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SHEARON HARRIS NUCLEAR POWER PLANT
1987-1988 ANNUAL ENVIRONMENTAL MONITORING REPORT

Prepared by:

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Environmental Assessment Unit
Biological Assessment Unit

Environmental Services Section

CAROLINA POWER & LIGHT COMPANY

NEW HILL, NORTH CAROLINA

May 1990

Reviewed and Approved by:

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

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Manager
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This copy of the report is not a controlled document as detailed in the Biological Monitoring Unit, Biological Assessment Unit, and Environmental Assessment Unit Procedures Manual and Quality Assurance Manual. Any changes made to the original of this report subsequent to the date of issuance can be obtained from:

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Acknowledgments

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Special thanks are given to members of Carolina Power & Light Company's Chemistry Laboratory for conducting the chemical analyses and to members of the Office Services Unit at the Harris Energy & Environmental Center for assistance with the processing and proofing of the final report and preparation of the figures.

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Metric Conversion and Units of Measure Table

Length

1 micron (μm) = 4.0×10^{-5} inch

1 millimeter (mm) = 1000 μm = 0.04 inch

1 centimeter (cm) = 10 mm = 0.4 inch

1 meter (m) = 100 cm = 3.28 feet

1 kilometer (km) = 1000 m = 0.62 mile

Area

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

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

Weight

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

1 milligram (mg) = 3.5×10^{-5} ounce

1 gram (g) = 1000 mg = 0.035 ounce

1 kilogram (kg) = 1000 g = 2.2 pounds

1 metric ton = 1000 kg = 1.1 tons

1 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)

Conductivity

Microsiemens/centimeter = $\mu S/cm$ = $\mu mhos/cm$

EXECUTIVE SUMMARY

Harris Lake was impounded in December 1980 and reached full pool in early 1983. Power plant operations began in early 1987. This report focuses on the period of the first two years of plant operations (1987-1988) and assesses the water quality, water chemistry, and biota of Harris Lake and surrounding lands.

With the initiation of plant operations, Harris Lake began receiving cooling tower blowdown discharge near the main dam. As a result, phosphorus concentrations increased in the downstream area of the lake in 1987, especially in the bottom waters. Zinc phosphate was used at the plant as a corrosion inhibitor. Nitrogen concentrations also increased during 1987 in this area, probably as a result of discharges from the Harris sewage treatment plant and oxygen-scavenging compounds used in the power plant. During 1988, phosphorus and nitrogen concentrations increased throughout other areas of the lake as a result of mixing and diffusion. This process was exaggerated by the extreme drought conditions that occurred from late 1987 through late 1988. During this period, little or no water flowed over the main dam spillway and there was no flushing of the lake.

The increases in concentrations of phosphorus and nitrogen resulted in increased algal biomass throughout much of the lake. The overall result of these changes was that Harris Lake changed from a lake of low productivity to one of medium productivity within the range (for nutrient and algal concentrations) typical of many southeastern United States reservoirs. The trend of increased nutrients in the lake, while currently an asset to the overall productivity, bears scrutiny to ensure that potential future increases in nutrients do not result in the lake becoming too highly productive and prone to excessive algal blooms. Planned modifications to the circulating water system should reduce the quantities of cooling tower blowdown to the lake.

Other aspects of water quality, water chemistry, and trace elements were essentially unaffected by Harris Plant operations with the exception

of slightly elevated (above background) concentrations of zinc in lake sediments near the cooling tower blowdown pipe discharge. The probable source of zinc was the zinc phosphate used at the plant for corrosion control. Even though slightly elevated, the concentrations of zinc were considered to be low and of no biological concern.

Harris Lake supported homogeneous, diverse populations of phytoplankton and zooplankton. Phytoplankton populations increased from previous low levels to moderate levels which were similar to other piedmont North Carolina reservoirs. This increase was in response to the increases in nitrogen and phosphorus in the lake. Zooplankton biomass and taxa richness declined from previous levels but densities increased. These changes were attributed to increases in larval fish populations and the introduction of threadfin shad into the lake.

Benthic macroinvertebrate populations were similar throughout the lake, an indication of the similarity of habitats and environmental conditions. The most significant change to the benthic community was the increase of the Asiatic clam *Corbicula fluminea*. Asiatic clams are a biofouling organism with the potential to block pipes and tubes in raw water systems. This non-native species was collected in 1988 near the Hollemans Crossroad boat ramp where it was probably introduced into the lake by boaters. No clams were collected from the intake canal areas of the main lake and auxiliary reservoir, the plant intake structures, or the auxiliary reservoir.

Harris Lake supported a productive and diverse fish community dominated by gizzard shad, largemouth bass, and bluegill. Based on results of a fishing tournament held during 1988, the previously documented slow growth rate of largemouth bass may have accelerated. An increase in growth rate was probably the result of the introduction of threadfin shad into the lake and/or the increased abundance of smaller gizzard shad which provided an improved food source. No impacts from power plant operations on the fish community were observed.

The lake continued to support large areas of submersed aquatic vegetation. The dominant species were pondweed, naiad, watershield, and lotus which were all native to the region. However, hydrilla *Hydrilla verticillata* was discovered growing in Harris Lake during 1988 in the White Oak arm. This introduced species has the ability to outcompete native plant species and colonize large areas of the lake. Hydrilla is not expected to interfere with power plant operations. The auxiliary reservoir continued to remain nearly devoid of submersed vegetation.

Harris Lake and surrounding lands provided good habitat for many species of birds, which were the primary focus of terrestrial wildlife studies. Two federally endangered species, the bald eagle and the red-cockaded woodpecker, were observed on Harris site lands during the study period. The American coot, pied-billed grebe, ring-necked duck, and ruddy duck were the waterfowl species observed most frequently and in greater numbers on Harris Lake. Wood duck usage of nest boxes erected in portions of Harris Lake continued to increase. Monitoring of bird mortality from collisions with the cooling tower during migration periods documented an extremely low number of birds killed due to impact with this structure.

1.0 INTRODUCTION

The Shearon Harris Nuclear Power Plant nonradiological environmental monitoring program continued during 1987 and 1988. This program included investigations of the water quality and chemistry, plankton, benthic macroinvertebrates, fish, and vegetation of the 1660-hectare Harris Lake and the surrounding terrestrial vertebrate communities. Trace element concentrations in lake water were sampled during 1987. During 1988, trace element concentrations were determined for lake water, fish, plankton, and sediments.

The Harris Plant circulating and cooling tower makeup water systems began testing operations in January 1987, and the plant began commercial operation in May of that year. Thus, the studies conducted in 1987 and 1988 reflected conditions resulting from the first two years of plant operations.

2.0 METHODS

2.1 Data Collection

Water Quality and Water Chemistry

Water quality variables (i.e., water temperature, dissolved oxygen, pH, and specific conductance) were measured monthly during 1987 and bimonthly (beginning in January) during 1988 at Stations E2, H2, and P2 at 1-m intervals from surface to bottom (Tables 2.1, 2.2; Figure 2.1). Instruments were calibrated in the laboratory and field-checked prior to use. Secchi disk transparency, a measure of water clarity, was also determined at each station. Surface water chemistry samples were collected monthly during 1987 and bimonthly (beginning in January) during 1988 at Stations E2, H2, and P2; and a bottom water sample was also collected at Station E2. Samples were collected with a nonmetallic Van Dorn sampler, transferred to prewashed sample containers, and transported on ice to CP&L's Chemistry Laboratory. Samples were collected, preserved, and analyzed according to standard methods (USEPA 1979; APHA 1986). Standards, spikes, and replicate analyses were used to determine the accuracy and precision of the analytical techniques.

Trace Elements

Water samples from Stations E2 (surface and bottom) and H2 and P2 (surface only) were analyzed for aluminum (Al), arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn). Samples were collected monthly in 1987 and bimonthly (beginning in January) in 1988.

Fish (brown bullhead, bluegill, and largemouth bass) were collected during May 1988; net plankton ($\geq$ 163 μm) and sediment samples were collected during July 1988. Whole bodies of fish were analyzed following removal of the stomach and intestine. Sediments were sieved to obtain the fraction with particle size < 63 μm. All fish, net plankton, and sediment samples were homogenized and freeze-dried. Tissues were digested using nitric acid and microwave heating technique (Patterson et al. 1988). All tissue values were expressed on a dry-weight basis. Sediments and tissue samples were analyzed for As, Cd, Cu, Hg, Se, and Zn. Standard techniques were employed by the Chemistry Laboratory (CP&L 1980) and by the Nuclear Services Laboratory (NCSU 1985). Precision and accuracy of the water, tissue, and sediment data was ensured by using analytical standards, certified reference materials, and analytical replications (Appendix A). Laboratory reporting limits were established as the blank concentration plus three standard deviations of the blank concentration.

Phytoplankton (Algae)

Phytoplankton samples were collected monthly during 1987 and bimonthly in 1988 (beginning in January) at Stations E2, H2, and P2 (Tables 2.1 and 2.2; Figure 2.1). Sample collection methods and laboratory processing procedures were consistent with those previously described (CP&L 1984a, 1984b).

Data collected in 1987 and 1988 were compared with those of previous years. Contaminated laboratory reagents resulted in inaccurate determinations of chlorophyll *a* concentrations from January through April 1986 and required omission of these data from statistical comparisons.

Zooplankton

Wisconsin net tows (bottom or from 12 m to surface) were used to collect zooplankton at Stations E2, H2, and P2 (Tables 2.1 and 2.2; Figure 2.1). Two tows were taken at each station. During the first tow, an 80-μm mesh net was used to collect rotifers, protozoa, and copepod nauplii. During the second tow, a 153-μm mesh net was used to collect adult copepods, copepodites, and cladocerans. Samples were collected monthly in 1987 and bimonthly (beginning in January) in 1988. Samples were preserved and analyzed according to methods described in previous studies (CP&L 1984a). Nauplii, rotifers, and protozoans were identified and counted from a 1-ml subsample in a Sedgewick-Rafter counting cell.

Benthic Macroinvertebrates

Three replicate petite Ponar grabs from the 2-m depth were taken bimonthly (beginning in January) at Stations E1, H1, and P1 (Figure 2.1) during 1987 and 1988. Methods of sample preservation, laboratory processing, and organism enumeration were similar to those used during 1985 (CP&L 1986).

Asiatic clam *Corbicula fluminea* sampling frequency for the main lake (V3) and auxiliary reservoir (Z1) intake canals was bimonthly (beginning in January) and coincided with the regular monitoring program during 1987 and 1988. Samples were processed as during 1985 (CP&L 1986). Methods for the 1987 whole lake shoreline survey were the same as in 1985, but during 1988, sampling was carried out at ten predetermined shoreline stations. Sampling was conducted in October of each year.

During 1987 and 1988, 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. All samples were collected as in 1985 with the exception of the sprinkler system which was sampled at an inspection pipe leading from the service water building. Samples collected during 1987 were field-sieved using a 300-μm mesh wash bucket, and samples collected in 1988 were returned to the laboratory for processing.

Fish

The sampling effort during 1987 and 1988 consisted of electrofishing during February, May, August, and November at ten stations (E1, E3, H1, H3, P1, P3, S1, S3, V1, V3) and larval push net sampling during April-June at five stations (E1, H3, P3, S1, V3; Figure 2.1). During 1988, cove rotenone sampling was conducted at Areas E, H, and P. Methods used during both years were the same as in 1986 (CP&L 1987).

All fish collected were identified to the lowest possible taxon, counted, measured for total length 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) where applicable.

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

A major largemouth bass fishing tournament was held during March 1987 (292 anglers) and a minor one during October 1988 (80 anglers). All largemouth bass brought to the weigh station by the contestants were weighed and measured by CP&L biologists. In addition, all healthy largemouth bass were tagged with Floy 67-C tags and released (515 fish in 1987 and 220 fish in 1988).

Terrestrial Studies

Birds were systematically monitored during 1987 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 (January, April, July, October) beginning at sunrise using the method described in CP&L (1985). Spring and winter bird counts were scheduled once during May and December, respectively. The purpose of these counts was to identify breeding and overwintering populations by surveying several habitat types at the Harris site. 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 2.1).

Surveys were conducted during 1987 to monitor the use of artificial nest boxes by wood ducks and bluebirds. Bluebird nest boxes placed in Wildlife Management Area 1 and the Exclusion Area Refuge were checked periodically for nesting activity from March through August of 1987.

The red-cockaded woodpecker refuge site was monitored once a week from April through July 1987 for nesting activity. Cavity trees were tapped during each visit to see if an adult flushed. If an adult was present, North Carolina State University 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 from collisions with the 160-m-tall cooling tower at the SHNPP was conducted during 1987 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, reptiles, and amphibians observed while conducting other field activities were recorded as miscellaneous observations.

Quantitative vegetation surveys were conducted during 1987 in seven compartments located in Wildlife Management Area 2 and the Greentree Reservoir basin. 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 relative importance of canopy trees.

Aquatic Vegetation

Three qualitative surveys of Harris Lake and the auxiliary reservoir were conducted between June and October in 1987 and 1988. Methods followed those utilized since 1984 (CP&L 1985). Portions surveyed of the lake and auxiliary reservoir were in Areas I, E, P, Q, S, V, and Z (Figure 2.1). Special emphasis was placed on public access points, such as boat ramps and road crossings, where the introduction of potentially troublesome species was most likely.

2.2 Statistical Analyses

For purposes of statistical analyses, if some concentrations for a specific chemical or trace element value were estimated to be below the detection level and some concentrations were measured above the detection level, a mean of all values was calculated by using the above detection values plus one-half the detection level for the "less than" values. The resultant reported mean based on such left-censored data would then have been less than the laboratory detection level.

Data from all programs, except aquatic vegetation and terrestrial studies, were analyzed with the General Linear Models procedure of the Statistical Analysis System®. One-way analyses of variance (ANOVA) blocked on month tested the 1987 and 1988 data separately for reservoir spatial differences (Transects/Stations E, H, P) in aqueous trace element concentrations, phytoplankton and zooplankton densities and biomass, and benthic invertebrate densities and taxonomic richness. A one-way ANOVA tested the 1988 sediment and biota trace element data and the 1988 water chemistry data for spatial differences. A paired t-test tested surface vs. bottom water chemistry and trace element data at Station E2 for 1987 and 1988.

The 1983-1988 data for phytoplankton and zooplankton densities and biomass, benthic invertebrate densities and taxonomic richness, larval fish catch-per-unit effort, and water chemistry concentrations were tested with two-way ANOVAs to determine long-term spatial and temporal trends within the reservoir. The aqueous trace element concentration data base was analyzed with two-way ANOVAs for monthly data from 1983 through 1987. To facilitate comparisons of phytoplankton, zooplankton, and benthic invertebrate data, bimonthly values were selected from the data bases to correspond to months sampled in 1988. The two-way ANOVAs tested year and either station or transect as the main effects. The interaction term was either year-by-station or year-by-transect. A month blocking factor was used for all data except the larval fish data where sampling trip was used as the blocking factor.

To satisfy the normality, homogeneity of variances, and additive effect assumptions of some of the ANOVA models, the data were transformed with either a natural logarithmic $\log_e (X + 1)$ or square root procedure $(X + 0.5)^{1/2}$. When a significant difference was found among the main effects (i.e., station/transect and/or year), a mean separation procedure provided a statistical ranking of the treatment means. The mean separation procedures used were either the Fisher's protected least significant difference (LSD) test or the Duncan's multiple range test. A Type I error rate of 5% ($\alpha = 0.05$) was used to judge the significance of all tests.

Table 2.1 Harris Lake environmental monitoring program for 1987.

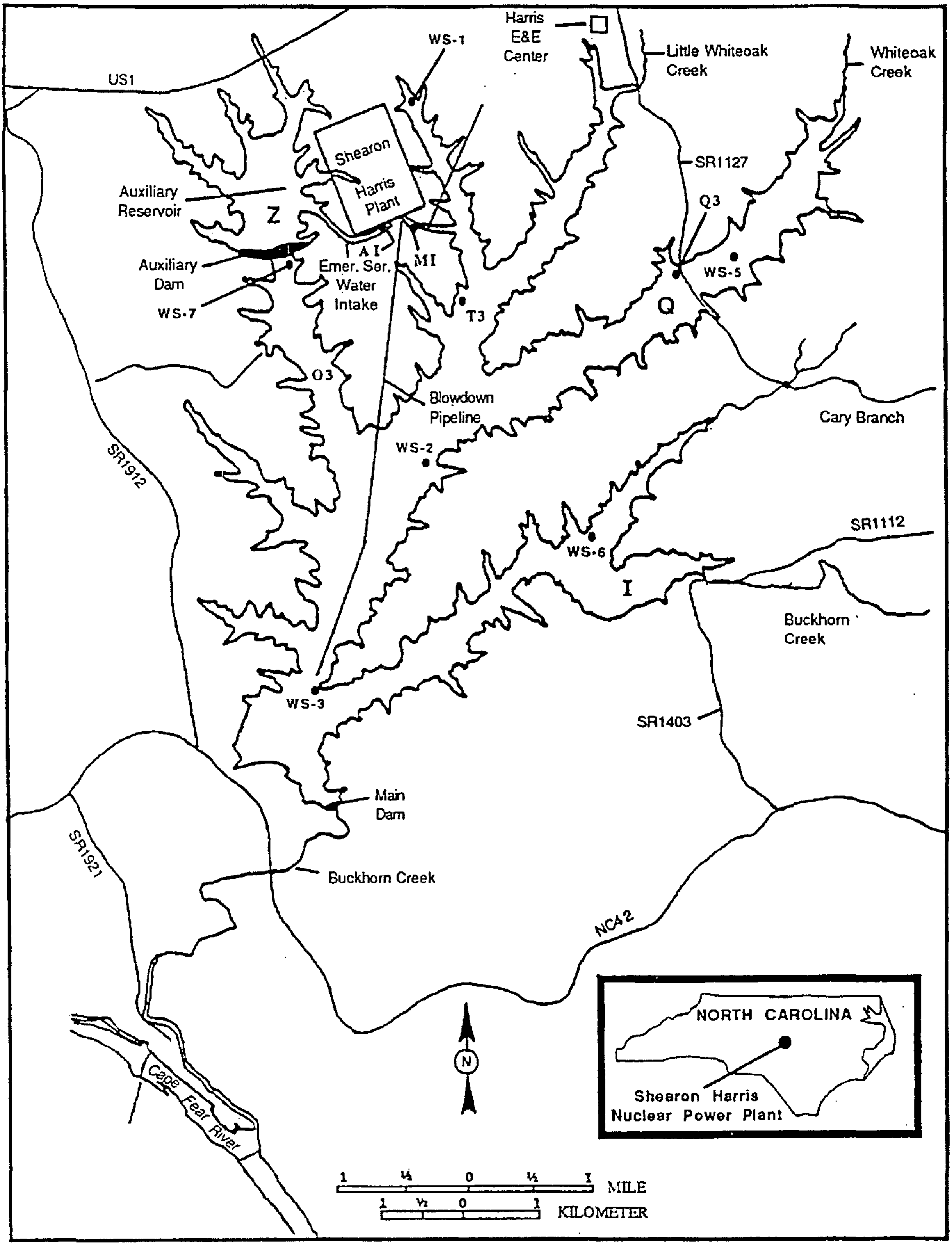
Program	Frequency	Location
Water quality	Monthly	E2, H2, P2
Water chemistry	Monthly	E2, H2, P2
Trace elements		
Lake water	Monthly	E2, H2, P2
Phytoplankton and Zooplankton	Monthly	E2, H2, P2
Benthic invertebrates		
Monitoring	Bimonthly	E1, H1, P1
Intake canals *Corbicula* survey	Bimonthly	V3, Z1
Shoreline *Corbicula* survey	Annually	Stations at 1.6-km intervals around shoreline
Corbicula survey of emergency service water and cooling tower makeup systems	Biannually	Emergency service water and cooling tower makeup system intake structures
Fish		
Electrofishing	Quarterly	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
Troublesome aquatic vegetation survey	Spring, summer, fall	I, E, P, Q, S, V, Z
Terrestrial vertebrates		
Miscellaneous terrestrial vertebrate observations	Variable	Throughout site
Roadside bird survey	Quarterly	Merry Oaks-Buckhorn Dam route

Table 2.1 (cont.)

Program	Frequency	Location
Waterfowl survey	Once every two weeks (Jan-Mar, Oct-Dec)	WS1, WS2, WS3, WS5, WS6, WS7, WS8, WS9
Spring and Christmas bird counts	Biannually	Harris Lake and Harris lands
Wildlife management		
Bluebird nest box program	March 1-August 31	Wildlife Management Areas
Habitat inventory	Once per compartment (inventories conducted during spring, summer, and fall)	Wildlife Management Area 2--Compartments 14-20
Red-cockaded wood-pecker refuge moni-toring	Once weekly April 1-July 31; once monthly January 1-March 31, August 1-December 31	Refuge area

Table 2.2 Harris Lake environmental monitoring program for 1988.

Program	Frequency	Location
Water quality	Bimonthly	E2, H2, P2
Water chemistry	Bimonthly	E2, H2, P2
Trace elements		
Lake water	Bimonthly	E2, H2, P2
Sediment	Annually	E, H, P
Net plankton	Annually	E, H. P
Fish	Annually	E, H. P
Phytoplankton and Zooplankton	Bimonthly	E2, H2, P2 S2 (phytoplankton only)
Benthic invertebrates		
Monitoring	Bimonthly	E1, H1, P1
Intake canal *Corbicula* survey	Bimonthly	V3, Z1
Shoreline *Corbicula* survey	Annually	E3, H1, O1, P1, Q1, T3, MI, AI
Corbicula survey of emergency service water and cooling tower makeup systems	Biannually	Emergency service water and cooling tower makeup system intake structures
Fish		
Electrofishing	Quarterly	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
Rotenone	September	E, H, P
Troublesome aquatic vegetation survey	Spring, summer, fall	I, E, P, Q, S, V, Z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Whiteoak Creek
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Q3
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MI
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Emer. Ser. Water Intake
WS-7
T3
Q
O3
Blowdown Pipeline
Cary Branch
WS-2
SR1912
SR1112
WS-6
I
Buckhorn Creek
WS-3
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3.0 WATER QUALITY AND WATER CHEMISTRY

3.1 Water Quality

During 1987 and 1988, Harris Lake had thermal characteristics typical of a Piedmont reservoir with maximum surface water temperatures occurring during midsummer (Figure 3.1). The lake was thermally stratified from April through October 1987. During 1988 when only bimonthly data were available, stratification was detected in May, July, and September, while the lake was isothermal the remainder of the year (Appendix B). The power plant circulating water system utilizes a closed-cycle cooling tower for heat removal. There was a discharge of slightly warmed cooling tower blowdown and other plant wastewaters into the lower depths of Harris Lake near Station E2.

In a previous study (CP&L 1988), the cooling tower blowdown was found to have had a minimal influence on the water column thermal patterns in the immediate blowdown discharge area from May 1987 to April 1988. There was no thermal influence outside of a maximum area of approximately 10.9 ha. The area of influence was usually less than 2.8 ha. The blowdown monitoring station was approximately 1.5 kilometers away from Station E2 (Figure 2.1).

The mean dissolved oxygen (DO) concentration of Harris Lake surface waters was 7.8 mg/liter in 1987 and 8.9 mg/liter in 1988. During 1987, near anoxic conditions (< 1.0 mg/liter DO) generally occurred below 5 m from June through September (Appendix B). A similar pattern was seen during 1988, except that DO concentrations of < 1.0 mg/liter occurred below 7 m during September. During 1987 and 1988, as well as during previous years, Harris Lake exhibited a sharply defined depth interval (5-7 m) below which DO concentrations rapidly declined from > 6.0 to 0.0 mg/liter (CP&L 1984a, 1985, 1986, 1987).

The mean conductivity (specific conductance) for 1987 was 74 μS/cm and for 1988 was 91 μS/cm. These values included data from all stations and depths. Conductivity increased during late 1987 and remained high during 1988 (Figure 3.1). This trend may have been due to the cooling tower blowdown discharge increasing ion concentrations in the lake as well as low rainfall during 1988. For both years, Station E2 exhibited a higher annual mean conductivity than H2 and P2 which were similar to each other (Table 3.1). Also, the minimum conductivity at all stations was higher during 1988 than in 1987 (Table 3.1). During 1986, prior to power plant operations, the conductivity was similar at all three stations (mean = 62 μS/cm, range = 32-79 μS/cm). Despite these increases, the conductivity was still within the range expected for lakes in the region.

Conductivity values have been increasing since 1984, with the greatest increase between 1987 and 1988 (Figure 3.2). Reduced precipitation from 1985 to 1986 and 1988 resulted in a low lake level that allowed only minimal, if any, water releases from the lake. This could have increased the ion concentration in the impoundment resulting in increased conductivity during those years. Initiation of power plant operations during February 1987 may have contributed to the increased conductivity. The pH did not appear to have been significantly influenced by the drought conditions.

During 1987, the pH range (5.6 to 7.6) was slightly lower than the range for 1988 (5.9 to 8.1) (Table 3.1). The highest pH recorded was 8.1 during May 1988. Higher pH values are often measured in the surface waters during the warmer months as a result of the higher photosynthetic rates of algae. The mean Secchi disk transparency (Secchi depth) for 1987 was 1.4 m and for 1988 was 1.3 m. This slight decrease in mean Secchi depth may have been due to increased phytoplankton populations.

Precipitation was below average during three of the six years from 1983 through 1988 (Figure 3.2). Two years with the lowest precipitation on record occurred consecutively, 1985 and 1986. Precipitation during 1988 was similar to 1985 and 1986, while the other years had above normal precipitation, especially 1984. Due to the high retention time of Harris Lake, reduced precipitation could have resulted in changes in certain water quality parameters (i.e., conductivity) as well as water chemistry parameters.

The annual temperature in Harris Lake increased in response to the drought conditions of 1985 and 1986 (Figure 3.2). The water temperature then decreased in 1987 when above average rainfall occurred. The low rainfall in 1988 seemed to result in only a minimal increase in water temperature.

3.2 Ions and Nutrients

During 1987, the surface concentrations of calcium were statistically higher at E2 and P2 than at H2 (Table 3.2). All other ions were not significantly different between stations for 1987. Also, most ions, other than calcium, were not higher in concentration at E2 bottom than E2 surface. Hardness was similar at Stations E2 and P2 and was significantly higher at these stations than at H2 (Table 3.2). Alkalinity and turbidity were significantly different at E2 and H2, while P2 was not different from the other stations. Alkalinity, hardness, and turbidity concentrations were higher at E2 bottom than at E2 surface.

During 1988, the calcium concentration at Station E2 was higher than at H2 and P2 (Table 3.3). There were significant differences in sodium concentrations between Stations E2 and H2, while P2 was similar to both E2 and H2 (Table 3.3). All other ions were not significantly different among stations. Concentrations of most ions at E2 bottom were similar to surface values with the exception of calcium and magnesium. Hardness was higher at Station E2 than at H2, with P2 being similar to both stations (Table 3.3). Alkalinity was similar among all stations. Alkalinity and hardness continued to be higher at E2 bottom than E2 surface. Turbidity was not different among surface stations but was higher at E2 bottom than E2 surface.

An increase in ion concentrations (e.g., chloride, sodium, and sulfate) occurred in Harris Lake from 1987 to 1988 (Table 3.4; Figures 3.3 and 3.4). These ions began increasing during either March, April, or May 1987 and continued into either July or September 1988. Alkalinity and hardness also increased between these two years.

From 1983 to 1988, several trends in surface water ion concentrations occurred. The record low precipitation for 1985, 1986, and 1988 appeared to contribute to the higher levels of alkalinity and calcium during these years (Figure 3.4) since both parameters decreased in concentration during 1987, a wetter year. The increases in chloride, sulfate, sodium, and the resulting increase in conductivity (Table 3.4; Figure 3.5) appeared to be a result of reduced rainfall and power plant operations, particularly the cooling tower blowdown discharge. Power plant effects were also indicated by the higher concentrations of most of these ions at Station E2 than at P2 and/or H2. It appeared that there was little, if any, influence from upstream runoff.

During 1987, certain nutrients, especially most of the fractions of phosphorus and total nitrogen, were significantly higher at Station E2 than at H2 and P2 (Table 3.2). Concentrations of other nutrients--such as nitrate + nitrite nitrogen, dissolved organic phosphorus, and total organic carbon--showed no differences among stations.

During 1988, only total phosphorus and total dissolved phosphorus were significantly higher at Station E2 than at H2 and P2 (Table 3.3). Silica was higher at H2 than at E2 and P2 for both years. The concentrations of nearly all nutrients were higher at E2 bottom than any surface station during both years. The concentration of total nitrogen was over twice as high at E2 bottom during 1988 as in 1987 (Table 3.2). Only total organic carbon and nitrate + nitrite nitrogen were similar at both depths.

The concentrations of total phosphorus were similar during 1987 and 1988 and were significantly higher than during 1983-1986 (Table 3.4; Figure 3.5). This increase was probably a result of power operations, specifically the discharge of the cooling tower blowdown containing phosphorus. Zinc phosphate was used at the plant as a corrosion inhibitor.

Total nitrogen concentrations were also similar during 1987 and 1988. The effect of the newly created lake caused higher total nitrogen concentrations during 1983 than any year since (Table 3.4; Figure 3.5).

This high value, considered atypical of conditions since 1983, was eliminated from trend statistical analyses resulting in a significant increase in total nitrogen between 1986 and 1987 (Table 3.4; Figure 3.5). This increase was also probably attributable to blowdown discharges which included wastewater treatment plant effluents and nitrogen containing oxygen-scavaging compounds used in power plant systems. These increases, while higher than previous years, are within the range expected for Piedmont reservoirs.

Seasonal patterns in nutrient concentrations indicated there was a buildup of phosphorus and nitrogen in the hypolimnion (lower depths) of the lake during summer stratification. Surface water concentrations of these nutrients typically declined during summer as they were taken up by algae (Figures 3.3 and 3.4). In the fall during destratification and mixing of the lake waters, these nutrients appeared to be dispersed throughout the water column.

During 1983, 1984, 1985, and 1986, the total nitrogen to total phosphorus ratio (TN:TP) ranged from 21:1 to 41:1 (Table 3.4). During 1984, 1987, and 1988, TN:TP decreased to 18:1-16:1 due to increases in phosphorus. This level is considered typical for many southeastern reservoirs.

Since initiation of power plant operations in early 1987, Harris Lake has shifted from an oligomesotrophic lake to a mesotrophic/alpha-eutrophic lake according to the classification of Weiss and Kuenzler (1976). Factors indicating this change include increased conductivity, increased total phosphorus concentrations, and reduced Secchi disk transparency. This shift in trophic status was also indicated by increased overall productivity and algal biomass (chlorophyll *a*) in the lake (see Section 5.0).

Table 3.1 Means and ranges of water quality variables from Harris Lake during 1987 and 1988. Data include all depths at each station.

1987

Station	Variable	Mean	Minimum	Maximum
E2	Temperature (°C)	13.9	5.8	23.6
	Dissolved oxygen (mg/liter)	5.8	0	10.3
	pH	6.4	5.7	7.6
	Conductivity (μS/cm)	80	36	373
	Secchi depth (m)	1.5	1.2	2.2
H2	Temperature (°C)	15.6	5.6	28.4
	Dissolved oxygen (mg/liter)	6.3	0	10.3
	pH	6.3	5.7	7.2
	Conductivity (μS/cm)	70	34	160
	Secchi depth (m)	1.3	0.8	1.8
P2	Temperature (°C)	15.6	5.6	27.9
	Dissolved oxygen (mg/liter)	6.5	0	10.5
	pH	6.2	5.6	7.2
	Conductivity (μS/cm)	71	39	140
	Secchi depth (m)	1.4	1.0	1.8

1988

Station	Variable	Mean	Minimum	Maximum
E2	Temperature (°C)	14.0	4.8	27.6
	Dissolved oxygen (mg/liter)	5.6	0.0	11.4
	pH	6.6	6.0	7.9
	Conductivity (μS/cm)	100	70	208
	Secchi depth (m)	1.33	1.0	1.5
H2	Temperature (°C)	14.3	3.5	28.9
	Dissolved oxygen (mg/liter)	6.6	0	10.3
	pH	6.4	5.9	8.1
	Conductivity (μS/cm)	87	68	135
	Secchi depth (m)	1.2	1.0	1.4
P2	Temperature (°C)	14.0	3.8	28.5
	Dissolved oxygen (mg/liter)	7.8	0.5	11.1
	pH	6.4	5.9	7.9
	Conductivity (μS/cm)	86	75	118
	Secchi depth (m)	1.4	1.0	1.7

Table 3.2 Means and ranges (in parentheses) of chemical variables in Harris Lake during 1987. Statistical analyses were performed only on surface data. Variables with the same superscript were not significantly different ($P > 0.05$).

Variable	E2 Surface	H2 Surface	P2 Surface	E2 Bottom
Total alkalinity (as $CaCO_3$)	14 (11-19)[a]	12 (8-16)[b]	13 (10-16)[ab]	25 (12-59)
Hardness (calculated as $CaCO_3$)	15 (13-18)[a]	14 (12-17)[b]	15 (13-18)[a]	18 (14-23)
Total solids	62 (49-91)	62 (40-83)	58 (31-82)	80 (47-127)
Total dissolved solids	51 (5-91)	46 (25-77)	43 (5-77)	62 (18-103)
Turbidity (NTU)	3.0 (1.8-5.6)[b]	4.6 (1.7-12)[a]	3.5 (0.82-7.5)[ab]	9.7 (2.1-66)
Nutrients (mg/liter)				
Total nitrogen	0.48 (0.32-0.69)[a]	0.42 (0.27-0.60)[b]	0.44 (0.31-0.66)[b]	1.0 (0.40-3.9)
Ammonia nitrogen	0.07 (< 0.02-0.24)[a]	0.04 (< 0.02-0.12)[b]	0.05 (< 0.02-0.17)[ab]	0.51 (0.01-1.8)
Nitrate + nitrite--N	0.06 (< 0.01-0.16)	0.06 (< 0.01-0.21)	0.05 (< 0.01-0.14)	0.08 (0.01-0.16)
Total phosphorus	0.037 (0.008-0.072)[a]	0.027 (0.010-0.061)[b]	0.024 (0.009-0.072)[b]	0.174 (0.009-1.300)
Total dissolved phosphorus	0.022 (0.005-0.053)[a]	0.013 (0.004-0.030)[b]	0.013 (0.002-0.053)[b]	0.118 (0.003-0.760)
Dissolved molybdate reactive phosphorus	0.011 (< 0.001-0.044)[a]	0.003 (< 0.001-0.018)[b]	0.005 (< 0.001-0.039)[b]	0.113 (0.001-0.790)
Dissolved organic phosphorus	0.026 (0.006-0.038)	0.024 (0.009-0.043)	0.019 (0.008-0.033)	0.061 (0.008-0.510)
Total particulate phosphorus	0.015 (0.003-0.025)[a]	0.014 (0.006-0.031)[ab]	0.011 (0.001-0.019)[b]	0.056 (0.000-0.540)
Total organic carbon	6.1 (5.6-6.8)	5.7 (2.5-6.5)	6.0 (4.5-6.9)	6.6 (5.7-8.0)
Silica	1.8 (0.3-3.1)[b]	2.4 (0.4-5.4)[a]	1.6 (0.2-2.9)[b]	3.6 (1.4-8.2)
Total nitrogen: Total phosphorus	14:1 (40:1-10:1)	16:1 (27:1-10:1)	18:1 (34:1-10:1)	6:1 (44:1-3:1)
Ions (mg/liter)				
Calcium	3.7 (3.2-4.3)[a]	3.4 (2.8-3.9)[b]	3.6 (3.2-4.3)[a]	4.4 (3.4-6.1)
Chloride	4.4 (3.6-5.0)	4.2 (3.6-5.0)	4.4 (3.7-5.2)	4.3 (3.4-5.0)
Magnesium	1.5 (1.3-1.7)	1.5 (1.2-1.7)	1.5 (1.3-1.8)	1.6 (1.4-2.1)
Potassium	2.0 (1.6-2.9)	1.9 (1.5-2.7)	1.9 (1.4-2.8)	2.0 (1.6-2.7)
Sodium	5.5 (4.2-8.2)	5.0 (3.8-6.5)	5.0 (4.0-6.5)	5.0 (2.2-6.4)
Sulfate	6.8 (5.5-8.1)	6.8 (5.7-8.0)	7.1 (5.6-8.8)	5.4 (0.5-8.1)

Table 3.3 Means and ranges (in parentheses) of chemical variables in Harris Lake during 1988. Statistical analyses were performed only on surface data. Variables with the same superscript were not significantly different ($P > 0.05$).

