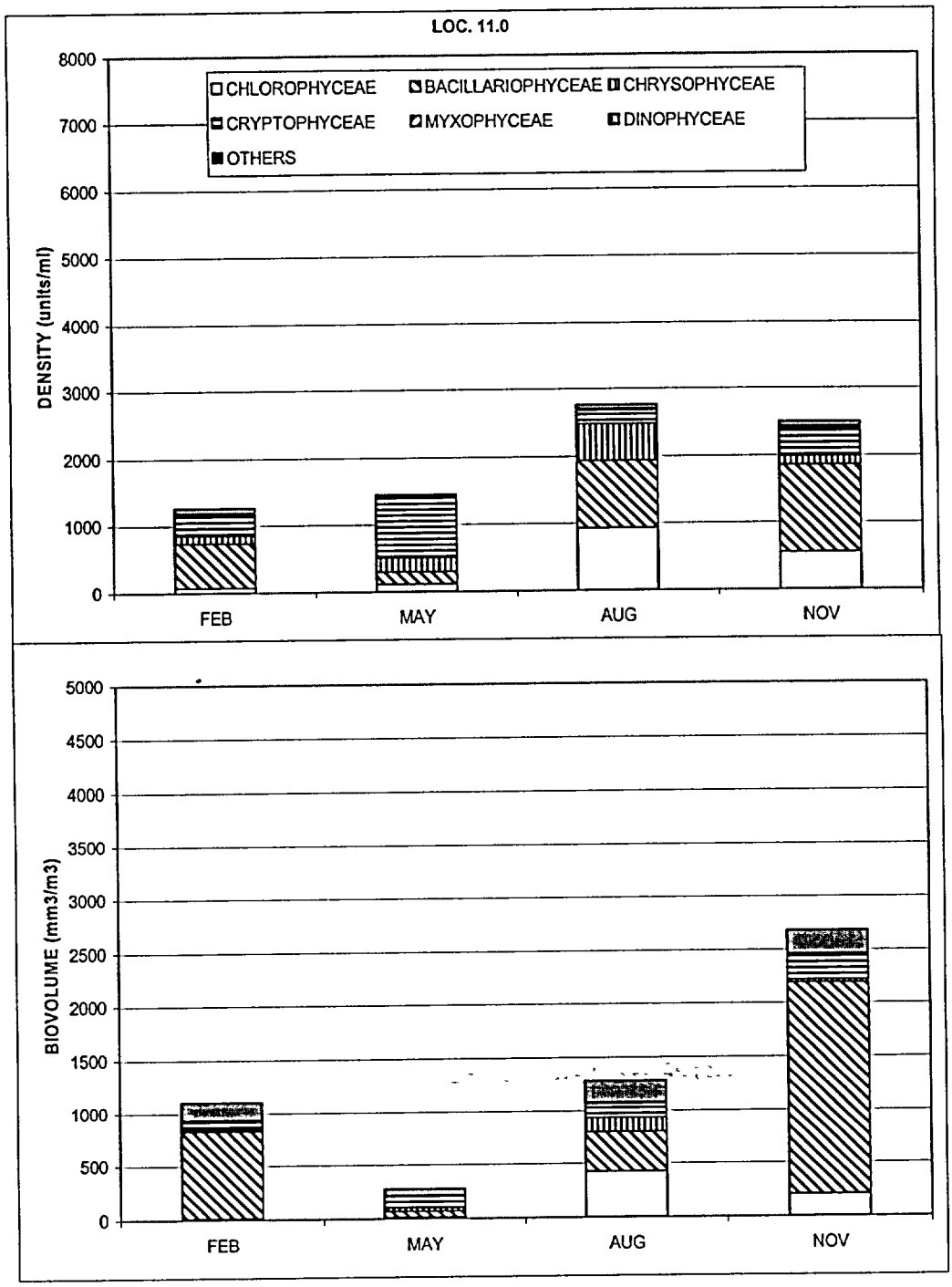

Figure 3-7. Class composition (mean density and biovolume) of phytoplankton from euphotic zone samples collected at Location 11.0 in Lake Norman, NC, during 2001

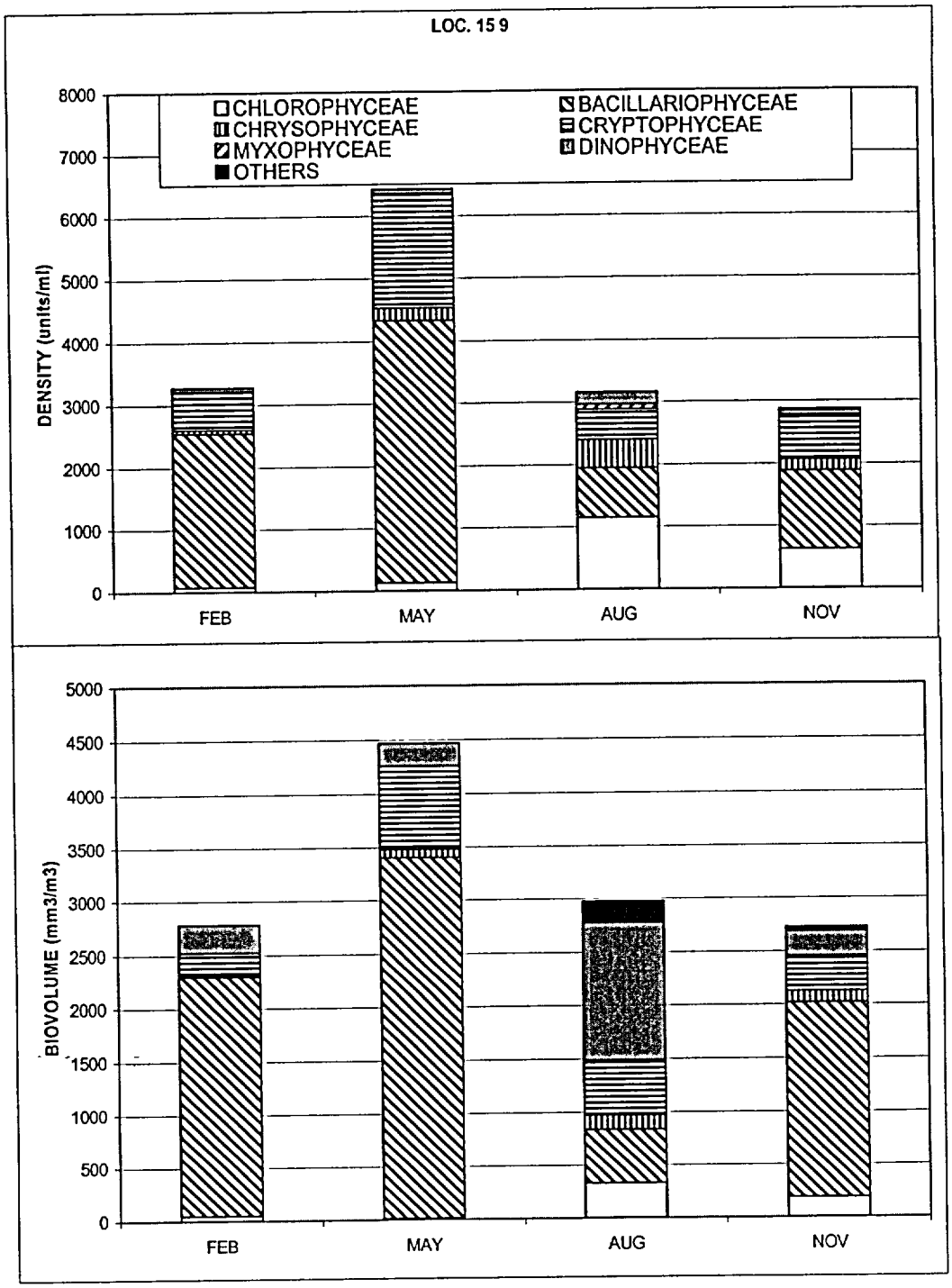

Figure 3-8. Class composition (density and biovolume) of phytoplankton from euphotic zone samples collected at Location 15.9 in Lake Norman, NC, during 2001.

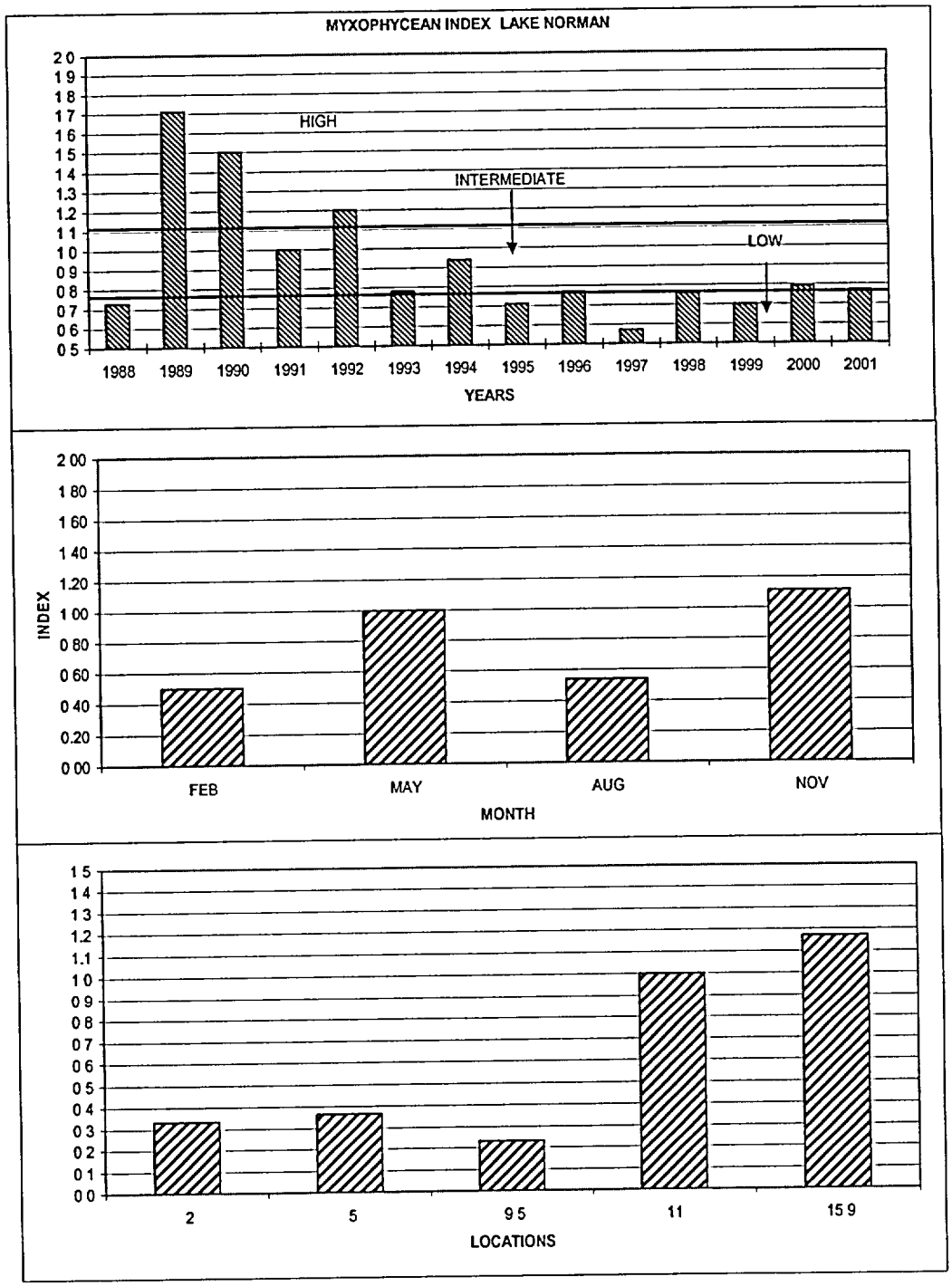

Figure 3-9. Myxophycean index values by year (top), each season in 2000 (mid), and each location in Lake Norman, NC, during 2001 .

CHAPTER 4
ZOOPLANKTON

INTRODUCTION

The objectives of the Lake Norman Maintenance Monitoring Program for zooplankton are to:

1. Describe and characterize quarterly patterns of zooplankton standing crops at selected locations on lake Norman; and
2. compare and evaluate zooplankton data collected during this study (February, May, August, and November 2001) with historical data collected during the period 1987-2000.

Previous studies of Lake Norman zooplankton populations have demonstrated a bimodal seasonal distribution with highest values generally occurring in the spring, and a less pronounced fall peak. Considerable spatial and year-to-year variability has been observed in zooplankton abundance in Lake Norman (Duke power Company 1976, 1985; Hamme 1982; Menhinick and Jensen 1974).

METHODS AND MATERIALS

Duplicate 10 m to surface and bottom to surface net tows were taken at Locations 2.0, 5.0, 9.5, 11.0, and 15.9 in Lake Norman (Chapter 2, Figure 2-1) on 9 February, 1 May, 6 August, and 5 November 2001. For discussion purposes the 10 m to surface tow samples are called epilimnetic samples and the bottom to surface net tow samples are called whole column samples. Locations 2.0 and 5.0 are defined as the Mixing Zone and Locations 9.5, 11.0 and 15.9 are defined as Background Locations. Field and laboratory methods for zooplankton standing crop analysis were the same as those reported in Hamme (1982). Zooplankton standing crop data from 2001 were compared with corresponding data from quarterly monitoring begun in August 1987.

A one way ANOVA was performed on epilimnetic total zooplankton densities by quarter. This was followed by a Duncan's Multiple Range Test to determine which location means were significantly different.

RESULTS AND DISCUSSION

Total Abundance

During 2001, some degree of seasonal variability was observed in epilimnetic samples. Maximum epilimnetic densities were highest in May at all but Location 9.5, where the maximum occurred in November (Table 4-1, Figure 4-1). The lowest epilimnetic densities at Locations 2.0, 5.0, and 15.9 occurred in February, while annual minimum densities at Locations 9.5 and 11.0 were observed in May and August, respectively. Epilimnetic densities ranged from a low of 25,860/m^3 at Location 15.9 in February, to a high of 450,300/m^3 at this same location in May. This maximum was the highest zooplankton density yet observed during the Program. Maximum densities in the whole column samples were observed at Locations 2.0 and 15.9 in May, at Location 5.0 in August, and at Locations 9.5 and 11.0 in November. Minimum whole column densities were observed in February at all but Location 11.0, which had its lowest density in August. Whole column densities ranged from 21,000/m^3 at Location 5.0 in February, to 236,300/m^3 at Location 15.9 in May.

Historically, maximum epilimnetic zooplankton densities at Lake Norman locations have most often been observed in May, with annual peaks observed in February about 25% of the time. Annual maxima have only occasionally been recorded for August and November.

Total zooplankton densities were most often higher in epilimnetic samples than in whole column samples during 2001, as has been the case in previous years (Duke Power Company 2001). This is related to the ability of zooplankton to orient vertically in the water column in response to physical and chemical gradients and the distribution of food sources, primarily phytoplankton, which are generally most abundant in the euphotic zone (Hutchinson 1967).

