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SHEARON HARRIS NUCLEAR POWER PLANT
1986
ANNUAL ENVIRONMENTAL MONITORING REPORT

Prepared by:

R. J. Blue	-	Terrestrial Vertebrates
R. L. Corpening	-	Benthic Macroinvertebrates
K. A. MacPherson	-	Report Editor
M. A. Mallin	-	Zooplankton
M. A. Pamperl	-	Phytoplankton
J. B. Richardson, Jr.	-	Terrestrial Vertebrates
D. H. Schiller	-	Aquatic Vegetation
M. M. Smart	-	Trace Elements
W. A. Swartley	-	Water Quality and Chemistry
J. M. Swing	-	Fish
W. J. Warren-Hicks	-	Statistical Analyses
R. C. Yates	-	Project Scientist

Biology Unit

Environmental Services Section

CAROLINA POWER & LIGHT COMPANY

NEW HILL, NORTH CAROLINA

June 1987

Reviewed and Approved by:

Bobby J. Ward
Principal Scientist
Biology Unit

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

Manager
Environmental Services Section

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

Manager
Environmental Services Section
Carolina Power & Light Company
Shearon Harris Energy & Environmental Center
Route 1, Box 327
New Hill, North Carolina 27562

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Metric-English Conversion Table

Length

1 micron (μm) = 4.0×10^{-5} inch

1 millimeter (mm) = 100 μm = 0.04 inch

1 centimeter (cm) = 10 mm = 0.4 inch

1 meter (m) = 100 cm = 3.28 feet

1 kilometer (km) = 1000 m = 0.62 mile

Area

1 square meter (m^2) = 10.76 square feet

1 hectare = 10,000 m^2 = 2.47 acres

Weight

1 microgram (μg) = 10^{-3} mg or 10^{-6} g = 3.5×10^{-8} ounce

1 milligram (mg) = 3.5×10^{-5} ounce

1 gram (g) = 1000 mg = 0.035 ounce

1 kilogram (kg) = 1000 g = 2.2 pounds

1 metric ton = 1000 kg = 1.1 tons

1 kg/hectare = 0.89 pound/acre

Volume

1 milliliter (ml) = 0.034 fluid ounce

1 liter = 1000 ml = 0.26 gallon

Temperature

Degrees Celsius (°C) = 5/9 (°F - 32)

EXECUTIVE SUMMARY

Monthly monitoring in 1986 noted few changes in the physical, chemical, and biotic contents of Harris Lake. Trace element concentrations were low, and annual means were below North Carolina state water quality standards and action levels. Elevated mercury levels occurred but were typical of new impoundments and should decline with time. Phytoplankton (algae) numbers were low due to overall low nutrients in the watershed and were comparable to other piedmont reservoirs. Zooplankton community structure changed from that of previous years, with significant declines in density and biomass among several taxa groups, possibly as a result of increased predation from the significantly higher densities of larval fish. Macroinvertebrate density and taxonomic richness were not significantly different from previous years, and the dominant taxa were influenced by the aquatic vegetation in shallow areas of the lake. No Asiatic clams were observed during 1986.

Fish biomass was the lowest recorded to date, although significantly higher densities of larval fish were collected. Largemouth bass continued to exhibit slow growth, possibly as a result of overcrowding or unavailability of prey due to excessive aquatic vegetation. Aquatic vegetation, primarily pondweed, increased in the shallow areas of Harris Lake due to changes in water quality brought on by a severe drought. No potential vegetation problems were observed in the auxiliary reservoir. Emphasis in the terrestrial vertebrate program in 1986 shifted to wildlife management activities.

Harris land management activities continued during 1986. The wood duck nest box programs and other Harris management activities were successful. The bald eagle and red-cockaded woodpecker continued to utilize the Harris lands and adjacent areas. A bird collision survey noted no significant mortality as a result of impact with the SHNPP cooling tower during peak bird migration periods.

1.0 INTRODUCTION

The Shearon Harris Nuclear Power Plant (SHNPP) nonradiological environmental monitoring program, required by the U.S. Nuclear Regulatory Commission, continued during 1986. This program included investigations of the water quality and chemistry of the 1660-hectare Harris Lake as well as studies of the plankton, benthic macroinvertebrates, fish, and vegetation of Harris Lake and the terrestrial vertebrate communities on lands surrounding the lake. Trace element concentrations in the sediments and biota of Harris Lake were determined for the first time. An outline of the 1986 SHNPP study plan is presented in Table 1.1, and sampling locations are shown in Figures 1.1 and 1.2.

Data from the studies described in this report, together with the results of prior studies (see CP&L 1986a), have been collected to provide a preoperational data base for comparative assessments of potential future operational effects of the SHNPP. These environmental assessments were required to support the SHNPP operating license proceedings and future National Pollutant Discharge Elimination System (NPDES) Permit renewals.

Table 1.1 Shearon Harris Nuclear Power Plant nonradiological environmental monitoring program for 1986.

Program	Frequency	Location
Water quality (temperature, DO, pH, specific conductance, Secchi depth)	Once per calendar month	E2, H2, P2 (surface to bottom at 1-m intervals)
Water chemistry	Once per calendar month	E2, (surface and bottom); H2, P2 (surface)
Phytoplankton	Once per calendar month	E2, H2, P2
Chlorophyll and ^{14}C	Once per calendar month	E2, H2, P2
Zooplankton	Once per calendar month	E2, H2, P2
Benthos		
Ponar	Once every other month (Jan, Mar, May, Jul, Sep, Nov)	E1, H1, P1 (3 replicates at 2 m)
Intake canal *Corbicula* survey	Once every other month (Jan, Mar, May, Jul, Sep, Nov)	V3, Z1 (3 samples per station)
Shoreline *Corbicula* survey	Once per year (Oct)	Stations at 1.6-km intervals around shoreline
Corbicula survey of emergency service water, cooling tower makeup, and fire protection systems	Twice per year (Apr, Oct)	Emergency service water and cooling tower makeup system, intake structures, and fire protection sprinkler system
Fish		
Electrofishing	Once every three months (Feb, May, Aug, Nov)	E1, E3, H1, H3, P1, P3, S1, S3, V1, V3
Larval push net	Alternate weeks (two trips per month, Apr-Jun)	E1, H3, P3, S1, V3
Cove rotenone	Once per year (Sep)	E, H, P

Table 1.1 (continued)

Program	Frequency	Location
Trace elements (bluegill, large-mouth bass, catfish, sediments, zoo-plankton, benthos, vegetation)	Once per year	E, H, P
Troublesome aquatic vegetation survey	Spring, summer, fall	I, L, P, Q, S, V, Z
Terrestrial verte-brates		
Misc. terrestrial vertebrate observations	Variable	Throughout site
Roadside bird survey	Once every three months (Jan, Apr, Jul, Oct)	Merry Oaks-Buckhorn Dam route
Waterfowl survey	Once every two weeks (Jan-Mar, Oct-Dec)	WS1, WS2, WS3, WS5, WS6, WS7, WS8, WS9
Spring and Christmas bird counts	Twice per year (May, Dec)	Harris Lake and Harris lands
Wood duck nest box program	Mar-Jun	Harris Lake
Bluebird nest box program	March 15-August 31	Wildlife Management Area 1
Red-cockaded wood-pecker refuge monitoring	Once weekly April 1-July 15; once monthly January 1-March 13, July 16-December 31	Refuge area
Cooling tower bird collision study	Once weekly April-May; September-October	Cooling tower
Waterfowl hunter survey	All legal hunting days	Harris Lake

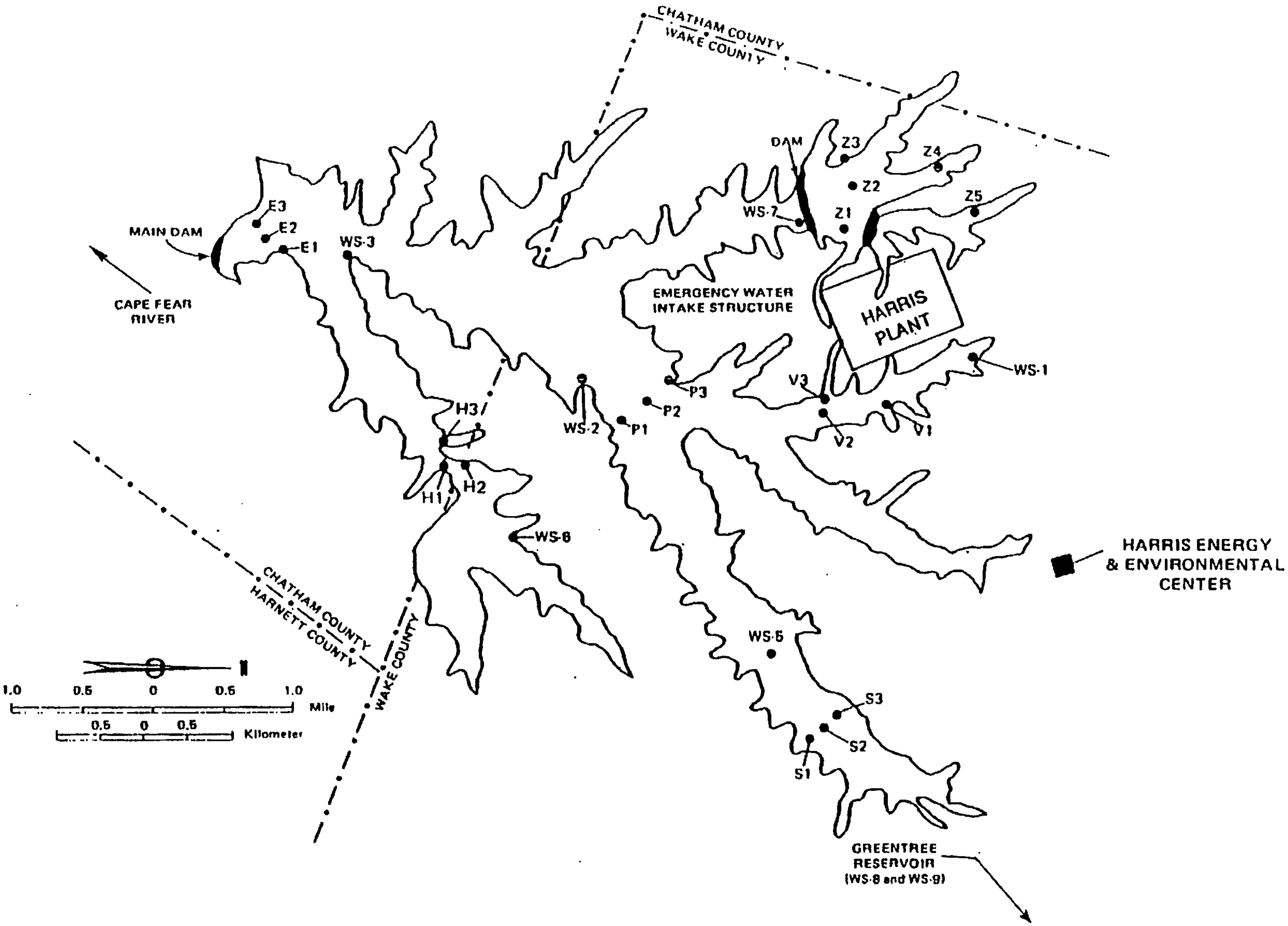

Figure 1.1 Harris Lake sampling stations

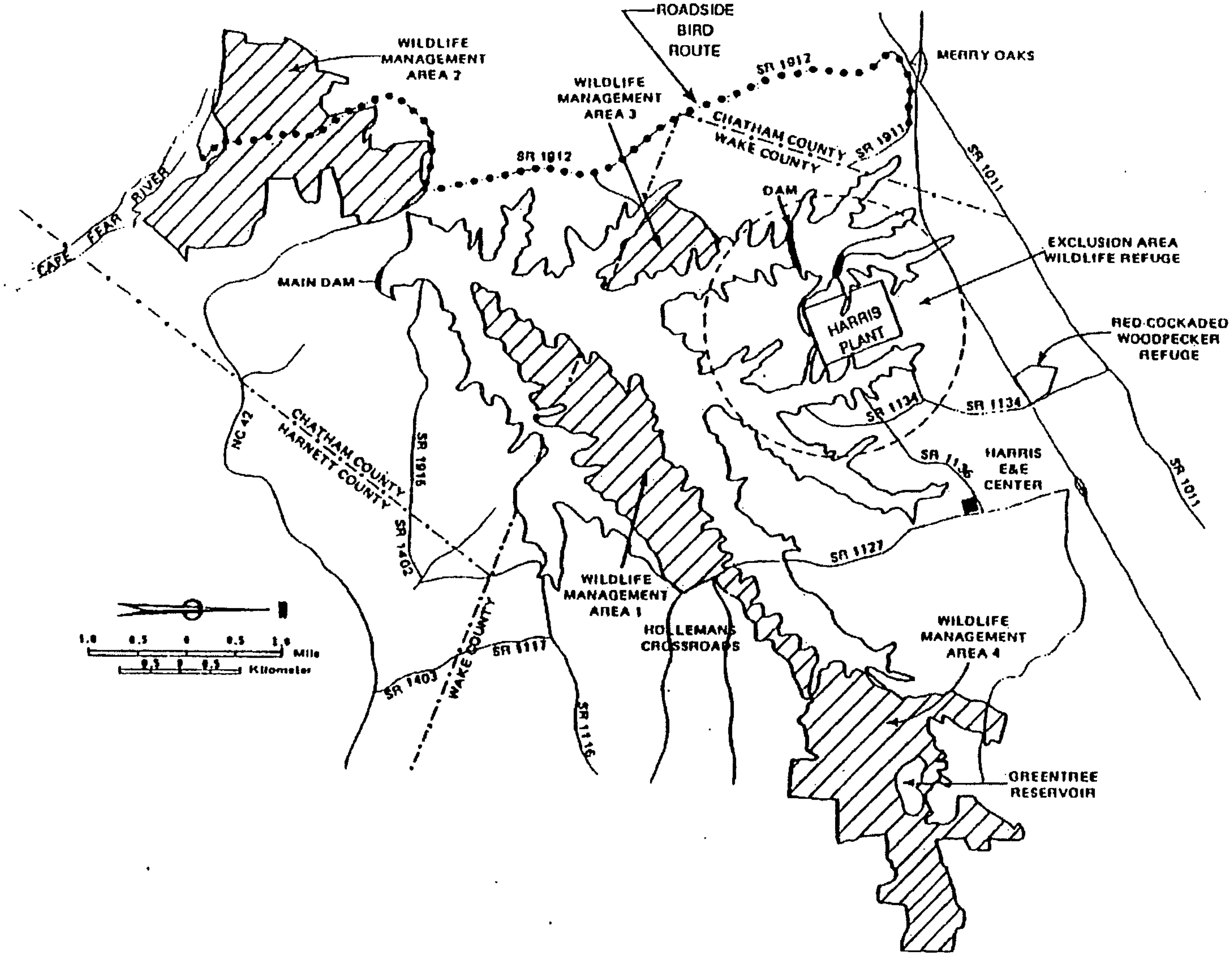

Figure 1.2 Harris lands management areas

2.0 WATER QUALITY AND WATER CHEMISTRY

2.1 Introduction

The Harris Lake 1986 water quality and water chemistry data analyses included spatial and temporal interpretation of the 1986 and 1983-1986 data. A discussion of aqueous trace element concentrations in Harris Lake can be found in Section 3.0.

2.2 Methods

Physical and chemical variables were monitored at the stations, depths, and frequencies listed in Table 1.1; sampling locations are illustrated in Figure 1.1. Water quality was monitored with a Martek® XV water quality microprocessor, which was calibrated monthly and operationally checked prior to field use. Twenty-six chemical variables (Table 2.1) were analytically determined or empirically calculated by the CP&L Analytical Chemistry Laboratory (CP&L 1986a).

The Statistical Analysis System was used for data interpretation. Descriptive statistics (i.e., mean and range) were determined for all data (Appendix A). Analysis of variance (ANOVA) and Duncan's multiple range test were used to detect significant treatment (i.e., station and year) differences and to compare treatment means, respectively. Paired t-tests determined annual (1986) differences between surface and bottom chemistry at Station E2. Unless otherwise noted, all statistical tests used in the interpretive analyses were determined to be significant at the $P \leq 0.05$ level of significance.

2.3 Results and Discussion

2.3.1 Water Quality

The annual surface mean temperature of Harris Lake was 18.6°C during 1986, which represented a 0.2°C decline from 1985 (18.8°C). The reservoir was thermally stratified from March through October with the thermocline well established between 4 and 8 m by mid-June. By mid-October, the thermocline was positioned between 9 and 13 m and had a temperature gradient of 7.7°C. Fall turnover occurred in November as in the previous year (CP&L 1986a).

Dissolved oxygen (DO) and percent saturation of annual means for lake surface waters were 7.9 mg/liter and 82%, respectively. Near anoxic conditions (< 1.0 mg/liter) generally occurred below 5 m from June through September. During 1986, as well as previous years, Harris Lake exhibited a sharply defined depth interval (5-7 m) where DO concentrations rapidly declined from > 6.0 to 0.0 mg/liter (CP&L 1984, 1985, 1986a). This narrow depth band possibly represents a preferred zone for microbial respiration. Dissolved oxygen supersaturation (> 100%) did not occur during 1986 as it did in 1985. Also, no significant areal differences were noted for temperature, DO, or DO saturation during 1986 (Table 2.1). Monthly changes were similar to 1985 results, while no temporal differences were evident among years 1983-1986 (Table 2.2).

2.3.2 Water Chemistry

Harris Lake surface waters continued to exhibit slightly acidic conditions, weak buffering capacities, and a low degree of mineralization. Respective annual means of pH, total alkalinity, and specific conductance were 6.7, 16.3 mg/liter, and 62 µmhos/cm. Total alkalinity concentrations at Station E2 were significantly greater than those found at Stations H2 and P2 (Table 2.1). There was also a significant twofold difference in total alkalinity concentrations between surface and bottom waters of E2 (Table 2.3). No significant between-year differences (1985-1986) were noted for any of the above variables (Table 2.2).

Few changes were observed in the ionic composition of surface waters during 1986 (Table 2.2). Annual mean concentrations of calcium, magnesium, iron, aluminum, and manganese were 3.8, 1.6, 0.17, 0.03, and 0.18 mg/liter, respectively (Table 2.1). The conservative ions, sodium ($\bar{x}$ = 5.0 mg/liter) and chloride ($\bar{x}$ = 4.6 mg/liter) significantly increased 0.7 and 0.4 mg/liter over 1985, probably as a result of concentration due to 1986 drought conditions. Calculated hardness concentrations were in the soft-water range (Table 2.1) common to most piedmont reservoirs. Although several spatial and temporal differences were noted in the ionic composition of the lake (Tables 2.1-2.3), none appeared to be ecologically significant.

Total nitrogen (N), nitrate-nitrite, and ammonia (NH_3-N) had respective annual ranges of 0.18-0.57 mg/liter, < 0.01-0.22 mg/liter, and < 0.02-0.22 mg/liter during 1986. Both total N and NH_3-N had significantly higher bottom concentrations at E2 when compared to surface values (Table 2.3); however, significant areal and yearly differences were not observed.

Total phosphate concentrations were low, typical of a southeastern reservoir. Respective annual means of total phosphate, total dissolved phosphate (TDP), and dissolved inorganic phosphate (measured as DMRP) in Harris Lake surface waters were 0.013, 0.007, and < 0.001 mg/liter. The empirically calculated total particulate phosphate (TPP) and dissolved organic phosphate (DOP) fractions had respective annual means (ranges) of 0.006 mg/liter (0.001-0.018) and 0.007 mg/liter (< 0.001-0.011). The TPP and TDP concentrations were equally balanced with respect to the total phosphate pool, whereas DOP comprised 86% of the TDP pool. Spatial differences were limited to DOP which had a significantly greater concentration at E2 than at H2 or P2. No significant between-year differences were noted for any phosphate fraction.

2.4 Summary

The 1986 Harris Lake water quality and water chemistry monitoring programs revealed few changes from previous years in physical and chemical content of the reservoir. Seasonal stratification, ionic composition, and nutrient concentrations were similar to most other piedmont reservoirs. Surface waters were slightly acidic, poorly buffered, and low in mineralization. The primary nutrients phosphorus and nitrogen were low and exhibited little spatial or temporal variability.

Table 2.1 Statistical analyses of physical and chemical constituents in Harris Lake surface waters during 1986.

