HARRIS NUCLEAR PLANT
2008 ENVIRONMENTAL MONITORING REPORT

March 2009

Environmental Health and Safety Services

Progress Energy Carolinas, Inc.
Raleigh, North Carolina

Preface

This copy of the report is not a controlled document as detailed in the Biology Program Quality Assurance Manual. Any changes made to the original of this report subsequent to the date of issuance can be obtained from:

Director
Environmental Health and Safety Services
Progress Energy Carolinas, Inc.
410 South Wilmington Street
Raleigh, North Carolina 27601-1551

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Appendices (continued)

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
SO_4^{2-} - Sulfate
Ca^{2+} - Total calcium
Mg^{2+} - Total magnesium
Na^+ - Total sodium
TN - Total nitrogen
NH_3-N - Ammonia-nitrogen

NO_3^- + NO_2^- - N - Nitrate + nitrite-nitrogen
TP - Total phosphorus
TOC - Total organic carbon
TS - Total solids
TDS - Total dissolved solids
TSS - Total suspended solids
Al - Total aluminum

Cd - Total cadmium
Cu - Total copper
Hg - Total mercury

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 waters into the reservoir near the main dam. Results of environmental monitoring during 2008 indicated no detectable adverse effects to the aquatic environment due to power plant operation.

Nutrient concentrations, including total phosphorus and total nitrogen concentrations, remained stable for the reporting period (2004-2008) and were in an acceptable range for a productive reservoir in this area. The concentrations of most chemical constituents did not exhibit any consistent statistically significant temporal changes and were in ranges that are not considered detrimental to the biological community.

Bluegill, redear sunfish, and largemouth bass dominated the fish community in Harris Reservoir during 2008. Annual catch rates for bluegill, redear sunfish, and largemouth bass were variable among years but no adverse trends in population density were evident. Length-frequency distributions indicated good reproduction with multiple size groups present for all species. The largemouth bass population remains balanced with a large percentage of larger fish present in the population.

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 2008. The attempt to control hydrilla in the auxiliary reservoir by releasing grass carp has been effective in reducing the quantity and area covered by this vegetation.

HARRIS NUCLEAR PLANT
2008 ENVIRONMENTAL MONITORING REPORT

Reservoir Description

Harris Reservoir, located in Chatham and Wake Counties, North Carolina, was created by impounding Buckhorn Creek, a tributary of the Cape Fear River (Figure 1). The main body of Harris Reservoir has a surface area of 1680 ha; the auxiliary reservoir has a surface area of 130 ha. 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 continued in many areas of the drainage basin.

Harris Reservoir was constructed to supply cooling tower makeup and auxiliary reservoir water supply 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 cooling tower. Tributaries also receive NPDES-permitted discharges from the Harris Energy and Environmental Center and from wastewater treatment plants for Apex and Holly Springs, North Carolina. The reservoir is a source of drinking water for Plant employees.

Several non-native aquatic species have become established in Harris Reservoir. The Asiatic clam, *Corbicula fluminea*, became established during 1984. Hydrilla, *Hydrilla verticillata*, was documented during 1988 and creeping water primrose, *Ludwigia uruguayensis*, was found during 1990. Both plant species have become the dominant vegetation in the littoral zone. Hydrilla was found in the auxiliary reservoir during 1993 but has been eliminated there by periodic stocking of the triploid variety of Asian grass carp. The presence of the Asiatic clam and aquatic vegetation in the main reservoir has not provided any operational challenges to the power plant.

Harris Reservoir provides significant boating and angling opportunities for the surrounding communities. The reservoir has a reputation for trophy fish with largemouth bass anglers and is subject to relatively heavy angling pressure (Jones et al. 2000). On July 1, 2002, the North Carolina Wildlife Resources Commission (NCWRC) initiated a slot limit for largemouth bass in an effort to protect this trophy fishery resource. Under these regulations, all largemouth bass that are 16-20 in. (406-508 mm) total length must be released alive by anglers.

Objectives

The primary objectives of the 2008 Harris Nuclear Plant non-radiological environmental monitoring program were to: (1) assess the reservoir's overall water quality, (2) identify any natural or power plant-induced effects on the water quality in the reservoir, (3) document the introduction and expansion of non-native plant and animal populations in the reservoir, and (4) demonstrate the existence of a reasonable recreational fishery. These objectives have also been addressed in previous annual monitoring reports with the most recent detailed in CP&L 1996, 1997, 1998, 1999, 2000 and PEC 2003, 2004, 2008.

Methods

The 2008 environmental program included monitoring the reservoir's: (1) limnological characteristics (water quality, water chemistry, and chlorophyll *a*, (2) distribution of aquatic vegetation, (3) possible presence of the zebra mussel and the quagga mussel, and (4) fisheries community (Table 1). Sampling methods, data summaries, and statistical analyses for data collected during 2008 were similar to those used for data collected during previous years with the exception of a one-year water quality/chemistry special study (CP&L 2000, PEC 2008) (Tables 2 and 3). For the special study, water quality/chemistry sampling was conducted on a monthly frequency rather than quarterly with the exception of June-September when water quality, phytoplankton, and chlorophyll a sampling was conducted twice per month. During April-November, two additional stations were sampled in the reservoir. Station M2 was located mid-way between Stations P2 and E2. Station T2 was located at the mouth of the Little White Oak Creek arm of the reservoir where it intersects the main body of the reservoir upstream of Station P2. Long-term limnological data for the most recent five years (2004-2008) was analyzed using data collected from the surface at Stations E2, H2, P2, and S2 only.

Electrofishing data were collected biannually from 2000 to 2008. Several indices besides catch-rate (number per hour) were used to assess the fish population. The relative weight (Wr) was calculated for selected species to provide an indication of the relative health of selected gamefish populations. Relative weight (W_r) is defined where W_o is the observed weight of each fish and W_s is the length-specific standard weight predicted by a weight-length regression equation constructed to represent the species as a whole ($W_r = W_o / W_s * 100$). Relative weight (Anderson and Neumann 1996) was calculated for bluegill (Hillman 1982), redear sunfish (Pope et al. 1995), and largemouth bass (Wege and Anderson 1978). Values approaching 100 are considered optimal. Length-frequency histograms provided an indication of successful reproduction and recruitment for these species. Three stock assessment indices based on length were used as indicators of a balanced largemouth bass population (Gablehouse 1984). These indices include: (1) Proportional Stock Density (PSD), the percentage of all fish ≥ 300 mm; (2) Relative Stock Density for preferred length (RSD_P), the percentage of all fish ≥ 380 mm; and (3) Relative Stock Density for memorable length (RSD_M), the percentage of all fish ≥ 510 mm. Ranges for acceptable values are reported with the results.

Supporting data summaries and appropriate statistical analyses were used to describe and interpret the environmental quality of the reservoir (Table 3). Where statistically significant results were reported, a Type I error rate of 5% (% = 0.05) was used and Fisher's protected least significant difference test was applied to determine where significant differences in mean values occurred. Statistically different results were evaluated based upon the presence or absence of large-scale trends or differences in magnitude of the reported mean values. In some cases statistical differences were detected for datasets exhibiting low variability but the difference in the means were so small as to have no biological importance.

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 the N. C. Division of Water Quality's Laboratory Certification Program to perform water and wastewater testing. The University of Missouri at Columbia, a vendor approved by PEC for this testing, conducted total phosphorus analysis. The accuracy and precision of laboratory analyses of water chemistry data were determined with analytical standards, spikes, and replicates. Quality assurance information including the accuracy and percent recovery of water chemistry standards is available upon request. In this report where concentrations were less than the laboratory-reporting limit, the concentrations were assumed to be at one-half the reporting limit for the calculation of the mean.

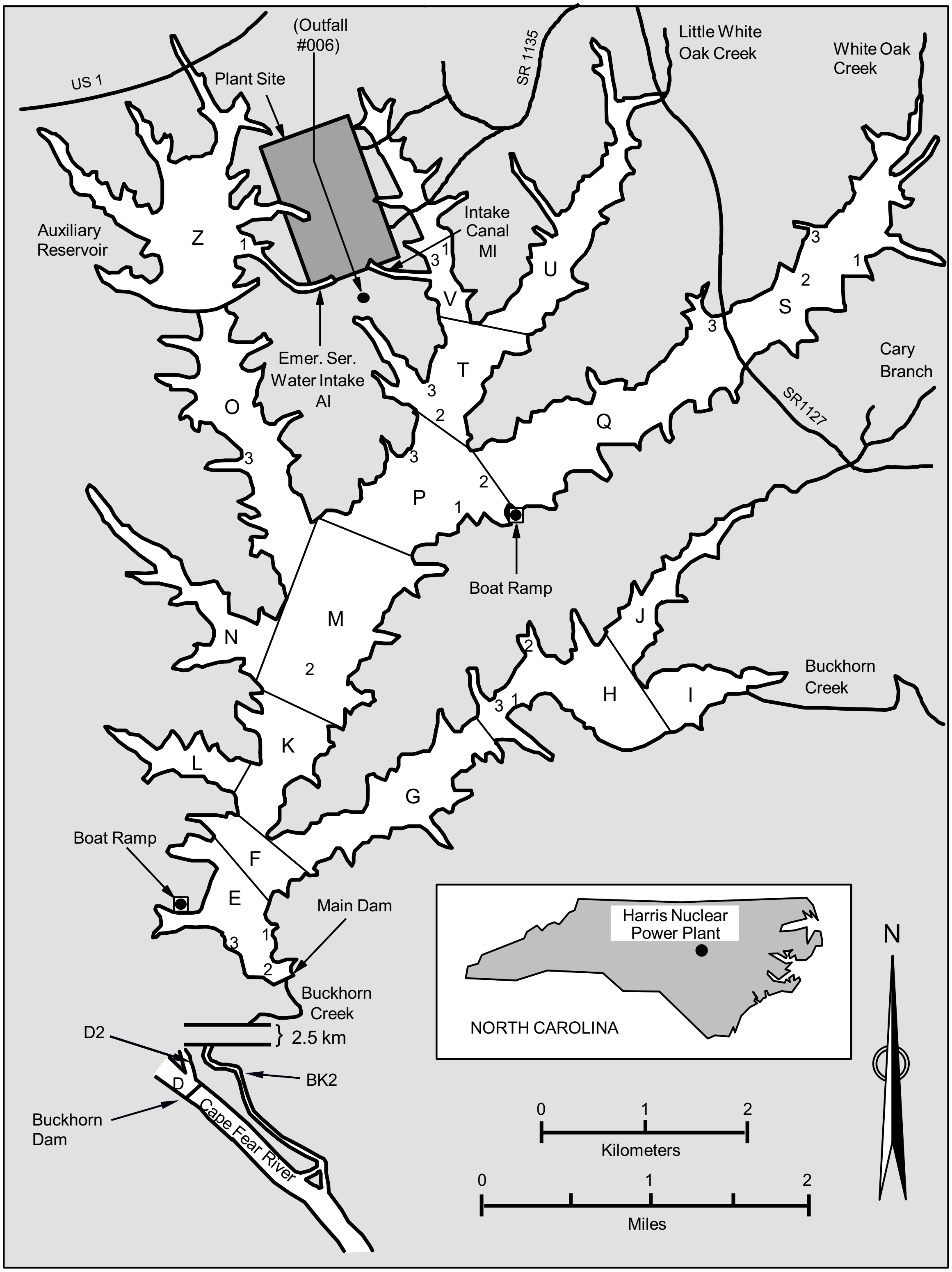


Figure 1. Sampling areas and stations at Harris Reservoir during 2008.