Although spatial distribution varied among locations from season to season, a general pattern of increasing values from Mixing Zone to Background Locations was observed during 2001 (Tables 4-1 and 4-2, Figures 4-1 and 4-4). Location 15.9, the uppermost location, had significantly higher densities than Mixing Zone locations in all but February, when Location 11.0 demonstrated the significant maximum (Table 4-2). In most previous years of the Program, Background Locations had higher mean densities than Mixing Zone locations (Duke Power Company 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001).

Historically, both seasonal and spatial variability among epilimnetic zooplankton densities had been much higher among Background Locations than among Mixing Zone locations. The uppermost location, 15.9, showed the greatest range of densities during 2001 (Table 4-1, Figures 4-2 and 4-3). Apparently epilimnetic zooplankton communities are more greatly influenced by environmental conditions at the up-lake locations than at the down-lake locations. Location 15.9 represents the transition zone between river and reservoir where populations would be expected to fluctuate due to the dynamic nature of this region of Lake Norman. At the locations nearest the dam (Locations 2.0 and 5.0), seasonal variations are dampened and the overall production would be lower due to the relative stability of this area (Thornton, et al. 1990). A similar trend was observed in the phytoplankton communities (Chapter 3).

Epilimnetic zooplankton densities during all but May of 2001 were within the seasonal ranges of those observed during previous years of the Program. The mean epilimnetic zooplankton density at Location 15.9 in May 2001 was the highest value yet observed for this, or any location, during any previous quarter. This high epilimnetic zooplankton concentration may have been a response to comparatively high phytoplankton concentrations in this part of the lake during May 2001 (Chapter 3). Although phytoplankton chlorophyll and density values were not the highest ever observed; phytoplankton have typically displayed very high densities at this location during May. At the time of sampling, zooplankton had likely reached their peak after grazing on the algae, which could well have been in decline by that time.

The highest February densities recorded during the Program at Locations 5.0 and 9.5 occurred in 1995, and in 1996 at Locations 2.0 and 11.0 (Figure 4-2). The long term February maximum at Location 15.9 was observed in 1992. Long term maximum densities for May occurred at Locations 2.0, 5.0, and 9.5 in 2000, at Location 11.0 in 1995, and at Location 15.9 in 2001. Long term August maxima occurred in 1988 at all but Location 15.9, which had its highest August value in 1996 (Figure 4-3). November long term maxima at Locations 2.0 through 9.5 occurred in 1988, and at Locations 11.0 and 15.9 in November 1999. Since 1990, the densities at Mixing Zone Locations in May, August, and November have not fluctuated much between years; while year-to-year fluctuations in densities during February have occasionally been quite substantial, particularly between 1991 and 1997. The Background Locations continue to exhibit considerable year-to-year variability in all seasons (Figures 4-2 and 4-3).

Community Composition

One hundred and eight zooplankton taxa have been identified since the Lake Norman Maintenance Monitoring Program began in August 1987 (Table 4-3). Forty-six taxa were identified during 2001, as compared to fifty-one taxa recorded during 2000 (Duke Power Company 2001). No previously unreported taxa were identified in 2001.

Copepods were dominant most often during 2001 (Table 4-1, Figures 4-4 and 4-5). These microcrustaceans were dominant at Locations 9.5, and 15.9 (epilimnion) in February, at Locations 2.0, and 9.5 (whole column) in May, at all but Location 9.5 (epilimnion) in August, and at Location 11.0 (whole column) in November. Cladocerans were dominant at Locations 2.0 and 11.0 in February, Location 9.5 (epilimnion) in August, and Locations 2.0 and 5.0 in November. Rotifers dominated zooplankton at Locations 5.0 and 15.9 (whole column) in February, at Locations 5.0, 9.5 (epilimnion), 11.0, and 15.9 in May, and at Locations 5.0, 11.0 (epilimnion) and 15.9 in November. Microcrustaceans remained dominant in all areas of the lake during 2001. Compared with 2000, the percent composition of microcrustaceans had decreased in all areas of the lake in both epilimnetic and whole column samples (Figures 4-6 through 4-8). During most years of the Program, microcrustaceans dominated Mixing Zone samples, but were less important among Background locations.

Copepoda

Copepod populations were consistently dominated by immature forms (primarily nauplii) during 2001, as has always been the case. Adult copepods seldom constituted more than 8% of the total zooplankton density at any location. *Tropocyclops* and *Epischura* were the most important constituents of adult populations (Table 4-4).

Copepods tended to be more abundant, if not dominant, at Background Locations than at Mixing Zone Locations during 2001, and their densities peaked in May at both Mixing Zone and Background Locations. Copepods showed similar spatial and seasonal trends during 2000 (Table 4-1, Figure 4-5). Historically, maximum copepod densities were most often observed in May.

Cladocera

Bosmina was the most abundant cladoceran observed in 2001 samples, as has been the case in most previous studies (Duke Power Company 2000, Hamme 1982). *Bosmina* often comprised greater than 5% of the total zooplankton densities in both epilimnetic and whole column samples, and was the dominant zooplankter in most February samples, and in all Mixing Zone samples in November. *Daphnia* and *Bosminopsis* were also important among cladocerans (Table 4-4). During May, *Daphnia* dominated cladoceran populations at Locations 2.0, 5.0, and 9.5. *Bosminopsis* dominated cladoceran populations at Locations 9.5 (epilimnion), 11.0, and 15.9 in August. *Bosminopsis* expressed higher dominance during August 2001 as compared to August 2000. *Diaphanosoma*, which was the dominant cladoceran in May 2000, was never dominant among cladoceran populations during 2001. Similar patterns of *Daphnia-Bosminopsis* dominance have been observed in past years of the Program (Duke Power Company 2001).

Long-term seasonal trends of cladoceran densities were variable: From 1990 to 1993, peak densities occurred in February; while in 1994 and 1995, maxima were recorded in May (Figure 4-5). During 1996, peak cladoceran densities occurred in May in the Mixing Zone, and in August among Background Locations. During 1997, cladoceran densities again peaked in May. Maximum cladoceran densities in 1998 occurred in August. During 1999, maximum densities in the Mixing Zone were observed in May, while Background Locations showed peaks in August. During 2000, peak cladoceran densities were again observed in May. In 2001, maximum cladoceran densities in the Mixing Zone occurred in February, while Background locations showed peaks in November. Spatially, cladocerans were more important at Mixing Zone Locations than at other locations (Table 4-1, Figure 4-4).

Rotifera

Keratella was the most abundant rotifer in 2001 samples. This taxon dominated rotifer populations at Locations 2.0, 5.0 (whole column), 11.0 (whole column), and 15.9 in February. *Keratella* also dominated rotifer populations at Location 15.9 in August, and all but Location 2.0 in November (Table 4-4). *Polyarthra* was dominant in most May samples, as well as at Location 11.0 (epilimnion) in February, and Locations 2.0 and 5.0 in August. *Conochilus* dominated rotifer populations at Location 9.5 in February, Location 11.0 (whole column) in May, and Location 2.0 in November. *Asplanchna* was the dominant rotifer in samples from Locations 9.5 and 11.0 in August, while *Synchaeta* was the dominant rotifer at

Location 5.0 (epilimnion) in February. All of these taxa have been identified as important constituents of rotifer populations, as well as zooplankton communities, in previous studies (Duke power Company 2001; Hamme 1982).

Long term tracking of rotifer populations indicated high year-to-year seasonal variability. Peak densities have most often occurred in February and May, with an occasional peak in August (Figure 4-5, Duke Power Company 1989, 2001). During 2001, peak densities at most locations were observed in May.

FUTURE STUDIES

No changes are planned for the zooplankton portion of the Lake Norman Maintenance Monitoring Program in 2002 and 2003.

SUMMARY

Maximum epilimnetic zooplankton densities most often occurred in May, while minimum values were recorded in February (Locations 2.0, 5.0, and 15.9), and August (Locations 9.5 and 11.0). In most whole column samples, maximum densities occurred in May (Location 15.9), August (Locations 2.0 and 5.0), and November (Locations 9.5 and 11.0). Minimum values were most often observed in February. As in past years, epilimnetic densities were higher than whole column densities. Mean zooplankton densities tended to be higher among Background Locations than among Mixing Zone locations during 2001, and a general pattern of increasing values from downlake to uplake was observed. In addition, long term trends showed much higher year-to-year variability at Background Locations than at Mixing Zone Locations.

Epilimnetic zooplankton densities during all but May of 2001 were within ranges of those observed in previous years. The epilimnetic density at Location 15.9 in May 2001 was the highest recorded during the Program, and may have represented an ongoing lag response to comparatively high phytoplankton standing crops uplake at that time.

One hundred and eight zooplankton taxa have been recorded from Lake Norman since the Program began in 1987 (forty-six were identified during 2001). No previously unreported taxa were identified during 2001.

Copepods dominated zooplankton standing crops most often during 2001. Overall relative abundance of copepods in 2001 had decreased slightly since 2000. Cladocerans were occasionally dominant in February, August and November, while rotifers were dominant in most samples in August, and occasionally during all other quarters. Overall, the relative abundance of rotifers had increased since 2000. Historically, copepods and rotifers have shown annual peaks in May; while cladocerans continued to demonstrate year-to-year variability.

Copepods were dominated by immature forms with adults seldom accounting for more than 8% of zooplankton densities. The most important adult copepods were *Tropocyclops*, and *Epischura*, as was the case in previous years. *Bosmina* was the predominant cladoceran, as has also been the case in most previous years of the Program. *Daphnia* and *Bosminopsis* dominated cladoceran populations in May and August. The most abundant rotifers observed in 2001, as in many previous years, were *Keratella* and *Polyarthra*, while *Conochilus* and *Asplanchna* were occasionally important among rotifer populations during each quarter.

Lake Norman continues to support a highly diverse and viable zooplankton community. Long term and seasonal changes observed over the course of the study, as well seasonal and spatial variability observed during 2001, were likely due to environmental factors and appears not to be related to plant operations.

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Table 4-1. Total zooplankton densities (no. X 1000/m^3), densities of major zooplankton taxonomic groups, and percent composition (in parentheses) of major taxa in 10m to surface (10-S) and bottom to surface (B-S) net tow samples collected from Lake Norman in February, May, August, and November 2001.

Date	Sample Type	Taxon	Locations 2.0	5.0	9.5	11.0	15.9
2/9/01	10-S	COPEPODA	10.6	5.0	28.3	24.6	16..3
			(24.6)	(17.4)	(46.7)	(40.2)	(63.0)
		CLADOCERA	17.6	8.4	24.8	36.0	9.5
			(41.0)	(29.3)	(40.9)	(58.7)	(36.7)
		ROTIFERA	14.8	15.2	7.5	0.7	7.6
			(34.4)	(53.3)	(12.4)	(1.1)	(29.4)
		TOTAL	**43.0**	**28.6**	**60.5**	**61.3**	**33.4**
	B-S depth (m) of tow for each Location 2.0=30 5.0=18 9.5=20 11.0=25 15.9=21	COPEPODA	4.4	4.2	17.4	22.8	7.8
			(14.3)	(19.9)	(48.7)	(39.0)	(36.1)
		CLADOCERA	13.6	8.2	10.8	27.6	4.5
			(43.7)	(38.8)	(30.2)	(47.4)	(20.7)
		ROTIFERA	13.1	8.7	7.5	8.0	9.3
			(42.1)	(41.3)	(21.1)	(13.6)	(43.1)
		TOTAL	**31.1**	**21.0**	**35.7**	**58.3**	**21.7**
5/1/01	10-S	COPEPODA	41.9	42.2	15.9	66.3	101.7
			(46.6)	(42.5)	(14.0)	(39.9)	(22.6)
		CLADOCERA	7.7	9.6	9.6	27.0	10.6
			(8.5)	(10.3)	(8.4)	(15.9)	(2.3)
		ROTIFERA	40.4	47.4	92.2	76.8	338.0
			(44.9)	(47.8)	(81.5)	(45.2)	(75.1)
		TOTAL	**90.0**	**99.2**	**117.7**	**170.1**	**450.3**
	B-S depth (m) of tow for each Location 2.0=30 5.0=20 9.5=20 11.0=24 15.9=20	COPEPODA	21.7	24.8	26.3	34.5	53.0
			(53.2)	(42.5)	(61.4)	(42.8)	(22.4)
		CLADOCERA	3.6	5.3	8.3	8.8	5.8
			(8.9)	(9.2)	(19.4)	(10.9)	(2.4)
		ROTIFERA	15.5	28.2	8.2	37.4	183.0
			(38.0)	(48.3)	(19.2)	(46.4)	(77.4)
		TOTAL	**40.8**	**58.4**	**42.9**	**80.7**	**241.7**

Table 4-1 (continued).

Date	Sample Type	Taxon	Locations 2.0	5.0	9.5	11.0	15.9
8/6/01	10-S	COPEPODA	33.1	29.0	18.3	35.4	58.3
			(62.3)	(42.5)	(36.7)	(64.6)	(53.7)
		CLADOCERA	13.2	10.4	19.8	15.0	22.2
			(24.9)	(15.3)	(39.6)	(27.4)	(20.4)
		ROTIFERA	6.8	28.8	11.8	4.4	28.1
			(12.8)	(42.2)	(23.7)	(8.0)	(25.9)
		TOTAL	**53.2**	**68.3**	**50.0**	**54.8**	**108.6**
	B-S depth (m) of tow for each Location 2.0=30 5.0=18 9.5=20 11.0=24 15.9=20	COPEPODA	22.3	33.7	20.2	33.9	55.2
			(62.4)	(54.5)	(50.0)	(70.4)	(53.1)
		CLADOCERA	10.2	7.7	16.7	10.0	25.5
			(28.4)	(12.4)	(41.4)	(20.8)	(24.5)
		ROTIFERA	3.3	20.5	3.4	4.2	23.2
			(9.2)	(33.1)	(8.6)	(8.6)	(22.4)
		TOTAL	**35.8**	**61.9**	**40.4**	**48.2***	**103.9**
11/5/01	10-S	COPEPODA	15.4	12.6	22.6	34.6	57.2
			(31.9)	(29.3)	(17.1)	(39.6)	(45.0)
		CLADOCERA	28.3	23.8	9.9	10.6	12.1
			(58.6)	(55.6)	(7.4)	(12.1)	(9.5)
		ROTIFERA	4.6	6.4	100.2	42.1	57.8
			(9.6)	(15.0)	(75.5)	(48.2)	(45.4)
		TOTAL	**48.4**	**42.9**	**132.8**	**87.2**	**127.2**
	B-S depth (m) of tow for each Location 2.0=28 5.0=17 9.5=19 11.0=24 15.9=19	COPEPODA	13.1	14.4	19.6	42.1	27.2
			(39.6)	(38.3)	(21.3)	(48.1)	(31.3)
		CLADOCERA	18.9	20.1	13.5	16.2	13.2
			(57.1)	(53.3)	(14.6)	(18.5)	(15.2)
		ROTIFERA	1.1	3.2	59.2	29.2	46.5
			(3.2)	(8.4)	(64.1)	(33.4)	(53.5)
		TOTAL	**33.1**	**37.6**	**92.3**	**87.6**	**86.9**

*= *Chaoborus* observed in sample (110/m^3, 0.2%).

Table 4-2. Duncan's Multiple Range Test on epilimnetic zooplankton densities (no. X 1000/m^3) in Lake Norman, NC during 2001.

