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Job Messages

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HARRIS NUCLEAR PLANT
1998 ENVIRONMENTAL MONITORING REPORT

July 1999

Environmental Services Section

CAROLINA POWER & LIGHT COMPANY
New Hill, North Carolina

Preface

This copy of the report is not a controlled document as detailed in the *Environmental Services Section Biology Program Procedures 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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Carolina Power & Light Company
3932 New Hill-Holleman Road
New Hill, North Carolina 27562-0327

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Metric-English Conversion and Units of Measure

Length
1 micron (μm) = 4.0 x 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 (ha) = 10,000 m^2 = 2.47 acres

Volume
1 milliliter (ml) = 0.034 fluid ounce
1 liter = 1000 ml = 0.26 gallon
1 cubic meter = 35.3 cubic feet

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

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

Specific conductance
μS/cm = Microsiemens/centimeter

Turbidity
NTU = Nephelometric Turbidity Unit

Water Chemistry Abbreviations

Cl^-	Chloride	TOC	Total organic carbon	Cu	Total copper
SO_4^{2-}	Sulfate	TS	Total solids	Hg	Total mercury
Ca^{2+}	Total calcium	TDS	Total dissolved solids	Ni	Total nickel
Mg^{2+}	Total magnesium	TSS	Total suspended solids	Pb	Total lead
Na^+	Total sodium	Al	Total aluminum	Se	Total selenium
TN	Total nitrogen	As	Total arsenic	Zn	Total zinc
NH_3-N	Ammonia nitrogen	Cd	Total cadmium		
TP	Total phosphorus	Cr	Total chromium		

Executive Summary

Harris Reservoir supplies makeup water to the closed-cycle cooling system for the Harris Nuclear Plant. The Harris Nuclear Plant discharges primarily cooling tower blowdown along with low volume waste discharges into the reservoir near the main dam.

Nutrient concentrations, including total phosphorus and total nitrogen concentrations, remained stable for the reporting period (1994-1998) and were in an acceptable range for a productive reservoir in this area. The concentrations of most chemical constituents did not exhibit any consistent significant temporal changes and were not in ranges considered detrimental to the biological community.

At single locations during May and July, the chlorophyll *a* concentration exceeded the state water quality standard. Although elevated chlorophyll *a* were observed, phytoplankton density estimates indicate only a moderate bluegreen algal bloom present at one station in Harris Reservoir during May 1998. Algal blooms have been a concern in previous years because blooms indicate increased nutrient loading which can degrade water quality.

Monitoring of biofouling organisms continued in 1998. No Asiatic clams were found in the Harris Nuclear Plant main reservoir service water and cooling water makeup systems. Relatively low densities of Asiatic clams were found in the Harris Nuclear Plant auxiliary emergency service water system. The presence of Asiatic clams in these systems did not affect power plant operations. No clams were found in the power plant's fire protection system. Zebra mussels, another potential biofouling organism, were not collected in the main or the auxiliary reservoirs. To date, this organism has not been found in North Carolina waters.

Bluegill, redear sunfish, and largemouth bass continued to dominate the fishery in Harris Reservoir during 1998. Semiannual catch rates for all three species were in the range of semiannual values reported for 1991-1994 and length-frequency distributions indicated multiple age groups present in the population for all three species. Despite the heavy fishing pressure indicated by the NCWRC creel survey, the largemouth bass population remains balanced with no missing size classes.

Hydrilla stands reaching the surface of the water were not observed in the intake canal in Harris Reservoir or in the littoral zone of the auxiliary reservoir during 1998. Attempts to control hydrilla in the auxiliary reservoir by releasing grass carp during the falls of 1994, 1996, and 1997 appear to have been effective in reducing the quantity and area covered by this vegetation. These fish are expected to help prevent the proliferation of aquatic vegetation for the next several years.

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Reservoir Description

The main body of Harris Reservoir has a surface area of 1680 ha; the auxiliary reservoir has a surface area of 130 ha (Appendix 1). The main reservoir has a maximum depth of 18 m, a mean depth of 5.3 m, a volume of 8.9×10^7 m^3, a full-pool elevation of 67.1 m National Geodetic Vertical Datum (NGVD), and an average residence time of 28 months. The reservoir began filling in December 1980, and full-pool elevation was reached in February 1983. The 64.5-km shoreline is mostly wooded, and the 183.9-km^2 drainage area is mostly rolling hills with land used primarily for forestry and agriculture. The conversion of areas from forestry or agricultural purposes to residential uses continues in many areas of the drainage.

Harris Reservoir has a "Class C" water quality classification (NCDEM 1994a). Class C waters are suitable for aquatic life propagation and maintenance of biological integrity (including fishing and fish), wildlife, secondary recreation, agriculture, and any other usage except for primary recreation or as a source of water supply for drinking, culinary, or food processing purposes (NCDEM 1994b).

Historical Overview

Harris Reservoir was constructed to supply cooling tower makeup and auxiliary reservoir makeup water to the 900-MW Harris Nuclear Plant which began commercial operation in May 1987. In 1986 the bottom waters of the reservoir near the main dam began receiving National Pollutant Discharge Elimination System (NPDES)-permitted wastewater discharges from the power plant combined outfall. Tributaries also receive NPDES-permitted discharges from the Harris Energy and Environmental Center and from wastewater treatment plants at Apex and Holly Springs.

The environmental monitoring programs that were conducted after Harris Nuclear Plant initiated commercial operation determined that Harris Reservoir was a typical southeastern, moderately productive reservoir with seasonal oxygen-deficient subsurface waters, elevated nutrient and algal concentrations, an abundance of rooted shallow-water aquatic plants, and a productive sport fishery.

Throughout its history, the reservoir has increased in biological productivity. Nutrient loadings from point and nonpoint sources increased the algal biomass of Harris Reservoir from a low/moderate range to a moderate/high range within the period 1986-1989. In 1994, Harris Reservoir was described as support-threatened because of elevated nutrient levels (primarily total nitrogen) (NCDEM 1995). Support-threatened reservoirs are those that fully support their designated uses but may not fully support uses in the future (unless pollution control action is taken) because of anticipated sources or adverse pollution trends (NCDEM 1994a). The annual mean total nitrogen concentration increased through 1993, but from 1994 to 1997 concentrations remained similar. Total phosphorus concentrations remained stable during 1994 through 1997 and at levels acceptable for southeastern, productive reservoirs.

With the increase in nutrients, an increase in algal biomass (as estimated by chlorophyll *a* concentrations) was observed throughout much of the reservoir. On at least one occasion each year from 1989 to 1994, the chlorophyll *a* concentrations were above the North Carolina water quality standard (40 μg/liter) in Harris Reservoir. During 1995 and 1996 no measured chlorophyll *a* concentration exceeded 40 μg/liter. A single chlorophyll *a* concentrations above 40 μg/liter was observed during 1997. Chlorophyll *a* concentrations above 40 μg/liter imply algal blooms and potential water quality degradation.

In 1984 the reservoir was colonized by the Asiatic clam (*Corbicula fluminea*). This nonnative organism has the potential to block power plant pipes and tubes in raw-water systems. Although densities remained at low levels in Harris Nuclear plant service water and cooling water makeup systems during the 1994-1997 period, the presence of shells along the shoreline in many areas indicate substantial numbers of clams inhabiting the main reservoir. Asiatic clams have not interfered with power plant operations at the Harris Nuclear Plant.

The aquatic plant hydrilla (*Hydrilla verticillata*) was initially found in 1988 growing in the White Oak Creek arm. Within a two-year period, this nonnative species had displaced native species and become the dominant littoral zone plant species. Since 1990 creeping water primrose (*Ludwigia uruguayensis*) has also increased its littoral zone coverage in the main reservoir. Hydrilla and water primrose were observed in the auxiliary reservoir in 1993 and by 1994 they were widespread. The distribution and abundance of hydrilla and water primrose in 1997 were similar to distribution and abundance patterns in previous years. Despite these shifts in the structure of the aquatic macrophyte community, the community has not impacted Harris Nuclear Plant operations.

Objectives

The primary objective of the 1998 Harris Nuclear Plant environmental monitoring program was to provide an assessment of the effect of power plant operations on the water quality in Harris Reservoir. Secondary objectives of the program were to document any other environmental factors impacting water quality and to document the introduction and expansion of nonnative plant and animal populations in the reservoir. These objectives have also been addressed in previous reports (e.g., CP&L 1994a, 1994b, 1996a, 1996b, 1997, 1998).

Methods

Key indicators of the water quality of Harris Reservoir were assessed at various locations in the reservoir (Figure 1 and Table 1). These key indicators were used to describe and interpret the environmental quality of the reservoir and were included if there was an occurrence or the potential for a significant change, trend, or an abnormal event. Other items were included as key indicators when there was environmental, public, or regulatory interest.

The 1998 environmental program included monitoring the reservoir's: (1) limnological characteristics (water quality, water chemistry, and chlorophyll *a*), (2) Asiatic clam populations, (3) distribution of aquatic vegetation, (4) possible introductions of the zebra mussel and the quagga mussel, (5) fisheries populations and angling pressure. Sampling methods for all monitoring, except the creel survey, in 1998 were similar to those used in 1995 (CP&L 1996b) (Table 2). Creel survey methods were developed and implemented (July, 1997) by the North Caroline Wildlife Resources Commission (NCWRC). No largemouth bass fishing tournaments were monitored.