Table 1. Environmental monitoring program conducted at Harris Reservoir for 2008.

Program	Frequency	Location
Water quality	January-December (monthly) except for June-September (twice per month)	Stations E2, H2, P2, and S2 (surface to bottom at 1-m intervals)
	April-November	Added Stations M2 and T2 (surface to bottom at 1-m intervals)
Water chemistry	January-December (monthly)	Same as water quality
Plankton^{+}	Same as water quality	Same as water quality
Biofouling monitoring		
Zebra mussel surveys	Same as water quality	Same as water quality
Fisheries		
Electrofishing	February, May, August, November	Stations E1, E3, H1, H3, P1, P3, S1, S3, V1, and V3
Aquatic vegetation survey	Once per calendar year (Fall)	Areas MI and Z

$^{+}$Plankton included phytoplankton (algae) and chlorophyll *a* samples. Phytoplankton samples were collected and preserved but were not identified because all sampled chlorophyll *a* concentrations were < 40 µg/L, the North Carolina water quality standard.

Table 2. Field sampling and laboratory methods followed in the 2008 environmental monitoring program at Harris Reservoir.

Program	Method
Water quality	Temperature, dissolved oxygen, pH, and specific conductance were measured with calibrated YSI® multiparameter instruments and YSI® dissolved oxygen meters. Measurements were taken from surface to bottom at 1-m intervals. Water clarity was measured with a Secchi disk.
Water chemistry	Surface and bottom samples were collected in appropriate containers, preserved as needed, transported to the laboratory on ice, and analyzed according to USEPA (1979) and APHA (1995).
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 sub sample was taken and preserved with 5 ml of "M3" fixative.
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 sub sample was collected in a dark bottle. All samples were placed on ice and returned to the laboratory. In the laboratory a 250-ml sub sample was analyzed according to Strickland and Parsons (1972) and APHA (1995).
Electrofishing	Fifteen-minute samples were collected at each station using a Smith-Root Type 7.5 GPP 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.
Zebra mussel	The dock at the Holleman's boat ramp, or water quality station marker buoys were visually inspected for the presence of mussels during routine water quality monitoring.
Aquatic vegetation survey	Portions of the shoreline and/or littoral zone of the Harris Plant main reservoir 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 2008 environmental monitoring program at Harris Reservoir.

Program	Variable	Transfor-mation	Statistical Test/model+	Main effect(s)
Water quality	Specific conductance and Secchi disk transparency	None	One-way, block on month	Station
	Specific conductance and Secchi disk transparency	None	Two-way, block on month	Station, year
Water chemistry	Selected monitoring variables	None	One-way, block on month	Station
	Selected monitoring variables	None	Two-way, block on month	Station, year
Phytoplankton	Chlorophyll *a*	None	One-way, block on month	Station
	Chlorophyll *a*	None	Two-way, block on month	Station, year
Fisheries	No. fish per hour	ln(x + 1)	One-way, block on month	Transect

+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.

RESULTS OF ENVIRONMENTAL MONITORING AT HARRIS RESERVOIR DURING 2008

Lake Level

- The annual daily mean lake level has been less than full-pool since 2005 as a result of persistent drought conditions during those years (Appendix 1). Annual winter-time mean daily lake levels were the lowest on record since 2000 during both 2006 and 2008. Fluctuating and/or declining lake levels can potentially affect water chemistry, the distribution and abundance of aquatic vegetation, and fisheries production.

Limnology

Temperature and Dissolved Oxygen

- Mean surface water temperature was lowest during January at all locations sampled during 2008 (Appendix 2). The warmest surface water temperatures occurred during August. Temperature profiles of the stations traditionally sampled (Stations S2, P2, E2, and H2) indicated that Harris Reservoir waters (except Station S2) were strongly stratified at 4-5 m deep during June, July, and August (Appendix 3). Harris Reservoir waters were either well mixed or very weakly stratified during the remainder of the year. Fall turnover occurred sometime during September. Results are consistent with previous years in that Harris Reservoir typically stratifies at 4-5 m deep.

- Mean dissolved oxygen of the surface waters ranged from 7.4 to 11.8 mg/L (Appendix 2). At no time were anoxic conditions detected in the surface waters of Harris Reservoir during 2008. During June, July, and August, however, portions of the hypolimnion were anoxic (i.e., conditions where dissolved oxygen concentrations are less than 1 mg/L) at Stations E2, H2, and P2 (Appendix 4). Station S2, which is comparatively shallow, also exhibited a decrease in oxygenation near the bottom during April, July, and August but otherwise was well mixed and oxygenated for the remainder of the year. A bottom-water oxygen decline is typical at the deeper stations 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 (Secchi disk transparency, Solids, and Turbidity)

- The mean secchi disk transparency depth (a water clarity indicator) was generally less at the headwater region (Station S2) compared to all other stations during 2008 (Appendix 5). This pattern was statiscally significant when the additional special study stations were included in the analysis of data from April through November (Appendix 6.) There was no significant change noted in the reservoir-wide annual mean Secchi disk transparency values during the period 2004 to 2008 (Appendix 7).

- Annual mean turbidity values varied inversely with secchi disk transparency depth and were significantly greater at Station S2 compared to all other stations during 2008 (Appendices 5 and 6). Higher turbidity and lower secchi disk transparency depth values at this station are not unusual. Station S2 is relatively shallow and subject to re-suspension of sediments by wind. This effect may have been compounded by lower lake level during 2008 resulting in relatively more exposed, less vegetated shoreline. No significant difference was detected in the annual mean turbidity values from 2004-2008 (Appendix 7).

- There were no significant spatial trends for total dissolved solids in the surface waters during 2008 (Appendices 5 and 6). Annual mean total dissolved solids concentrations were greater in the bottom waters at Station E2 and S2 compared to Stations H2 and P2 (Appendix 8). However the magnitude of the differences was not biologically significant or indicative of adverse effects from power plant operation. A significant difference was detected in the annual reservoir-wide mean concentration of total dissolved solids (Appendix 7). However, no adverse trend was evident.

Chlorophyll *a*

- During 2008, no chlorophyll *a* concentrations exceeded the North Carolina water quality standard of 40 µg/L (NCDEM 1992). However, mean chlorophyll *a* concentrations (an indicator of algal biomass) in Harris Reservoir continued to be indicative of moderate biological productivity. There were no significant spatial differences in chlorophyll *a* concentrations during 2008 indicating consistent productivity throughout the reservoir (Appendices 5 and 6). While statistically significant fluctuations in annual mean chlorophyll *a* concentrations were observed from 2004 through 2008, no adverse trends were indicated (Appendix 7).

Nutrients and Total Organic Carbon (surface waters)

- Significant spatial differences among stations were detected for total phosphorus, nitrate + nitrite-N, total nitrogen, and total organic carbon concentrations during 2008 (Appendix 5). Significant spatial differences in nutrient concentrations were detected only for total phosphorous and total organic carbon for the special study data collected from April through November (Appendix 6). Nutrient and total organic carbon concentrations were greater in the upper reservoir at Station S2. This pattern is consistent with the naturally occurring higher productivity of the headwaters of most lakes and reservoirs in the southeast. There was no significant difference in the nutrient concentrations of the special study stations (Stations M2 and T2) compared to the downstream stations routinely sampled (Stations E2, H2, and P2).

- The surface concentrations for nitrate + nitrite-N, total phosphorous, and total organic carbon were statistically different across the 5-year study period (Appendix 7). However, no adverse trends were evident and the magnitude of the differences were relatively small. The slight increase in the concentrations of total phosphorus and total organic carbon may have been related to the relatively low lake levels and retention time over the latter 4 years.

Specific Conductance, Ions, and Hardness (surface waters)

- During 2008, a statistical difference in the calcium and magnesium mean concentrations was detected among Stations E2, H2, P2, and S2 (Appendix 5). This also held true for total phosphorous and total alkalinity among all stations analyzed from April through November (Appendix 6). However, the difference in the values for these parameters was relatively small and there were no biologically meaningful spatial differences in conductivity, ion concentration, or hardness during 2008 (Appendices 5 and 6).

- Statistical differences were detected for the mean annual calcium, chloride, magnesium, and sulfate concentrations across years from 2004 to 2008 (Appendix 7). However, these values represented relatively small changes of no biological importance and may have been related to the declining lake levels and increased retention time since 2004.

- The annual reservoir mean conductivity was similar among years during the period 2004-2008 (Appendix 7). Although statistical differences were detected for hardness among years, the magnitude of the differences was relatively small.

pH and Total Alkalinity

- The median pH in the surface waters of Harris Reservoir ranged between 7.6 and 7.9 during 2008 (Appendices 5 and 6). No excessively high pH values (> 9.1) were recorded during 2008.