February	Location	**5.0**	**15.9**	**2.0**	**9.5**	**11.0**
	Mean	28.6	33.4	43.0	60.5	61.3
May	Location	**2.0**	**5.0**	**9.5**	**11.0**	**15.9**
	Mean	90.0	99.2	117.7	170.1	450.3
August	Location	**9.5**	**2.0**	**11.0**	**5.0**	**15.9**
	Mean	50.0	53.2	54.8	68.3	108.6
November	Location	**5.0**	**2.0**	**11.0**	**15.9**	**9.5**
	Mean	42.9	48.4	87.2	127.2	132.8

Table 4-3. Zooplankton taxa identified from samples collected quarterly on Lake Norman from 1988 through 2001.

TAXON	88	89	90	91	92	93	94	95	96	97	98	99	00	01
COPEPODA														
Cyclops thomasi Forbes	X	X	X				X	X		X	X	X	X	X
C. vernalis Fischer									X					
C. spp. O. F. Muller	X	X	X	X	X	X	X	X	X	X	X			X
Diaptomus birgei Marsh	X	X	X	X		X							X	
D. mississippiensis Marsh	X	X	X	X	X	X	X	X	X	X	X	X	X	X
D. pallidus Herick		X	X			X		X	X	X		X		
D. reighardi Marsh												X		
D. spp. Marsh	X	X	X	X	X	X	X	X	X	X	X	X	X	
Epishura fluviatilis Herrick								X	X	X	X	X	X	X
Ergasilus spp.									X					
Eucyclops agilis (Koch)											X			
Mesocyclops edax (S. A. Forbes)	X	X	X				X	X	X	X	X	X	X	X
M. spp. Sars	X	X		X	X	X	X	X	X	X				X
Tropocyclops prasinus (Fischer)	X	X	X					X	X	X	X	X	X	X
T. spp.	X	X	X	X	X	X	X	X	X	X				X
Calanoid copepodites	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyclopoid copepodites	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Harpacticoidea					X	X			X					
Nauplii	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Parasitic copepods												X		
CLADOCERA														
Alona spp.Baird									X	X				
Alonella spp. (Birge)							X					X		
Bosmina longirostris (O. F. M.)	X	X	X			X				X	X	X	X	X
B. spp. Baird	X	X		X	X	X	X	X	X	X	X		X	X
Bosminopsis dietersi Richard	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ceriodaphnia lacustris Birge				X						X	X	X	X	X
C. spp. Dana	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chydorus spp. Leach				X		X	X	X	X	X		X		X
Daphnia ambigua Scourfield	X	X	X						X	X	X	X		X
D. catawba Coker									X	X				X
D. galeata Sars									X					
D. laevis Birge									X					
D. longiremis Sars									X	X			X	X
D. lumholzi Sars				X		X	X	X	X		X	X	X	
D. mendotae (Sars) Birge										X	X	X	X	
D. parvula Fordyce	X	X	X					X	X	X	X	X	X	X
D. pulex (de Geer)									X	X				

Table 4-3 (continued)

TAXON	88	89	90	91	92	93	94	95	96	97	98	99	00	01
CLADOCERA (continued)														
D. pulicaria Sars									X	X				
D. retrocurva Forbes									X	X	X	X	X	
D. schodleri Sars									X					
D. spp. Mullen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Diaphanosoma brachyurum (Lievin)										X	X	X	X	X
D. spp. Fischer	X	X	X	X	X	X	X	X	X	X	X		X	X
Eubosmina spp. (Baird)				X										
Holopedium amazonicum Stinge.	X	X	X							X	X	X	X	X
H. gibberum Zaddach			X							X	X			
H. spp. Stingelin	X	X		X	X	X	X	X	X	X			X	X
Ilyocryptus sordidus (Lieven)	X	X	X											
I. spinifer Herrick												X		
I. spp. Sars					X	X	X				X		X	
Latona setifera (O.F. Muller)				X										
Leptodora kindtii (Focke)	X	X	X		X	X	X	X	X	X	X	X	X	X
Leydigia spp. Freyberg						X	X	X	X	X				
Moina spp. Baird				X										
Sida crystallina O. F. Muller	X		X	X	X									
Simocephalus expinosus					X									
Simocephalus spp. Schodler												X		
ROTIFERA														
Anuraeopsis spp. Lauterborne	X	X	X	X	X	X		X		X		X		
Asplanchna brightwelli Gosse											X		X	
A. priodonta Gosse											X	X	X	
A. spp. Gosse	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brachionus caudata Barr. & Daday	X	X	X											
B. havanensis Rousselet	X	X	X							X				
B. patulus O. F. Muller	X	X	X								X			
B. spp. Pallas				X		X		X	X		X			
Chromogaster ovalis (Bergendel)										X	X	X		X
C. spp. Lauterborne	X	X	X	X	X	X	X	X	X					
Collotheca balatonica Harring									X	X	X	X	X	
C. mutabilis (Hudson)									X	X	X	X	X	
C. spp. Harring	X	X	X	X	X	X	X	X	X	X	X		X	X
Colurella spp. Bory de St. Vincent									X					
Conochiloides dossuarius Hudson										X	X	X	X	X
C. spp. Hlava	X	X	X	X	X	X	X	X	X	X				X
Conochilus unicornis (Rousselet)	X	X	X							X	X	X	X	X

Table 4-3 (continued)

TAXON	88	89	90	91	92	93	94	95	96	97	98	99	00	01
ROTIFER (continued)														
C. spp. Hlava	X	X	X	X	X	X	X	X	X	X				X
Filinia spp. Bory de St. Vincent						X	X				X			
Gastropus stylifer Imhof											X	X	X	X
G. spp. Imhof	X	X	X		X	X	X	X	X	X	X			X
Hexarthra mira Hudson										X	X	X	X	
H. spp. Schmada	X	X	X	X	X	X	X	X	X	X				X
Kellicottia bostoniensis (Rousselet)	X	X	X				X	X	X	X	X	X	X	X
K. longispina Kellicott										X	X	X	X	X
K. spp. Rousselet	X	X	X	X	X	X	X	X	X	X				X
Keratella cochlearis												X	X	
K. taurocephala Myers										X		X		
K. spp. Bory de St. Vincent	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lecane spp. Nitzsch	X	X	X		X		X	X		X	X		X	
Macrochaetus subquadratus Perty										X	X			
M. spp. Perty	X	X	X	X		X			X			X	X	
Monostyla stenroosi (Meissener)	X		X											
M. spp. Ehrenberg	X	X	X				X	X	X		X			
Notholca spp. Gosse							X		X		X			
Ploeosoma hudsonii Brauer				X			X	X	X	X	X	X	X	X
P. truncatum (Levander)	X	X	X				X	X	X	X	X	X	X	X
P. spp. Herrick	X	X	X	X	X	X	X	X	X		X			X
Polyarthra euryptera (Weirzeijski)	X	X	X								X			
P. major Burckhart										X		X	X	
P. vulgaris Carlin	X	X	X							X		X	X	X
P. spp. Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pompholyx spp. Gosse									X					
Ptygura libra Meyers										X	X		X	
P. spp. Ehrenberg	X	X	X		X	X	X	X	X	X				
Synchaeta spp. Ehrenberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trichocerca capucina (Weireijski)	X	X	X				X	X	X	X	X			
T. cylindrica (Imhof)	X	X	X					X	X	X	X	X	X	
T. longiseta Schrank										X				
T. multicrinis (Kellicott)											X	X	X	
T. porcellus (Gosse)								X	X	X		X	X	
T. pusilla Jennings										X				
T. similis Lamark								X						
T. spp. Lamark	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trichotria spp. Bory de St. Vincent									X					

Table 4-3 (continued)

TAXON	88	89	90	91	92	93	94	95	96	97	98	99	00	01
ROTIFERA (continued)														
Unidentified Bdelloida	X	X	X		X	X	X			X	X	X		
Unidentified Rotifera				X	X	X	X	X	X	X	X	X	X	
INSECTA														
Chaoborus spp. Lichtenstein	X	X	X	X	X	X					X	X		X
OSTRACODA (unidentified)											X			

Table 4-4. Dominant taxa among copepods (adults), cladocerans, and rotifers, and their percent composition (in parentheses) of copepod, cladoceran and rotifer densities in Lake Norman samples during 2001.

	FEBRUARY	MAY	AUGUST	NOVEMBER
		COPEPODA	**EPILIMNION**	
2.0	*Epischura* (6.0)	*Epischura* (4.7)	*Tropocyclops* (4.4)*	*Tropocyclops* (8.9)*
5.0	*Tropocyclops* (4.4)	*Epischura* (7.4)	*Tropocyclops* (6.7)*	*Tropocyclops* (8.5)
9.5	*Epischura* (19.8)	*Epischura* (6.6)	*Tropocyclops* (6.8)	*Epischura* (5.4)
11.0	*Cyclops* (1.6)*	*Epishura* (8.0)	*Tropocyclops* (4.3)	*Tropocyclops* (7.6)
15.9	*Epischura* (1.2)*	*Epischura* (3.3)	*Tropocyclops* (5.7)*	*Tropocyclops* (2.5)*
		COPEPODA	**WHOLE COLUMN**	
2.0	*Epischura* (10.9)	*Epischura* (5.0)	*Tropocyclops* (4.3)	*Epischura* (6.8)
5.0	*Mesocyclops* (4.8)	*Epischura* (3.5)	*Tropocyclops* (4.9)	*Tropocyclops* (4.4)
9.5	*Epischuria* (8.6)	*Epischura* (4.1)	*Tropocyclops* (3.9)	*Tropocyclops* (11.3)
11.0	*Epischuria* (2.5)	*Epischra* (7.0)	*Tropocyclops* (5.6)	*Diaptomus* (9.0)
15.9	*Cyclops* (7.4)	*Epischras* (2.3)	*Tropocyclops* (4.0)	*Tropocyclops* (3.9)
		CLADOCERA	**EPILIMNION**	
2.0	*Bosmina* (100.0)	*Daphnia* (53.2)	*Bosmina* (78.0)	*Bosmina* (94.2)
5.0	*Bosmina* (100.0)	*Daphnia* (36.8)	*Bosmina* (64.8)	*Bosmina* (98.4)
9.5	*Bosmina* (100.0)	*Daphnia* (58.1)	*Bosminopsis* (55.7)	*Bosmina* (100.0)
11.0	*Bosmina* (95.2)	*Bosmina* (36.9)	*Bosminopsis* (63.9)	*Bosmina* (85.9)
15.9	*Bosmina* (93.9)	*Bosmina* (70.3)	*Bosminopsis* (72.4)	*Bosmina* (94.9)
		CLADOCERA	**WHOLE COLUMN**	
2.0	*Bosmina* (98.4)	*Daphnia* (48.3)	*Bosmina* (83.3)	*Bosmina* (85.2)
5.0	*Bosmina* (97.5)	*Daphnia* (43.6)	*Bosmina* (54.8)	*Bosmina* (93 2)
9.5	*Bosmina* (100.0)	*Daphnia* (61.7)	*Bosmina* (48.4)	*Bosmina* (98.5)
11.0	*Bosmina* (95.4)	*Bosmina* (41.4)	*Bosminopsis* (62.7)	*Bosmina* (63.1)
15.9	*Bosmina* (93.6)	*Bosmina* (68.3)	*Bosminopsis* (57.1)	*Bosmina* (86.0)

Table 4-4 (continued)

	FEBRUARY	MAY	AUGUST	NOVEMBER
		ROTIFERA	**EPILIMNION**	
2.0	*Keratella* (27.8)	*Polyarthra* (57.8)	*Polyarthra* (100.0)	*Conochilus* (44.1)
5.0	*Synchaeta* (33.6)	*Plyarthra* (56.2)	*Polyarthra* (98.5)	*Keratella* (63.5)
9.5	*Conochilus* (44.9)	*Polyarthra* (49.7)	*Asplanchna* (75.2)	*Keratella* (59.6)
11.0	*Polyarthra* (45.3)	*Polyarthra* (51.6)	*Asplanchna* (26.3)	*Keratella* (64.7)
15.9	*Keratella* (28.1)	*Polyarthra* (52.7)	*Keratella* (66.7)	*Keratella* (55.1)
		ROTIFERA	**WHOLE COLUMN**	
2.0	*Keratella* (63.1)	*Polyarthra* (53.8)	*Polyarthra* (67.9)	*Conochilus* (44.4)
5.0	*Keratella* (37.5)	*Polyarthra* (56.5)	*Polyarthra* (98.5)	*Keratella* (33.7)
9.5	*Conochilus* (34.7)	*Polyarthra* (46.3)	*Asplanchna* (57.7)	*Keratella* (56.6)
11.0	*Keratella* (49.3)	*Conochilus* (43.8)	*Asplanchna* (26.6)	*Keratella* (65.0)
15.9	*Keratella* (45.7)	*Polyarthra* (51.1)	*Keratella* (52.1)	*Keratella* (48.9)

* = Only adults present in samples.

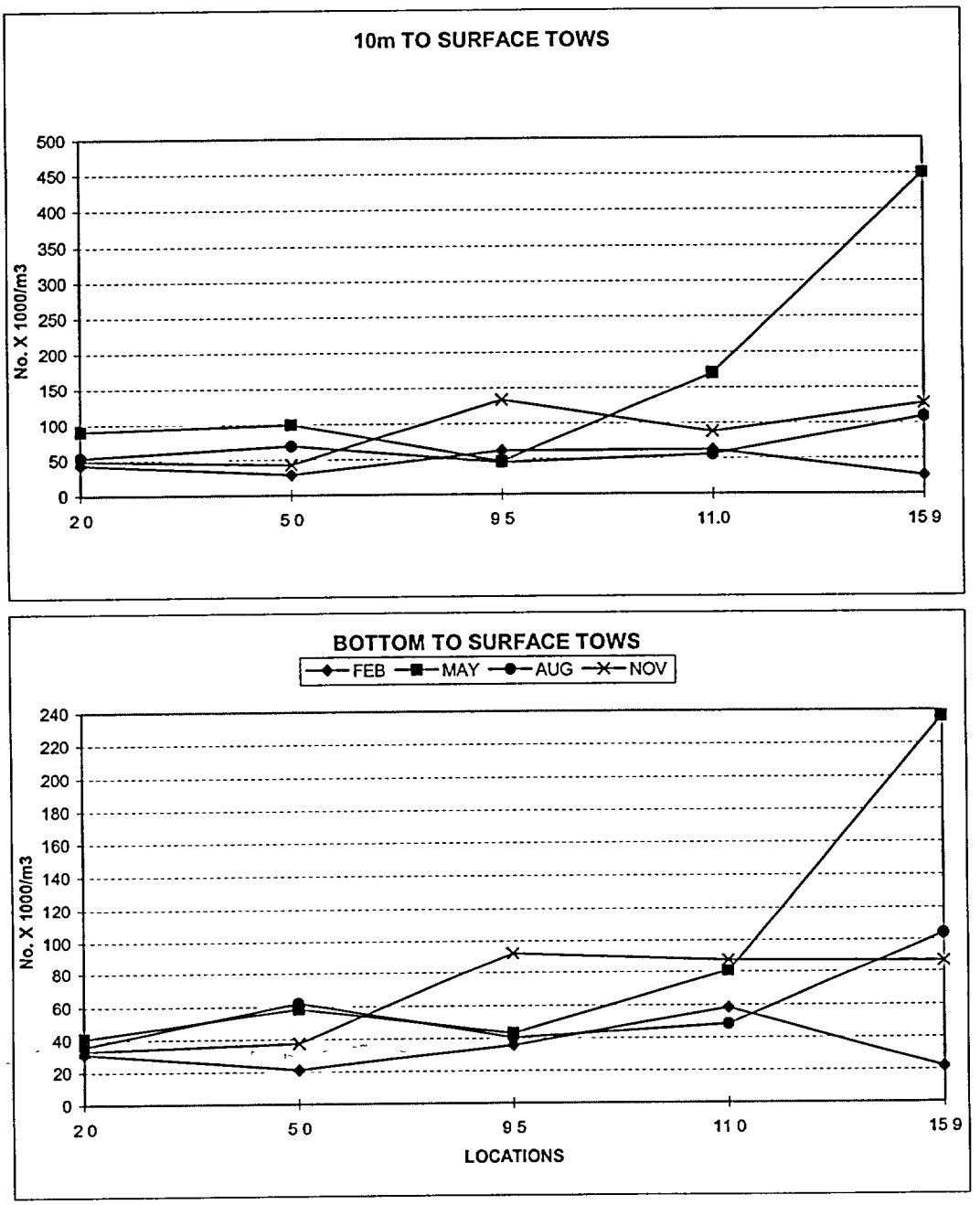


Figure 4-1. Total zooplankton density by location for samples collected in Lake Norman, NC, in 2001.