Variable	Station E2	Station H2	Station P2
Temperature (°C)	18.5 (5.8-30.2)	18.7 (5.2-30.0)	18.5 (5.7-30.3)
Dissolved oxygen	7.9 (6.0-10.0)	7.8 (5.5-9.8)	7.9 (5.6-9.4)
DO saturation (%)	82 (67-98)	81 (61-98)	82 (62-97)
pH (standard units)	6.7 (6.2-7.1)	6.7 (6.2-7.4)	6.8 (6.3-7.6)
Specific conductance (μmhos/cm)	62 (38-75)	62 (39-79)	61 (32-76)
Secchi depth (m)	1.6 (1.2-2.1)	1.5 (1.0-2.3)	1.6 (1.2-2.5)
Total alkalinity (as $CaCO_3$)	17.1 (14.6-20.0)[a]	15.8 (14.0-19.0)[b]	16.0 (12.0-18.7)[b]
Chloride	4.6 (4.2-5.1)	4.5 (4.0-4.9)	4.6 (4.2-5.0)
Sulfate	5.7 (5.0-6.3)	5.6 (5.1-6.1)	5.7 (5.0-6.2)
Total dissolved silica (as SiO_2)	2.1 (0.7-3.0)[a]	2.6 (8.0-4.1)[b]	1.9 (0.6-2.9))[a]
Total nitrogen (as N)	0.37 (0.18-0.57)	0.35 (0.20-0.50)	0.35 (0.20-0.48)
Nitrate-nitrite (as N)	0.07 (< 0.01-0.21)	0.06 (0.01-0.20)	0.07 (< 0.01-0.22)
Ammonia (as N)	0.07 (< 0.02-0.22)	0.06 (< 0.02-0.17)	0.06 (< 0.02-0.16)
Total phosphate (as P)	0.012 (0.008-0.015)	0.014 (0.009-0.027)	0.012 (0.009-0.018)
Total particulate phosphate (as P)‡	0.006 (0.004-0.008)	0.007 (0.001-0.018)	0.006 (0.003-0.011)
Total dissolved phosphate (as P)	0.007 (0.004-0.009)	0.007 (0.005-0.010)	0.007 (0.004-0.008)
Dissolved molybdate reactive phosphate (as P)	0.001 (< 0.001-0.001)	0.001 (< 0.001-0.002)	0.001 (< 0.001-0.001)
Dissolved organic phosphate (as P)‡	0.006 (< 0.001-0.01)[a]	0.007 (< 0.001-0.011)[b]	0.007 (< 0.001-0.009)[b]
Hardness calculated (as $CaCO_3$)‡	16.1 (11.7-18.5)	15.8 (11.0-18.4)	16.2 (12.4-18.6)
Total calcium	3.9 (2.7-4.5)	3.8 (2.6-4.4)	3.9 (3.0-4.5)
Total magnesium	1.6 (1.2-1.8)	1.5 (1.1-1.8)	1.6 (1.2-1.8)
Total sodium	5.0 (4.1-5.5)	5.0 (4.4-5.7)	5.0 (4.4-5.4)
Total aluminum	0.03 (< 0.02-0.06)	0.03 (< 0.02-0.15)	0.03 (< 0.02-0.06)
Total iron	0.17 (< 0.05-0.53)	0.17 (< 0.05-0.38)	0.18 (< 0.05-0.35)
Total manganese	0.20 (< 0.02-0.58)	0.14 (< 0.02-0.38)	0.20 (< 0.02-0.80)
Total organic carbon	6.2 (4.5-8.1)	6.3 (4.9-7.7)	6.6 (5.3-7.7)
Total solids (103°C)	59 (38-89)	57 (36-77)	60 (41-82)
Total dissolved solids (180°C)	53 (30-82)	50 (30-77)	45 (23-73)
Turbidity (NTU)	2.9 (1.7-5.1)	3.7 (2.0-10.2)	3.2 (2.2-4.4)
Total potassium	1.6 (1.3-1.9)	1.6 (1.4-1.8)	1.6 (1.3-2.0)

Annual station means (ranges) are reported in mg/liter unless otherwise noted. Station means with different alphabetized superscripts are significantly different; means without superscripts are not significantly different ($P > 0.05$).

‡Calculated empirically.

Table 2.2 Statistical analyses of selected physical and chemical constituents in Harris Lake surface waters, 1983-1986.

Variable	1983	1984	1985	1986
Temperature (°C)	18.4	17.7	18.8	18.6
pH (standard units)	6.6	6.5	6.6	6.7
Specific conductance (μmhos/cm)	82[a]	42[c]	55[b]	62[b]
Total alkalinity (as $CaCO_3$)	16.6[a]	12.8[b]	15.8[a]	16.3[a]
Chloride	5.1[a]	3.8[b]	4.2[c]	4.6[d]
Sulfate	5.5[a]	5.0[b]	5.1[b]	5.7[a]
Dissolved organic phosphate (as P)‡	0.005[a]	0.003[b]	0.005[a]	0.008[c]
Total calcium	4.7[a]	3.5[b]	4.0[c]	3.8[c]
Total sodium	4.6[a]	3.8[b]	4.3[c]	5.0[d]

Annual reservoir (E2, H2, P2) means are reported in mg/liter unless otherwise noted. Reservoir means with different alphabetized superscripts are significantly different; means without superscripts are not significantly different ($P > 0.05$).

‡Calculated empirically.

Table 2.3 Paired t-test results of selected surface and bottom chemical analytes at Station E2 in Harris Lake during 1986.

Variable	Surface mean	Bottom mean
Temperature (°C)	18.5	10.0‡
Dissolved oxygen	7.9	2.8‡
DO saturation (%)	82	29‡
Specific conductance (μmhos/cm)	62	119‡
Total alkalinity (as $CaCO_3$)	17.1	30.1‡
Sulfate	5.7	4.6‡
Chloride	4.6	4.6
Reactive silica (as SiO_2)	2.1	3.7‡
Total nitrogen (as N)	0.36	0.86‡
Nitrate-nitrite (as N)	0.07	0.08
Ammonia (as N)	0.07	0.68‡
Total sodium	5.0	5.4
Total calcium	3.9	4.5‡
Total magnesium	1.6	1.7
Total iron	0.17	3.68‡
Total aluminum	0.03	0.04
Total manganese	0.20	2.43‡
Total potassium	1.6	1.8
Total solids (103°C)	59	79‡
Total dissolved solids (180°C)	53	62
Turbidity (NTU)	2.9	5.7‡
Hardness (calculated as $CaCO_3$)	16.1	18.1‡

‡Bottom concentration significantly different from surface concentration. Annual means are reported in mg/liter unless units otherwise noted.

3.0 TRACE ELEMENTS

3.1 Introduction

During 1986, trace element concentrations in sediments and biota were studied for the first time at Harris Lake, while the trace element water chemistry program continued as in previous years. The samples collected in 1986 provided baseline and preoperational data.

3.2 Methods

Surface water samples were collected monthly at Stations E2, H2, and P2 (Figure 1.1) and a bottom sample was collected at E2. Sediments, zooplankton, benthos, and fish were collected in May and June and macrophytes were collected in September. Benthos and sediments were collected with a petite Ponar grab, zooplankton with surface tows using a 156-μm mesh net, macrophytes with a D-frame net, and fish by electrofishing. The latter consisted of bluegill *Lepomis macrochirus*, largemouth bass *Micropterus salmoides*, and bullheads *Ictalurus* sp. Samples were transported on ice to the laboratory and were immediately processed or frozen. Care was taken to minimize sample contamination.

Water samples were preserved, digested, and analyzed by USEPA (1979) approved methods. Percent recovery of standards ranged from 98% to 107% (Appendix B). Sediments, macrophytes, zooplankton, benthos, and fish were frozen, lyophilized, homogenized, and then digested in a perchloric, nitric, and sulfuric acid solution. Arsenic (As), cadmium (Cd), copper (Cu), mercury (Hg), selenium (Se), and zinc (Zn) were determined in the digestate with atomic absorption spectroscopy techniques (USEPA 1979). Some samples were also analyzed with neutron activation techniques (NCSU 1985). Before processing the fish, lengths and weights were determined and the gastrointestinal tract was removed.

All tissue concentrations are expressed on a dry-weight basis. Means and standard deviations of certified standards analyzed during 1986 are in Appendix B. Lower reporting limits depended on tissue sample size and ranged from 0.05 tc 0.90, 1 to 2, 2 to 20, 0.02 to 0.03, and 50 μg/g for As, Cd, Cu, Hg, and Zn, respectively.

3.3 Results and Discussion

3.3.1 Water and Sediment

Concentrations of trace elements in the water were low, and for most elements, the annual mean was less than laboratory reporting limits (Table 3.1). Only copper and aluminum had concentrations that were consistently above reporting limits. Station averages for copper were from 1 to 2 μg/liter and concentrations ranged from < 1 to 7 μg/liter. Station averages for aluminum were from 25 to 43 μg/liter and concentrations ranged from < 20 to 150 μg/liter. All variables, including copper, were well below the concentrations allowed by North Carolina water quality standards and action levels (NCDEM 1986). Concentrations in the water have not changed significantly from 1984 or 1985 levels.

Sediment concentrations of trace elements were also low and were indicative of unpolluted conditions (Table 3.2; Baker 1980).

3.3.2 Biota

In the biota, concentrations of trace elements were low and indicative of unimpacted, unpolluted conditions (Table 3.2). Concentrations were also similar throughout the reservoir. Mercury in fish was the only element that deviated, and it was elevated (0.18 to 1.76 μg/g dry weight) at specific transects (Table 3.2). The elevated mercury concentrations were natural in occurrence; mercury is often elevated in tissues immediately after reservoir inundation and then decreases over time (Wren et al. 1983; Bodaly et al. 1984). Mercury concentrations in fish tissues from Harris Lake were similar to those in fish tissues from Mayo Reservoir (CP&L 1987); both reservoirs reached full pool in 1983, and at Mayo Reservoir mercury tissue concentrations have consistently decreased through time.

3.4 Summary

Trace element concentrations in the water were low and all values were below North Carolina State Water Quality Standards and Action Levels. Since impoundment most trace element concentrations have remained below laboratory reporting limits. In sediments and biota, trace element concentrations were uniform throughout the reservoir and indicative of unimpacted, unpolluted conditions. Elevated mercury concentrations were not unexpected and should decline over time.

Table 3.1 Mean and range of trace elements (μg/liter), North Carolina water quality standards, laboratory reporting limits, and the number of analyses below reporting limits at Harris Lake during 1986. All samples were below NCDEM water quality standards and action levels.

Variable	Water concentrations (μg/liter) E2 (surface)	E2 (bottom)	H2 (surface)	P2 (surface)	Laboratory reporting limit (percent of samples below limit)‡		Water quality standards (percent of samples below standards)¶	
Al	25 (< 20-60)	43 (< 20-100)	36 (< 20-150)	30 (< 20-60)	20.0	(23)	§	(--)
As	< 1 (<1-1)	1 (< 1-2)	< 1 (< 1-1)	< 1	1.0	(85)	50.0	(100)
Cd	< 0.5	< 0.5	< 0.5	< 0.5	0.5	(94)	2.0	(100)
Cr	< 2	< 2	< 2	< 2	2.0	(96)	50.0	(100)
Cu	2 (< 1-7)	2 (< 1-6)	1 (< 1-4)	1 (< 1-5)	1.0	(15)	15.0	(100)
Pb	< 1 (< 1-2.4)	< 1 (< 1-1.9)	< 1 (< 1-1.8)	< 1 (< 1-2)	1.0	(50)	25.0	(100)
Hg	< 0.10	< 0.10	< 0.10 (< 0.10-0.16)	< 0.10	0.10	(90)	0.20	(100)
Ni	< 5 (< 5-5)	< 5 (< 5-5)	< 5 (< 5-6)	< 5 (< 5-6)	10.0	(85)	50.0	(100)
Se	< 1 (< 1-1)	< 1 (< 1-1)	< 1 (< 1-1)	< 1	1.0	(88)	5.0	(100)
Zn	< 20	< 20	< 20	< 20	20.0	(100)	50.0	(100)

‡Based on the blank plus three standard deviations of the blank.

¶From NCDEM (1986); Cu and Zn are action levels.

§No state water quality standard.

Table 3.2 Mean trace element concentration and standard error (μg/g dry weight, n = 3) in sediments, macrophytes, zooplankton, benthos, and fish from Harris Lake during 1986.

Sample matrix (fish length)	Transect	Concentrations (μg/g dry weight)‡				
		As	Cu	Hg	Se	Zn
Sediment	E	4.3 ± 1.4	13 ± 0.3	0.31 ± 0.24	0.2 ± 0	38 ± 2
	H	6.6 ± 0.9	16 ± 1.5	0.18 ± 0.09	0.3 ± 0	85 ± 9
	P	2.2 ± 0.3	15 ± 0.3	0.04 ± 0.01	0.2 ± 0	77 ± 8
Macrophyte	E	1.1 ± 0.1	8 ± 0.6	< 0.02	0.2 ± 0	33 ± 2
	H	1.3 ± 0.2	6 ± 0.5	< 0.02	0.2 ± 0	34 ± 3
	P	0.9 ± 0.2	6 ± 0.2	< 0.02	0.2 ± 0	34 ± 1
Zooplankton	E	< 0.05	< 20	< 0.03	1.1 ± 0.4	88 ± 0
	H	2.4	< 20	0.85	1.7 ± 0.2	93 ± 4
	P	< 0.05	< 20	< 0.03	1.6 ± 0.2	92 ± 3
Benthos	E	< 0.05	24	< 0.03	1.3 ± 0.1	96 ± 6
	H	< 0.05	< 20	0.23	1.7 ± 0.3	123 ± 1
	P	< 0.05	< 20	0.12	1.8 ± 0.1	122 ± 7
Fish						
Bluegill (155-195 mm)	E	< 0.1	14 ± 6	0.60	0.9 ± 0.5	89 ± 6
	H	1.6	25 ± 12	< 0.03	1.0 ± 0.1	84 ± 29
	P	< 0.1	8	0.18	1.4 ± 0.1	83 ± 3
Bullheads (247-290 mm)	E	< 0.1	< 5	0.32	0.7 ± 0.9	63 ± 9
	H	< 0.1	< 5	< 0.03	0.9 ± 0.2	73 ± 9
	P	< 0.1	7	1.3	1.3 ± 0.1	78 ± 9
Largemouth bass (250-283 mm)	E	< 0.1	6	1.76	1.7 ± 0.2	97 ± 12
	H	< 0.1	5	1.58	1.7 ± 0.6	85 ± 3
	P	< 0.1	< 5	0.42	1.5 ± 0.0	96 ± 12

‡Standard error values are given when all replicate concentrations were greater than analytical reporting limits. Sediment particle sizes analyzed were < 63 μm. The macrophyte sampled was *Najas* sp.; the benthos and zooplankton were mixed samples representative of each community.

¶Cadmium concentrations were less than 1.6 μg/g, the lower analytical reporting level.

4.0 PHYTOPLANKTON

4.1 Introduction

Quarterly monitoring of the phytoplankton of Harris Lake began in 1982 shortly before the lake reached full pool. Monthly monitoring was started in 1983 and continued through 1986 to provide baseline information for comparison with future studies at Harris Lake.

4.2 Methods

At Stations E2, H2, and P2, samples were collected at the surface, Secchi depth, and twice Secchi depth with a Van Dorn® sampler. A subsample from each depth was placed in an opaque bottle, held on ice, and later returned to the laboratory for measurement of phytoplankton biomass as estimated by chlorophyll *a* concentrations (CP&L 1987). The other subsamples from each depth were composited and preserved with M3 (Meyer 1971) for later identification and enumeration of the phytoplankton at each station. Primary productivity, as estimated by carbon fixation rates, was measured at surface, 0.5-, 1.0-, and 2.0-m depths at each station, and the samples were processed in accordance with APHA guidelines (APHA 1985).

Statistical analysis of 1986 data consisted of a two-way analysis of variance testing station effects blocked on months. Duncan's multiple range tests were used to detect differences in yearly station means when the statistical model was significant ($P \leq 0.05$). Statistical analyses of 1983 through 1986 data consisted of two-factor analyses of variance blocked on months testing year and transect main effects and a year-by-transect interaction. When the interaction term was nonsignificant ($P > 0.05$), Duncan's multiple range test was used to further test the results.

4.3 Results and Discussion

Phytoplankton densities in Harris Lake were low in 1986 but within the density ranges reported from other piedmont reservoirs (Weiss and

Kuenzler 1976; CP&L 1986a, 1986b, 1987). Densities ranged from 626 units/ml (P2, January) to 8039 units/ml (P2, September) (Table 4.1). Station H2 had higher densities than the other two stations in 10 months during 1986. Annual mean density differences were statistically but not ecologically significant (4543 units/ml vs. 3209 and 3320 units/ml at H2, E2, and P2, respectively).

Chlorophyceae (green algae) and Chrysophyceae (chrysophytes; primarily *Chrysochromulina* spp.) were usually more abundant than other phytoplankton classes in Harris Lake (Table 4.1). Green algae dominated the phytoplankton at E2 and P2 during six months (June through November) and H2 during four months (June through September). At the former two stations, green algae composed more than 70% of the total assemblage during three of the six months they were most abundant. Chrysophytes were dominant in two months at E2, five months at H2, but only one month at P2. This class was also codominant a number of times. Myxophyceae (cyanobacteria) and Cryptophyceae (cryptophytes) were only occasionally important in the lake's phytoplankton. Bacillariophyceae (diatoms) were not abundant in Harris Lake in 1986, although they have been in the past (CP&L 1986a).

Seasonal variations in phytoplankton were not pronounced in 1986 as fluctuations were relatively small (Figure 4.1). The greater increases in densities generally occurred in summer and autumn when temperatures and day length were most favorable for green algal growth. Predation by zooplankton may have also been a factor in phytoplankton fluctuations in 1986, particularly in late summer and early autumn, as increases in zooplankton coincided with decreases in phytoplankton and vice versa (Figures 4.1 and 5.3).

Phytoplankton assemblages in Harris Lake were strongly influenced by nutrient concentrations in the water, particularly those of dissolved molybdate reactive phosphorus (DMRP), the form of phosphorus most readily utilized by phytoplankton. Surface concentrations of DMRP never exceeded 0.001 mg/liter at any of the sampling stations in 1986, and annual mean concentrations were < 0.001 mg/liter (Section 2.0). These levels were low enough to restrict phytoplankton growth (Wetzel 1983). As for other important nutrients, nitrate/nitrite concentrations were also low, and total dissolved silica concentrations were low enough to restrict the growth of most diatoms (Kilham 1971).

The number of taxa identified from Harris Lake varied from 9 (P2, January) to 39 (E2, August) (Table 4.2). Annual means of taxa per station for E2, H2, and P2 were similar (27, 29, and 27, respectively), although this was not always the case on a month-by-month basis. Shannon-Wiener diversity index values were relatively high (31 of 36 values greater than 3.0) at all stations (Table 4.3) indicating that many taxa had similar abundances rather than one or a few taxa dominating the phytoplankton assemblages.

During 1986 biomass (chlorophyll *a* concentration) was less than 25 μg/liter except in March and April at H2 and April at P2 (Figure 4.2). Fluctuations in biomass were attributable not only to changes in phytoplankton densities but also to assemblage composition. The greatest biomass observed at H2, 49 μg/liter in March, primarily resulted from the presence of *Cryptomonas* and *Peridinium* species which are large taxa and contain greater amounts of chlorophyll than most other phytoplankters observed in Harris Lake. The peak biomass at P2 resulted from larger colonies of *Dinobryon divergens* than are usually observed (each colony equals one reporting unit regardless of colony size; APHA 1985). Sharp increases in biomass were not observed in late summer and early autumn, even though densities increased because the more abundant taxa were small green algae and cyanobacteria that contain only small amounts of chlorophyll (Reynolds 1984).

Primary productivity in Harris Lake generally increased from April through July and then again in September (Figure 4.3). During these periods of increasing productivity, densities and composition of the phytoplankton were fluctuating. Productivity was greater when small green algae and cyanobacteria were more abundant because small taxa often assimilate more carbon than larger forms due to their higher growth rates and larger surface-to-volume ratios (Findenegg 1965; Malone 1971;

Kalff 1972). Life stage of the phytoplankton was also a factor as those entering senescence will assimilate little or no carbon (Round 1981). Productivity rates were low in late autumn, winter, and early spring because these are times of slow growth for phytoplankton due to less favorable temperatures and available light.

Comparison of the years in which samples have been collected monthly indicated some statistically significant differences in 1986 in Harris Lake (Table 4.4). Diatoms (Bacillariophyceae) have been declining gradually since 1983, while green algae (Chlorophyceae) and chrysophytes (Chrysophyceae) have been increasing within the same time period. Total phytoplankton densities and biomass (i.e., chlorophyll *a* concentration) have also been increasing gradually; however, at this time the ecological significance of these trends is inconsequential. For instance, the greatest increase in annual mean density between 1983 and 1986 (total phytoplankton at E2) was less than 2500 units/ml, which is a minor variation for phytoplankton. Consistently low nutrient levels over the years have kept phytoplankton densities low and variations in the assemblages minor. This will continue in the future as long as nutrient inputs to Harris Lake are negligible.

4.4 Summary

Phytoplankton densities in Harris Lake were low in 1986 but comparable to those that have been observed elsewhere in some piedmont reservoirs. Green algae and yellow-green algae were usually the most abundant phytoplankton classes, while cyanobacteria (formerly blue-green algae) and cryptophytes were only occasionally important. Seasonal variations in the phytoplankton were not pronounced. Zooplankton feeding may have had some effect on phytoplankton in late summer and early autumn; however, nutrient limitation was the primary controlling factor for phytoplankton. Biomass and primary productivity fluctuated in relation to both density and composition of the phytoplankton; nothing unusual was noted for these variables.

Table 4.1 Phytoplankton class densities (units/ml) in Harris Lake during 1986.

Station/class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
E2													
Bacillariophyceae	452	477	175	100	326	151	126	100	201	0	25	151	190
Chlorophyceae	728	979	502	952	451	1179	2010	3415	5600	3568	804	601	1731
Chrysophyceae	1609	1156	679	402	879	301	50	151	553	427	377	377	580
Cryptophyceae	603	402	351	126	226	402	0	150	277	276	151	804	314
Myxophyceae	50	25	75	753	0	301	75	578	1282	804	201	100	354
Total phytoplankton	3442	3190	1857	2358	2008	2359	2261	4394	7963	5100	1558	2033	3209
H2													
Bacillariophyceae	301	275	226	126	150	125	125	176	301	151	50	327	195
Chlorophyceae	702	803	728	1105	551	1332	3015	3089	3995	2284	1203	853	1636
Chrysophyceae	4021	1458	1483	754	2337	301	628	779	955	1985	1457	3493	1638
Cryptophyceae	603	503	1282	201	276	402	151	75	176	226	201	1357	454
Myxophyceae	50	75	0	2035	0	578	578	452	1256	1005	553	125	559
Total phytoplankton	5702	3139	4121	4221	3414	2788	4572	4596	6683	5676	3464	6155	4543
P2													
Bacillariophyceae	25	226	251	125	176	100	50	25	25	75	25	25	93
Chlorophyceae	225	526	1258	677	528	1256	2940	2939	6106	2988	1129	1004	1798
Chrysophyceae	276	754	1130	980	1357	151	252	176	376	754	302	1181	641
Cryptophyceae	25	126	251	226	377	352	403	150	151	226	125	1709	344
Myxophyceae	75	0	25	980	25	376	477	426	1356	629	251	276	408
Total phytoplankton	626	1707	2940	3038	2538	2260	4147	3791	8039	4697	1857	4220	3320

Summation of class densities may not equal the total density because minor classes have not been included in the table.

Table 4.2 Number of phytoplankton taxa identified from Harris Lake during 1986.

	Month												
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
E2	25	25	21	28	22	30	25	39	34	34	19	21	26.9
H2	31	26	19	27	19	24	37	33	35	35	35	24	28.8
P2	9	24	25	23	19	30	37	35	31	35	30	26	27.0

Table 4.3 Shannon-Wiener diversity index values for phytoplankton from Harris Lake during 1986.

	Month											
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E2	3.3	3.6	3.7	4.1	3.7	4.2	4.0	3.9	3.4	4.1	3.8	3.3
H2	2.7	3.3	2.9	3.7	2.3	3.8	4.6	4.0	3.8	3.7	3.8	2.7
P2	2.6	3.5	3.7	3.7	3.0	4.4	4.6	3.7	3.2	4.1	4.3	3.1

Table 4.4 Comparisons of phycology data at Harris Lake using Duncan's multiple range test, 1983-1986.