Supporting data summaries and appropriate statistical analyses were used to describe and interpret the environmental quality of the reservoir (Table 3). Monthly precipitation data from Sanford, North Carolina, during 1994 to 1998 are presented as a reference to interpret the environmental data (Figure 2).

Three stock assessment indices were used as indicators of a balanced largemouth bass population (Gablehouse 1984). Proportional stock density (PSD) is the percentage of all fish $\geq$ 200 mm that are also $\geq$ 300 mm. Relative stock density preferred length (RSD_P) is the percentage of all fish $\geq$ 200 mm that are also $\geq$ 380 mm. Relative stock density memorable length (RSD_M) is the percentage of all fish $\geq$ 200 mm that are also $\geq$ 510 mm. Relative weight (W_r) indices were also calculated based upon standard weight equations developed for bluegill (Hillman [1982]), redear sunfish (Pope et al. [1995]), and largemouth bass (Wege and Anderson [1978]).

All analytical testing, except total phosphorus analyses, completed in support of the Harris Reservoir environmental monitoring program was performed by testing laboratories that are certified by North Carolina Division of Water Quality's (NCDWQ) Laboratory Certification Program to perform water and wastewater testing. The validity of these data was assured through CP&L's quality control program. For calculation of means in this report, concentrations of less than the reporting limit were assumed to be at one-half the reporting limit.

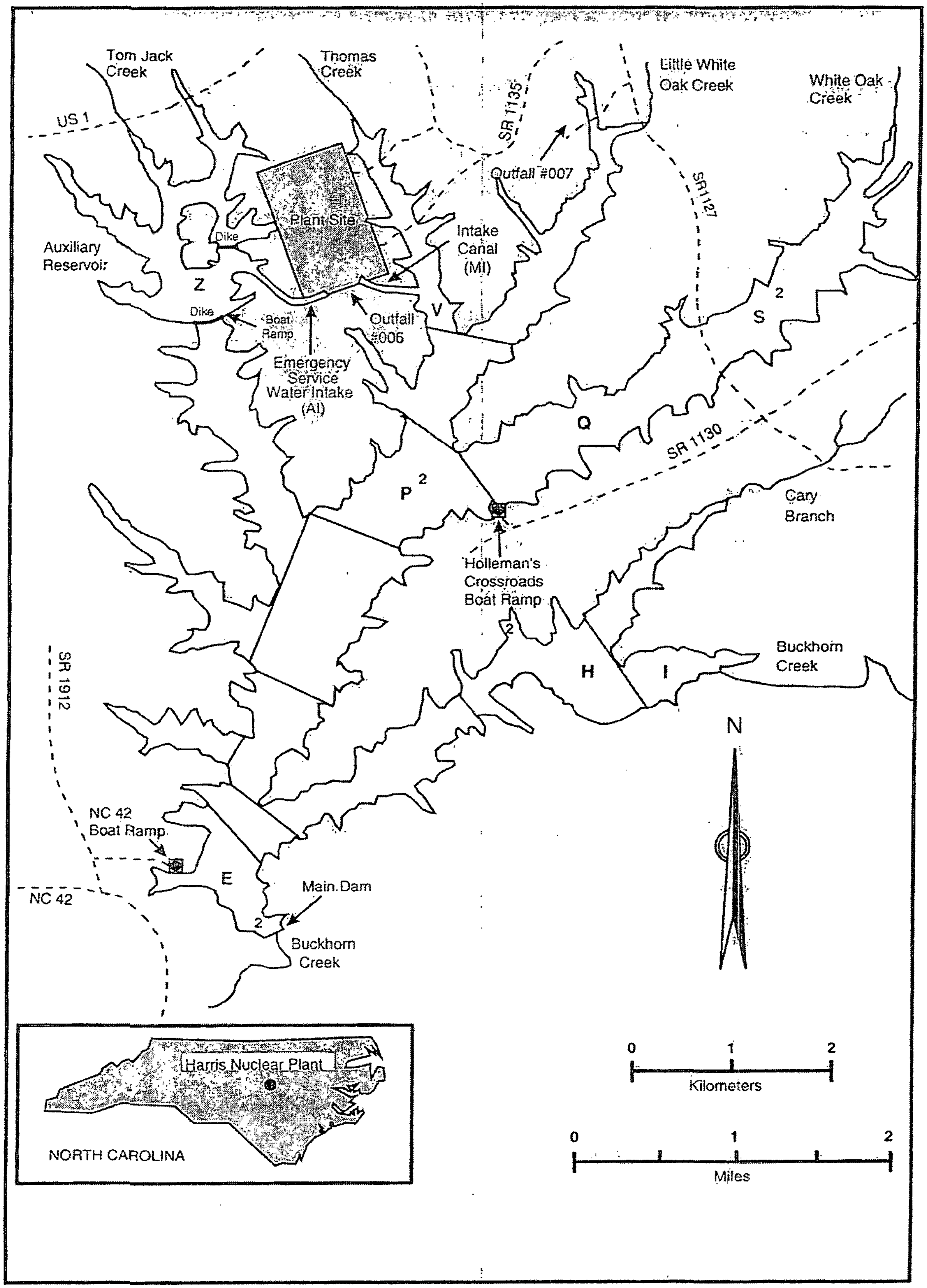


Figure 1. Sampling areas and stations at Harris Reservoir during 1998.

Table 1. Environmental monitoring program at Harris Reservoir for 1998.

Program	Frequency	Location
Limnology		
Water quality (temperature, dissolved oxygen, pH, conductivity, Secchi disk transparency)	Jan, May, Jul, Nov	Stations E2, H2, P2, and S2 (surface to bottom at 1-m intervals)
Water chemistry	Jan, May, Jul, Nov	Stations E2, H2, P2, and S2 (surface samples at all stations, bottom sample at E2 only)
Chlorophyll *a*	Jan, May, Jul, Nov	Stations E2, H2, P2, and S2
Biofouling monitoring surveys		
Asiatic clam (*Corbicula*)	May, Nov	Emergency service water and cooling tower makeup system intake structures
Zebra mussel	Jan, May, Jul, Nov	Areas E, P or Q, and V
Fisheries		
Electrofishing	Twice per calendar year (May, Nov)	Stations E1, E3, H1, H3, P1, P3, S1, S3, V1, and V3
Aquatic vegetation survey	Nov	Areas V and Z

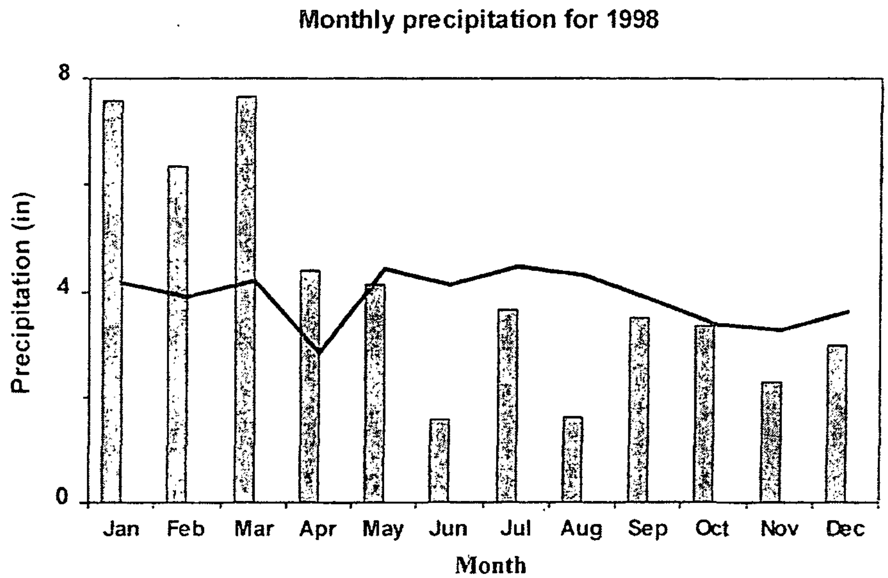
Table 2. Field sampling and laboratory methods followed in the 1998 environmental monitoring program at Harris Reservoir.