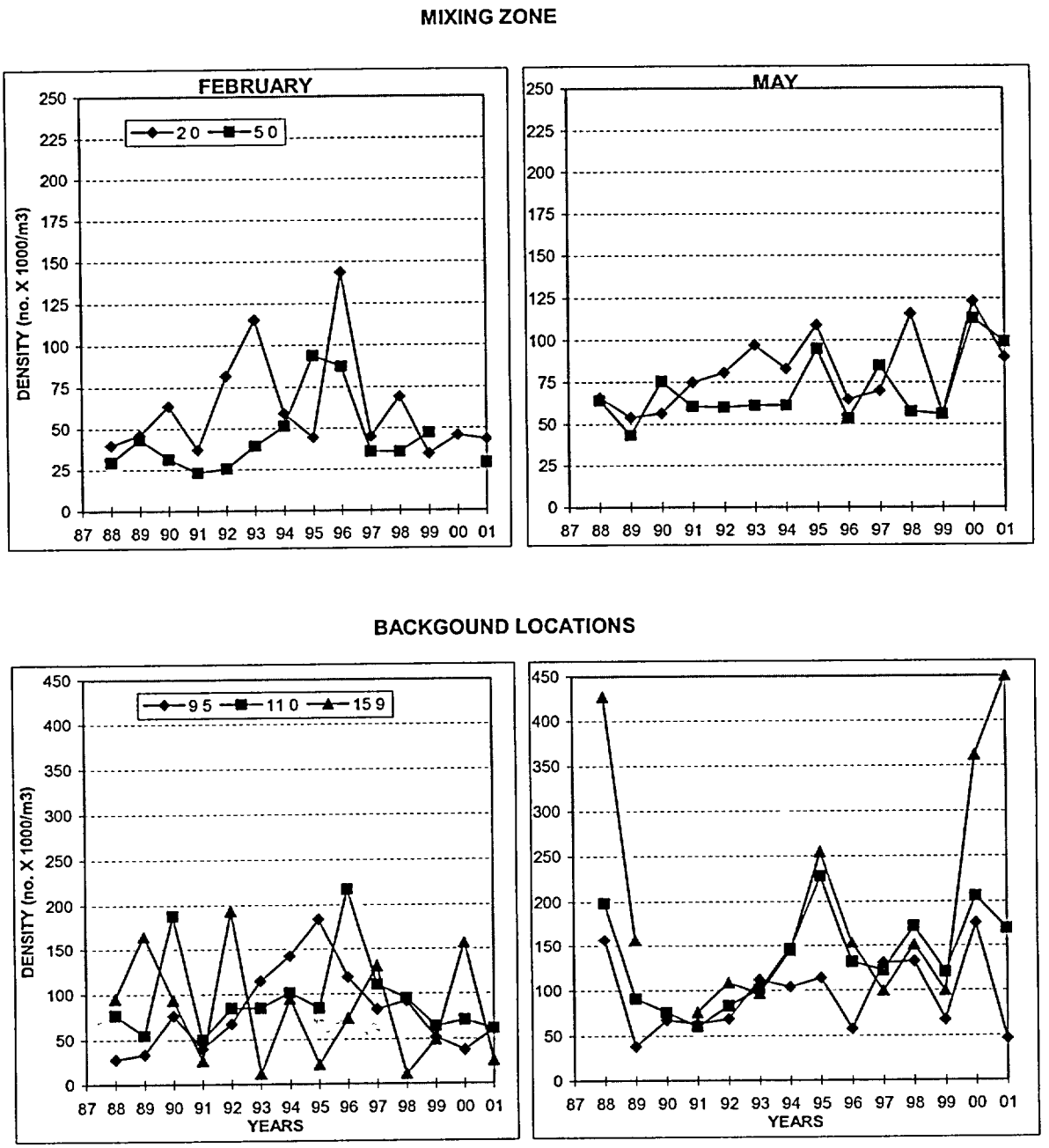


Figure 4-2. Total zooplankton densities by location for epilimnetic samples collected in Lake Norman, NC, in February and May of 1988 through 2001.

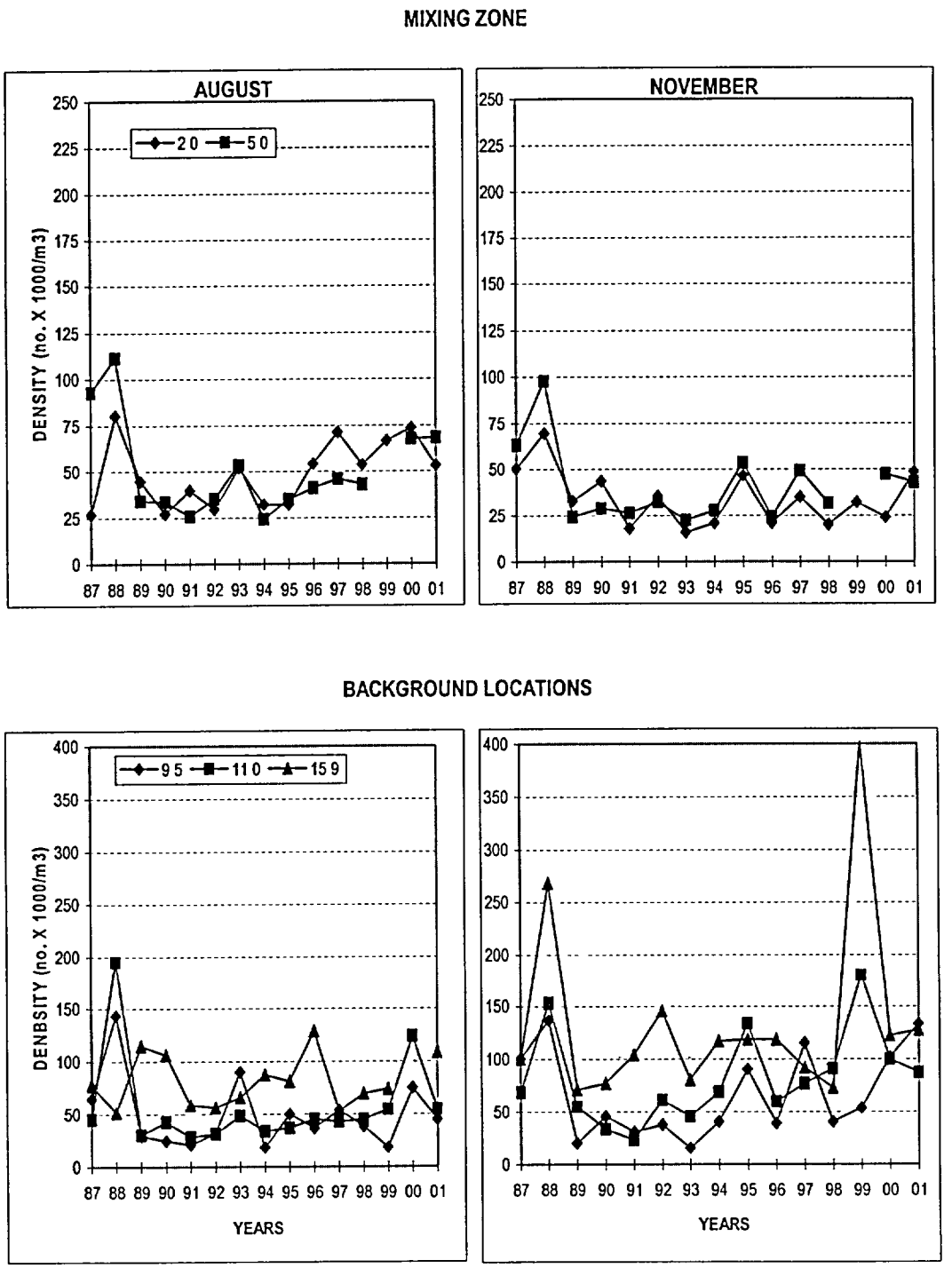


Figure 4-3. Total zooplankton densities by location for epilimnetic samples collected in Lake Norman, NC, in August and November of 1987 through 2001.

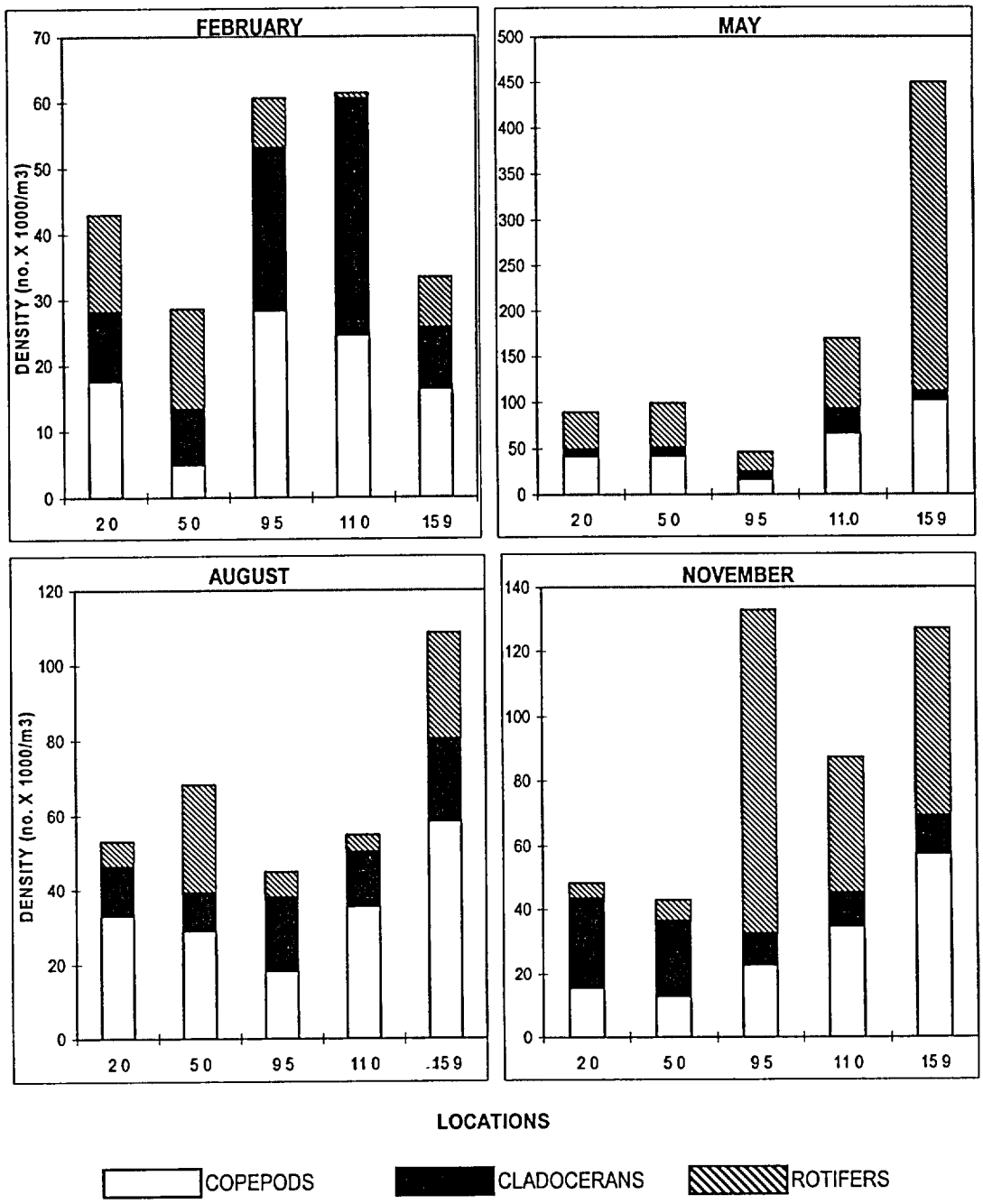


Figure 4-4. Zooplankton community composition by month for epilimnetic samples collected in Lake Norman, NC, in 2001.