Class or parameter	Comparison among years			
Bacillariophyceae (diatoms)	1984	1983	1985	1986
Chlorophyceae (green algae)	1986	1985	1984	1983
Chrysophyceae (yellow-green algae)	1986	1985	1984	1983
Total phytoplankton	1986	1985	1984	1983
Chlorophyll *a*	1986	1984		

Years are arranged such that the year with the greatest density or biomass is on the left and that with the least on the right; years underscored by the same line were not significantly different ($P > 0.05$).

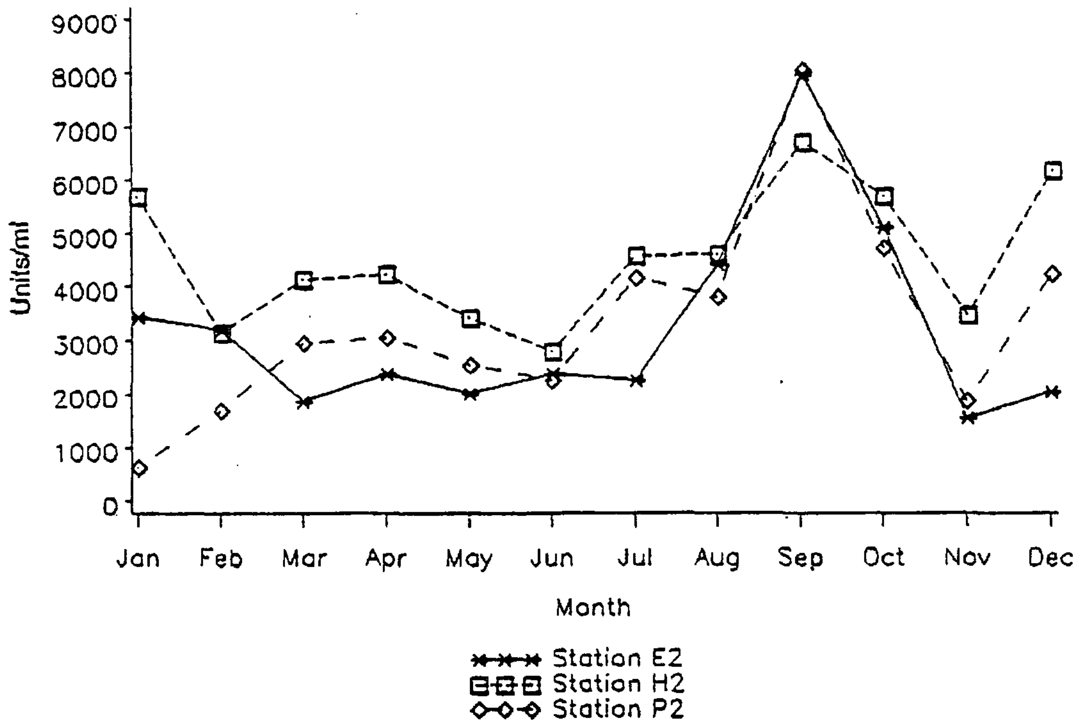

Figure 4.1 Phytoplankton densities in Harris Lake during 1986.

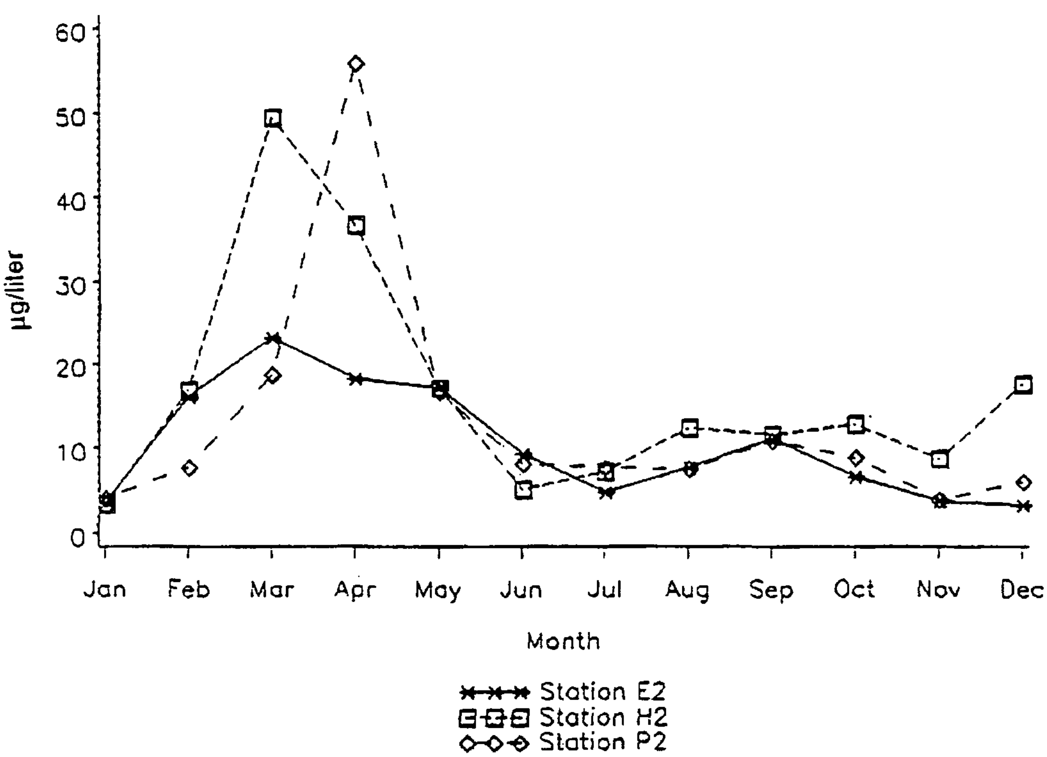

Figure 4.2 Chlorophyll concentrations in Harris Lake during 1986.

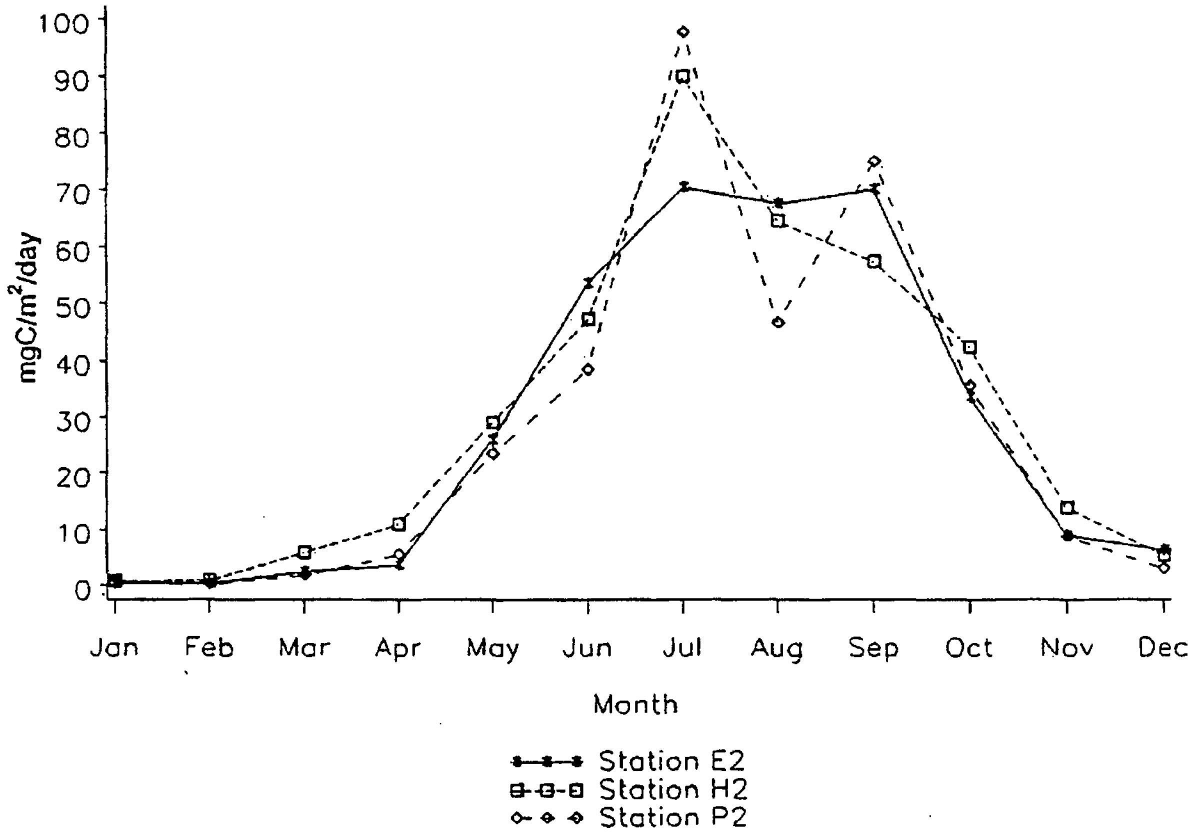

Figure 4.3 Primary productivity in Harris Lake during 1986.

5.0 ZOOPLANKTON

5.1 Introduction

The Harris Lake zooplankton sampling during 1986 represents the fourth year of the postimpoundment and preoperational monitoring program (CP&L 1984, 1985, 1986a). To maintain continuity and yearly compatibility of data, methodologies and sampling locations remained identical to the 1983, 1984, and 1985 study plans. Data analysis for 1984, 1985, and 1986 was expanded relative to 1983 due to the addition of zooplankton biomass comparisons.

5.2 Methods

Bottom-to-surface vertical tows were used to collect zooplankton at Stations E2, H2, and P2 (Figure 1.1). Tows were taken monthly using a #10 mesh-sized net (0.156 mm) to collect adult copepods and cladocerans and a #20 mesh-sized net (0.076 mm) to collect rotifers and copepod nauplii. Samples were preserved and processed as in previous years (CP&L 1984). No zooplankton sampling was conducted on the auxiliary reservoir in 1986.

Station density and biomass comparisons for 1986 were made using a two-way analysis of variance (ANOVA) blocked on months. A two-factor ANOVA tested station, year, and station-year interaction for 1983-1986. A significance level of $P \leq 0.05$ was used in all cases. Duncan's multiple range test was used to rank significantly different station sample means when no significant interactions were present.

5.3 Results and Discussion

5.3.1 Community Composition and Density

The 1986 Harris Lake zooplankton community was diverse with 5 copepod, 11 cladoceran, 24 rotifer, and 3 protozoan taxa found in the samples (Table 5.1). Fewer taxa were collected in 1986 than in 1985; these were mainly littoral cladocerans (e.g., *Simocephalus*, *Camptocercus*, *Sida*, etc.) found only on rare occasions in previous years and never in significant numbers. Reduced numbers of these taxa may have been a result of reservoir aging and fewer available niches for taxa. The community was dominated numerically by rotifers, cladocerans, and copepods, respectively (Figure 5.1). The protozoan community was sparsely represented due to the type of collection gear used.

The composition of the Harris Lake zooplankton biomass contrasted with the density composition (Figure 5.2). Biomass was dominated almost totally by cladocerans and copepods because individual rotifer biomass is so small. Rotifers are an important food item for very small larval fish, but the increased biomass of larger zooplankton becomes more important as fish grow.

Total zooplankton densities for the reservoir during 1986 were moderate (Figure 5.3). Densities peaked in May and July, decreased from August through October, and increased in winter. The winter increase was possibly a response to increased fall phytoplankton densities. Of the copepods, *Diaptomus pallidus* was numerous only in summer and late fall. *D. reighardi* maintained fairly constant densities all year with the exception of winter and early spring. *Mesocyclops edax* was abundant in the warmer months, and *Tropocyclops prasinus* maintained low densities most of the year. *Cyclops bicuspidatus thomasi* had its greatest densities in spring.

The cladoceran community was abundant and diverse in 1986. These taxa are filter-feeders, and because phytoplankton abundance was relatively low in Harris Lake, the filter-feeding zooplankton may be consuming largely bacteria and detritus. *Daphnia ambigua*, *Bosmina longirostris*, and *B. coregoni* dominated the spring cladoceran community. In summer, *Daphnia ambigua*, *D. parvula*, *Ceriodaphnia reticulata*, *B. coregoni*, *Diaphanosoma brachyurum*, and *Holopedium amazonicum* were prevalent with *D. ambigua* and *B. coregoni* dominating in the fall.

Several rotifer taxa were numerically important in 1986 (Table 5.1). Again, this was likely due to the large amount of filterable material. Total densities were variable with numbers ranging from 3,571/m^3 in April to 59,779/m^3 in July. Densities displayed peak numbers in summer and late winter and lowest numbers in spring and fall.

In contrast to previous years, there was little difference in zooplankton densities or biomass among stations during 1986 (Figure 5.3). Only cyclopoid copepods and nauplii showed significantly different biomass between H2 and E2 (Table 5.2). When all sampling years were combined, E2 densities and biomass values were significantly less than at the upstream stations for most taxa groups except cladocerans (Table 5.3). During 1986 there was a significant decrease in densities and biomass for total zooplankton, total copepods, cyclopoid copepods, nauplii, and total rotifers (Table 5.3, Figure 5.4). This may have been a result of increased predation from the greater larval fish densities (Section 7.3.1).

5.3.2 Taxa Richness and Diversity

Taxa richness (number of individual taxa per sample) was moderate to high in Harris Lake and generally similar among stations in 1986 (Table 5.4). Temporally, lowest richness occurred in early spring and highest summer through late fall. Shannon-Wiener diversity index values were also high (Table 5.5). Diversity was high at all three stations and was generally highest late summer through winter.

5.4 Summary

The 1986 Harris Lake zooplankton community structure differed from that of previous years. There were fewer cladoceran taxa found in the samples, possibly indicating fewer niches for different species. This may have been a result of reservoir aging and stabilization. There was very little difference in zooplankton density and biomass among stations in 1986. A significant decrease in density and biomass among several taxa groups was noted from 1985 to 1986. Taxonomic richness was moderate to high and diversity was high all year.

Table 5.1 Zooplankton taxa collected at Harris Lake during 1986.

Copepoda

- *Diaptomus pallidus*[‡]
- *D. reighardi*[¶]
- *C. bicuspidatus thomasi*[‡]
- *Mesocyclops edax*[‡]
- *Tropocyclops prasinus*

Cladocera

- *Daphnia ambigua*[¶]
- *D. parvula*
- *Ceriodaphnia reticulata*[¶]
- *Bosmina longirostris*[¶]
- *B. coregoni*[¶]
- *Alona monocantha*
- *Alona* sp.
- *Leydigia quadrangularis*
- *Chydorus sphaericus*
- *Diaphanosoma brachyurum*[‡]
- *Holopedium amazonicum*[‡]

Protozoa

- *Difflugia* sp.[‡]
- *Codonella* sp.
- *Epistylus* sp.

Rotifera

- *Keratella americana*
- *K. cochlearis*[¶]
- *K. crassa*[¶]
- *Kellicottia bostoniensis*[‡]
- *Monostyla* sp.
- *Trichocerca longiseta*
- *T. similis*
- *T. multicrinis*
- *Asplanchna priodonta*
- *Synchaeta* spp.[¶]
- *Polyarthra* spp.[¶]
- *P. euryptera*
- *Ploesoma truncatum*
- *Filinia longiseta*
- *Pompholyx sulcata*[¶]
- *Hexarthra* sp.[¶]
- *Conochilus unicornis*[‡]
- *Conochiloides coenobasis*
- *Ptygura* sp.
- *Collotheca* sp.[‡]

[‡]Taxa comprised 1% to $<$ 3% of total zooplankton density in lake.

[¶]Taxa comprised $\geq$ 3% of total zooplankton density in lake.

Table 5.2 Significant results of ANOVA and Duncan's multiple range test on various zooplankton density and biomass variables for Harris Lake during 1986.

Taxa group	Density	Biomass		
Cyclopoid copepods		H2	P2	E2
Copepod nauplii		H2	P2	E2

Stations connected by underlying bars are not significantly different (P > 0.05).

Table 5.3 Significant results of ANOVA and Duncan's multiple range test on various zooplankton density variables for Harris Lake, 1983-1986.

	Density						
Taxa group	Station			Year			
Total zooplankton	H2	P2	E2	85	83	84	86
Total copepods	H2	P2	E2	83	85	84	86
Total cyclopoid copepods	H2	P2	E2	83	85	84	86
Total nauplii	H2	P2	E2	83	85	84	86
Total cladocerans				85	83	84	86
Total rotifers	H2	P2	E2	85	84	83	86

Stations and years connected by underlying bars are not significantly different (P > 0.05). Values decrease from left to right.

Table 5.4 Zooplankton taxonomic richness for Harris Lake during 1986.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
E2	19	17	15	17	21	21	22	18	19	20	20	20	19.1
H2	15	17	15	14	19	20	25	22	19	19	19	20	18.7
P2	19	15	11	13	21	18	23	21	21	19	20	20	18.4
All	17.7	16.3	13.7	14.7	20.3	19.7	23.3	20.3	19.7	19.3	19.7	20.0	18.7

Table 5.5 Zooplankton Shannon-Wiener diversity index values for Harris Lake during 1986.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E2	3.1	3.4	2.7	3.2	3.7	3.4	2.1	3.2	3.3	3.4	3.5	3.5
H2	2.9	2.8	2.7	3.1	3.5	3.7	3.1	3.7	3.3	3.1	3.7	3.5
P2	3.3	3.0	2.5	3.0	3.6	3.6	3.5	3.2	3.4	3.3	3.6	3.4
All	3.5	3.2	2.8	3.2	3.7	3.8	2.9	3.6	3.5	3.4	3.7	3.5

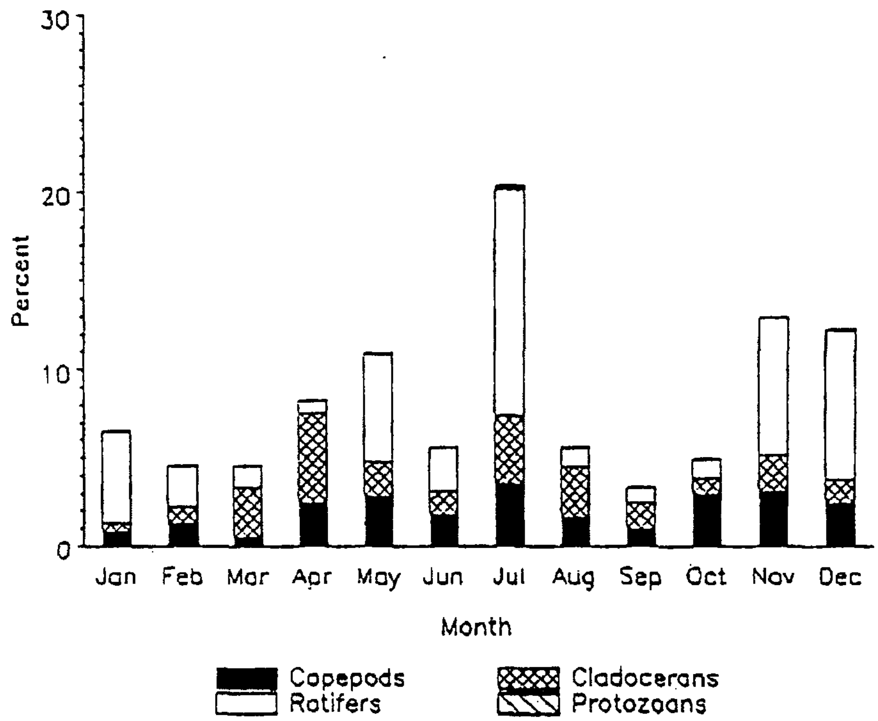

Figure 5.1 Percent composition of total zooplankton density by major taxonomic group for Harris Lake during 1986.

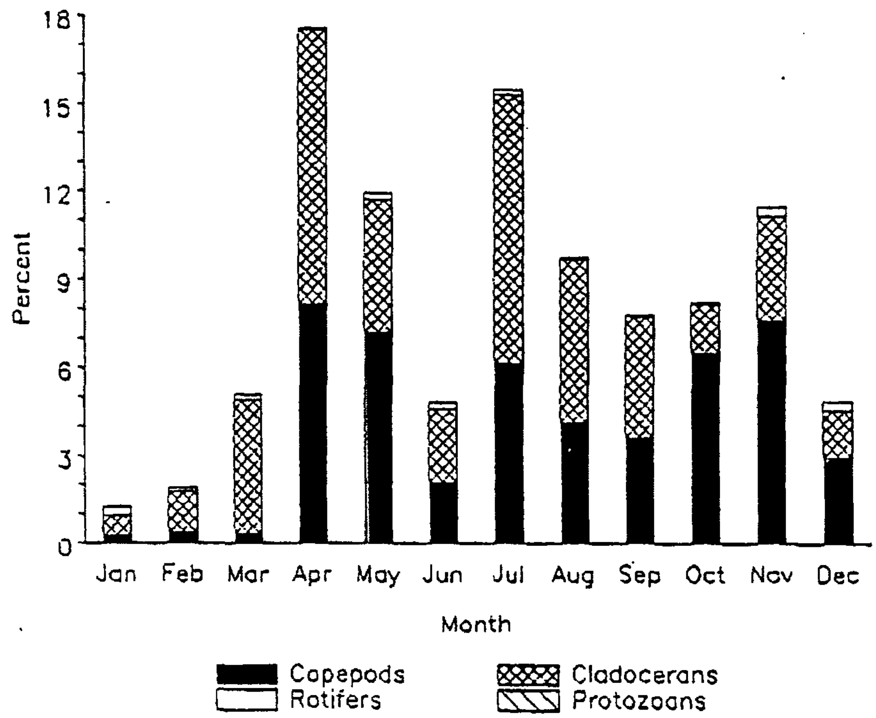

Figure 5.2 Percent composition of total zooplankton biomass by major taxonomic group for Harris Lake during 1986.