Variable	E2 Surface	H2 Surface	P2 Surface	E2 Bottom
Total alkalinity (as $CaCO_3$)	16 (13-18)	15 (12-18)	15 (12-18)	42 (13-100)
Hardness (calculated as $CaCO_3$)	17 (14-18)^{a}	16 (15-18)^{ab}	16 (13-18)^{b}	22 (17-32)
Turbidity (NTU)	2.8 (2.0-3.7)	2.9 (1.2-4.9)	2.7 (1.4-4.3)	10 (2.4-23)
Nutrients (mg/liter)				
Total nitrogen	0.46 (0.36-0.61)	0.48 (0.40-0.62)	0.48 (0.40-0.67)	2.67 (0.50-6.10)
Ammonia nitrogen	0.07 (< 0.02-0.26)	0.04 (< 0.02-0.10)	0.05 (0.02-0.13)	2.04 (0.02-6.00)
Nitrate + nitrite--N	0.08 (< 0.01-0.19)	0.07 (< 0.01-0.13)	0.07 (0.01-0.15)	0.07 (0.01-0.19)
Total phosphorus	0.038 (0.023-0.075)^{a}	0.026 (0.016-0.031)^{b}	0.023 (0.015-0.031)^{b}	0.312 (0.032-1.100)
Total dissolved phosphorus	0.022 (0.011-0.038)^{a}	0.013 (0.010-0.015)^{b}	0.012 (0.009-0.016)^{b}	0.264 (0.020-1.000)
Dissolved molybdate reactive phosphorus	0.010 (< 0.001-0.032)	0.002 (< 0.001-0.003)	0.002 (< 0.001-0.003)	0.249 (0.008-0.980)
Dissolved organic phosphorus	0.028 (0.016-0.043)	0.013 (0.010-0.015)	0.022 (0.013-0.030)	0.063 (0.015-0.120)
Total particulate phosphorus	0.016 (0.008-0.037)	0.013 (0.006-0.017)	0.011 (0.003-0.020)	0.048 (0.007-0.100)
Total organic carbon	6.6 (4.9-7.5)	6.7 (5.0-7.7)	6.8 (5.1-7.5)	6.8 (0.83-13)
Silica	0.9 (0.1-1.8)^{b}	1.4 (0.8-2.3)^{a}	0.8 (0.1-1.5)^{b}	3.2 (0.1-7.8)
Total nitrogen: Total phosphorus	13:1 (16:1-9:1)	18:1 (25:1-19:1)	21:1 (27:1-22:1)	9:1 (16:1-6:1)
Ions (mg/liter)				
Calcium	3.9 (3.1-4.2)^{a}	3.8 (3.2-4.2)^{b}	3.8 (3.0-4.2)^{b}	5.5 (4.0-8.2)
Chloride	5.8 (5.1-6.5)	5.7 (4.9-6.4)	5.7 (4.9-6.4)	5.6 (5.1-5.8)
Magnesium	1.7 (1.5-1.9)	1.7 (1.6-1.9)	1.7 (1.4-1.9)	2.1 (1.7-2.8)
Sodium	8.0 (7.3-8.8)^{a}	7.5 (6.4-8.8)^{b}	7.7 (6.4-9.0)^{ab}	7.8 (7.2-8.8)
Sulfate	8.8 (7.6-9.8)	8.5 (7.8-9.2)	8.9 (7.5-10)	5.3 (0.5-10)

Table 3.4 Annual lake (Stations E2, H2, and P2 combined) means (mg/liter) of selected chemical constituents in Harris Lake surface waters, 1983-1988. Means with the same superscript were not significantly different ($P > 0.05$). Analyses were based on bimonthly data for 1983-1987 to coincide with 1988 sampling frequency.

Variable	1983	1984	1985	1986	1987	1988
Total alkalinity (as $CaCO_3$)	16^{a}	13^{b}	15^{a}	16^{a}	13^{b}	15^{a}
Hardness‡	19^{a}	--	17^{b}	16^{b}	15^{c}	17^{b}
Chloride	5.1^{b}	3.9^{e}	$4.1^{d,e}$	4.6^{c}	$4.3^{c,d}$	5.7^{a}
Sulfate	5.7^{c}	5.0^{d}	5.0^{d}	5.7^{c}	6.8^{b}	8.7^{a}
Total nitrogen§	0.70	0.37^{c}	$0.40^{b,c}$	0.35^{c}	$0.44^{a,b}$	0.47^{a}
Total phosphorus	0.017^{b}	0.018^{b}	0.013^{b}	0.013^{b}	$0{:}024^{a}$	0.029^{a}
TN:TP¶	41:1	21:1	31:1	30:1	18:1	16:1
Total calcium	4.8^{a}	3.5^{c}	4.0^{b}	3.8^{b}	3.5^{c}	3.8^{b}
Total sodium	$4.6^{c,d}$	3.7^{e}	4.5^{d}	$4.9^{b,c}$	5.1^{b}	7.8^{a}

‡Calculated empirically.

¶Statistics not performed on TN:TP.

§1983 data eliminated from statistical analyses.

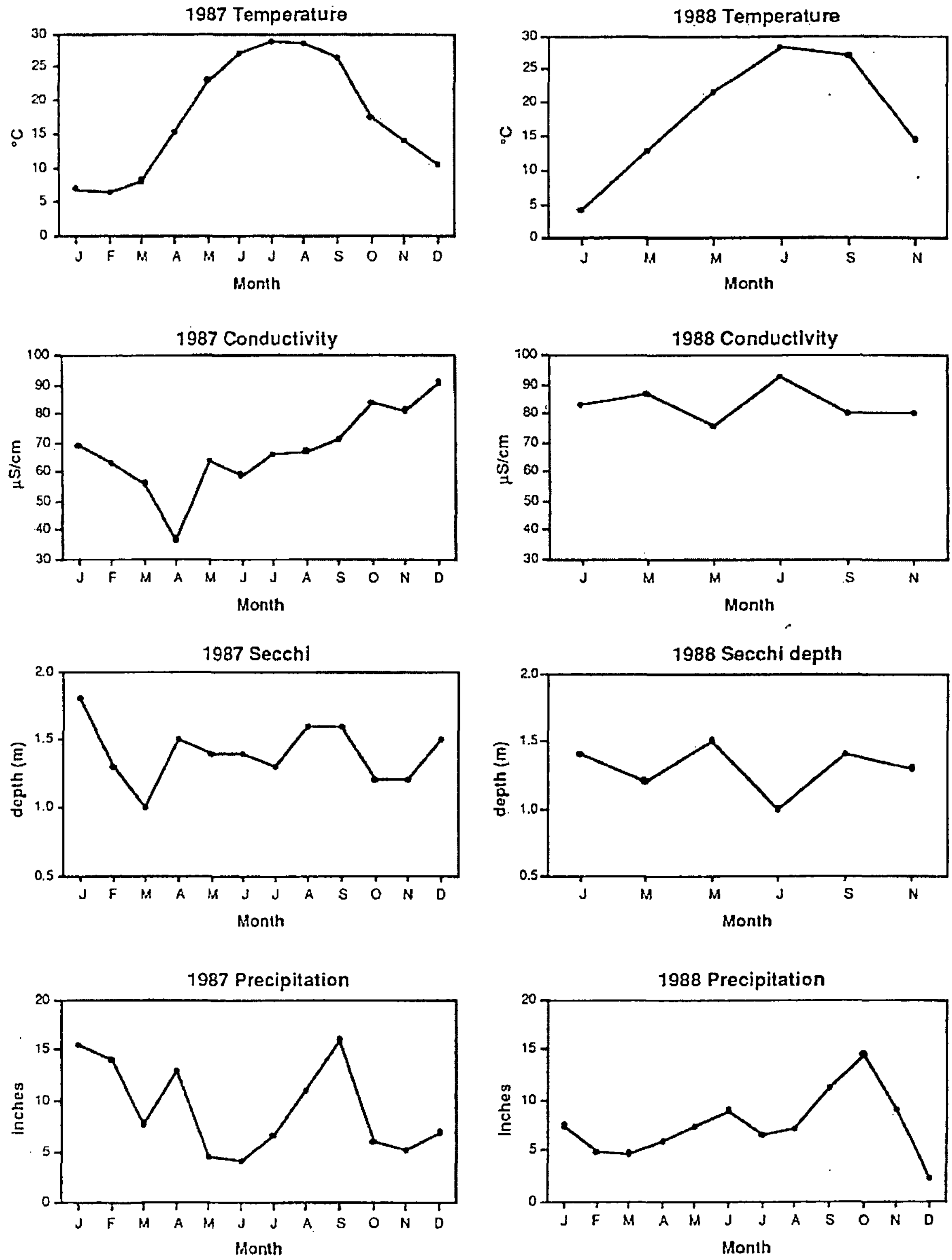


Figure 3.1 Trends of selected water quality parameters in Harris Lake surface waters, 1987-1988.

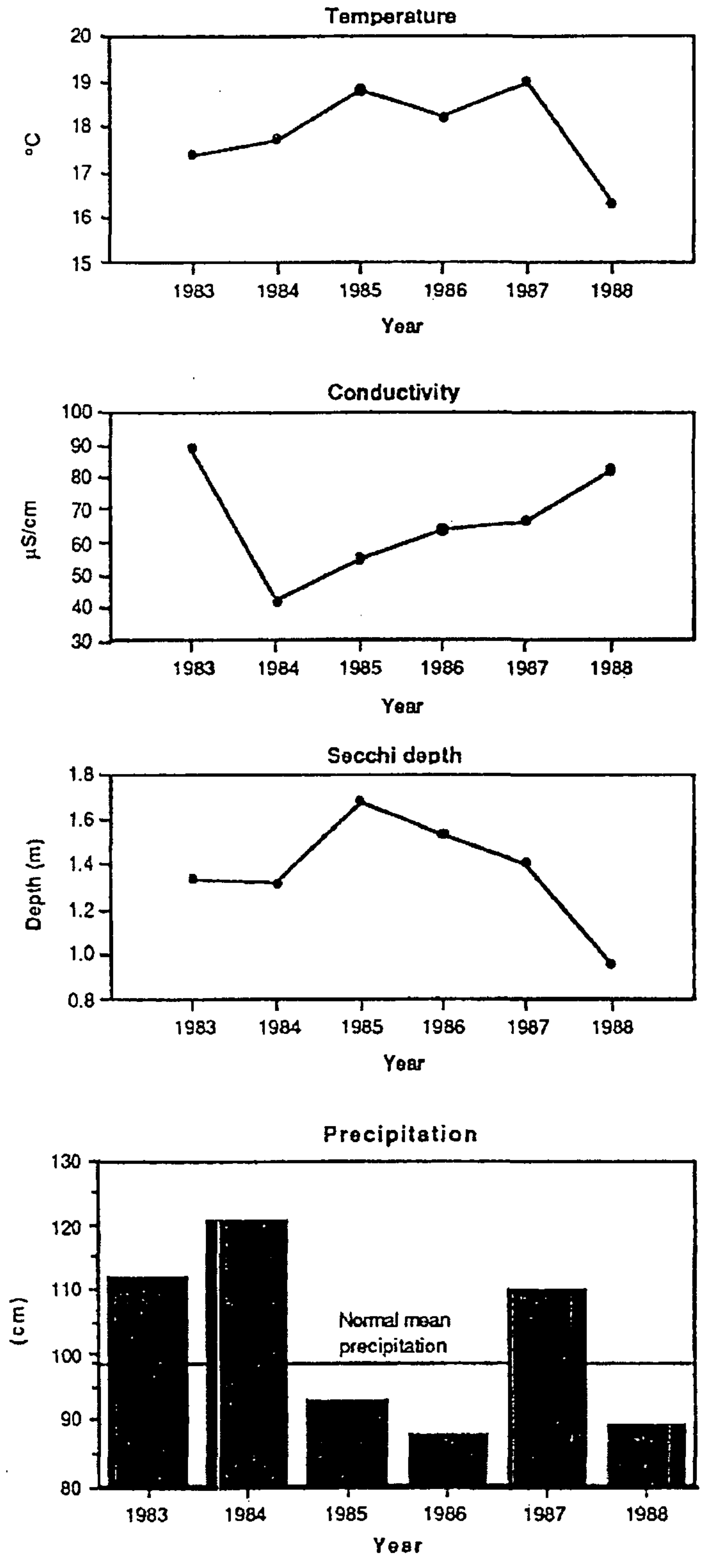


Figure 3.2 Trends of selected water quality parameters in Harris Lake surface waters, 1983-1988.

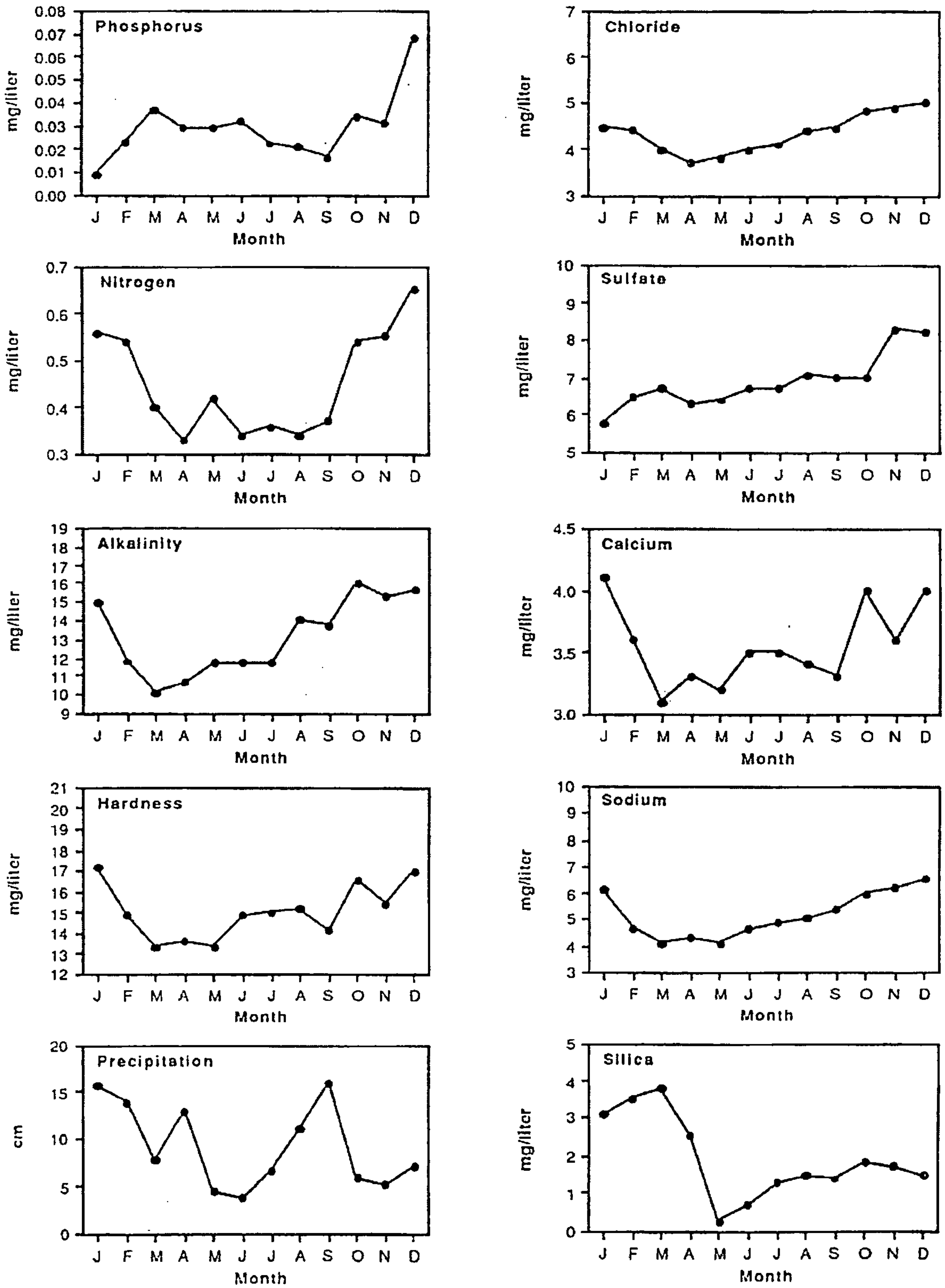


Figure 3.3 Trends of selected water chemistry constituents in Harris Lake surface waters, 1987.

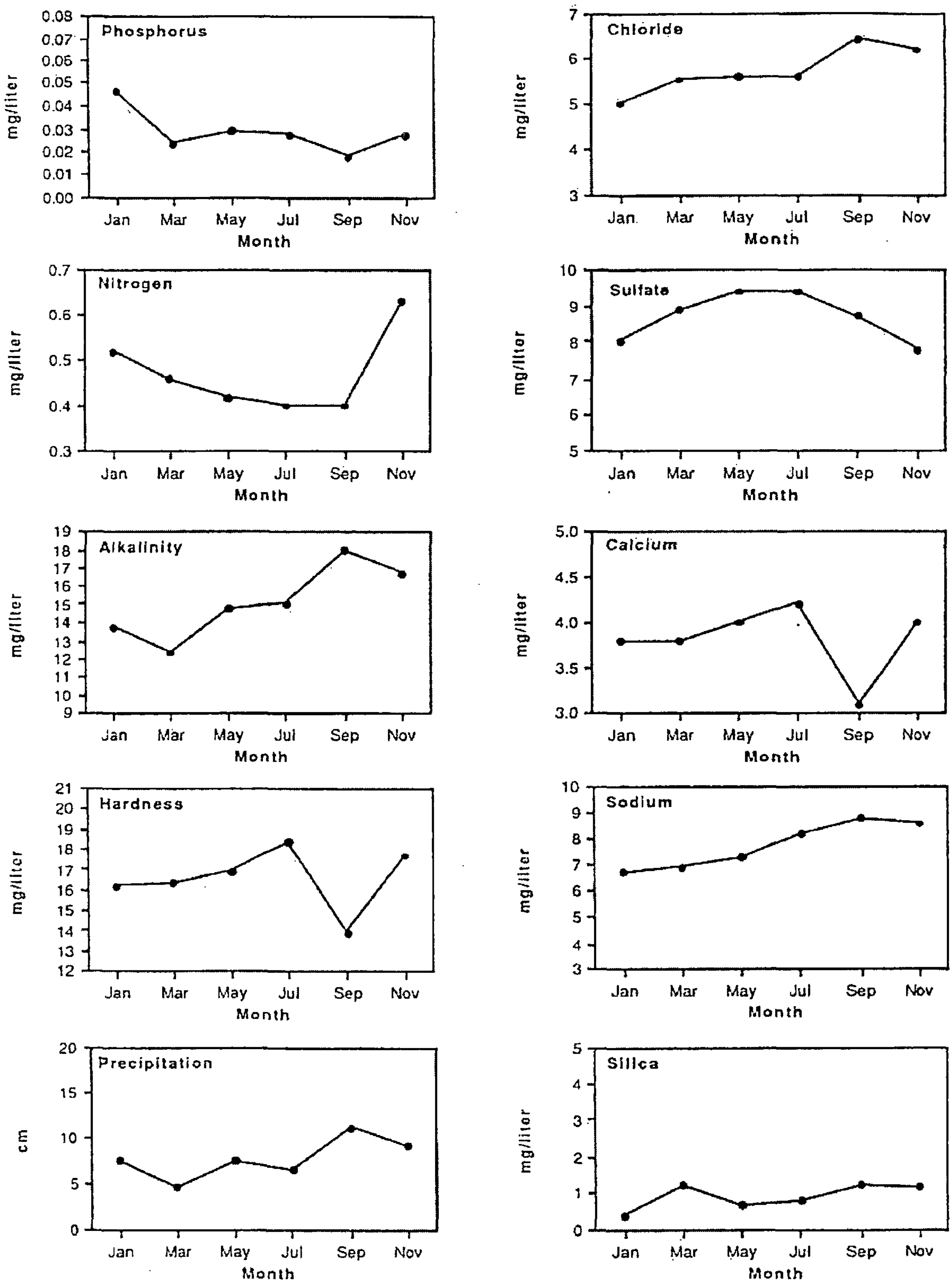


Figure 3.4 Trends of selected water chemistry constituents in Harris Lake surface waters, 1988.

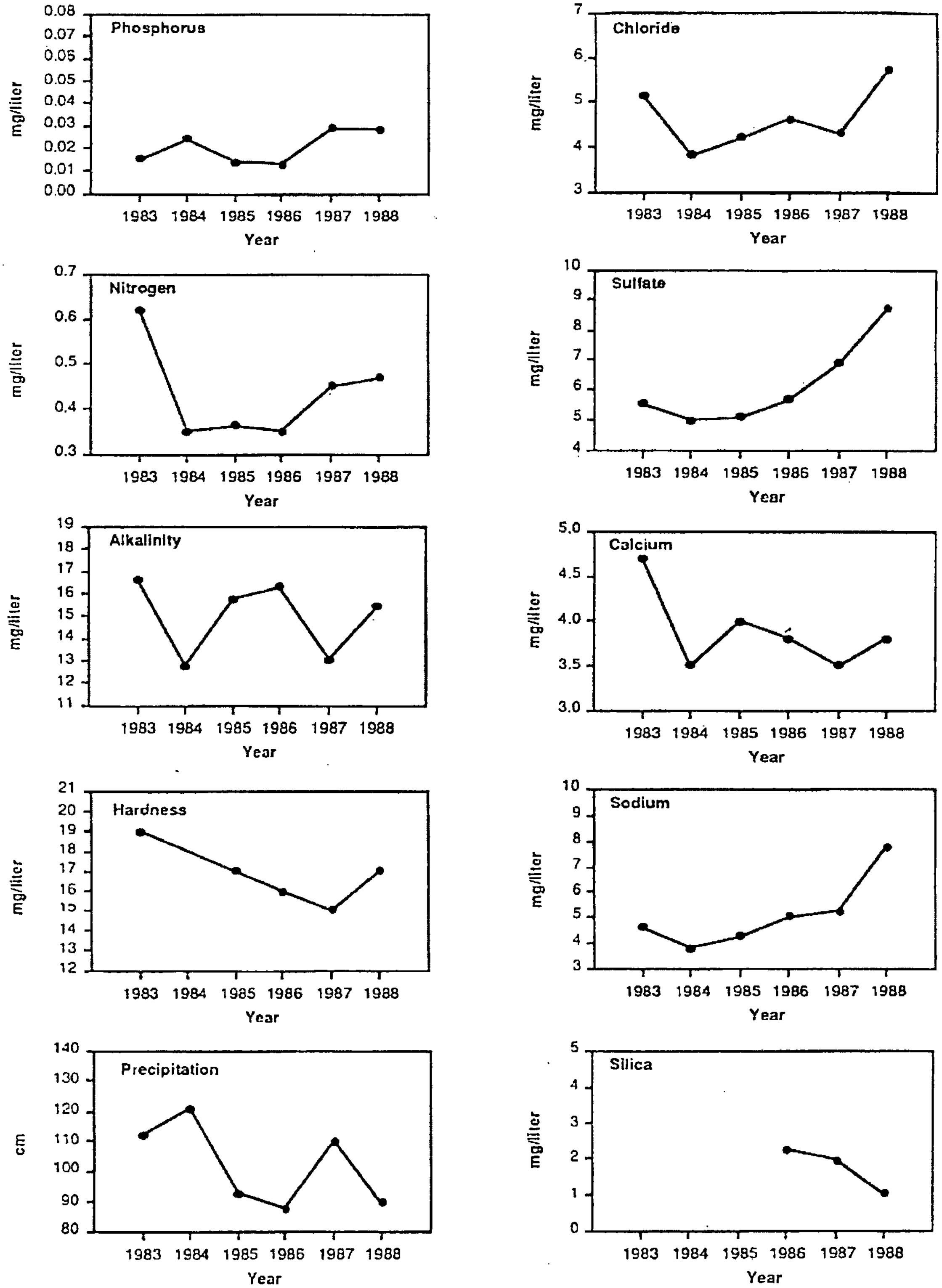


Figure 3.5 Trends of selected water chemistry constituents in Harris Lake surface waters, 1983-1988. Means for 1983-1987 based on twelve months of data; means for 1988 based on six months of data.

4.0 Trace Elements (Including Iron)

4.1 Water

Individual aqueous trace element concentrations during 1987 and 1988 were low except for iron (Appendix C). During 1987, 5 of the 36 individual mercury values, 1 of the 36 zinc values, and 4 of the 36 iron values were greater than the North Carolina Water Quality Standards or Action Levels. During 1988, 4 of the 6 iron values (from the hypolimnion at Station E2) were greater than the Water Quality Action Level. All mean concentrations except for iron in 1987 and 1988 were less than the North Carolina Water Quality Standards and Action Levels (Tables 4.1 and 4.2).

Iron concentrations in the anoxic hypolimnion at Station E2 were greater than the North Carolina Water Quality Action Level (1000 µg/liter) during summer stratification periods (Appendix C). High iron concentrations in the anoxic hypolimnion were expected as ferric iron was reduced to ferrous iron. This was a natural process expected in the reservoirs with similar soils in the Piedmont of North Carolina. Annual mean iron concentrations at E2 were 3335 µg/liter and 7558 µg/liter in 1987 and 1988, respectively (Tables 4.1 and 4.2).

There were no significant spatial differences in any of the surface water concentrations of trace elements during either year except for copper in 1987 (Tables 4.1 and 4.2). Copper concentrations were significantly higher at Station E2 than at either H2 or P2.

At Station E2 during 1987, only manganese concentrations were significantly greater in the bottom waters than in surface waters (Table 4.1). The difference in manganese concentrations was due to reducing conditions that favored the dissolution of manganese from sedimentary material during summer stratification (Appendix C). There were no significant differences between surface and bottom concentrations of any trace element during 1988 (Table 4.2). Although iron concentrations at Station E2 were greater in the bottom waters than in the surface waters, extreme variability among the monthly or bimonthly data precluded detecting any statistically significant differences during 1987 or 1988.

Detectable temporal differences (1983-1987 and 1983-1988) were limited to aluminum, copper, iron, manganese, and nickel concentrations (Tables 4.3 and 4.4). Decreased aluminum, iron, manganese, and nickel concentrations seemed related to natural conditions, cycling, and aging of the reservoir. Copper concentrations in the surface waters have been gradually increasing since 1986.

4.2 Sediment

Sediment concentrations of trace elements during 1988 were generally low (Table 4.5). There was, however, significantly more zinc in the sediments at Transect E than at Transects H or P. The mean zinc concentration measured at Transect E during 1988 was approximately 4.5 times the mean concentration measured during 1986 (170 μg/g and 38 μg/g, respectively) (CP&L 1987). Although the increase in zinc concentration between 1986 and 1988 was probably related to zinc in the power plant's cooling tower blowdown (zinc phosphate was used at the plant as a corrosion inhibitor), the resultant concentrations were still within the range of zinc concentrations found in unenriched sediments (e.g., Martin and Hartman 1984) and not considered harmful to the lake's biota.

4.3 Aquatic Biota

Trace element concentrations in the net plankton and three species of fish remained low (Table 4.5), and as determined in 1986 (CP&L 1987), concentrations were statistically similar throughout the reservoir. Mercury concentrations in all fish tissues remained slightly elevated. As in 1986, the mercury concentrations were attributed to the naturally increased availability of mercury in the new lake (Wren et al. 1983; CP&L 1987).

Table 4.1 Means and standard errors of trace element concentrations in the waters of Harris Lake during 1987[‡]. Statistical analyses are given when concentrations were at or above the analytical reporting limits. All concentrations are in μg/liter and sample size equaled 12.

Trace element	Station: E2 (Surface)	Station: E2 (Bottom)	Station: H2	Station: P2	Laboratory Reporting Limits	N.C. Water Quality Standards[¶]
Aluminum	41 ± 11	46 ± 9	55 ± 19	53 ± 9	20	None
Arsenic	0.5 ± 0.0	1.0 ± 0.3	0.6 ± 0.1	< 1.0	1.0	50
Cadmiumm	0.06 ± 0.01	< 0.1	0.06 ± 0.01	0.07 ± 0.01	0.1	2
Chromium	1.1 ± 0.1	< 2.0	< 2.0	< 2.0	2.0	50
Copper	3.8 ± 0.4[a]	4.2 ± 0.4	3.0 ± 0.4[b]	3.4± 0.5[b]	1.0	15
Iron	144 ± 24	3335 ± 1815	160 ± 27	152 ± 22	50	1000
Lead	0.6 ± 0.1	0.9 ± 0.2	0.8 ± 0.2	0.7 ± 0.1	1.0	25
Manganese	224 ± 88	3048 ± 1116[§]	116 ± 19	149 ± 29	20	None
Mercury	0.16 ± 0.10	0.26 ± 0.16	0.13 ± 0.07	< 0.1	0.1	0.2
Nickel	< 5.0	< 5.0	< 5.0	2.7 ± 0.2	5.0	50
Selenium	< 1	< 1	0.5 ± 0.0	< 1	1	5
Zinc	< 20	15 ± 2	11 ± 1	15 ± 5	20	50

[‡]Fisher's protected least significant difference procedure was applied only if the overall F test for the treatment was significant. Means followed by the same superscript were not significantly different ($P > 0.05$).

[¶]From NCDEM (1986): Copper, iron, and zinc are Action Levels.

[§]Mean concentrations in the bottom and surface waters were significantly different ($P < 0.05$).

Table 4.2 Means and standard errors of trace element concentrations in the waters of Harris Lake during 1988‡. Statistical analyses are given when concentrations were at or above the analytical reporting limits. All concentrations are in μg/liter and sample size equaled 6.

Trace element	Station E2 (Surface)	Station E2 (Bottom)	Station H2	Station P2	Laboratory Reporting Limits	N.C. Water Quality Standards¶
Aluminum	64 ± 12	55 ± 13	47 ± 7	52 ± 10	20	None
Arsenic	0.7 ± 0.1	1.2 ± 0.3	< 1.0	< 1.0	1.0	50
Cadmiumm	< 0.1	0.06 ± 0.01	0.09 ± 0.04	0.06 ± 0.01	0.1	2
Chromium	< 2.0	< 2.0	< 2.0	< 2.0	2.0	50
Copper	4.2 ± 0.9	3.7 ± 0.7	3.5 ± 0.4	3.4 ± 0.4	1.0	15
Iron	81 ± 28	7558 ± 3501	92 ± 26	73 ± 20	50	1000
Lead	< 1.0	0.6 ± 0.1	< 1.0	< 1.0	1.0	25
Manganese	157 ± 67	7810 ± 3594	67 ± 7	87 ± 17	20	None
Mercury	0.05 ± 0.00	< 0.05	< 0.05	< 0.05	0.05£	0.2
Nickel	< 5.0	< 5.0	< 5.0	< 5.0	5.0	50
Selenium	< 1	< 1	< 1	< 1	1	5
Zinc	12 ± 2	13 ± 2	12 ± 2	12 ± 2	20	50

‡Fisher's protected least significant difference procedure was applied only if the overall F test for the treatment was significant. Means followed by the same superscript were not significantly different ($P > 0.05$).

¶From NCDEM (1986): Copper, iron, and zinc are Action Levels.

§Mean concentrations in the bottom and surface waters were significantly different ($P < 0.05$).

£Detector sensitivity permitted the lowering of the detection level from 0.1 in 1987 to 0.05 in 1988 by the CP&L Chemistry Laboratory.

Table 4.3 Means and ranges of trace element concentrations in the surface waters of Harris Lake, 1983-1987‡. Statistical analyses are given when the majority of concentrations were at or above the analytical reporting limits. All units are µg/liter and sample size equaled 36 (January, February, . . ., December) in 1983-1987 unless otherwise noted.

Trace element	Year				
	1983	1984	1985	1986	1987
Aluminum	59[a] (< 10-170)	--¶	--¶	31[b] (< 20-150)	50[a] (< 20-220)
Arsenic	0.5 (< 1.0-1.0)	0.5 (< 1.0-1.0)	0.5 (< 1.0-1.0)	0.5 (< 1.0-1.0)	0.5 (< 1.0-1.0)
Cadmium	0.7 (< 1.0-6.0)	0.5 (< 1.0-1.0)	0.5 (< 0.5-1.0)	0.18 (< 0.1-0.36)	0.06 (< 0.1-0.17)
Chromium	< 5.0	< 5.0	< 5.0	1.3 (< 2.0-9.0)	1.0 (< 2.0-2.3)
Copper	1.8[b] (< 1.0-5.0)	2.0[b] (< 1.0-6.0)	3.5[a] (< 1.0-16)	1.5[b] (< 1.0-7.0)	3.4[a] (< 1.0-6.4)
Iron	658[a] (80-2000)	773[a] (770-780)§	--¶	173[b] (< 50-530)	15[b] (< 50-350)
Lead	1.4 (< 2.0-8.0)	1.4 (< 2.0-5.0)	1.2 (< 1.0-4.0)	0.8 (< 1.0-2.4)	0.7 (< 1.0-3.1)
Manganese	323[a] (40-1500)	--¶	--¶	180[b] (< 20-800)	163[b] (42-1100)
Mercury	0.1 (< 0.1-0.4)	0.1 (< 0.1-0.2)	< 0.1	0.1 (< 0.1-0.67)	0.1 (< 0.1.0-1.0.2)
Nickel	7.5 (< 10-20)	7.2 (< 10-30)	5.2 (< 5.0-11)	2.9 (< 5.0-6.0)	2.6 (< 5.0-5.1)
Selenium	0.5 (< 1-1)	< 1 (< 1-1)	0.5 (< 1-1)	0.5 (< 1-1)	0.5 (< 1-1)
Zinc	15 (< 20-180)	10 (< 20-20)	23 (< 20-270)	< 20	12 (< 20-70)

‡Mean concentrations of an element with the same superscript were not significantly different among years ($P > 0.05$).

¶No data.

§Sample size equaled three.

Table 4.4 Means and ranges of trace element concentrations in the surface waters of Harris Lake, 1983-1988‡. Statistical analyses are given when the majority of concentrations were at or above the analytical reporting limits. All units are µg/liter and sample size equaled 18 (January, March, . . ., November) in 1983-1988 unless otherwise noted.

Trace element	1983	1984	1985	1986	1987	1988
Aluminum	52[a] (< 10-150)	--¶	--¶	32[b] (< 20-150)	56[a] (< 20-220)	55[a] (< 20-90)
Arsenic	< 1.0	0.6 (< 1.0-1.0)	0.6 (< 1.0-1.0)	0.5 (< 1.0-1.0)	< 1.0	0.5 (< 1.0-1.0)
Cadmium	0.8 (< 1.0-6.0)	0.5 (< 1.0-1.0)	0.5 (< 0.5-1.0)	0.2 (< 0.5-< 1.0)	0.1 (< 0.1-0.13)	0.1 < 0.1-0.30
Chromium	< 5.0	< 5.0	2.3 (< 2.0-< 5.0)	1.1 (< 2.0-2.0)	< 2.0	< 2.0
Copper	2.4[bc] (< 1.0-5.0)	1.9[c] (< 1.0-6.0)	1.8[c] (< 1.0-4.0)	1.9[c] (< 1.0-7.0)	3.5[ab] (< 1.0-6.4)	3.7[a] (1.5-8.1)
Iron	680[a] (80-2000)	773[a] (770-780)§	--¶	165[b] (< 50-470)	154[b] (< 50-350)	82[b] (< 50-170)
Lead	< 2.0	1.4 (< 2.0-4.0)	1.3 (< 2.0-4.0)	0.8 (< 1.0-2.0)	0.9 (< 1.0-3.1)	< 1.0
Manganese	314[a] (40-1500)	--¶	--¶	137[b] (40-340)	126[b] (42-520)	103[b] (50-480)
Mercury	0.1 (< 0.1-0.3)	0.1 (< 0.1-0.2)	< 0.1	< 0.1	0.2 (< 0.1-1.2)	0.04 (< 0.05-0.05)
Nickel	9.7[a] (< 10-20)	5.8[b] (< 10-10)	4.9[b] (< 10-10)	2.8[c] (< 5.0-5.0)	2.6[c] (< 5.0-5.1)	< 5[c]
Selenium	0.5 (< 1-1)	0.5 (< 1-1)	0.5 (< 1-1)	0.5 (< 1-1)	< 1	< 1
Zinc	< 20	< 20	< 20	< 20	(< 20-20)	12 (< 20-20)

‡Mean concentrations of an element with the same superscript were not significantly different among years (P > 0.05).

¶No data.

§Sample size equaled three.

Table 4.5 Means and standard errors of trace element concentrations in the sediments, net plankton, and fish from Harris Lake during 1988. All concentrations are in μg/g dry weight and sample size equaled three unless otherwise noted.

		Trace element‡¶					
Sample matrix	Transect	As	Cd	Cu	Hg	Se	Zn
Sediment	E	1.9 ± 0.4	< 3	16 ± 3	< 0.02	< 0.8	170 ± 17[a]
	H	1.9 ± 0.1	< 3	12 ± 1	< 0.02	< 0.8	74 ± 9[b]
	P	1.4 ± 0.1	< 3	24 ± 16	< 0.02	< 0.8	79 ± 26[b]
Net plankton	E	1.4 ± 0.2	0.04 ± 0.03	22 ± 4	< 0.04	3.6 ± 0.3	103 ± 3
	H	1.7 ± 0.1	0.04 ± 0.02	18 ± 3	0.03 ± 0.01	3.2 ± 0.1	94 ± 1
	P	0.08 ± 0.2	0.01 ± 0.00	16 ± 1	0.04 ± 0	3.0 ± 0.2	34 ± 4
Fish (species/ length, mm)							
Bluegill (94-135)	E	< 0.8	0.02 ± 0.01	4.9 ± 0.8	0.09 ± 0.01	< 0.8	95 ± 3
	H	< 0.8	0.02 ± 0.01	4.4 ± 0.4	0.21 ± 0.02	< 0.8	174 ± 75
	P	< 0.8	0.03 ± 0.01	13 ± 6	0.14 ± 0.01	< 0.8	99 ± 5
Brown bullhead (255-285)	E	< 0.8	0.01 ± 0.01	3.8 ± 0.7	0.72 ± 0.10	< 0.8	80 ± 2
	H	< 0.8	0.03 ± 0.01	4.1 ± 1.3	0.44 ± 0.10	< 0.8	63 ± 12
	P	< 0.8	0.04 ± 0.03	5.2 ± 1.3	0.48 ± 0.12	< 0.8	62 ± 1
Largemouth bass (244-357)	E	< 0.8	< 0.01	2.1 ± 1.3	1.31 ± 0.48	< 0.8	73 ± 2
	H	< 0.8	0.17 ± 0.14	1.7 ± 0.4	0.38 ± 0.02	< 0.8	82 ± 6
	P§	< 0.8	0.02 ± 0.02	4.3 ± 1.0	1.32 ± 0.30	< 0.8	72 ± 5

‡Standard error values are given when all replicate concentrations were greater than the analytical reporting limits. Concentrations of an element for a given sample matrix with the same superscript were not significantly different among transects ($P > 0.05$).

¶Mean and range of dry to fresh weight ratios for conversion to "wet-weight" basis: plankton 0.054 (0.04-0.074); whole fish 0.25 (0.19-0.31); sediment 0.38 (0.28-0.54).

§Sample size equaled 5.