- In 2008 the total alkalinity concentrations were statistically different among stations only for the special study data set collected from April through June (Appendices 5 and 6). The annual mean total alkalinity concentration in the surface waters was statistically different among years but the magnitude of the differences was relatively small and no adverse trend was evident (Appendix 7).

Trace Metals –Copper (surface waters)

- The mean annual concentrations of copper in surface waters was not significantly different among stations during 2008 or among years from 2004 to 2008 (Appendices 5, 6, and 7).

Chemical Constituents from the Bottom Waters at Stations E2, H2, P2, S2

- The concentrations of most chemical constituents in the bottom waters of the deepest station (Station E2) near the dam and Harris Plant blowdown pipe were within typical ranges expected for a productive, southeastern reservoir and were not considered detrimental to the biological community (Appendix 8).

- Statistical variation among stations for the bottom waters of Harris Reservoir was evident for several variables (Appendix 8). In all cases, except for manganese, the magnitude of the differences were relatively small. The concentrations of most variables were greater in the bottom waters compared to the surface waters. However, the spatial pattern across the lake paralleled that of the surface waters. Higher nitrate-nitrite-N and turbidity values were greater at Station S2 due to its location in the more productive headwaters and shallow depth. The much greater magnitude of manganese concentrations in the bottom at Station E2 is typical in Harris Reservoir each year and is related to natural lake stratification. Anoxic conditions in the hypolimnion release manganese from the sediments. Since this generally occurs in the deepest part of the lake and in anoxic waters, it was not considered to be biologically detrimental to the aquatic community. Much of the re-suspended manganese is rapidly assimilated by phytoplankton during fall turnover and the remainder precipitates out as manganese oxide. A similar process occurs for iron and is important with respect to natural spatial and temporal cycling of micronutrients such as iron and manganese (Goldman and Horne 1983).

Biofouling Monitoring Surveys

- No zebra mussels, *Dreissena polymorpha*, or quagga mussels, D. *bugensi*s, potentially serious biofouling organisms to power plant operations, were observed in Harris Reservoir or the auxiliary reservoir during 2008. Zebra mussels and quagga mussels are not expected to thrive in Harris Reservoir because concentrations of alkalinity, calcium, total hardness, and pH are sub optimal for mussel growth and reproduction (Claudi and Mackie 1993).

Fisheries

- Twenty fish species were collected with quarterly electrofishing sampling during 2008 (Appendix 9). In addition, three genera not identified to species were collected. These included unidentified shiner, *Notropis* spp., unidentified killifish, *Fundulus* spp., and hybrid sunfish, *Lepomis* spp. Unidentified killifish were first collected during 2006 when two individuals were collected from Transect P. Three individuals were collected during 2008. These individuals most closely resembled banded killifish, *Fundulus diaphanus*. However, meristics counts overlapped with other species. Specimens preserved in alcohol have been transferred to Dr. Wayne Starnes with the North Carolina Museum of Natural Science for positive identification.

- Bluegill, threadfin shad, redear sunfish, and largemouth bass, comprised approximately 90% of the mean number per hour collected (Appendix 10). This has historically been the case for the fish species composition collected with electrofishing sampling (CP&L 2001, PEC 2008). The mean annual electrofishing catch rates for the dominant recreational species (bluegill, redear sunfish, and largemouth bass) were relatively consistent from 2000 to 2008 (Appendices 10 and 11). The catch rates for black crappie are typically more variable due to the pelagic nature of this species. Similarly, the mean annual catch rates for the dominant forage species were also variable due to the pelagic nature of these species which makes them less vulnerable to the electrofishing gear.

- Statistical differences in the mean catch rate among transects were observed for bluegill, redear sunfish, and total catch during 2008 (Appendix 12). Significantly more redear sunfish were collected from Transects E and H (lower reservoir) compared to Transects P, S, and V. This pattern was also true for the combined 2000-2008 database. Although significant differences in the catch rates for bluegill occurred among stations with both the 2008 and long-term databases, there was no consistent pattern. Generally, bluegill was collected throughout Harris Reservoir. A similar result was evident for the distribution of largemouth bass, golden shiner, and total fish for the 2000 to 2008 database.

- Significant differences in the mean annual catch rates among years were detected for threadfin shad, golden shiner, bluegill, redear sunfish, and total fish (Appendix 12). However, no consistent pattern or adverse trends were evident.

- The length-frequency distribution for bluegill indicated strong recruitment and no missing year classes at all locations sampled during 2008 (Appendix 13). Additionally, there were adequate numbers of older, larger fish to support a recreational fishery. Long-term data indicate similar results for reproduction and recruitment from 2000-2008 (Appendix 14).

- Similar to previous years, the length-frequency distributions for redear sunfish indicated the presence of older, larger fish in the population capable of supporting a viable redear sunfish fishery in Harris Reservoir (Appendices 15 and 16). Consistent length distributions were evident for all years since 2000.

- The length-frequency distributions of largemouth bass indicated good reproduction and recruitment with no missing year classes among transects during 2008 and among years from 2000-2008 (Appendices 17 and 18). The values for Proportional Stock Density (PSD) and Relative Stock Density preferred length (RSD_p) were consistent with objectives for a large bass management strategy (Gablehouse 1984; Willis et al. 1993). The management objective for the largemouth bass population is for the reservoir to contain a large number of big bass equating to a PSD in the range of 50 to 80 and an RSD_p in the range from 30 to 60.

Also, the relative stock density memorable length index has been in the range of values indicative of a balanced (0-10) or large bass management strategy (10-25) since 2000.

- The annual mean relative weight values for bluegill and redear sunfish were 88 and 82, respectively, during 2008 (Appendix 19). The annual mean relative weight values for bluegill ranged from 82 to 88 since 2000 (Appendix 20). For redear sunfish the annual mean relative weight has ranged from 77 to 83 during the same time period. Although less than optimal, the relative weight values were consistent with relatively high population densities for these two species. The annual mean relative weight for largemouth bass was 100 during 2008 and has ranged from 94 to 101 since 2000 indicating healthy, robust body condition (Appendices 19 and 20).

- No disease outbreaks in fish were noted in Harris Reservoir during 2008 and the abundance of hybrid sunfish was relatively low at all locations indicating no significant environmental stress for the resident fish populations.

Aquatic Vegetation

- A visual survey revealed no stands of hydrilla , *Hydrilla verticillata*, a non-native submersed plant, reaching the surface of the water of the intake canal in Harris Reservoir during 2008. Little aquatic vegetation was present near the intake area (Transect V) compared to previous years. Some creeping water primrose and hydrilla were present in isolated patches. Reduction in the biomass of both species was likely related to drought conditions and low water level experienced since 2005.

- During November 2008 hydrilla stands extending to the water surface were observed in the littoral zone at Transect S. Hydrilla dominated the aquatic plant community at Transects P, E, and H. Creeping water primrose was present although reduced in areal coverage compared to previous years as a result of drought conditions since 2005. Small amounts of *Eleocharis* sp. and *Utricularia* sp. were observed lake-wide.

- No hydrilla was observed in the auxiliary reservoir during 2008. Other plant species such as *Eleochris* spp. and creeping water primrose were noted along most shorelines, predominantly in the back of coves. Both plants pose little or no threat to plant operations. The continued presence of grass carp (*Ctenopharyngodon idella*) from previous stockings has provided adequate control of potential nuisance overgrowth stands in the auxiliary reservoir.

CONCLUSIONS

During 2008, 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 during 2008 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 had 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 1995 and at levels acceptable for southeastern, productive reservoirs. Assessments of other water quality parameters, including solids, turbidity, total organic carbon, ions (calcium, chloride, magnesium, sodium, and sulfate), total alkalinity, hardness, and metals, indicate few if any consistent statistically significant spatial or temporal trends with none of these variables at concentrations that would be detrimental to the aquatic community.

No nuisance algal blooms, as indicated by chlorophyll *a* concentrations, or exotic mussels were detected in the main reservoir during 2008. Reservoir-wide chlorophyll *a* concentrations demonstrated no consistent statistically significant temporal trend for the period 2004-2008.

Based on surveys conducted during 2008, no stands of the aquatic plant hydrilla extending to the surface of the water were observed in the littoral zone of the intake canal of the main reservoir. The abundance of aquatic vegetation in the littoral zone was somewhat less than previous years due to drought conditions experienced since 2005. 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 continued to control the amount and area coverage of hydrilla during 2008. No operational impacts have occurred at the Harris Nuclear Plant because of aquatic vegetation biofouling.

Bluegill, redear sunfish, and largemouth continued to dominate the fishery in Harris Reservoir during 2008. Results indicate the presence of a balanced largemouth bass population exhibiting strong reproduction and the presence of a large percentage of older, larger fish. Abundant forage species such as shad and other sunfish have resulted in very healthy, robust body condition for largemouth bass.

REFERENCES

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* B. R. Murphy and D. W. Willis (eds.). Fisheries Techniques. Second edition. American Fisheries Society, Bethesda, MD.

APHA. 1995. Standard methods for the examination of water and wastewater. 19th ed. American Public Health Association, Washington, DC.

CP&L. 1996. Shearon Harris Nuclear Power Plant 1995 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

CP&L. 1997. Shearon Harris Nuclear Power Plant 1996 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

CP&L. 1998. Shearon Harris Nuclear Power Plant 1997 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

CP&L. 1999. Shearon Harris Nuclear Power Plant 1998 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

CP&L. 2000. Shearon Harris Nuclear Power Plant 1999 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

PEC. 2003. Harris Nuclear Plant 2002 annual environmental monitoring report. Progress Energy Carolinas, New Hill, NC.

PEC. 2004. Harris Nuclear Plant 2003 annual environmental monitoring report. Progress Energy Carolinas, New Hill, NC.

PEC. 2008. Harris Nuclear Plant 2006 annual environmental monitoring report. Progress Energy Carolinas, Inc., New Hill, NC.

Claudi, R., and G. L. Mackie. 1993. Practical manual for zebra mussel monitoring and control. Lewis Publishers, Boca Raton, FL.

Gablehouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. N. A. J. Fish. Mange. 4:273-285.

Goldman C. R., and A. J. Horne. 1983. Limnology. McGraw-Hill, Inc. Columbus, OH. 464 pp.