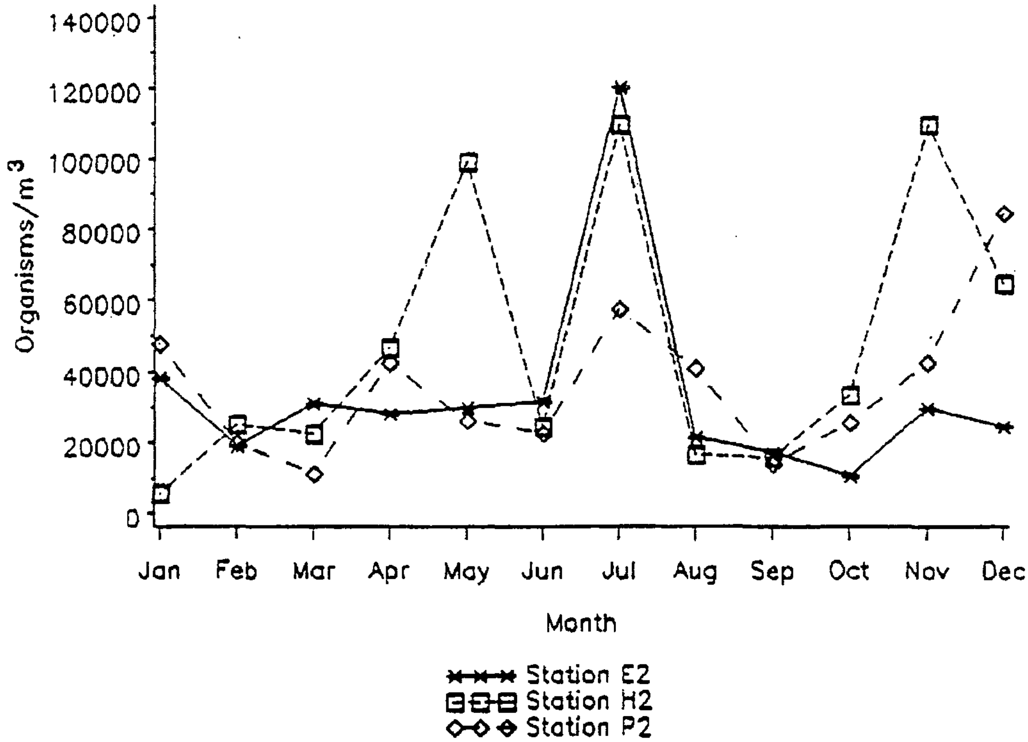

Figure 5.3 Total zooplankton densities by station for Harris Lake during 1986.

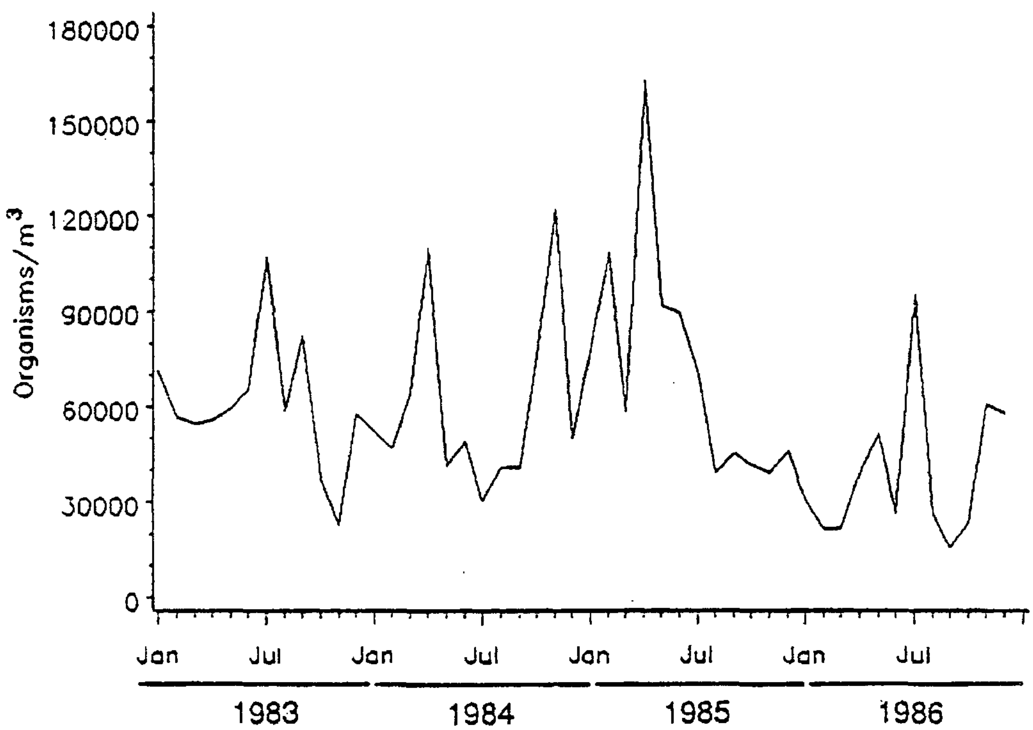

Figure 5.4 Mean total zooplankton densities in Harris Lake, 1983-1986.

6.0 BENTHIC MACROINVERTEBRATES

6.1 Introduction

The purpose of the 1986 sampling program was to monitor the benthic macroinvertebrate assemblages of Harris Lake and to document any successional changes in community structure. Additional surveys were conducted in the main lake as well as in the cooling tower makeup and service water intake systems for the presence of the Asiatic clam, *Corbicula fluminea*.

6.2 Methods

Three replicate petite Ponar grabs (0.023 m^2) were taken at Stations E1, H1, and P1 (Figure 1.11) during 1986 at the 2-m depth. Sampling frequency increased from quarterly during 1985 (February, May, August, and November) to every other month in 1986 (January, March, May, July, September, and November). Methods of sample preservation, laboratory processing, organism enumeration, and data conversions were identical to those used during 1985 (CP&L 1986a).

Asiatic clam sampling frequency for the main lake (V3) and auxiliary reservoir (Z1) intake canals were also increased from quarterly in 1985 to every other month during 1986. Sample processing for 1986 was conducted in the same manner as in 1985 (CP&L 1986a). Methodology for the 1986 whole lake shoreline survey was the same as in 1985.

During 1986 the emergency service water system intake structures at the main lake and auxiliary reservoir were sampled in April and October for the presence of Asiatic clams. Cooling tower makeup and fire protection sprinkler systems were also sampled for Asiatic clams during 1986. All samples were collected essentially in the same manner as in 1985 with the exception of the sprinkler system, which was sampled at an inspection pipe leading from the service water building. Samples were field sieved using a 300-μm mesh wash bucket, and any clam specimens found were to be returned to the laboratory for identification.

A two-way factorial analysis of variance (ANOVA) model was applied to 1986 density and taxonomic data. Main treatments included month and station. Yearly comparisons between data collected from 2 meters during 1984, 1985, and 1986 were made quarterly by considering January and February as winter months and August and July as summer months. For these comparisons, another two-way ANOVA was applied to density and taxonomic data blocking on months. Main treatments were year and station. When significant main treatment effects were detected and there were no significant interactions, Duncan's multiple range test was used to determine significant differences in the means. Means were listed in decreasing order from left to right, and those underscored by the same line were not significantly different ($P \geq 0.05$). Geometric and back-transformed means have been presented to increase readability.

Mean diversity, which is a measurement of taxa richness and distribution of individuals among taxa, was determined for 1986 data by applying the Shannon-Wiener diversity index (Margalef 1957).

6.3 Results and Discussion

6.3.1 Dominant Taxa Composition and Densities

Eighty-eight macroinvertebrate taxa were collected during the 1986 benthic sampling program (Table 6.1). Larval and pupal chironomids, along with aquatic oligochaetes, were the dominant taxa with 37 and 19, respectively. Thirty-two miscellaneous taxa collected included various mayflies and caddisflies. Fifty-seven taxa were common to all stations. There were two fewer taxa collected quarterly in 1986 as compared to 1985 (CP&L 1986a).

Polypedilum sp., *Tanytarsus* sp., and *Zavreliella varipennis* were the dominant chironomids, with their highest annual mean organism densities being observed at Station E1 with 2490 (9.4%), 1753 (6.6%) and 1370 (5.3%) organisms/m^2, respectively (Table 6.2). *Tanytarsus* sp. was dominant at all stations during 1986. Phytophilic genera, such as *Zavreliella varipennis* and *Polypedilum* sp. in particular, are highly mobile and move freely among aquatic macrophytes feeding on various detrital material and associated periphyton. Dominance of these phytophilic genera is common in lakes such as Harris Lake where the substrate is strongly influenced by aquatic vegetation (Sephton et al. 1983).

Dero nivea, *Stylaria lacustris*, *Specaria josinae*, and *Ilyodrilus templetoni* were the dominant oligochaetes during 1986 (Table 6.2). Highest annual mean densities of *Dero nivea* and *Stylaria lacustris* were observed at Station E1 with 5169 (19.6%) and 1863 (7.2%) organisms/m^2, respectively. *Ilyodrilus templetoni* and *Specaria josinae* were most dominant at Station H1 with 2119 (8.2%) and 1889 (7.4%) organisms/m^2. Dominance of these oligochaetes can be attributed to the presence of aquatic macrophytes and the associated periphyton which is utilized as a food source (Learner et al. 1978).

6.3.2 Overall Densities

In 1986 the highest densities occurred in March ranging from 20,408 to 36,610 organisms/m^2 (Figure 6.1). The lowest densities were observed in September ranging from 8,768 to 18,542 organisms/m^2. Highest annual mean organism densities were found at Stations E1 (26,416 organisms/m^2) and H1 (25,699 organisms/m^2), while the lowest density was observed at Station P1 (15,443 organisms/m^2).

Significant differences in organism densities were detected between months and transects for 1986. Geometric means indicated the spring (March and May), winter (January), and fall (November) densities were higher than summer densities (July and September). Also organism densities at Stations E1 and H1 were higher than P1.

	1986					
Month	Mar	Jan	Nov	May	Jul	Sep
Geometric mean density (organisms/m^2)	26,718	25,797	24,464	23,946	14,750	13,120

	1986		
Station	E1	H1	P1
Geometric mean density (organisms/m^2)	24,108	23,558	15,418

Density comparisons for quarterly data between 1984, 1985, and 1986 indicated significant differences in stations with no differences in mean densities over years.

	1984-1986		
Station	E1	H1	P1
Geometric mean density (organisms/m^2)	22,375	19,749	12,247

The temporal density patterns for 1986 were typical with overwintering aquatic insects reaching peak periods of density during the fall (November) and winter (January) and aquatic oligochaetes dominating the spring (March and May). Lower densities during the summer (July and September) can be attributed to seasonal emergence of aquatic insects (CP&L 1985). These seasonal patterns are common in southeastern reservoirs where chironomids and aquatic oligochaetes are dominant (Voshell 1976). There were no differences in overall densities for years, which indicates that the benthic communities at Harris Lake have reached a period of ecological stability in their successional development.

Spatially the densities remained the same for both 1986 and between year comparisons, with H1 and E1 having higher organism densities than P1. This is probably due to a more heterogeneous substrate at Stations E1 and H1 than at P1. Stations E1 and H1 substrates consist of aquatic macrophytes along with submerged wood and detritus. Station P1 substrates are influenced by aquatic macrophytes but consist largely of sand which provided less habitat for benthic macroinvertebrates.

6.3.3 Taxa Richness and Diversity

Taxonomic richness (i.e., numbers of taxa) for 1986 showed a temporal pattern similar to that described for densities since taxa/sample during the summer months was lower than during the other months (Figure 6.2). The number of taxa per sample was highest during May (spring) ranging from 30 to 38 and lowest during September (summer) ranging from 19 to 25. Significant temporal differences were detected between months during 1986.

	1986					
Months	May	Jan	Mar	Nov	July	Sep
Mean richness (taxa/sample)	29.3	28.1	28.0	26.0	23.0	20.1

Spatially, as with the densities, Stations E1 and H1 were significantly higher in mean numbers of taxa/sample than P1, due to substrate differences.

	1986		
Station	E1	H1	P1
Mean (taxa/sample)	28.1	26.8	23.0

As with the densities, taxonomic temporal patterns were the result of oligochaetes dominating in the spring (May and March) and overwintering aquatic insects dominating in the fall (November) and winter (January).

There were no significant differences in taxonomic comparisons between years (1984, 1985, 1986) which is a further indication of ecological stability in the benthic community.

Shannon-Wiener diversity values continued to be high during 1986 (Table 6.3). Values ranged from 4.7 in May to 3.2 in September at Station E1. These values are an indication that overall taxa richness is high and individual organisms are uniformly distributed among the different taxa.

6.3.4 Asiatic Clam

No Asiatic clams were collected during any of the 1986 surveys conducted at Harris Lake, the intake canals, the emergency service water or cooling tower intake structures, or the fire protection sprinkler system.

6.4 Summary

During 1986 the dominant genera were various juvenile midges found around aquatic vegetation and aquatic worms, indicating that aquatic vegetation continued to influence taxonomic composition. Overall density patterns and number of different taxa were typical of southeastern reservoirs in that overwintering aquatic insects dominated the fall and winter months, while aquatic worms were more abundant in the spring. In comparisons between years (1984, 1985, 1986), there were no differences in overall density or number of different taxa, which indicates that Harris Lake had reached ecological stability in the benthic community. Diversities continued to be relatively high at all stations, and no Asiatic clams were collected.

Table 6.1 Benthic invertebrate taxa collected from Harris Lake during 1986.

- Coelenterata
  - Hydrozoa
    - Hydroida
      - Hydridae
        - *Hydra* sp.
- Platyhelminthes
  - Turbellaria
    - Tricladida
      - Planariidae
        - *Dugesia* sp.
- Rhynchocoela
  - Hoplonemertini
    - Prostomidae
      - *Prostoma rubrum*
- Annelida
  - Clitellata
    - Oligochaeta
      - Naididae
        - *Amphichaeta americana*
        - *Chaetogaster diaphanus*
        - *Dero flabelliger*
        - *D. furcata*
        - *D. nivea*
        - *Haemonais waldvogeli*
        - *Nais variabilis*
        - *Pristina aequiseta*
        - *P. leidyi*
        - *Pristinella osborni*
        - *Slavina appendiculata*
        - *Specaria josinae*
        - *Stylaria lacustris*
      - Opistocystidae
        - *Crustipellis tribranchiata*
      - Tubificidae
        - *Aulodrilus pigueti*
        - *Ilyodrilus templetoni*
        - *Limnodrilus hoffmeisteri*
- Arthropoda
  - Crustacea
    - Amphipoda
      - Talitridae
        - *Hyallela azteca*
- Decapoda
      - Palaemonidae
        - *Palaemonetes*
- Insecta
    - Ephemeroptera
      - Ephemeridae
        - *Hexagenia* sp.
      - Caenidae
        - *Caenis* sp.
    - Odonata
      - Anisoptera
        - Corduliidae
          - *Tetragoneuria* sp.
        - Libellulidae
          - *Celithemis* sp.
          - *Pachydiplax longipennis*
          - *Perithemis* sp.
      - Zygoptera
        - Coenagrionidae
          - *Argia* sp.
          - *Enallagma* sp.
    - Megaloptera
      - Sialidae
        - *Sialis* sp.
    - Trichoptera
      - Polycentropodidae
        - *Cernotina* sp.
        - *Phylocentropus* sp.
      - Hydroptilidae
        - *Oxyerthira* sp.
        - *Hydroptila* sp.
        - *Orthotrichia* sp.
      - Leptoceridae
        - *Oecetis* sp.
        - *Triaenodes* sp.

Table 6.1 (continued)

Coleoptera
  Haliplidae
    Peltodytes sp.
Diptera
  Chaoboridae
    Chaoborus punctipennis
  Ceratopogonidae
    Bezzia sp.
  Chironomidae
   Tanypodinae
    Ablabesmyia sp.
    A. annulata
    Clinotanypus sp.
    Coelotanypus sp.
    Djalmabatista pulcher
    Labrundinia sp.
    Procladius sp.
    Tanypus sp.
   Orthocladiinae
    Corynoneura sp.
    Cricotopus sp.
    C. sylvestris
    Hydrobaenus johannseni
    Nanocladius sp.
    N. sp. nr. *balticus*
    Parakiefferiella sp.
    Psectrocladius sp.
    Thienemanniella sp.
    Zalutschia zalutschicola
   Chironominae
    Chironomini
     Chironomus sp.
     Cladopelma sp.
     Cryptochironomus sp.
     Cryptotendipes sp.
     Dicrotendipes sp.
     Endochironomus sp.
     Glyptotendipes sp.
     Kiefferulus dux
     Nilothauma sp.
     Pagastiella ostansa
     Parachironomus sp.
     Paralauterborniella nigrohalteralis
     Polypedilum sp.
     Stenochironomus sp.
     Zavreliella varipennis
    Pseudochironominii
     Pseudochironomus sp.
    Tanytarsini
     Cladotanytarsus sp.
     Paratanytarsus sp.
     Tanytarsus sp.
  Tabanidae
    Tabanus sp.
 Acari
Mollusca
 Gastropoda
  Basommatophora
   Ancylidae
   Physidae
     Physa sp.
   Planorbidae
     Helisoma sp.
 Pelecypoda
  Heterodonta
   Sphaeriidae
     Pisidium sp.
     Sphaerium sp.

Table 6.2 Relative percentages and annual mean densities of dominant[‡] benthic taxa collected from Harris Lake during 1986.

Taxon	Station E1 No./m^2	Station E1 %	Station H1 No./m^2	Station H1 %	Station P1 No./m^2	Station P1 %
Chironomidae						
Polypedilum	2,490	9.4	--	--	887	5.0
Tanytarsus	1,753	6.6	1,336	5.2	1,064	6.0
Zavreliella varipennis	1,370	5.3	--	--	--	--
Ablablesmyia	1,359	5.2	--	--	--	--
Labrundinia	--	--	1,385	5.4	--	--
Oligochaeta						
Dero nivea	5,169	19.6	4,834	18.8	2,459	14.0
Stylaria lacustris	1,863	7.2	1,784	6.9	--	--
Specaria josinae	--	--	1,890	7.4	1,275	7.2
Ilyodrilus templetoni	--	--	2,119	8.2	--	--
Tubificidae immature	1,347	5.0	1,796	7.0	2,882	16.2
Ephemeroptera						
Caenis	1,321	5.1	--	--	904	5.1
Other taxa	9,741	38.2	10,553	41.0	8,271	46.5
Total annual mean density[¶]	25,417		25,699		17,744	

[‡]Annual mean density ≥ 5% of total annual mean density.

[¶]Sums may differ from totals due to rounding.

Table 6.3 Shannon-Wiener diversity index values for benthic macroinvertebrates collected at Harris Lake during 1986.

Station	Month: Jan	Mar	May	Jul	Sep	Nov
E1	4.0	4.1	4.7	3.7	3.2	3.7
H1	4.3	4.1	3.9	3.9	4.0	3.6
P1	4.2	4.2	4.3	3.3	3.3	3.7

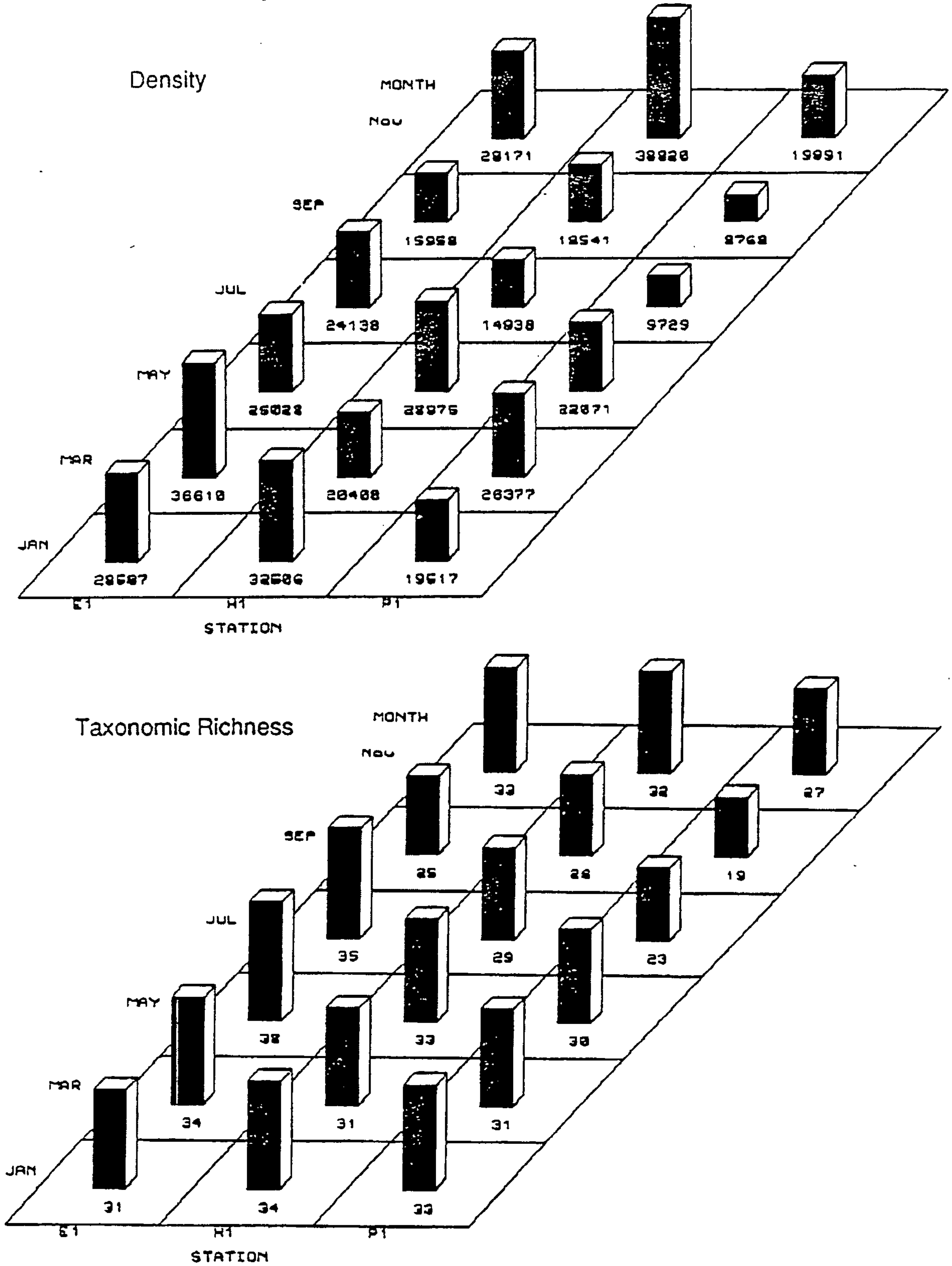

Figure 6.1 Densities (organisms/m^2) and taxonomic richness of benthic macroinvertebrates collected in Harris Lake during 1986.