Program	Method
Water quality	Temperature, dissolved oxygen, pH, and conductivity were measured with calibrated Martek Mark XV® and YSI® instruments. Measurements were taken from surface to bottom at 1-m intervals. Water clarity was measured with a Secchi disk.
Water chemistry	Surface (Stations E2, H2, P2, and S2) and bottom samples (Station E2) were collected with a nonmetallic Van Dorn sampler, transferred to appropriate containers, transported to the laboratory on ice, and analyzed according to accepted laboratory methods.
Chlorophyll *a*	Equal amounts of water from the surface, the Secchi disk transparency depth, and twice the Secchi disk transparency depth were obtained with a Van Dorn sampler, placed in a plastic container and mixed, then a 1000-ml subsample was collected in a dark bottle. All samples were placed on ice and returned to the laboratory. In the laboratory a 250-ml subsample from each depth was analyzed according to Strickland and Parsons (1972) and APHA (1992).
Phytoplankton	Equal amounts of water from the surface, the Secchi disk transparency depth, and twice the Secchi disk transparency depth were obtained with a Van Dorn sampler and mixed in a plastic container. A 250-ml subsample was taken and preserved with 5 ml of "M3" fixative.
Electrofishing	Fifteen-minute samples were collected at each station using a Smith-Root Type VI-A equipped, Wisconsin-design electrofishing boat with pulsed DC current. Fish were identified, measured to the nearest mm, weighed to the nearest gram, examined for the presence of disease and deformities, and released.
Asiatic clam	Seven samples were collected with a petite Ponar from the emergency service water and cooling tower makeup intake structures. Samples were sieved through a No. 5 U.S. Standard Testing Sieve (4mm mesh). The sieved material was preserved with 5% formalin and returned to the laboratory where the clams were counted and measured. Results were recorded on the Harris Nuclear Plant Biofouling Investigation Form.
Zebra mussel	An artificial substrate sampler, constructed of a PVC frame and fitted with removable PVC plates, was placed near the cooling tower makeup intake structure. This sampler, the dock at the Holleman's boat ramp, or the water quality station marker buoy was visually inspected for the presence of mussels during routine water quality or Asiatic clam survey monitoring.
Aquatic vegetation survey	Portions of the shoreline and/or littoral zone of the main reservoir Harris Plant intake canal and auxiliary reservoir were systematically surveyed by boat to document the presence of aquatic vegetation specifically hydrilla and creeping water primrose.

Table 3. **Statistical analyses performed on data collected for the 1998 environmental monitoring program at Harris Reservoir.**

Program	Variable	Statistical test/model[1]	Main effect(s)	Interaction term
Limnology	Water temperature, conductivity, Secchi disk transparency depth, and selected chemical variables	One-way, block on month Two-way, block on month	Station Station, year	 Station-by-year
Water chemistry	Monitoring variables	One-way, block on month Two-way, block on month	Station Station, year	 Station-by-year
Phytoplankton	Density and chlorophyll *a*	One-way, block on month Two-way, block on month	Station Station, year	 Station-by-year
Fisheries	Number per hour ln(x+1) transformation	One-way, block on month	Transect	

[1]Statistical tests used were one-way and two-way analysis of variance models. A Type I error rate of 5% ($\alpha = 0.05$) was used to judge the significance of all tests. Fisher's protected least significant difference (LSD) test was applied to determine where differences in means occurred.



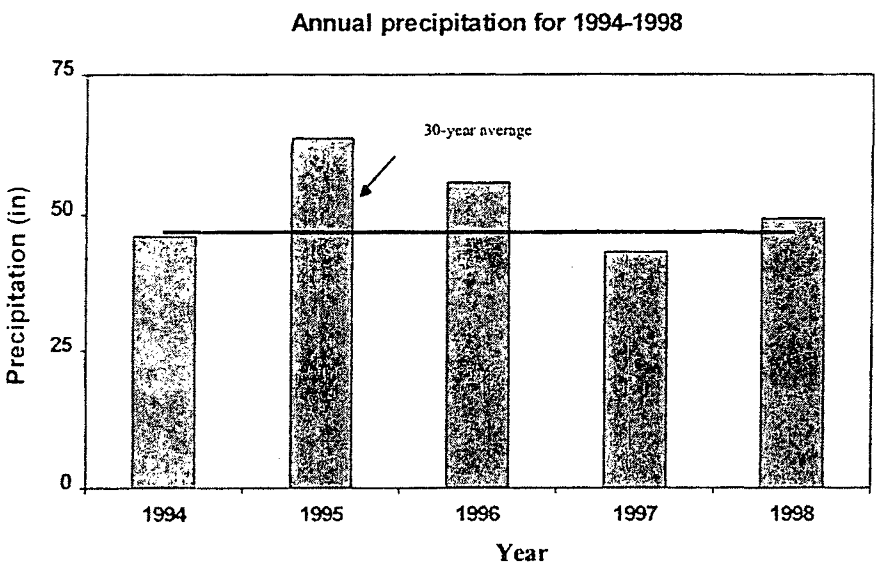


Figure 2. Monthly and yearly precipitation recorded at Sanford, North Carolina, 1994-1998 (source: The State Climate Office of North Carolina).

Results of Environmental Monitoring at Harris Reservoir During 1998

Limnology

Annual precipitation

- Annual precipitation at Sanford, North Carolina, during 1998 (49.1 in) was greater than the thirty-year average (1961-1990) (Figure 2). Total monthly precipitation was above the thirty-year average January through April and below the average November and December during 1998.

Temperature and Dissolved Oxygen

- During 1998 Harris Lake surface water temperatures ranged from 9.3 to 29.6°C (Appendix 1). The waters at all reservoir stations were stratified during May (except Station S2) and July and were freely circulating during January and November. Portions of the hypolimnion were anoxic (i.e., conditions where dissolved oxygen concentrations are less than 1 mg/liter) at Stations E2 and H2 during July (Appendix 1). This bottom-water oxygen decline is typical during the warm summer months in Harris Reservoir and in other southeastern productive water bodies when well-defined thermoclines develop and block bottom waters from mixing with the upper, more oxygenated waters.

Water Clarity

- The Secchi disk transparency depth (a water clarity indicator) annual mean value was similar at all stations (S2, P2, E2, and H2) during 1998 (Appendix 2). This spatial pattern is not typical of patterns during previous years when Secchi disk transparency was significantly less in the upper reservoir (Station S2) compared to the other stations. Except for an increased Secchi disk transparency value during 1995, annual mean Secchi disk transparency values remained similar from 1994 through 1998.

- There were no significant spatial trends for solids (i.e., total solids, total dissolved solids, and total suspended solids) or turbidity during 1998 for surface waters at Stations E2, H2, P2, and S2 (Appendices 2 and 3). There were no consistent statistically significant temporal trends for these variables during the 1994-1998 period (Appendix 4).

Nutrients (surface waters)

- There were no significant spatial differences among stations for mean nutrient (i.e., phosphorus, ammonia-N, nitrate + nitrite-N, and total nitrogen) concentrations in Harris Reservoir during 1998 (Appendix 2). There were no statistically significant temporal trends for nutrient concentrations during the 1994-1998 period (Appendix 4).

Ions (surface waters)

- There were no significant spatial differences in ion concentrations during 1998 (Appendix 2).

- With the exception of annual mean sulfate concentrations which were significantly less for 1998 compared to concentrations during 1994-1997, there were no consistent temporal trends for the other ion concentrations during the 1994-1998 comparison period (Appendix 4).

pH, Total Alkalinity, Total Organic Carbon, and Hardness

- The median pH in the surface waters of Harris Reservoir was 7.3 during 1998 (Appendix 1).

- In 1998 total alkalinity, total organic carbon, and hardness concentrations were not statistically different among stations (Appendix 2).

- There were no consistent significant temporal trends in annual mean total alkalinity, total organic carbon, or hardness concentrations during the 1994-1998 comparison period (Appendix 4).

Trace Metals and Metalloids (surface waters)

- Mean concentrations of trace elements in Harris Reservoir were generally low during 1998 with most concentrations less than or near their respective laboratory reporting limits (Appendix 3). No significant spatial trends were observed during 1998 (Appendix 2). During 1998 aluminum ranged from < 50 to 301 μg/liter with the greater value recorded in a headwater region where aluminum concentrations may have been influenced by watershed sources located upstream of the reservoir (Appendices 2 and 3).

- Except for copper concentrations which were significantly greater during 1998 compared to the 1994-1997 comparison period, there were no significant temporal differences among trace element concentrations in Harris Reservoir for the period 1994 to 1998 (Appendix 4).

Chemical Constituents in the Bottom Waters at Station E2

- The concentrations of most chemical constituents in the bottom waters remain within a range expected for productive, southeastern reservoir waters and were not considered detrimental to the biological community Appendix 3).

- In the bottom waters at Station E2, there were no significant differences among years (1994-1998) for solids (total, dissolved, and suspended solids), turbidity, most nutrients (i.e., nitrate + nitrite-N, ammonia-N, and total phosphorus), total organic carbon, ions (calcium, chloride, magnesium, sodium, and sulfate), total alkalinity, hardness, and metals (Appendices 3 and 5). Total nitrogen concentrations were similar during the period 1994-1998. There was extreme variability in chemical concentrations between periods of stratification and periods of uniform mixing throughout the water column. This variability was the probable cause for being unable to detect any significant temporal differences in the chemical constituents in bottom waters.

Algal Biomass and Phytoplankton Abundance

- During May 1998 at Station H2 and again during July 1998 at Station E2, mean chlorophyll *a* concentrations exceeded the North Carolina water quality standard of 40 µg/liter (NCDEM 1992) (Appendix 2). During May 1997 chlorophyll *a* concentrations at Station S2 also exceeded the North Carolina water quality standard of 40 µg/liter (CP&L, 1998). Prior to 1997, chlorophyll *a* concentrations had not exceeded the water quality standard since January 1994. Algal densities were moderately high (62,458 units/ml) during May 1998 (Appendix 6). The numerically dominant taxa were blue-green algae with *Oscillatoria* spp. accounting for two-thirds of all algae collected during May 1998 (Appendix 7). These algae can be responsible for nuisance algal blooms sufficient to degrade water quality. During July 1998 algal densities at Station E2 were moderate (26,016 units/ml.). The numerically dominant taxa included a green algae (*Ankistrodesmus falcatus,* 4021 units/ml) a flagellated algae (*Cryptomonas erosa,* 4398 units/ml.) and a blue-green algae (*Oscillatoria* spp., 3896 units/ml) (Appendix 6 & 7).