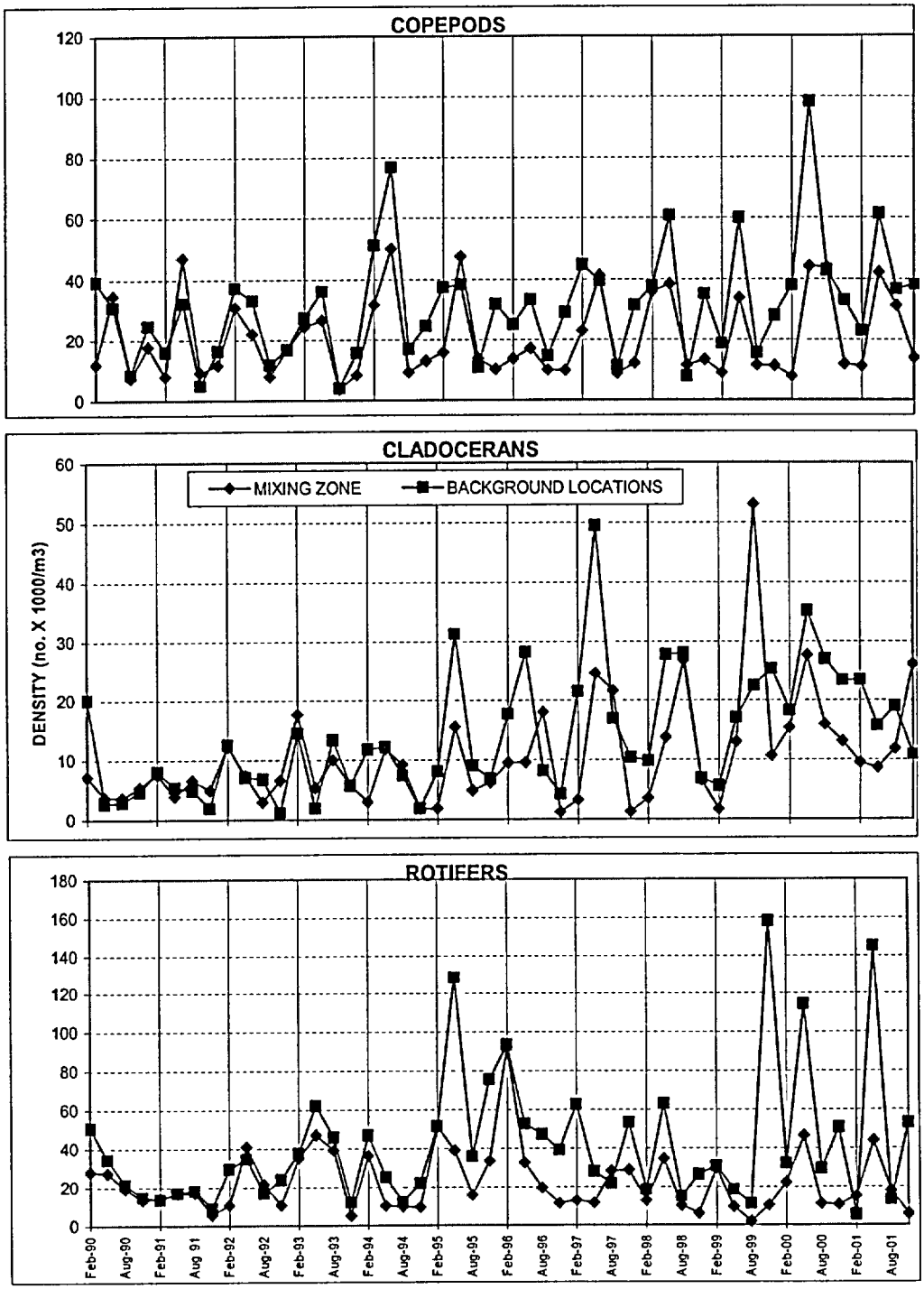
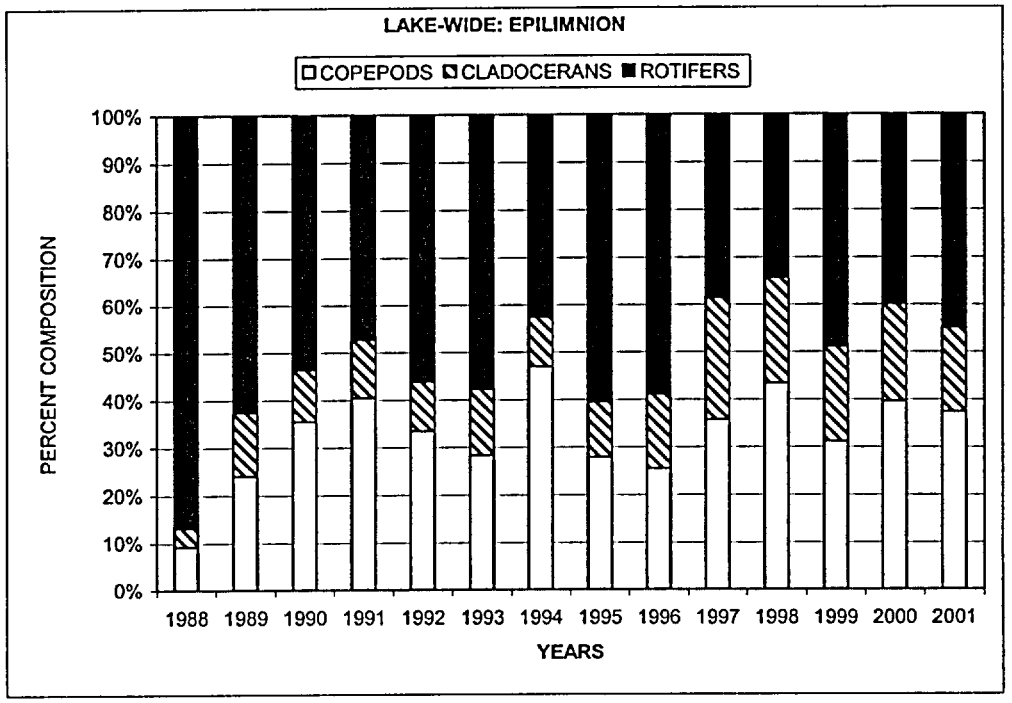


Figure 4-5. Zooplankton composition by quarter for epimlimnetic samples collected in Lake Norman, NC, from 1990 through 2001.



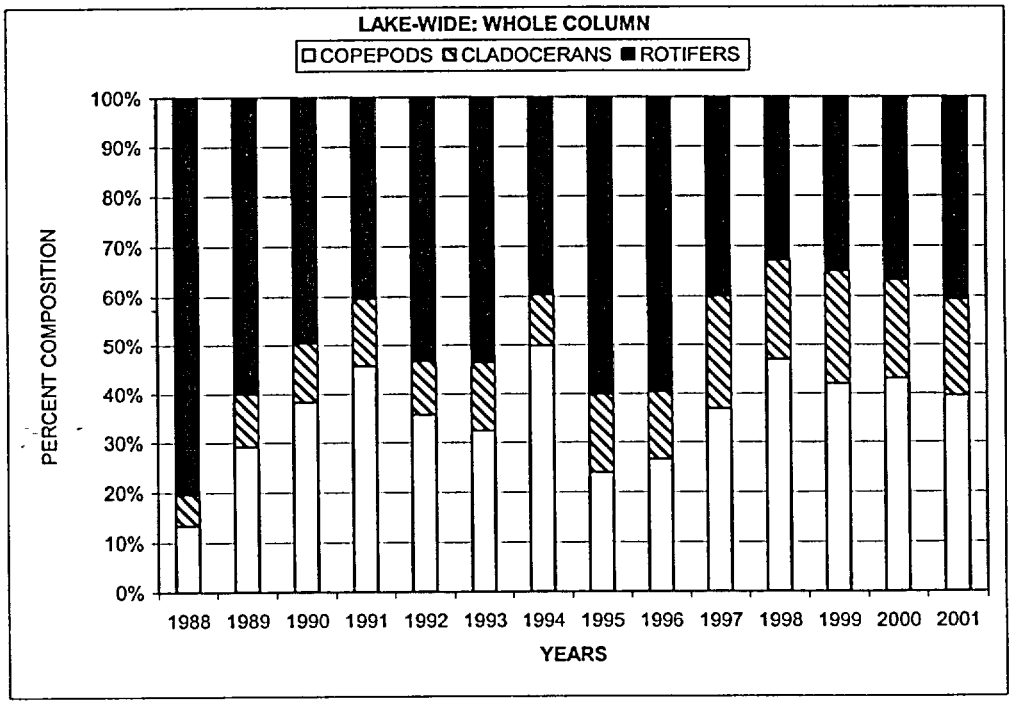
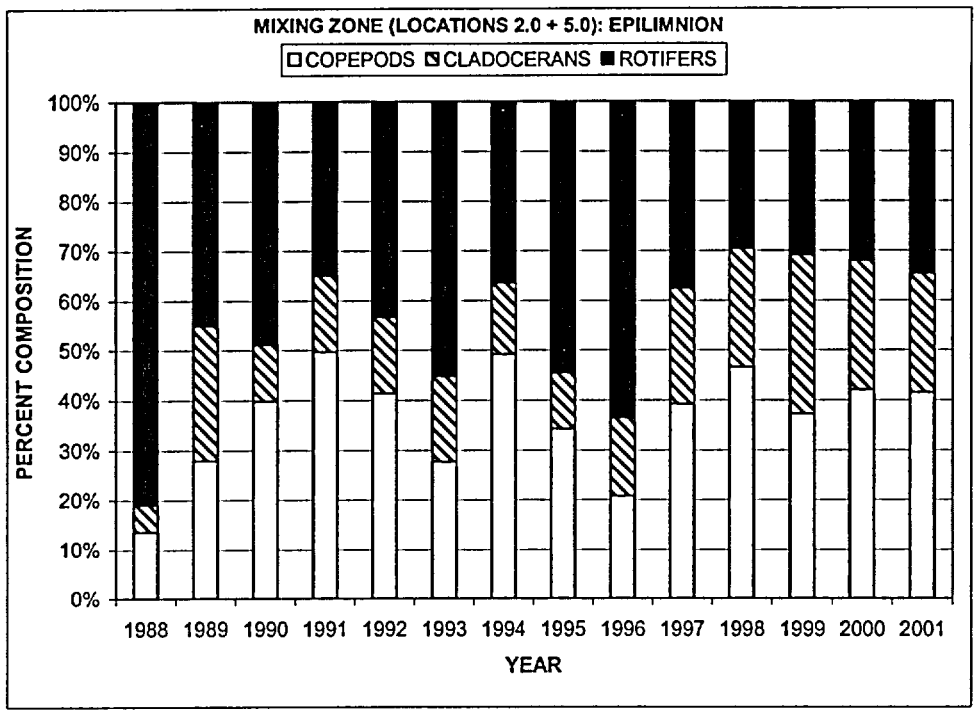


Figure 4-6. Annual lake-wide percent composition of major zooplankton taxonomic groups from 1988 through 2001.



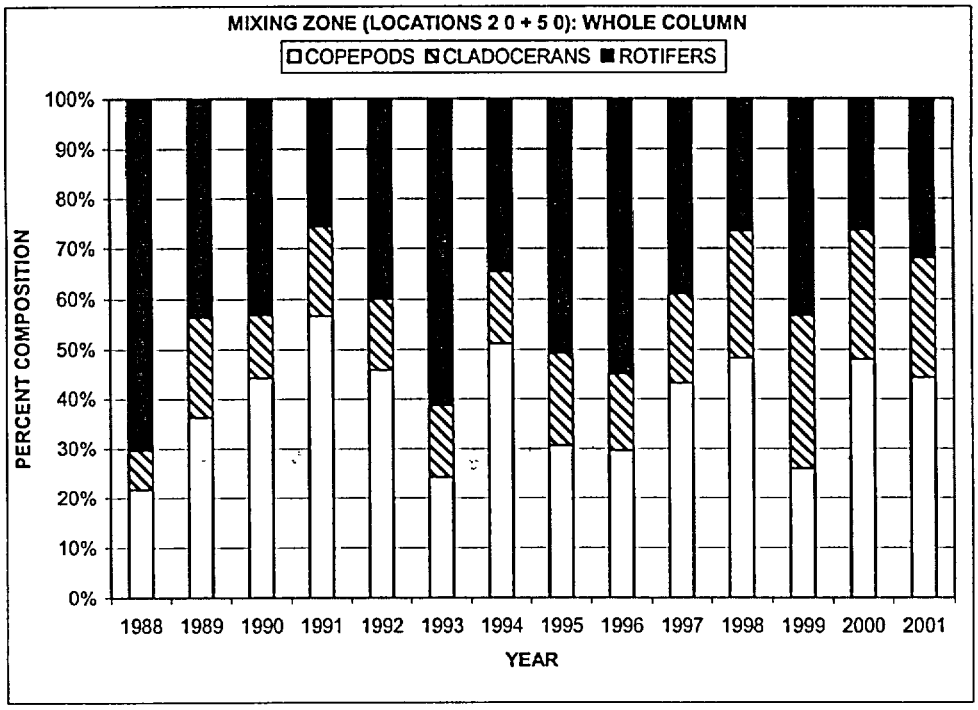
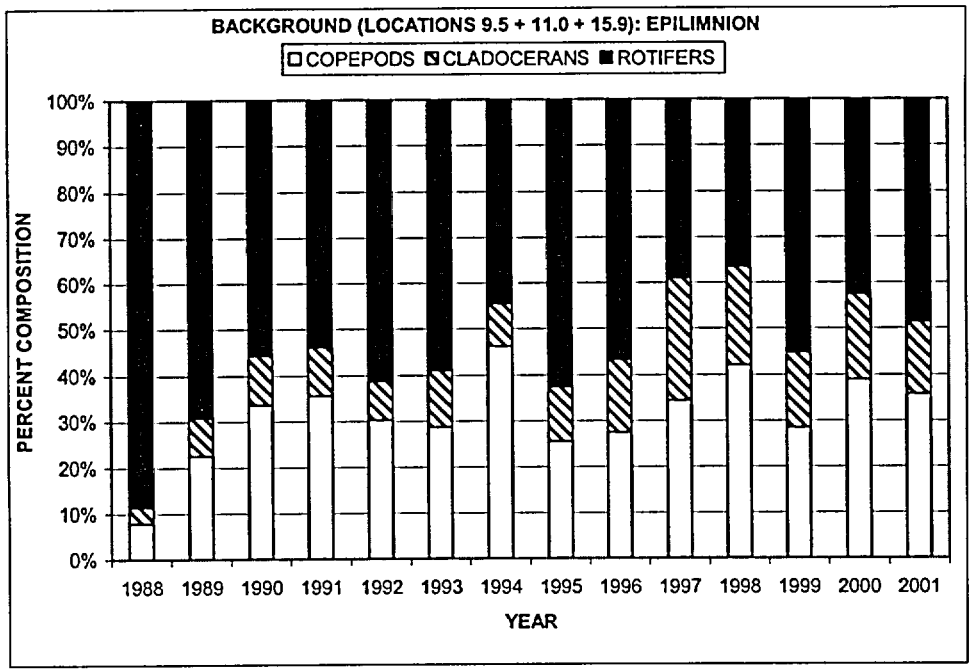


Figure 4-7. Annual percent composition of major zooplankton taxonomic groups from Mixing Zone Locations: 1988 through 2001.



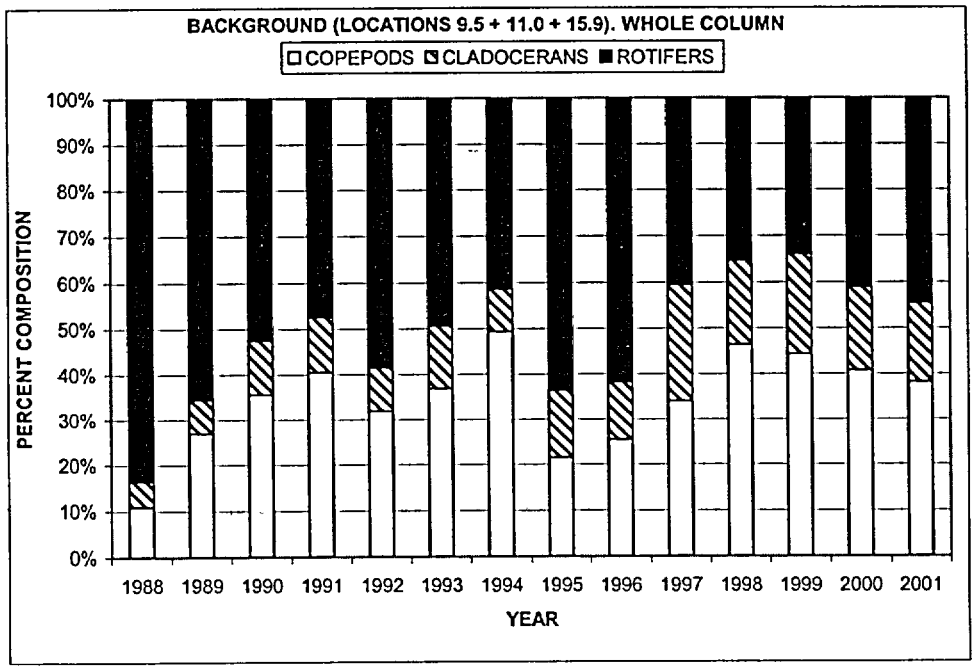


Figure 4-8. Annual percent composition of major zooplankton taxonomic groups from Background Locations: 1988 through 2001.