5.0 PHYTOPLANKTON

Phytoplankton densities in Harris Lake were moderate in 1987 and 1988 relative to other North Carolina piedmont reservoirs (Weiss and Kuenzler 1976). Monthly density estimates ranged from 2,538 units/ml (P2, March) to 12,617 units/ml (H2, December) during 1987. In 1988 densities ranged from 1,659 (E2, November) to 8,848 units/ml (H2, March). Densities were elevated (relative to other CP&L impoundments) during November and December 1987 and March 1988 at Station H2 (Tables 5.1 and 5.2) (CP&L 1989). Weiss and Francisco (1984) stated that algal densities from 3,000 to 10,000 units/ml indicate that a lake is mildly eutrophic (mesoeutrophic). Mean density estimates during 1987 showed significantly greater phytoplankton abundance at H2 (6,943 units/ml) than at E2 (5,345 units/ml) and P2 (4,937 units/ml) which were not significantly different. During 1988, yearly mean phytoplankton densities were significantly greater at H2 (5,806 units/ml) and E2 (4,407 units/ml) compared to P2 (3,850 units/ml) (Table 5.3). This spatial pattern of higher phytoplankton densities at H2 than at P2 was also observed in 1986 (CP&L 1987).

The greater densities measured at H2 may be a reflection of various environmental factors, possibly including less wind-induced mixing of the water column and/or shallower water column depth compared to E2. This headwater area of the lake is narrow relative to the E2 and P2 locations and appeared to be better sheltered from wind-induced water column mixing due to the proximity of a gently rolling shoreline terrain. In either case (i.e., less mixing or shallower water column depth) phytoplankton cells would remain for a proportionately longer time in the euphotic zone (upper layers of a body of water into which sufficient light penetrates to permit growth of green plants). Phytoplankton growth in this zone was expected to be greater than in areas where extensive water column mixing and/or a relatively deep water column allowed phytoplankton to circulate to depths with restricted light penetration. The time phytoplankton remain in areas with less than adequate light could result in reduced phytoplankton photosynthesis which might be reflected in decreased abundance.

Reservoirwide mean phytoplankton density estimates continued to gradually increase from 1983 through 1987-1988 (Figure 5.1). This trend included significantly greater phytoplankton densities in 1987 than in 1985, while significantly greater densities were also present from 1984 to 1986 compared to 1983 (Table 5.3). Reservoirwide mean phytoplankton density estimates were similar during 1987 and 1988 (Table 5.3). The increase in total phytoplankton abundance from the 1984-1985 to 1987-1988 periods appeared to be a reflection of an increase in macronutrient concentrations (e.g., various forms of nitrogen and phosphorus; see Section 3.0). The increased macronutrient concentrations in 1987 and 1988 appeared to be related to macronutrients contained in water released from the power plant. Another factor possibly influencing macronutrient concentrations and phytoplankton densities may have been lake retention time. During years with below normal rainfall (e.g., 1986 and 1988; see Section 3.0), lake retention time would be expected to have increased relative to years when rainfall was at or above normal levels. Since 1987 lake retention also increased due to evaporative water loss associated with operation of the power plant cooling tower. At various times throughout 1986-88, lake water levels were insufficient for water outflow (personal observation). Weiss and Francisco (1984) reported that nutrient levels and retention times were major factors influencing phytoplankton abundance in nearby B. Everett Jordan Lake.

During 1987 and 1988, the Chlorophyceae (green algae), the Chrysophyceae (chrysophytes; primarily *Chrysochromulina* spp.), and the Cryptophyceae were usually more abundant than other phytoplankton classes represented in Harris Lake (Tables 5.1 and 5.2). The Chlorophyceae (green algae) were numerically dominant during 1987 at various times in the spring, summer, and fall, while in 1988 the green algae were also dominant at times throughout the year. The Chrysophyceae and the Cryptophyceae were seasonally abundant throughout both years. Myxophyceae (blue-green algae) were on occasion numerically dominant during the spring and summer with density peaks in July 1987 and 1988. Myxophyceae densities were relatively low such that water quality was not adversely influenced. During 1987, representatives of the Chlorophyceae and Myxophyceae were present in significantly greater densities at H2 than at E2, while there were no significant differences in estimated densities between P2 and H2 or between E2 and P2 (Table 5.3). Densities of Chrysophyceae were significantly greater at H2 than at either P2 or E2 during 1983-1988. During 1988, Chrysophyceae densities continued to be significantly greater at H2 than at P2, while no difference was detected between densities at E2 and P2 or between H2 and E2. Reservoirwide densities of the Chlorophyceae, Cryptophyceae, and Myxophyceae have gradually increased since 1983 with densities significantly higher in 1987 than 1983 (Table 5.3). These statistically significant increases were, in part, a reflection of unexplained, short-term (November and December 1987) increases in Chlorophyceae and Cryptophyceae densities at H2.

Seasonal variations in phytoplankton densities during 1985 and 1986 were characterized as relatively small (CP&L 1986, 1987). These fluctuations included relatively higher densities in the summer and fall when temperatures and day length were favorable for algal growth. With the onset of shorter day lengths and cooler water temperatures, phytoplankton densities typically declined (e.g., November 1986 at E2 and P2). During 1987 and 1988, seasonal variations in phytoplankton became more pronounced and included unexpected density peaks during the fall of 1987 and/or the winter of 1988 depending on location. A peak in density occurred during November and December 1987 at H2 (Figure 5.1).

Seasonal fluctuations during 1988 in phytoplankton densities included abundance peaks in January (P2) or March (E2 and H2) followed by declines in abundance with only minor summer density increases during July and September at P2 and E2, respectively (Figure 5.1). The density decline in May may be related to phytoplankton grazing by zooplankton or fish, while the fall and winter increases may be related to increased macronutrient availability associated with the lake turnover.

Chlorophyll *a* concentrations in 1987 were, with a few exceptions (e.g., February and November at H2 and March at E2), moderate with yearly means of 20.1, 15.7, and 11.5 μg/liter at H2, E2, and P2, respectively. A peak in chlorophyll *a* concentrations (37.3 μg/liter) occurred during November 1987 at H2 (Figure 5.2). The chlorophyll *a* concentration at this station approached levels (NCDEM water quality standard: values not to exceed 40 μg/liter) indicative of eutrophic water (Weiss and Francisco 1984). However, this peak in chlorophyll *a* concentration was only observed at one station on one occasion. During 1987, significantly higher yearly mean chlorophyll *a* concentrations were observed at H2 than at E2, while P2 was not significantly different than either H2 or E2. This spatial difference in chlorophyll *a* concentrations partially reflected the elevated chlorophyll *a* concentration at H2 during November 1987. In 1988, chlorophyll *a* concentrations at H2 and E2 were significantly higher compared to P2 (Table 5.3). The mean annual chlorophyll *a* concentration at E2 increased from 1987 (15.7 μg/liter) to 1988 (22 μg/liter).

Reservoirwide mean chlorophyll *a* concentrations were significantly higher during 1987 than in either 1986 or 1984. A further increase in chlorophyll *a* concentrations above 1987 levels was observed in 1988 with the yearly mean increasing from 15.7 μg/liter (1987) to 20.3 μg/liter. Furthermore during 1988, the number of elevated chlorophyll *a* concentrations increased from a single peak in 1987 to two peaks occurring during March and July at E2, a peak at P2 in January, and a peak at H2 in July (Figure 5.2). The 1987 and 1988 increases in chlorophyll *a* concentrations appeared to be related to increased macronutrient (particularly phosphorus) availability and/or increased lake retention time.

To evaluate the possible influence of macronutrient introductions from upstream sources (e.g., Holly Springs' sewage treatment plant effluent), a chlorophyll *a* monitoring station was established in the headwater region (Station S2) of Harris Lake. Mean annual chlorophyll *a* concentration at S2 during 1988 was lower than concentrations at other lake stations indicating minimal biologically available macronutrient additions from upstream.

Typically in North Carolina piedmont reservoirs, increased macronutrients availability can stimulate phytoplankton growth which, in turn, may result in increased biomass (indicated by chlorophyll *a* concentrations) and/or phytoplankton density. Chlorophyll *a* concentrations, total phytoplankton densities, and total phosphorus concentrations, when applied to the Weiss and Francisco (1984) tentative trophic classification system, indicated Harris Lake has increased in trophic classification from oligomesotrophic to mesoeutrophic during the past several years. Such increases in trophic classification typically reflect the cultural eutrophication ("aging") of a lake or reservoir. This aging process (indicated by increased trophic status) may be greatly accelerated by macronutrient additions. Ultimately this aging process can result in a reduction in overall water quality. Such reductions in water quality have not been observed at Harris Lake. Increases in the trophic status of Harris Lake appeared to reflect several environmental factors including increased lake retention time (due to low rainfall and/or evaporative loss of cooling tower makeup) and macronutrient availability resulting from additions associated with plant blowdown.

Table 5.1 Phytoplankton class densities (units/ml) by month in Harris Lake during 1987.

Station/class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
E2													
Bacillariophyceae	578	880	1206	653	101	176	603	302	176	452	251	528	492
Chlorophyceae	603	1005	855	1860	3142	4624	2111	2262	2212	1709	1181	3066	2053
Chrysophyceae	1131	1784	3418	1558	302	377	201	151	0	377	151	251	808
Cryptophyceae	126	628	955	1005	1458	1860	452	2538	905	1885	930	1960	1225
Myxophyceae	126	25	0	352	628	1634	3594	804	553	452	276	226	723
Total phytoplankton	2564	4323	6434	5429	5680	8822	6987	6158	3896	4926	2865	6057	5345
H2													
Bacillariophyceae	327	327	452	955	276	251	553	478	201	276	377	880	446
Chlorophyceae	1056	1759	1181	2739	3745	3468	1910	2312	2362	2086	3393	4650	2555
Chrysophyceae	2463	3217	3016	327	754	452	251	75	452	1483	5228	578	1525
Cryptophyceae	352	578	1056	829	1056	1734	553	955	829	1307	2136	4976	1363
Myxophyceae	251	151	25	452	905	1307	3996	1206	704	779	427	930	928
Total phytoplankton	4449	6032	5730	5302	6811	7238	7364	5127	4725	6082	11838	12617	6943
P2													
Bacillariophyceae	804	327	276	880	327	176	503	276	150	226	276	729	413
Chlorophyceae	1382	1232	528	2438	3418	3745	1835	1206	2262	2664	1985	2639	2111
Chrysophyceae	1307	1056	930	1508	528	603	402	101	478	101	126	151	608
Cryptophyceae	251	75	804	804	804	1081	779	377	603	1910	1181	2790	955
Myxophyceae	302	126	0	352	1081	1206	3242	855	603	855	201	779	800
Total phytoplankton	4046	2815	2538	5982	6283	6912	6786	2865	4197	5831	3795	7188	4937

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

Table 5.2 Phytoplankton class densities (units/ml) by month in Harris Lake during 1988.

Station/class	Jan	Mar	May	Jul	Sep	Nov	Mean
E2							
Bacillariophyceae	553	277	25	100	151	226	222
Chlorophyceae	2110	5503	2311	830	1783	803	2223
Chrysophyceae	226	628	1181	352	25	352	461
Cryptophyceae	327	327	1357	351	1458	201	670
Myxophyceae	226	25	151	2060	1006	50	586
Total phytoplankton	3468	7691	5027	3921	4675	1659	4407
H2							
Bacillariophyceae	652	378	126	50	226	251	280
Chlorophyceae	3292	5982	1380	829	1559	678	2287
Chrysophyceae	1332	1181	4448	377	628	1784	1625
Cryptophyceae	377	1106	377	301	302	1835	717
Myxophyceae	603	101	402	2187	1381	25	783
Total phytoplankton	6333	8848	6736	3971	4348	4599	5806
P2							
Bacillariophyceae	352	201	226	251	125	251	234
Chlorophyceae	3619	3720	729	804	1131	502	1751
Chrysophyceae	1231	301	427	553	402	452	561
Cryptophyceae	754	478	955	503	503	779	662
Myxophyceae	151	276	126	2236	377	25	532
Total phytoplankton	6158	5152	2488	4599	2664	2036	3850

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

Table 5.3 Results of analysis of variance and Duncan's multiple range tests to determine spatial and temporal trends of phytoplankton density and biomass from Harris Lake, 1983-1988.

Short-term analyses 1987

Density (units/ml)	H2	E2	P2	
	6943	5345	4937	
Biomass (µg/liter)	H2	E2	P2	
	20.1	15.7	11.5	
Numerically abundant phytoplankton (units/ml)				
Chlorophyceae	H2	P2	E2	
	2555	2111	2053	
Myxophyceae	H2	P2	E2	
	928	800	723	

Short-term analyses 1988

Density (units/ml)	H2	E2	P2	
	5806	4407	3850	
Biomass (µg/liter)	E2	H2	P2	S2
	22	22	17	10
Numerically abundant phytoplankton (units/ml)				
Chrysophyceae	H2	E2	P2	
	1525	808	608	

Long-term analyses 1983-1988

Density (units/ml)						
Year	87	88	86	84	85	83
	5388	4688	3691	3281	3102	1983
Biomass (µg/liter)						
Year‡	88	87	86	84		
	17.0	15.2	9.5	9.3		
Year	88	87	84			
	20.3	15.7	6.5			
Station		H2	E2	P2		
		17.2	14.2	12.1		

Table 5.3 (continued)

Long-term analyses 1983-1988 continued

Numerically important phytoplankton (units/ml)

Chlorophyceae

Year	87	88	86	85	84	83
	2240	2087	1722	1297	1143	885

Cryptophyceae

Year	87	88	85	86	84	83
	1181	683	371	342	544	178

Myxophyceae

Year	87	84	88	86	85	83
	817	638	634	440	329	216

Cryptophyceae

Station	H2	P2	E2
	59	517	79

Chrysophyceae

Station	H2	P2	E2
	975	530	471

‡Chlorophyll *a* concentrations from May-December used for computation.

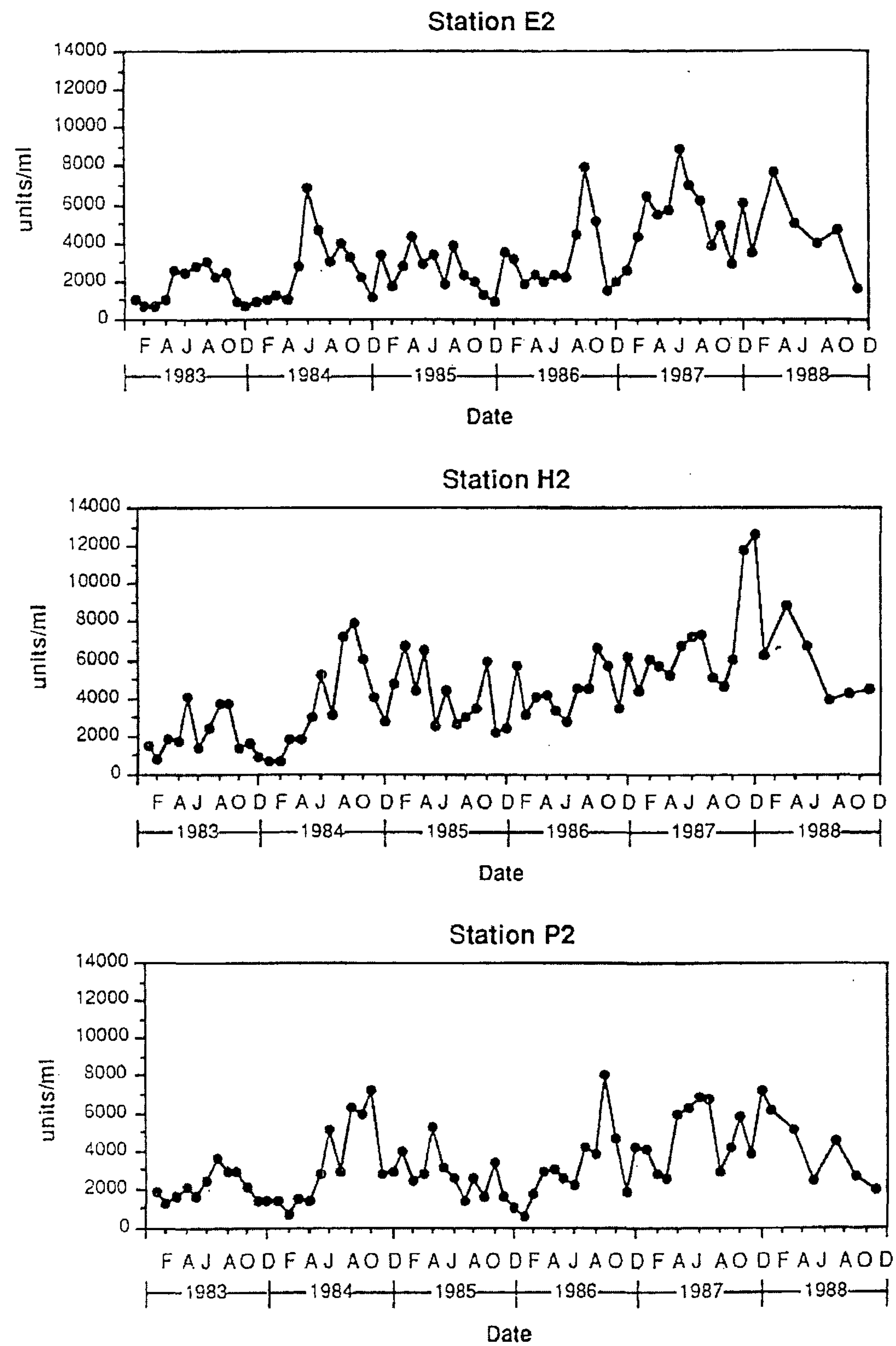


Figure 5.1 Phytoplankton densities from Stations E2, H2, and P2 in Harris Lake, 1983-1988.

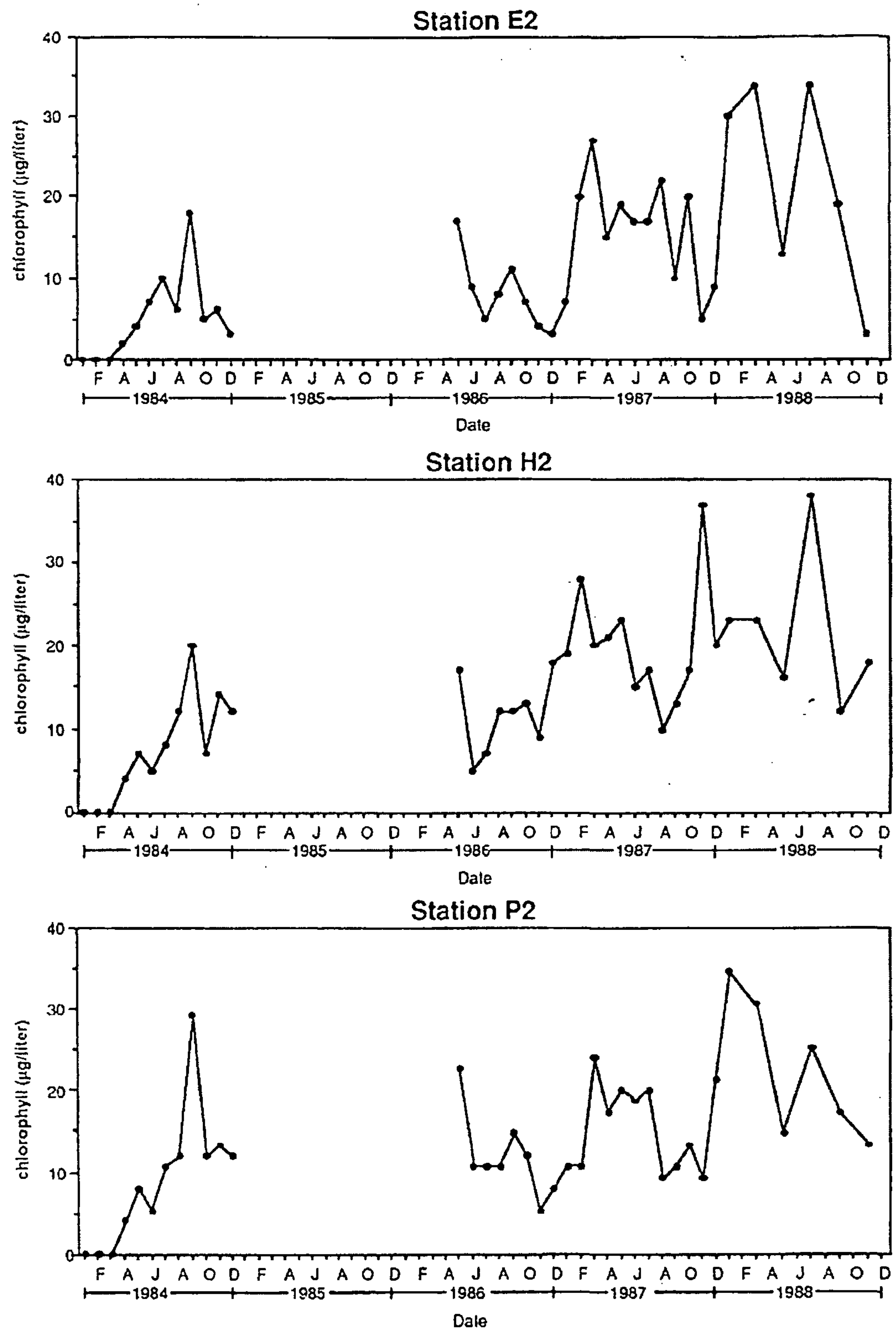


Figure 5.2 Chlorophyll *a* concentrations (µg/liter) from Stations E2, H2, and P2 in Harris Lake, 1984-1988. (Chlorophyll *a* samples for January through April 1986 were not correctly analyzed and data were omitted from graph.

6.0 ZOOPLANKTON

During 1987 there were 43 zooplankton taxa collected from Harris Lake; 28 taxa were collected during 1988 (Tables 6.1 and 6.2). This decrease in taxa number occurred for all taxa groups (copepods, cladocerans, rotifers) and was primarily the result of the loss of less abundant taxa probably due to reduced sampling frequency. The number of taxa found at each station was similar among stations within each year.

Taxa richness varied significantly among months for both 1987 and 1988 (Figure 6.1). There were spring (March and April) and summer (August) peaks in taxa richness during 1987 with the lowest taxa richness occurring in May and December. During 1988, bimodal peaks in taxa richness were not evident. The lowest numbers of taxa occurred in January and March which represented a continuation of the low numbers observed during December 1987. Taxa richness increased and remained significantly higher from May to November 1988. Rotifers accounted for the high number of taxa during the warmer months.

The annual mean density of zooplankton was 82,096/m^3 during 1987 and 74,544/m^3 during 1988. During 1987, organism density at H2 was significantly higher than at E2 and P2 which were not significantly different from each other (Table 6.3). High organism density at H2 was due to high numbers of copepods and rotifers. Cladocerans were not different in abundance among stations. There were no station or taxa group differences in zooplankton densities during 1988 (Table 6.3).

Zooplankton densities varied significantly among months for both years. During 1987, organism densities reached peaks in spring (April, May), and fall (September, October and November), with the lowest densities occurring during winter (January, February, March, and December) and summer (June, July) (Figure 6.1). This bimodal pattern was repeated during 1988 when organism densities were highest in May and November. Increases in cladocerans (*Bosmina longirostris*, *Daphnia ambigua*, *Daphnia parvula*, *Ceriodaphnia lacustris*), rotifers (*Keratella cochlearis*, *Polyarthra euryptera*, *Kellicotia bostoniensis*, *Pompholyx sulcata*), and copepods (nauplii) resulted in these increases. Decreases in zooplankton during the summer months might have been due to increased predation by larval and planktivorous fish on the larger zooplankters (*Daphnia* spp. and copepods).

Annual mean zooplankton biomass was 60.3 mg/m^3 in 1987 and 27.9 mg/m^3 in 1988. The decrease in annual biomass in 1988 was due to decreases in the density of larger cladocerans and the copepod *Diaptomus pallidus*, a large zooplankter. Rotifer biomass, on the other hand, increased from 1987 to 1988.

Zooplankton biomass followed a temporal trend similar to organism density with concomitant spring and fall peaks (Figure 6.1). During 1987 there were differences in temporal trends of density and biomass. However, during 1988, biomass and density were nearly identical in their monthly trends. Biomass increased more rapidly during February 1988 than did density because of an increase in the large zooplankter, *Diaptomus pallidus*, and the small zooplankter, *Bosmina longirostris*. During November 1988, biomass decreased as density increased due to an increase in rotifers which have less biomass than copepods and cladocerans.

There were significant differences among stations for total biomass during 1987 (Stations H2 and E2 were different and P2 was similar to both) (Table 6.3). There were no differences in cladoceran biomass among stations, while rotifer biomass was highest at H2 with E2 and P2 being similar and lower. Copepods biomass was highest at H2 and lowest at E2 with biomass at P2 similar to both E2 and H2 (Table 6.3).

During 1988 there were no significant differences among stations for total biomass or for rotifer, copepod, or cladoceran biomass. There were also no differences in copepod or cladocerans biomass among months. Rotifers, however, exhibited differences among months with biomass in January and March being significantly lower than during other months. The increase in total zooplankton biomass during November 1988 (Figure 6.1) was due mostly to an increase in rotifers (*Keratella cochlearis*, *Kellicottia bostoniensis*), calanoid copepodites, and the cladoceran *Bosmina longirostris*.

Since the impoundment reached full pool in 1983, the zooplankton have exhibited some changes in overall trends of density and biomass. There has been a decrease in biomass and an increase in the density of smaller-sized organisms from 1983 through 1988 (Figure 6.2). There has also been a decrease in taxa richness (Figure 6.2).

Zooplankton density remained relatively constant from 1983 through 1985. It decreased during the drought year of 1986 but rapidly increased the following year when there was above-average precipitation. During 1988, total zooplankton decreased but remained above the densities of 1983-1985. During these changes in zooplankton density, biomass declined. This decline in biomass, despite increases in organism density, was due to decreases in cladocerans and certain copepods. Rotifers have been increasing in density but since their biomass is so small compared to the larger zooplankters, there has been a minimal offsetting effect on the total biomass.

The reduction of larger zooplankters was probably partially due to increased predation by the introduction of threadfin shad in 1987 (Section 8.0). Threadfin shad feed on zooplankton throughout their life, while gizzard shad, which were already in the lake, feed mostly on zooplankton while in the larval and juvenile stages. The size-selective cropping by threadfin shad, along with the increased overall larval fish populations, was the probable cause of the recent changes in the zooplankton community.

Table 6.1 Zooplankton taxa collected at Harris Lake during 1987.‡

Copepoda (29.1%)	Rotifera (57.2%)
Diaptomus pallidus (2.7%)	*Keratella americana* (0.1%)
D. reighardi (< 0.1%)	*K. cochlearis* (14.6%)
Cyclops (0.1%)	*K. crassa* (0.4%)
C. vernalis (0.7%)	*Kellicottia bostoniensis* (7.6%)
Mesocyclops edax (0.5%)	*Platyias patulus* (< 0.1%)
Tropocyclops prasinus (< 0.1%)	*Trichotria* (< 0.11%)
Paracyclops fimbriatus (< 0.1%)	*Lecane luna* (< 0.11%)
Ergasilus (< 0.1%)	*Monostyla* (0.1%)
Copepodites (4.4%)	*Trichocerca longiseta* (0.9%)
Nauplii (20.7%)	*T. multicrinis* (< 0.1%)
Cladocera (13.6%)	*T. similis* (0.1%)
Daphnia ambigua (1.8%)	*Ascomorpha* (0.4%)
D. parvula (1.3%)	*Asplanchna priodonta* (0.8%)
Ceriodaphnia lacustris (2.1%)	*Synchaeta* (1.6%)
Bosmina longirostris (6.4%)	*Polyarthra* (2.6%)
Alona (< 0.1%)	*P. euryptera* (9.3%)
Alonella acutirostris (< 0.1%)	*Filinia longiseta* (0.3%)
Leydigia quadrangularis (< 0.1%)	*Pompholyx sulcata* (8.4%)
Chydorus sphaericus (0.5%)	*Hexarthra* (0.1%)
Diaphanosoma brachyurum (0.8%)	*Conochilus unicornis* (9.5%)
Holopedium cf. *gibberum* (0.7%)	*Ptygura* (0.2%)
Leptodora kindtii (< 0.1%)	*Collotheca* sp. (0.4%)
Protozoa (0.1%)	
Codonella (0.1%)	
Epistylus (< 0.1%)	

‡Percent composition of total annual mean density enclosed within parentheses.

Table 6.2 Zooplankton taxa collected at Harris Lake during 1988.‡

Copepoda (30.4%)	Rotifera (61.6%)
Diaptomus pallidus (0.8%)	*Keratella cochlearis* (8.1%)
Mesocyclops edax (1.2%)	*Kellicottia bostoniensis* (14.2%)
Tropocyclops prasinus (< 0.1%)	*Lecane* (0.7%)
Calanoid copepodites (4.3%)	*Monostyla* (0.1%)
Cyclopoid copepodites (6.8%)	*Trichocerca multicrinis* (5%)
Nauplii (17.4%)	*Gastropus stylifer* (0.9%)
	Ascomorpha (1.7%)
Cladocera (8.0%)	*Asplanchna priodonta* (0.6%)
Daphnia ambigua (< 0.1%)	*Asplanchna* (< 0.1%)
D. parvula (2.7%)	*Synchaeta* (0.4%)
Ceriodaphnia lacustris (1.0%)	*Polyarthra euryptera* (24.2%)
Bosmina longirostris (2.9%)	*Filinia longiseta* (< 0.1%)
Alona monachantha (< 0.1%)	*Pompholyx sulcata* (0.3%)
Chydorus sphaericus (0.2%)	*Hexarthra* (< 0.1%)
Diaphanosoma brachyurum (1.0%)	*Conochiloides exiguus* (4.6%)
Holopedium cf. *gibberum* (1.0%)	*Conochilus unicornis* (5.3%)
	Collotheca (0.5%)

‡Percent composition of total annual mean density enclosed within parentheses.

Table 6.3 Mean zooplankton density and biomass by station in Harris Lake during 1987 and 1988.‡

1987

Taxonomic group	Density (No./m^3) E2	Density (No./m^3) H2	Density (No./m^3) P2	Biomass (mg/m^3) E2	Biomass (mg/m^3) H2	Biomass (mg/m^3) P2
Copepods	$17{,}289^{b}$	$33{,}322^{a}$	$21{,}068^{b}$	25.6^{b}	49.0^{a}	$36.2^{a,b}$
Cladocerans	8,015	11,121	14,350	17.2	17.6	26.8
Rotifers	$28{,}652^{b}$	$80{,}303^{a}$	$31{,}990^{b}$	2.0^{b}	4.8^{a}	1.8^{b}
Total	$53{,}972^{b}$	$124{,}904^{a}$	$67{,}408^{b}$	44.8^{b}	71.4^{a}	$64.8^{a,b}$

1988

Taxonomic group	Density (No./m^3) E2	Density (No./m^3) H2	Density (No./m^3) P2	Biomass (mg/m^3) E2	Biomass (mg/m^3) H2	Biomass (mg/m^3) P2
Copepods	27,128	19,078	21,850	23.8	8.5	9.8
Cladocerans	9,107	4,453	4,338	13.4	6.3	8.8
Rotifers	55,263	45,148	37,267	3.8	5.1	4.5
Total	91,498	68,679	63,455	41.0	19.8	23.0

‡Fisher's protected least significant difference test was applied only if the overall F-test for treatments was significant. Means with different alphabetized superscripts were significantly different ($P < 0.05$). Protozoans not included due to low densities.

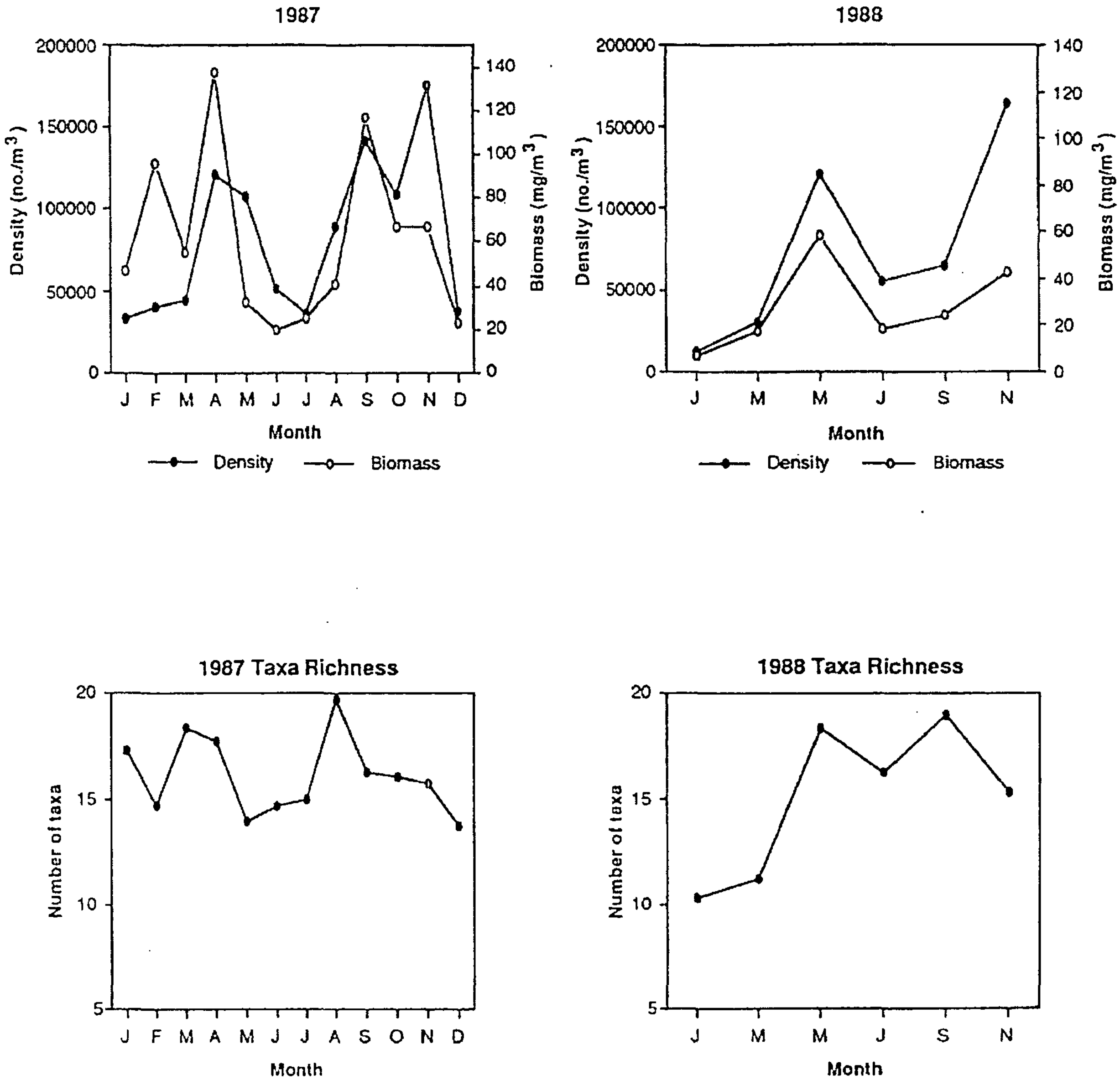


Figure 6.1 Zooplankton density, biomass and taxa richness in Harris Lake during 1987 and 1988.

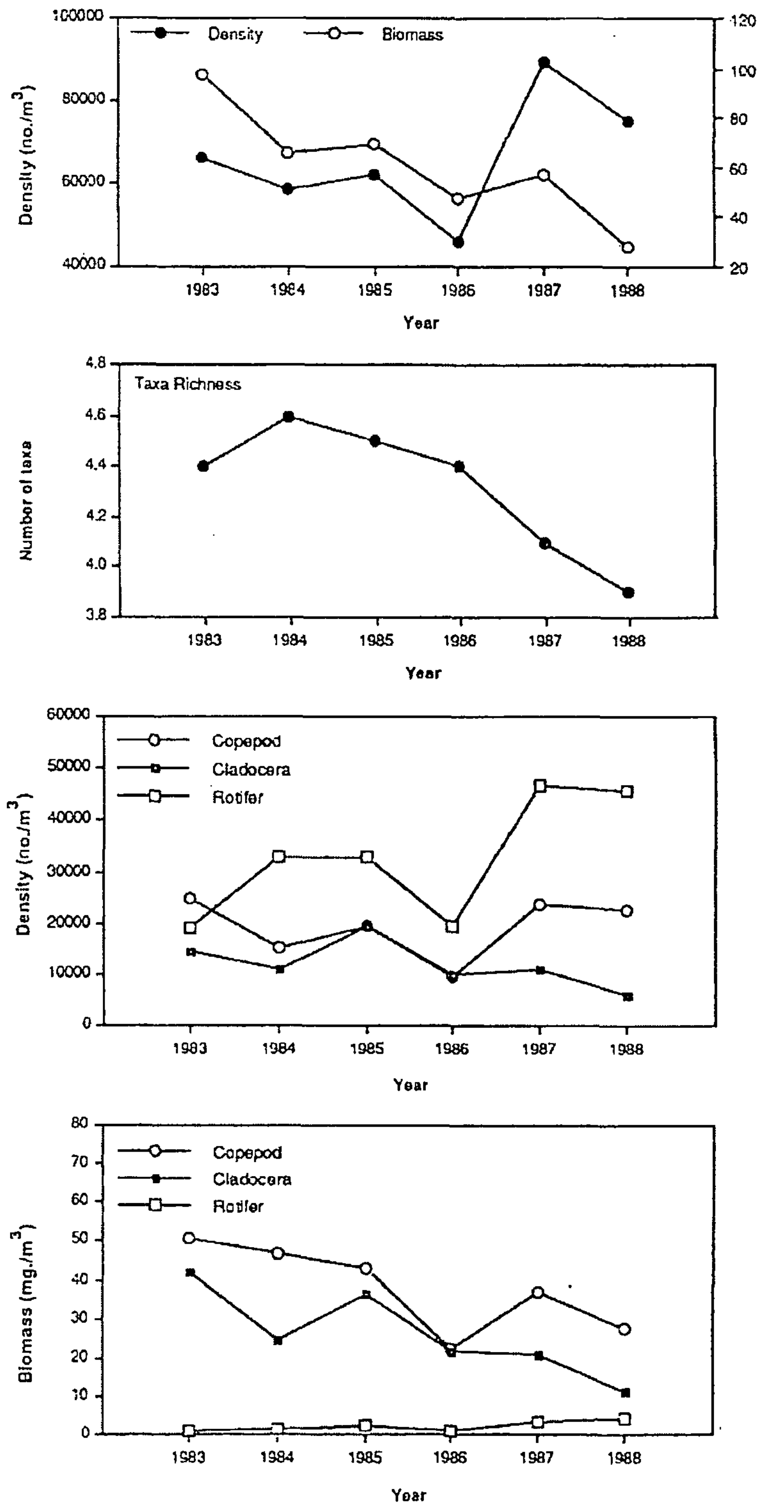


Figure 6.2 Zooplankton density, biomass and taxa richness in Harris Lake, 1983-1988.