- Reservoir-wide annual mean chlorophyll *a* concentrations were significantly greater during 1998 compared to chlorophyll *a* concentrations during 1994-1996 (Appendix 4).

Biofouling Monitoring Surveys

Asiatic Clam

- Asiatic clams caused no operational problems for the Harris Nuclear Plant nor were they collected from the fire protection system during 1998.

- During 1998 no Asiatic clams were collected from the main reservoir service water or cooling water makeup systems indicating lower densities than observed in 1996 (Appendix 8). Mean clam densities were lower during 1998 in the auxiliary reservoir service water system compared to clam densities during 1996 and 1997. All Asiatic clams collected during 1998 were approximately 2-4 years old based on their size ranges.

Zebra Mussel and Quagga Mussel

- No zebra mussels (*Dreissena polymorpha*) or quagga mussels (D. *bugensis*), potentially serious biofouling organisms to power plant operations, were found in Harris Reservoir or the auxiliary reservoir during 1998. Zebra mussels and quagga mussels are not expected to thrive in Harris Reservoir because concentrations of alkalinity, calcium, total hardness, and pH are suboptimal for mussel growth and reproduction (Claudi and Mackie 1993).

Fisheries

- A total of 17 fish species were collected with semiannual electrofishing sampling during 1998 (Appendix 9). The number of species collected during 1998 was similar to the number collected with both semiannual and quarterly sampling during previous years (CP&L 1996a, 1996b).

- Threadfin shad, bluegill, redear sunfish, and largemouth bass comprised 87% of the mean number per hour collected. With the exception of threadfin shad, these three recreationally important species have historically dominated electrofishing samples from Harris Reservoir (Appendix 9 and CP&L 1996a, 1996b). An extremely large catch rate for threadfin shad at Station V3 during November (2,532 fish/hour) skewed results for species composition. One species absent from electrofishing samples during 1998 but present during previous years was pumpkinseed. This may be the result of increased interspecific competition with bluegill and redear sunfish as their populations have increased or the result of reduced sampling frequency.

- There was no significant difference in the mean catch rate between transects for any species except for redear sunfish. As the following table of geometric mean catch rates indicates, significantly more redear sunfish were collected from Transect H compared to transects P, S, and V.

	Transect				
	E	H	P	S	V
Mean number per hour	4.2[ab]	5.1[a]	2.8[c]	3.0[c]	3.7[bc]

- The annual mean electrofishing catch rate for bluegill of 88 per hour was in the range of values (71-118) reported for semiannual data from 1991 through 1994 (Appendix 9 and CP&L 1996a). The length-frequency distribution for bluegill indicated moderately strong recruitment during 1998 (Appendix 10). Additionally, there were adequate numbers of older, larger fish present sufficient to support a recreational fishery. Results of the NCWRC creel survey completed in June indicated that approximately 7% of angler effort at Harris Reservoir is directed at this species and approximately 53% of the bluegill caught by anglers were released (Jones et al. In press). The mean relative weight of bluegill collected during 1998 was less than optimal (100 = optimum) but was consistent with the range that might be expected under relatively high population densities (Appendix 11).

- The annual mean electrofishing catch rate for redear sunfish of 67 per hour was greater than the range of values (21-38) reported for semiannual data from 1991 through 1994 (Appendix 9 and CP&L 1996a). Similar to previous years, the length-frequency distribution for redear sunfish during 1998 indicated low recruitment (Appendix 10). However, the relatively high mean electrofishing catch rate and the presence of older, larger fish in the population indicate a viable redear sunfish fishery exist in Harris Reservoir. Similar to bluegill, the less than optimal mean relative weight was in the range consistent with a relatively large population density (Appendix 11).

- The annual mean electrofishing catch rate for largemouth bass of 39 per hour was similar to or greater than the range of values (10-39) reported for semiannual data from 1991 through 1994 (Appendix 9 and CP&L 1996a). The length-frequency distribution for largemouth bass indicated strong recruitment and the presence of multiple age classes during 1998 (Appendix 10). The values for proportional stock density, relative stock density preferred length, and relative stock density memorable length were in the range of values reported by Gablehouse

(1984) as indicative of a balanced largemouth bass population for the low to moderate density management strategy. Results of the NCWRC creel survey completed in June indicated that approximately 67% of the 118 hours per hectare of angler effort at Harris Reservoir was directed at this species (Jones et al. In press). According to the authors, this effort was greater than or equal to the angler effort expended on this species recorded at Lakes Norman (1993), Wylie (1994, 1995), or Gaston (1997)---all lakes with much greater surface area than Harris Reservoir. The mean relative weight of largemouth bass collected during 1998 indicated healthy, robust body conditions (Appendix 11).

Aquatic Vegetation

- A visual survey revealed no stands of hydrilla (*Hydrilla verticillata*), a non-native submersed plant, in the intake canal in Harris Reservoir during 1998. The survey also revealed that creeping water primrose (*Ludwigia uruguayensis*) was established in approximately the same locations and existed in amounts similar to those observed during 1997. Although creeping water primrose was well established in this region, no impacts to the Harris Plant have occurred nor are they expected because of the low velocity of water drawn from the main reservoir into the cooling tower makeup water intake structure. During November 1998 no hydrilla stands extending to the water surface were observed in the littoral zone of the auxiliary reservoir. The presence of hydrilla stands in the auxiliary reservoir during 1998 has substantially diminished from the size and extent of stands observed in 1996 and 1997.

- Approximately 800 grass carp (*Ctenopharyngodon idella*) were released into the auxiliary reservoir during the falls of 1994, 1996, and 1997. These fish were released to control the growth and spread of aquatic vegetation. The fish released in 1994, 1996 and 1997 apparently have grown to sufficient size and were present in sufficient number to decrease the size and extent of hydrilla stands such that plants did not reach the water surface during 1998.

CONCLUSIONS

During 1998 the Harris Reservoir continued to show characteristics of a typical southeastern, biologically productive reservoir with seasonally occurring oxygen-deficient subsurface waters, elevated nutrient concentrations, and an abundance of rooted shallow-water aquatic plants.

The environmental monitoring program conducted in 1998 continued to provide an assessment of the effects of the Harris Nuclear Plant's operation on the various components of the aquatic environment. Most key indicators of the environmental quality in Harris Reservoir were unchanged from the previous five years. Nutrient concentrations have been a concern in Harris Reservoir since phosphorous and nitrogen concentrations increased rapidly in the late 1980s and early 1990s. Water quality assessments determined that nutrient concentrations have remained stable since 1994 and at levels acceptable for southeastern, productive reservoirs. Annual mean total nitrogen concentrations in Harris Reservoir surface waters were similar during the 1994-1998 comparison period. Assessments of water quality parameters in Harris Reservoir bottom waters at Station E2, including nutrient (i.e., phosphorus, ammonia-N, nitrate + nitrite-N, and total nitrogen), solid (total, dissolved, and suspended solids), turbidity, total organic carbon, ion (calcium, chloride, magnesium, sodium, and sulfate), total alkalinity, hardness, and metal concentrations, indicate few if any consistent statistically significant spatial or temporal trends. Generally these concentrations would not be detrimental to the aquatic community.

The frequency of nuisance algal blooms, as indicated by chlorophyll *a* concentrations, increased from one during 1997 to two during 1998. For the third year since 1994 a measured chlorophyll *a* concentration has exceeded the North Carolina water quality standard of 40 µg/l. Reservoir-wide chlorophyll *a* concentrations demonstrated no consistent statistically significant temporal trend for the 1994-1998 period. A moderate algal bloom dominated by bluegreen algae was observed during May 1998 in Harris Reservoir at Station H2.

The presence of Asiatic clams in the Harris Nuclear Plant emergency service water system did not impact plant operations in 1998. During 1998 no Asiatic clams were collected from the main reservoir service or makeup water systems indicating lower densities during 1998 than observed in 1996. Mean clam densities were lower during 1998 in the auxiliary reservoir service water system compared to clam densities during 1996 and 1997. All Asiatic clams collected during 1998 were approximately 2-4 years old based on their size ranges.

Neither the zebra mussel nor the quagga mussel were found in the main reservoir or the auxiliary reservoir during 1998. Although these biofouling organisms have yet to be found in North Carolina, their potential biofouling impact to Harris Nuclear Plant operations warranted continued monitoring.

Bluegill, redear sunfish, and largemouth bass continued to dominate the fishery in Harris Reservoir during 1998. Semiannual catch rates for all three species were in the range of semiannual values reported for 1991-1994 and length-frequency distributions indicated multiple age groups present in the population for all three species. Despite the heavy fishing pressure indicated by the NCWRC creel survey, the largemouth bass population remains balanced with no missing year classes.