CHAPTER 5
FISHERIES

INTRODUCTION

In accordance with the NPDES permit for McGuire Nuclear Station (MNS), monitoring of specific fish population parameters was continued during 2001. The components of the 2001 fish monitoring program for Lake Norman were to:

1. Continue striped bass mortality monitoring throughout the summer;
2. Continue a cooperative striped bass study with NCWRC to evaluate striped bass growth and condition as a function of stocking rates, forage availability, and summer striped bass habitat in Lake Norman;
3. Continue annual, fall hydroacoustic/purse seine forage population assessments;
4. Continue to support the bioenergetics study on Lake Norman, to include spring, summer and fall hydroacoustic and purse seine samples and fall gill net samples to enumerate and describe species composition of the lake's shad and herring populations;
5. Revise annual, spring shoreline electrofishing program to be conducted every 2 years, beginning spring 1999, with next sample scheduled for spring 2001;
6. Continue to cooperate with NCWRC on a shoreline plantings demonstration project on Lake Norman;
7. Continue Duke participation on the Lake Norman Advisory Committee and assist the NCWRC in accessing and interpreting relevant Duke data, relative to Committee activities.

METHODS AND MATERIALS

The spring shoreline electrofishing portion of the MNS maintenance monitoring program was conducted on March 4 (MNS mixing zone), April 5 (Marshall Steam Station mixing zone) and April 16 (mid-lake reference area). The locations sampled were the same locations sampled during 1999; Ten 300-m transects were sampled in each of three areas of Lake Norman (MNS mixing zone, mid-lake reference area, and Marshall Steam Station mixing zone), for a total of 30 transects. The MNS mixing zone transects were located within the area between Ramsey Creek and Channel Marker 1 A. The mid-lake reference transects were located in the area between Channel Marker 7 and Channel Marker 9, while the Marshall

Steam Station (MSS) mixing zone transects were located in the area between Channel Marker 14 and the NC Highway 150 Bridge. All transects were subjectively selected to include the various habitat types that exist in Lake Norman and that could be effectively sampled. The only areas excluded were shallow flats where the boat could not access the area within 3-4 m of the shoreline. All sampling was conducted during daylight and when water temperatures generally ranged from 15 to 20 C. Except for largemouth bass, all fish collected were identified to species, and total number and total weight were obtained for each species. Individual total lengths (mm) and weights (g) were obtained for all largemouth bass collected.

The mixing zone was monitored for striped bass mortalities during all summer sampling trips on the lake. Additionally, from July 5 through September 14, weekly surveys were conducted specifically to search for dead or dying striped bass in the main channel areas of the entire lake from Cowan's Ford Dam to uplake of NC Highway 150.

During 2001, gill net sampling for striped bass condition was conducted during the winter (January 30 - February 1) and fall (November 6 - 9). These data were collected as part of the cooperative bioenergetics study being conducted by the NCWRC, North Carolina State University and Duke. Due to the collection of sufficient striped bass data during sampling for the bioenergetics study, no additional data were collected from the December striped bass tournament.

The materials and methods for the purse seine and hydroacoustics sampling on Lake Norman during 2001 are presented in a separate report included as Attachment 1.

During 2001, the gill netting for shad and alewives was conducted by the NCWRC to evaluate the taxa composition and size distribution of Lake Norman forage species. As in previous years, netting was conducted in creel zones 3, 4, and 5 (Figure 5-1). Since the sampling was conducted by the NCWRC, the results of that sampling are not presented in this report.

RESULTS AND DISCUSSION

As in previous years, spring shoreline electrofishing of Lake Norman yielded variable catches among the three areas sampled (Tables 5-1 through 5-3). In the MNS mixing zone area, a total of 923 fish were collected, weighing a total of 62.60 kg and representing 19 taxa (Table

5-1). Although the total number of fish collected during 2001 (923 fish) was less than half the number collected during 2000 (2,175 fish), the total biomass during 2001 (62.60 kg) was more than 1.5 times higher than during 2000 (38.13 kg). The total number of taxa collected during 2001 (19 taxa) was slightly higher than during 2000 (17 taxa). In addition to the typical historical species collected from the MNS mixing zone area, one bowfin, one walleye and six spotted bass were collected during 2001. Spotted bass were introduced into the reservoir by fishermen and were collected for the first time during 2001. The abundance and distribution of spotted bass is apparently increasing, as evidenced by the collection of this species from three of the ten sample transects.

The substantially lower total number of fish collected from the MNS mixing zone area during 2001 is primarily attributable to lower catches of redbreast sunfish and bluegill. These lower catches may be reflective of increased predation on these species due to the increasing abundance of blue and flathead catfish in lower Lake Norman. The higher biomass during 2001 is primarily attributable to higher largemouth bass biomass and to the collection of 14 common carp, a species not collected during 2000. Individual transect catches ranged from a low of 13 fish to a high of 156 fish.

The total catch from the reference area was 1,951 fish, weighing 81.07 kg and representing 17 taxa (Table 5-2). During 2001, the total number of taxa was only slightly higher than during 2000 (16 taxa). The total number of fish collected during 2001 was about 48 % higher than the number collected during 2000 (1,314 fish), however, the biomass of fish collected during 2001 was slightly lower than during 2000 (89.28 kg). Individual transect catches ranged from 84 to 339 fish.

The total catch from the MSS mixing zone area was 1,946 fish, weighing 118.85 kg and representing 19 taxa (Table 5-3). Unlike the previous two years, during 2001, the MSS mixing zone area did not yield the highest number of fish, although the catch was only slightly less than that for the highest area, the reference area (1,951 fish). The total biomass from this area was substantially higher than that for the MNS mixing zone area (62.60 kg) and the reference area (81.07 kg).

Compared to the 2000 sample, the total number of fish collected from the MSS mixing zone area during 2001 was about 28 % lower than during 2000 (2,496 fish), however, the total biomass was about 40 % higher than during 2000 (84.93 kg). The number of taxa collected during 2001 (19 taxa) was slightly higher than during 2000 (17 taxa). Individual transect

catches ranged from 79 fish to 329 fish. Similar to the 2000 sample, the 2001 sample included the collection of a single rainbow trout.

The condition of Lake Norman striped bass, as indicated by relative weight (Wr), varied by season. During the winter, 96 % of the 107 striped bass collected had Wr values of ≥.80, and 42 % had Wr values ≥.90 (Figure 5-2). The lowest Wr recorded during the winter was .76. Three fish had Wr values > 1.00, with the highest Wr value being 1.03.

The Wr values for striped bass collected during the fall indicated substantially poorer body condition than was present during the winter (Figure 5-3). During the fall, only 38 % of the 82 striped bass collected had Wr values ≥.80, and only 6 % had Wr values ≥.90. The lowest Wr value during the fall was .63, while the highest Wr was .96. The poorer body condition during the fall is consistent with striped bass condition decreases noted during previous years, however, the fall 2001 sample indicates that the degree of body condition decrease during 2001 was more dramatic than in previous years. The poorer condition of Lake Norman striped bass during the fall 2001 is probably related to the additional summer stress resulting from the extended drought. Additionally, forage availability may also be a factor in the poorer condition, as increasing populations of blue and flathead catfish over the past several years may be resulting in increased competition for forage.

General monitoring of Lake Norman and specific monitoring of the MNS mixing zone for striped bass mortalities during the summer of 2001, yielded nine mortalities within the mixing zone and nine mortalities in the main channel outside the mixing zone. The 18 observed mortalities ranged in size from 455 mm to 670 mm. Specific observations by date were:

DATE	LOCATION	LENGTH (mm)	NUMBER
July 5	Vicinity of MNS Intake	491	1
	Vicinity of Channel Marker 21	522	1
August 3	Vicinity of MNS Intake	653	1
August 8	Vicinity of Channel Marker 6	510	1
	Vicinity of Channel Marker D 5	535	1
	Vicinity of Channel Marker D 8	534	1
August 17	Vicinity of MNS Intake	534	1
	Vicinity of Cowans Ford Dam	485	2
		521	
	Vicinity of Channel Marker 1	489	3
		491	
		526	
August 22	Vicinity of Channel Marker D 1	553	2
		554	
August 27	Vicinity of Cowans Ford Dam	670	1
	Vicinity of Channel Marker D 2	476	1
	Vicinity of Channel Marker D 7	455	1
	Vicinity of Channel Marker 14	530	1

Results of the purse seine and hydroacoustics sampling on Lake Norman during 2001 are presented in a separate report included as Attachment 1.

FUTURE FISH STUDIES

- Continue striped bass mortality monitoring throughout the summer.
- Continue a cooperative striped bass study with NCWRC to evaluate striped bass growth and condition as a function of stocking rates, forage availability, and summer striped bass habitat in Lake Norman.
- Continue the annual, fall hydroacoustic/purse seine forage population assessment.
- Continue spring electrofishing program on a two-year frequency, with the next sample scheduled for the spring 2003.

- Continue the late summer purse seine sample and fall small mesh gill net sample to monitor changes in Lake Norman forage population.
- Cover December Striper Swipers tournament to obtain striped bass body condition data.
- Support cooperative NCSU bioenergetics study on Lakes Badin and Norman by assisting in the collection of striped bass, forage, and summer habitat data for Lake Norman, as requested by the NCWRC.
- Assist and support the NCWRC in the evaluation of a shoreline plantings demonstration project begun by the NCWRC and a local fishing club during 2000 in the vicinity of Duke Power State Park.

The future studies/activities outlined above are subject to revision, based on an annual review of the data submitted to date and a re-evaluation of the McGuire Maintenance Monitoring program by the NCWRC.

SUMMARY

In accordance with the Lake Norman Maintenance Monitoring Program for the NPDES permit for MNS, specific fish monitoring programs were coordinated with the NCWRC and continued during 2001. General monitoring of Lake Norman and specific monitoring of the MNS mixing zone for striped bass mortalities during the summer of 2001, yielded nine mortalities within the mixing zone and nine mortalities in the main channel outside the mixing zone.

Spring shoreline electrofishing of Lake Norman yielded variable catches for the three areas sampled; the MNS mixing zone area, a mid-lake reference area, and the MSS mixing zone area. The highest total catch numerically was from the mid-lake reference area, followed by the MSS mixing zone, and MNS mixing zone areas, respectively. The highest total catch gravimetrically was from the MSS mixing zone area, followed by the mid-lake reference and MNS mixing zone areas, respectively. The total number of taxa collected was the same for the MSS and MNS mixing zone areas and slightly lower for the mid-lake reference area.

The condition of Lake Norman striped bass, as indicated by relative weight (Wr), varied by season. Striped bass condition was substantially better during the winter than during the fall. During the winter, 96 % of the striped bass collected had Wr values $\geq$.80, while only 38 % of the fall striped bass had Wr values $\geq$.80. The poorer body condition during the fall is consistent with striped bass condition decreases noted during previous years, however, the

degree of body condition decrease during 2001 was more dramatic than in previous years and is probably related to the extended drought.

During June 2001, forage fish densities in the six zones of Lake Norman ranged from 2,401 to 9,841 fish/ha. No trend in forage fish abundance was evident. The estimated population was approximately 74 million fish. Purse seine sampling indicated that these fish were 17.97% threadfin shad, 81.92% alewives, and 0.11% gizzard shad.

September 2001 forage fish densities ranged from a low of 3,173 fish/ha (Zone 6) to a high of 11,513 fish/ha (Zone 2). The estimated forage population was approximately 78 million fish. Purse seine sampling indicated that these fish were 76.47% threadfin shad, 23.52% alewives, and 0.01% gizzard shad.

During December 2001, forage fish densities in the six zones of Lake Norman ranged from 1,451 to 8,647 fish/ha. There appeared to be fewer fish in the downlake zones. The estimated forage population was approximately 47 million fish. Purse seine sampling indicated that these fish were 82.66% threadfin shad, 16.46% alewives and 0.88% gizzard shad.

Through consultation with the NCWRC, the Lake Norman fisheries program continues to be reviewed and modified annually to address fishery issues. Fisheries data continue to be collected through cooperative monitoring programs with the NCWRC, to allow the Commission's assessment and management of Lake Norman fish populations. Fisheries data to date indicate that the Lake Norman fishery is consistent with the trophic status and productivity of the reservoir. However, one aspect of the Lake Norman fishery that continues to warrant close monitoring in the future is the composition of forage populations. The introduction of alewives by fishermen over the past several years appears to be resulting in the establishment of a substantial alewife population and could have a dramatic impact on lake-wide forage populations and game species.

Table 5-1. Numbers and biomass of fish collected from electrofishing ten 300-m transects in the MNS mixing zone of Lake Norman during March 2001.

	Transect																					
	1		2		3		4		5		6		7		8		9		10		ALL	
Species	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG
Longnose gar																			1	2.165	1	2.165
Bowfin	1	1.697																			1	1.697
Gizzard shad	2	1.183	9	3 420	2	1 085	3	1 065							1	0 535					17	7.288
Threadfin shad									5	0.011											5	0.011
Greenfin shiner	2	0 003			2	0 005			1	0 001							2	0.004	6	0.009	13	0.022
Whitefin shiner	12	0.035	4	0 005	33	0 082	4	0 010	42	0 042	57	0 048	4	0 011	1	0 004	64	0.118	48	0.123	269	0 478
Common carp	4	4.892	1	1.012			1	2 250					1	2.180	1	2 365	3	4 685	3	3.780	14	21.164
Spottail shiner	1	0.004			2	0.012			1	0.006					1	0 004	1	0 006	21	0.101	27	0.133
Channel catfish							1	0 640			1	0 430							2	0.510	4	1.580
White bass									2	0.614											2	0 614
Redbreast sunfish	25	0.337	23	0 281	4	0 033	6	0.104			2	0 015	3	0 055	8	0.185	1	0 033	2	0 014	74	1 057
Green sunfish											7	0.009									7	0 009
Warmouth					5	0 090									1	0.005	3	0.011			9	0.106
Bluegill	71	0 519	49	0.545	53	0 395	69	0 540	4	0 023	1	0 006	3	0 029	5	0.039	16	0.125	4	0 017	275	2.238
Redear sunfish	18	0.662	18	0.516	33	0.565	21	0.455	6	0.337	1	0 002	1	0 016	10	0.310	2	0.016	7	1.020	117	3.899
Hybrid sunfish	3	0 029	8	0.165	6	0.100	3	0 058			1	0.007			5	0.125			1	0.007	27	0.491
Spotted bass	1	0.171	2	0.135															3	1.345	6	1.651
Largemouth bass	16	3.920	13	5.830	6	1.466	6	1.402					1	1.175	5	1.057	3	0.813	4	1 005	54	16 668
Walleye							1	1.330													1	1.330
All	156	13.452	127	11.909	146	3 833	115	7.854	61	1.034	70	0 517	13	3 466	38	4.629	95	5 811	102	10 096	923	62.601

Table 5-2. Numbers and biomass of fish collected from electrofishing ten 300-m transects in the mid-lake reference area of Lake Norman during April 2001.