7.0 BENTHIC MACROINVERTEBRATES

There were 83 benthic macroinvertebrate taxa collected from Harris Lake during 1987 and 72 collected during 1988 (Table 7.1). Despite fewer taxa collected during 1988, the distribution among the major taxa groups remained similar. During 1987, there were 35 chironomid, 20 oligochaete, and 28 miscellaneous taxa collected; and during, 1988 there were 35 chironomid, 14 oligochaete, and 23 miscellaneous taxa collected. Few differences in taxa composition were noted among stations for both years. Fifty-five taxa were common to all stations during 1987 and fifty-three taxa were found at all stations during 1988.

Prior to 1987, no Asiatic clams *Corbicula fluminea* were collected from Harris Lake during the regularly scheduled monitoring, although two individuals had been collected in special Asiatic clam surveys. During 1988, this biofouling organism was collected only at Station P1 near the Holleman's Crossroads boat ramp (Figure 2.1) in November. The clams were probably introduced by boaters. The size distribution of individuals indicated the population has been in the lake approximately two years. Their estimated density at P1 was 847/m^2. Bottom samples collected from the water intake structures of the power plant contained no Asiatic clams during 1987 and 1988.

During both 1987 and 1988, there were no significant differences in taxa richness among Stations E1, H1, and P1. However, there were significant differences in taxa richness among months. Significantly more taxa were collected during January, March, May, and July of 1987 than during September and November (Figure 7.1). During 1988, taxa richness was statistically similar in January and November. Taxa richness in November was also similar to taxa richness in all other months, except May. Taxa richness in May was significantly lower than all other months (Figure 7.1).

During the 1986-1988 period, there were significant differences in taxa richness among stations, months, and years. Taxa richness has traditionally been lower at Station P1 than E1 and H1, but during 1987, taxa richness at P1 was similar to taxa richness at H1. Temporally, there were significant differences among months with the most taxa occurring in January and March. There were significantly fewer taxa during September than during any other month for 1986-1988 (Figure 7.2). The taxa richness in each of the three years was significantly different with a decreasing trend from 1986 to 1988.

The dominant organisms ($\geq$ 5% of the mean annual density) during 1987 were mostly oligochaetes, especially *Dero nivea* (Table 7.2). This taxon was often nearly twice as abundant as any other taxon at all stations. The other dominant taxa included mostly oligochaetes and, to a lesser extent, chironomids.

During 1988, there was less dominance by a single taxon with different dominant taxa at each station (Table 7.3). *Glyptotendipes* was by far the most abundant taxon at E1, *Dero nivea* was the most abundant at H1, and *Specaria josinae* was most abundant at P1. The annual dominance of certain taxa usually resulted from high numbers of a taxon collected at a particular time of the year. This is not unusual for benthic organisms as clumping can result from patchiness reflecting preferred habitats or food availability.

There were no significant differences in organism density among stations for 1987 and 1988. However, there were differences in density among months. The highest densities in 1987 were found in March and May, followed closely by January, July, and November (Figure 7.1). Significantly fewer organisms were present in September. During 1988, there was a different pattern of organism density. The highest densities were found in January and November followed by July, September, May, and March (Figure 7.1). The main reason for the differences in abundance by months each year was the seasonal abundance of certain taxa. These taxa, primarily the annual dominant taxa, experienced large increases in abundance one month and were then much lower or absent the next month. These fluctuations were not unexpected since benthic organisms, especially oligochaetes, can respond rapidly to environmental conditions.

Organism density was similar for 1986 and 1987 but was significantly lower during 1988 (Figure 7.2). There was no obvious reason for this decrease but it might have been a result of increased predation by fish or a natural cycle in the overall benthic community of the lake.

There have been few changes in the functional feeding groups or the habitat preferences of the benthic organisms in Harris Lake over the last three years. The most common functional feeding group during both years was collector-gatherer (usually > 67%) followed by engulfer-carnivore (usually > 8%) (Table 7.4). Most benthic organisms were burrowers with fewer sprawlers and clingers. Sprawlers and clingers prefer hard substrates and aquatic vegetation as habitats. As hard habitats are removed or covered by siltation, these organisms will decline.

Table 7.1 Benthic macroinvertebrate taxa collected from Harris Lake during 1987 and 1988.‡

- Coelenterata
  - Hydrozoa
    - Hydroida
      - Hydridae
        - *Hydra*
- Platyhelminthes
  - Turbellaria
    - Tricladida
      - Planariidae
        - *Dugesia*
- Rhynchocoela
  - Hoplonemertini
    - Prostomidae
      - *Prostoma rubrum* ('88)
- Annelida
  - Clitellata
    - Oligochaeta
      - Naididae
        - *Amphichaeta americana*
        - *Bratislavia unidentata* ('87)
        - *Chaetogaster diaphanus*
        - *Dero flabelliger*
        - *D. nivea*
        - *Haemonais waldvogeli* ('87)
        - *Nais variabilis*
        - *Pristina aequiseta* ('87)
        - *P. breviseta*
        - *P. leidyi*
        - *Pristinella longisoma*
        - *Slavina appendiculata*
        - *Specaria josinae*
        - *Stylaria lacustris*
        - *Vejdovskyella comata*
      - Opistocystidae
        - *Crustipellis tribranchiata*
      - Tubificidae
        - *Aulodrilus pigueti*
        - *Ilyodrilus templetoni* ('87)
        - *Limnodrilus hoffmeisteri* ('87)
    - Hirudinea
- Arthropoda
  - Crustacea
    - Amphipoda
      - Talitridae
        - *Hyallela azteca*
  - Insecta
    - Ephemeroptera
      - Baetidae
        - *Callibaetis* ('88)
      - Ephemeridae
        - *Hexagenia*
      - Caenidae
        - *Caenis*
    - Odonata
      - Anisoptera
        - Libellulidae
          - *Perithemis* ('87)
      - Zygoptera
        - Coenagrionidae
          - *Enallagma* ('87)
    - Megaloptera
      - Sialidae
        - *Sialis*
    - Trichoptera
      - Polycentropodidae
        - *Cernotina*
        - *Phylocentropus* ('87)
      - Hydroptilidae
        - *Oxyethira*
        - *Hydroptila* ('87)
        - *Orthotrichia*
      - Leptoceridae
        - *Oecetis*
        - *Triaenodes*
    - Coleoptera
      - Haliplidae
        - *Peltodytes* ('87)
    - Diptera
      - Chaoboridae
        - *Chaoborus punctipennis*

Table 7.1 (continued)

- Ceratopogonidae
  - *Alluaudomyia*
  - *Bezzia*
- Chironomidae
  - Tanypodinae
    - *Ablabesmyia annulata*
    - *A. janta* ('88)
    - *A. peelensis* ('88)
    - *A. rhamphe* gp.
    - *A.* sp. ('88)
    - *Clinotanypus* ('87)
    - *Coelotanypus tricolor*
    - *Labrundinia*
    - *L.* sp. 4 Roback[¶]
    - *L. neopilosella*
    - *Procladius*
    - *Tanypus stellatus* ('87)
  - Orthocladiinae
    - *Bryophaenocladius* ('87)
    - *Corynoneura*
    - *Cricotopus*
    - *Nanocladius*
    - *N.* sp. nr. *balticus*
    - *Parakiefferiella*
    - *Psectrocladius* ('87)
    - *Thienemanniella*
  - Chironominae
    - Chironomini
      - *Chironomus*
      - *Cladopelma*
      - *Cryptochironomus*
      - *Cryptotendipes*
      - *Dicrotendipes*
      - *Endochironomus*
      - *Glyptotendipes*
      - *Nilothauma*
      - *Pagastiella ostansa*
      - *Parachironomus*
      - *Paralauterborniella nigrohalteralis*
      - *Polypedilum*
      - *Stenochironomus* ('88)
      - *Zavreliella varipennis*
    - Pseudochironominii
      - *Pseudochironomus*
    - Tanytarsini
      - *Cladotanytarsus*
      - *Paratanytarsus*
      - *Stempellina* ('88)
      - *Tanytarsus*
- Tabanidae
  - *Tabanus* ('87)

Arachnida
- Acari

Mollusca
- Gastropoda
  - Basommatophora
    - Ancylidae ('87)
    - Physidae
      - *Physa* ('87)
    - Planorbidae
      - *Helisoma*
- Pelecypoda
  - Eulamellibranchia
    - Unionidae
      - *Anodonta*
  - Heterodonta
    - Sphaeriidae
      - *Pisidium* ('87)
      - *Sphaerium*
    - Corbiculidae
      - *Corbicula fluminea* ('88)

[‡]Taxa with "('87)" were collected only during 1987 and those with "('88)" were collected only during 1988. All other taxa were collected in both years.

[¶]Previously reported as *Labrundinia becki*.

Table 7.2 Annual mean densities (organisms/m^2) of dominant benthic invertebrate taxa by station in Harris Lake during 1987.‡

Taxon	Station E1 Density	E1 %	Station H1 Density	H1 %	Station P1 Density	P1 %
Dero nivea	6,980	28.7	4,949	21.1	3,571	19.0
Tubificidae immature	1,892	8.9	--	--	--	--
Stylaria lacustris	1,438	6.8	1,677	7.2	2,009	10.7
Tanytarsus	1,244	5.9	2,098	8.9	1,143	6.1
Hydra	1,079	5.1	--	--	--	--
Ilyodrilus templetoni	--¶	--	2,684	11.5	--	--
Caenis	--	--	--	--	1,136	6.1
Specaria josinae	--	--	--	--	1,079	5.7
Pristina aequiseta	--	--	--	--	966	5.1
Polypedilum	--	--	--	--	954	5.1
Other taxa	8,467	40.1	9,835	46.5	6,055	37.3
Total mean annual density	21,187	--	23,433	--	18,769	--

‡Annual mean density of taxa ≥ 5% of the mean annual density.

¶Taxon might have been collected but its density was < 5% of the total annual mean density.

Table 7.3 Annual mean densities (organisms/m^2) of dominant benthic invertebrate taxa by station in Harris Lake during 1988.‡

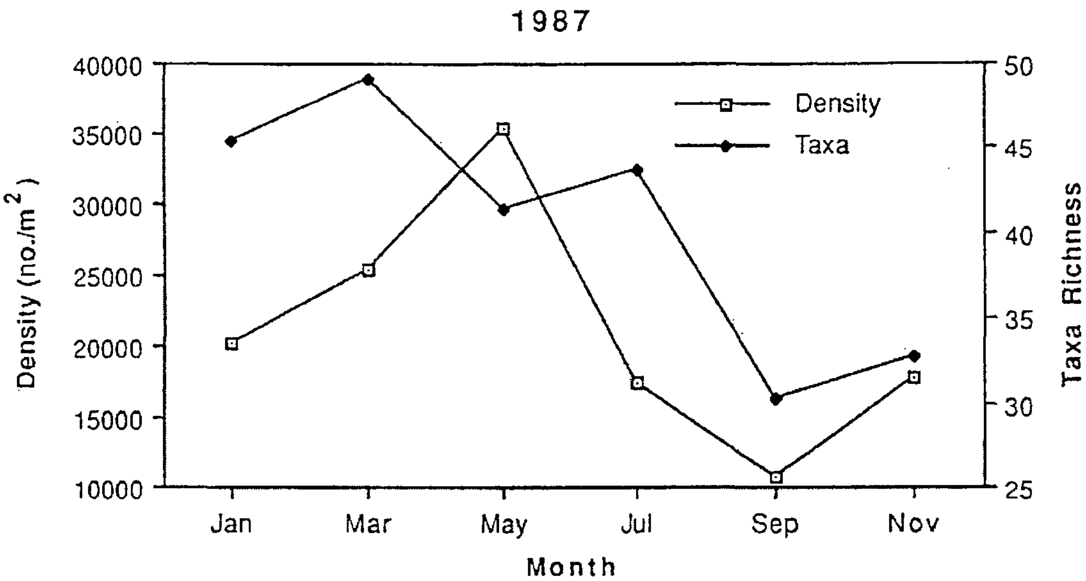
	Station					
	E1		H1		P1	
	Density	%	Density	%	Density	%
Glyptotendipes	4,863	27.8	--	--	--	--
Specaria josinae	1,572	9.0	1,308	6.9	4,315	24.5
Dero nivea	1,292	7.4	2,266	12.0	--	--
Cladotanytarsus	1,100	6.3	1,257	6.7	--	--
Tanytarsus	1,005	5.7	918	5.0	--	--
Stylaria lacustris	--¶	--	1,628	8.6	1,507	8.6
Hydra	--	--	1,590	8.4	1,007	5.7
Polypedilum	--	--	--	--	1,050	6.0
Other taxa	7,638	43.8	9,865	52.4	9,721	52.2
Total mean annual density	17,474	--	18,832	--	17,606	--

‡Dominant taxa ≥ 5% of the mean annual density.

¶Taxon might have been collected but its density was < 5% of the total annual mean density.

Table 7.4 Habit preferences, trophic status, and functional feeding groups as a percentage of the mean annual density of benthic macroinvertebrates in Harris Lake during 1987 and 1988.

	Year					
	1987			1988		
	E1	H1	P1	E1	H1	P1
Habit Preference						
Burrower	67	63	60	50	47	61
Sprawler	14	13	17	2	5	9
Clinger	13	15	14	30	26	20
Climber	5	7	7	4	6	5
Functional Feeding Group						
Collector-gatherer	74	73	70	55	61	65
Collector-filterer	4	5	4	15	7	6
Piercer-carnivore	6	3	5	5	10	6
Engulfer-carnivore	9	11	10	8	13	13
Scraper-grazer	4	4	5	3	3	3
Shedder-herbivore	2	3	4	11	3	4



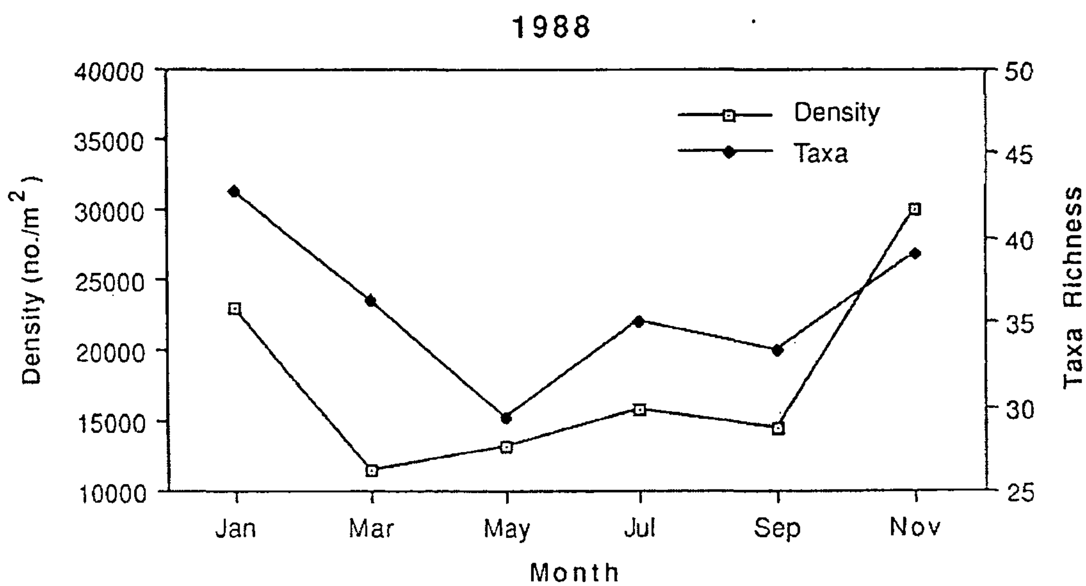


Figure 7.1 Mean taxa richness and density of benthic macroinvertebrates in Harris Lake during 1987 and 1988.

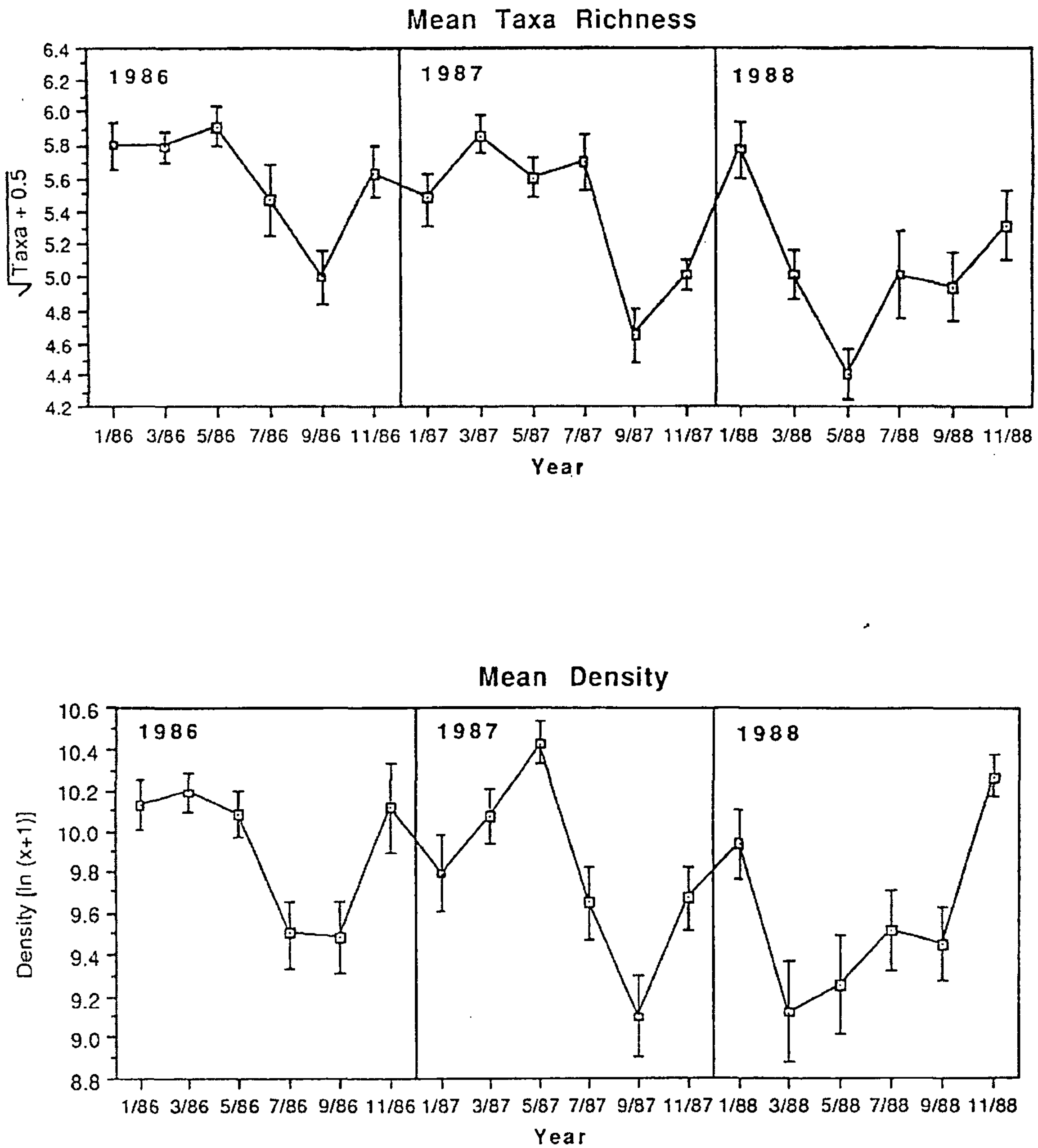


Figure 7.2 Mean taxa richness and density of benthic macroinvertebrates in Harris Lake, 1986-1988.

8.0 FISH

8.1 Species Composition

During 1987 and 1988, 17 species of fish representing 7 families and 28 species representing 9 families were collected from Harris Lake, respectively (Table 8.1). These numbers were similar to those observed in previous years with the differences reflecting sampling effort rather than a shift in species composition. No previously uncollected species were found during 1987. However, two species not previously seen in Harris Lake were collected during 1988. A bowfin was collected at Area S in the White Oak Creek arm of the reservoir; and threadfin shad were collected at Areas E, H, and P during rotenone sampling (Figure 2.1). Bowfin were probably present in White Oak Creek prior to filling of the reservoir, although none were collected during preimpoundment studies. The North Carolina Wildlife Resources Commission (NCWRC) stocked approximately 12,000 threadfin shad into Harris Lake during April 1988 to provide additional prey for largemouth bass and black crappie.

8.2 Larval Fish

Estimates of total larval fish densities measured during 1987 and 1988 showed similar temporal patterns when compared to previous years (Figure 8.1) (CP&L 1987). Larval fish densities continued to be dominated by shad (*Dorosoma* spp.) during May and *Lepomis* spp. during June (Figure 8.2). Densities of *Dorosoma* spp. were significantly higher during 1986 and 1988 than during 1983 and 1984. Densities during 1987 were significantly lower than 1986 levels but not different from 1988 densities. However, due to the introduction of threadfin shad during the spring of 1988, caution should be used when comparing 1988 *Dorosoma* spp. densities to previous years. Densities of *Lepomis* spp. showed no significant differences among years.

8.3 Juvenile and Adult Fish

Electrofishing and standing crop data from 1987 and 1988 documented that the fish community continued to be dominated by gizzard shad, largemouth bass, and bluegill; similar observations were made in previous years (Tables 8.2-8.6). Annual mean electrofishing catch rates for bluegill increased in 1988, while catch rates for gizzard shad and largemouth bass remained similar to previous years (Figure 8.3).

Cove rotenone sampling during 1988 showed the second highest total biomass estimate recorded at Harris Lake since 1982 (Table 8.5) (CP&L 1984a). Increases from previous years in gizzard shad, bluegill, black crappie, channel catfish, and golden shiner biomass accounted for the majority of the increase. Densities of these species also increased with the exception of bluegill (Table 8.5). Largemouth bass biomass decreased to the lowest level since 1982 (Figure 8.4); however, densities increased to the highest levels since 1982 (Table 8.5) (CP&L 1984a). Biomass and densities of pumpkinseed and redear sunfish were difficult to document due to combining these two species < 65 mm in length into one group during 1984 and 1986. However, it appeared that both density and biomass for both species increased during 1988 (Table 8.5). As in 1986, Area H had the highest total biomass followed by Areas E and P (Table 8.6).

Length-frequency distributions for the dominant species collected during cove rotenone sampling indicated good young-of-year recruitment during 1988 (Figures 8.5-8.13). Recruitment of gizzard shad and brown bullhead was particularly high during 1988 (Figures 8.7 and 8.12). Largemouth bass also showed exceptionally high numbers of young-of-year fish (Figure 8.13). This increase in reproductive success of largemouth bass was also observed at Mayo (CP&L 1989) and Sutton (CP&L in prep.) lakes during 1988. As in past years, few largemouth bass > 355 mm were collected. The abundant densities of aquatic macrophytes which occurred in Harris Lake provided abundant protective cover for young fish and macroinvertebrates food sources. This factor probably reduced predation resulting in reduction of growth rates of largemouth bass. Length-frequency distributions for redear sunfish $\geq$ 65 mm remained similar to previous years, while pumkinseed showed an increase in fish between 75 and 100 mm (Figures 8.5 and 8.6). Condition factors in 1988 for most species were slightly lower than in 1986 (Table 8.7). Values were only slightly lower than those reported by Carlander (1969, 1977) indicating fish were in a relatively healthy condition.

The presence of threadfin shad in cove rotenone samples indicated a successful stocking in Harris Lake during 1988. The benefits to the sport fishery (i.e., increased growth rates and more harvestable-sized largemouth bass and black crappie) may not be realized for several years. Although threadfin shad have been reported to reduce survival of young largemouth bass and other sunfishes due to competition for zooplankton food sources (von Geldern and Mitchell 1975; Davies et al. 1979; Ziebell et al. 1986), the increased recruitment of largemouth bass and black crappie indicated no short-term detrimental impact from the threadfin shad introduction. The susceptibility of adult threadfin shad to temperature-related winter mortality may limit the population size and thus minimize competition for zooplankton with sunfishes. Restocking of threadfin shad may be necessary to sustain the population.

These data show that Harris Lake supports a good sport fish population. Increases in density and biomass of many species indicate no negative impact on the fish community during the first two years of operation of the Harris Plant. However, because of the unknown effect (positive or negative) of increased nutrient inputs attributed to Harris Plant discharge, future monitoring of the fish population is warranted.

8.4 Largemouth Bass Tournaments

During the two-day largemouth bass tournament held in 1987 (292 anglers), a total of 765 largemouth bass was weighed and measured by CP&L biologists. Of this total, 68 fish (8.9%) were greater than 355 mm in length (Figure 8.14). NCWRC regulations require that six of the eight fish limit be $\geq$ 14 inches (356 mm). These tournament anglers were selecting for large fish and only retained the largest largemouth bass caught.

These results indicated that there were low numbers of largemouth bass of legal size (> 355 mm) in Harris Lake. This has been attributed to slow growth rates in previous years (Swing 1986). Mean condition factors for largemouth bass $\leq$ 355 mm (N = 696) and > 355 mm (N = 69) were 1.26 and 1.32, respectively, indicating fish in relatively good condition.

During the 1988 tournament (80 anglers), 223 largemouth bass were weighed and measured by CP&L biologists. Since the anglers could not weigh in fish $\leq$ 355 mm, all but two largemouth bass were > 355 mm (Figure 8.15). These data indicated that by the fall of 1988 there was a substantial number of legal size fish in Harris Lake. This increase from 1987 could be attributed to growth over two growing seasons and/or to the addition of threadfin shad to the food base which may have increased growth rates during 1988. Although cove rotenone and electrofisher sampling did not collect many largemouth bass $\geq$ 355 mm, the tournament data indicated that largemouth bass of that size were present in the reservoir. The mean condition factor for largemouth bass $\geq$ 355 mm was good (K = 1.34) and was similar to values reported by Carlander (1977).

Table 8.1 Fish species collected from Harris Lake, 1985-1988.

Scientific name	Common name	1985	1986	1987	1988
Amiidae	bowfins				
Amia calva	bowfin				X
Anguillidae	freshwater eels				
Anguilla rostrata	American eel	X	X	X	
Clupeidae	herrings				
Dorosoma cepedianum	gizzard shad	X	X	X	X
D. petenense	threadfin shad				X
Esocidae	pikes				
Esox americanus americanus	redfin pickerel		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. petersoni	coastal shiner				X
Catostomidae	suckers				
Erimyzon oblongus	creek chubsucker		X		X
Moxostoma anisurum	silver redhorse				X
Ictaluridae	bullhead catfishes				
Ictalurus spp.	unidentified bullhead		X		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		
N. gyrinus	tadpole madtom				X
Plyodictis olivaris	flathead catfish		X		X
Poeciliidae	livebearers				
Gambusia affinis	mosquitofish	X	X		X
Centrarchidae	sunfishes				
Acantharchus pomotis	mud sunfish		X		
Centrarchus macropterus	flier	X		X	X
Enneacanthus 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		
P. nigromaculatus	black crappie	X	X	X	X
Percidae	perches				
Etheostoma spp.	unidentified darter		X	X	X
E. fusiforme	swamp darter	X	X		X

Table 8.2 Fish (number/hour) collected by electrofishing from Harris Lake during 1987.

Species	Area E	Area H	Area P	Area S	Area V	Mean
American eel			0.5		0.5	0.2
Gizzard shad	5.0	9.5	5.0	8.0	16.0	8.7
Chain pickerel	1.5	1.5	0.5	0.5	2.5	1.3
Golden shiner	3.0		6.0	2.5	0.5	2.4
Unidentified shiner	0.5		0.5			0.2
Yellow bullhead	0.5		0.5		1.0	0.4
Brown bullhead	17.0	21.5	13.5	19.5	12.0	16.7
Flat bullhead				0.5		0.1
Flier				1.5		0.3
Bluespotted sunfish				0.5		0.1
Hybrid sunfish			0.5		0.5	0.2
Redbreast sunfish	2.0	0.5	1.0		0.5	0.8
Green sunfish			0.5		0.5	0.2
Pumpkinseed	3.0	6.5	9.0	7.5	4.0	6.0
Warmouth	6.5	9.0	10.5	11.5	17.5	11.0
Bluegill	16.5	41.5	16.0	23.5	19.0	23.3
Redear sunfish	6.0	6.5	10.0	3.0	9.0	6.9
Largemouth bass	33.5	34.5	27.0	15.0	37.5	29.5
Black crappie	2.0		1.5	4.5	3.0	2.2
Total	97.0	131.0	102.5	98.0	124.0	110.5

Table 8.3 Fish (number/hour) collected by electrofishing from Harris Lake during 1988.

Species	Area E	Area H	Area P	Area S	Area V	Mean
Bowfin				0.5		0.1
Gizzard shad	9.0	3.0	7.5	17.0	5.5	8.4
Chain pickerel	2.5	1.5	1.5	1.5	4.5	2.3
Rosyside dace		0.5				0.1
Golden shiner	6.5	9.0	2.0	0.5	8.5	5.3
Unidentified shiner			1.5		0.5	0.4
Coastal shiner		3.0				0.6
Creek chubsucker	0.5					0.1
Yellow bullhead				0.5	1.5	0.4
Brown bullhead	17.0	15.0	18.0	18.5	10.5	15.8
Flat bullhead		0.5				0.1
Channel catfish				0.5		0.1
Hybrid sunfish	0.5				0.5	0.2
Flier				0.5		0.1
Bluespotted sunfish					0.5	0.1
Redbreast sunfish	2.5	1.5			0.5	0.9
Green sunfish	0.5	1.0				0.3
Pumpkinseed	18.0	20.5	16.0	8.0	16.0	15.7
Warmouth	10.0	8.5	8.5	9.5	9.0	9.1
Bluegill	25.0	116.5	29.0	28.0	233.5	86.4
Redear sunfish	9.0	5.5	8.0	6.5	8.0	7.4
Largemouth bass	67.5	35.0	20.0	14.5	26.0	32.6
Black crappie	4.5	0.5	4.0	2.5	28.0	7.9
Unidentified darter					0.5	0.1
Swamp darter		0.5			1.0	0.3
Total	172.5	222.5	116.0	108.5	354.5	194.8

Totals may differ from sums due to rounding.

Table 8.4 Annual mean catch rate (number/hour) of fish collected by electrofishing in Harris Lake, 1983-1988.

Species	1983	1984	1985	1986	1987	1988
Bowfin						0.1
American eel	0.8	0.9	0.5	0.2	0.2	
Gizzard shad	15.6	10.4	5.5	10.8	8.7	8.4
Redfin pickerel	0.3			0.1		
Chain pickerel	1.2	2.5	0.8	0.8	1.3	2.3
Rosyside dace						0.1
Golden shiner	2.3	3.9	1.8	1.3	2.4	5.3
Unidentified shiner	0.5	2.3	4.5	0.5	0.2	0.4
Coastal shiner						0.6
Creek chubsucker	0.1					0.1
Yellow bullhead	0.7	2.0	2.1	0.8	0.4	0.4
Brown bullhead	9.9	5.2	12.7	11.3	16.7	15.8
Flat bullhead			0.3		0.1	0.1
Channel catfish			0.3			0.1
Mosquitofish	0.1		< 0.1			
Hybrid sunfish	1.7	0.8	1.2		0.2	0.2
Flier	1.1	0.5	< 0.1		0.3	0.1
Bluespotted sunfish	0.2				0.1	0.1
Redbreast sunfish	3.0	1.5	0.9	1.4	0.8	0.9
Green sunfish	4.9	2.1	1.2	0.2	0.2	0.3
Pumpkinseed	13.8	11.0	9.3	5.5	6.0	15.7
Warmouth	8.6	9.9	9.9	11.1	11.0	9.1
Bluegill	34.4	33.2	30.6	40.6	23.3	86.4
Redear sunfish	6.0	4.7	3.1	4.6	6.9	7.4
Largemouth bass	63.8	44.9	32.7	48.3	29.5	32.6
White crappie				0.1		
Black crappie	2.8	2.4	2.0	1.5	2.2	7.9
Unidentified darter						0.1
Swamp darter			0.2	0.3		0.3
Total	171.8	137.3	119.4	140.8	110.5	194.8

Totals may differ from sums due to rounding.

Table 8.5 Fish (number and weight/hectare) collected in rotenone sampling at Harris Lake during 1984, 1986, and 1988.

Species	1984		1986		1988	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
American eel	0.5	0.2	2.0	0.8		
Unidentified shad					2.6	< 0.1
Gizzard shad	2,291.4	264.4	608.7	87.9	3,485.6	167.8
Threadfin shad					274.7	11.0
Redfin pickerel	5.9	0.2	4.1	0.3	1.3	< 0.1
Chain pickerel	6.9	3.2	30.2	2.5	32.5	4.8
Golden shiner	266.3	1.0	230.9	1.3	795.9	7.8
Creek chubsucker	3.5	0.2	0.4	0.1	2.4	0.3
Silver redhorse	86.8	114.2			34.0	5.2
Unidentified shiner	157.9	0.1	75.7	0.1	297.6	0.4
Unidentified bullhead	85.2	< 0.1	90.8	0.3	29.3	0.1
Yellow bullhead	22.1	2.0	26.5	2.0	51.5	1.4
Brown bullhead	5.5	0.6	127.2	19.5	266.9	2.6
Flat bullhead	9.7	0.8	11.9	1.0	105.3	2.6
Channel catfish			34.3	7.2	13.5	14.1
Tadpole madtom					0.5	< 0.1
Pirate perch	0.9	< 0.1				
Mosquitofish	138.4	< 0.1	228.1	0.1	175.9	0.1
Hybrid sunfish	3.7	0.3	2.1	0.2	4.3	0.2
Unidentified sunfish	752.5	0.5			6.5	< 0.1
Mud sunfish			0.8	< 0.1		
Flier	1.6	0.3			2.1	0.1
Bluespotted sunfish	413.8	0.3	517.6	0.3	2,143.4	1.7
Redbreast sunfish	529.2	3.4	197.3	1.5	778.1	5.3
Green sunfish	144.4	0.8	159.2	0.4	37.3	0.3
Pumpkinseed/redear‡	2,237.0	2.2	3,104.2	4.1		
Pumpkinseed‡	101.4	6.0	144.4	3.4	4,627.9	18.3
Warmouth	3,136.5	11.7	3,392.1	18.1	2,370.7	13.9
Bluegill	15,971.0	32.4	42,288.4	45.5	24,426.9	67.3
Redear sunfish‡	70.4	5.4	88.0	6.4	1,827.7	12.3
Largemouth bass	239.2	22.6	469.4	28.4	1,026.8	20.8
Black crappie	179.5	0.8	289.3	4.7	1,802.4	15.1
Unidentified darter	287.2	< 0.1	152.5	< 0.1		
Swamp darter			28.6	< 0.1	133.8	0.1
Sawcheek darter	4.9	< 0.1				
Total	27,152.9	473.8	58,304.8	235.8	44,781.3	373.6

Totals may differ from sums due to rounding.

‡Pumpkinseed and redear sunfish < 65 mm were combined during 1984 and 1986.

Table 8.6 Fish (number and weight/hectare) collected in rotenone sampling at Harris Lake during 1988.

Species	Area E		Area H		Area P		Mean	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
Unidentified shad					7.8	< 0.1	2.6	< 0.1
Gizzard shad	1,907.3	133.1	7,896.6	305.7	652.9	64.6	3485.6	167.8
Threadfin shad	119.1	1.1	703.4	31.9	1.6	< 0.1	274.7	11.0
Redfin pickerel	2.4	< 0.1			1.6	< 0.1	1.3	< 0.1
Chain pickerel	29.2	9.3	7.3	2.5	60.9	2.6	32.5	4.8
Golden shiner	325.6	0.9	231.6	5.8	1,830.7	16.6	795.9	7.8
Unidentified shiner	337.7	0.5	141.3	0.2	413.9	0.5	297.6	0.4
Coastal shiner			71.4	0.1			23.8	< 0.1
Creek chubsucker			7.3	1.0			2.4	0.3
Silver redhorse			101.9	15.7			34.0	5.2
Unidentified bullhead	29.2	0.1	30.6	0.2	28.1	0.1	29.3	0.1
Yellow bullhead	41.3	1.3	55.3	0.6	57.8	2.3	51.5	1.4
Brown bullhead	97.2	0.9	163.1	3.8	540.5	3.0	266.9	2.6
Flat bullhead	172.5	6.2	90.3	0.5	53.1	1.0	105.3	2.8
Channel catfish	7.3	6.6	17.5	13.1	15.6	22.7	13.5	14.1
Tadpole madtom			1.5	< 0.1			0.5	< 0.1
Mosquitofish	420.3	0.2	48.1	< 0.1	59.4	< 0.1	175.9	0.1
Hybrid sunfish	9.7	0.3			3.1	0.2	4.3	0.2
Flier	4.9	< 0.1	1.5	0.3			2.1	0.1
Bluespotted sunfish	2.4	< 0.1	235.9	0.3	6191.8	4.8	2143.4	1.7
Unidentified sunfish	19.4	< 0.1					6.5	< 0.1
Redbreast sunfish	850.4	11.6	1,465.1	4.2	18.7	< 0.1	778.1	5.3
Green sunfish	38.9	0.3	46.6	0.4	26.6	0.3	37.3	0.3
Pumpkinseed	605.0	7.1	4,781.4	16.6	8,497.4	31.2	4,627.9	18.3
Warmouth	738.6	13.7	5,208.1	14.6	1,165.3	13.4	2,370.7	13.9
Bluegill	5,146.1	71.7	33,356.1	75.0	34,778.3	55.1	24,426.9	67.3
Redear sunfish	87.5	11.1	595.7	10.2	4,800.1	15.7	1,827.7	12.3
Largemouth bass	1,020.5	13.2	930.6	18.5	1,129.3	30.8	1,026.8	20.8
Black crappie	1,771.3	21.5	1,556.9	8.8	2,079.0	14.8	1,802.4	15.1
Swamp darter	38.9	< 0.1	342.3	0.2	20.3	< 0.1	133.8	0.1
Total	13,822.6	310.8	58,087.3	530.0	62,433.9	279.9	44,781.3	373.6

Totals may differ from sums due to rounding.