Based on surveys conducted during 1998, stands of the aquatic plant, hydrilla, extending to the surface of the water were not observed in the littoral zone throughout the intake canal of the main reservoir. Hydrilla also was not observed extending to the surface of the water in the littoral zone of the auxiliary reservoir, as was the case during 1996. The reduced size and extent of aquatic vegetation stands in the auxiliary reservoir indicates that grass carp released in the fall of 1994, 1996, and 1997 markedly reduced the amount and areal coverage of hydrilla during 1998. These fish are expected to prevent the proliferation of aquatic vegetation in the auxiliary reservoir. No operational impacts have occurred at the Harris Nuclear Plant because of aquatic vegetation biofouling.

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Appendix 1. **Water temperature, dissolved oxygen, conductivity, pH, and Secchi disk transparency data collected from Harris Reservoir during 1998.**

January 12, 1998

Depth (m)	Temperature (°C)				Dissolved oxygen (mg/L)				Conductivity (µS/cm)				pH				Secchi disk depth (m)			
	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2
0.2	10.0	11.3	9.3	11.5	12.8	12.4	11.4	9.2	77	74	75	83	8.3	8.1	7.0	6.6	1.4	1.0	1.6	0.4
1.0	10.0	11.1	9.3	11.4	12.8	12.3	11.4	9.4	77	74	75	83	8.3	8.0	7.0	6.6				
2.0	10.0	11.1	9.3	11.4	12.8	12.2	11.4	9.1	77	74	75	83	8.3	7.9	7.0	6.6				
3.0	9.0	11.0	9.3	10.8	12.0	12.1	11.4	8.7	77	74	75	81	7.8	7.8	7.0	6.6				
4.0	8.9	10.0	9.1	10.3	11.8	11.6	11.4	8.8	77	74	75	79	7.7	7.7	7.0	6.5				
5.0	8.8	9.0	8.9		11.5	11.0	11.2		77	74	75		7.6	7.5	6.9					
6.0	8.6	8.2	8.8		11.3	10.1	10.9		77	74	75		7.5	7.3	6.9					
7.0	8.5	8.1	8.8		11.0	9.8	10.7		75	74	75		7.4	7.2	6.9					
8.0	8.3	8.1	8.8		10.8	9.5	10.5		75	74	75		7.4	7.1	6.8					
9.0	8.1	8.1			10.4	5.7			74	76			7.3	6.7						
10.0	8.0				10.0				74				7.2							
11.0	7.8				9.7				74				7.1							
12.0	7.7				9.3				74				7.0							
13.0	7.7				9.0				73				7.0							
14.0	7.7				7.9				74				6.7							
15.0	7.6				7.8				74				6.7							

May 5, 1998

Depth (m)	Temperature (°C)				Dissolved oxygen (mg/L)				Conductivity (µS/cm)				pH				Secchi disk depth (m)			
	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2
0.2	20.6	21.2	20.7	21.2	10.3	10.5	10.7	9.0	72	71	72	72	7.4	7.5	7.4	7.1	1.1	1.1	1.0	0.6
1.0	20.4	21.1	20.7	21.0	10.2	10.5	10.7	9.1	72	71	72	72	7.4	7.5	7.4	7.1				
2.0	19.0	19.7	20.6	20.9	10.4	8.9	10.6	9.1	70	70	72	72	7.4	7.5	7.4	7.1				
3.0	18.7	19.1	20.5	20.4	9.4	7.6	10.5	7.7	69	69	71	71	7.4	7.4	7.4	7.1				
4.0	18.6	17.8	20.4	20.0	9.3	6.1	10.2	6.2	69	71	71	72	7.4	7.4	7.2	7.1				
5.0	18.4	17.1	19.8	19.6	9.2	4.7	9.1	4.5	69	72	71	76	7.3	7.3	7.1	7.0				
6.0	17.6	16.9	18.6		6.9	3.9	7.4		70	73	71		7.3	7.1	7.0					
7.0	17.1	16.6	17.6		5.7	3.6	6.2		72	74	70		7.1	6.8	6.9					
8.0	16.9	16.2	17.2		5.0	1.8	5.5		74	77	72		6.9	6.7	6.9					
9.0	16.5		16.8		4.8		4.0		75		73		6.9		6.9					
10.0	16.2		16.3		4.7		3.6		75		76		6.8		6.9					
11.0	15.0				4.6				75				6.8							
12.0	13.6				4.0				76				6.8							
13.0	12.9				3.6				77				6.7							
14.0	12.2				2.2				83				6.5							
15.0	12.1				2.1				83				6.4							
16.0	11.9				1.9				86				6.4							
17.0	11.8				1.8				91				6.3							

Appendix 1 (continued)

July 8, 1998

Depth (m)	Temperature (°C)				Dissolved oxygen (mg/L)				Conductivity (µS/cm)				pH				Secchi disk depth (m)			
	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2
0.2	29.4	29.6	28.7	29.0	8.0	8.0	8.8	8.3	87	86	85	83	7.2	7.3	7.4	7.3	1.6	1.4	1.8	1.8
1.0	29.4	29.6	28.7	29.0	7.9	8.0	8.6	8.1	87	86	85	83	7.2	7.3	7.5	7.3				
2.0	28.5	29.2	28.7	28.9	6.6	7.2	8.6	8.0	87	86	85	83	7.2	7.3	7.5	7.3				
3.0	27.1	28.4	28.7	27.7	2.8	4.7	8.5	3.3	88	86	85	89	7.1	7.1	7.5	6.9				
4.0	23.2	27.5	28.2	27.2	0.9	1.4	6.8	2.4	103	86	85	93	6.3	6.8	7.4	6.7				
5.0	22.1	24.3	25.8		0.8	1.0	1.3		105	98	91		6.2	6.2	7.1					
6.0	21.3	20.8	22.5		0.8	0.9	1.3		106	103	100		6.2	6.2	7.0					
7.0	20.6	20.1	20.5		0.8	0.9	1.2		108	105	99		6.2	6.1	6.2					
8.0	19.4	19.6	19.4		0.8	0.8	1.1		101	110	103		6.1	6.0	6.2					
9.0	18.8				0.8				98				6.1							
10.0	18.2				0.8				97				6.0							
11.0	17.5				0.8				99				6.0							
12.0	15.9				0.8				109				6.0							
13.0	15.1				0.8				120				6.0							
14.0	14.8				0.8				124				6.0							

November 6, 1998

Depth (m)	Temperature (°C)				Dissolved oxygen (mg/L)				Conductivity (µS/cm)				pH				Secchi disk depth (m)			
	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2	E2	H2	P2	S2
0.2	17.0	16.5	16.4	14.4	7.0	7.3	7.4	9.2	74	72	70	66	6.9	6.9	6.8	6.5	1.2	1.4	1.1	1.4
1.0	17.0	16.5	16.4	14.4	6.9	7.2	7.3	9.0	74	72	70	66	6.9	6.9	6.9	6.4				
2.0	17.0	16.4	16.4	14.3	6.8	7.1	7.2	9.0	74	72	70	66	6.9	6.9	6.8	6.4				
3.0	17.0	16.4	16.4	14.3	6.8	7.1	7.1	8.8	74	72	70	66	6.9	6.9	6.8	6.4				
4.0	16.9	16.4	16.4		6.7	7.0	7.0		74	72	70		6.9	6.9	6.8					
5.0	16.9	16.3	16.4		6.7	7.0	7.0		74	72	70		6.8	6.8	6.8					
6.0	16.9	16.2	16.4		6.6	6.9	6.9		74	72	70		6.8	6.8	6.8					
7.0	16.9	16.2	16.3		6.5	6.7	6.9		74	72	70		6.8	6.8	6.8					
8.0	16.9	16.2	16.3		6.5	6.6	6.8		74	72	70		6.8	6.8	6.8					
9.0	16.9	16.2			6.5	6.6			74	72			6.8	6.7						
10.0	16.9				6.5				74				6.8							
11.0	16.9				6.5				74				6.8							
12.0	16.9				6.5				74				6.7							
13.0	16.8				6.5				74				6.7							
14.0	16.8				6.5				74				6.7							
15.0	16.8				6.5				74				6.7							
16.0	16.8				6.5				76				6.7							

Appendix 2. Means, ranges, and spatial trends of selected limnological variables from the surface waters of Harris Reservoir during 1998.[1]