	Transect																					
	1		2		3		4		5		6		7		8		9		10		ALL	
Species	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG
Gizzard shad	1	0 541			1	0 381	21	8 279											1	0 474	24	9 675
Greenfin shiner	2	0.008	3	0.006	1	0.003	3	0.008	1	0.002			1	0.001	3	0.005	7	0 011	2	0 003	23	0 047
Whitefin shiner	138	0.341	43	0.134	82	0.249	71	0.160	21	0 052	114	0.322	1	0.004	73	0.200	86	0.145	41	0.129	670	1.736
Common carp	1	1.580	1	1.926	3	4.904	1	1.572	2	5 603			3	5.107					1	1.214	12	21.906
Spottail shiner	22	0 084			7	0 029	27	0.112	1	0 003	115	0 555			1	0.007	39	0.156	4	0 014	216	0.960
Channel catfish			1	0.420	2	0.433	1	0.577	1	0.265	2	0 444	1	0 414	1	0 202	1	0 202			10	2.957
Flathead catfish					2	2.413															2	2.413
White bass																			1	0.310	1	0.310
Redbreast sunfish	12	0 216	9	0.157	29	0 680	14	0.467	29	0 357	7	0 102	5	0 209	16	0 357	13	0 580	9	0 240	143	3 365
Warmouth	6	0.058	3	0.153	2	0.021	1	0.001	7	0.400	1	0 006			5	0 038	1	0 011	3	0 011	29	0 699
Bluegill	114	0 648	57	0.343	50	0.643	14	0.076	80	0 624	17	0.145	43	0.475	122	0.708	59	0.602	15	0.084	571	4.348
Redear sunfish	27	0 761	7	0.100	4	0.212	10	0 638	18	0 298	2	0 513	26	0 661	13	0.447	4	0 094	2	0 028	113	3.752
Hybrid sunfish	2	0 016	1	0.008	2	0 063	2	0.095	9	0 238	1	0 044	2	0 229	6	0 286	8	0 220	2	0 071	35	1.270
Largemouth bass	13	4.239	7	1.472	18	4.946	8	2.852	18	4.392	3	0.120	18	7.020	5	0 590	4	0 338	1	0.541	95	26 510
Black crappie	1	0 311											1	0.259					2	0.540	4	1.110
Tessellated darter											1	0 001			1	0 001					2	0 002
Yellow perch													1	0 009							1	0 009
All	339	8 803	132	4.719	203	14 977	173	14.837	187	12 234	263	2 252	102	14.388	246	2 841	222	2.359	84	3 659	1,951	81.069

Table 5-3. Numbers and biomass of fish collected from electrofishing ten 300-m transects in the Marshall Steam Station mixing zone area of Lake Norman during April 2001.

	Transect																					
	1		2		3		4		5		6		7		8		9		10		ALL	
Species	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG	N	KG
Gizzard shad									1	0.311											1	0.311
Threadfin shad							5	0 015	46	0.226											51	0.241
Greenfin shiner									5	0 014											5	0.014
Whitefin shiner	57	0.168	48	0.167	68	0.235	31	0.159	8	0 033	48	0 183	71	0 252	49	0.177	20	0.055	95	0.245	495	1.674
Common carp	1	1.170	3	4.730	2	3.910					9	15 270	1	1.850			7	13 350	3	5 705	26	45 985
Spottail shiner	21	0 097	43	0 201	12	0 064	1	0 004					23	0.122	7	0 036	22	0.138	57	0 260	186	0 922
Shorthead redhorse			1	0 345																	1	0 345
Channel catfish	3	0.960			2	0.975			1	0.268	2	0 609	1	1.100					2	0 830	11	4.742
Flathead catfish	1	0 675											1	0 860							2	1.535
Rainbow trout																			1	0 028	1	0 028
White perch											1	0.154									1	0.154
Striped bass																			1	0 965	1	0.965
Redbreast sunfish	1	0.036	3	0.144	11	0.258	27	0.377	4	0.010	1	0 002	45	0.740	57	0.770	9	0.183	5	0 265	163	2.785
Warmouth					1	0 015	3	0 019	1	0.001			3	0.025	1	0.014	1	0.007			10	0 081
Bluegill	26	0.260	11	0.208	53	0.570	144	1 007	152	0.800	4	0 081	96	0.730	190	1.346	21	0.160	4	16 000	701	21.162
Redear sunfish	8	0.365	18	0.780	15	0.725	8	0.254	24	0.397	6	0 290	37	1.100	7	0 245	4	0 149	7	0.330	134	4.635
Hybrid sunfish					1	0 012	8	0 087	6	0 068	1	0.085	6	0.175	5	0.147	4	0.171			31	0.745
Largemouth bass	10	2.597	8	2.920	22	7.661	8	1.385	11	4.925	7	2.159	15	1.570	13	2 488	18	3 669	13	3.151	125	32.525
Tessellated darter			1	0.001																	1	0.001
All	128	6.328	136	9.496	187	14.425	235	3 307	259	7.053	79	18 833	299	8 524	329	5 223	106	17.882	188	27.779	1,946	118.850

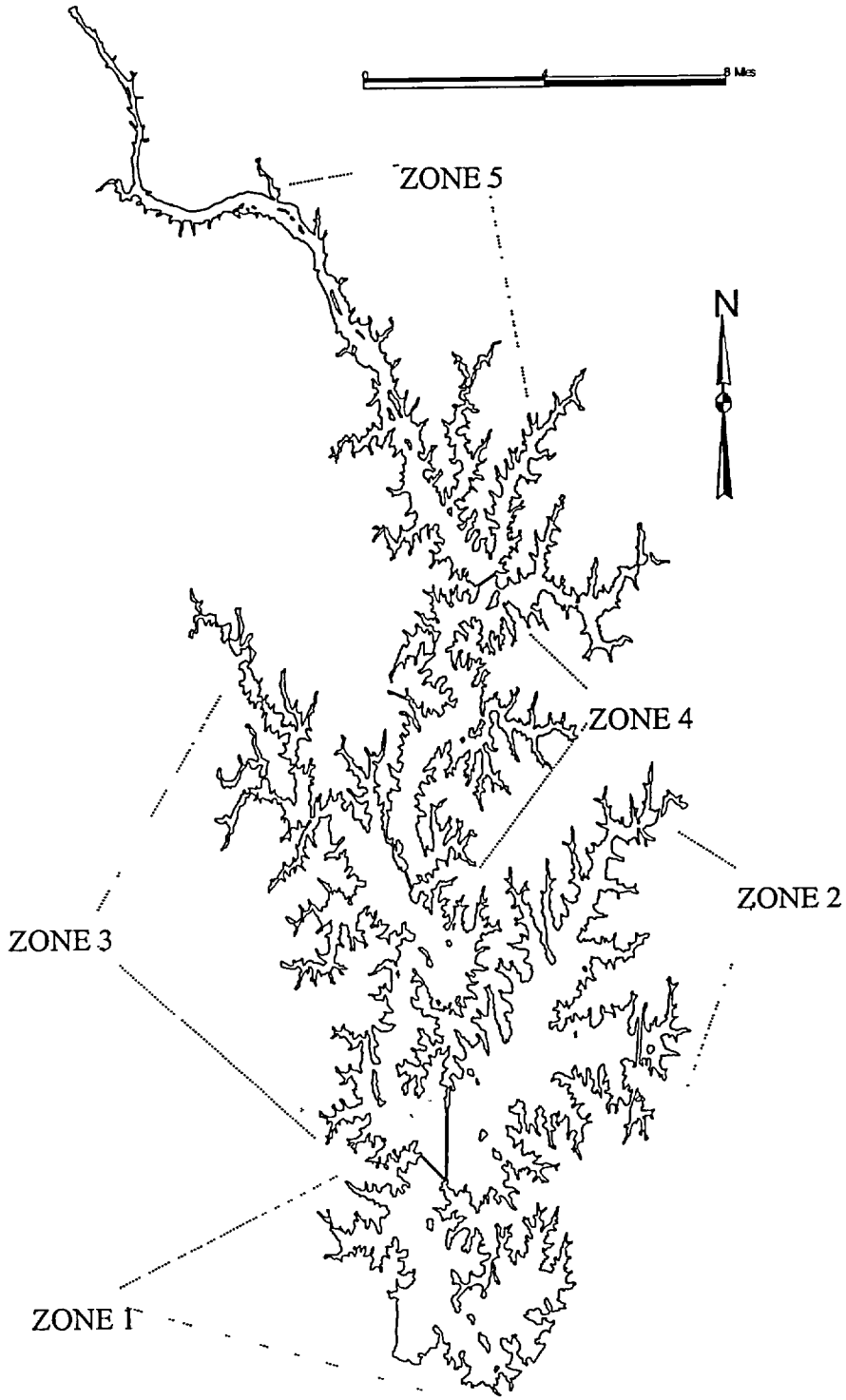


Figure 5-1. Sampling zones on Lake Norman, North Carolina.

Figure 5-2. Lake Norman striped bass relative weight (Wr) at total length (mm) for the Winter 2001 sample.

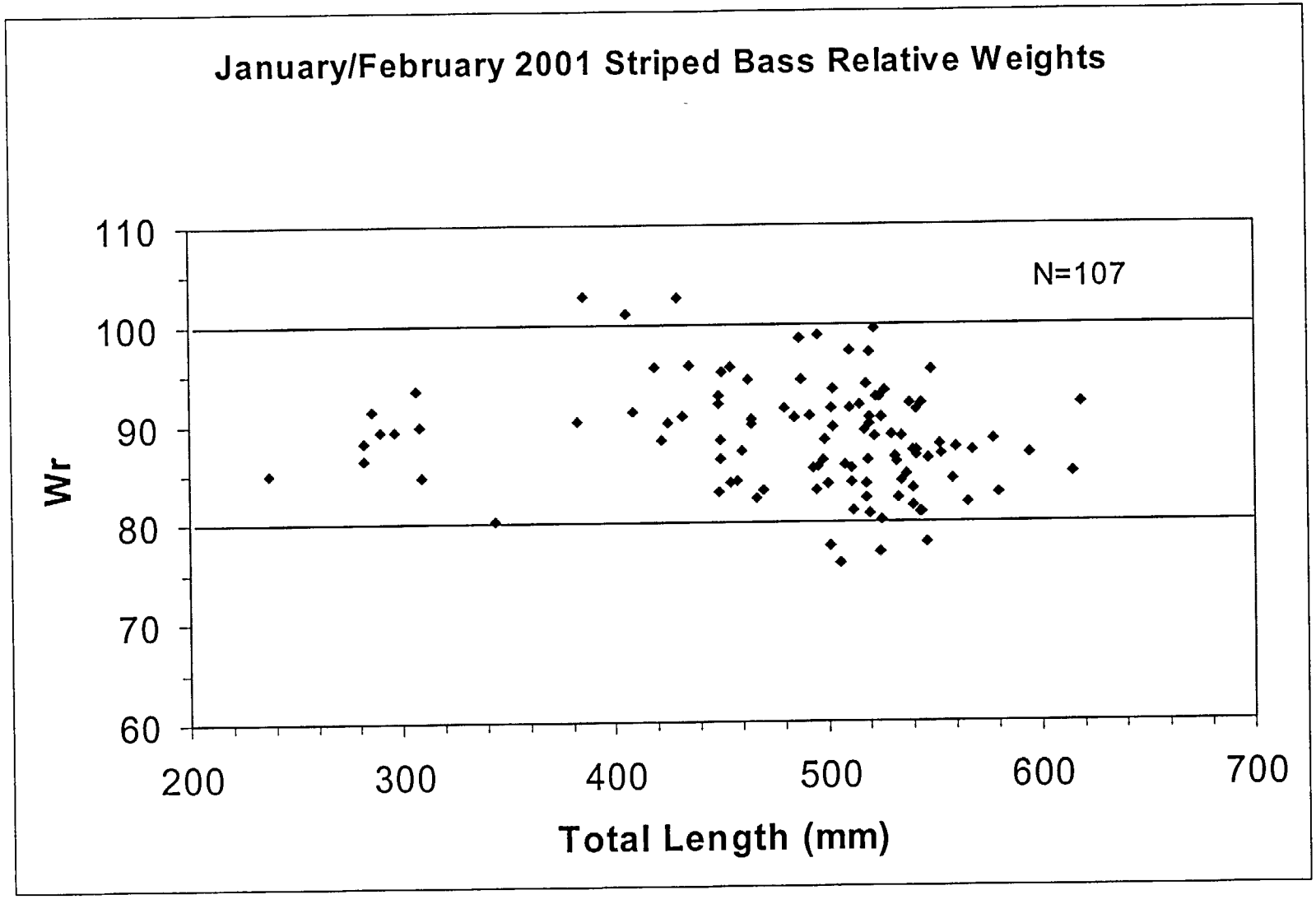
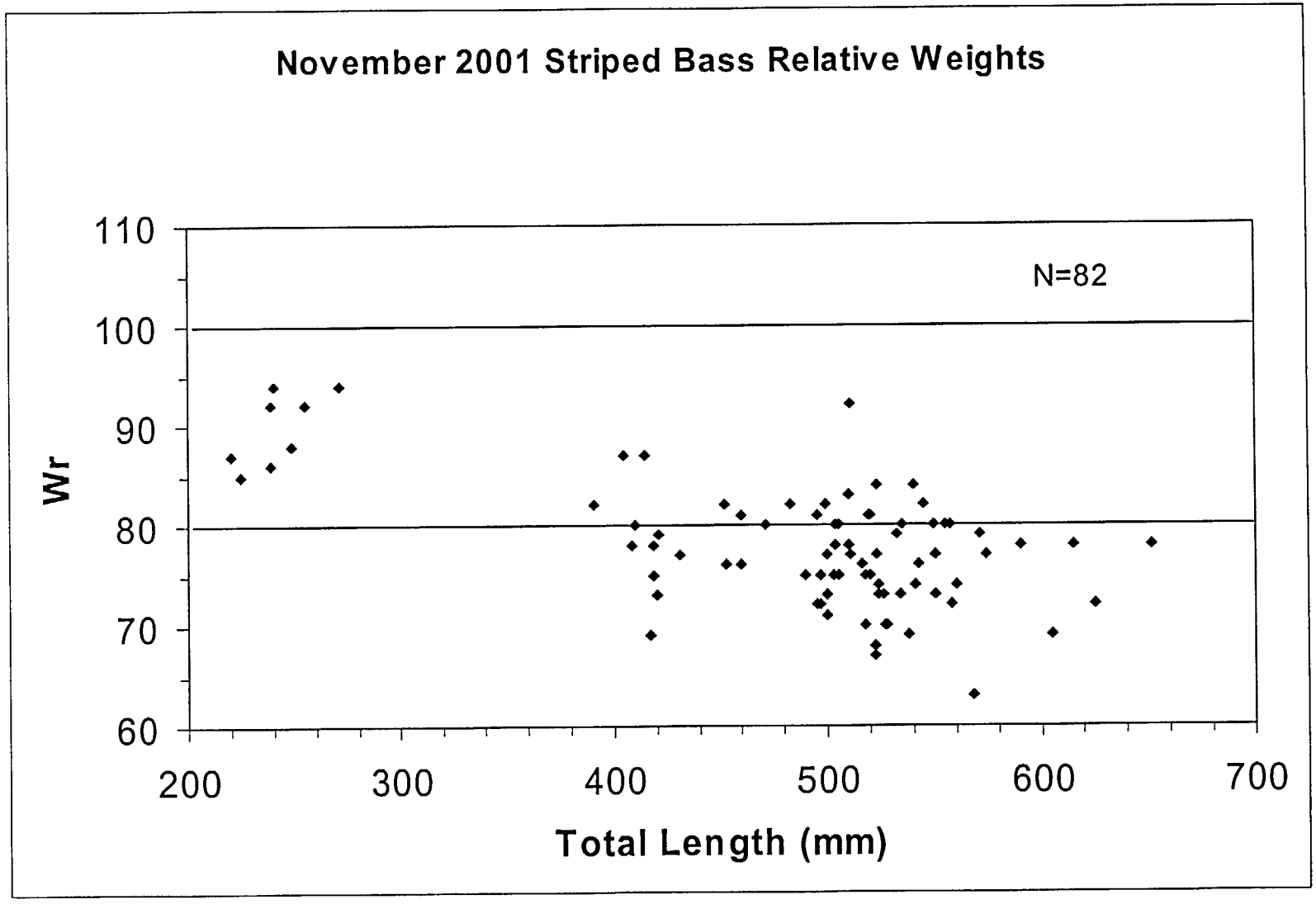


Figure 5-3. Lake Norman striped bass relative weight (Wr) at total length (mm) for the Fall 2001 sample.