Table 8.7 Condition factor (K) of selected species of fish collected with rotenone in Harris Lake during 1984, 1986, and 1988.

Species	Size class (mm)	1984	1986	1988
Gizzard shad	≤ 200	1.9	‡	0.9
	> 200	0.8	0.8	0.8
Brown bullhead	50-100	‡	1.4	0.9
	101-200	‡	1.1	0.9
	> -200	‡	1.2	1.1
Redbreast sunfish	50-100	‡	1.8	1.5
	101-200	1.8	1.8	1.6
Pumpkinseed	50-100	1.8	1.8	1.7
	101-200	1.8	1.8	1.7
Warmouth	50-100	1.8	1.9	1.8
	101-200	1.8	1.9	1.8
Bluegill	50-100	1.6	1.6	1.7
	101-200	1.7	1.8	1.7
	> 200	1.6	1.8	1.7
Redear sunfish	50-100	1.6	1.8	1.8
	101-200	1.5	1.8	1.7
	> 200	1.5	1.7	1.7
Largemouth bass	50-100	1.0	1.1	1.2
	101-150	1.0	1.2	1.2
	200-250	1.2	1.3	1.6
	251-300	1.1	1.2	1.3
	> 300	‡	1.2	1.4
Black crappie	50-100	1.3	1.4	1.3
	101-200	1.2	1.3	1.2
	> 200	‡	1.4	1.6
Threadfin shad	50-100	¶	¶	0.8
	> 100	¶	¶	0.9

‡Sample size too small for valid estimate.

¶Species not present in reservoir.

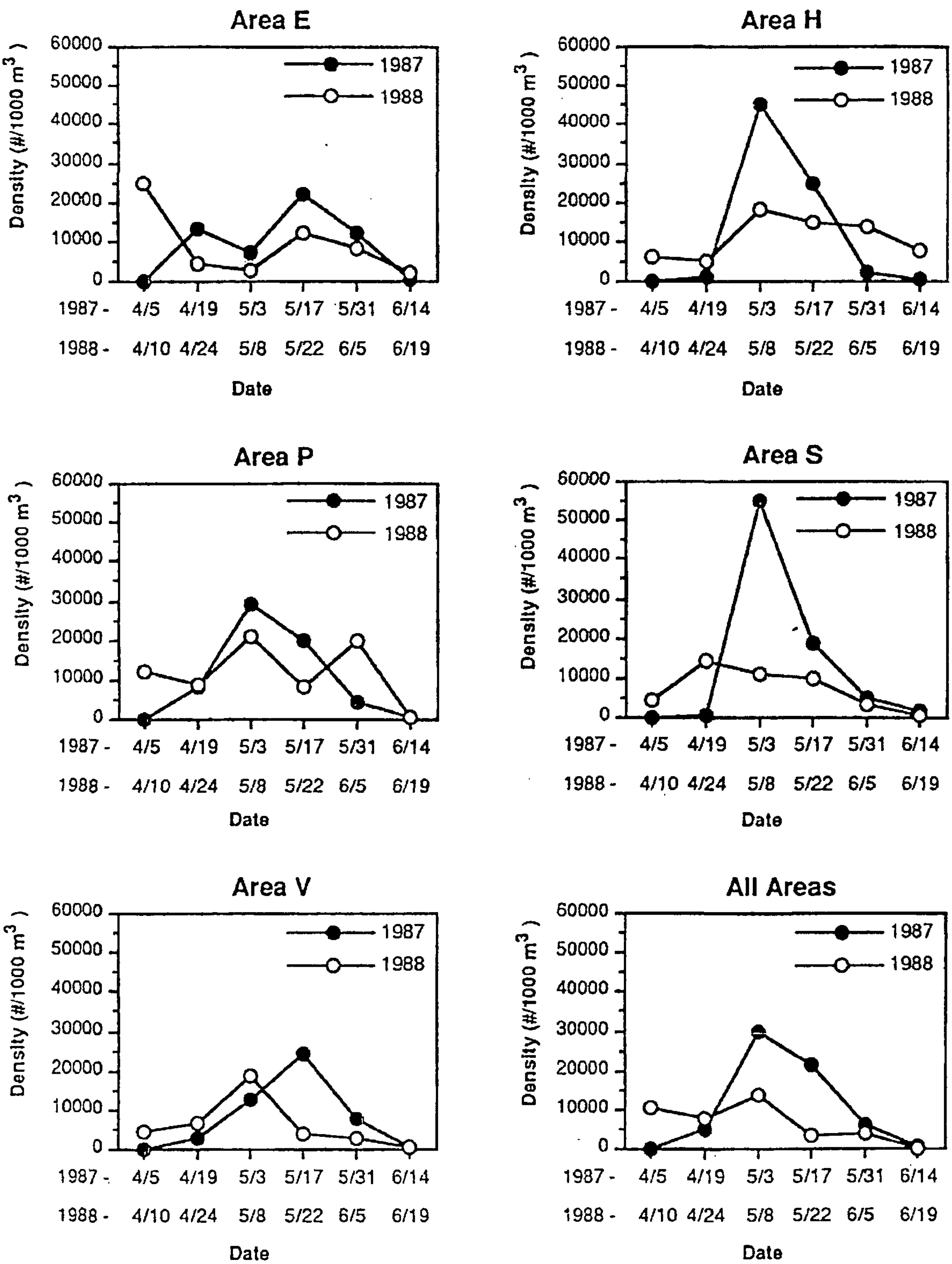


Figure 8.1 Larval fish push net density estimates from Harris Lake during 1987 and 1988.

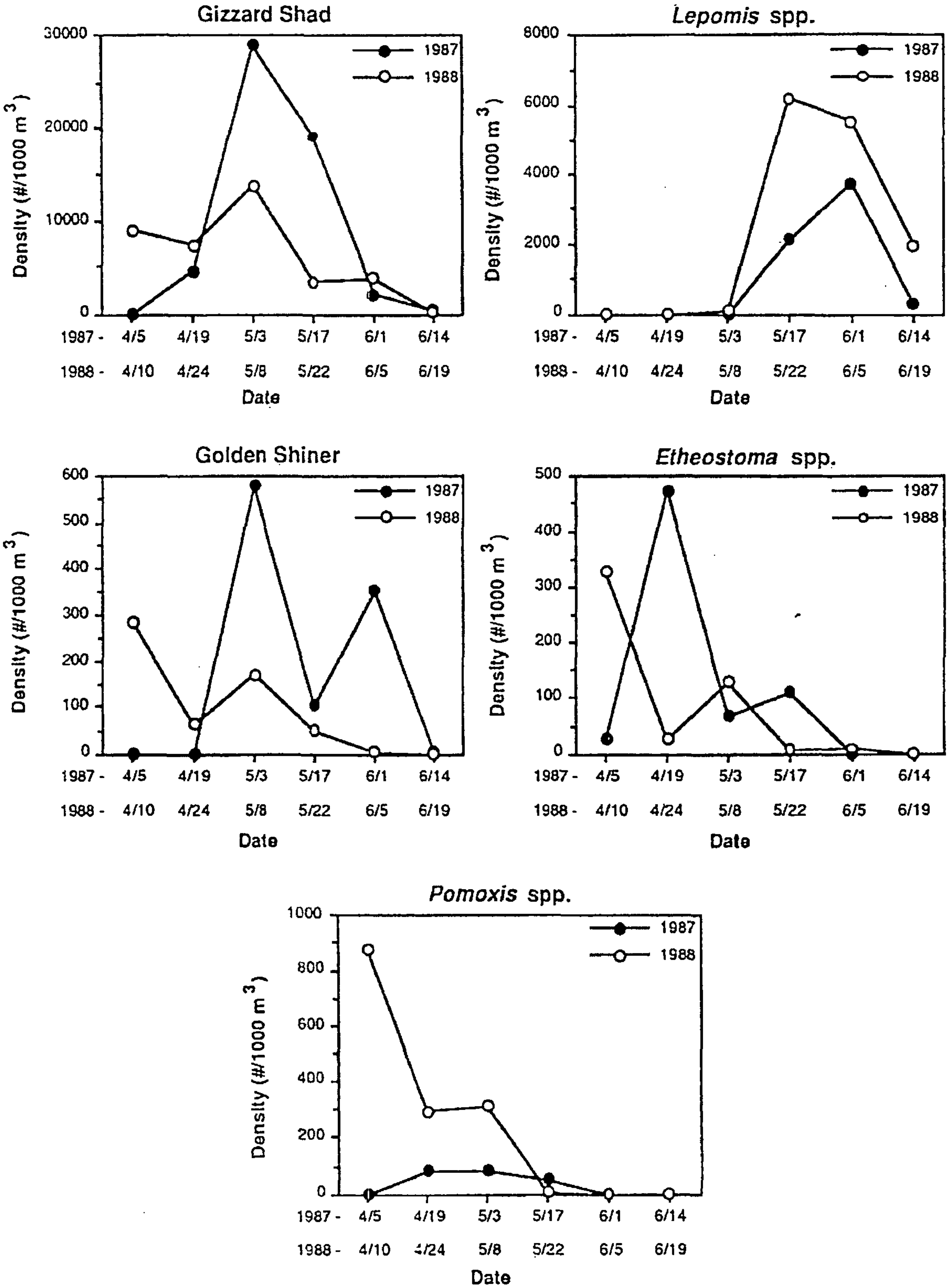


Figure 8.2 Larval fish push net density estimates by species from Harris Lake during 1987 and 1988. Note that different scales were used for density.

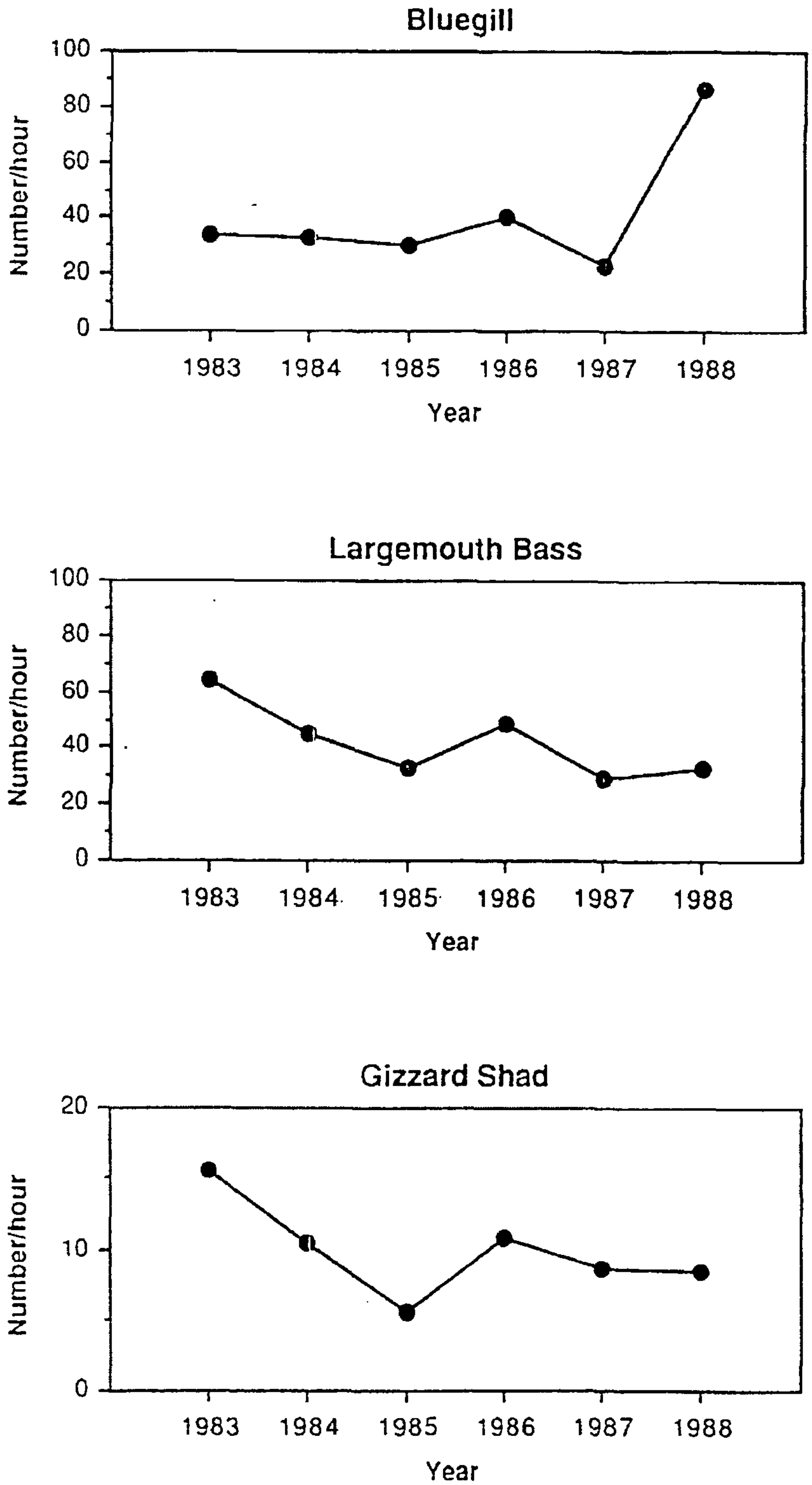


Figure 8.3 Electrofishing catch rates (number/hour) for selected species of fish collected by electrofishing from Harris Lake, 1983-1988. Note that different scales were used for catch rate.

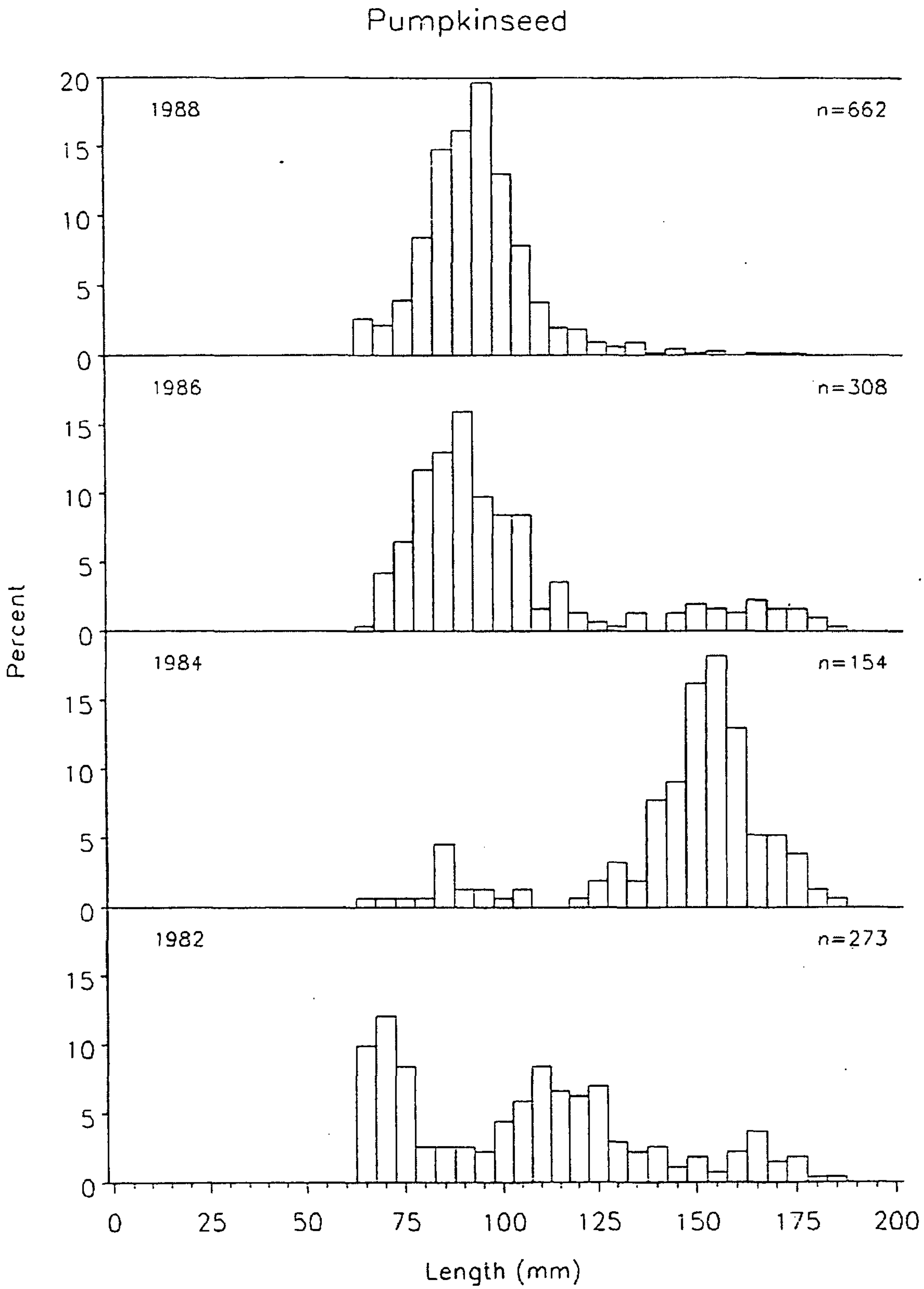


Figure 8.5 **Length-frequency distribution of pumpkinseed collected from cove rotenone samples at Harris Lake, 1982-1988. Fish < 65 mm were excluded.**

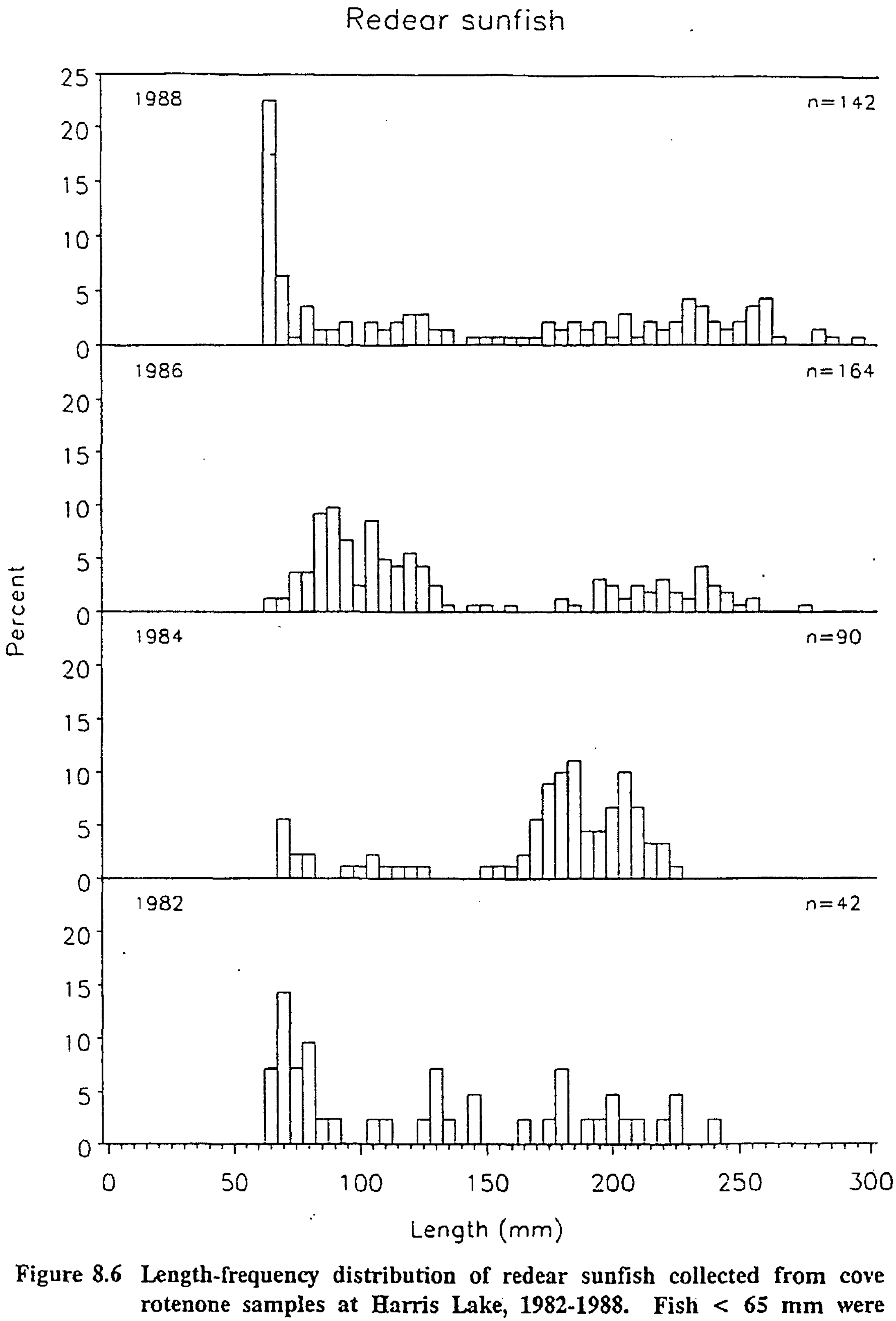


Figure 8.6 Length-frequency distribution of redear sunfish collected from cove rotenone samples at Harris Lake, 1982-1988. Fish < 65 mm were excluded.

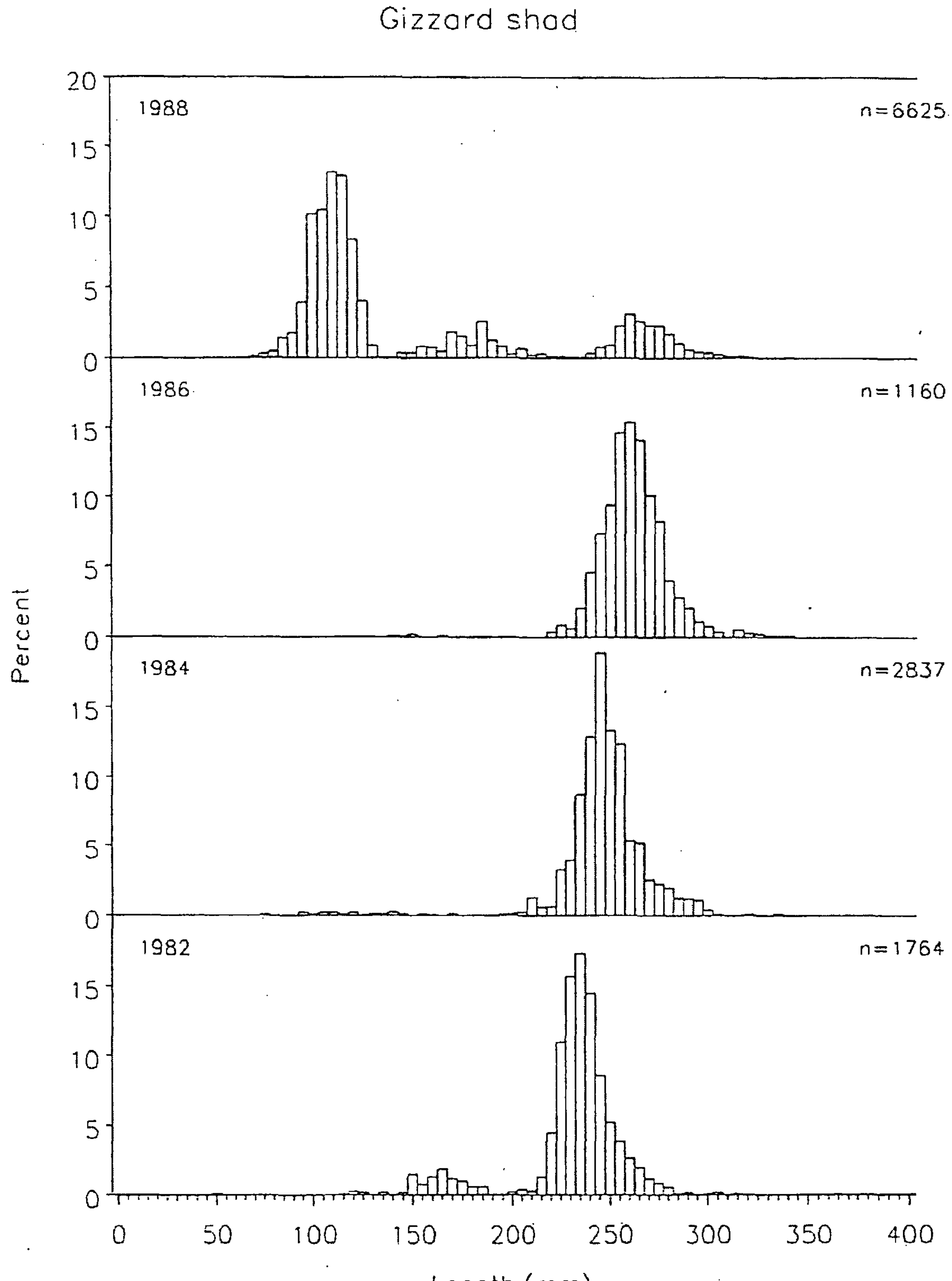


Figure 8.7 Length-frequency distribution of gizzard shad collected from cove rotenone samples at Harris Lake, 1982-1988.

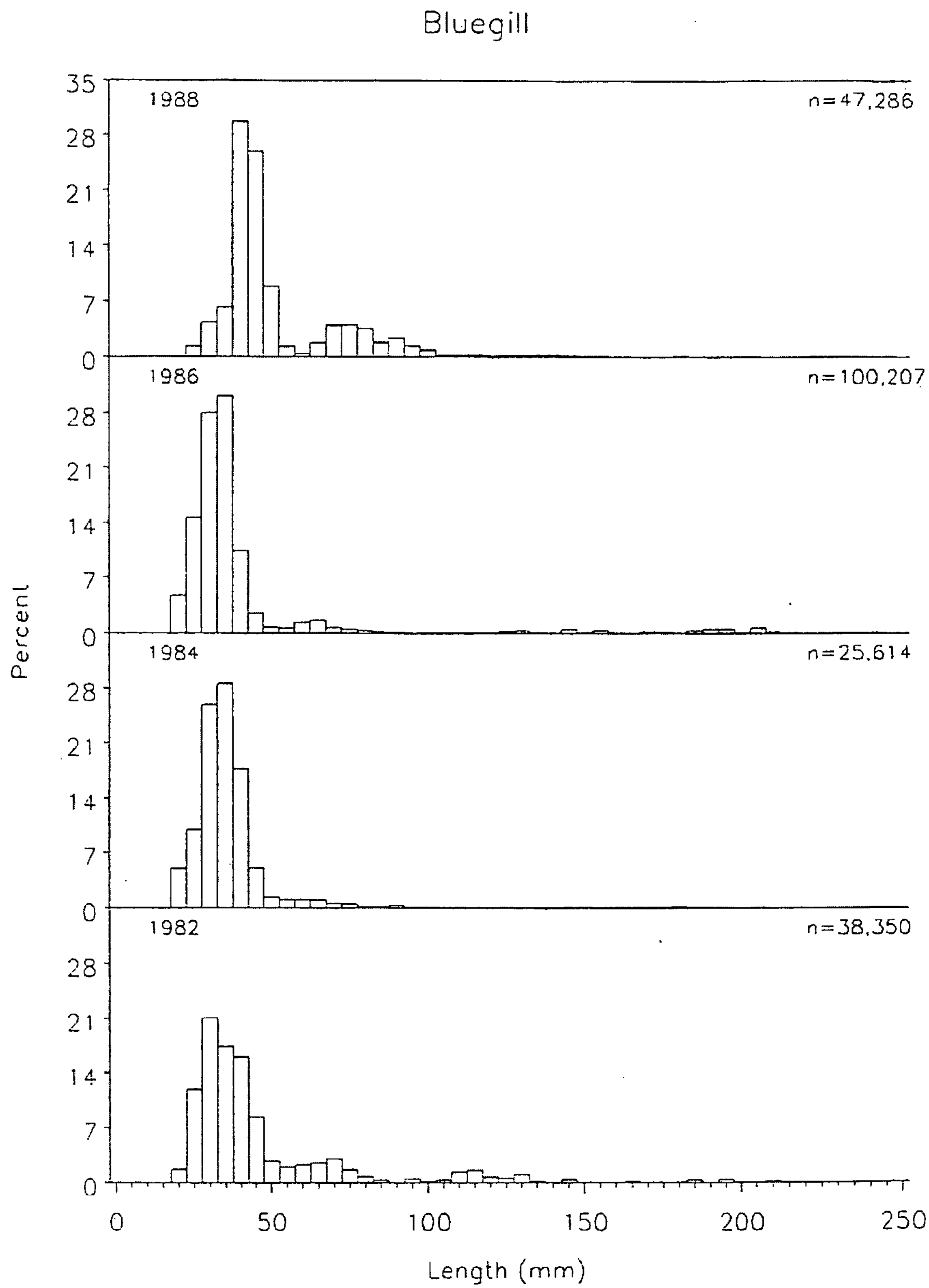


Figure 8.8 Length-frequency distribution of bluegill collected from cove rotenone samples at Harris Lake, 1982-1988.

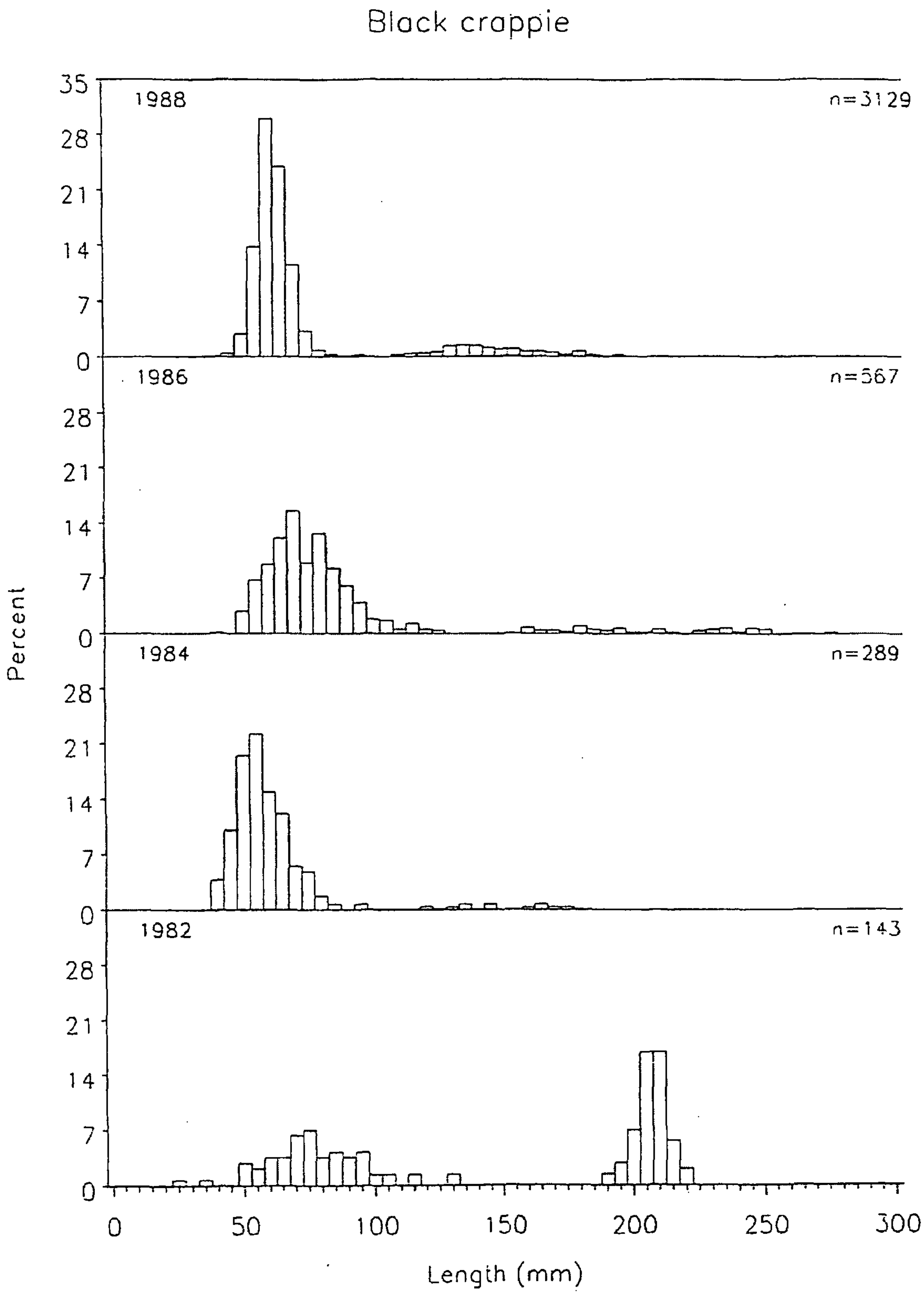


Figure 8.9 Length-frequency distribution of black crappie collected from cove rotenone samples at Harris Lake, 1982-1988.

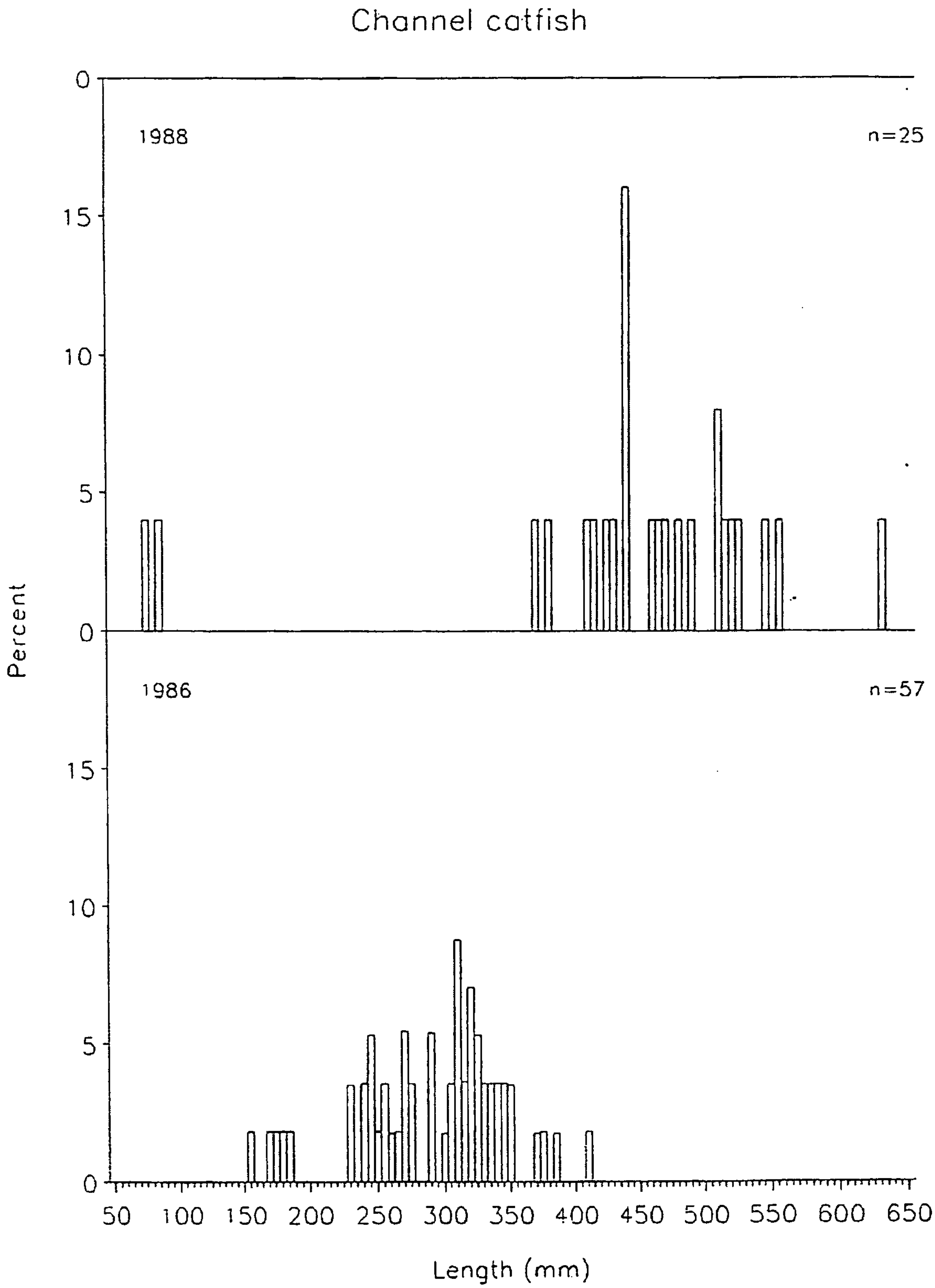


Figure 8.10 Length-frequency distribution of channel catfish collected from cove rotenone samples at Harris Lake, 1982-1988.