7.0 FISH

7.1 Introduction

Preoperational fisheries monitoring in Harris Lake continued during 1986. Monitoring studies during previous years (1982-1985) indicated a diverse fish community with largemouth bass exhibiting slow growth (CP&L 1984, 1985, 1986a). The results of the sampling effort are presented in this section.

7.2 Methods

The sampling effort during 1986 consisted of electrofishing during February, May, August, and November at 10 stations (E1, E3, H1, H3, P1, P3, S1, S3, V1, V3); rotenone sampling during September (Areas E, H, and P); and larval push net sampling during April-June at five stations (E1, H3, P3, S1, V3) in Harris Lake (Figure 1.1). Electrofishing was conducted for 15 minutes at each station using a Smith-Root Type VI-A control unit and a 3500-watt generator. Operating voltage was 360 volts DC with the pulse width set between 2 and 4 amperes. Larval fish sampling was conducted using a tandem push net apparatus (Tarplee et al. 1979) towed for six minutes at each station. Rotenone sampling methodology was the same as in past years (CP&L 1985).

All fish collected were identified to the lowest possible taxon, counted, measured for total length (TL) to the nearest millimeter, and weighed to the nearest gram (juvenile and adult fish only). Group weights were taken for smaller fish (usually < 40-mm TL) where applicable.

Condition factor (K), which is a measure of the relative well-being of a fish based on a proportional relationship between length and weight ($K = W \times 10^5/L^3$), was computed for selected species collected during May by size group.

The 1983-1986 larval fish density data were analyzed by a two-way ANOVA ($P \leq 0.05$) using area and year. A Duncan's multiple range test was used to compare treatment means if the interactions were not significant.

7.3 Results and Discussion

Twenty-five species of fish representing nine families were collected from Harris Lake during 1986 (Table 7.1), compared to nineteen species in 1985, and reflected increased sampling effort. The flathead catfish was the only previously uncollected species caught during 1986. One specimen was collected at Area E during collection of samples for the Radiological & Chemical Support Section.

7.3.1 Larval Fish

Densities of larval fish collected during 1986 are presented in Figure 7.1 by area and Figure 7.2 by species. Densities of total fish (all species combined) and gizzard shad collected during 1986 were significantly greater than densities collected during 1983 and 1984. This was probably due to natural year-to-year variation rather than changes in habitat.

7.3.2 Juvenile and Adult Fish

The 1986 electrofishing and standing crop data are presented in Tables 7.2 and 7.3. Length-frequency histograms for selected species are presented in Figures 7.3-7.11.

Results from sampling during 1986 indicated no major changes in species composition (Table 7.1). The fish community continued to be dominated by gizzard shad, largemouth bass, bluegill, warmouth, and brown bullhead. Total biomass was the lowest recorded to date (Table 7.4). Individually, gizzard shad biomass decreased, while largemouth bass, bluegill, warmouth, and brown bullhead biomass increased from 1984 levels (Table 7.4). Increased abundance of aquatic macrophytes may have influenced these changes.

No major changes in length-frequency distributions were noted for these major species or other recreationally important species including redbreast sunfish, black crappie, pumpkinseed, and redear sunfish (Figures 7.3-7.10). Condition factors for most species examined showed little change from previous years, although brown bullhead (50-100 mm) showed an increase in condition from 0.9 in 1982 to 1.4 in 1986 (Table 7.5). In general, condition factors for Harris Lake fish were lower than those reported by Carlander (1969, 1977).

7.3.3 Largemouth Bass Growth

Largemouth bass continued to exhibit slow growth during 1986 (Swing 1986). No largemouth bass larger than 350 mm were collected in rotenone sampling (Figure 7.4). All sampling in Harris Lake indicated that there were adequate numbers of forage *Lepomis* spp. in the littoral areas, although very few juvenile gizzard shad were collected. An aquatic vegetation survey conducted during October 1986 found that all areas of the reservoir shallower than 3 meters supported dense stands of vegetation (36% of the total reservoir area). Because of the excessive cover largemouth bass have been unable to feed effectively on their major prey (juvenile *Lepomis* spp.), thus reducing growth.

Another factor probably contributing to reduced growth was the high densities of largemouth bass throughout the reservoir. These densities (469/hectare) were much higher than values reported by Carlander (1977) and may have increased competition for the limited amount of available prey, thereby contributing to the stunting of largemouth bass in Harris Lake.

Elimination of aquatic macrophytes in Harris Lake may improve largemouth bass growth, although the improvement may not be significant. Because the reservoir supports a good bluegill and black crappie fishery and the uncertainty of improved largemouth bass growth with removal of aquatic macrophytes, no plans to remove or reduce aquatic macrophytes in Harris Lake are planned.

7.4 Summary

Twenty-five species of fish representing nine families were collected from Harris Lake during 1986. The flathead catfish was the only previously uncollected species found.

Larval fish densities peaked during May. Significantly higher densities of gizzard shad larvae were collected during 1986 than in previous years.

The total biomass estimate for Harris Lake was the lowest recorded to date due to a decrease in gizzard shad. Species contributing the greatest amount of biomass were gizzard shad, bluegill, largemouth bass, and brown bullhead. Gizzard shad biomass decreased from 1984 estimates, while bluegill, largemouth bass, warmouth, and brown bullhead estimates increased. No major shifts in length frequencies were found and condition factors remained relatively unchanged.

Largemouth bass continued to exhibit slow growth during 1986. No largemouth bass larger than 350 mm were collected in rotenone sampling. Factors suspected to be contributing to the slow growth rate were overcrowding resulting in stunting and/or unavailability of prey due to excessive aquatic vegetation.

Table 7.1 Fish species collected from Harris Lake, 1983-1986.

Scientific name	Common name	1983	1984	1985	1986
Anguillidae	freshwater eels				
Anguilla rostrata	American eel	X	X	X	X
Clupeidae	herrings				
Dorosoma cepedianum	gizzard shad	X	X	X	X
Esocidae	pikes				
Esox americanus americanus	redfin pickerel	X	X		X
E. niger	chain pickerel	X	X	X	X
Cyprinidae	carps and minnows				
Clinostomus funduloides	rosyside dace	X			
Notemigonus crysoleucas	golden shiner	X	X	X	X
Notropis spp.	unidentified shiner	X	X	X	X
N. alborus	whitemouth shiner	X			
N. altipinnis	highfin shiner	X			
N. analostanus	satinfin shiner	X			
N. petersoni	coastal shiner	X			
Catostomidae	suckers				
Erimyzon spp.	unidentified chubsucker	X			
E. oblongus	creek chubsucker	X	X		X
Moxostoma anisurum	silver redhorse		X		
M. robustum	smallfin redhorse	X			
Ictaluridae	bullhead catfishes				
Ictalurus spp.	unidentified bullhead	X	X		X
I. brunneus	snail bullhead	X	X		
I. melas	black bullhead	X			
I. natalis	yellow bullhead	X	X	X	X
I. nebulosus	brown bullhead	X	X	X	X
I. platycephalus	flat bullhead	X	X	X	X
I. punctatus	channel catfish	X		X	X
Noturus spp.	unidentified madtom				X
Plyodictis olivaris	flathead catfish				X
Poeciliidae	livebearers				
Gambusia affinis	mosquitofish	X	X	X	X

Table 7.1 (continued)

Scientific name	Common name	1983	1984	1985	1986
Centrarchidae	sunfishes				
Acantharchus pomotis	mud sunfish	X			X
Centrarchus macropterus	flier	X	X	X	
Enneacanthus spp.	unidentified sunfish	X			
E. gloriosus	bluespotted sunfish	X	X		X
Lepomis spp.	unidentified sunfish	X	X	X	X
Lepomis sp.	hybrid sunfish	X	X	X	
L. auritus	redbreast sunfish	X	X	X	X
L. cyanellus	green sunfish	X	X	X	X
L. gibbosus	pumpkinseed	X	X	X	X
L. gulosus	warmouth	X	X	X	X
L. macrochirus	bluegill	X	X	X	X
L. microlophus	redear sunfish	X	X	X	X
Micropterus salmoides	largemouth bass	X	X	X	X
Pomoxis spp.	unidentified crappie	X	X		X
P. annularis	white crappie	X	X		X
P. nigromaculatus	black crappie	X	X	X	X
Percidae	perches				
Etheostoma spp.	unidentified darter	X	X		X
E. fusiforme	swamp darter	X		X	X
E. olmstedi	tessellated darter	X			
E. serriferum	sawcheek darter		X		

Table 7.2 Fish (number/hour) collected by electrofishing from Harris Lake during 1986.

Species	Area E	Area H	Area P	Area S	Area V	Mean
American eel	0.5				0.5	0.2
Gizzard shad	2.5		1.5	36.5	13.5	10.8
Redfin pickerel				0.5		0.1
Chain pickerel	1.0	1.0		1.0	1.0	0.8
Golden shiner			0.5	5.0	1.0	1.3
Unidentified shiner	1.5	0.5	0.5			0.5
Yellow bullhead	1.0	1.0		0.5	1.5	0.8
Brown bullhead	8.5	8.5	12.0	15.0	12.5	11.3
Pumpkinseed/redear		3.0			4.0	1.4
Redbreast sunfish	2.0	3.0	1.0	1.0		1.4
Green sunfish			0.5		0.5	0.2
Pumpkinseed	1.5	3.5	13.0	5.0	4.5	5.5
Warmouth	10.5	10.0	12.5	10.0	12.5	11.1
Bluegill	13.0	94.0	26.0	25.0	45.0	40.6
Redear sunfish	0.5	4.0	11.0	3.0	4.5	4.6
Largemouth bass	58.0	39.5	57.5	31.0	55.5	48.3
White crappie			0.5			0.1
Black crappie		0.5	3.0	1.0	3.0	1.5
Swamp darter		0.3		1.5		0.3
Total	100.5	168.5	139.5	136.0	159.5	140.8

Totals may differ from sums due to rounding.

Table 7.3 Fish (number and weight/hectare) collected in rotenone sampling at Harris Lake during 1986.

Species	Area E		Area H		Area P		Mean	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
American eel	2.3	1.1			3.7	1.2	2.0	0.8
Gizzard shad	763.3	112.8	953.1	133.5	109.9	17.4	608.7	87.9
Redfin pickerel	2.3	< 0.1	2.6	0.2	7.4	0.5	4.1	0.3
Chain pickerel	73.3	4.8	3.6	0.3	14.8	2.3	30.2	2.5
Golden shiner	314.0	0.5	49.0	2.0	329.7	1.3	230.9	1.3
Creek chubsucker			1.3	0.3			0.4	0.1
Unidentified shiner	80.2	0.1	112.2	0.2	34.6	< 0.1	75.7	0.1
Unidentified bullhead	107.7	0.3	70.9	0.3	93.9	0.2	90.8	0.3
Yellow bullhead	18.3	0.5	16.8	1.1	44.5	4.4	26.5	2.0
Brown bullhead	48.1	4.1	174.1	28.8	159.3	25.6	127.2	19.5
Flat bullhead	32.1	2.5	1.3	0.3	2.5	0.3	11.9	1.0
Channel catfish	68.8	13.9	16.8	4.3	117.3	3.5	34.3	7.2
Mosquitofish	373.6	0.1	190.9	0.2	119.8	< 0.1	228.1	0.1
Hybrid sunfish			1.3	0.1	4.9	0.4	2.1	0.2
Mud sunfish					2.5	< 0.1	0.8	< 0.1
Bluespotted sunfish			795.7	0.5	757.0	0.5	517.6	0.3
Redbreast sunfish	359.9	2.3	199.9	2.3	32.1	< 0.1	197.3	1.5
Green sunfish	284.2	0.5	101.9	0.4	91.4	0.3	159.2	0.4
Pumpkinseed/redear	1,831.4	2.1	2,885.0	4.4	4,596.3	5.9	3,104.2	4.1
Pumpkinseed	84.8	2.2	145.7	3.9	202.5	4.1	144.4	3.4
Warmouth	2,720.7	19.6	3,934.8	13.5	3,520.7	21.1	3,392.1	18.1
Bluegill	40,224.5	42.1	60,209.7	54.9	44,411.2	39.3	48,288.4	45.5
Redear sunfish	100.9	8.0	90.3	5.3	72.9	5.0	88.0	6.1
Largemouth bass	566.1	30.6	435.9	21.6	406.3	33.0	469.4	28.4
Black crappie	353.0	5.7	112.2	2.3	402.6	6.1	289.3	4.7
Unidentified darter	98.6	< 0.1	166.4	0.2	192.6	< 0.1	152.5	< 0.1
Swamp darter	16.0	< 0.1	69.6	< 0.1			28.6	< 0.1
Total	48,544.1	253.9	70,739.8	281.1	55,630.3	172.5	58,304.8	235.8

Totals may differ from sums due to rounding errors.

Table 7.4 Fish (number and weight/hectare) collected in rotenone sampling at Harris Lake during 1982, 1984, and 1986

Species	1982		1984		1986	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
American eel	15.3	2.4	0.5	0.2	2.0	0.8
Gizzard shad	1,482.0	160.1	2,291.4	264.4	608.7	87.9
Eastern mudminnow	0.7	< 0.1				
Redfin pickerl	132.3	3.7	5.9	0.2	4.1	0.3
Chain pickerel	18.7	3.7	6.9	3.2	30.2	2.5
Golden shiner	239.0	3.4	266.3	1.0	230.9	1.3
Creek chubsucker	2.0	0.3	3.5	0.2	0.4	0.1
Silver redhorse			86.8	114.2		
Unidentified shiner	10.0	< 0.1	157.9	0.1	75.7	0.1
Unidentified bullhead	97.0	0.4	85.2	< 0.1	90.8	0.3
Snail bullhead	4.3	0.7				
White catfish	1.3	2.2				
Yellow bullhead	19.0	1.7	22.1	2.0	26.5	2.0
Brown bullhead	436.7	43.6	5.5	0.6	127.2	19.5
Flat bullhead	12.0	1.9	9.7	0.8	11.9	1.0
Channel catfish					34.3	7.2
Unidentified madtom	22.7	< 0.1				
Margined madtom	2.3	< 0.1				
Pirate perch	113.0	0.1	0.9	< 0.1		
Mosquitofish	400.1	0.2	138.4	< 0.1	228.1	0.1
Hybrid sunfish	18.0	1.2	3.7	0.3	2.1	0.2
Unidentified sunfish			752.5	0.5		
Mud sunfish	21.3	0.7			0.8	< 0.1
Flier	8.7	0.5	1.6	0.3		
Bluespotted sunfish	2,167.3	1.9	413.8	0.3	517.6	0.3
Redbreast sunfish	362.0	7.3	529.2	3.4	197.3	1.5
Green sunfish	3,095.7	7.6	144.4	0.8	159.2	0.4
Pumpkinseed/redear			2,237.0	2.2	3,104.2	4.1
Pumpkinseed	1,746.0	7.9	101.4	6.0	144.4	3.4
Warmouth	6,556.3	15.8	3,136.5	11.7	3,392.1	18.1
Bluegill	20,965.7	19.1	15,971.0	32.4	42,288.4	45.5
Redear sunfish	43.7	1.6	70.4	5.4	88.0	6.4
Largemouth bass	540.3	52.8	239.2	22.6	469.4	28.4
White crappie	1.0	< 0.1				
Black crappie	86.0	6.4	179.5	0.8	289.3	4.7
Unidentified darter	10.3	< 0.1	287.2	< 0.1	152.5	< 0.1
Swamp darter					28.6	< 0.1
Sawcheek darter	8.0	< 0.1	4.9	< 0.1		
Total	38,637.7	359.2	27,152.9	473.8	58,304.8	235.8

Totals may differ from sums due to rounding errors.

Table 7.5 Condition factor (K) of selected species of fish collected with rotenone in Harris Lake during 1982, 1984, and 1986.

Species	Size class (mm)	1982	1984	1986
Gizzard shad	≤ 200	1.4	1.9	‡
	> 200	0.9	0.8	0.8
Brown bullhead	50-100	0.9	‡	1.4
	101-200	1.1	‡	1.1
	> -200	1.1	‡	1.2
Redbreast sunfish	50-100	1.7	‡	1.8
	101-200	1.9	1.8	1.8
Pumpkinseed	50-100	1.7	1.8	1.8
	101-200	1.9	1.8	1.8
Warmouth	50-100	2.1	1.8	1.9
	101-200	1.9	1.8	1.9
Bluegill	50-100	1.8	1.6	1.6
	101-200	2.1	1.7	1.8
	> 200	2.3	1.6	1.8
Redear sunfish	50-100	1.3	1.6	1.8
	101-200	1.6	1.5	1.8
	> 200	1.8	1.5	1.7
Largemouth bass	50-100	1.3	1.0	1.1
	101-150	1.2	1.0	1.2
	200-250	1.2	1.2	1.3
	251-300	1.2	1.1	1.2
	> 300	1.7	‡	1.2
Black crappie	50-100	1.2	1.3	1.4
	101-200	1.4	1.2	1.3
	> 200	1.4	‡	1.4

‡Sample size too small for valid estimate.

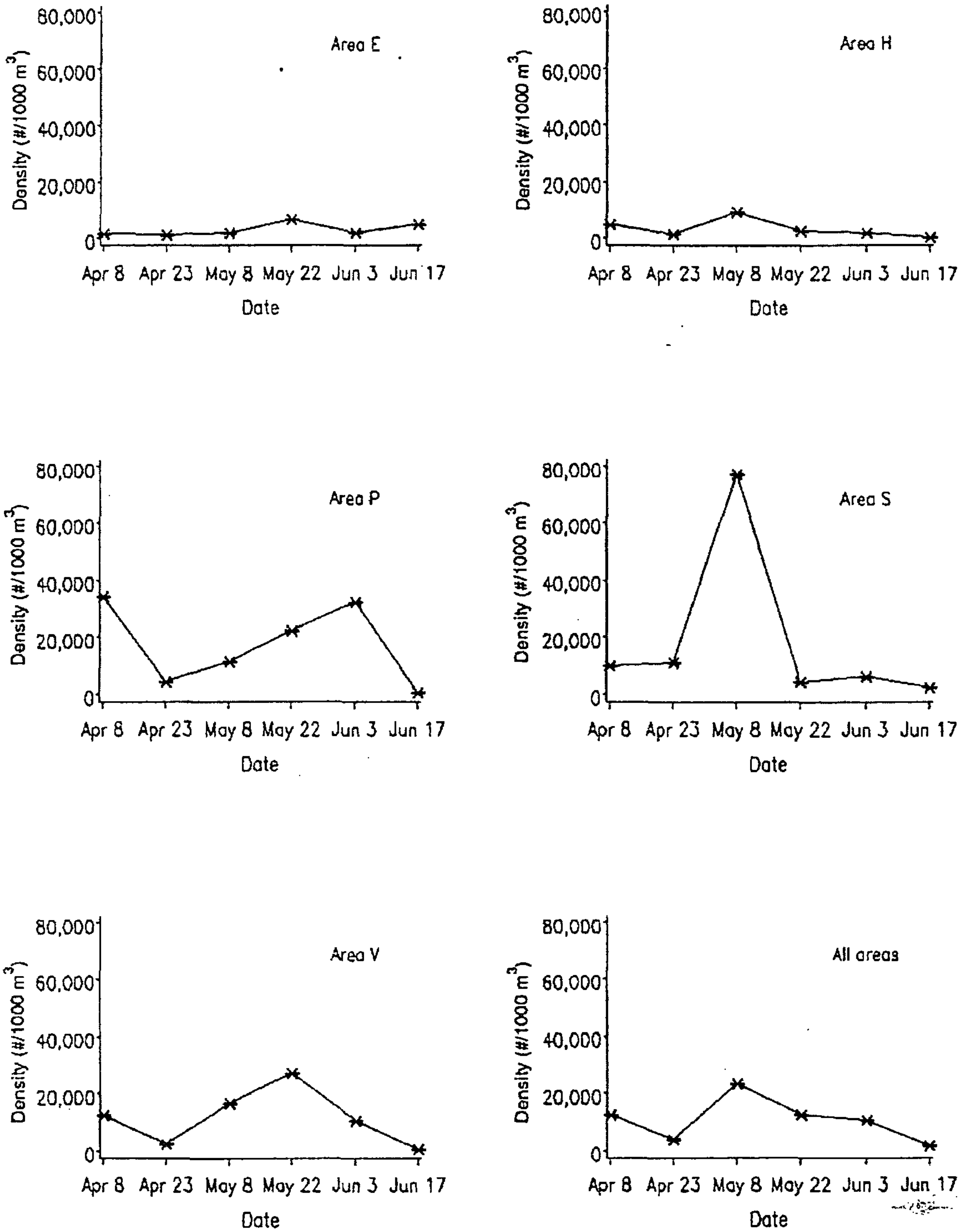

Figure 7.1 Larval fish push net density estimates from Harris Lake during 1986.