Hillman, W. P. 1982. Structure and dynamics of unique bluegill populations. Master's thesis. University of Missouri, Columbia, MO.

Jones, W. T., W. J. Collart, D. Hinshaw, and S. V. Horn. 2000. Piedmont fisheries investigations final report. Harris lake Creel Survey, 1997-1998. Division of Inland Fisheries, North Carolina Wildlife Resources Commission, Raleigh, NC.

NCDEM. 1992. North Carolina lake assessment report. Report No. 92-02. Water Quality Section, Division of Environmental Management, North Carolina Department of Environment, Health, and Natural Resources, Raleigh, NC.

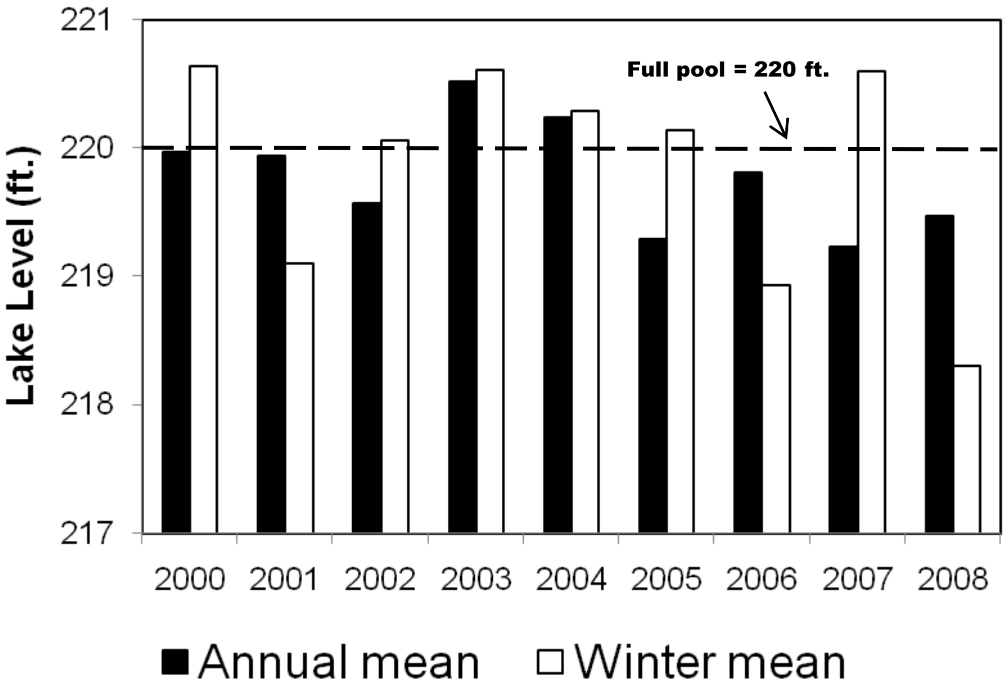
Nelson, J.S., E.J. Crossman, H. Espinsoa-Pérez, L T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, Maryland.

Pope, K. L, M. L. Brown, and D. W. Willis. 1995. Proposed revision of the standard weight (W_s) equation for redear sunfish. J. Freshwater Ecology. 10: 129-134.

Strickland, J. D. H., and T. R. Parsons. 1972. A practical handbook of seawater analysis. Bulletin No. 167 (2nd ed.). Fisheries Research Board of Canada.

Wege, G. J., and R. O. Anderson. 1978. Relative weight (Wr): a new index of condition for largemouth bass. Pages 79-91 *in* G. D. Novinger and J. D. Dillard, editors. New approaches to management of small impoundments. American Fisheries Society, North Central Division. Special Publication 5, Bethesda Maryland.

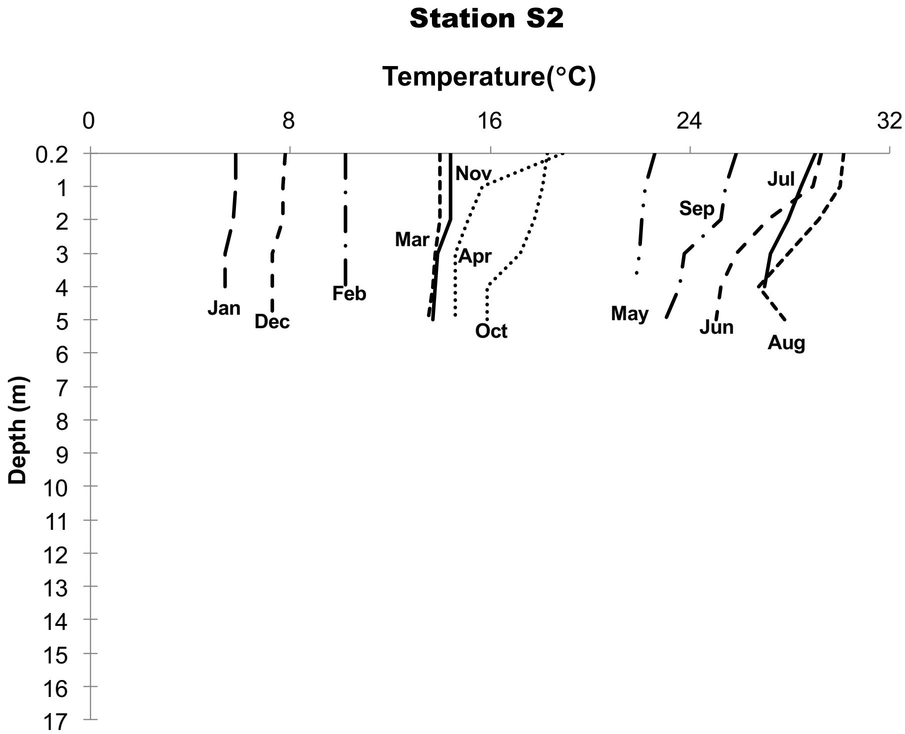
Willis, D. W., B. R. Murphy, and C. S. Guy. 1993. Stock density indices: development, use, and limitations. Reviews in Fisheries Science 1: 203-222.

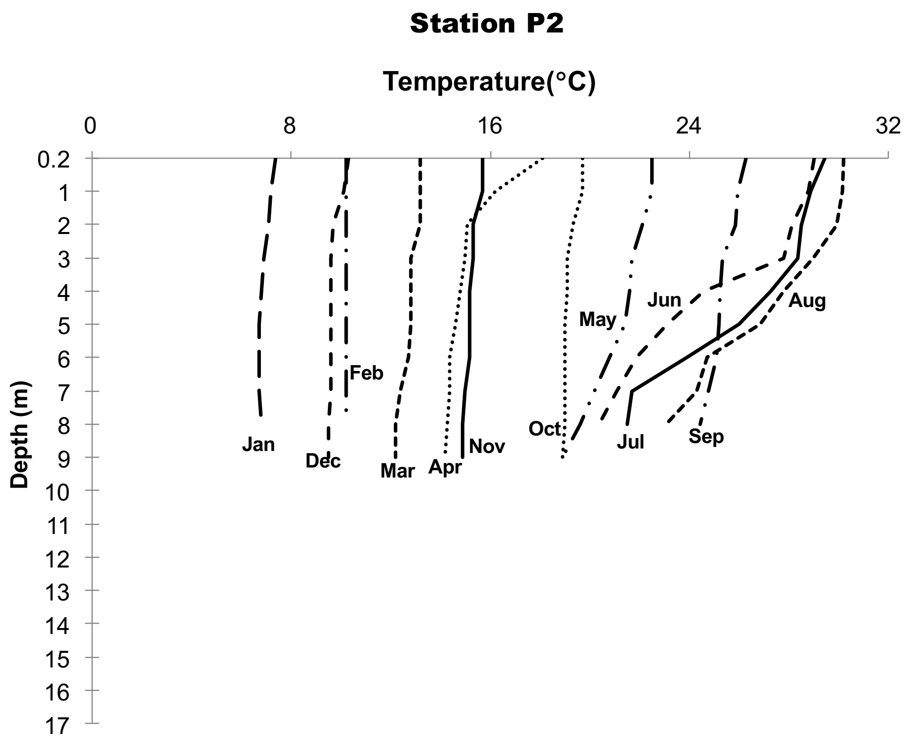


Appendix 1. Annual and winter mean daily lake level for Harris Reservoir, 2000- 2008 (Winter-time means include data from December of the preceding year through February of the year of record).

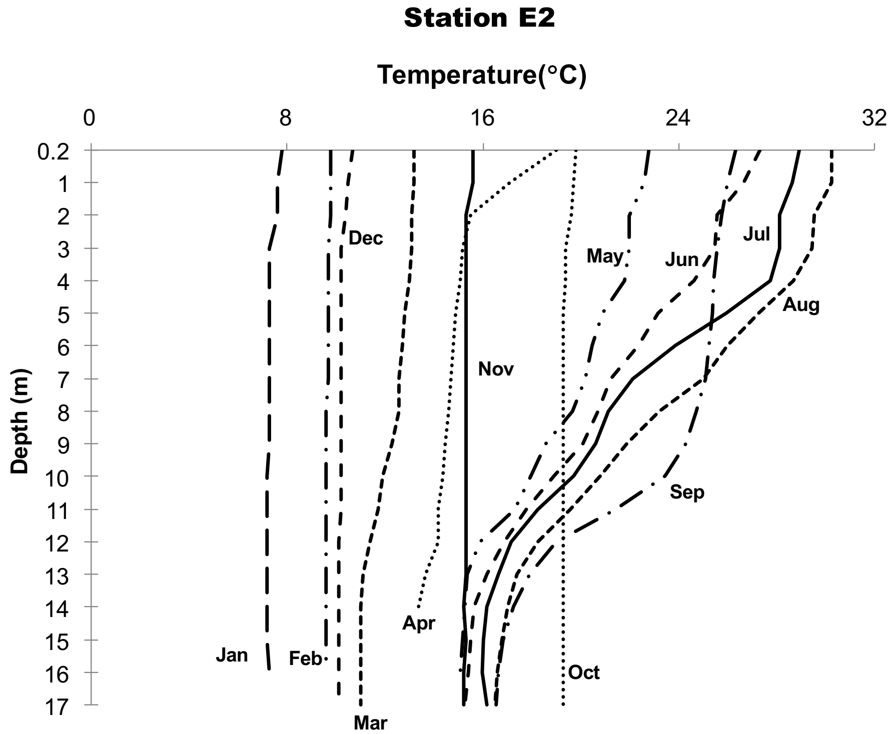
Appendix 2. Mean water temperature (°C) and dissolved oxygen (mg/L) recorded from the surface waters of Harris Reservoir during 2008.