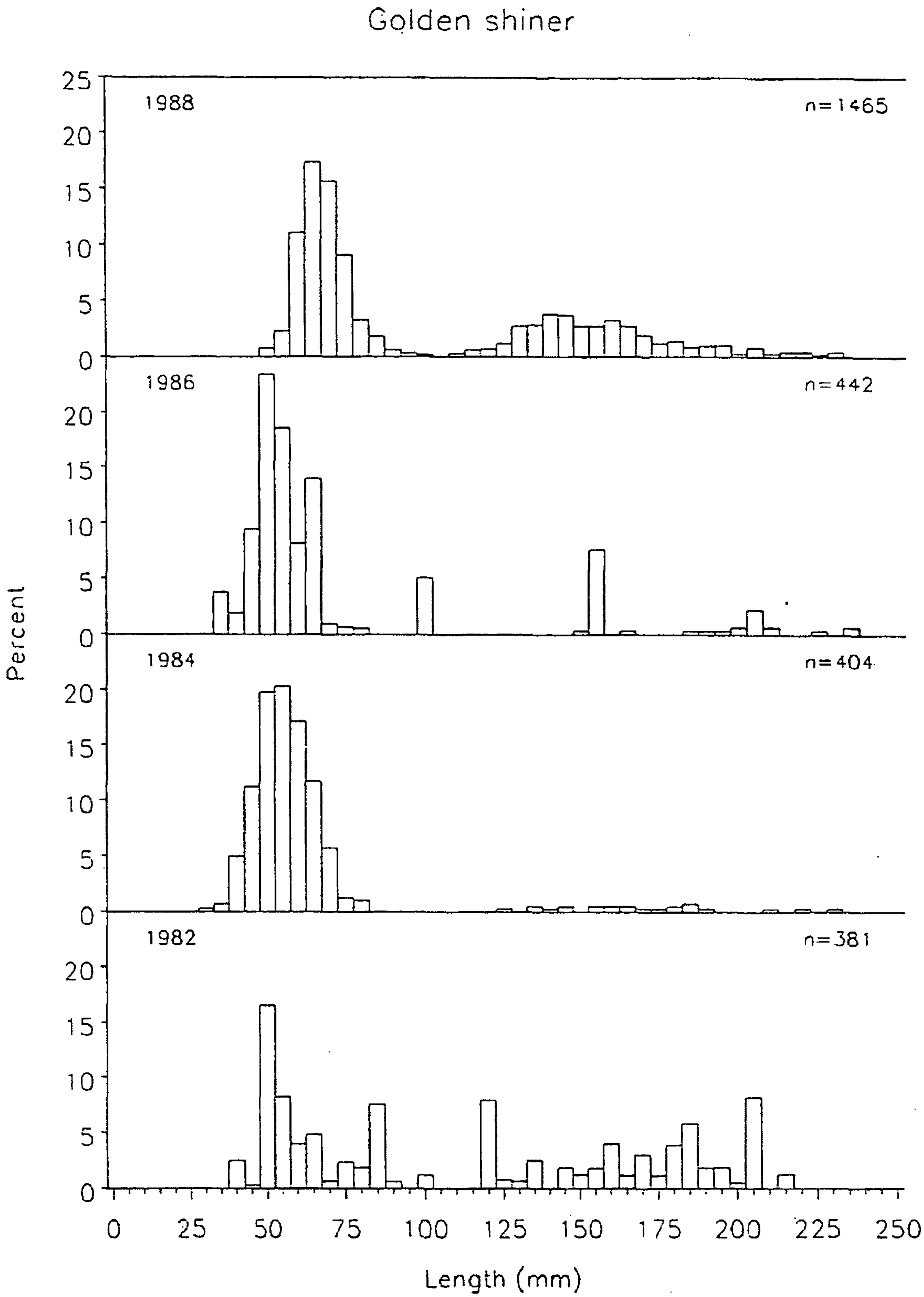


Figure 8.11 Length-frequency distribution of golden shiner collected from cove rotenone samples at Harris Lake, 1982-1988.

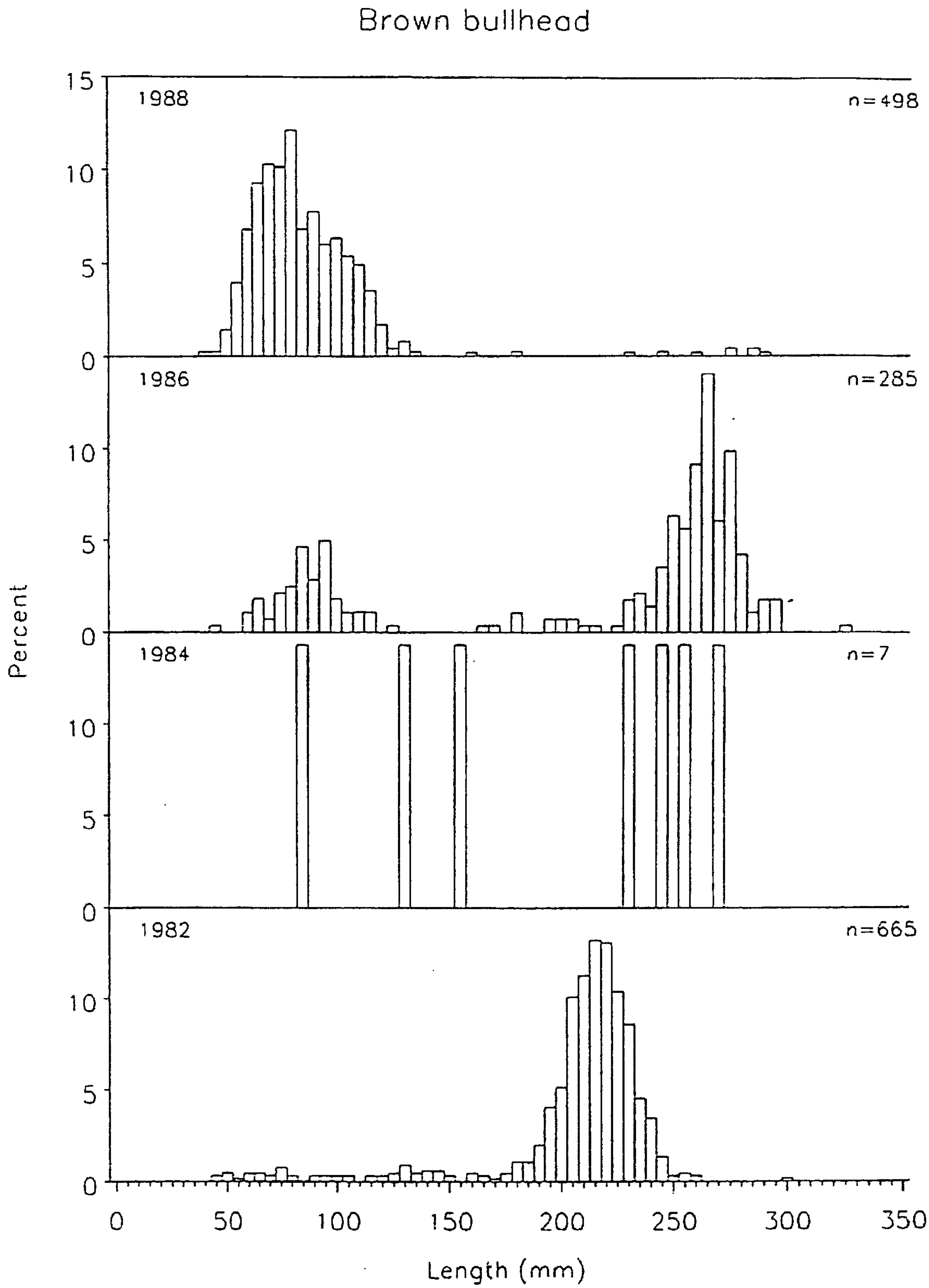


Figure 8.12 Length-frequency distribution of brown bullhead collected from cove rotenone samples at Harris Lake, 1982-1988.

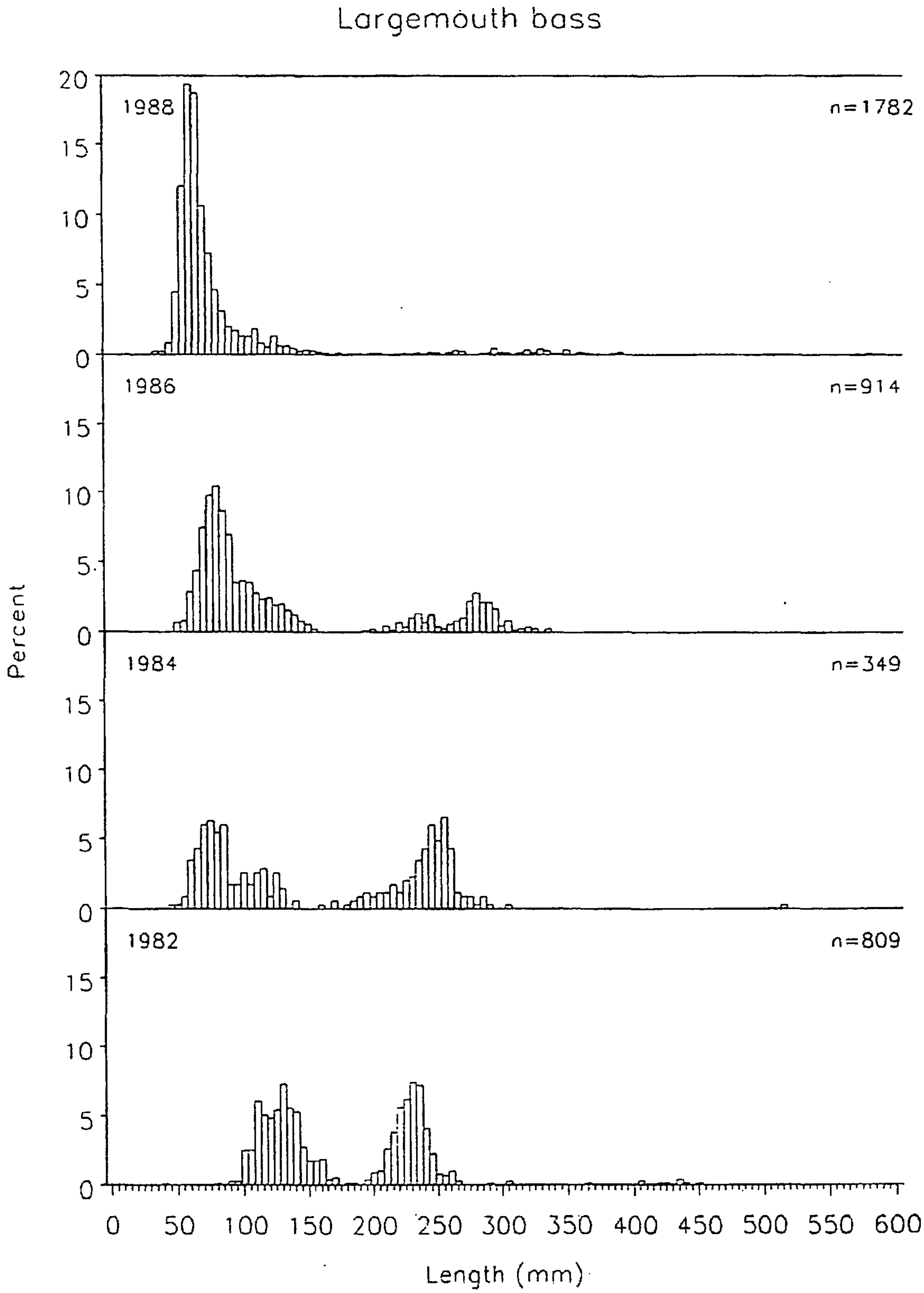


Figure 8.13 Length-frequency distribution of largemouth bass collected from cove rotenone samples at Harris Lake, 1982-1988.

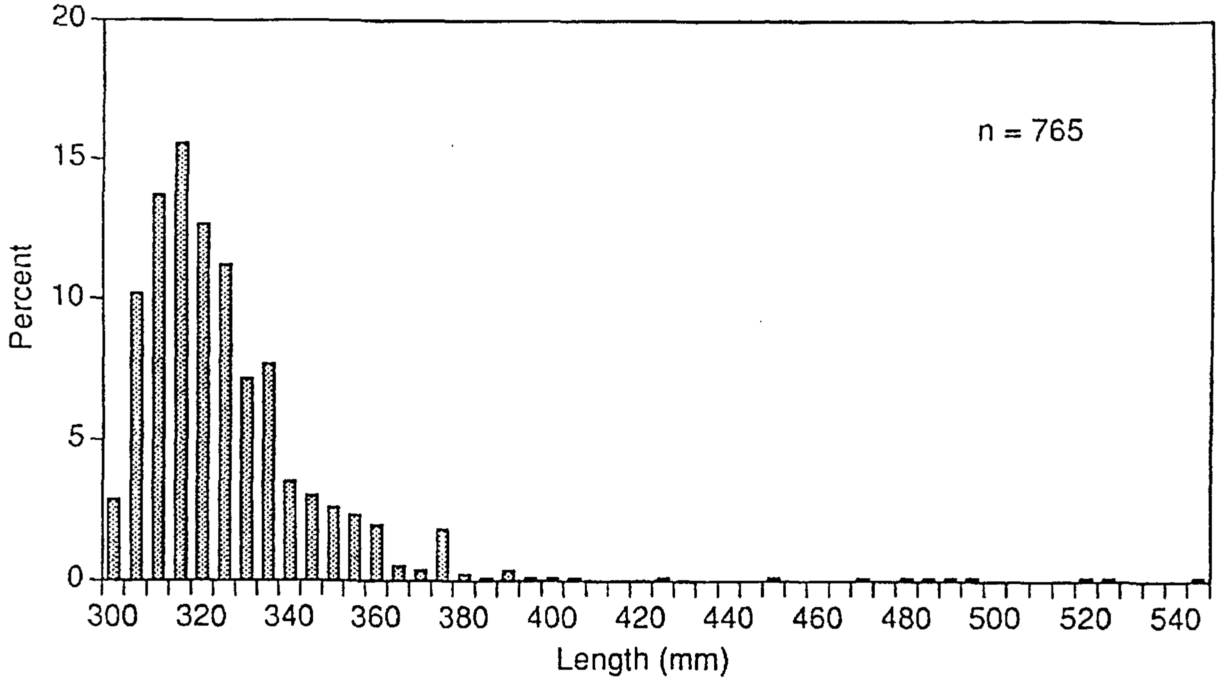


Figure 8.14 Length-frequency distribution of largemouth bass collected from a largemouth bass fishing tournament conducted on Harris Lake during March 1987.

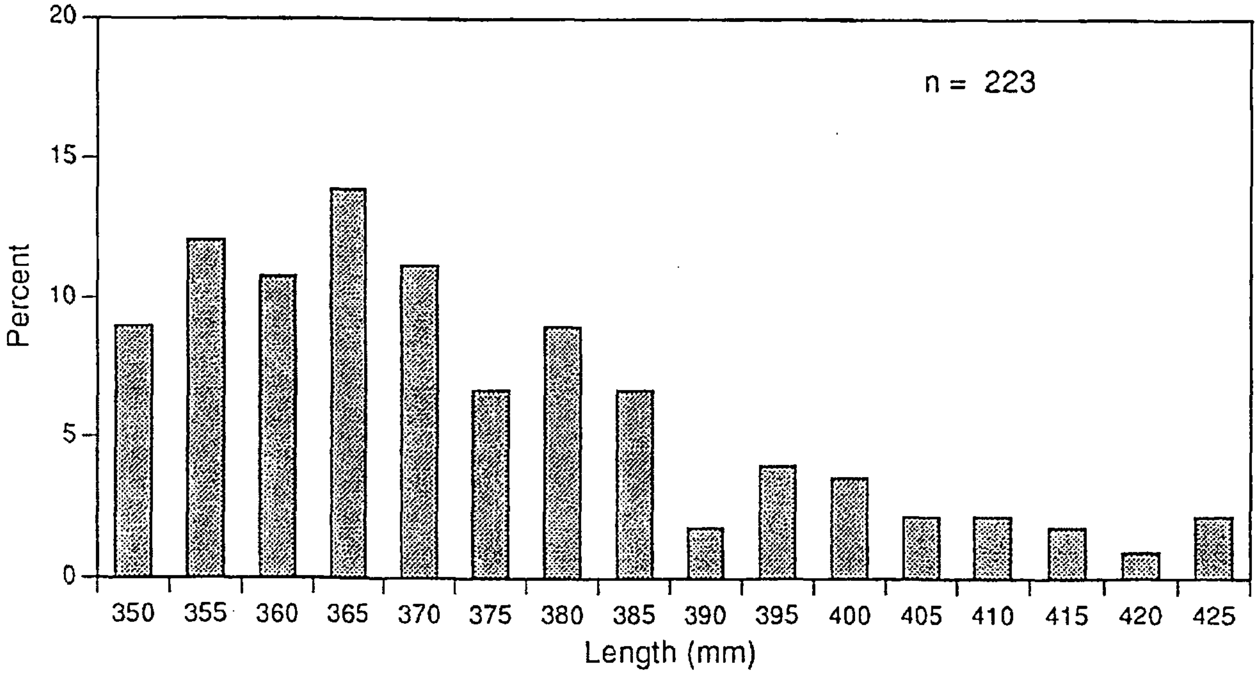


Figure 8.15 Length-frequency distribution of largemouth bass collected from a largemouth bass fishing tournament conducted on Harris Lake during October 1988.

9.0 TERRESTRIAL STUDIES

9.1 Birds

During 1987, 96 species of birds were observed on and around Harris Lake (Table 9.1). An average of 98 species (range = 84 - 124) has been observed over the 14-year monitoring period from 1972 through 1987. During these 14 years, 181 species of birds have been observed. No previously unobserved species were documented during 1987.

During the 1987 roadside bird surveys, 20 species were observed during the winter quarter, 38 species during the spring quarter, 38 species during the summer quarter, and 23 species during the fall quarter. The Shannon-Wiener diversity values for each quarter (winter--3.8, spring--4.6, summer--4.7, fall--3.9) were similar to those from previous years' surveys and no trends were discernible.

During the 1987 spring bird count, 68 species were observed compared to 69 during the 1986 survey. The winter bird count was not completed in 1987 due to inclement weather conditions and a total species number was not tabulated. All birds seen during the winter survey were included in the species list for the year (Table 9.1).

Fifteen species of birds were observed during waterfowl surveys during 1987 (Table 9.2). Those species observed in the largest concentrations with the highest frequency were the American coot, ring-necked duck, pied-billed grebe, and ruddy duck. These results were similar to previous years with the exception of the ruddy duck which was observed in higher numbers during 1987 than during past years.

Twelve species of game birds were observed on the SHNPP site during 1987. Eight of these were observed during waterfowl surveys (Table 9.2). Additional game species observed during other surveys included the American black duck, blue-winged teal, bobwhite quail, and mourning dove.

Nineteen wood duck nests were established during 1987 in the nest boxes at Harris Lake. Nests in 16 boxes were successful; 3 were abandoned before hatching. Nest box utilization increased from 16% in 1986 to 42% in 1987. Two hundred and fifteen eggs were laid and one hundred and seventy eggs (83%) were known to have hatched. Fourteen nests were in wooden boxes, three nests were in Tom Tubbs dark plastic boxes, and two nests were in plastic bucket boxes (Table 9.3). This was the first year since box establishment in 1984 that the darkly colored Tom Tubbs plastic boxes were used by wood ducks. Nine of the nesting hens were banded with U.S. Fish and Wildlife Service leg bands for the first time during 1987 with three banded hens returning from previous years. One wood duck has now been documented as nesting successfully at Harris Lake for three consecutive years.

During 1987, 14 bluebird boxes were located in the Wildlife Refuge Area and Management Area 1. Ten of the boxes were used during the nesting period. There were 21 successful nests (nestlings survived to fledge) established with an average clutch size of 4.6 eggs (range 3-6 eggs). Three consecutive nests were successfully established in four of the boxes. There was no evidence of predation at any of the boxes during the nesting period. One box placed very near the Harris Energy & Environmental Center rear parking area was repeatedly used by house sparrows. This box was later removed.

Two federally listed endangered species, the red-cockaded woodpecker and the bald eagle, were observed at the SHNPP site during 1987. The red-cockaded woodpeckers occupying the SHNPP colony site during 1986 were not observed after March 1987. The colony site remained unoccupied throughout the remainder of the year. During August 1987, two separate observations were made of an adult bald eagle over Harris Lake. These eagles were probably part of a large transient population inhabiting nearby Jordan Lake.

Cooling tower casualties documented during the 1987 surveys consisted of three bird species (solitary vireo, pine warbler, and American redstart) and one unidentified bird. These casualties, which totaled five individuals, were all observed in the fall. This was an extremely low mortality when compared to bird kills documented at other tall structures (Marsden et al. 1980; Maehr et al. 1983) and was not considered to have a significant impact on migratory birds moving through the area.

9.2 Quantitative Vegetation Studies

Results of the point-quarter analyses in the seven compartments sampled during 1987 showed estimated total stand densities ranging from 931 to 2132 trees/hectare and estimated total basal areas from 26.6 to 46.8 m^2/ hectare. Basal area is the cross-sectional area of the tree stem at 1.4 m above the ground. Much of the study area, which lies between the Cape Fear River and Harris Lake, was planted in loblolly pine *Pinus taeda*, the dominant species in four of the seven compartments (Figure 9.1). Those compartments not planted in pine were dominated by red oak *Quercus rubra* and white oak *Q. alba* (Figure 9.1).

Point-quarter analyses have been conducted in the Greentree Reservoir basin for 3 consecutive years at 36 fixed sample points. The results demonstrated a decrease in total stand density with each successive year from 1985 to 1987 (Table 9.4). From the 1985 to 1986 sampling period, 4.2% of the trees sampled died, and from the 1986 to the 1987 sampling period, 8.3% died. Much of the mortality occurred along the creek and near the dam and may have been related to mechanical injury during impoundment construction. When a tree died, it was replaced in the sampling process by the next nearest tree to the center point in that quadrant. This greater distance from the center point resulted in lower standard density values. The total basal area estimate was highest during 1987 (Table 9.4).

The dominant species in the Greentree Reservoir for all three years were yellow poplar, sweetgum, and red maple (Table 9.5). These species are considered to be marginal as food producers for waterfowl (USFS 1969). However, some species present in the reservoir with lower importance values (willow oak and black gum) are considered good food producers. Through selected species management, these species can be enhanced to improve food production in the reservoir.

Table 9.1 Birds observed at the Shearon Harris Nuclear Power Plant site during 1987.

Common name	Common name
loons	sandpipers
common loon	spotted sandpiper
grebes	gulls, terns, and skimmers
horned grebe	ring-billed gull
pied-billed grebe	laughing gull
cormorants	pigeons and doves
double-crested cormorant	rock dove
	mourning dove
herons	
great blue heron	cuckoos
great egret	yellow-billed cuckoo
green-backed heron	black-billed cuckoo
swans, geese, and ducks	nightjars
mallard	chuck-will's-widow
American black duck	
blue-winged teal	swifts
wood duck	chimney swift
canvasback	
lesser scaup	kingfishers
ring-necked duck	belted kingfisher
bufflehead	
ruddy duck	woodpeckers
	downy woodpecker
hawks and eagles	red-cockaded woodpecker
northern harrier	yellow-bellied sapsucker
red-tailed hawk	pileated woodpecker
bald eagle	red-bellied woodpecker
osprey	northern flicker
new world vultures	tyrant flycatchers
turkey vulture	eastern kingbird
	eastern phoebe
falcons	eastern wood pewee
American kestrel	acadian flycatcher
pheasants, grouse, and quails	swallows
bobwhite	purple martin
	barn swallow
rails	northern rough-winged swallow
American coot	
plovers	jays and crows
killdeer	blue jay
	American crow

Table 9.1 (continued)

Common name	Common name
titmice	new world passerines (cont.)
tufted titmouse	prothonotary warbler
Carolina chickadee	parula warbler
	yellow warbler
wrens	yellow-rumped warbler
Carolina wren	pine warbler
	prairie warbler
old world warblers and thrushes	ovenbird
golden-crowned kinglet	common yellowthroat
ruby-crowned kinglet	yellow-breasted chat
blue-gray gnatcatcher	hooded warbler
wood thrush	American redstart
American robin	finches
eastern bluebird	evening grosbeak
	American goldfinch
mimic thrushes	
mockingbird	old world sparrows
gray catbird	house sparrow
brown thrasher	
starlings	
starling	
vireos	
red-eyed vireo	
solitary vireo	
white-eyed vireo	
new world passerines	
brown headed cowbird	
red-winged blackbird	
eastern meadowlark	
orchard oriole	
common grackle	
white-throated sparrow	
chipping sparrow	
field sparrow	
dark-eyed junco	
song sparrow	
rufous-sided towhee	
cardinal	
blue grosbeak	
indigo bunting	
summer tanager	

Table 9.2 Birds observed during waterfowl surveys at the Shearon Harris Nuclear Power Plant site during 1987.

Horned grebe	Ring-necked duck‡
Pied-billed grebe	Bufflehead‡
Common loon	Ruddy duck‡
Ring-billed gull	Great blue heron
Mallard‡	American coot‡
Wood duck‡	Killdeer
Canvasback‡	Belted kingfisher
Lesser scaup‡	

‡Classified as game species.

Table 9.3 Box type, clutch size, and percent hatching for wood duck nest boxes on Harris Lake during 1987.

Box number	Box type	Clutch size	Number of eggs hatched	Hatching success (percent)
1	Bucket	12	12	100
2	"Tom Tubbs"	9	0	0
3	Wooden	14	0	0
4	Bucket	12	12	100
5	Wooden	12	12	100
6	"Tom Tubbs"	12	11	92
7	Wooden	12	12	100
7	Wooden	7	7	100
12	Wooden	20	19	95
13	Wooden	13	10	77
14	"Tom Tubbs"	6	6	100
16	Wooden	12	12	100
16	Wooden	2	0	0
19	Wooden	13	10	77
22	Wooden	14	13	93
22	Wooden	10	‡	‡
29	Wooden	12	12	100
36	Wooden	11	10	91
41	Wooden	12	12	100
Total		215	170	83¶

‡Number of eggs hatched and hatching success could not be determined.

¶Total hatching success (170/205) was calculated after deleting nest with 10 eggs from total clutch size (215-10 = 205) because number hatched was not known for this nest.

Table 9.4 Total density and total basal area of trees sampled by point-quarter analysis in the Greentree Reservoir basin at the Shearon Harris Nuclear Power Plant, 1985-1987.

Year	Total density (trees/ha)	Total basal area (m^2/ha)
1985	866	34.1
1986	821	32.8
1987	814	34.4

Table 9.5 Importance values (based on relative basal area, relative density, and relative frequency) for trees sampled by point-quarter analyses in the Greentree Reservoir basin at the Shearon Harris Nuclear Power Plant, 1985-1987.

Species	Importance Value		
	1985	1986	1987
Yellow poplar	64.9	62.7	59.6
Sweetgum	49.5	51.4	53.4
Red maple	43.1	43.6	44.3
Hophornbeam	32.9	31.0	30.5
Dogwood	19.8	19.9	16.9
Beech	18.1	18.3	19.2
Ironwood	17.4	18.2	18.4
White oak	16.5	15.0	15.9
Loblolly pine	11.5	11.7	12.2
Red oak	8.0	8.1	8.5
Sweet pignut hickory	4.2	4.3	4.4
American ash	4.0	4.0	4.2
Shortleaf pine	2.7	2.7	2.9
Black gum	2.0	3.8	4.2
Sourwood	1.9	1.8	1.9
Willow oak	1.8	1.8	1.8
Sugar maple	1.7	1.7	1.7
Total	300.0	300.0	300.0

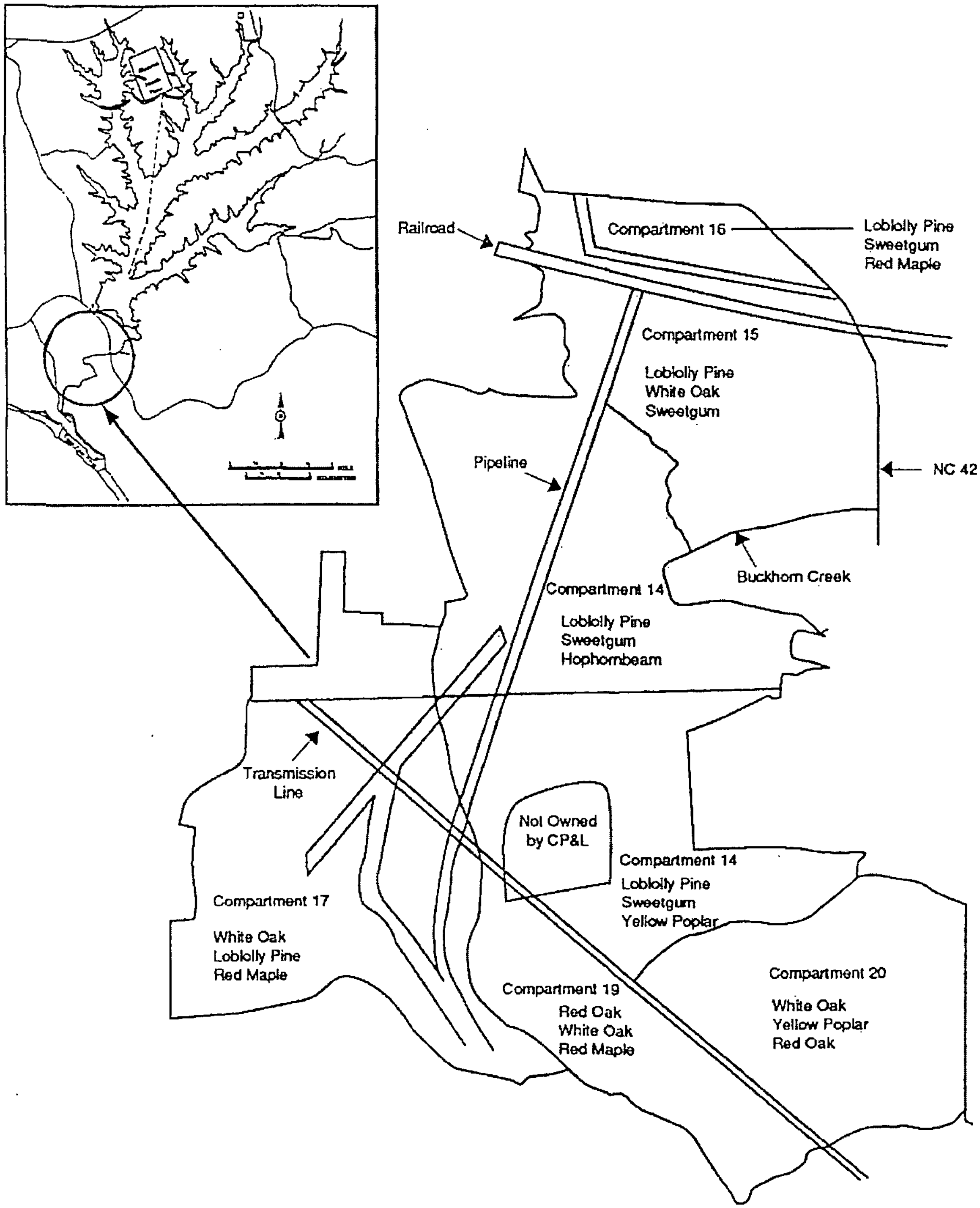


Figure 9.1 Tree species with the highest importance values (based on relative basal area, relative density, and relative frequency) in wildlife management compartments 14-20 (Wildlife Management Area 2) on Shearon Harris Nuclear Power Plant Game Lands during 1987.

10.0 AQUATIC VEGETATION

After major increases in the number of species and overall coverage of aquatic vegetation from 1983 through 1986, the composition and coverage remained relatively constant in Harris Lake during 1987 and 1988. Fifty-eight species of aquatic or wetland plants were observed in or immediately adjacent to the lake and auxiliary reservoir (Table 10.1). The number of species observed during the 1987-1988 period was lower than the total number observed in 1986 (69). This reduction reflected a reduced effort to identify minor emergent shoreline species rather than any detectable change in the overall structure of aquatic vegetation.

10.1 Harris Lake

In 1987, Harris Lake continued to be dominated by three distinct communities: emergent, submersed, and floating leaf. The emergent community was essentially unchanged from 1986 and previous years. Dominant species continued to be cat-tail *Typha latifolia*, bulrushes *Scirpus cyperinus* and *S. atrovirens*, water primrose *Ludwigia leptocarpa*, rushes *Juncus effusus* and *J. coriaceus*, and increased amounts of burreed *Sparganium americanum*. Creeping water primrose *Ludwigia uruguayensis*, another component of this community, continued to spread into several areas despite previous efforts to remove it by hand. Three small (ca. 5 m dia.) patches were treated with a registered aquatic herbicide (Rodeo®) during the summer of 1987. Another small patch observed near the main dam in October was not treated because it was too late in the year for the herbicide to be effective. During 1988 several small patches of creeping water primrose were observed growing near the main dam and the Highway 42 boat ramp (Area E) and in other scattered locations in Areas G, F, L, and K (Figure 2.1). This species can produce long (up to 5 m) stems that float on the water forming thick surface mats that could potentially impact certain uses of the lake.

The floating-leaf community continued to be dominated by watershield *Brasenia schreberi*. This species has spread into many shallow areas near the shoreline, extending out to a maximum depth of about 1.5 m. Although it occurred throughout all major arms, the greatest concentration was in the White Oak Creek arm upstream of the SR 1127 bridge (Area S) (Figure 2.1). Lotus *Nelumbo lutea* occurred in two stands in Area S in 1987. These expanded in size from 1986 to cover about 1 ha. During 1988 two more stands were observed in Area S. This resulted in the establishment of lotus on both sides of the White Oak Creek channel in Area S with the likelihood that it will ultimately expand its coverage to much of the area above the SR 1127 bridge. Small scattered patches of water-lily *Nymphaea odorata* also occurred throughout the lake but these have not expanded beyond about 2 m in diameter. Most of these patches occurred within larger stands of watershield and apparently have not been able to compete successfully.

Submersed vegetation in the lake continued to be dominated by pondweeds *Potamogeton berchtoldii* and *P. diversifolius*, and naiads *Najas minor*, *N. gracillima*, and *N. quadalupensis*. In 1987 and 1988, almost all areas of the lake less than 3 m deep supported populations of these species either in mixed or homogeneous stands. Although the amount of *P. berchtoldii* in Harris Lake decreased in 1987 from previous years, it increased during 1988 to approximately the same level as in 1986. The abundance of this species apparently varies from year to year, perhaps in response to environmental factors such as temperature, turbidity, and/or water levels.

The most significant change in the submerged community was the establishment of hydrilla *Hydrilla verticillata*. Hydrilla was observed in June 1988 growing in several small stands along the downstream side of the SR 1127 causeway. Subsequent surveys during the summer and fall revealed the hydrilla was well established along both sides of the White Oak Creek arm of the lake in Areas P and Q. The greatest concentration occurred along the north shore near where the Harris-Harnett 230-kV transmission line crosses the lake. Several stands also occurred near the Hollemans Crossroad boat ramp.

Hydrilla has the potential to spread into all areas of Harris Lake less than 3 m deep (580 ha or 36 percent of the lake surface area). Although it is not likely to impact power plant operations, hydrilla could significantly impact recreational activities on the lake and alter the biological relationships of organisms in the lake. Because of the potential problems caused by hydrilla, a registered aquatic herbicide

(Aquathol K®) was applied to all known areas where hydrilla grew in July and again in October. Additional herbicide applications will be made in the spring of 1989 and the results of these applications will be used to formulate a long-term management strategy. Possible options to gain control of hydrilla include the introduction of grass carp.

10.2 Auxiliary Reservoir

Vegetation in the auxiliary reservoir during 1987 and 1988 was essentially unchanged from 1986. The emergent community was dominated by the same species that occurred around Harris Lake. Submersed vegetation was sparse, limited to water depths less than 1 m deep, and consisted of pondweed *P. berchtoldii*, and muskgrass *Chara* sp. and *N. minor*. No hydrilla was observed in the auxiliary reservoir and no submersed vegetation grew in the emergency service water intake canal. Floating-leaf vegetation continued to be absent from the auxiliary reservoir and intake canal.

Table 10.1 Aquatic and wetland plants observed in or adjacent to Harris Lake and the auxiliary reservoir during 1987 and 1988.

Family/Species

Submersed Vegetation

- Characeae
  - *Chara* sp.
  - *Nitella flexilis*
- Potamogetonaceae
  - *Potamogeton berchtoldii*
  - *P. diversifolius*
- Najadaceae
  - *Najas gracillima*
  - *N. guadalupensis*
  - *N. minor*
- Hydrocharitaceae
  - *Hydrilla verticilatta*
- Cyperaceae
  - *Eleocharis baldwinii*
- Haloragaceae
  - *Myriophyllum brasiliense*
- Lentibulariaceae
  - *Utricularia inflata*

Floating-Leaf Vegetation

- Azollaceae
  - *Azolla caroliniana*
- Nymphaeaceae
  - *Nymphaea odorata*
- Nelumbonaceae
  - *Nelumbo lutea*
- Cabombaceae
  - *Brasenia schreberi*
- Onagraceae
  - *Ludwigia uruguayensis*

Emergent Vegetation

- Osmundaceae
  - *Osmunda cinnamomea*
- Typhaceae
  - *Typha latifolia*
- Sparganiaceae
  - *Sparganium americanum*
- Alismataceae
  - *Alisma subcordatum*
  - *Sagittaria engelmanniana*
- Poaceae
  - *Echinochloa crusgalli*
  - *Erianthus giganteus*
  - *Leersia oryzoides*
  - *Panicum dichotomiflorum*
  - *P. stipitatum*
  - *Zizaniopsis aquatica*

Emergent Vegetation (continued)

- Cyperaceae
  - *Carex lurida*
  - *C. odoratus*
  - *C. pseudovegetus*
  - *E. microcarpa*
  - *E. obtusa*
  - *E. quadrangulata*
  - *Fimbristylis autumnalis*
  - *Rhynchospora corniculata*
  - *Scirpus atrovirens*
  - *S. cyperinus*
- Juncaceae
  - *Juncus acuminatus*
  - *J. coriaceus*
  - *J. effusus*
  - *J. marginatus*
  - *J. tenuis*
- Salicaceae
  - *Populus deltoides*
  - *Salix nigra*
- Saururaceae
  - *Saururus cernuus*
- Betulaceae
  - *Betula nigra*
  - *Alnus serrulata*
- Polygonaceae
  - *Polygonum pensylvanicum*
  - *P. hydropiperoides*
- Platanaceae
  - *Platanus occidentalis*
- Melastomataceae
  - *Rhexia mariana*
- Onagraceae
  - *Ludwigia leptocarpa*
  - *L. palustris*
- Cornaceae
  - *Cornus amomum*
- Rubiaceae
  - *Cephalanthus occidentalis*
- Campanulaceae
  - *Lobelia siphilitica*
- Asteraceae
  - *Mikania scandens*
  - *Pluchea foetida*

11.0 SUMMARY

Harris Lake began filling in December 1980 and reached full pool in early 1983. Harris Plant commercial operations began in early 1987. Biological, water quality, and water chemistry monitoring of the lake has been conducted since the lake began filling. These monitoring studies can be divided into three periods: (1) while the lake was filling (1981-1982), (2) after the lake reached full pool but prior to power plant operations (1983-1986), and (3) after power plant operations were initiated. The 1987-1988 sampling period focused on lake conditions during the first two years after power plant operations were initiated.