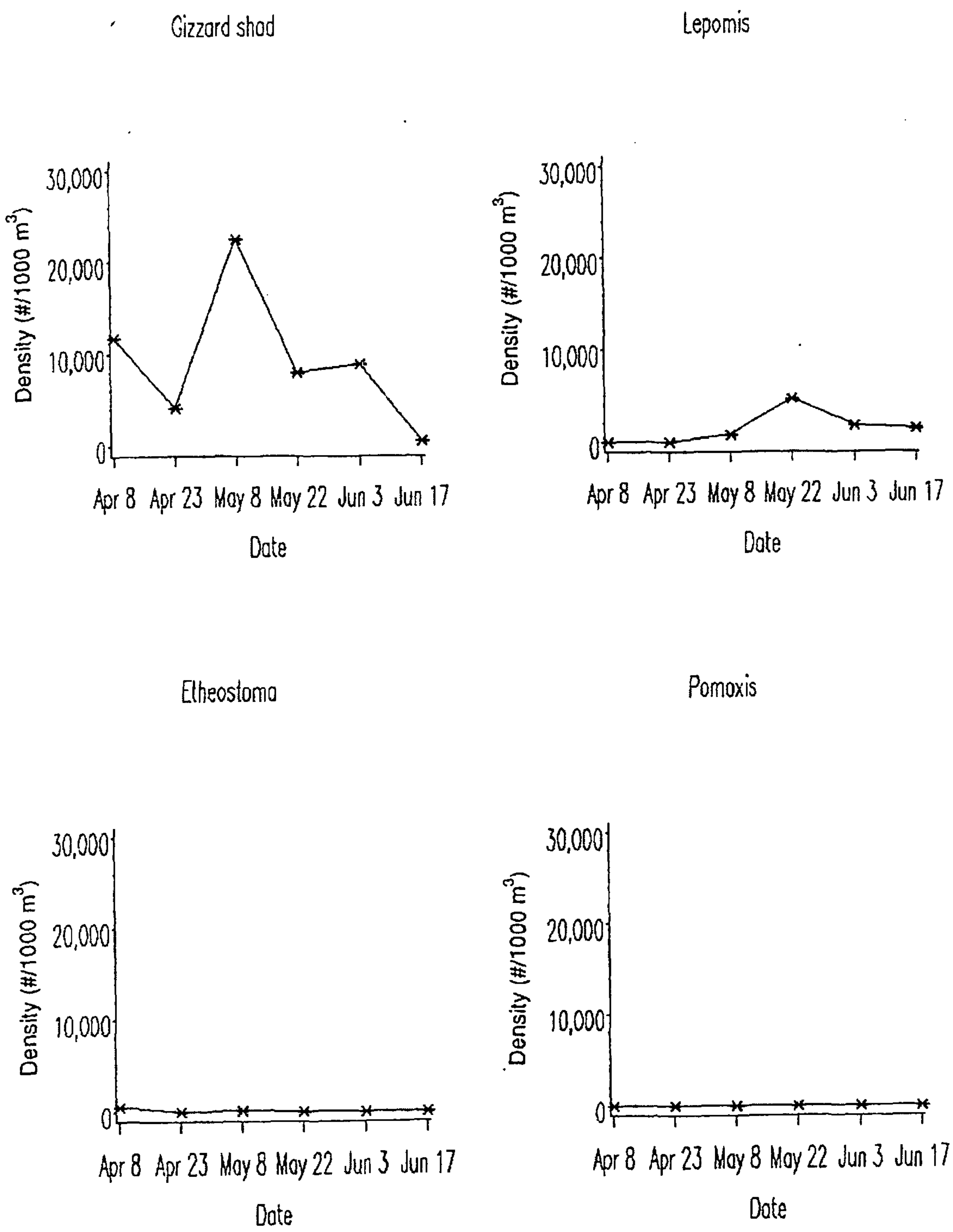

Figure 7.2 **Larval fish push net density estimates by species from Harris Lake during 1986.**

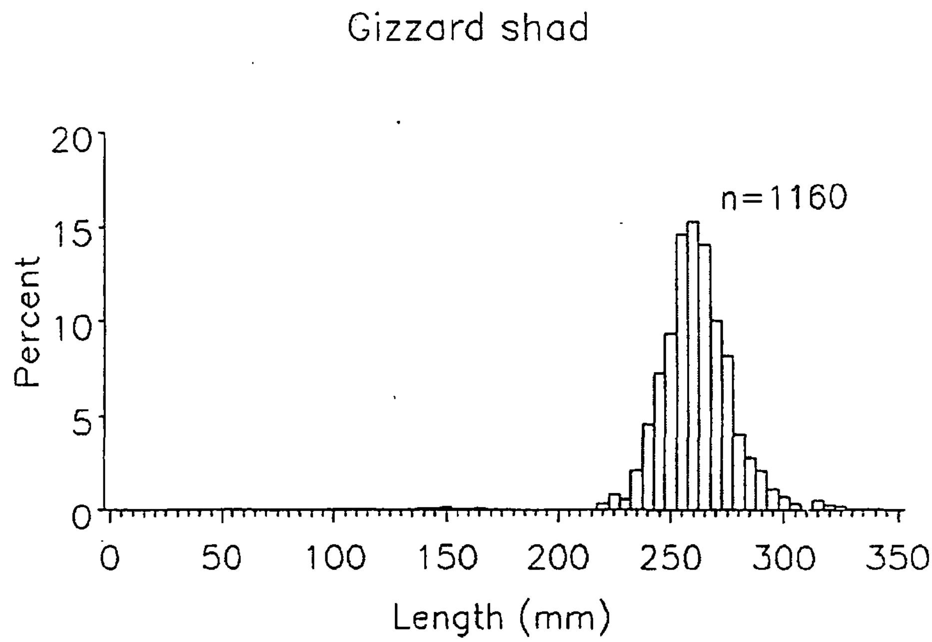

Figure 7.3 **Length-frequency distribution of gizzard shad collected from cove rotenone samples at Harris Lake during 1986.**

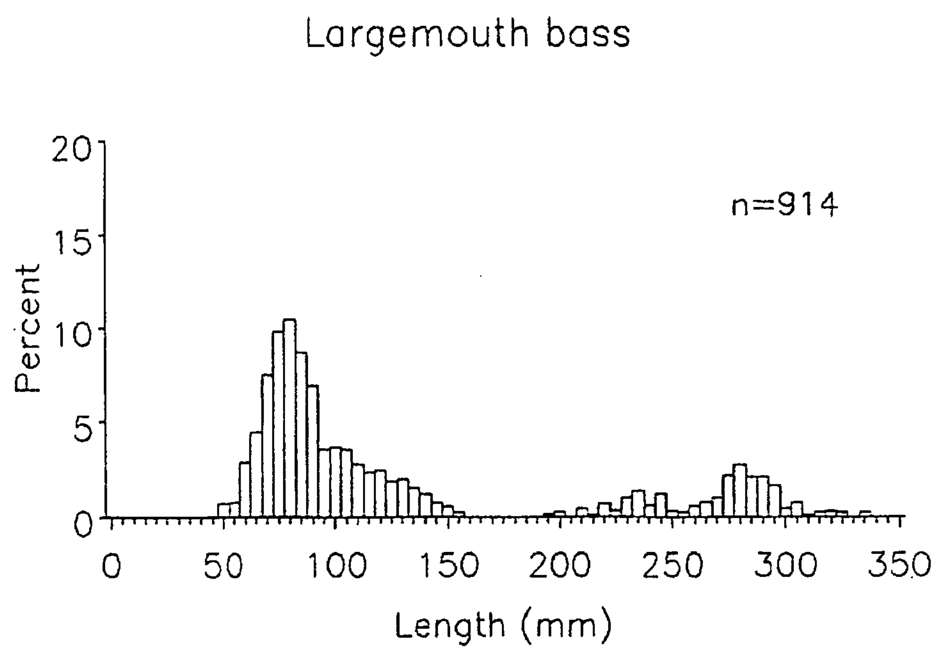

Figure 7.4 **Length-frequency distribution of largemouth bass collected from cove rotenone samples at Harris Lake during 1986.**

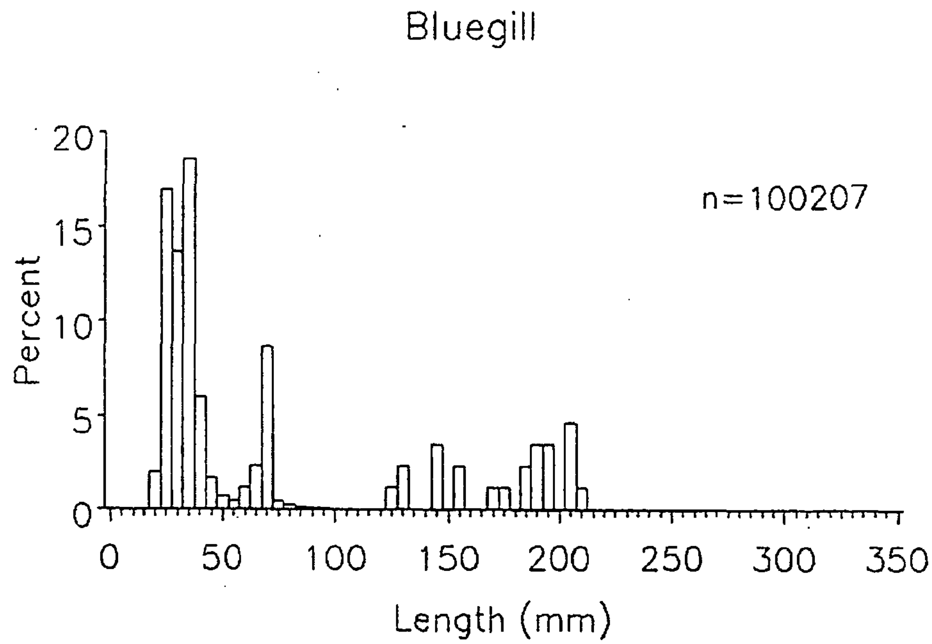

Figure 7.5 **Length-frequency distribution of bluegill collected from cove rotenone samples at Harris Lake during 1986.**

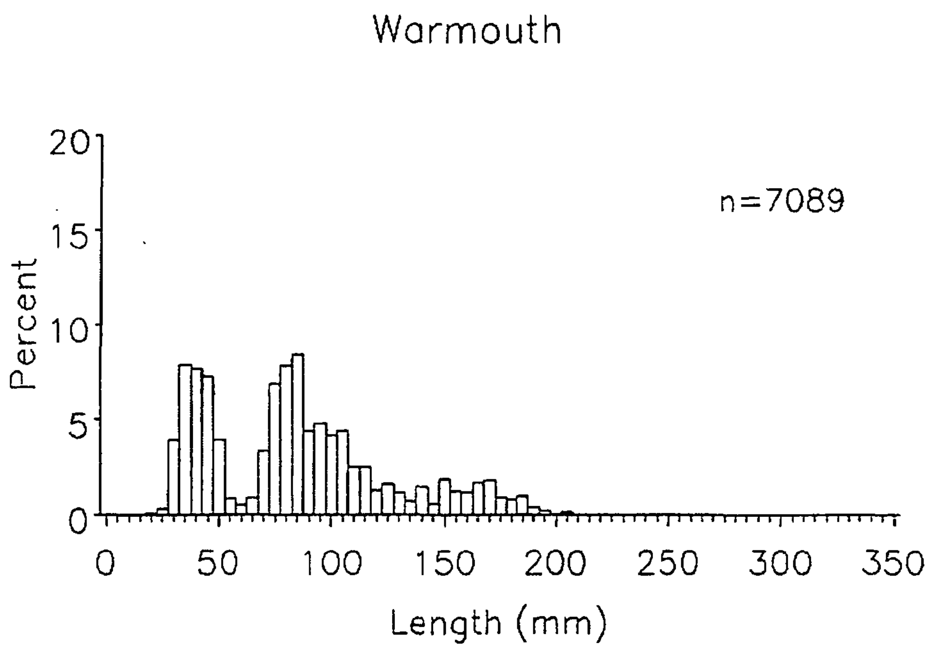

Figure 7.6 **Length-frequency distribution of warmouth collected from cove rotenone samples at Harris Lake during 1986.**

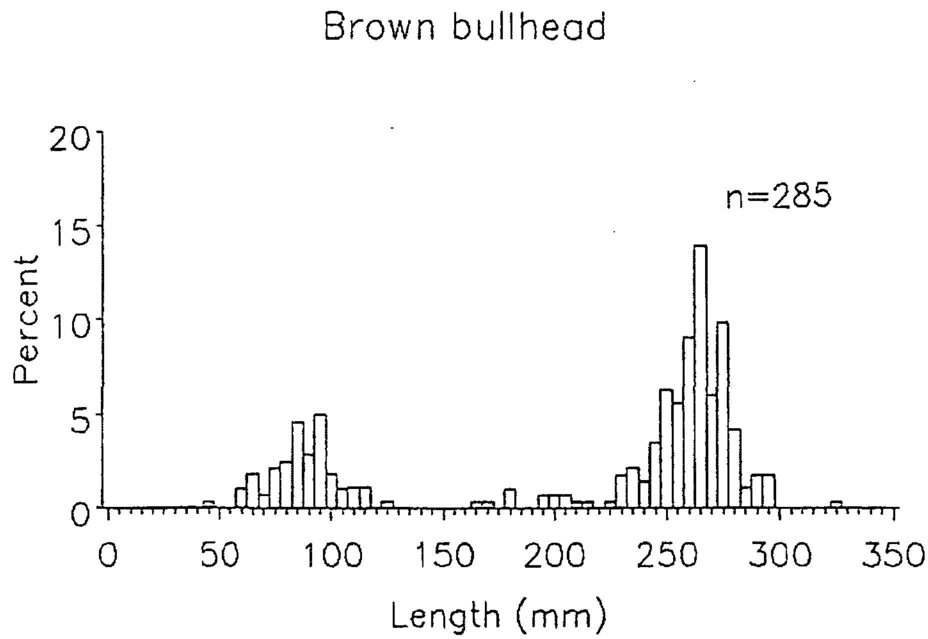

Figure 7.7 **Length-frequency distribution of brown bullhead collected from cove rotenone samples at Harris Lake during 1986.**

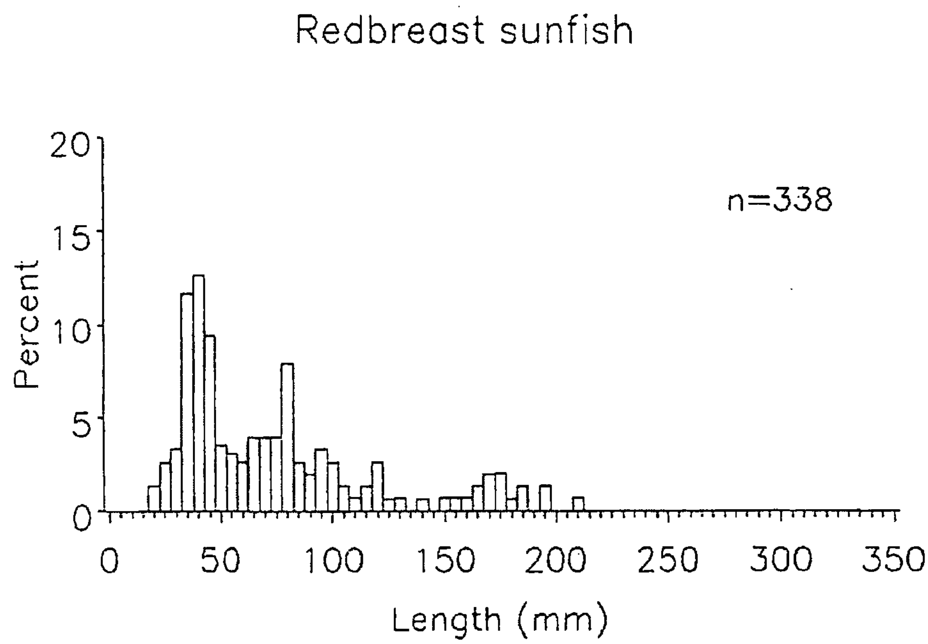

Figure 7.8 **Length-frequency distribution of redbreast sunfish collected from cove rotenone samples at Harris Lake during 1986.**

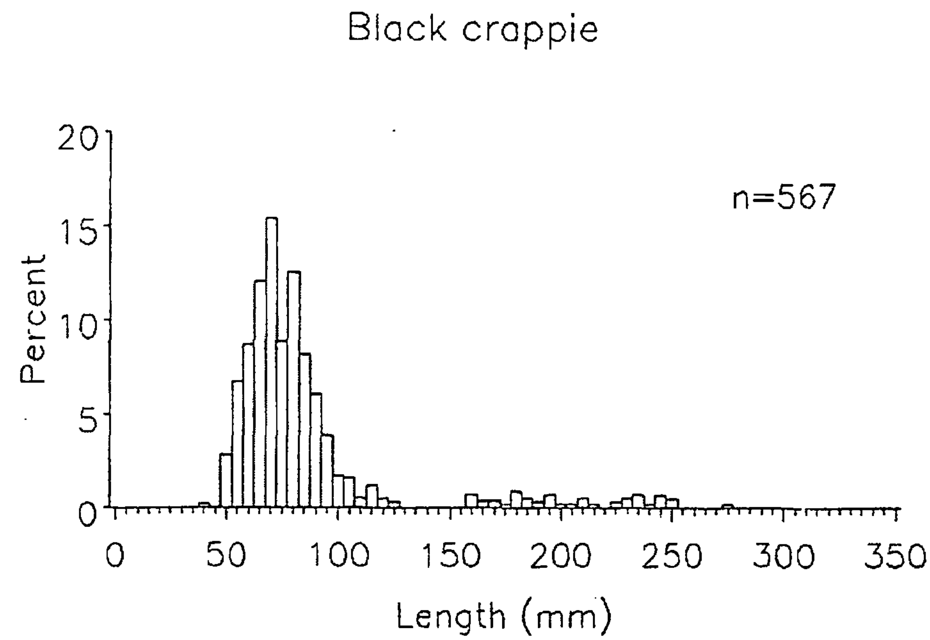

Figure 7.9 Length-frequency distribution of black crappie collected from cove rotenone samples at Harris Lake during 1986.

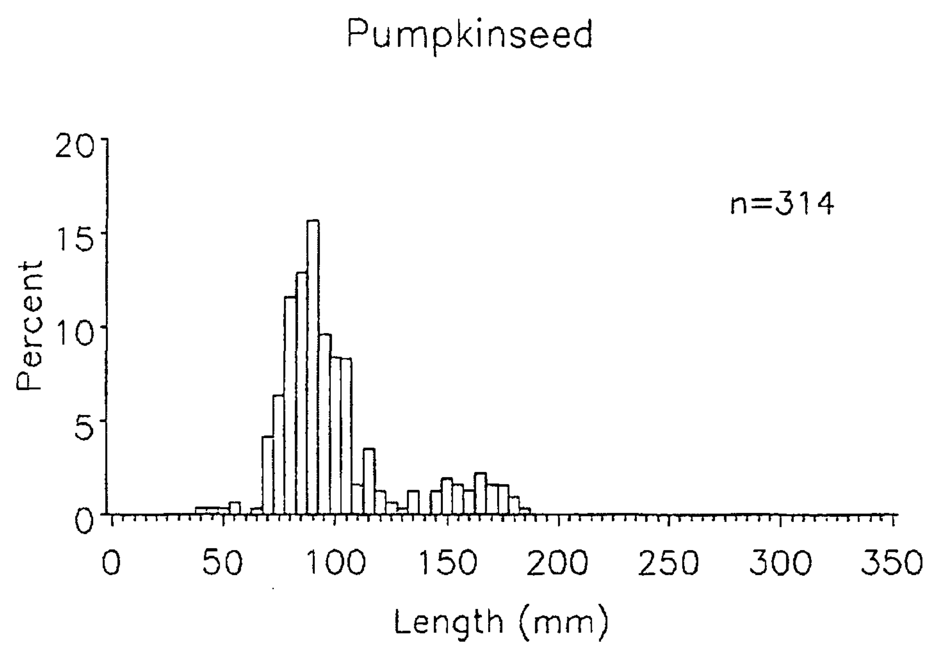

Figure 7.10 Length-frequency distribution of pumpkinseed collected from cove rotenone samples at Harris Lake during 1986.

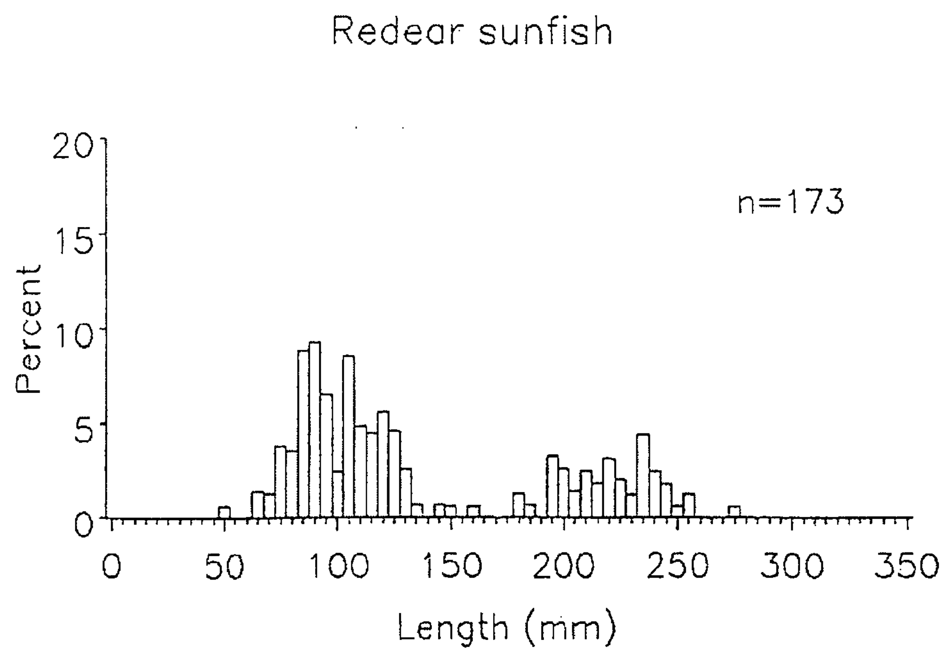

Figure 7.11 Length-frequency distribution of redear sunfish collected from cove rotenone samples at Harris Lake during 1986.

8.0 TERRESTRIAL VERTEBRATES

8.1 Introduction

During 1986 emphasis was given to wildlife management program activities around the SHNPP and Harris Lake. Terrestrial vertebrate populations continued to be monitored through regular surveys and miscellaneous observations. Quantitative vegetation monitoring was initiated in Wildlife Management Areas 1 and 2 and the Greentree Reservoir to describe species composition and density of timber stands in these areas. Studies investigating bird collisions with the SHNPP cooling tower during peak migration periods and waterfowl hunting at Harris Lake were also conducted.

8.2 Methods

Birds were systematically monitored during 1986 through roadside bird surveys, spring and winter bird counts, and waterfowl surveys. Miscellaneous observations of birds were also recorded. The roadside bird surveys were conducted twice each quarter beginning at sunrise using the method described in CP&L (1985). Spring and winter bird counts were conducted once during May and December, respectively. The purpose of these counts was to identify breeding and wintering populations by visiting as many habitat types as possible. Waterfowl surveys were conducted biweekly from January through March and October through December at eight points (WS-1 through WS-3 and WS-5 through WS-9) along the Harris Lake margin, the auxiliary reservoir, and at the Greentree Reservoir (Figure 1.1).

A waterfowl hunter survey was conducted at Harris Lake during the 1986-1987 waterfowl hunting season to determine species harvested, harvest rates, areas hunted, and hunting pressure. Surveys were conducted 5 evenings and each morning of the 21 legal waterfowl hunting days at Harris Lake. Hunters were surveyed by questionnaires placed on the windshield of each vehicle parked at both public boat ramps and the bridges on SR 1127 and SR 1116. Hunters were asked to return the completed questionnaire in an attached envelope.