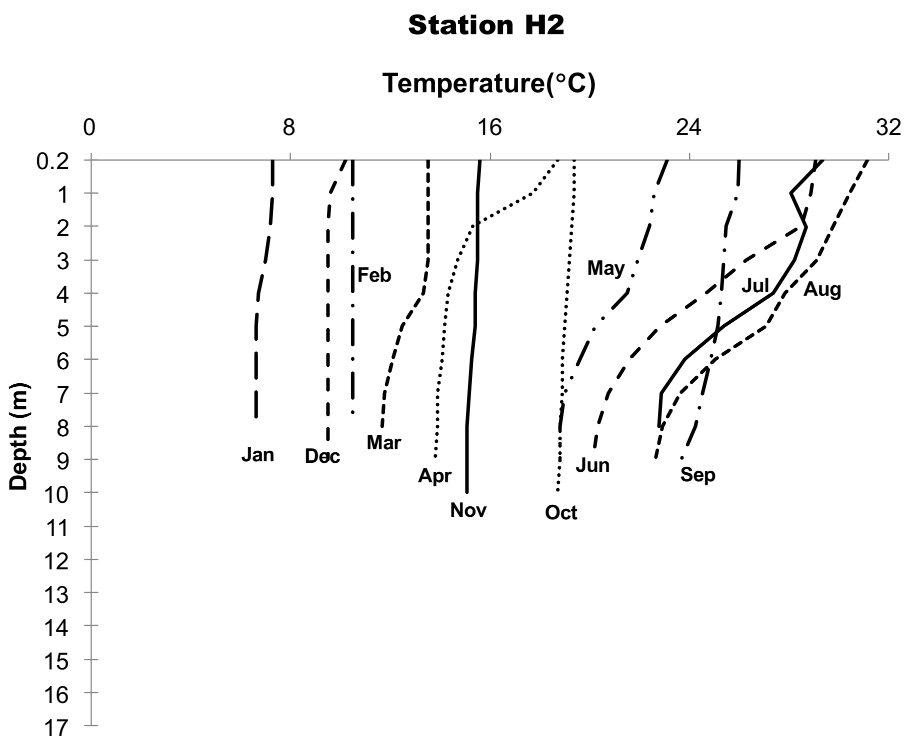
	Month											
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
						Temperature (°C)						
S2	5.8	10.2	14.0	18.9	22.6	29.3	29.0	30.2	25.9	18.3	14.7	7.8
T2				18.9	22.8	29.2	29.1	30.4	26.0	19.2	15.4	
P2	7.4	10.2	13.2	18.1	22.5	29.0	29.5	30.2	26.3	19.7	15.7	10.3
M2				20.0	22.3	28.5	29.0	30.1	26.2	19.6	15.4	
E2	7.8	9.8	13.2	19.0	22.8	27.3	29.0	30.3	26.4	19.8	15.6	10.7
H2	7.3	10.5	13.5	18.7	23.1	29.1	29.4	31.2	26.0	19.4	15.6	10.2
						Dissolved oxygen (mg/L)						
S2	10.4	8.0	8.2	10.4	8.1	9.0	7.2	8.4	8.5	9.5	10.5	10.4
T2				11.2	9.0	8.7	8.3	8.6	8.2	8.2	9.9	
P2	11.8	8.9	9.7	10.2	9.5	8.9	8.4	8.6	7.8	8.4	10.1	10.3
M2				11.2	9.5	8.0	8.6	8.7	7.9	7.2	7.8	
E2	11.1	8.6	10.6	10.8	9.8	9.6	8.6	9.0	7.9	7.0	7.4	8.3
H2	11.2	8.7	10.4	10.1	9.8	9.0	8.2	8.8	7.4	7.8	9.3	9.8



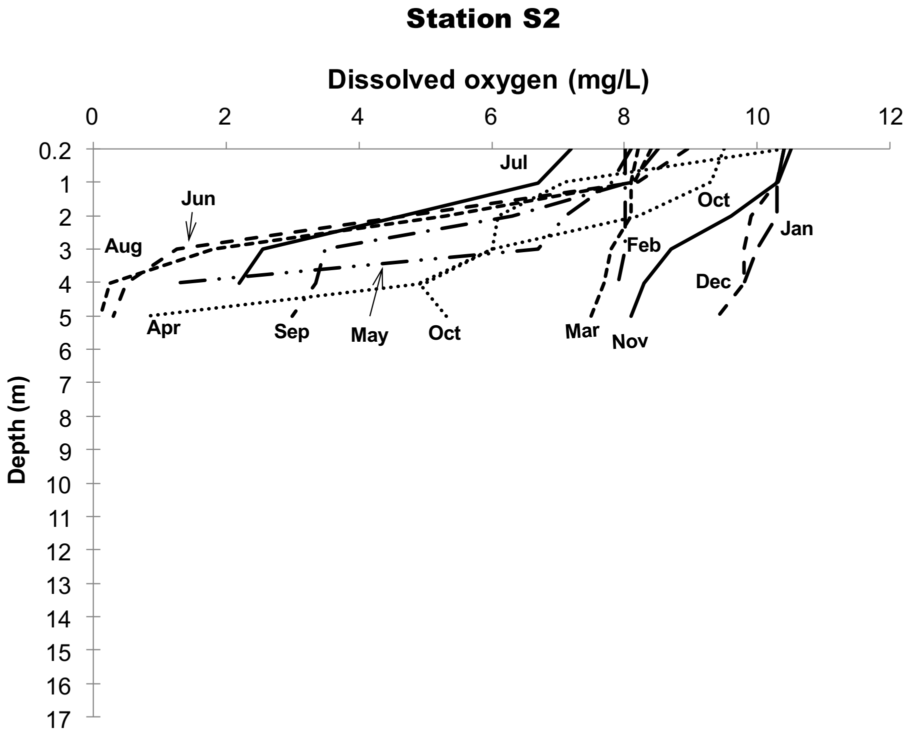


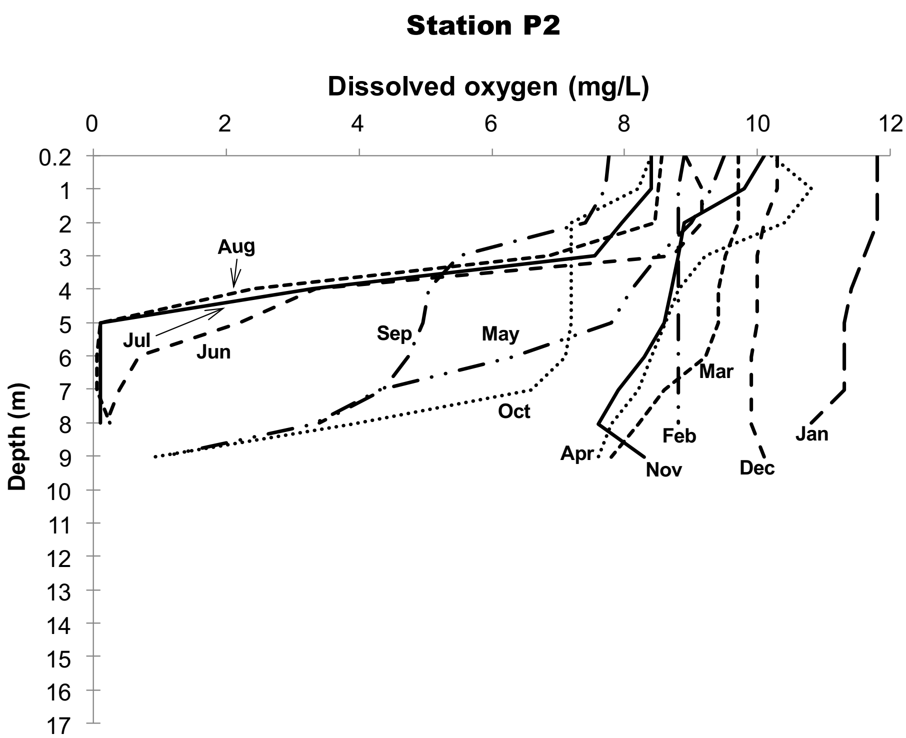
Appendix 3. Water temperature profiles recorded at Stations S2, P2, E2, and H2 in Harris Reservoir during 2008.