Water quality changed slightly during 1987 and 1988 from previous years. Conductivity and pH values increased, while Secchi disk transparency decreased. These changes were attributed to discharges from the cooling tower blowdown and reduced flushing of the lake because of low precipitation. However, they were not of enough magnitude to cause Harris Lake to exhibit conditions outside the range of other piedmont lakes.

Total nitrogen and most of the fractions of phosphorus were significantly higher at Station E2 (near the point where the cooling tower blowdown discharges into the lake) than at other stations in the lake in 1987. During 1988, differences in the concentrations of these constituents between Station E2 and other sample stations (P2 and H2) were reduced, although all concentrations remained elevated over those measured prior to 1987. This indicated an initial buildup in 1987 at Station E2 after power plant operations were begun followed by the diffusion of these materials into other portions of the lake during 1988. This process was magnified because of reduced precipitation during 1988, resulting in reduced lake flushing. Power plant operations also appeared to have caused increases in concentrations of chloride, sulfate, sodium, and conductivity in lake waters, while reduced precipitation apparently caused increases in alkalinity and calcium.

Trace element concentrations in Harris Lake water during 1987 and 1988 were generally similar among stations and years. However, zinc concentrations were significantly greater in the sediment at Station E2 than at other locations and increased over those of 1986, although they were still below state water quality standards. The zinc increase was probably a result of the discharge of zinc compounds used by the Harris Plant to reduce corrosion in the plant's piping system. However, the measured concentrations remained within the range of unenriched sediments. Trace element concentrations in water and fish remained low.

Phytoplankton densities increased from the moderate levels of 1986 to moderate-to-high levels in 1987 and 1988. The Chlorophyceae and Chrysophyceae were usually the numerically important phytoplankton classes, while the Myxophyceae and the Cryptophyceae were only occasionally important during both 1987 and 1988. A moderate unexplained bloom of Chlorophyceae, Chrysophyceae, and Cryptophyceae occurred at Station H2 during November and December of 1987. Except for this relatively minor bloom, seasonal variations in phytoplankton densities were not pronounced. Chlorophyll *a* levels were significantly increased in 1987 and 1988 over those in prior years. Chlorophyll *a* concentrations approached levels indicative of eutrophic water on one occasion in 1987 and two occasions in 1988. The increases in phytoplankton density and chlorophyll *a* levels appeared to reflect the increases in nitrogen and phosphorus concentrations.

During 1987 and 1988, overall zooplankton biomass and taxa richness continued downward trends that have been documented since 1983. However, total zooplankton density increased over that reported in previous years. The decrease in biomass was attributed to the reduction of larger zooplankters as a result of the increased size-selective planktivory following the introduction of threadfin shad into the lake and to an overall increase in larval fish populations of other species. This has caused a shift to smaller zooplankters, especially rotifers. The decrease in taxa was the result of the loss of several species of low abundance and did not significantly change the overall taxonomic makeup of zooplankton populations. Differences among stations for organism density and biomass were detected in 1987 but not for 1988.

Benthic macroinvertebrate populations in Harris Lake during 1987-1988 remained similar to those of previous years. The most significant change in the benthic community was an expansion of the population of Asiatic clams *Corbicula fluminea*. Small numbers of this biofouling organism were first collected from the lake near the main dam in 1985. None had been collected again until November 1988 when increased numbers were collected at Station P1 near the Holleman's Crossroad boat ramp. No Asiatic clams were collected from the main or auxiliary intake canals or from the intake structures.

For both 1987 and 1988, there were no spatial differences in benthic macroinvertebrate taxa richness or organism density, although there were seasonal differences. These similarities were in contrast to the period of 1986-1987 when several differences were observed. However, taxa richness and organism density continued to exhibit previously observed downward trends during 1987 and 1988. These changes reflected the natural aging and stabilization of the lake ecosystem.

During 1987 and 1988, 17 species representing 7 families and 28 species representing 9 families of fish were collected from Harris Lake, respectively. Two previously undocumented species (bowfin and threadfin shad) were collected. Threadfin shad were introduced into Harris Lake during the spring of 1987 by the North Carolina Wildlife Resources Commission. Larval fish catches continued to be dominated by shad and sunfish and in 1988 densities were among the highest ever collected in the lake.

Biomass estimates for gizzard shad, bluegill, black crappie, channel catfish, and golden shiner in 1988 increased over those of previous years. Densities of these species also increased, except for bluegill. In 1988, largemouth bass biomass decreased to the lowest levels since 1982, while densities increased to the highest levels. Recruitment for these species was good during 1988. Largemouth bass tournament results indicated few largemouth bass of harvestable size ($\geq$ 356 mm) were caught during 1987. However, during 1988, increased numbers of harvestable size fish were caught.

During 1987, 96 species of birds were observed around the Harris Plant, a decrease of 2 from the average number of species observed over a 14-year period from 1972 to 1987. Diversity indices for each quarter in 1987 were also similar to those of previous years. Surveys of Harris Lake, the auxiliary reservoir, and the Greentree Reservoir indicated similar waterfowl utilized these areas. Wood duck nest box utilization at Harris Lake increased during 1987 to 42% from 16% in 1986. Point-quarter analyses conducted in the Greentree Reservoir from 1985 through 1987 documented that yellow poplar, sweetgum, and red maple were the dominant species during all three years. These species are considered to be marginal as food producers for waterfowl. There were a few individuals of species considered to be good food producers scattered in the reservoir basin which could be enhanced through selective management.

The submersed vegetation of Harris Lake was essentially unchanged in 1987 and 1988 from 1986. Dominant species continued to be *Potamogeton berchtoldii* and *Najas minor*. *Hydrilla verticillata*, a potentially problematic species, was discovered growing in the White Oak Creek arm of the lake in 1988. Although no impacts to power plant operations are expected from hydrilla, it has the potential to affect other uses of the lake. Floating leaf and emergent vegetation was essentially unchanged from previous years and was dominated by *Brasenia schreberi*, *Nelumbo lutea*, *Typha latifolia*, *Scirpus cyperinus*, and *S. atrovirens*. The auxiliary reservoir supported small quantities of submersed vegetation but floating-leaf vegetation was absent.

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Appendix A

Accuracy and Percent Recovery of Water Chemistry Standards During 1987-1988 and Trace Element Standards During 1988

Appendix A1 Mean percent recovery and sample size of water chemistry standards for the CP&L Analytical Chemistry Laboratory during 1987.

Variable	Standard (mg/liter)	Mean recovery ± standard deviation	Percent recovery	Sample size
Total phosphorus	0.01	0.010 ± 0.001	100	39
	0.02	0.020 ± 0.002	100	40
DMRP	0.002	0.0021 ± 0.0002	105	40
	0.005	0.0051 ± 0.0002	102	38
Total nitrogen	0.10	0.103 ± 0.008	103	43
	0.20	0.201 ± 0.012	101	46
Ammonia nitrogen	0.02	0.023 ± 0.004	115	12
	0.10	0.104 ± 0.004	104	12
Nitrate + nitrite-nitrogen	0.05	0.050 ± 0.003	99	11
	0.10	0.102 ± 0.005	102	11
Calcium	5.0	4.95 ± 0.180	99	16
	10.0	9.95 ± 0.285	99	16
Sulfate	2.0	2.03 ± 0.063	102	32
	5.0	4.99 ± 0.123	99	32
Arsenic	0.005	0.0050 ± 0.0004	99	18
	0.010	0.0098 ± 0.0005	98	18
Copper	0.005	0.0050 ± 0.00020	100	26
	0.010	0.0098 ± 0.00032	98	26
Mercury	0.0005	0.000467 ± 0.000051	93	55
	0.0010	0.000965 ± 0.000048	97	44
Selenium	0.005	0.0046 ± 0.0004	92	24
	0.010	0.0094 ± 0.0003	94	24
Chloride	1.0	1.05 ± 0.034	105	35
	2.0	2.02 ± 0.056	101	35

Appendix A1 (continued)

Variable	Standard (mg/liter)	Mean recovery $\pm$ standard deviation	Percent recovery	Sample size
Sodium	1.0	1.04 ± 0.072	104	26
	2.0	2.04 ± 0.091	102	26
Nickel	0.010	0.010 ± 0.000547	101	32
	0.030	0.031 ± 0.001210	103	32
Iron	0.50	0.484 ± 0.0203	97	23
	1.0	0.995 ± 0.0499	99	23
Zinc	0.10	0.0968 ± 0.0050	97	17
	0.50	0.4845 ± 0.010	97	15
Lead	0.010	0.01002 ± 0.000468	100	32
	0.030	0.03082 ± 0.001056	103	16
Magnesium	5.0	5.096 ± 0.1519	102	16
	10.0	10.01 ± 0.3157	100	16
Manganese	0.10	0.0993 ± 0.0046	99	16
	0.50	0.4947 ± 0.0089	99	16
Potassium	1.0	1.010 ± 0.0341	101	21
	2.0	2.002 ± 0.0384	100	21
Chromium	0.004	0.00405 ± 0.000214	101	34
	0.006	0.00625 ± 0.000211	104	18
Cadmium	0.0005	0.000496 ± 0.000020	99	16
	0.0010	0.001035 ± 0.000052	104	16
Aluminum	0.050	0.0506 ± 0.00170	101	28
	0.100	0.1002 ± 0.00399	100	27
Silica	1.0	0.994 ± 0.0201	99	9
	10.0	10.10 ± 0.1753	101	13

Appendix A2 Mean percent recovery and sample size of water chemistry standards for the CP&L Analytical Chemistry Laboratory during 1988.

Variable	Standard (mg/liter)	Mean recovery ± standard deviation	Percent recovery	RSD[‡] (%)	Sample size
Total phosphorus	0.010	0.010 ± 0.001	101	6.9	54
	0.020	0.020 ± 0.001	101	4.0	48
Dissolved molybdate reactive phosphorus	0.002	0.002 ± 0	105	7.4	39
	0.005	0.005 ± 0	99	3.5	54
Total nitrogen	0.100	0.099 ± 0.005	99	4.8	42
	0.200	0.199 ± 0.010	100	5.1	60
Ammonia nitrogen	0.020	0.022 ± 0.002	112	8.7	30
	0.100	0.101 ± 0.005	101	4.7	30
Nitrate + nitrite-nitrogen	0.050	0.046 ± 0.005	93	10.0	36
	0.100	0.095 ± 0.008	95	7.9	36
Calcium	1.00	0.95 ± 0.068	95	7.2	30
	10.00	9.87 ± 0.619	99	6.3	24
Sulfate	2.0	2.13 ± 0.313	107	14.7	111
	5.0	5.07 ± 0.355	101	7.0	108
Arsenic	0.005	0.005 ± 0.001	103	11.2	93
	0.010	0.009 ± 0.000	94	2.6	6
Copper	0.0050	0.0050 ± 0.00031	100	6.2	75
	0.0100	0.0102 ± 0.00043	102	4.2	75
Mercury	0.00010	0.00010 ± 0.000010	102	9.8	39
	0.00050	0.00049 ± 0.000031	98	6.2	78
Selenium	0.005	0.005 ± 0	101	6.6	114
	0.010	0.009 ± 0	89	5.5	18
Chloride	1.00	1.05 ± 0.037	105	3.6	102
	2.00	1.94 ± 0.141	97	7.3	93

[‡]RSD = relative standard deviation = standard deviation ÷ mean.

Appendix A2 (continued)

Variable	Standard (mg/liter)	Mean recovery ± standard deviation	Percent recovery	RSD‡ (%)	Sample size
Sodium	1.0	1.00 ± 0.039	100	3.9	57
	2.0	1.98 ± 0.068	99	3.5	57
Nickel	0.010	0.0099 ± 0.00053	100	5.3	72
	0.030	0.0311 ± 0.00121	104	3.9	72
Iron	0.100	0.102 ± 0.006	102	6.3	48
	1.000	0.974 ± 0.033	97	3.4	36
Zinc	0.050	0.050 ± 0.005	100	10.3	33
	0.500	0.495 ± 0.010	99	2.0	24
Lead	0.0020	0.0021 ± 0.00011	105	5.4	75
	0.0050	0.0052 ± 0.00023	105	4.4	78
Magnesium	1.00	1.00 ± 0.059	100	5.9	27
	10.00	10.03 ± 0.557	100	5.6	27
Manganese	0.050	0.051 ± 0.004	101	7.1	36
	0.500	0.496 ± 0.013	99	2.7	12
Total organic carbon	9.18	8.52 ± 0.24	93	2.8	63
Chromium	0.004	0.0041 ± 0.00021	103	5.1	75
	0.006	0.0062 ± 0.00022	104	3.5	75
Cadmium	0.00025	0.000253 ± 0.000009	101	3.7	72
	0.00050	0.000510 ± 0.000025	102	4.8	72
Aluminum	0.050	0.050 ± 0.0026	100	5.2	72
	0.075	0.076 ± 0.0027	101	3.5	69
Silica	1.0	0.969 ± 0.041	97	4.2	33
	10.0	9.843 ± 0.171	98	1.7	36

Appendix A3 Accuracy and precision of trace element analyses for samples of tissues and sediment by the CP&L Chemistry Laboratory during 1988.

Matrix/ Element	Reference material	95% confidence interval for certified value (µg/g)	Mean of recovered concentration (µg/g)	(n)	RSD[‡] of standards (%)	RSD of field sample replicates (%)
Tissue						
As	Copepod (IAEA MA-A-1)	5.5-7.9	6.2	13	15.8	0-6.7
	Fish (IAEA MA-A-2)	2.4-2.8	2.6	8	13.9	--
	Albacore tuna (NBS-RM50)	2.5-4.1	2.7	17	21.4	--
Cd	Copepod (IAEA MA-A-1)	0.69-0.81	0.69	16	12.2	0-80
	Fish (IAEA MA-A-2)	0.058-0.074	0.063	14	21.7	--
	Bovine liver (NBS-1577a	0.38-0.50	0.44	6	26.1	--
Cu	Copepod (IAEA MA-A-1)	8.4-8.8	7.2	6	11.0	0-71
	Albacore tuna (NBS-RM50)	4.2-4.4	4.3	3	36	--
	Bovine liver (NBS-1577	183-203	179	3	2.2	--
	Albacore tuna (NBS-RM50)	3.9-4.1	3.5	7	29	--
Hg	Copepod (IAEA MA-A-1)	0.26-0.30	0.27	7	39.1	0-57
	Fish (IAEA MA-A-2)	0.43-0.51	0.55	5	30.4	--
Se	Copepod (IAEA MA-A-1)	2.6-3.4	3.03	11	12.9	0.6-23
	Fish (IAEA MA-A-2)	1.1-2.3	1.2	8	18.9	--
	Albacore tuna (NBS-RM50)	2.8-4.4	3.5	8	16.6	--
Zn	Fish (IAEA MA-A-2)	32-34	31	14	14.1	0.1-9.1
	Bovine liver (NBS-1577a)	114-143	127	3	0.5	--
	Copepod (IAEA MA-A-1)	154-162	156	12	4.8	--
Sediments						
As	River sediment (NBS-1645)	66[¶]	75	9	1.8	0.5-20
	Estuarine sediment (NBS-1646)	10.3-12.9	11	9	5.3	--
Cd	River sediment (NBS-1645)	8.7-12	13	7	5.4	1.0-8.2
	Estuarine sediment (NBS-1646	0.29-0.43	< 3	3	0	--
Cu	River sediment (NBS-1645)	90-128	122	5	9.3	0.9-21
	Estuarine sediment (NBS-1646)	15-21	20	6	6.9	--
Hg	River sediment (NBS-1645)	0.6-1.6	1.03	6	8.2	0.2-6.3
	Estuarine sediment (NBS-1646)	0.051-0.075	0.058	3	12	--
Se	River sediment (NBS-1645)	1.5[¶]	1.3	4	14	1.8-16
Zn	River sediment (NBS-1645)	1550-1890	1713	10	4.2	2.6-99
	Estuarine sediment (NBS-1646)	132-144	133	7	7.7	--

[‡]RSD = relative standard deviation = standard deviation ÷ mean.

[¶]"Noncertified" values provided by the National Bureau of Standards.

Appendix A4 Mean, relative standard deviation (RSD), and sample size of certified standards analyzed by neutron activation during 1988.

Element	Matrix Reference material		95% confidence interval for known concentration (µg/g)	Mean of recovered concentration (µg/g)	n	RSD‡ (%)
As	Oyster	(NBS-1566)	12.68-14.12	13.55	1	--¶
	Bovine liver	(NBS-1577a)	0.041-0.053	< 0.10	6	--
	Tuna	(NBS-RM50)	2.9-3.7	3.2	6	2.9
Cd	Oyster	(NBS-1566)	3.1-3.9	3.3	2	3.7
	Bovine liver	(NBS-1577a)	0.38-0.50	< 0.75	6	--
Cu	Oyster	(NBS-1566)	59.5-66.5	65.5	1	--
	Bovine liver	(NBS-1577a)	151-165	159	17	1.8
	Oil	(NBS-1084)	94-102	98	4	1.3
Hg	Bovine liver	(NBS-1577a)	0.002-0.006	< 0.10	6	--
	Tuna	(NBS-RM50)	0.94-0.96	0.94	6	2.9
Se	Oyster	(NBS-1566)	1.6-2.6	2.1	2	7.2
	Bovine liver	(NBS-1577a)	0.64-0.78	0.71	12	3.6
	Tuna	(NBS-RM50)	3.2-4.0	3.7	6	2.5
Zn	Oyster	(NBS-1566)	838-866	833	2	1.5
	Bovine liver	(NBS-1577a)	115-131	124	12	2.5
	Tuna	(NBS-RM50)	12.6-14.6	13.9	6	1.4

‡RSD = relative standard deviation = standard deviation ÷ mean.

¶--RSD could not be determined.

Appendix B

Water Quality Data from
Harris Lake During 1987 and 1988

1987 Shearon Harris Water Quality

Month=January

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	7.1	6.8	6.9	9.1	9.6	9.7	6.7	6.9	6.7	70	66	70	2.2	1.3	1.8
1.0	7.1	6.8	6.9	9.1	9.7	9.8	6.7	6.9	6.7	70	66	70	.	.	.
2.0	7.1	6.7	6.9	9.1	9.7	9.9	6.8	7.0	6.7	70	66	69	.	.	.
3.0	7.1	6.7	6.9	9.1	9.7	10.2	6.8	7.0	6.7	70	66	68	.	.	.
4.0	7.1	6.7	6.9	9.2	9.8	10.2	6.8	7.0	6.7	70	65	68	.	.	.
5.0	7.1	6.7	6.9	9.3	9.8	10.5	6.8	7.0	6.7	69	65	68	.	.	.
6.0	7.0	6.6	6.8	9.3	9.8	10.5	6.8	7.0	6.8	69	64	68	.	.	.
7.0	7.0	6.5	6.8	9.4	9.7	10.5	6.9	7.1	6.8	69	64	68	.	.	.
8.0	7.0	6.4	6.7	9.4	9.6	10.5	6.9	7.1	6.8	69	64	68	.	.	.
9.0	7.0	6.3	6.7	9.5	9.6	10.5	6.9	7.1	6.8	69	64	68	.	.	.
10.0	7.0	6.2	6.7	9.5	9.6	10.4	6.9	7.1	6.8	69	65	67	.	.	.
11.0	7.0	.	.	9.6	.	.	6.9	.	.	69	.	.	.	.	.
12.0	7.0	.	.	9.6	.	.	6.9	.	.	69	.	.	.	.	.
13.0	7.0	.	.	9.6	.	.	6.9	.	.	69	.	.	.	.	.
14.0	7.0	.	.	9.7	.	.	7.0	.	.	69	.	.	.	.	.
15.0	7.5	.	.	9.0	.	.	7.0	.	.	239	.	.	.	.	.
16.0	8.1	.	.	5.9	.	.	7.1	.	.	373	.	.	.	.	.

Month=February

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	6.6	6.4	6.5	10.4	10.3	10.3	6.9	6.6	6.7	67	58	63	1.5	1.0	1.5
1.0	6.6	6.4	6.5	10.5	10.3	10.3	6.9	6.6	6.7	66	57	63	.	.	.
2.0	6.3	6.4	6.5	10.6	10.3	10.4	6.9	6.5	6.6	66	57	62	.	.	.
3.0	6.2	6.3	6.5	10.6	10.3	10.5	6.9	6.5	6.6	66	55	61	.	.	.
4.0	6.2	6.0	6.3	10.6	10.3	10.5	6.9	6.5	6.6	65	55	61	.	.	.
5.0	5.9	5.9	5.9	10.7	10.3	10.4	6.9	6.5	6.6	65	55	61	.	.	.
6.0	5.9	5.8	5.7	10.7	10.3	10.3	6.9	6.5	6.6	65	55	61	.	.	.
7.0	5.9	5.7	5.6	10.7	10.3	10.3	6.9	6.5	6.6	65	55	61	.	.	.
8.0	5.8	5.6	5.6	10.6	10.3	10.4	6.9	6.5	6.6	65	55	61	.	.	.
9.0	5.8	5.6	5.6	10.6	10.3	10.5	6.9	6.5	6.6	65	55	61	.	.	.
10.0	5.8	.	5.6	10.6	.	10.5	6.9	.	6.6	65	.	61	.	.	.
11.0	5.8	.	.	10.7	.	.	6.8	.	.	65	.	.	.	.	.
12.0	5.8	.	.	10.7	.	.	6.9	.	.	66	.	.	.	.	.
13.0	5.8	.	.	10.8	.	.	6.9	.	.	67	.	.	.	.	.
14.0	5.8	.	.	10.9	.	.	6.9	.	.	67	.	.	.	.	.
15.0	5.8	.	.	10.9	.	.	6.9	.	.	67	.	.	.	.	.
16.0	5.8	.	.	11.0	.	.	6.9	.	.	67	.	.	.	.	.

1987 Shearon Harris Water Quality

Month=March

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	7.8	8.0	8.2	6.0	5.4	5.4	7.5	7.0	7.0	61	53	54	1.2	0.8	1.0
1.0	7.9	7.9	8.1	6.0	5.5	5.5	7.4	7.0	7.1	64	52	54	.	.	.
2.0	7.8	7.7	8.1	6.0	5.5	5.5	7.5	7.0	7.1	64	53	54	.	.	.
3.0	7.8	7.6	7.9	5.9	5.6	5.5	7.5	7.0	7.1	59	54	55	.	.	.
4.0	7.8	7.6	7.8	5.8	5.6	5.5	7.5	7.0	7.1	56	54	56	.	.	.
5.0	7.7	7.6	7.7	5.6	5.6	5.6	7.5	7.0	7.1	56	54	55	.	.	.
6.0	7.7	7.6	7.7	5.6	5.7	5.6	7.5	7.1	7.2	56	53	55	.	.	.
7.0	7.7	7.6	7.6	5.5	5.7	5.6	7.5	7.1	7.2	56	54	55	.	.	.
8.0	7.7	7.5	7.5	5.2	5.7	5.6	7.5	7.1	7.2	56	56	54	.	.	.
9.0	7.7	7.3	7.5	5.1	5.6	5.6	7.5	7.1	7.2	56	57	54	.	.	.
10.0	7.7	.	.	4.8	.	.	7.5	.	.	56	.	.	.	.	.
11.0	7.7	.	.	4.6	.	.	7.5	.	.	56	.	.	.	.	.
12.0	7.7	.	.	4.4	.	.	7.5	.	.	56	.	.	.	.	.
13.0	7.7	.	.	4.0	.	.	7.6	.	.	56	.	.	.	.	.
14.0	7.7	.	.	3.7	.	.	7.5	.	.	56	.	.	.	.	.

Month=April

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	15.8	15.4	15.0	8.8	8.6	8.4	6.7	6.3	6.3	36	35	39	1.3	1.3	1.8
1.0	15.7	15.4	15.0	8.8	8.7	8.4	6.4	6.3	6.3	37	34	39	.	.	.
2.0	15.6	15.3	14.7	8.9	8.8	8.5	6.4	6.3	6.2	37	34	40	.	.	.
3.0	15.5	14.7	14.7	9.2	8.4	8.6	6.4	6.3	6.2	38	34	40	.	.	.
4.0	15.4	14.0	14.5	9.5	8.0	8.6	6.4	6.3	6.2	38	35	39	.	.	.
5.0	15.2	12.2	14.3	9.9	7.2	8.5	6.4	6.3	6.2	38	35	39	.	.	.
6.0	12.6	12.0	14.0	9.4	7.2	8.1	6.4	6.2	6.2	39	35	40	.	.	.
7.0	11.8	11.8	12.4	9.2	7.3	6.8	6.3	6.2	6.1	39	36	40	.	.	.
8.0	11.2	11.6	12.1	9.1	7.0	6.7	6.3	6.2	6.1	39	36	40	.	.	.
9.0	10.9	11.3	11.8	9.0	5.4	6.0	6.3	6.1	6.1	39	38	40	.	.	.
10.0	10.6	.	11.5	8.9	.	4.9	6.3	.	6.0	38	.	44	.	.	.
11.0	10.1	.	.	8.5	.	.	6.3	.	.	38	.	.	.	.	.
12.0	9.6	.	.	7.3	.	.	6.2	.	.	42	.	.	.	.	.
13.0	9.4	.	.	6.5	.	.	6.2	.	.	41	.	.	.	.	.
14.0	9.2	.	.	6.4	.	.	6.1	.	.	41	.	.	.	.	.
15.0	9.0	.	.	4.5	.	.	6.1	.	.	42	.	.	.	.	.
16.0	9.0	.	.	4.4	.	.	6.1	.	.	42	.	.	.	.	.
17.0	9.0	.	.	4.2	.	.	6.1	.	.	44	.	.	.	.	.

Month=May

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	21.4	22.1	21.4	8.7	8.3	7.8	6.6	6.6	6.2	65	63	64	1.5	1.5	1.3
1.0	21.4	22.0	21.4	8.6	8.2	7.6	6.6	6.5	6.2	65	63	64	.	.	.
2.0	21.4	21.9	21.4	8.6	8.1	7.7	6.5	6.4	6.1	65	63	63	.	.	.
3.0	21.4	20.2	21.1	8.5	6.5	7.5	6.5	6.0	6.1	65	66	63	.	.	.
4.0	21.4	18.8	20.2	8.4	5.2	6.8	6.4	5.8	6.0	64	67	64	.	.	.
5.0	21.2	17.8	18.3	8.3	4.2	5.2	6.4	5.8	5.8	64	67	66	.	.	.
6.0	19.2	17.2	17.5	6.4	3.6	4.6	6.0	5.8	5.8	67	67	66	.	.	.
7.0	17.3	16.0	16.2	4.7	1.5	0.7	6.0	5.8	5.7	67	69	66	.	.	.
8.0	16.5	16.0	15.2	4.3	1.5	0.2	5.8	5.8	5.7	68	69	75	.	.	.
9.0	14.8	15.8	.	3.8	0.8	.	5.8	5.8	.	69	69	.	.	.	.
10.0	13.7	.	.	3.5	.	.	5.8	.	.	72	.	.	.	.	.
11.0	12.5	.	.	3.1	.	.	5.8	.	.	72	.	.	.	.	.
12.0	11.6	.	.	2.8	.	.	5.9	.	.	73	.	.	.	.	.
13.0	10.7	.	.	1.6	.	.	6.0	.	.	76	.	.	.	.	.
14.0	10.7	.	.	1.6	.	.	6.0	.	.	76	.	.	.	.	.

Month=June

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	26.1	26.6	26.2	6.5	7.0	6.4	6.7	6.9	6.7	60	58	59	1.4	1.3	1.4
1.0	26.1	26.6	26.2	6.4	6.9	6.3	6.5	6.8	6.7	62	58	60	.	.	.
2.0	26.0	26.5	26.0	6.2	6.8	6.3	6.3	6.5	6.7	65	59	60	.	.	.
3.0	25.5	26.2	25.8	5.4	5.6	5.8	6.1	6.4	6.6	69	59	59	.	.	.
4.0	23.6	24.0	24.6	1.0	3.2	3.1	6.0	6.3	6.2	70	59	62	.	.	.
5.0	20.9	21.5	23.0	0.0	0.8	0.8	6.0	6.1	6.0	70	68	62	.	.	.
6.0	18.1	19.4	19.8	0.0	0.0	0.1	6.0	6.0	6.0	72	69	71	.	.	.
7.0	16.8	17.3	17.3	0.0	0.0	0.0	5.8	6.2	6.2	72	81	83	.	.	.
8.0	15.6	16.1	16.0	0.0	0.0	0.0	5.8	6.3	6.3	69	93	94	.	.	.
9.0	15.2	.	15.2	0.0	.	0.0	5.8	.	6.3	68	.	99	.	.	.
10.0	14.1	.	14.5	0.0	.	0.0	5.7	.	6.5	69	.	122	.	.	.
11.0	12.6	.	.	0.0	.	.	5.8	.	.	72	.	.	.	.	.
12.0	11.0	.	.	0.0	.	.	5.9	.	.	77	.	.	.	.	.
13.0	10.2	.	.	0.0	.	.	5.9	.	.	83	.	.	.	.	.
14.0	9.8	.	.	0.0	.	.	6.2	.	.	102	.	.	.	.	.
15.0	9.7	.	.	0.0	.	.	6.5	.	.	125	.	.	.	.	.
16.0	9.6	.	.	0.0	.	.	6.5	.	.	126	.	.	.	.	.

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Month=July

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	28.5	28.3	27.7	7.2	7.0	6.3	6.4	6.2	5.9	66	65	66	1.2	1.4	1.2
1.0	28.5	28.3	27.6	7.3	7.0	6.2	6.3	6.2	5.9	66	65	66	.	.	.
2.0	28.5	28.3	27.6	7.3	6.9	6.2	6.0	6.2	5.9	66	64	66	.	.	.
3.0	28.4	28.2	27.6	7.2	6.5	6.3	6.0	6.1	5.9	66	64	66	.	.	.
4.0	28.4	27.5	27.6	7.2	2.8	6.1	6.0	5.9	5.9	67	65	66	.	.	.
5.0	26.9	26.1	26.7	2.2	0.4	2.4	6.0	5.7	5.6	67	71	69	.	.	.
6.0	20.9	21.7	22.5	0.0	0.0	0.1	6.0	6.0	5.6	91	97	71	.	.	.
7.0	18.5	19.0	19.8	0.0	0.0	0.1	6.1	6.1	6.0	92	120	101	.	.	.
8.0	17.7	18.0	18.9	0.0	0.0	0.0	6.1	6.2	6.0	94	136	104	.	.	.
9.0	16.0	.	.	0.0	.	.	6.0	.	.	91	.	.	.	.	.
10.0	14.8	.	.	0.0	.	.	6.0	.	.	89	.	.	.	.	.
11.0	13.1	.	.	0.0	.	.	6.2	.	.	100	.	.	.	.	.
12.0	12.0	.	.	0.0	.	.	6.3	.	.	109	.	.	.	.	.
13.0	11.4	.	.	0.0	.	.	6.5	.	.	129	.	.	.	.	.
14.0	11.1	.	.	0.0	.	.	6.7	.	.	135	.	.	.	.	.

Month=August

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	28.6	28.4	27.9	6.8	6.3	6.1	6.4	6.3	6.1	67	65	69	1.5	1.7	1.7
1.0	28.5	28.4	27.9	6.5	6.3	6.1	6.4	6.3	6.1	67	65	68	.	.	.
2.0	28.4	28.4	27.9	6.2	6.2	6.0	6.4	6.3	6.1	67	65	68	.	.	.
3.0	28.4	28.3	27.9	6.2	6.3	6.0	6.4	6.3	6.1	67	66	68	.	.	.
4.0	28.3	28.3	27.9	6.3	6.2	6.0	6.4	6.3	6.0	67	70	69	.	.	.
5.0	28.2	26.5	26.5	6.2	0.2	1.6	6.2	5.8	5.8	69	78	74	.	.	.
6.0	27.1	22.8	23.0	2.8	0.0	0.0	6.0	6.1	6.1	72	107	109	.	.	.
7.0	20.4	20.8	20.4	0.0	0.0	0.0	6.3	6.1	6.1	117	128	116	.	.	.
8.0	18.6	19.6	.	0.0	0.0	.	6.3	6.4	.	112	160	.	.	.	.
9.0	16.5	.	.	0.0	.	.	6.3	.	.	103	.	.	.	.	.
10.0	14.8	.	.	0.0	.	.	6.3	.	.	103	.	.	.	.	.
11.0	13.6	.	.	0.0	.	.	6.5	.	.	107	.	.	.	.	.
12.0	12.3	.	.	0.0	.	.	6.6	.	.	116	.	.	.	.	.
13.0	12.2	.	.	0.0	.	.	6.7	.	.	120	.	.	.	.	.
14.0	12.0	.	.	0.0	.	.	6.8	.	.	133	.	.	.	.	.

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Month=September

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	26.5	27.6	27.3	8.2	7.6	8.1	6.7	7.2	6.3	76	72	65	1.5	1.8	1.4
1.0	26.6	27.3	27.3	7.8	7.4	7.8	6.7	7.0	6.4	77	76	71	.	.	.
2.0	26.5	27.2	27.3	7.5	7.4	7.6	6.7	6.8	6.4	77	76	74	.	.	.
3.0	26.3	26.6	26.9	6.4	4.9	6.1	6.6	6.4	6.2	77	76	75	.	.	.
4.0	26.1	26.0	25.7	4.0	2.2	4.0	6.4	6.2	5.7	79	77	78	.	.	.
5.0	25.5	25.2	24.7	2.9	0.6	0.5	6.2	6.1	5.7	80	80	82	.	.	.
6.0	24.9	24.5	24.0	2.5	0.4	0.3	6.1	6.2	5.7	89	82	87	.	.	.
7.0	23.6	23.5	23.6	0.4	0.2	0.2	6.1	6.3	5.9	100	89	91	.	.	.
8.0	20.8	22.3	21.2	0.3	0.1	0.1	6.2	6.4	6.3	111	111	140	.	.	.
9.0	17.9	.	.	0.2	.	.	6.5	.	.	119	.	.	.	.	.
10.0	16.2	.	.	0.2	.	.	6.5	.	.	122	.	.	.	.	.
11.0	14.1	.	.	0.2	.	.	6.6	.	.	125	.	.	.	.	.
12.0	12.8	.	.	0.2	.	.	6.8	.	.	134	.	.	.	.	.
13.0	12.0	.	.	0.2	.	.	6.9	.	.	144	.	.	.	.	.
14.0	11.7	.	.	0.1	.	.	7.1	.	.	166	.	.	.	.	.

Month=October

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	17.5	17.4	17.3	6.1	6.5	7.0	6.7	6.7	6.7	92	81	79	1.2	1.2	1.2
1.0	17.4	17.4	17.3	6.1	6.5	6.9	6.7	6.7	6.7	93	82	80	.	.	.
2.0	17.4	17.4	17.3	6.1	6.6	6.8	6.7	6.7	6.7	94	83	81	.	.	.
3.0	17.3	17.4	17.3	5.9	6.6	6.7	6.7	6.7	6.7	94	83	83	.	.	.
4.0	17.3	17.2	17.2	5.9	6.5	6.8	6.7	6.7	6.7	94	84	85	.	.	.
5.0	17.3	17.0	17.1	5.9	6.4	6.7	6.7	6.7	6.7	94	84	86	.	.	.
6.0	17.3	17.0	17.1	5.9	6.4	6.8	6.7	6.7	6.6	94	84	87	.	.	.
7.0	17.3	16.9	17.0	6.0	6.4	6.7	6.7	6.7	6.6	94	84	88	.	.	.
8.0	17.3	16.8	17.0	6.1	6.4	6.6	6.7	6.7	6.6	94	82	88	.	.	.
9.0	17.3	.	.	6.1	.	.	6.7	.	.	94	.	.	.	.	.
10.0	17.2	.	.	6.0	.	.	6.7	.	.	94	.	.	.	.	.
11.0	17.2	.	.	5.9	.	.	6.7	.	.	94	.	.	.	.	.
12.0	13.1	.	.	0.1	.	.	6.7	.	.	129	.	.	.	.	.
13.0	12.0	.	.	0.0	.	.	7.3	.	.	179	.	.	.	.	.