Variable[2]	Station			
	E2	H2	P2	S2
Solids (mg/liter)				
Total	66 (30-90)	65 (50-88)	60 (48-74)	79 (44-148)
Total dissolved	66 (56-77)	63 (58-69)	66 (52-76)	80 (54-127)
Total suspended	< 6 NA	4.1 (< 3-10)	< 6 NA	7.9 (< 3-24)
Turbidity (NTU)	3.1 (2.5-4.0)	4.8 (3.2-7.4)	3.4 (2.0-4.0)	12 (2.8-33)
Secchi disk transparency (m)	1.3 (1.1-1.6)	1.3 (1.0-1.4)	1.4 (1.0-1.8)	1.1 (0.4-1.8)
Chlorophyll *a* (µg/liter)	27.8 (7.8-48.5)	36.8 (16.5-86.8)	20.5 (6.0-36.5)	13.6 (3.0-30.2)
Nutrients (mg/liter)				
Ammonia-N	< 0.1 NA	< 0.1 NA	< 0.1 NA	< 0.1 (< 0.1-01)
Nitrate + Nitrite-N	< 0.05 (< 0.05-0.05)	< 0.05 NA	< 0.05 NA	0.09 (< 0.05-0.33)
Total nitrogen (TN)	0.59 (0.50-0.62)	0.58 (< 0.5-0.87)	0.45 (< 0.05-0.69)	0.63 (0.43-1.1)
Total phosphorus (TP)	0.037 (0.031-0.048)	0.036 (0.028-0.044)	0.030 (0.025-0.036)	0.033 (0.016 -0.053)
TN:TP[3]	16 (13-20)	NA	NA	21 (13-33)
Total organic carbon (mg/liter)	6.9 (6.0-7.3)	7.2 (6.6-7.7)	7.3 (6.3-7.9)	7.5 (7.1-8.2)
Ions (mg/liter)				
Calcium	9.2 (3.8-25)	4.0 (3.5-4.6)	3.8 (3.4-4.7)	4.3 (3.6-4.8)
Chloride	8.8 (6.2-10)	7.7 (5.5-10)	9.0 (6.0-10)	8.8 (6.0-10)
Magnesium	1.4 (<1.0-1.8)	1.7 (1.5-1.9)	1.6 (1.4-1.9)	1.8 (1.5-2.0)
Sodium	10.2 (8.3-13)	9.8 (8.5-12)	9.6 (7.5-13)	9.7 (8.6-12)
Sulfate	6.8 (4.0-12)	6.9 (4.0-<12)	7.3 (5.0-13)	7.5 (5.0-12)
Total alkalinity (mg/liter as $CaCO_3$)	13 (11-17)	13 (10-16)	13 (8-16)	12 (9.0-15)
Hardness (calculated as mg equivalents $CaCO_3$/liter)	27 (16-57)	17 (15-19)	16 (14-20)	18 (16-20)
Conductivity (µS/cm)	78 (72-87)	74 (68-86)	76 (70-85)	76 (66-83)

Appendix 2 (continued)

Variable	N.C. water quality standard	Station			
		E2	H2	P2	S2
Metals (µg/liter) Aluminum	None	< 100 NA	86 (< 50-140)	< 100 NA	153 (54-301)
Cadmium	2	< 0.5 NA	< 0.5 NA	< 0.5 NA	< 0.5 NA
Copper	75[4]	< 10 NA	< 10 NA	< 10 NA	< 10 NA
Mercury	0.012	< 0.02 NA	< 0.02 NA	< 0.02 NA	< 0.02 NA

[1]Laboratory reporting limits for total aluminum, copper, ammonia nitrogen, nitrate-nitrite and total suspended solid concentrations were changed during 1998.

[2]Fisher's protected least significant difference test was applied only if the overall F test for the treatment was significant. Sample size equaled 4 for all variables unless otherwise noted. The variable TN:TP was not subjected to statistical analyses.

[3]Variable was not subjected to statistical analyses.

[4]This value is an action level, not a water quality standard. An action level is for toxic substances which are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics, or associated waste characteristics (NCDEM 1994b).

NA = Not applicable

Appendix 3. Concentrations of chemical variables in Harris Reservoir during 1998.[1]

Station E2

Month	Alkalinity	Hardness	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na	TN	NH_3-N	$NO_3^- + NO_2^-$-N
Jan	13	57	10	12	25	< 1.0	13	0.61	< 0.07	< 0.02
May	12	19	6.2	< 12	4.5	1.8	8.8	0.50	< 0.10	< 0.05
Jul	11	16	9.0	4.0	3.8	1.5	8.3	0.62	< 0.05	0.03
Nov	17	17	10	5.0	3.9	1.8	11	0.62	0.07	0.05

Month	TP	TOC	Turbidity	TS	TDS	TSS	Al	Cd	Cu	Hg	TN:TP
Jan	0.048	6.0	4.0	90	77	< 6	< 50	< 0.5	1.9	< 0.20	12.7
May	0.034	7.1	3.4	58	56	< 3	< 100	< 0.5	< 10	< 0.20	14.7
Jul	0.035	7.2	2.5	30	64	< 3	< 50	< 0.5	3.8	< 0.20	17.7
Nov	0.031	7.3	2.5	84	67	< 3	75	< 0.5	2.5	< 0.20	20.0

Station H2

Month	Alkalinity	Hardness	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na	TN	NH_3-N	$NO_3^- + NO_2^-$-N
Jan	13	15	6.3	11	3.5	1.5	12	0.87	< 0.07	< 0.02
May	10	19	5.5	< 12	4.6	1.9	8.5	< 0.50	< 0.10	< 0.05
Jul	12	17	10	4.0	4.2	1.5	9.0	0.61	< 0.05	0.04
Nov	16	17	9.0	6.0	3.8	1.8	10	0.60	0.08	< 0.02

Month	TP	TOC	Turbidity	TS	TDS	TSS	Al	Cd	Cu	Hg	TN:TP
Jan	0.044	6.6	7.4	88	67	10	140	< 0.5	1.5	< 0.20	19.8
May	0.040	7.2	4.7	54	58	4	110	< 0.5	< 10	< 0.20	NA
Jul	0.031	7.7	3.2	50	58	< 3	< 50	< 0.5	7.4	< 0.20	19.7
Nov	0.028	7.4	4.0	69	69	< 3	69	< 0.5	1.7	< 0.20	21.4

Station P2

Month	Alkalinity	Hardness	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na	TN	NH_3-N	$NO_3^- + NO_2^-$-N
Jan	15	16	10	13	3.6	1.6	13	0.57	< 0.07	0.05
May	8.0	20	6.0	< 12	4.7	1.9	8.8	< 0.05	< 0.10	< 0.05
Jul	12	14	10	5.0	3.4	1.4	7.5	0.52	< 0.05	0.04
Nov	16	16	10	5.0	3.5	1.7	9.4	0.69	0.08	0.03

Month	TP	TOC	Turbidity	TS	TDS	TSS	Al	Cd	Cu	Hg	TN:TP
Jan	0.031	6.3	3.7	74	76	< 6	53	< 0.5	1.9	< 0.20	18.3
May	0.036	7.7	4.0	56	68	3	< 100	< 0.5	< 10	< 0.20	NA
Jul	0.026	7.9	2.0	48	52	< 3	< 50	< 0.5	4.7	< 0.20	20.0
Nov	0.025	7.1	4.0	63	68	< 3	71	< 0.5	1.5	< 0.20	27.6

Appendix 3 (continued)

Station S2

Month	Alkalinity	Hardness	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na	TN	NH_3-N	$NO_3^-+NO_2^-$-N
Jan	14	19	10	12	4.6	1.8	12	1.05	0.10	0.33
May	9.0	20	6.0	< 12	4.8	2.0	8.7	0.51	< 0.10	< 0.05
Jul	11	16	10	5.0	4.1	1.5	8.6	0.43	< 0.05	< 0.02
Nov	15	16	9.0	7.0	3.6	1.8	9.4	0.52	< 0.05	< 0.02

Month	TP	TOC	Turbidity	TS	TDS	TSS	Al	Cd	Cu	Hg	TN:TP
Jan	0.053	7.1	33	148	127	24	301	< 0.5	1.5	< 0.20	19.8
May	0.039	8.2	8.4	62	72	5	160	< 0.5	< 10	< 0.20	13.1
Jul	0.023	7.5	2.8	44	54	< 3	54	< 0.5	6.0	< 0.20	18.7
Nov	0.016	7.1	3.8	63	68	< 3	98	< 0.5	1.5	< 0.20	32.5

Station E2 (bottom)

Month	Alkalinity	Hardness	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na	TN	NH_3-N	$NO_3^-+NO_2^-$-N
Jan	14	16	10	14	3.7	1.6	13	0.99	0.12	0.40
May	21	23	6.3	< 12	5.5	2.3	9.9	1.00	0.37	0.06
Jul	35	22	11	5.0	5.6	2.0	9.5	2.04	1.26	0.06
Nov	16	18	9.0	4.0	4.0	1.9	10	0.65	0.12	0.05

Month	TP	TOC	Turbidity	TS	TDS	TSS	Al	Cd	Cu	Hg	TN:TP
Jan	0.056	6.7	6.6	87	62	6	54	< 0.5	2.0	< 0.20	17.7
May	0.200	9.0	34	90	78	9	440	< 0.5	< 10	< 0.20	5.0
Jul	0.301	11	8.0	78	84	7	54	< 0.5	4.6	< 0.20	6.8
Nov	0.032	7.3	3.1	72	71	< 3	72	< 0.5	3.3	0.30	20.3

(1) Units are in mg/L except for trace metals and metalloids (μg/L), turbidity (NTU), total alkalinity (mg/L as $CaCO_3$), and hardness (calculated as mg equivalents $CaCO_3$/L). Laboratory reporting limits for total aluminum, copper, ammonia nitrogen, nitrate-nitrite and total suspended solid concentrations were changed during 1998.