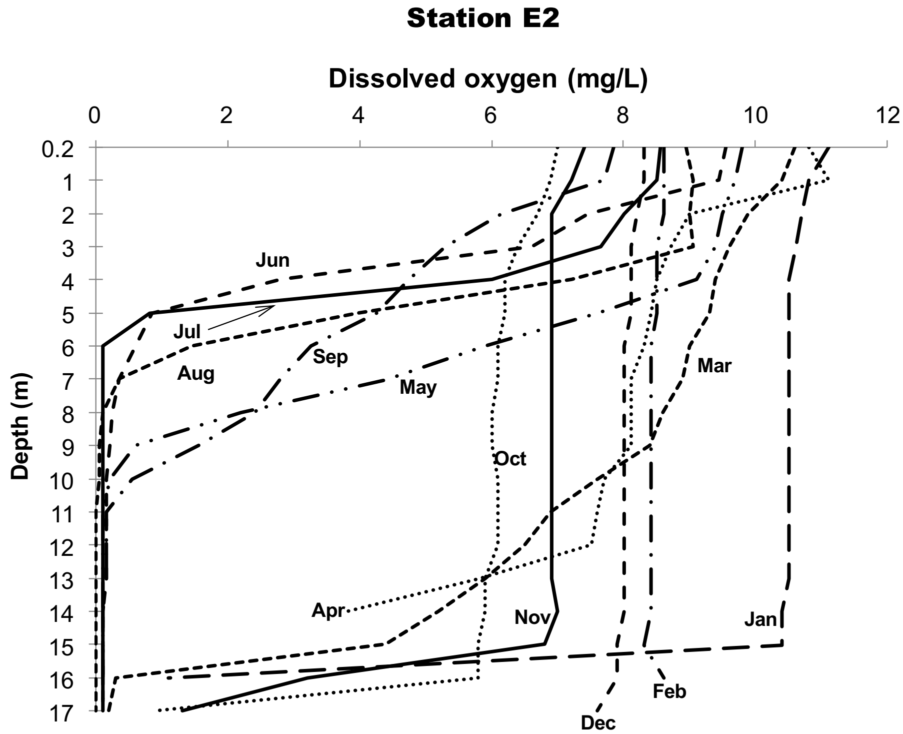


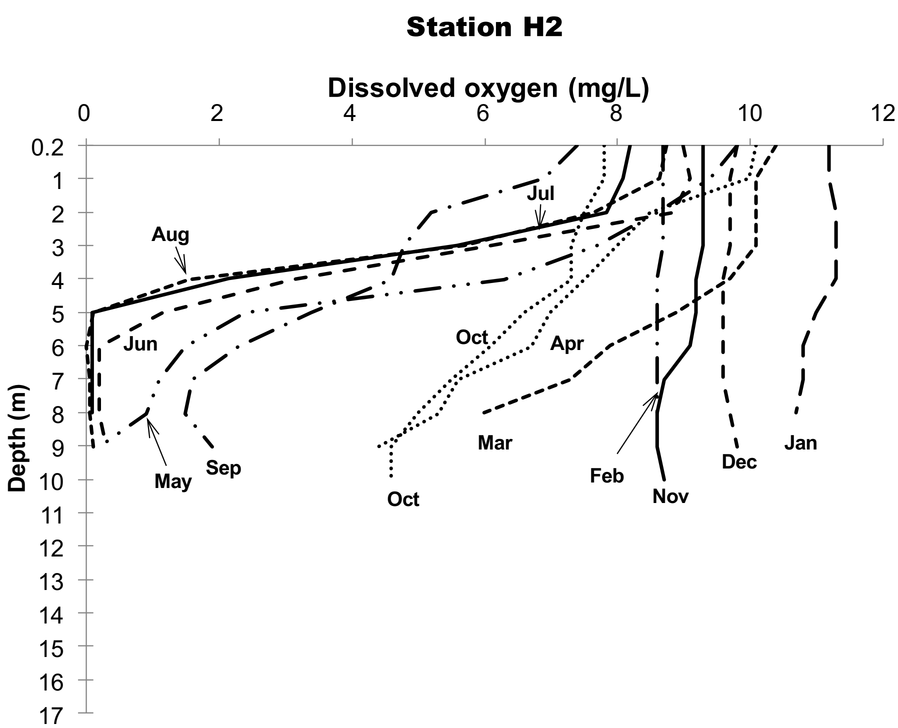
Appendix 3 (continued)





Appendix 4. Dissolved oxygen profiles recorded at Stations S2, P2, E2, and H2 in Harris Reservoir during 2008.





Appendix 4. (continued)

Appendix 5. Means, ranges, and spatial trends of selected limnological variables from the surface waters of Harris Reservoir during 2008.[+]

Variable	Station			
	E2	H2	P2	S2
Total dissolved solids (mg/liter)	92 (78-108)	86 (69-102)	87 (68-100)	91 (38-112)
Turbidity (NTU)	4.8[b] (2.3-8.4)	5.4[b] (2.6-10)	4.3[b] (1.6-9.3)	15[a] (5.0-40)
Secchi disk transparency (m)	1.2 (0.9-1.5)	1.2 (0.7-1.5)	1.3 (0.9-1.8)	0.9 (0.3-1.4)
Chlorophyll *a* (µg/L)	9.4 (3.3-15)	10 (3.6-15)	11 (3.9-19)	9.3 (3.3-26)
Nutrients (mg/L)				
Ammonia-N	0.07 (< 0.02-0.43)	0.08 (< 0.02-0.47)	0.04 (< 0.02-0.22)	0.04 (< 0.02-0.12)
Nitrate + Nitrite-N	0.05[b] (< 0.02-0.15)	0.03[b] (< 0.02-0.11)	0.03[b] (< 0.02-0.07)	0.10[a] (< 0.02-0.38)
Total nitrogen	0.89[b] (0.6-1.4)	0.80[b] (0.50- 1.30)	0.81[b] (0.57-1.25)	1.05[a] (0.63-1.56)
Total phosphorus	0.042[b] (0.024-0.056)	0.033[b] (0.022-0.043)	0.032[b] (0.021-0.047)	0.061[a] (0.025-0.124)
Total organic carbon (mg/L)	8.6[b] (7.9-10)	8.4[b] (7.3-9.2)	8.6[b] (7.7-9.2)	9.4[a] (8.4-11)
Ions (mg/L)				
Calcium	5.0[b] (4.2-5.9)	4.8[b] (3.7-5.8)	5.0[b] (3.8-6.1)	5.6[a] (4.2-7.1)
Chloride	20 (15-22)	19 (14-22)	19 (17-22)	19 (13-24)
Magnesium	2.0[a] (0.7-2.7)	1.9[ab] (0.8-2.6)	2.0[a] (0.6-2.6)	1.9[b] (0.8-2.6)
Manganese	87 (< 10-186)	67 (33-138)	74 (31-151)	96 (22-160)
Sodium	15 (13-17)	14 (12-16)	15 (12-17)	14 (10-18)
Sulfate	16 (12-20)	16 (10-20)	16 (9.0-20)	15 (< 5.0-20)
Total alkalinity (mg/L as $CaCO_3$)	19 (14-25)	19 (14-25)	19 (14-25)	21 (15-26)
Hardness (calculated as mg equivalents $CaCO_3$/L)	21 (15-25)	20 (16-24)	21 (12-24)	22 (18-25)
Conductivity (µS/cm)	145 (115-160)	140 (109-157)	141 (108-159)	140 (103-163)
pH[¶]	7.6 (7.1-9.1)	7.6 (7.2-9.0)	7.7 (7.3-90)	7.6 (7.1-8.9)

Appendix 5. (continued)

Variable	N.C. water quality standard	Station			
		E2	H2	P2	S2
Metals (µg/L)					
Copper	7[£]	5.4 (< 1.0-22)	5.0 (< 1.0-24)	4.7 (< 1.0-19)	2.9 (< 1.0-9.1)

[+]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 ($P > 0.05$)—see shaded row. Sample size equaled 4 for all variables unless otherwise noted. The mean separation technique may yield separations that are obscured by data rounding.

[¶]Median values are reported for pH instead of mean values.

[£]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).

Appendix 6. Means, ranges, and spatial trends of selected limnological variables from the surface waters of Harris Reservoir during April-November, 2008.[+]

Variable	Station					
	E2	**H2**	**P2**	**M2**	**T2**	**S2**
Total dissolved solids (mg/L)	93 (77-108)	89 (74-102)	91 (82-100)	97 (78-110)	97 (84-104)	89 (38-107)
Turbidity (NTU)	4.5[b] (2.3-8.4)	5.1[b] (2.9-9.4)	3.8[b] (2.2-5.6)	4.2[b] (2.4-7.8)	3.9[b] (1.2-5.7)	8.9[a] (5.0-22)
Secchi disk transparency (m)	1.2[a] (1.0-1.5)	1.3[a] (1.0-1.5)	1.3[a] (0.9-1.8)	1.3[a] (0.9-1.8)	1.2[a] (0.9-1.7)	1.0[b] (0.6-1.4)
Chlorophyll *a* (µg/L)	9.0 (5.1-14)	8.7 (5.1-13)	9.9 (4.5-16)	7.8 (3.9-12)	9.0 (6.3-11)	7.0 (3.5-12)
Nutrients (mg/liter)						
Ammonia-N	0.10 (< 0.02-0.43)	0.10 (< 0.02-0.47)	0.04 (< 0.02-0.22)	0.05 (< 0.02-0.18)	0.06 (< 0.02-0.21)	0.03 (< 0.02-0.12)
Nitrate + Nitrite-N	0.03 (< 0.02-0.10)	0.02 (< 0.02-0.04)	0.02 (< 0.02-0.05)	0.02 (< 0.02-0.08)	all values < 0.02	0.02 (< 0.02-0.10)
Total nitrogen	0.93 (0.67-1.37)	0.83 (0.54- 1.25)	0.79 (0.57-1.25)	0.90 (0.68-1.37)	0.99 (0.66-1.49)	0.96 (0.63-1.39)
Total phosphorus	0.040[a] (0.024-0.056)	0.032[b] (0.022-0.043)	0.031[b] (0.021-0.037)	0.033[b] (0.022-0.048)	0.033[b] (0.023-0.049)	0.043[a] (0.025-0.074)
Total organic carbon (mg/L)	8.8[b] (8.4-10)	8.7[b] (8.3-9.1)	8.8[b] (8.4-9.2)	8.8[b] (8.3-9.2)	8.8[b] (8.2-9.2)	9.3[a] (8.4-11)
Ions (mg/L)						
Calcium	5.0 (4.2-5.9)	4.8 (3.7-5.8)	5.2 (3.9-6.1)	5.2 (3.6-6.3)	5.1 (4.3-6.1)	5.3 (4.2-6.3)
Chloride	20 (15-22)	20 (17-21)	19 (18-22)	20 (18-21)	20 (17-22)	19 (13-21)
Magnesium	2.1[abc] (1.4-2.7)	2.0[bc] (1.4-2.6)	2.1[ab] (1.5-2.6)	2.2[a] (1.5-2.7)	2.1[ab] (1.3-2.7)	2.0[c] (1.4-2.6)
Manganese	70 (< 10-186)	70 (33-138)	81 (31-151)	92 (26-207)	79 (32-124)	84 (22-138)
Sodium	15 (13-16)	14 (12-16)	15 (13-17)	15 (14-18)	15 (13-17)	14 (10-18)
Sulfate	16 (12-20)	16 (10-20)	16 (9.0-20)	16 (9.1-21)	16 (14-20)	15 (< 5.0-20)
Total alkalinity (mg/L as $CaCO_3$)	19[b] (14-25)	20[ab] (14-25)	19[b] (14-25)	19[b] (15-25)	19[b] (15-24)	21[a] (15-26)
Hardness (calculated as mg	21 (19-25)	20 (17-24)	21 (18-24)	22 (17-25)	22 (18-24)	21 (18-25)
Conductivity (µS/cm)	147 (132-160)	144 (123-157)	145 (127-159)	146 (131-160)	144 (127-162)	143 (103-158)
pH[¶]	7.7 (7.1-9.1)	7.7 (7.2-9.0)	7.8 (7.3-9.0)	7.7 (7.1-9.1)	7.9 (7.3-9.0)	7.7 (7.3-8.9)

Appendix 6 (continued)

Variable	N.C. water quality standard	Station					
		E2	H2	P2	M2	T2	S2
Metals (µg/L)							
Copper	7[£]	3.4 (< 1.0-6.0)	2.8 (< 1.0-5.1)	4.1 (< 1.0-19)	2.3 (< 1.0-3.4)	2.3 (< 1.0-4.0)	2.0 (< 1.0-2.9)

[+]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 ($P > 0.05$)—see shaded row. Sample size equaled 4 for all variables unless otherwise noted. The mean separation technique may yield separations that are obscured by data rounding.