Attachment 1:

Lake Norman Hydroacoustic and Purse Seine Data: 2001

INTRODUCTION

In accordance with the NPDES permit for McGuire Nuclear Station (MNS), monitoring of forage fish population parameters was conducted in 2001. This monitoring included a mobile hydroacoustic survey to estimate forage fish density and population size. Purse seine sampling was also employed to determine species composition and size distribution for target strength evaluation. A joint Duke Power / NCWRC / NCSU study to evaluate striped bass bioenergetics in Lakes Norman and Badin necessitated two additional hydroacoustic assessments and purse seine samples in 2001.

METHODS AND MATERIALS

Three mobile hydroacoustic surveys of the entire lake were conducted on June 12 and 13, (Bioenergetics Study), September 10 and 11 (MNS NPDES), and December 5 and 6 (Bioenergetics Study) to estimate forage fish populations. Hydroacoustic surveys employed multiplexing, side-scan and down-looking transducers to detect surface-oriented fish and deeper fish (2.0 m to bottom), respectively. Both transducers were capable of determining target strength directly by measuring fish position relative to the acoustic axis. The lake was divided into six zones due to its large size, spatial heterogeneity, and multiple power generation facilities.

Purse seine samples were collected on June 12, September 10, and December 3, 2001 from the lower (main channel near Marker 1), mid (mouth of Davidson Creek), and uplake (just downlake of Lake Norman (Duke Power) State Park) areas of the reservoir. The purse seine measured 118 x 9 m (400 x 30 ft) with a mesh size of 4.8-mm (3/16 in). A subsample of forage fish collected from each area was used to determine taxa composition and size distribution.

RESULTS AND DISCUSSION

Forage fish densities in the six zones of Lake Norman ranged from 2,401 to 9,841 fish/ha in June 2001 (Table 1). No trend in forage fish abundance (e.g., higher densities uplake as compared to downlake) were evident. The estimated population was approximately 74 million fish. Purse seine sampling indicated that these fish were 17.97% threadfin shad,

81.92% alewives, and 0.11% gizzard shad. The length frequency distribution indicated that alewives dominated a single large size class of forage fish under 80 mm (Figure 1).

September 2001 forage fish densities ranged from a low of 3,173 (Zone 6) to a high of 11,513 (Zone 5). The estimated forage population was approximately 78 million fish. Purse seine sampling indicated that these fish were 76.47% threadfin shad, 23.52% alewives, and 0.01% gizzard shad. The length frequency distribution indicated that threadfin shad dominated a single large size class of forage fish with a modal length of approximately 60 mm with alewives occupying the higher range of this size class (Figure 2).

Forage fish densities in the six zones of Lake Norman ranged from 1,451 to 8,647 fish/ha in December 2001. There appeared to be fewer fish in the downlake zones. The estimated forage population was approximately 47 million fish. Purse seine sampling indicated that these fish were 82.66% threadfin shad, 16.46% alewives, and 0.88% gizzard shad. The length frequency distribution indicated that threadfin shad dominated a single large size class of forage fish with a modal length of approximately 65 mm while alewives occupied a higher size class with a modal length of approximately 90 mm (Figure 3).

The 2001 population estimates demonstrated some interesting results with the highest estimate occurring in September. The 2000 population estimates demonstrated a steady decline from the first sample (July) through the last (December) in contrast to the trend seen in 2001. Our initial fears about conducting a June population estimate, and missing a large portion of the threadfin shad population that may have been spawning in near-shore locations, appears to have been well founded. This supposition is supported by the low percentage and extremely small size of threadfin shad in the June 2001 purse seine hauls as compared to the dominating percentages and much larger sizes on the two subsequent purse dates. Despite the bitterly cold winter of 2000 – 2001, past data has consistently shown that large numbers of threadfin shad survive in the heated waters near the Marshall Steam Station and the McGuire Nuclear Station and would have been available during June 2001. Therefore we can only surmise that a large percentage of the threadfin shad population was inaccessible to the purse seine and hydroacoustic gear by occupying near-shore areas and that the June 2001 population is an underestimate of the true forage fish population size in Lake Norman. If we assume that the June estimate should be higher, it still appears that the numbers of forage fish decline steadily throughout the year. Undoubtedly, natural mortality from disease, starvation, and

predation from Lake Norman's numerous piscivorous species and adult alewives undoubtedly contributed to this decline. Fishing mortality, from bait collectors, probably represented a small proportion of the total mortality for forage fish. Population estimates in 2001 are in line with values measured from 1997 to 2000 but are lower than the estimates from 1993 to 1996.

FUTURE FISH STUDIES

- Continue the annual fall hydroacoustic/purse seine forage population assessment.

Table 1. Lake Norman forage fish densities and population estimates by zone, and lakewide populations estimates and 95% confidence limits from three hydroacoustic samples in 2001.

	Density (no/hectare)			Population Estimate		
Zone	June	September	December	June	September	December
1	6,596	4,752	1,451	15,045,476	10,839,312	3,309,731
2	4,720	4,264	2,695	14,547,512	13,142,074	8,306,260
3	4,636	6,241	1,999	16,019,791	21,565,900	6,907,584
4	5,261	5,236	5,325	6,476,291	6,445,516	6,555,075
5	9,841	11,513	8,647	20,725,146	24,246,378	22,343,848
6*	2,401	3,173		1,147,678	1,516,694	
Total				73,961,894	77,755,875	47,422,498
95% LCL				69,832,155	69,997,022	41,601,019
95% UCL				78,091,633	85,514,728	53,243,977

* Less than one report (denisty estimate) was collected in Zone 6 due to low water levels. Zones 5 and 6 were combined for one density and one population estimate.

Figure 1. Lake Norman (combined) forage fish – June 2001.

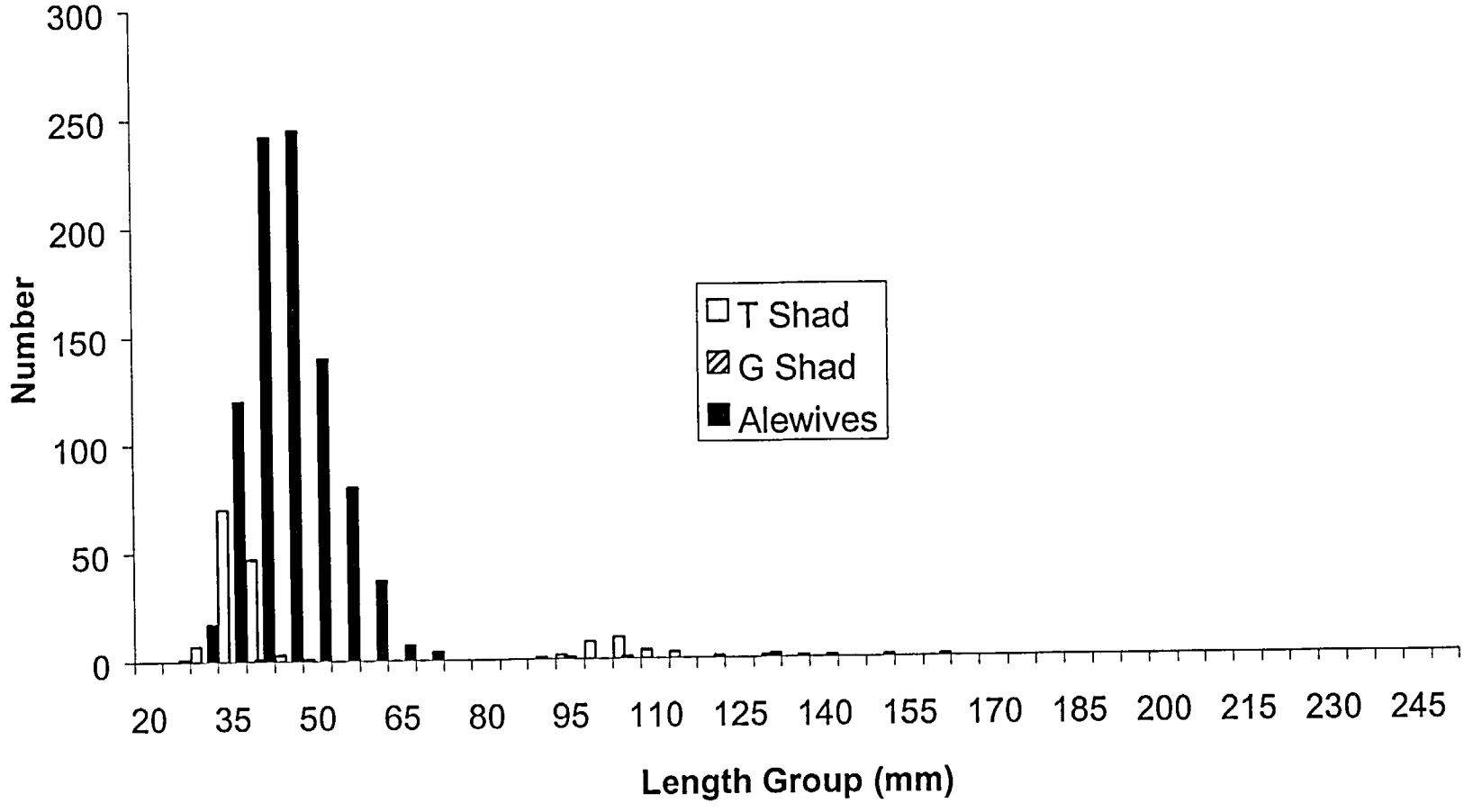


Figure 2. Lake Norman (combined) forage fish – September 2001.

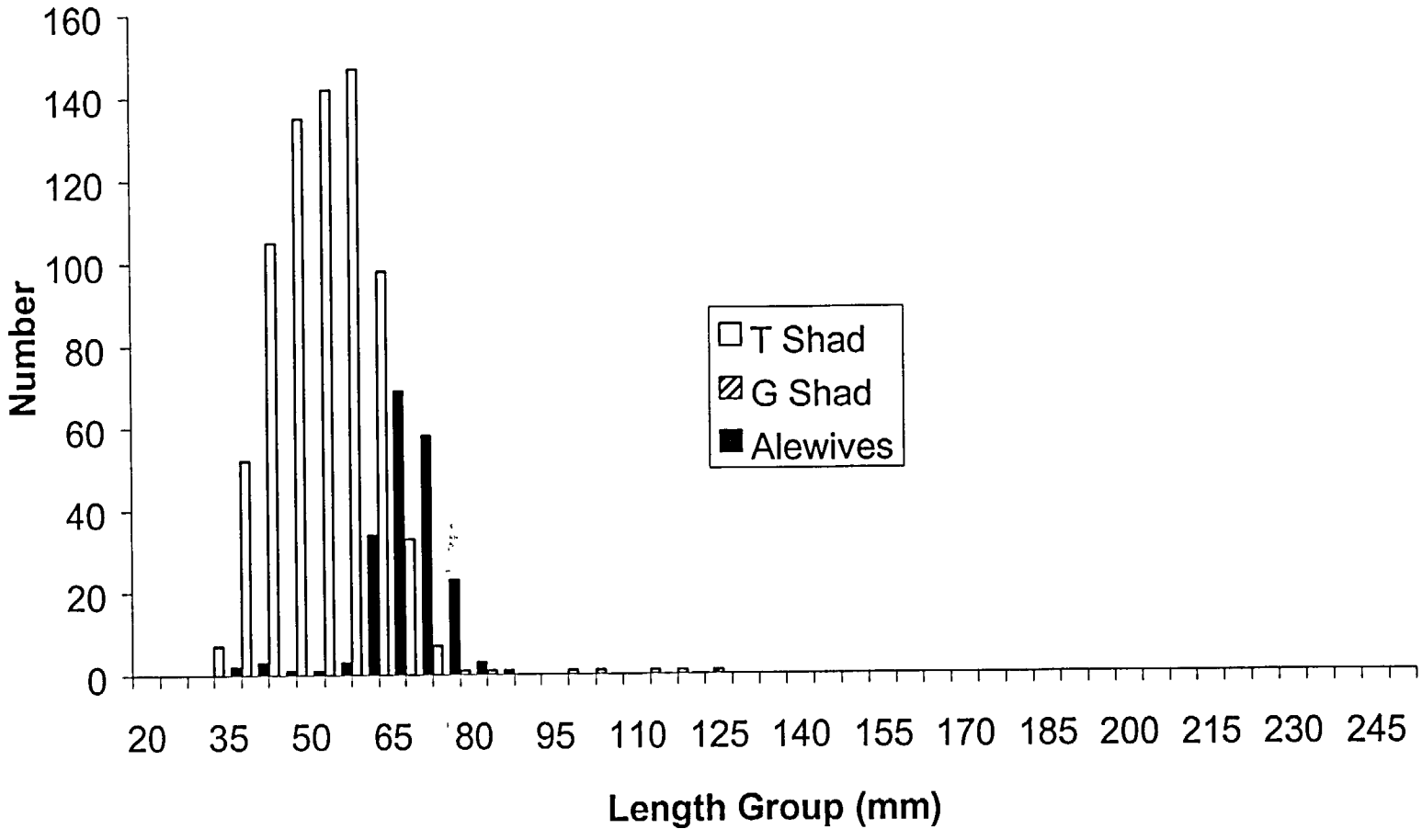


Figure 3. Lake Norman (combined) forage fish – December 2001.