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Month=November

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	13.8	13.8	13.7	6.1	7.3	7.4	6.4	6.4	6.7	84	79	81	1.5	1.1	1.1
1.0	13.8	13.9	13.7	6.1	7.5	7.4	6.4	6.5	6.7	84	79	81	.	.	.
2.0	13.8	13.9	13.7	6.1	7.5	7.4	6.4	6.5	6.7	84	79	81	.	.	.
3.0	13.8	13.8	13.7	6.1	7.3	7.4	6.4	6.5	6.7	84	79	81	.	.	.
4.0	13.8	13.8	13.7	6.1	7.3	7.4	6.4	6.5	6.7	84	79	81	.	.	.
5.0	13.8	13.8	13.7	6.1	7.3	7.4	6.4	6.5	6.7	84	79	81	.	.	.
6.0	13.8	13.8	13.7	6.1	7.3	7.4	6.4	6.5	6.7	84	79	81	.	.	.
7.0	13.7	13.7	13.7	6.0	7.3	7.4	6.4	6.5	6.7	82	79	81	.	.	.
8.0	13.7	13.6	13.7	6.0	6.2	7.4	6.4	6.5	6.6	82	78	80	.	.	.
9.0	13.7	.	.	6.0	.	.	6.4	.	.	82	.	.	.	.	.
10.0	13.7	.	.	6.0	.	.	6.4	.	.	82	.	.	.	.	.
11.0	13.7	.	.	6.0	.	.	6.4	.	.	82	.	.	.	.	.
12.0	13.7	.	.	6.0	.	.	6.4	.	.	82	.	.	.	.	.
13.0	13.7	.	.	6.0	.	.	6.4	.	.	82	.	.	.	.	.
14.0	13.6	.	.	5.6	.	.	6.4	.	.	82	.	.	.	.	.

Month=December

Depth (m)	Temp (°C)			DO (mg/l)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	10.4	10.7	10.8	9.6	10.0	9.5	6.5	6.5	6.2	92	92	88	1.7	1.2	1.6
1.0	10.4	10.6	10.8	9.6	9.9	9.4	6.5	6.6	6.2	92	90	88	.	.	.
2.0	10.3	9.6	10.5	9.5	9.9	9.5	6.5	6.6	6.2	92	88	88	.	.	.
3.0	10.1	9.3	10.4	9.2	9.6	9.5	6.5	6.7	6.2	92	88	88	.	.	.
4.0	10.0	9.2	10.0	8.7	9.4	9.5	6.5	6.7	6.2	92	88	88	.	.	.
5.0	10.0	8.8	9.2	8.5	9.3	9.1	6.5	6.7	6.2	92	88	88	.	.	.
6.0	9.9	8.8	9.0	8.4	9.0	9.1	6.5	6.7	6.2	92	88	88	.	.	.
7.0	9.9	8.7	9.0	8.2	8.6	9.0	6.5	6.7	6.2	92	88	88	.	.	.
8.0	9.9	7.9	9.0	8.2	8.4	9.0	6.6	6.7	6.2	92	90	89	.	.	.
9.0	9.8	.	.	8.6	.	.	6.6	.	.	92	.	.	.	.	.
10.0	9.8	.	.	8.7	.	.	6.6	.	.	92	.	.	.	.	.
11.0	9.8	.	.	8.5	.	.	6.6	.	.	92	.	.	.	.	.
12.0	9.8	.	.	8.5	.	.	6.6	.	.	92	.	.	.	.	.
13.0	9.8	.	.	8.2	.	.	6.6	.	.	92	.	.	.	.	.
14.0	9.8	.	.	8.0	.	.	6.6	.	.	92	.	.	.	.	.
15.0	9.7	.	.	8.0	.	.	6.6	.	.	92	.	.	.	.	.
16.0	9.7	.	.	8.0	.	.	6.7	.	.	92	.	.	.	.	.

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Month=January

Depth (m)	Temp (°C) E2	Temp (°C) H2	Temp (°C) P2	DO (mg/L) E2	DO (mg/L) H2	DO (mg/L) P2	pH E2	pH H2	pH P2	Cond (µS/cm) E2	Cond (µS/cm) H2	Cond (µS/cm) P2	Secchi (m) E2	Secchi (m) H2	Secchi (m) P2
0.2	4.9	3.6	3.8	10.5	9.2	10.5	6.9	6.4	7.0	86	80	81	1.4	1.3	1.6
1.0	4.9	3.6	3.8	10.5	9.3	10.5	6.9	6.4	7.0	86	80	81			
2.0	4.9	3.6	3.8	10.5	9.4	10.5	6.9	6.4	7.0	86	80	81			
3.0	4.9	3.5	3.8	10.5	9.6	10.7	6.9	6.4	7.0	86	80	81			
4.0	4.9	3.5	3.8	10.6	9.7	10.8	6.9	6.4	7.0	86	80	81			
5.0	4.8	3.5	3.9	10.8	9.9	10.9	6.9	6.3	7.0	86	80	81			
6.0	4.8	3.5	3.9	10.8	10.0	10.9	6.9	6.3	7.0	86	80	81			
7.0	4.8	3.5	3.9	10.9	10.1	10.9	6.9	6.3	7.0	86	80	81			
8.0	4.8	.	3.9	10.9	.	11.1	6.9	.	7.0	86	.	81			
9.0	4.8	.	.	11.0	.	.	6.9	.	.	86	.	.			
10.0	4.8	.	.	11.2	.	.	6.9	.	.	86	.	.			
11.0	4.8	.	.	11.2	.	.	6.9	.	.	86	.	.			
12.0	4.8	.	.	11.3	.	.	6.9	.	.	86	.	.			
13.0	4.8	.	.	11.3	.	.	6.9	.	.	86	.	.			
14.0	4.8	.	.	11.4	.	.	6.9	.	.	86	.	.			

Month=March

Depth (m)	Temp (°C) E2	Temp (°C) H2	Temp (°C) P2	DO (mg/L) E2	DO (mg/L) H2	DO (mg/L) P2	pH E2	pH H2	pH P2	Cond (µS/cm) E2	Cond (µS/cm) H2	Cond (µS/cm) P2	Secchi (m) E2	Secchi (m) H2	Secchi (m) P2
0.2	9.4	10.5	9.5	10.9	10.2	10.2	7.9	7.2	7.1	88	90	83	1.2	1.1	1.4
1.0	9.4	9.7	9.5	10.9	10.3	10.2	7.9	7.0	7.1	89	91	83			
2.0	9.4	9.5	9.5	11.0	10.0	10.2	7.8	7.0	7.1	88	91	83			
3.0	9.3	9.4	9.4	11.1	10.0	10.3	7.8	7.0	7.1	88	91	83			
4.0	9.3	9.4	9.4	11.1	9.9	10.4	7.7	6.9	7.1	88	91	83			
5.0	9.3	9.3	9.4	11.1	10.0	10.4	7.4	6.9	7.1	88	91	83			
6.0	9.3	9.3	9.3	11.1	10.0	10.5	7.4	6.8	7.1	88	92	83			
7.0	9.3	9.1	9.3	11.2	9.7	10.5	7.3	6.8	7.1	88	95	83			
8.0	9.3	8.8	9.3	11.2	7.2	10.5	7.3	6.8	7.1	88	95	83			
9.0	9.3	.	.	11.3	.	.	7.2	.	.	88	.	.			
10.0	9.3	.	.	11.3	.	.	7.1	.	.	88	.	.			
11.0	9.2	.	.	11.3	.	.	6.9	.	.	88	.	.			
12.0	9.2	.	.	11.2	.	.	6.7	.	.	92	.	.			
13.0	8.5	.	.	8.4	.	.	6.7	.	.	92	.	.			
14.0	8.3	.	.	7.4	.	.	6.7	.	.	92	.	.			

1988 Shearon Harris Water Quality

Month=May

Depth (m)	Temp (°C)			DO (mg/L)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	21.3	22.3	21.1	8.9	9.6	8.9	7.6	8.0	6.9	70	68	91	1.5	1.3	1.7
1.0	21.0	22.2	20.9	9.3	9.3	8.8	7.7	8.0	6.9	71	69	92			
2.0	20.7	22.2	20.6	9.2	9.9	8.7	7.8	8.1	6.8	72	70	92			
3.0	20.3	20.0	19.6	8.5	10.0	7.8	7.7	7.2	6.6	73	72	92			
4.0	19.4	19.2	19.0	7.2	7.3	7.1	7.5	7.0	6.4	73	76	92			
5.0	18.9	18.2	18.1	6.9	5.5	5.8	7.4	6.6	6.4	74	78	94			
6.0	18.0	17.6	17.3	5.7	4.6	5.1	7.1	6.5	6.2	75	79	95			
7.0	17.0	16.7	16.7	4.6	4.5	3.6	7.0	6.4	6.1	76	80	96			
8.0	15.5	15.5	15.4	3.8	1.1	1.0	6.8	6.4	6.0	73	81	102			
9.0	14.2	.	.	3.4	.	.	6.8	.	.	74	.	.			
10.0	13.7	.	.	3.0	.	.	6.6	.	.	70	.	.			
11.0	12.0	.	.	1.5	.	.	6.6	.	.	70	.	.			
12.0	10.9	.	.	1.0	.	.	6.6	.	.	71	.	.			
13.0	10.8	.	.	0.8	.	.	6.8	.	.	83	.	.			

Month=July

Depth (m)	Temp (°C)			DO (mg/L)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	27.6	28.9	28.5	8.4	9.9	10.5	7.0	7.8	7.9	93	93	94	1.0	1.0	1.0
1.0	27.4	28.9	28.3	8.6	10.1	10.7	6.6	7.7	7.9	93	93	94			
2.0	26.7	27.8	27.9	8.5	9.0	10.4	6.3	6.2	7.9	94	93	96			
3.0	25.7	26.1	27.6	4.0	3.5	10.0	6.0	6.0	7.6	94	95	95			
4.0	25.1	25.2	26.1	1.3	0.5	4.6	6.1	6.1	6.7	97	100	95			
5.0	23.5	23.7	24.1	0.6	0.0	2.5	6.2	6.1	6.3	110	105	96			
6.0	21.7	22.1	22.5	0.4	0.0	3.0	6.3	6.1	6.2	125	115	105			
7.0	19.2	20.3	19.8	0.2	0.0	3.0	6.4	6.1	6.1	124	125	118			
8.0	17.6	19.3	.	0.0	0.0	.	6.4	6.1	.	122	130	.			
9.0	16.3	.	.	0.0	.	.	6.5	.	.	120	.	.			
10.0	15.2	.	.	0.0	.	.	6.6	.	.	120	.	.			
11.0	14.0	.	.	0.0	.	.	6.7	.	.	128	.	.			
12.0	13.0	.	.	0.0	.	.	6.8	.	.	140	.	.			
13.0	11.9	.	.	0.0	.	.	6.8	.	.	150	.	.			
14.0	11.6	.	.	0.0	.	.	6.8	.	.	160	.	.			
15.0	11.4	.	.	0.0	.	.	6.8	.	.	170	.	.			
16.0	11.3	.	.	0.0	.	.	6.8	.	.	175	.	.			

1988 Shearon Harris Water Quality

Month=September

Depth (m)	Temp (°C)			DO (mg/L)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	26.3	27.7	27.3	8.2	6.0	8.7	7.1	6.9	6.1	80	80	81	1.3	1.4	1.4
1.0	25.6	25.1	25.4	8.0	5.9	8.4	7.1	6.9	6.1	83	82	81			
2.0	24.5	24.6	24.5	6.5	5.9	8.0	7.1	6.9	6.1	84	84	84			
3.0	23.9	24.0	24.0	5.4	4.0	6.1	7.0	6.8	6.1	85	85	84			
4.0	23.8	23.8	23.7	4.9	4.0	5.6	6.9	6.3	6.1	86	87	84			
5.0	23.7	23.7	23.6	4.7	4.2	4.9	6.7	6.0	6.1	88	87	84			
6.0	23.6	23.5	23.5	4.3	3.0	4.4	6.3	6.0	5.9	95	89	86			
7.0	23.5	23.2	23.1	4.1	2.4	2.0	6.1	5.9	5.9	100	92	92			
8.0	21.8	22.2	22.7	0.4	1.9	0.5	6.0	5.9	5.9	112	132	99			
9.0	18.7	19.8	.	0.2	1.3	.	6.5	6.3	.	140	135	.			
10.0	16.4	.	.	0.2	.	.	6.5	.	.	140	.	.			
11.0	15.2	.	.	0.1	.	.	6.5	.	.	142	.	.			
12.0	13.8	.	.	0.1	.	.	6.5	.	.	170	.	.			
13.0	13.0	.	.	0.0	.	.	6.7	.	.	170	.	.			
14.0	12.4	.	.	0.0	.	.	6.8	.	.	181	.	.			
15.0	12.2	.	.	0.0	.	.	6.9	.	.	191	.	.			
16.0	12.0	.	.	0.0	.	.	.	.	.	191	.	.			

Month=November

Depth (m)	Temp (°C)			DO (mg/L)			pH			Cond (µS/cm)			Secchi (m)		
	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2	E2	H2	P2
0.2	15.0	14.6	14.9	5.8	7.6	7.1	6.2	6.3	6.4	83	77	79	1.2	1.3	1.4
1.0	14.6	14.5	14.6	5.6	7.7	7.3	6.2	6.4	6.4	82	76	79			
2.0	14.3	14.3	14.5	5.5	7.7	7.2	6.2	6.5	6.4	82	75	78			
3.0	14.3	14.2	14.4	5.4	7.7	7.2	6.2	6.5	6.4	81	74	77			
4.0	14.3	14.2	14.4	5.5	7.7	7.3	6.2	6.5	6.4	81	73	77			
5.0	14.3	14.1	14.4	5.5	7.2	7.3	6.2	6.4	6.4	81	73	77			
6.0	14.2	14.1	14.4	5.6	7.2	7.5	6.2	6.4	6.4	81	72	76			
7.0	14.2	14.1	14.4	5.6	6.9	7.5	6.2	6.4	6.4	81	71	75			
8.0	14.2	13.9	14.4	5.6	4.2	7.4	6.2	6.1	6.4	80	70	75			
9.0	14.2	13.6	.	5.6	2.8	.	6.3	6.0	.	79	70	.			
10.0	14.2	.	.	5.5	.	.	6.3	.	.	79	.	.			
11.0	14.2	.	.	5.5	.	.	6.3	.	.	79	.	.			
12.0	14.2	.	.	5.2	.	.	6.3	.	.	81	.	.			
13.0	14.2	.	.	5.2	.	.	6.2	.	.	82	.	.			
14.0	13.7	.	.	2.0	.	.	6.2	.	.	92	.	.			
15.0	12.9	.	.	0.4	.	.	6.9	.	.	172	.	.			
16.0	12.4	.	.	0.1	.	.	7.1	.	.	208	.	.			

Appendix C

Concentrations of Chemical Variables in the Harris Lake During 1987 and 1988

Key to abbreviations used in Appendix C.

Abbreviation	Variable
Cl^-	Chloride
SO_4^{2-}	Sulfate
Ca^{2+}	Total calcium
Mg^{2+}	Total magnesium
Na^+	Total sodium
K^+	Total potassium
TOTAL N	Total nitrogen
NH_3-N	Ammonia (as nitrogen)
$NO_3^- + NO_2^-$ -N	Nitrate + nitrite nitrogen
TOTAL P	Total phosphorus
TDP	Total dissolved phosphorus
DMRP	Dissolved molybdate reactive phosphorus
TOC	Total organic carbon
TS	Total solids
TDS	Total dissolved solids
Trace Elements	
Al	Total aluminum
As	Total arsenic
Cd	Total cadmium
Cr	Total chromium
Cu	Total copper
Fe	Total iron
Hg	Total mercury
Mn	Total manganese
Ni	Total nickel
Pb	Total lead
Se	Total selenium
Zn	Total zinc

Appendix C1. Concentrations of chemical variables in Harris Lake during 1987. Units are mg/liter except trace elements which are in µg/liter and turbidity which is in NTU.

STATION E2, SURFACE

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	17	4.5	6.2	4.2	1.7	8.2	1.7	0.59	0.15	0.16	0.008	0.005	0.002	2.9	5.9
Feb	14	4.5	6.4	3.9	1.5	5.3	1.7	0.57	0.03	0.16	0.026	0.012	0.003	2.7	6.1
Mar	12	4.5	7.1	3.4	1.4	4.6	1.6	0.39	< 0.02	0.15	0.049	0.027	0.011	3.1	5.9
Apr	11	3.8	5.5	3.4	1.4	4.3	1.6	0.41	< 0.02	< 0.01	0.037	0.021	0.004	2.1	6.1
May	11	3.6	5.8	3.2	1.3	4.2	1.7	0.41	< 0.02	< 0.01	0.042	0.025	0.007	0.3	6.8
Jun	12	4.0	6.4	3.6	1.5	4.7	1.8	0.34	< 0.02	< 0.01	0.035	0.020	0.001	0.6	5.7
Jul	12	4.2	6.9	3.5	1.5	4.9	1.8	0.34	< 0.02	< 0.01	0.022	0.010	0.001	1.2	5.7
Aug	14	4.3	7.3	3.5	1.6	5.0	1.8	0.36	< 0.02	0.01	0.027	0.013	0.004	1.5	5.6
Sep	14	4.4	7.4	3.2	1.4	5.3	2.0	0.32	< 0.02	< 0.01	0.018	0.011	0.009	1.4	6.4
Oct	19	5.0	7.0	4.3	1.7	6.3	2.7	0.64	0.19	0.01	0.058	0.033	0.024	2.1	6.5
Nov	16	4.9	8.1	4.0	1.6	6.3	2.6	0.66	0.24	0.08	0.047	0.029	0.020	1.9	5.7
Dec	15	5.0	8.0	3.9	1.6	6.6	2.9	0.69	0.21	0.15	0.072	0.053	0.044	1.6	6.3

Month	Turbidity	TS	TDS	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	2.2	50	49	30	< 1	< 0.1	< 2.0	1.0	220	< 0.10	90	< 5.0	< 1.0	< 1	< 20
Feb	3.0	82	54	90	< 1	< 0.1	< 2.0	4.0	140	< 0.10	60	< 5.0	< 1.0	< 1	< 20
Mar	5.3	75	63	130	< 1	0.1	< 2.0	4.0	190	< 0.10	60	< 5.0	1.8	< 1	< 20
Apr	4.4	57	58	53	< 1	< 0.1	2.3	3.8	150	0.21	80	< 5.0	< 1.0	< 1	< 20
May	3.0	50	30	60	< 1	< 0.1	< 2.0	5.0	210	< 0.10	200	< 5.0	< 1.0	< 1	< 20
Jun	2.8	42	35	20	< 1	< 0.1	< 2.0	3.7	70	< 0.10	130	< 5.0	< 1.0	< 1	< 20
Jul	2.6	54	60	< 20	< 1	< 0.1	< 2.0	2.1	60	< 0.10	80	< 5.0	< 1.0	< 1	< 20
Aug	2.3	‡	‡	< 20	< 1	< 0.1	< 2.0	1.8	< 50	< 0.10	130	< 5.0	< 1.0	< 1	< 20
Sep	1.8	59	52	< 20	< 1	0.1	< 2.0	5.3	< 50	1.2	49	< 5.0	< 1.0	< 1	< 20
Oct	3.0	91	91	20	1	< 0.1	< 2.0	4.2	250	< 0.10	1100	< 5.0	< 1.0	< 1	< 20
Nov	3.0	42	66	20	< 1	< 0.1	< 2.0	6.1	240	< 0.10	520	< 5.0	< 1.0	< 1	< 20
Dec	2.6	80	< 10	40	< 1	< 0.1	< 2.0	4.7	150	< 0.10	190	< 5.0	< 1.0	< 1	< 20

‡Denotes missing data.

Appendix C1. (continued)

STATION E2, BOTTOM

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	15	4.5	6.3	4.4	1.7	5.4	1.6	0.69	0.16	0.15	0.009	0.003	0.001	2.9	6.0
Feb	16	4.4	6.5	3.9	1.6	5.2	1.7	0.51	0.05	0.16	0.022	0.011	0.002	2.7	6.0
Mar	12	4.2	6.8	3.4	1.4	4.5	1.6	0.45	< 0.02	0.15	0.045	0.025	0.009	3.1	6.1
Apr	16	3.9	4.9	3.8	1.5	4.9	1.8	0.40	0.15	0.15	0.023	0.013	0.003	3.4	6.2
May	14	3.4	5.4	3.5	1.4	2.2	1.8	0.52	0.23	0.09	0.063	0.056	0.046	3.1	6.4
Jun	41	4.3	3.1	5.2	1.8	4.9	1.9	1.4	1.1	< 0.01	0.054	0.050	0.037	5.3	8.0
Jul	38	4.1	3.5	5.8	2.1	4.7	1.9	1.5	1.1	< 0.01	0.21	0.19	0.20	5.0	7.6
Aug	36	4.2	4.2	4.8	1.7	4.9	2.0	1.2	0.90	< 0.01	0.22	0.22	0.21	4.1	6.8
Sep	59	4.2	< 1.0	6.1	2.0	4.7	2.1	3.9	1.8	< 0.01	1.3	0.76	0.79	8.2	7.9
Oct	18	5.0	7.0	4.3	1.7	6.3	2.6	0.66	0.19	0.02	0.053	0.034	0.024	2.1	6.5
Nov	17	4.9	8.1	3.8	1.6	6.2	2.6	0.67	0.24	0.08	0.042	0.024	0.015	1.9	5.7
Dec	15	5.0	8.0	3.8	1.6	6.4	2.7	0.63	0.2	0.14	0.051	0.032	0.024	1.4	6.0

Month	Turbidity	TS	TDS	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	2.1	54	50	20	< 1	< 0.1	< 2.0	1.0	210	2.0	120	< 5.0	1.0	< 1	< 20
Feb	2.8	84	52	50	< 1	< 0.1	< 2.0	4.0	190	< 0.10	70	< 5.0	< 1.0	< 1	< 20
Mar	5.2	71	60	120	< 1	< 0.1	< 2.0	5.0	200	0.10	60	< 5.0	2.7	< 1	< 20
Apr	7.4	89	56	26	< 1	< 0.1	< 2.0	4.0	640	0.18	920	< 5.0	< 1.0	< 1	< 20
May	2.9	69	36	70	< 1	< 0.1	< 2.0	6.3	300	< 0.10	970	< 5.0	1.4	< 1	20
Jun	8.1	78	60	30	1	< 0.1	< 2.0	5.4	5200	0.18	9200	< 5.0	< 1.0	< 1	32
Jul	4.6	83	88	90	1	< 0.1	< 2.0	3.9	6100	< 0.10	7400	< 5.0	1.5	< 1	30
Aug	8.0	‡	‡	50	1	< 0.1	< 2.0	1.5	4400	< 0.10	6200	< 5.0	< 1.0	< 1	20
Sep	66	127	100	40	4	< 0.1	< 2.0	4.8	22000	0.24	9700	< 5.0	< 1.0	< 1	< 20
Oct	3.2	100	97	< 20	1	< 0.1	< 2.0	4.4	250	< 0.10	1100	< 5.0	< 1.0	< 1	< 20
Nov	3.2	47	63	20	< 1	< 0.1	< 2.0	5.5	310	0.15	530	< 5.0	< 1.0	< 1	< 20
Dec	3.2	78	18	30	< 1	< 0.1	< 2.0	4.3	220	< 0.10	280	< 5.0	< 1.0	< 1	< 20

‡Denotes missing data.

Appendix C1. (continued)

STATION H2, SURFACE

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	13	4.5	5.7	3.9	1.6	5.1	1.8	0.54	0.07	0.14	0.010	0.004	0.001	4.2	6.2
Feb	9	4.2	6.6	3.2	1.3	4.2	1.5	0.52	< 0.02	0.21	0.027	0.011	0.002	5.3	6.1
Mar	8	3.6	6.4	2.8	1.2	3.8	1.6	0.42	0.02	0.19	0.038	0.017	0.003	5.4	5.8
Apr	10	3.7	6.7	3.2	1.3	4.3	1.6	0.27	0.04	0.01	0.025	0.015	‡	3.2	5.7
May	13	3.7	6.1	3.2	1.3	4.1	1.6	0.38	0.02	< 0.01	0.031	0.017	0.002	0.4	5.9
Jun	12	3.9	7.0	3.4	1.4	4.6	1.8	0.35	< 0.02	< 0.01	0.030	0.016	0.001	0.8	5.7
Jul	11	3.9	6.3	3.3	1.5	5.0	1.7	0.37	< 0.02	< 0.01	0.018	0.007	0.002	1.5	6.0
Aug	13	4.4	7.0	3.3	1.6	5.1	1.8	0.34	< 0.02	< 0.01	0.019	0.009	< 0.001	1.6	2.5
Sep	13	4.5	6.7	3.2	1.4	5.4	2.1	0.34	< 0.02	< 0.01	0.015	0.008	0.001	1.4	6.5
Oct	14	4.7	6.9	3.7	1.6	5.9	2.3	0.48	0.05	0.01	0.024	0.010	0.001	1.7	6.4
Nov	15	4.7	8.0	3.4	1.5	6.2	2.5	0.46	0.07	0.04	0.025	0.010	0.001	1.8	5.9
Dec	16	5.0	7.9	3.9	1.7	6.5	2.7	0.60	0.12	0.11	0.061	0.030	0.018	1.5	6.2

Month	Turbidity	TS	TDS	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	3.4	58	43	80	< 1	< 0.1	< 2.0	< 1.0	190	< 0.10	60	< 5.0	< 1.0	< 1	< 20
Feb	11	67	53	160	1	< 0.1	< 2.0	2.0	270	< 0.10	100	< 5.0	< 1.0	< 1	< 20
Mar	12	79	53	220	< 1	< 0.1	< 2.0	2.0	350	< 0.10	100	< 5.0	3.1	< 1	< 20
Apr	4.2	55	40	41	< 1	< 0.1	< 2.0	3.0	220	0.13	110	< 5.0	< 1.0	< 1	< 20
May	3.3	72	30	40	< 1	< 0.1	< 2.0	4.6	190	< 0.10	170	< 5.0	< 1.0	< 1	< 20
Jun	3.8	40	38	< 20	< 1	0.2	< 2.0	4.5	110	< 0.10	110	< 5.0	< 1.0	< 1	20
Jul	3.0	58	64	25	< 1	< 0.1	< 2.0	2.7	90	< 0.10	70	< 5.0	1.5	< 1	< 20
Aug	2.1	‡	‡	< 20	< 1	< 0.1	< 2.0	< 1.0	60	< 0.10	110	< 5.0	< 1.0	< 1	< 20
Sep	1.7	41	42	< 20	< 1	< 0.1	< 2.0	4.1	50	< 0.10	42	< 5.0	< 1.0	< 1	< 20
Oct	4.4	83	77	< 20	1	< 0.1	< 2.0	3.3	200	< 0.10	300	< 5.0	< 1.0	< 1	< 20
Nov	3.6	48	40	30	< 1	< 0.1	< 2.0	4.4	90	0.95	100	< 5.0	< 1.0	< 1	< 20
Dec	2.8	76	25	20	1	< 0.1	< 2.0	4.2	100	< 0.10	120	< 5.0	< 1.0	1	< 20

‡Denotes missing data.

Appendix C1. (continued)

STATION P2, SURFACE

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	15	4.4	5.6	4.3	1.7	5.1	1.7	0.55	0.11	0.13	0.009	0.002	0.001	2.3	6.0
Feb	12	4.5	6.4	3.6	1.5	4.6	1.6	0.53	0.05	0.14	0.017	0.008	0.001	2.4	6.6
Mar	10	3.8	6.5	3.2	1.4	4.0	1.4	0.39	< 0.02	0.12	0.023	0.012	0.001	2.9	6.2
Apr	11	3.7	6.7	3.2	1.3	4.3	1.6	0.31	< 0.02	< 0.01	0.025	0.014	‡	2.1	6.4
May	11	4.2	7.3	3.2	1.3	4.0	1.6	0.46	0.02	< 0.01	0.013	0.012	0.002	0.2	6.9
Jun	11	4.0	6.6	3.5	1.5	4.6	1.8	0.32	< 0.02	< 0.01	0.032	0.016	0.001	0.6	5.9
Jul	12	4.1	7.0	3.6	1.6	4.7	1.7	0.37	< 0.02	< 0.01	0.025	0.010	0.001	1.2	5.7
Aug	15	4.5	7.1	3.5	1.6	5.2	1.8	0.32	< 0.02	< 0.01	0.018	0.010	0.001	1.5	4.5
Sep	14	4.6	7.1	3.4	1.4	5.5	2.2	0.32	< 0.02	< 0.01	0.014	0.007	0.001	1.5	6.3
Oct	15	4.7	7.0	3.9	1.6	5.9	2.4	0.51	0.09	0.02	0.019	0.008	0.001	1.7	6.2
Nov	15	5.2	8.8	3.5	1.5	6.0	2.4	0.53	0.15	0.05	0.021	0.008	0.001	1.5	5.6
Dec	16	4.9	8.7	4.2	1.8	6.5	2.8	0.66	0.17	0.13	0.072	0.053	0.039	1.3	6.2

Month	Turbidity	TS	TDS	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	2.1	54	45	40	< 1	0.1	< 2.0	1.0	240	< 0.10	70	< 5.0	1.1	< 1	< 20
Feb	4.8	58	50	70	< 1	< 0.1	< 2.0	2.0	300	< 0.10	50	< 5.0	< 1.0	< 1	< 20
Mar	7.5	70	64	130	< 1	< 0.1	< 2.0	2.0	220	< 0.10	90	< 5.0	< 1.0	< 1	< 20
Apr	3.1	44	50	56	< 1	< 0.1	< 2.0	3.7	140	< 0.10	70	< 5.0	< 1.0	< 1	< 20
May	3.1	66	35	60	< 1	< 0.1	< 2.0	3.1	180	< 0.10	220	< 5.0	< 1.0	< 1	< 20
Jun	3.1	31	34	20	< 1	< 0.1	< 2.0	3.2	78	< 0.10	160	< 5.0	< 1.0	< 1	< 20
Jul	2.8	67	69	50	< 1	0.1	< 2.0	2.7	60	< 0.10	120	5.1	2.0	< 1	< 20
Aug	2.6	‡	‡	30	< 1	< 0.1	< 2.0	2.2	110	< 0.10	170	< 5.0	< 1.0	< 1	< 20
Sep	0.8	46	< 10	20	< 1	0.1	< 2.0	6.4	50	< 0.10	52	< 5.0	< 1.0	< 1	< 20
Oct	3.7	76	77	90	< 1	< 0.1	< 2.0	4.2	180	< 0.10	410	< 5.0	< 1.0	< 1	< 20
Nov	4.8	41	40	50	< 1	0.1	< 2.0	5.9	120	< 0.10	180	< 5.0	< 1.0	< 1	< 20
Dec	3.0	82	< 10	20	< 1	< 0.1	< 2.0	4.2	140	< 0.10	200	< 5.0	< 1.0	< 1	70

‡Denotes missing data.

Appendix C2. Concentrations of chemical variables in Harris Lake during 1988. Units are mg/liter except trace elements which are in µg/liter and turbidity which is in NTU.

STATION E2, SURFACE

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	14	5.1	8.7	4.0	1.7	7.3	0.52	0.10	0.19	0.075	0.038	0.032	< 0.2	6.3
Mar	13	5.7	9.8	4.1	1.7	7.4	0.47	0.02	0.12	0.034	0.025	0.008	0.7	6.9
May	15	5.6	9.5	4.0	1.7	7.6	0.41	< 0.02	< 0.01	0.029	0.015	0.001	0.6	7.2
Jul	15	5.5	9.3	4.2	1.9	8.1	0.41	0.02	0.01	0.030	0.011	< 0.005	0.8	6.8
Sep	18	6.5	8.0	3.1	1.5	8.7	0.36	0.02	0.02	0.023	0.015	0.001	1.1	4.9
Nov	18	6.3	7.6	4.2	1.9	8.8	0.61	0.26	0.16	0.034	0.026	0.018	1.8	7.5

Month	Turbidity	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	3.0	80	< 1	< 0.1	< 2.0	4.8	170	< 0.10	170	< 5.0	< 1.0	< 1	20
Mar	3.3	50	1	< 0.1	< 2.0	4.1	80	< 0.10	80	< 5.0	< 1.0	< 1	< 20
May	2.0	76	< 1	< 0.1	< 2.0	4.4	< 50	< 0.10	70	< 5.0	< 1.0	< 1	< 20
Jul	3.7	90	< 1	< 0.1	< 2.0	2.4	< 50	< 0.10	90	< 5.0	< 1.0	< 1	< 20
Sep	2.4	< 20	1	< 0.1	< 2.0	1.5	< 50	< 0.05	50	< 5.0	< 1.0	< 1	< 20
Nov	2.3	80	< 1	< 0.1	< 2.0	8.1	160	0.05	480	< 5.0	< 1.0	< 1	< 20

STATION E2, BOTTOM

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	14	5.1	8.6	4.1	1.7	7.2	0.58	0.10	0.19	0.068	0.042	0.031	< 0.2	6.3
Mar	13	5.7	10	4.0	1.7	7.4	0.50	0.02	0.13	0.033	0.020	0.008	0.6	6.0
May	14	5.5	9.2	4.9	1.9	7.5	0.68	0.30	0.08	0.032	0.025	0.017	1.1	7.0
Jul	48	5.4	2.9	5.6	2.1	8.0	4.3	2.1	0.01	0.40	0.35	0.33	4.0	0.83
Sep	64	5.8	< 1.0	6.2	2.2	8.1	3.9	3.7	< 0.01	1.1	1.0	0.98	5.8	7.7
Nov	100	5.8	< 1.0	8.2	2.8	8.8	6.1	6.0	< 0.01	0.24	0.15	0.13	7.8	13

Month	Turbidity	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	3.0	90	< 1	< 0.1	< 2.0	5.3	160	< 0.10	170	< 5.0	< 1.0	< 1	20
Mar	3.5	40	< 1	< 0.1	< 2.0	5.2	90	< 0.10	90	< 5.0	< 1.0	< 1	< 20
May	2.4	97	1	< 0.1	< 2.0	4.2	2000	< 0.10	5600	< 5.0	< 1.0	< 1	20
Jul	10	50	2	< 0.1	< 2.0	2.9	7100	< 0.10	7600	< 5.0	1.1	< 1	< 20
Sep	20	30	2	0.1	< 2.0	1.0	16000	< 0.05	9400	< 5.0	< 1.0	< 1	< 20
Nov	23	20	1	< 0.1	< 2.0	3.5	20000	< 0.05	24000	< 5.0	< 1.0	< 1	< 20

Appendix C2. (continued)

STATION H2, SURFACE

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	14	4.9	7.9	3.7	1.6	6.4	0.47	0.02	0.11	0.031	0.014	0.002	1.1	6.7
Mar	12	5.4	8.4	3.7	1.6	6.8	0.51	< 0.02	0.11	0.020	0.011	0.003	2.3	6.2
May	13	5.6	8.8	3.9	1.7	7.0	0.43	< 0.02	< 0.01	0.030	0.014	0.001	0.9	7.5
Jul	15	5.6	9.0	4.2	1.9	8.1	0.40	0.02	0.01	0.027	0.011	< 0.005	0.8	7.2
Sep	18	6.4	9.2	3.2	1.6	8.8	0.44	0.05	0.03	0.016	0.010	0.002	1.3	5.0
Nov	16	6.1	7.8	3.9	1.8	8.4	0.62	0.10	0.13	0.029	0.015	0.003	1.8	7.7

Month	Turbidity	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	3.3	60	< 1	< 0.1	< 2.0	3.6	150	< 0.10	60	< 5.0	< 1.0	< 1	20
Mar	3.5	60	< 1	< 0.1	< 2.0	2.5	120	< 0.10	70	< 5.0	< 1.0	< 1	< 20
May	2.7	43	< 1	< 0.1	< 2.0	5.5	60	< 0.10	50	< 5.0	< 1.0	< 1	< 20
Jul	4.9	60	< 1	< 0.1	< 2.0	3.2	< 50	< 0.10	60	< 5.0	< 1.0	< 1	< 20
Sep	1.2	20	< 1	0.3	< 2.0	2.8	< 50	< 0.05	60	< 5.0	< 1.0	< 1	< 20
Nov	2.0	40	< 1	< 0.1	< 2.0	3.4	170	< 0.05	100	< 5.0	< 1.0	< 1	< 20

STATION P2, SURFACE

Month	Total Alkalinity ($CaCO_3$)	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	Total N	NH_3-N	$NO_3^-NO_2^-$-N	Total P	TDP	DMRP	Silica	TOC
Jan	13	4.9	7.5	3.7	1.6	6.4	0.57	0.02	0.15	0.031	0.011	0.003	< 0.2	6.7
Mar	12	5.3	8.6	3.7	1.6	6.6	0.40	0.02	0.09	0.017	0.011	0.002	0.6	6.6
May	16	5.6	10	4.0	1.7	7.2	0.41	0.03	0.01	0.028	0.015	< 0.002	0.6	7.5
Jul	15	5.8	10	4.2	1.9	8.4	0.40	0.02	0.01	0.025	0.010	< 0.005	0.8	7.2
Sep	18	6.4	9.0	3.0	1.4	9.0	0.41	0.05	0.02	0.015	0.009	0.002	1.1	5.1
Nov	16	6.3	8.1	3.9	1.9	8.6	0.67	0.13	0.13	0.019	0.016	0.002	1.5	7.3

Month	Turbidity	Al	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Se	Zn
Jan	2.8	70	< 1	< 0.1	< 2.0	4.8	110	< 0.10	70	< 5.0	< 1.0	< 1	< 20
Mar	3.0	70	< 1	< 0.1	< 2.0	4.2	80	< 0.10	70	< 5.0	< 1.0	< 1	< 20
May	2.2	62	< 1	< 0.1	< 2.0	3.1	50	< 0.10	70	< 5.0	< 1.0	< 1	20
Jul	4.3	60	< 1	< 0.1	< 2.0	2.3	< 50	< 0.10	90	< 5.0	< 1.0	< 1	< 20
Sep	1.4	< 20	< 1	0.1	< 2.0	2.2	< 50	< 0.05	50	< 5.0	< 1.0	< 1	< 20
Nov	2.4	40	< 1	< 0.1	< 2.0	3.6	150	< 0.05	170	< 5.0	< 1.0	< 1	< 20