[¶]Median values are reported for pH instead of mean values.

[£]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).

Appendix 7. Annual mean water chemistry variables from the surface waters of Harris Reservoir 2004-2008.[+]

Variable	Year 2004	2005	2006	2007	2008
Total dissolved solids (mg/L)	62[b]	69[b]	87[a]	67[b]	89[a]
Turbidity (NTU)	3.8	4.4	4.4	5.3	7.3
Secchi disk transparency (m)	1.6	1.5	1.3	1.3	1.1
Chlorophyll *a* (µg/L)	12[ab]	13[a]	13[a]	11[ab]	9.8[b]
Nutrients (mg/L)					
Ammonia-N	< 0.02	< 0.02	<0.02	< 0.02	0.06
Nitrate + nitrite-N	0.05[c]	0.07[bc]	0.12[a]	0.10[ab]	0.05[c]
Total nitrogen	0.69	0.91	0.93	0.80	0.89
Total phosphorus	0.025[c]	0.031[bc]	0.037[ab]	0.039[ab]	0.042[a]
Total organic carbon (mg/L)	7.8[c]	7.6[c]	7.9[c]	8.3[b]	8.8[a]
Ions (mg/L)					
Calcium	3.0[c]	5.0[ab]	4.5[b]	4.2[b]	5.1[a]
Chloride	13[d]	14[d]	18[b]	16[c]	19[a]
Magnesium	1.4[b]	2.0[a]	2.1[a]	1.9[a]	1.9[a]
Manganese				90	81
Sodium	9.2	11	13	12	15
Sulfate	10[c]	13[b]	15[a]	12[bc]	16[a]
Total alkalinity (mg/L as $CaCO_3$)	13[b]	19[b]	17[b]	16[a]	20[b]
Hardness (mg equivalents $CaCO_3$/L)	12[a]	21[a]	20[ab]	18[b]	21[a]
Conductivity (µS/cm)	95	116	137	116	141
Metals (µg/L)					
Copper	1.6	2.2	2.7	2.6	4.5

[+]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 ($P > 0.05$)—see shaded rows. Data were rounded to conform to significant digit requirements. The mean separation technique may yield separations that are obscured by data rounding.

Appendix 8. Means, ranges, and spatial trends of selected limnological variables from the bottom waters of Harris Reservoir during 2008.[+]

Variable	Station			
	E2	H2	P2	S2
Total dissolved solids (mg/L)	103[a] (81-138)	90[c] (71-118)	93[bc] (66-121)	102[ab] (89-132)
Turbidity (NTU)	7.0[b] (2.8-13)	8.1[b] (2.5-20)	5.8[b] (3.9-7.6)	18[a] (4.6-43)
Nutrients (mg/L)				
Ammonia-N	0.57 (< 0.02-3.46)	0.13 (< 0.02-0.46)	0.05 (< 0.02-0.19)	0.06 (< 0.02-0.16)
Nitrate + Nitrite-N	0.05[b] (< 0.02-0.16)	0.04[b] (< 0.02-0.11)	0.03[b] (< 0.02-0.08)	0.13[a] (< 0.02-0.59)
Total nitrogen	1.69 (0.90-3.90)	0.92 (0.43-1.44)	0.85 (0.28-1.16)	1.18 (0.71-2.04)
Total phosphorus	0.230 (0.044-1.067)	0.057 (0.029-0.257)	0.050 (0.021-0.171)	0.095 (0.025-0.319)
Total organic carbon (mg/L)	9.6[a] (8.0-12)	8.7[c] (7.3-10)	8.8[bc] (7.8-9.5)	9.4[ab] (8.5-10)
Ions (mg/L)				
Calcium	5.8[ab] (4.4-9.0)	5.1[b] (4.0-6.3)	5.2[b] (3.8-7.8)	6.0[a] (3.9-8.3)
Chloride	19 (16-22)	19 (17-22)	19 (17-22)	19 (14-25)
Magnesium	2.2[a] (0.8-2.3)	2.0[b] (0.8-2.9)	2.0[b] (0.6-2.9)	1.9[b] (0.7-2.8)
Manganese	2,162[a] (118-6,750)	532[b] (56-2,910)	724[b] (52-3,240)	285[b] (30-953)
Sodium	15 (11-18)	14 (12-18)	15 (13-18)	15 (11-21)
Sulfate	16 (7.8-18)	16 (13-19)	16 (14-21)	15 (< 2.0-21)
Total alkalinity (mg/L as $CaCO_3$)	32[a] (15-70)	21[b] (14-42)	21[b] (15-40)	24[b] (14-39)
Hardness (calculated as mg equivalents $CaCO_3$/L)	24 (17-31)	21 (16-25)	21 (12-29)	23 (18-29)

Appendix 8 (continued)

Variable	N.C. water quality standard	Station			
		E2	H2	P2	S2
Metals (µg/L)					
Copper	7[£]	5.0 (1.0-25)	3.5 (< 1.0-8.5)	3.2 (< 1.0-7.7)	2.9 (< 1.0-5.9)

[+]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 ($P > 0.05$)—see shaded row. Sample size equaled 4 for all variables unless otherwise noted. The mean separation technique may yield separations that are obscured by data rounding.

[£]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).

Appendix 9. Total number and weight (kg) of fish collected from Harris Reservoir with electrofishing sampling during 2008 and taxa collected since 2000.

Scientific name[+]	Common name	2000 to 2006	Total number	Total weight
Amiidae	**Bowfins**			
Amia calva	bowfin	X	13	28.6
Clupeidae	**herrings**			
Dorosoma cepedianum	gizzard shad	X	77	21.3
D. petenense	threadfin shad	X	929	8.3
Esocidae	**pikes**			
Esox niger	chain pickerel	X	18	6.8
Cyprinidae	**minnows**			
Cyprinus carpio	common carp	X	11	58.8
Notemigonus crysoleucas	golden shiner	X	39	1.1
Notropis spp.	unidentified shiner	X	12	< 0.1
N. petersoni	coastal shiner	X	8	< 0.1
Ictaluridae	**bullhead catfishes**			
Ameiurus. catus	white catfish	X	24	19.1
A. natalis	yellow bullhead	X	1	0.4
A. nebulosus	brown bullhead	X	6	1,9
A. platycephalus[&]	flat bullhead	X	5	0.2
A. brunneus	snail bullhead	X	1	0.1
Ictalurus punctatus	channel catfish	X	6	12.5
Cyprinodontidae	**killifishes**			
Fundulus spp.	unidentified killifish	X	3	< 0.1
Percichthyidae	**temperate basses**			
Monorone americana	white perch	X	1	0.4
Poeciliidae	**livebearers**			
Gambusia holbrooki	Eastern mosquitofish	X	0	0
Centrarchidae	**sunfishes**			
Enneacanthus gloriosus	bluespotted sunfish	X	7	< 0.1
Lepomis auritus	redbreast sunfish	X	0	0
L. gulosus	warmouth	X	41	2.3
L. macrochirus	bluegill	X	1,296	41.8
L. gibbosus	pumpkinseed	X	0	0
L. microlophus	redear sunfish	X	378	38.3
Lepomis hybrid	hybrid sunfish	X	3	0.2
Micropterus salmoides	largemouth bass	X	281	134.5
Pomoxis annularis	white crappie	X	0	0
P. nigromaculatus	black crappie	X	31	2.6
Percidae				
Etheostoma fusiforme	swamp darter	X	0	0
Total organisms			**3,191**	**379.3**
Total species		**25**	**20**	

[+]Taxonomic nomenclature follows Nelson et al. (2004).

Appendix 10. Mean number per hour for fish collected with electrofishing sampling by transect from Harris Reservoir during 2008.