Nest box programs were conducted to monitor the use of artificial nest boxes by wood ducks and bluebirds. Details of monitoring and box description for the wood duck nest program were presented in CP&L (1985). Bluebird nest boxes placed in Wildlife Management Area 1 were checked periodically for nesting activity from March through August.

The red-cockaded woodpecker refuge site was monitored once a week from April 15 through July 15 for nesting activity. Cavity trees were tapped during the day to see if an adult flushed. If an adult was present, North Carolina State University (NCSU) biologists were contacted to determine nest contents since they have the appropriate permits required for handling this endangered species.

A survey to monitor bird casualties as a result of collision with the 160-m-tall cooling tower at the SHNPP was conducted at least once weekly during the months of April-May and October-November (peak periods for spring and fall migration). The area around the cooling tower basin was inspected and any dead birds were counted and identified by species.

Mammals were not systematically monitored during 1986, but those observed while conducting other studies were recorded as miscellaneous observations.

Quantitative vegetation surveys were conducted in nine compartments located in Wildlife Management Areas 1 and 2 and the Greentree Reservoir basin. Wildlife Management Areas 1-3 were divided into compartments to create smaller units for planning and conducting wildlife and timber management activities. The point-quarter method, as described by Cottam and Curtis (1956), was used to characterize species composition and density of timber stands in these areas. The point-quarter method is a plotless sampling technique used to estimate basal area, relative basal area, density, relative density, frequency, and relative frequency of canopy tree species. These values are then used to calculate an importance value for each species encountered. In each compartment, 20 evenly spaced points were sampled along a 380-m transect. The Greentree Reservoir transect included 36 sample points. At each point an imaginary line was drawn perpendicular to the transect and the nearest tree to the point was identified in each of the four quadrants. The distance in meters and the diameter at breast height (dbh) in centimeters were recorded by species for each tree.

8.3 Results and Discussion

8.3.1 Birds

During 1986, 111 species of birds were observed (Table 8.1). This total is higher than the average of 95 species (range = 83-123) observed from 1978 to 1985. Sampling effort during 1986 was increased from 1985 with the resumption of the spring and winter bird counts. The yellow-crowned night heron, laughing gull, and black-throated blue warbler, previously unobserved at the SHNPP site, were observed during 1986. The bald eagle, a federally protected species, was observed once at Harris Lake during July. Increased recreational use of the lake may have discouraged use by bald eagles since they tend to avoid areas of high human activity (Fisher and Hartman 1983).

During the roadside bird surveys, 18 species were observed during the winter quarter, 37 species during the spring quarter, 42 species during the summer quarter, and 17 species during the fall quarter. The 1986 Shannon-Wiener diversity values for each quarter (winter--3.4, spring--4.8, summer--4.7, fall--3.6) were similar to those from previous years' surveys and no trends were discernible.

During the spring and winter bird counts, 69 and 49 species were observed, respectively. The results are very similar to the 1984 count totals (spring--70 species; winter--50 species).

Twenty-two species of birds were observed during the waterfowl surveys (Table 8.2). Those species observed in the largest concentrations with the highest frequency were the coot, ring-necked duck, mallard, and pied-billed grebe. These same four species were observed most frequently during 1984 and 1985.

Results of the 112 out of 268 waterfowl hunter questionnaires returned (41.8%) indicated 189 hunters harvested 161 ducks in 911.5 hunter-hours for a harvest rate of 0.18 duck/hour. At this rate, it required 5.7 hours to harvest one duck at Harris Lake. At Mattamuskeet National Wildlife Refuge, the harvest rate was 0.24 duck/hour during the 1986-1987 season. The 8-year average of 0.19 duck/hour was similar to the harvest rate at Harris Lake. The harvest (Table 8.4) consisted mostly of ring-necked ducks (59), wood ducks (24), American coots (20), and mallards (15). Ring-necked ducks, coots, and mallards were among the waterfowl species observed most frequently during the waterfowl surveys. The area north of the SR 1127 bridge (Area S) was the most heavily hunted area. The boat ramp near Holleman's crossroads was used more frequently (63%) by waterfowl hunters followed by the boat ramp near the main dam (25%) and each of the bridge access points (6%).

Fourteen species of game birds were observed on the SHNPP site during 1986. Eleven of these were observed during waterfowl surveys (Table 8.2). Three upland game species--the wild turkey, the bobwhite quail, and the mourning dove--were observed while conducting other surveys.

Seven wood duck nests were successfully established in the nest boxes at Harris Lake during 1986. Seventy-eight eggs were laid of which sixty-nine (88%) hatched. Four of the nests were in wooden boxes and three were in plastic bucket boxes (Table 8.3). Box utilization of 16% was the same as in 1985. No nest predation has occurred in the three years of the nest box program. Three of the nesting hens were banded during 1986, two hens were not banded, one hen returned from 1984, and another from 1985. Both returning wood ducks previously nested in wooden boxes but in 1986 they used bucket boxes. The boxes each hen had previously used were not used during 1986.

Only one bluebird box, located at the public access area reached via SR 1130, was used in 1986. Three successive nests were initiated in this same box. Nestlings were documented in the nest in all three instances after eggs were laid, but fledging success was not determined.

The pair of red-cockaded woodpeckers (as identified by color-coded leg bands) that occupied the SHNPP colony site during 1984 and 1985 was not observed after April 1986. Biologists from North Carolina State University (NCSU) reported observing the adult female from the Harris site at a colony site on Camp Mackall Military Reservation, Richmond County, North Carolina, in May 1986. This represents the longest distance relocation documented by NCSU biologists. During May, two unbanded red-cockaded woodpeckers were observed occupying the SHNPP colony site roost cavities. This pair subsequently nested successfully and fledged one juvenile female. The birds were banded by NCSU biologists and remained at the colony site through December 1986.

During 1986, cooling tower casualties consisted of six bird species (white-eyed vireo, yellow-throated vireo, red-eyed vireo, common yellow-throat, brown thrasher, common grackle) and one mammal species (red bat). A total of 25 individuals (23 birds, 2 mammals) was collected during the 4 months of monitoring. This was an extremely low mortality when compared to bird kills documented at other tall structures (Maehr et al. 1983; Marsden et al. 1980) and was not considered to have a significant impact on migratory birds moving through the area.

8.3.2 Mammals

Eight species of mammals (eastern mole, red bat, eastern cottontail, beaver, southern flying squirrel, red fox, bobcat, whitetail deer) were observed at the SHNPP site during 1986. The southern flying squirrel, flushed from a tree cavity while conducting habitat surveys, had not been previously observed at the SHNPP site. This species is probably common on the site, but due to its nocturnal habits is rarely seen.

8.3.3 Quantitative Vegetation Studies

Results of the point-quarter sampling in the 9 compartments showed estimated total stand densities ranging from 561 to 1533 trees/hectare and estimated total basal areas from 15.7 to 39.5 m^2/hectare (basal area is the cross-sectional area of the tree stem at 1.4 m above the ground).

The results of the point-quarter analysis for the Greentree Reservoir are presented in Table 8.5. The total estimated stand density is 821 trees/hectare and total estimated basal area is 32.8 m^2/hectare. Trees in the greentree basin with the highest importance values (relative basal area + relative density + relative frequency) were yellow poplar *Liriodendron tulipifera*, sweetgum *Liquidambar styraciflua*, red maple *Acer rubrum*, and hophornbeam *Ostrya virginiana*. The results of this analysis indicated that relatively few valuable mast-producing trees are present in the Greentree Reservoir, and future management activities should include selective thinning of less desirable species with subsequent replacement by oaks that produce small acorns.

8.4 Summary

During 1986, survey results for birds at the SHNPP site were similar to those reported from prior years except for the addition of three previously unobserved species (yellow-crowned night heron, laughing gull, black-throated blue warbler). The bald eagle and red-cockaded woodpecker (federally protected endangered species) continued to be observed during 1986. Eagles have been seen less frequently in 1985 and 1986, probably due to increased recreational use of Harris Lake. The hatching success in wood duck boxes increased from 1985. Three wood duck nests were located for the first time in the previously unused plastic bucket boxes. Only one bluebird box was used during 1986, although this box contained three consecutive nests. A waterfowl hunter survey showed those ducks harvested most frequently (with the exception of the wood duck) were among the species observed most often and in the greatest numbers during the waterfowl surveys. The waterfowl hunter survey resulted in a 41.8% return rate of questionnaires reporting a 0.18 duck/hour harvest rate. The southern flying squirrel, previously unobserved at the SHNPP site, was reported during 1986. Quantitative vegetation studies were completed in two wildlife management areas and the Greentree Reservoir. Results of this analysis indicated that relatively few valuable mast-producing trees are present in the Greentree Reservoir basin.

Table 8.1 Birds observed at the SHNPP site during 1986.

Scientific name	Common name
Gaviidae	loons
Gavia immer	common loon
Podicipedidae	grebes
Podiceps auritus	horned grebe
Podilymbus podiceps	pied-billed grebe
Phalacrocoracidae	cormorants
Phalacrocorax auritus	double-crested cormorant
Ardeidae	herons
Ardea herodias	great blue heron
Casmerodius albus	great egret
Butorides striatus	green-backed heron
Nycticorax violaceus	yellow-crowned night heron
Anatidae	swans, geese, and ducks
Anas platyrhynchos	mallard
A. rubripes	American black duck
A. americana	American wigeon
A. crecca	green-winged teal
A. discors	blue-winged teal
Aix sponsa	wood duck
Unidentified merganser	unidentified merganser
Aythya affinis	lesser scaup
A. collaris	ring-necked duck
Bucephala albeola	bufflehead
Oxyura jamaicensis	ruddy duck
Accipitridae	hawks and eagles
Circus cyaneus	northern harrier
Accipiter striatus	sharp-shinned hawk
Buteo jamaicensis	red-tailed hawk
Haliaeetus leucocephalus	bald eagle
Pandion haliaetus	osprey
Carthartidae	new world vultures
Cathartes aura	turkey vulture
Coragyps atratus	black vulture
Falconidae	falcons
Falco sparverius	American kestrel
Phasianidae	pheasants, grouse, and quails
Colinus virginianus	bobwhite
Meleagris gallopavo	wild turkey
Rallidae	rails
Fulica americana	American coot

Table 8.1 (continued)

Scientific name	Common name
Charadriidae	plovers
Charadrius vociferus	killdeer
Scolopacidae	sandpipers
Unidentified yellowlegs	unidentified yellowlegs
Laridae	gulls, terns, and skimmers
Larus delawarensis	ring-billed gull
L. atricilla	laughing gull
Columbidae	pigeons and doves
Columba livia	rock dove
Zenaida macroura	mourning dove
Cuculidae	cuckoos
Coccyzus americanus	yellow-billed cuckoo
Strigidae	typical owls
Strix varia	barred owl
Caprimulgidae	nightjars
Caprimulgus carolinensis	chuck-will's-widow
C. vociferus	whip-poor-will
Apodidae	swifts
Chaetura pelagica	chimney swift
Alcedinidae	kingfishers
Ceryle alcyon	belted kingfisher
Picidae	woodpeckers
Picoides villosus	hairy woodpecker
P. pubescens	downy woodpecker
P. borealis	red-cockaded woodpecker
Sphyrapicus varius	yellow-bellied sapsucker
Dryocopus pileatus	pileated woodpecker
Melanerpes erythrocephalus	red-headed woodpecker
M. carolinus	red-bellied woodpecker
Colaptes auratus	northern flicker
Tyrannidae	tyrant flycatchers
Tyrannus tyrannus	eastern kingbird
Myiarchus crinitus	great crested flycatcher
Sayornis phoebe	eastern phoebe
Contopus virens	eastern wood pewee
Empidonax virescens	acadian flycatcher

Table 8.1 (continued)

Scientific name	Common name
Hirundinidae	swallows
Progne subis	purple martin
Hirundo rustica	barn swallow
Stelgidopteryx serripennis	northern rough-winged swallow
Corvidae	jays and crows
Cyanocitta cristata	blue jay
Corvus brachyrhynchos	American crow
Paridae	titmice
Parus bicolor	tufted titmouse
P. carolinensis	Carolina chickadee
Certhiidae	creepers
Certhia americana	brown creeper
Troglodytidae	wrens
Thryothorus ludovicianus	Carolina wren
Troglodytes troglodytes	winter wren
Muscicapidae	old world warblers and thrushes
Regulus satrapa	golden-crowned kinglet
R. calendula	ruby-crowned kinglet
Polioptila caerula	blue-gray gnatcatcher
Catharus guttatus	hermit thrush
Hylocichla mustelina	wood thrush
Turdus migratorius	American robin
Sialia sialis	eastern bluebird
Minidae	mimic thrushes
Mimus polyglottos	mockingbird
Dumetella carolinensis	gray catbird
Toxostoma rufum	brown thrasher
Sturnidae	starlings
Sturnus vulgaris	starling
Vireonidae	vireos
Vireo olivaceus	red-eyed vireo
V. flavifrons	yellow-throated vireo
V. griseus	white-eyes vireo
Emberizidae	new world passerines
Agelaius phoeniceus	red-winged blackbird
Sturnella magna	eastern meadowlark
Icterus spurius	orchard oriole
Quiscalus quiscula	common grackle

Table 8.1 (continued)

Scientific name	Common name
Zonotrichia albicollis	white-throated sparrow
Spizella passerina	chipping sparrow
S. pusilla	field sparrow
Junco hyemalis	dark-eyed junco
Melospiza melodia	song sparrow
Passarella iliaca	fox sparrow
Pipilo erythrophthalmus	rufous-sided towhee
Cardinalis cardinalis	cardinal
Guiraca caerulea	blue grosbeak
Passerina cyanea	indigo bunting
Piranga rubra	summer tanager
Protonotaria citrea	prothonotary warbler
Parula americana	northern parula warbler
Dendroica caerulescens	black-throated blue warbler
D. coronata	yellow-rumped warbler
D. dominica	yellow-throated warbler
D. pinus	pine warbler
D. discolor	prairie warbler
Seiurus aurocapillus	ovenbird
S. noveboracensis	northern waterthrush
Geothlypis trichas	common yellowthroat
Icteria virens	yellow-breasted chat
Wilsonia citrina	hooded warbler
Setophaga ruticilla	American redstart
Fringillidae	finches
Carduelis tristis	American goldfinch
Passeridae	old world sparrows
Passer domesticus	house sparrow

Table 8.2 Birds observed during waterfowl surveys at the SHNPP site during 1986.

Horned grebe	Lesser scaup‡
Pied-billed grebe	Ring-necked duck‡
Common loon	Bufflehead‡
Ring-billed gull	Ruddy duck‡
Double-crested cormorant	Great blue heron
Mallard‡	American coot‡
American black duck‡	Unidentified yellowlegs
American wigeon‡	Killdeer
Green-winged teal‡	Northern harrier
Wood duck‡	Osprey
Unidentified merganser‡	Belted kingfisher

‡Classified as game species.

Table 8.3 Box type, clutch size, and percent hatching for wood duck nest boxes on Harris Lake during 1986.

Box number	Box type	Clutch size	Number of eggs hatched	Hatching success
5	Wooden	10	10	100%
11	Bucket	9	9	100%
12	Wooden	12	9	75%
15	Bucket	14	11	78% (return from 1984)
16	Wooden	9	7	77%
31	Bucket	13	12	92% (return from 1985)
45	Wooden	11	11	100%
Total		78	69	
Mean		11	10	88%

Table 8.4 Waterfowl harvested by hunters replying to the waterfowl hunter survey at Harris Lake during the 1986-1987 waterfowl hunting season.

Species	Total	Male	Female
Ring-necked duck	59	40	19
Wood duck	24	21	3
American coot	20	--	--
Mallard	15	9	6
Bufflehead	13	3	10
Lesser scaup	6	5	1
Ruddy duck	6	1	5
American wigeon	4	3	1
Unidentified duck	4	--	--
Blue-winged teal	3	1	2
Hooded merganser	3	2	1
Goldeneye	2	1	1
Redhead	1	1	0
Black duck	1	--	--
Total	161	87	49

Table 8.5 Point-quarter analysis of canopy trees in the Greentree Reservoir basin at the SHNPP site during 1986.

Species	Basal area (m^2/hectare)	Relative basal area (%)	Density (trees/ hectare)	Relative density (%)	Fre- quency	Relative frequency (%)	Impor- tance value
Yellow poplar	10.9	33.3	131.1	16.0	0.4	13.4	62.7
Sweetgum	7.1	21.6	119.8	14.6	0.5	15.2	51.4
Red maple	3.3	10.0	136.9	16.7	0.5	17.0	43.6
Hophornbeam	1.4	4.2	102.6	12.5	0.4	14.3	31.0
Dogwood	0.6	1.9	74.1	9.0	0.3	8.9	19.9
Beech	2.6	8.0	39.9	4.9	0.2	5.4	18.3
Ironwood	0.7	2.1	74.1	9.0	0.2	7.1	18.2
White oak	1.9	5.9	45.6	5.5	0.1	3.6	15.0
Loblolly pine	1.7	5.3	22.8	2.8	0.1	3.6	11.7
Red oak	1.1	3.4	17.1	2.1	0.1	2.7	8.1
Shagbark hickory	0.4	1.2	11.4	1.4	0.006	1.8	4.3
American ash	0.3	0.8	11.4	1.4	0.006	1.8	4.0
Blackgum	0.2	0.6	11.4	1.4	0.006	1.8	3.8
Shortleaf pine	0.4	1.1	5.7	0.7	0.03	0.9	2.7
Sourwood	0.05	0.2	5.7	0.7	0.03	0.9	1.8
Willow oak	0.05	0.1	5.7	0.7	0.03	0.9	1.7
Southern sugarmaple	0.03	0.1	5.7	0.7	0.03	0.9	1.7

9.0 AQUATIC VEGETATION

9.1 Introduction

During 1986, aquatic botany surveys were conducted in Harris Lake and the auxiliary reservoir. These surveys were conducted to monitor the species composition and coverage of plant communities and to detect the possible introduction of potentially troublesome species.

9.2 Methods

Four surveys of Harris Lake and the auxiliary reservoir were conducted between May and October. Methods followed those utilized since 1984 (CP&L 1985). Portions of the lake and auxiliary reservoir surveyed were in Areas I, L, P, Q, S, V, and Z (Figure 1.1). Special emphasis was placed on those areas where the introduction of potentially troublesome species might occur (public access points such as boat ramps and road crossings).

9.3 Results and Discussion

Development of aquatic vegetation continued in Harris Lake during 1986. Seventy species of aquatic plants were observed in or immediately adjacent to the lake and auxiliary reservoir (Table 9.1). This was four more than the total number observed in 1985 and reflected the addition of eight species and the disappearance of four. These changes involved species infrequently encountered during field surveys and did not reflect any observable shift in the overall structure of the aquatic vegetation of the auxiliary reservoir or Harris Lake.

9.3.1 Harris Lake

The aquatic vegetation of Harris Lake in 1986 continued to be dominated by three distinct communities: the emergent, the submersed, and the floating leaf.

The emergent community grew in a narrow zone (± 2 m wide) around most of the lake, expanding to cover several hectares in the headwater areas of the White Oak and Little White Oak Creek arms. This community was essentially unchanged from 1985. Dominant species included cat-tail *Typha latifolia*, rushes *Juncus effusus* and *J. coriaceus*, bulrushes *Scirpus cyperinus* and *S. atrovirens*, water primrose *Ludwigia leptocarpa*, and bur-reed *Sparganium americanum*. Creeping water primrose *Ludwigia uraguayinsis* was again observed in the lake. Three small areas of this potentially troublesome species were removed by hand from the vicinity of the boat ramp near Highway NC 42.

The floating-leaf community in Harris Lake was dominated by watershield *Brasenia schreberi*. Water-lily *Nymphaea odorata* and lotus *Nelumbo lutea* were present in smaller quantities. This community expanded in areal coverage from 1985 levels, especially in the White Oak Creek arm of the lake, with the greatest increase observed in the area above SR 1127 (Area S). One small (ca. 1-m diameter) area of watershield was observed in the upper end of the Buckhorn Creek arm (Area I) in October. This was the first evidence of floating-leaf vegetation in this arm of the lake.

Submersed vegetation in Harris Lake experienced the greatest increase of the three communities present. Although species composition was unchanged, major increases in coverage were observed. During May, bladderwort *Utricularia inflata* was the dominant species in the headwaters of the three major arms of the lake. In June large stands of pondweed *Potamogeton berchtoldii* dominated many areas of the lake less than 3 m deep. The greatest quantities of pondweed occurred along the north side of the White Oak Creek arm, in the upper end of the Buckhorn Creek arm, and in the upper end of the Little White Oak Creek arm. This distribution and coverage represented a major increase in the quantity of pondweed over that of 1985. Other dominants within the submersed community, especially during late summer and fall, were naiads *Najas minor*, *N. gracillima*, and *N. guadalupensis*.

In October all areas of Harris Lake less than 3 m deep supported submersed vegetation. Dominant species at that time continued to be naiads, with pondweed still present in small quantities. The area of the lake less than 3 m deep represents approximately 36% of the total, with the percentage ranging from about 14% near the dam to about 80% of the headwater areas (Area S). The increase in coverage of the submersed community was attributed to extreme drought conditions which resulted in reduced turbidity and slightly lower water levels during summer.

9.3.2 Auxiliary Reservoir

The emergent community around the auxiliary reservoir was essentially identical to the emergent community around Harris Lake. Dominants were cat-tail, bulrush, and various other sedges, rushes, and grasses. The major change from 1985 to 1986 was a general increase in coverage.

The only submersed vegetation in the auxiliary reservoir was variable leaf pondweed *Potamogeton diversifolius* and musk grass (probably *Chara contraria*). These species were confined to shallow (less than 1 m deep) areas near the shore and their presence did not represent a threat to this source of emergency service water.

Floating-leaf vegetation continued to be absent from the auxiliary reservoir.

9.4 Summary

The vegetation of Harris Lake increased from 1985 to 1986. The major change was an increase in the coverage of pondweed. By October, all areas of the lake less than 3 m deep supported three species of naiad and pondweed. This increase was attributed to reduced turbidity and water levels that resulted from the extreme drought conditions that persisted throughout the summer. Although the aquatic vegetation in Harris Lake does not pose a threat to water withdrawals for power plant operations, continued increases such as those observed over the past two years could result in future problems.