NA = Not Available

Appendix 4. Temporal trends of selected limnological variables from the surface waters of Harris Reservoir at Stations E2, H2, P2 and S2, 1994-1998.[1]

Variable	Year				
	1994	1995	1996	1997	1998
Solids (mg/liter)					
Total	69[b]	74[b]	89[a]	54[c]	68[b]
Total dissolved	65[abc]	62[bc]	78[a]	54[c]	69[ab]
Total suspended	3.2	2.8	4.4	3.7	4.0
Turbidity (NTU)	3.4	2.6	4.7	5.7	5.8
Secchi disk transparency (m)	1.5[b]	2.0[a]	1.6[b]	1.3[b]	1.2[b]
Chlorophyll *a* (µg/liter)	14.5[b]	12.4[b]	12.3[b]	23.8[a]	24.7[a]
Nutrients (mg/liter)					
Ammonia-N	0.04	0.03	0.05	0.03	0.05
Nitrate + nitrite-N	0.05	0.03	0.03	0.05	0.04
Total nitrogen	0.69	0.66	0.86	0.74	0.56
Total phosphorus	0.032	0.033	0.032	0.035	0.034
TN:TP[2]	25	22	27	22	20
Total organic carbon (mg/liter)	6.1[b]	7.1[a]	6.5[b]	7.2[a]	7.2[a]
Ions (mg/liter)					
Calcium	3.6	4.0	3.9	3.7	5.3
Chloride	9.3[a]	9.9[a]	9.8[a]	6.3[b]	8.6[a]
Magnesium	1.8[ab]	1.9[a]	1.7[b]	1.7[b]	1.6[b]
Sodium	11[a]	12[a]	9.2[b]	8.9[b]	9.8[b]
Sulfate	14[a]	14[a]	13[ab]	13[b]	7.1[c]
Total alkalinity (mg/liter as $CaCO_3$)	13[b]	15[a]	13[b]	12[b]	13[b]
Hardness (mg equivalents $CaCO_3$/liter)	16	18	17	16	20
Conductivity (µS/cm)	92[a]	96[a]	79[b]	81[b]	76[b]
Metals (µg/liter)					
Aluminum	74	38	58	76	83
Cadmium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Copper	1.3[b]	1.1[b]	2.0[b]	1.5[b]	3.5[a]
Mercury	< 0.05	0.1	0.1	0.1	0.1

[1] Fisher's protected least significant difference test was applied only if the overall F test for the treatment was significant. Means followed by the same superscript were not significantly different ($P > 0.05$). Data were rounded to conform to significant digit requirements. The mean separation technique may yield separations which are obscured by data rounding.

[2] Variable was not subjected to statistical analyses.

Appendix 5. **Temporal trends of selected limnological variables from the bottom waters of Harris Reservoir at Station E2, 1994-1998.**[1]

Variable	Year				
	1994	1995	1996	1997	1998
Solids (mg/liter)					
Total	81[b]	85[b]	113[a]	71[b]	82[b]
Total dissolved	75	77	87	78	74
Total suspended	6	4	4	6	6
Turbidity (NTU)	6.6	4.9	4.0	7.2	13
Nutrients (mg/liter)					
Ammonia-N	0.27	0.26	0.09	0.70	0.47
Nitrate + nitrite-N	0.08	0.06	0.19	0.07	0.14
Total nitrogen	1.1	0.9	1.3	1.3	1.2
Total phosphorus	0.10	0.10	0.15	0.11	0.15
TN:TP[2]	17	12	12	14	14
Total organic carbon (mg/liter)	6.8	7.2	7.4	7.8	8.5
Ions (mg/liter)					
Calcium	4.1	4.6	4.6	4.5	4.7
Chloride	10	12	9.7	6.8	9.1
Magnesium	2.0	2.1	2.0	1.9	2.0
Sodium	12	13	10	10	11
Sulfate	15[ab]	16[a]	14[ab]	11[bc]	7.1[c]
Total alkalinity (mg/liter as $CaCO_3$)	19	20	25	26	21
Hardness (mg equivalents $CaCO_3$/liter)	18	20	20	19	20
Metals (µg/liter)					
Aluminum	80	53	42	56	155
Copper	2.3	2.3	2.2	1.9	3.7
Cadmium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Mercury	< 0.05	0.1	0.1	0.1	0.2

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

[2]Variable was not subjected to statistical analyses.

Appendix 6. **Phytoplankton class densities (units/ml) by station from Harris Reservoir during 1998[1].**

Station/Class	Month[2]			
	Jan	May	Jul	Nov
Station E2			**26,016**	
Bacillariophyceae			1,634	
Chlorophyceae			7,667	
Chrysophyceae			629	
Cryptophyceae			4,775	
Myxophyceae			8,044	
Station H2		**62,458**		
Bacillariophyceae		7,164		
Chlorophyceae		5,153		
Chrysophyceae		2,514		
Cryptophyceae		4,524		
Myxophyceae		41,595		

[1]Summation of monthly densities may not equal the monthly mean total phytoplankton density at a station for a given month because minor classes (Xanthophyceae, Euglenophyceae, and Dinophyceae) have been excluded from the table.

[2]Monthly mean total phytoplankton density determined only for months when chlorophyll *a* concentrations equaled or exceeded the North Carolina water quality standard of 40 µg/l.

Appendix 7. Phytoplankton taxa identified from Harris Reservoir during 1998.

Class Taxon
Bacillariophyceae
Melosira distans
Synedra spp.
S. filiformis
Asterionella formosa[1]
Xanthophyceae
Chlorochromonas spp.
Centritractus belanophorus
Chrysophyceae
Mallomonas spp.
Chrysochromulina spp.
Chlorophyceae
Chlamydomonas spp.
Coelasrrum sphaericum
Chlorella spp.
Oocystis borgei
Ankistrodesmus falcatus[1]
A. convolutus[1]
A. braunii
Selenastrum minutum
Kirchneriella obesa
Tetraedron minimum
T. regulare
Scenedesmus acuminatus
Crucigenia irregularis
Staurastrum tetracerum
Dinophyceae
Peridinium pusillum[1]
Cryptophyceae
Chroomonas caudata
C. minuta
Cryptomonas erosa[1]
Myxophyceae
Chroococcus limneticus
C. minutus
Gloeocapsa spp.
Aphanocapsa spp.
Microcystis spp.[1]
Dactylococcopsis spp.
Gomphosphaeria wichurae[1]
Oscillatoria spp.[1]
Lyngbya limnetica
Anabaena spp.

[1]Taxa comprising > 5% during at least one month at one or more sampling stations during 1998.

Appendix 8. **Mean density (clams/m²) and range of Asiatic clams collected from the Harris Nuclear Plant emergency service water system (e.g., intake structures and the fire protection system), 1994-1998.**

Location	Mean density of live clams[1]				
	1994	**1995**	**1996**	**1997**	**1998**[2]
Main reservoir					
Intake canal	7 (0-14)	14 (0-14)	NS	NS	NS
Service water system	25 (0-86)	371 (0-948)	97 (0-388)	0	0
Cooling water makeup	22 (0-86)	280 (0-1121)	11 (0-43)	22 (0-86)	0
Auxiliary reservoir					
Intake canal	22 (0-86)	75 (0-201)	NS	NS	NS
Service water system	7 (0-29)	43 (0-216)	431 (129-2026)	452 (43-1591)	57 (0-172)
Fire protection system	0	0	0	0	0

[1]Density estimates were calculated by multiplying the number of live clams collected by the expansion factor of 43.1.

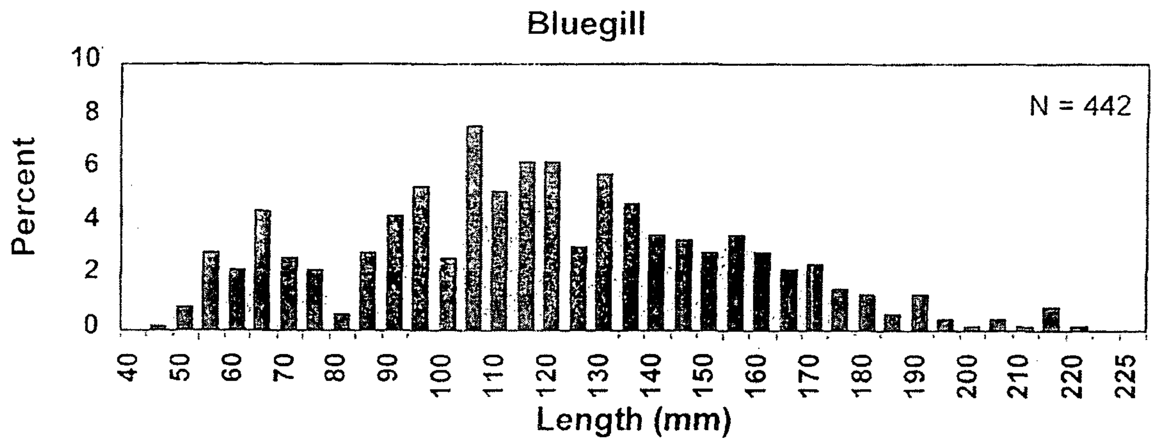
[2]Clam density estimates based upon May 1998 sampling. Intake structures were inspected by HNP personnel for the presence of Asiatic clams during fall 1998. Results of the fall 1998 inspection not included in above data summary.