The auxiliary reservoir supported small quantities of submersed vegetation and floating-leaf species were absent.

Table 9.1 Macrophytes observed in or adjacent to Harris Lake and the auxiliary reservoir during 1986.

Family	Species	Community‡
Characeae	*Chara* sp.	S
Characeae	*Nitella flexilis*	S
Osmundaceae	*Osmunda cinnamomea*	E
Azollaceae	*Azolla caroliniana*	F
Typhaceae	*Typha latifolia*	E
Sparganiaceae	*Sparganium americanum*	E
Potamogetonaceae	*Potamogeton berchtoldii*	S
Potamogetonaceae	*P. diversifolius*	S
Najadaceae	*Najas gracillima*	S
Najadaceae	*N. guadalupensis*	S
Najadaceae	*N. minor*	S
Alismataceae	*Alisma subcordata*	E
Alismataceae	*Sagittaria engelmanniana*	E
Alismataceae	*S. latifolia*	E
Alismataceae	*S. longirostra*	E
Hydrocharataceae	*Vallisneria americana*	S
Poaceae	*Echinochloa crusgalli*	E
Poaceae	*Erianthus giganteus*	E
Poaceae	*Leersia oryzoides*	E
Poaceae	*Panicum dichotomiflorum*	E
Poaceae	*P. stipitatum*	E
Cyperaceae	*Carex lurida*	E
Cyperaceae	*Cyperus erythrorhizos*	E
Cyperaceae	*C. odoratus*	E
Cyperaceae	*C. ovularis*	E
Cyperaceae	*C. pseudovegetus*	E
Cyperaceae	*C. strigosus*	E
Cyperaceae	*Eleocharis baldwinii*	E
Cyperaceae	*E. microcarpa*	E
Cyperaceae	*E. obtusa*	E
Cyperaceae	*E. quadrangulata*	E
Cyperaceae	*Fimbristylis autumnalis*	E
Cyperaceae	*Rhynchospora corniculata*	E
Cyperaceae	*Scirpus atrovirens*	E
Cyperaceae	*S. cyperinus*	E
Lemnaceae	*Wolffia papulifera*	F
Juncaceae	*Juncus acuminatus*	E
Juncaceae	*J. coriaceus*	E

Table 9.1 (continued)

Family	Species	Community‡
Juncaceae	*J. effusus*	E
Juncaceae	*J. marginatus*	E
Juncaceae	*J. tenuis*	E
Salicaceae	*Populus deltoides*	E
Salicaceae	*Salix nigra*	E
Saururaceae	*Saururus cernuus*	E
Betulaceae	*Betula nigra*	E
Betulaceae	*Alnus serrulata*	E
Polygonaceae	*Polygonum pensylvanicum*	E
Polygonaceae	*P. hydropiperoides*	E
Nymphaeaceae	*Nymphaea odorata*	F
Nelumbonaceae	*Nelumbo lutea*	F
Cabombaceae	*Brasenia schreberi*	F
Platanaceae	*Platanus occidentalis*	E
Rosaceae	*Rosa palustris*	E
Balsaminaceae	*Impatiens capensis*	E
Lythraceae	*Rotala ramosior*	E
Melastomataceae	*Rhexia mariana*	E
Onagraceae	*Ludwigia leptocarpa*	E
Onagraceae	*L. palustris*	E
Onagraceae	*L. uruguayinsis*	S
Haloragaceae	*Myriophyllum brasiliense*	S
Cornaceae	*Cornus amomum*	E
Scrophulariaceae	*Gratiola viscidula*	E
Scrophulariaceae	*Lindernia anagallidea*	E
Lentibulariaceae	*Mecardonia acuminata*	E
Lentibulariaceae	*Utricularia inflata*	S
Rubiaceae	*Cephalanthus occidentalis*	E
Campanulaceae	*Lobelia siphilitica*	E
Asteraceae	*Eclipta alba*	E
Asteraceae	*Pluchea camphorata*	E
Asteraceae	*Mikania scandens*	E

‡E = Emergent

F = Floating leaf

S = Submerged

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Appendix A

Concentrations of Chemical Variables in
Harris Lake During 1986

Appendix A. Concentrations of chemical variables in Harris Lake during 1986. Units are mg/liter except those marked with an asterisk (*) which are in µg/liter and turbidity which is in NTU. Trace elements are total concentrations.

Station	Month	Depth	Total alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total-N	NH_4^+-N	$NO_3^-NO_2^-N$
E2	Jan	Bot	19.6	4.4	6.2	4.2	1.6	5.0	1.7	•	0.21	0.17
	Feb		14.0	4.4	6.2	3.8	1.5	5.7	1.8	0.40	0.09	0.19
	Mar		14.7	4.6	6.6	4.0	1.6	5.0	1.6	0.36	•	0.22
	Apr		19.3	4.7	6.2	4.2	1.6	5.1	1.7	0.54	0.19	0.14
	May		36.0	4.6	4.6	5.3	1.9	5.3	1.6	0.90	0.81	0.01
	Jun		36.2	4.7	4.1	4.8	1.8	6.0	2.1	0.86	0.78	0.01
	Jul		34.4	4.9	4.7	5.0	1.8	5.5	1.8	0.82	0.67	<0.01
	Aug		57.6	4.8	< 1.0	3.5	1.3	5.5	2.0	1.90	1.90	<0.01
	Sep		41.9	5.0	3.7	4.4	1.5	6.2	1.8	1.30	1.10	0.02
	Oct		49.0	4.9	1.9	6.2	2.1	6.4	1.9	1.40	1.35	<0.01
	Nov		18.0	4.6	5.3	4.3	1.7	5.1	1.7	0.48	0.13	0.04
	Dec		20.0	3.9	4.7	4.2	1.7	4.2	1.4	0.48	0.24	0.10

Station	Month	Depth	Total P	TDP	TPP	DMRP	Disolved organic P	Silica	TOC	Turbidity	Hardness	Total solids
E2	Jan	Bot	0.015	0.008	0.007	0.001	0.007	3.0	4.3	2.5	17	53
	Feb		•	•	•	0.001	•	2.6	5.2	1.9	16	36
	Mar		0.011	0.007	0.004	0.001	0.006	2.2	5.4	1.8	17	59
	Apr		0.015	0.007	0.008	0.001	0.006	2.8	4.7	1.4	17	60
	May		0.023	0.009	0.014	0.001	0.008	4.2	7.3	5.8	21	109
	Jun		0.026	0.012	0.014	0.006	0.006	4.0	8.1	5.4	19	67
	Jul		0.026	0.016	0.010	0.009	0.007	3.5	7.9	6.8	20	91
	Aug		0.150	0.120	0.030	0.130	< 0.010	6.5	•	8.6	14	131
	Sep		0.027	0.017	0.010	0.013	0.004	4.2	•	9.4	17	103
	Oct		•	0.040	•	0.039	0.001	5.0	8.3	9.0	24	113
	Nov		0.009	0.004	0.005	0.004	0.000	3.0	8.4	8.9	18	68
	Dec		0.009	0.005	0.004	< 0.001	0.006	3.0	6.3	3.5	18	59

Station	Month	Depth	Total dissolved solids	As*	Cd*	Cr*	Cu*	Hg*	Ni*	Pb*	Se*	Zn*	Fe*	Al*	Mn*
E2	Jan	Bot	47	< 1	< 0.5	< 2	6	< 0.10	< 5	1.0	< 1	< 20	460	30	340
	Feb		29	< 1	< 0.5	< 2	1	< 0.10	5	< 1.0	< 1	< 20	240	30	120
	Mar		41	< 1	< 0.5	< 2	2	< 0.10	< 5	1.0	< 1	< 20	210	30	130
	Apr		18	< 1	< 0.5	< 2	2	0.24	< 5	1.0	< 1	< 20	350	70	1200
	May		70	1	< 0.5	< 2	2	< 0.10	< 5	2.0	1	< 20	5400	40	6300
	Jun		41	1	< 0.5	< 2	2	< 0.10	< 5	1.0	< 1	< 20	3400	40	70
	Jul		94	1	< 0.5	< 2	2	< 0.10	5	1.9	< 1	< 20	4800	60	4300
	Aug		81	1	< 0.1	< 2	1	< 0.10	< 5	1.0	< 1	< 20	8000	40	4400
	Sep		82	2	< 0.1	< 2	1	< 0.10	< 5	< 1.0	< 1	< 20	8300	100	4800
	Oct		114	2	0.1	< 2	2	< 0.10	< 5	< 1.0	1	< 20	12000	60	6400
	Nov		67	1	< 0.1	< 2	< 1	< 0.10	< 5	< 1.0	1	< 20	320	< 20	460
	Dec		57	1	< 0.1	< 2	1	< 0.10	< 5	1.0	< 1	< 20	560	< 20	600

•Are missing values.

Appendix A (continued)

Station	Month	Depth	Total alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total-N	NH_4^+-N	$NO_3^-NO_2^-N$
E2	Jan	Sur	19.0	4.4	5.9	4.2	1.6	4.9	1.9	•	0.20	0.16
	Feb		15.5	4.4	6.0	3.9	1.5	5.3	1.8	0.44	0.09	0.20
	Mar		16.0	4.5	6.3	3.9	1.6	5.0	1.6	0.42	•	0.21
	Apr		15.2	4.7	6.2	3.9	1.5	4.8	1.6	0.38	0.02	0.12
	May		15.0	4.8	6.1	4.0	1.6	5.0	1.5	0.28	0.02	0.01
	Jun		14.6	4.8	5.5	3.8	1.5	5.5	1.6	0.25	< 0.02	0.02
	Jul		18.5	4.9	5.8	4.1	1.7	5.1	1.6	0.18	< 0.02	0.01
	Aug		18.5	5.1	5.9	2.7	1.2	4.9	1.4	0.34	0.02	0.01
	Sep		15.7	4.3	5.2	3.4	1.4	4.1	1.3	0.38	0.02	0.02
	Oct		19.0	4.4	5.2	4.3	1.7	4.8	1.7	0.31	0.06	< 0.01
	Nov		18.0	4.5	5.5	4.1	1.6	5.1	1.7	0.47	0.12	0.04
	Dec		20.0	4.2	5.0	4.5	1.8	5.2	1.6	0.57	0.22	0.09

Station	Month	Depth	Total P	TDP	TPP	DMRP	Disolved organic P	Silica	TOC	Turbidity	Hardness	Total solids
E2	Jan	Sur	0.013	0.009	0.004	< 0.001	0.010	3.0	8.1	2.8	17	39
	Feb		•	•	•	0.001	•	2.5	5.2	2.9	16	38
	Mar		0.015	0.007	0.008	0.001	0.006	2.0	5.7	5.1	16	64
	Apr		0.015	0.007	0.008	< 0.001	0.008	1.7	6.3	2.2	16	58
	May		0.013	0.007	0.006	< 0.001	0.008	1.2	5.4	1.9	17	89
	Jun		0.013	0.008	0.005	< 0.001	0.009	0.7	4.5	1.7	16	39
	Jul		0.011	0.007	0.004	< 0.001	0.008	1.3	6.4	2.2	17	71
	Aug		0.014	0.007	0.007	0.001	0.006	1.6	•	2.8	12	67
	Sep		0.011	0.007	0.004	< 0.001	0.008	2.6	•	3.5	14	55
	Oct		0.007	•	•	< 0.001	•	2.7	7.3	3.4	18	63
	Nov		0.012	0.006	0.006	0.001	0.005	2.9	7.4	3.3	17	73
	Dec		0.010	0.004	0.006	< 0.001	0.005	3.0	6.1	3.2	19	57

Station	Month	Depth	Total dissolved solids	As*	Cd*	Cr*	Cu*	Hg*	Ni*	Pb*	Se*	Zn*	Fe*	Al*	Mn*
E2	Jan	Sur	50	< 1	< 0.5	< 2	7	< 0.10	< 5	< 1.0	< 1	< 20	470	40	340
	Feb		32	< 1	< 0.5	< 2	1	< 0.10	5	< 1.0	< 1	< 20	240	30	130
	Mar		41	< 1	< 0.5	< 2	3	< 0.10	< 5	< 1.0	< 1	< 20	170	60	50
	Apr		36	< 1	< 0.5	< 2	2	0.67	< 5	< 1.0	< 1	< 20	70	60	110
	May		55	< 1	< 0.5	< 2	2	< 0.10	< 5	1.0	< 1	< 20	70	20	40
	Jun		58	< 1	< 0.5	< 2	1	< 0.10	< 5	< 1.0	< 1	< 20	< 50	30	< 20
	Jul		73	< 1	< 0.5	< 2	1	< 0.10	< 5	< 1.0	< 1	< 20	< 50	30	60
	Aug		30	< 1	< 0.1	< 2	< 1	< 0.10	< 5	< 1.0	< 1	< 20	50	30	70
	Sep		59	< 1	< 0.1	< 2	1	< 0.10	< 5	< 1.0	< 1	< 20	140	20	130
	Oct		82	< 1	< 0.1	< 2	1	< 0.10	< 5	2.4	< 1	< 20	140	< 20	540
	Nov		67	1	< 0.1	< 2	1	< 0.10	< 5	< 1.0	1	< 20	140	< 20	300
	Dec		54	1	< 0.1	< 2	2	< 0.10	< 5	< 1.0	< 1	< 20	530	20	580

•Are missing values.

Appendix A (continued)

Station	Month	Depth	Total alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total-N	NH_4^+-N	$NO_3^-NO_2^-N$
H2	Jan	Sur	15.8	4.4	5.7	4.0	1.6	4.7	1.6	•	0.13	0.16
	Feb		14.7	4.5	5.9	3.6	1.4	5.7	1.8	0.32	0.04	0.20
	Mar		14.0	4.6	6.1	3.6	1.5	4.7	1.6	0.34	•	0.08
	Apr		15.7	4.8	6.1	3.8	1.5	5.1	1.5	0.40	0.02	0.08
	May		16.0	4.8	5.9	4.0	1.6	5.0	1.5	0.32	< 0.02	0.01
	Jun		14.5	4.8	6.1	3.8	1.5	5.7	1.6	0.26	< 0.02	0.02
	Jul		17.0	4.9	5.7	4.2	1.8	5.2	1.5	0.20	< 0.02	0.01
	Aug		15.0	4.6	5.3	3.0	1.3	4.6	1.4	0.28	< 0.02	0.01
	Sep		15.5	4.3	5.2	2.6	1.1	5.0	1.6	0.40	0.02	0.01
	Oct		17.5	4.4	5.1	4.4	1.8	4.8	1.7	0.32	0.06	0.01
	Nov		15.0	4.4	5.3	4.0	1.6	5.0	1.7	0.46	0.12	0.04
	Dec		19.0	4.0	5.1	4.4	1.8	4.4	1.4	0.50	0.17	0.09

Station	Month	Depth	Total P	TDP	TPP	DMRP	Disolved organic P	Silica	TOC	Turbidity	Hardness	Total solids
H2	Jan	Sur	0.016	0.008	0.008	< 0.001	0.009	3.8	6.2	2.8	17	54
	Feb		•	•	•	0.001	•	3.8	5.1	3.0	15	36
	Ma		0.027	0.009	0.018	0.002	0.007	4.1	6.1	10.2	15	68
	Apr		0.018	0.007	0.011	< 0.001	0.008	2.2	6.2	3.0	16	57
	May		0.016	0.007	0.009	< 0.001	0.008	1.4	4.9	•	17	77
	Jun		0.015	0.010	0.005	< 0.001	0.011	0.8	6.6	2.4	16	42
	Jul		0.013	0.007	0.006	< 0.001	0.008	1.2	6.8	2.0	18	61
	Aug		0.013	0.007	0.006	< 0.001	0.008	1.7	•	2.6	13	53
	Sep		0.012	0.007	0.005	< 0.001	0.008	2.5	•	3.7	11	63
	Oct		0.009	0.008	0.001	< 0.001	0.009	2.8	7.1	3.8	18	68
	Nov		0.009	0.005	0.004	< 0.001	0.006	3.1	7.7	3.7	17	51
	Dec		0.011	0.005	0.006	< 0.001	0.006	3.2	6.4	3.0	18	59

Station	Month	Depth	Total dissolved solids	As*	Cd*	Cr*	Cu*	Hg*	Ni*	Pb*	Se*	Zn*	Fe*	Al*	Mn*
H2	Jan	Sur	45	< 1	< 0.5	< 2	4	< 0.10	< 5	1.0	< 1	< 20	380	30	180
	Feb		32	< 1	< 0.5	< 2	1	< 0.10	6	1.0	< 1	< 20	220	30	80
	Mar		34	< 1	< 0.5	< 2	1	< 0.10	< 5	1.0	< 1	< 20	220	150	80
	Apr		30	< 1	< 0.5	< 2	1	0.14	< 5	< 1.0	1	< 20	120	50	90
	May		48	< 1	< 0.5	< 2	2	< 0.10	< 5	1.0	1	< 20	100	< 20	70
	Jun		53	< 1	< 0.5	< 2	1	< 0.10	< 5	1.0	< 1	< 20	< 50	40	< 20
	Jul		77	< 1	< 0.5	< 2	1	< 0.10	5	1.8	< 1	< 20	< 50	30	50
	Aug		30	< 1	< 0.1	< 2	< 1	0.16	< 5	< 1.0	< 1	< 20	110	20	60
	Sep		72	< 1	< 0.1	2	1	< 0.10	< 5	< 1.0	< 1	< 20	170	< 20	110
	Oct		68	< 1	0.1	< 2	1	< 0.10	< 5	< 1.0	< 1	< 20	220	< 20	380
	Nov		49	< 1	< 0.1	< 2	< 1	< 0.10	< 5	< 1.0	< 1	< 20	130	20	210
	Dec		56	1	0.4	< 2	1	< 0.10	< 5	1.0	< 1	< 20	310	< 20	370

•Are missing values.

Appendix A (continued)

Station	Month	Depth	Total alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total-N	NH_4^+-N	$NO_3^-NO_2^-N$
P2	Jan	Sur	17.4	4.4	5.8	4.1	1.6	4.4	1.3	•	0.14	0.17
	Feb		14.0	4.5	5.8	3.9	1.6	5.4	2.0	0.42	0.08	0.19
	Mar		12.0	4.6	6.2	3.7	1.5	4.8	1.6	0.38	•	0.22
	Apr		15.2	5.0	6.2	3.7	1.5	5.0	1.5	0.44	0.02	0.09
	May		16.0	4.9	6.0	4.1	1.6	5.1	1.5	0.29	< 0.02	0.01
	Jun		14.4	4.8	6.2	3.8	1.6	5.4	1.5	0.20	< 0.02	0.02
	Jul		18.0	4.9	5.8	4.0	1.7	5.1	1.6	0.26	< 0.02	0.01
	Aug		16.6	4.8	5.4	3.4	1.5	5.1	1.5	0.28	< 0.02	< 0.01
	Sep		16.8	4.2	5.1	3.0	1.2	4.9	1.5	0.38	0.02	0.01
	Oct		18.7	4.4	5.0	4.3	1.7	4.8	1.6	0.31	0.09	< 0.01
	Nov		16.0	4.5	5.2	4.0	1.6	5.0	1.6	0.48	0.13	0.04
	Dec		17.0	4.5	5.6	4.5	1.8	4.7	1.6	0.42	0.16	0.09

Station	Month	Depth	Total P	TDP	TPP	DMRP	Disolved organic P	Silica	TOC	Turbidity	Hardness	Total solids
P2	Jan	Sur	0.012	0.007	0.005	< 0.001	0.008	2.1	7.2	3.0	17	58
	Feb		•	•	•	< 0.001	•	1.8	5.3	2.7	16	43
	Mar		0.011	0.008	0.003	0.001	0.007	1.4	5.9	4.1	15	62
	Apr		0.018	0.007	0.011	< 0.001	0.008	1.4	6.5	2.9	15	59
	May		0.015	0.007	0.008	< 0.001	0.008	1.2	6.7	2.2	17	74
	Jun		0.014	0.008	0.006	< 0.001	0.009	0.6	6.5	2.2	16	41
	Jul		0.013	0.007	0.006	< 0.001	0.008	1.4	6.4	2.4	17	71
	Aug		0.011	0.007	0.004	< 0.001	0.008	1.8	•	3.2	15	60
	Sep		0.012	0.006	0.006	< 0.001	0.007	2.4	•	4.3	12	56
	Oct		0.011	0.007	0.004	< 0.001	0.008	2.8	7.3	4.4	18	53
	Nov		0.009	0.004	0.005	< 0.001	0.005	2.9	7.7	4.2	17	82
	Dec		0.009	0.004	0.005	< 0.001	0.005	2.6	6.2	2.8	19	57

Station	Month	Depth	Total dissolved solids	As*	Cd*	Cr*	Cu*	Hg*	Ni*	Pb*	Se*	Zn*	Fe*	Al*	Mn*
P2	Jan	Sur	46	< 1	< 0.5	< 2	5	< 0.10	< 5	2.0	< 1	< 20	350	40	220
	Feb		32	< 1	< 0.5	< 2	2	< 0.10	6	2.0	< 1	< 20	310	50	150
	Mar		23	< 1	< 0.5	< 2	2	< 0.10	< 5	1.0	< 1	< 20	140	40	60
	Apr		40	< 1	< 0.5	< 2	1	0.11	< 5	< 1.0	< 1	< 20	110	60	130
	May		49	< 1	< 0.5	< 2	1	< 0.10	< 5	1.0	< 1	< 20	70	< 20	50
	Jun		27	< 1	< 0.5	< 2	2	< 0.10	< 5	1.0	< 1	< 20	< 50	40	< 20
	Jul		73	< 1	< 0.5	< 2	1	< 0.10	5	< 1.0	< 1	< 20	60	20	90
	Aug		39	< 1	< 0.1	9	< 1	< 0.10	< 5	< 1.0	< 1	< 20	170	40	150
	Sep		45	< 1	< 0.1	< 2	1	< 0.10	< 5	< 1.0	< 1	< 20	190	20	230
	Oct		68	< 1	0.1	< 2	1	< 0.10	< 5	1.0	< 1	< 20	310	< 20	800
	Nov		49	< 1	< 0.1	< 2	< 1	< 0.10	< 5	< 1.0	< 1	< 20	120	20	190
	Dec		55	< 1	< 0.1	< 2	< 1	< 0.10	< 5	1.1	< 1	< 20	260	< 20	350

*Are missing values.