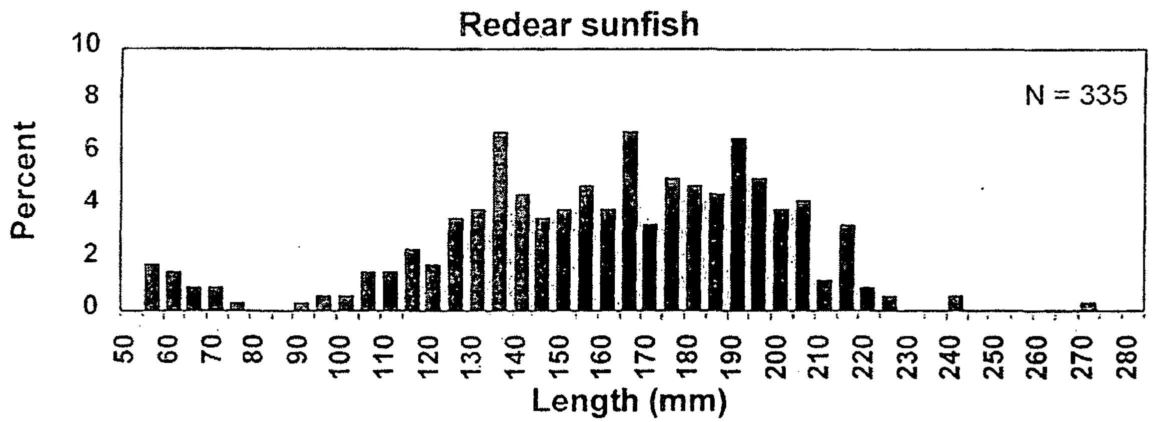
NS = Not sampled

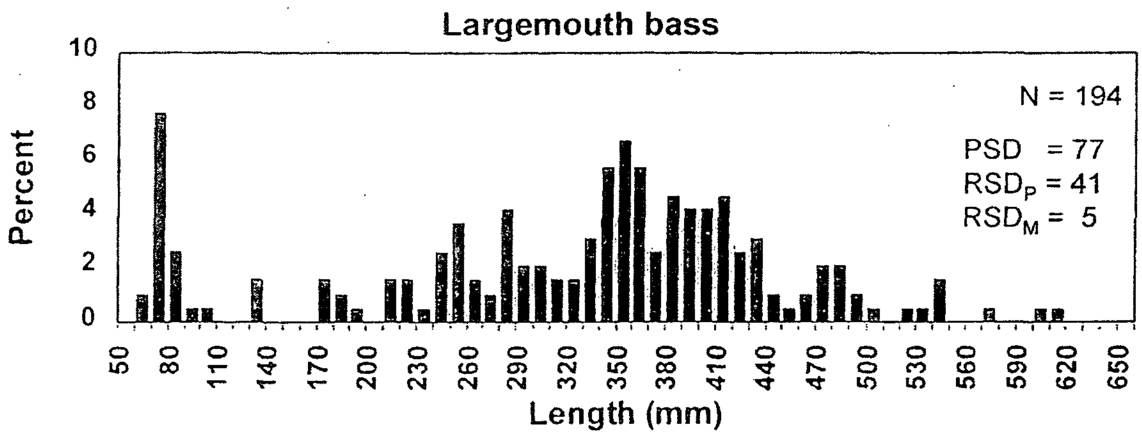
Appendix 9. **Mean number per hour for fish collected with electrofishing sampling by transect from Harris Reservoir during 1998.**

Taxon	Transect					Reservoir mean
	E	H	P	S	V	
Gizzard shad	5	9	14	13	20	12
Threadfin shad	0	0	23	3	633	132
Chain pickerel	1	2	0	2	1	1
Golden shiner	15	5	31	4	10	13
Unidentified shiner	0	14	0	1	7	4
Comely shiner	0	0	1	0	0	< 1
Snail bullhead	4	0	0	0	0	1
White catfish	0	0	0	0	1	< 1
Brown bullhead	0	1	1	0	11	3
Flat bullhead	0	1	0	0	4	1
Channel catfish	0	1	1	0	0	< 1
Bluespotted sunfish	0	0	0	0	7	1
Redbreast sunfish	4	2	0	0	0	1
Warmouth	1	1	0	0	6	2
Bluegill	38	114	76	38	176	88
Redear sunfish	74	172	20	22	47	67
Largemouth bass	35	26	41	34	58	39
Black crappie	23	3	0	3	4	7
Total[1]	**200**	**351**	**208**	**120**	**985**	**373**

[1]Summations may vary from column totals due to rounding.

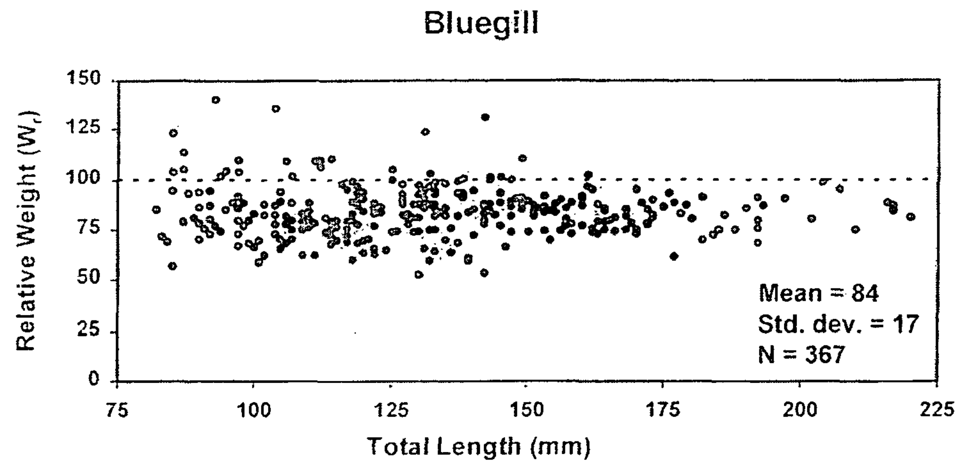


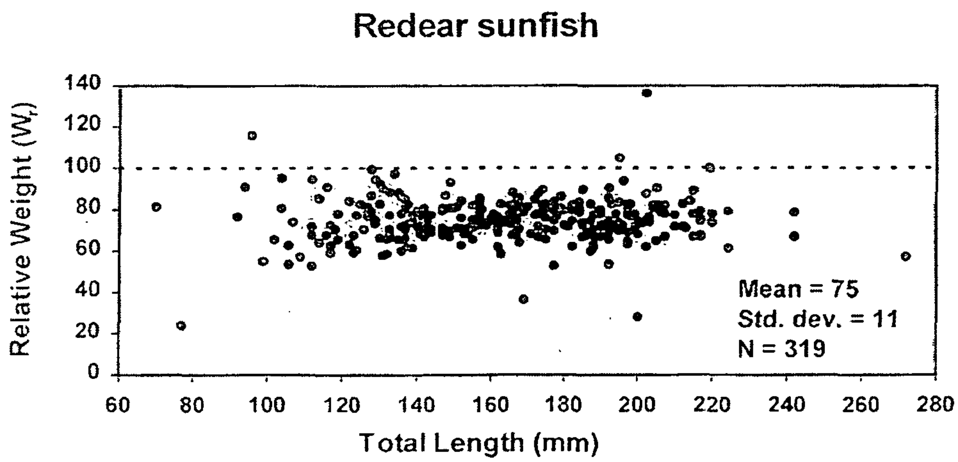


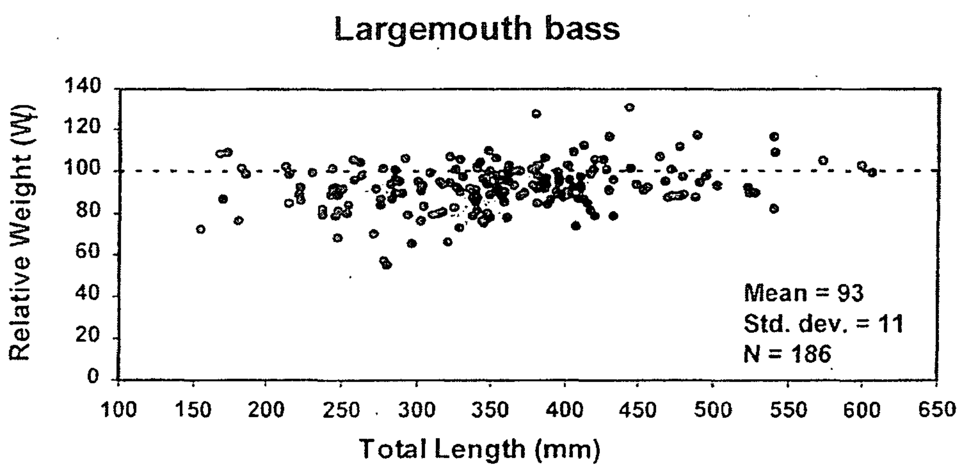


Note: PSD = Porportional stock density, RSD_P = Relative stock density preferred length, RSD_M = Relative stock density memorable length

Appendix 10. **Length-frequency distributions for bluegill, redear sunfish, and largemouth bass collected with electrofishing sampling from Harris Reservoir during 1998.**







Appendix 11. **Relative weight values for bluegill, redear sunfish, and largemouth bass collected with electrofishing sampling from Harris Reservoir during 1998.**