Taxon	Transect					Reservoir Mean
	E	H	P	S	V	
Bowfin	0	1	1	3	2	1
Gizzard shad	13	4	7	12	4	8
Threadfin shad	1	345	8	89	23	93
Common carp	0	1	0	3	3	1
Chain pickerel	0	2	1	5	3	2
Golden shiner	3	6	5	5	2	4
Shiner unidentified	1	0	2	1	3	1
Coastal shiner	0	0	0	4	1	1
White catfish	1	2	4	2	4	2
Yellow bullhead	1	0	0	0	0	< 1
Brown bullhead	1	0	2	1	1	1
Flat bullhead	0	3	0	0	0	1
Snail bullhead	1	0	0	0	0	< 1
Channel catfish	2	2	0	0	0	1
Killifish unidentified	1	1	0	0	1	< 1
White perch	0	0	0	1	0	< 1
Bluespotted sunfish	0	0	0	2	2	1
Warmouth	4	4	1	11	2	4
Bluegill	125	230	64	131	98	130
Redear sunfish	54	75	20	25	16	38
Hybrid sunfish	0	0	1	0	1	< 1
Largemouth bass	16	24	31	52	18	28
Black crappie	1	0	5	3	8	3
Total[+]	**219**	**695**	**150**	**346**	**186**	**319**

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

Appendix 11. Mean catch rates (number per hour) for the numerically dominant recreational and forage fish species collected with quarterly electrofishing sampling from Harris Reservoir, 2000-2008. [+]

	Year				
Taxon	**2000**	**2002**	**2004**	**2006**	**2008**
Gizzard shad	8	12	13	17	8
Threadfin shad	3	16	1	92	93
Golden shiner	9	13	8	3	4
Bluegill	96	117	102	152	130
Redear sunfish	67	92	44	39	38
Largemouth bass	27	29	24	28	28
Black crappie	5	21	21	22	3
Total (all species)	**241**	**322**	**244**	**369**	**319**

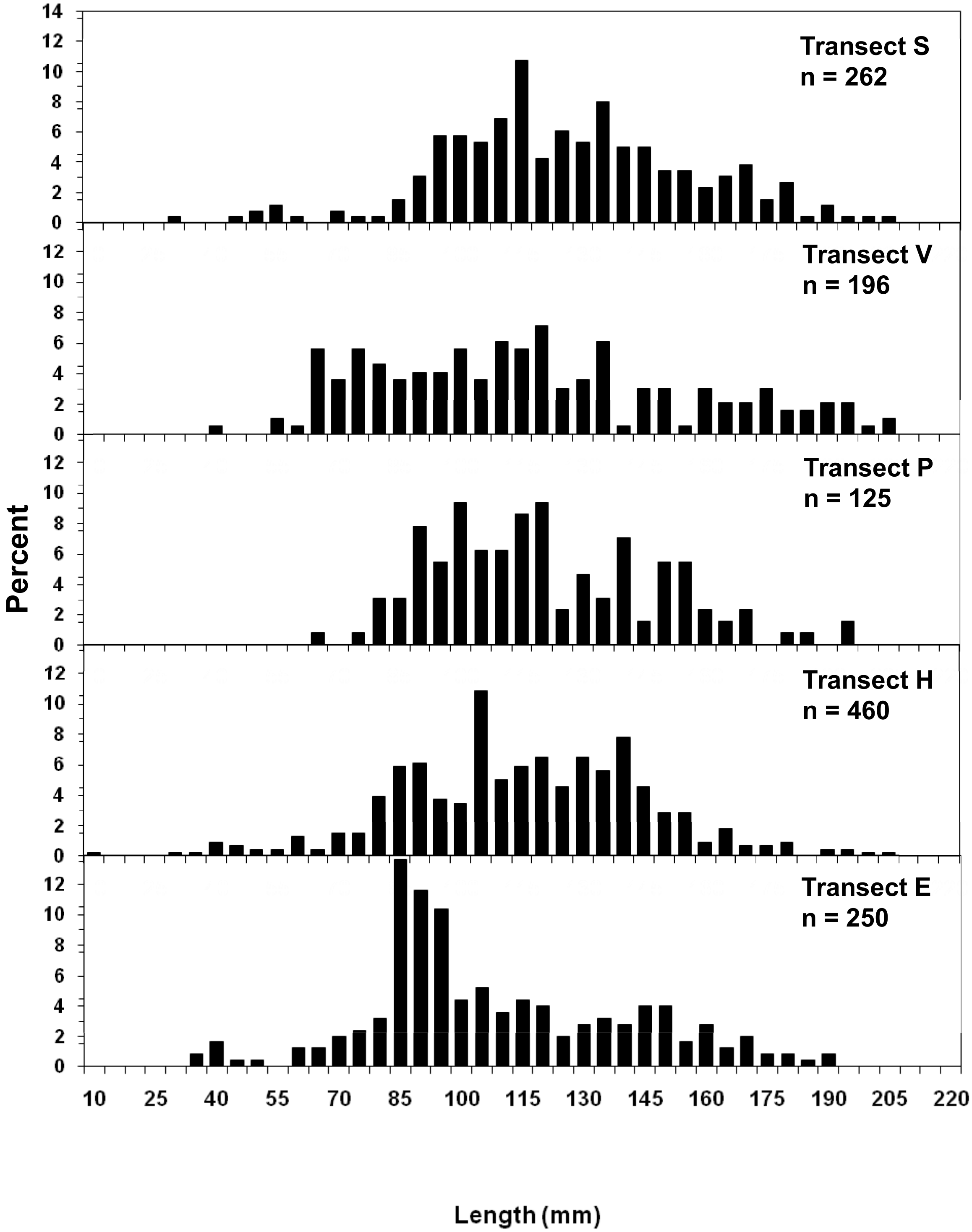
[+]Sampling was conducted every other year since 2000.

Appendix 12. Results for ANOVA of spatial and yearly trends (mean number per hour) of selected species collected with electrofishing sampling from Harris Reservoir, 2000-2008.

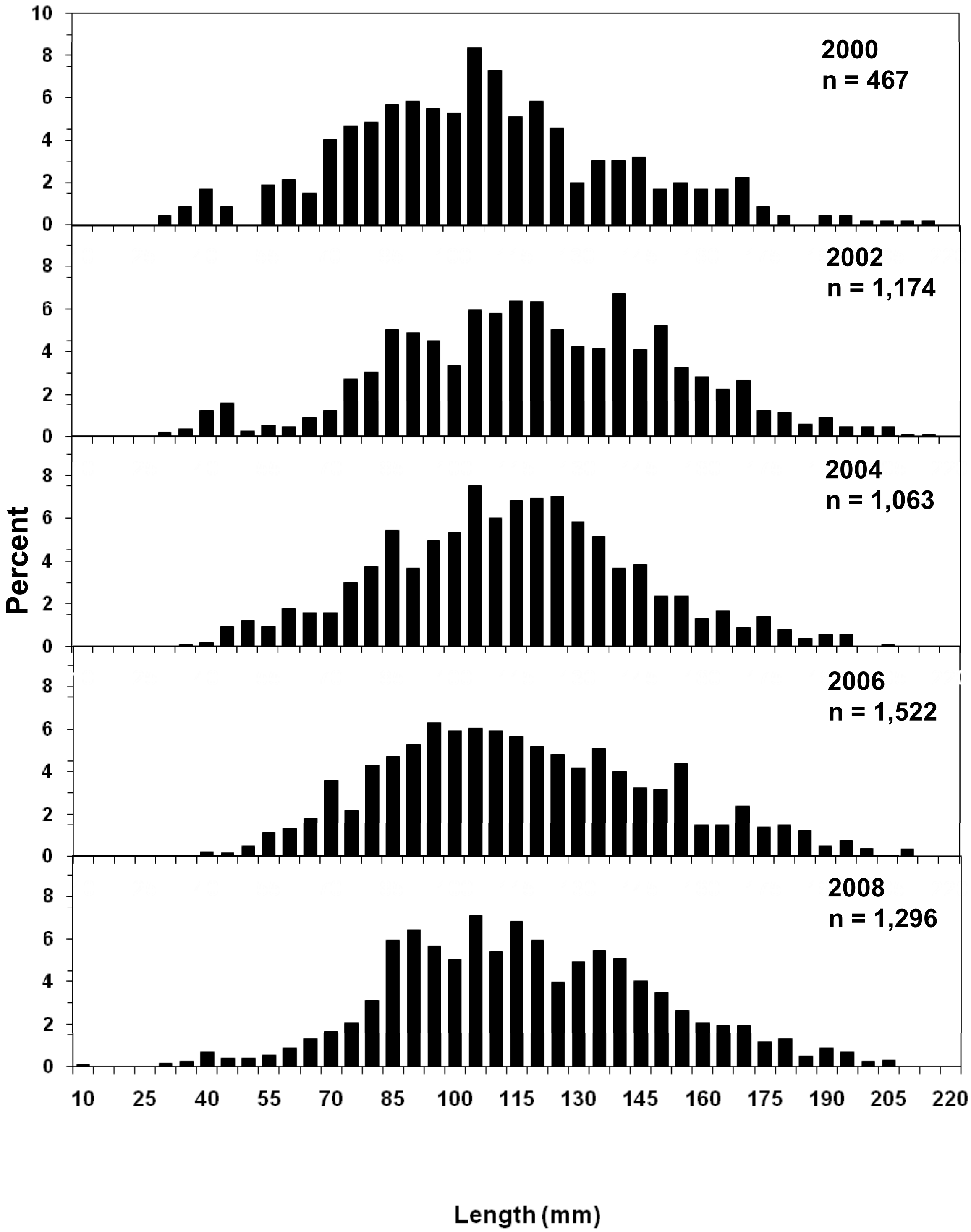
		Transect				
Source	**ANOVA⁺**	**H**	**E**	**P**	**V**	**S**
2008 Database						
Bluegill	**	5.3^{a}	4.4^{bc}	3.6^{c}	3.9^{bc}	4.6^{ab}
Redear sunfish	***	4.2^{a}	3.8^{a}	2.8^{b}	2.7^{b}	2.7^{b}
Total	***	6.1^{a}	5.2^{bc}	4.9^{c}	4.9^{c}	5.8^{ab}
2000-2008						
Golden shiner	*	1.0^{ab}	1.2^{ab}	1.4^{a}	0.7^{b}	1.5^{a}
Bluegill	*	4.7^{a}	4.3^{ab}	4.1^{b}	3.9^{b}	4.3^{ab}
Redear sunfish	**	4.4^{a}	4.0^{a}	3.2^{b}	2.6^{c}	2.7^{c}
Largemouth	*	2.8^{b}	2.9^{ab}	3.2^{a}	3.2^{a}	3.1^{a}
Total	***	5.8^{a}	5.4^{b}	5.3^{bc}	5.0^{c}	5.4^{b}

		Year				
Source	**ANOVA⁺**	**2000**	**2002**	**2004**	**2006**	**2008**
Threadfin shad	***	0.3^{c}	0.7^{bc}	0.2^{c}	1.6^{a}	1.3^{ab}
Golden shiner	***	1.2^{ab}	1.7^{a}	1.3^{ab}	0.8^{b}	0.8^{b}
Bluegill	*	4.0^{b}	4.5^{a}	4.0^{b}	4.5^{a}	4.4^{ab}
Redear sunfish	***	3.5^{b}	4.1^{a}	3.2^{bc}	2.7^{c}	3.2^{bc}
Total	*	5.2^{bc}	5.7^{a}	5.2^{c}	5.5^{ab}	5.4^{abc}

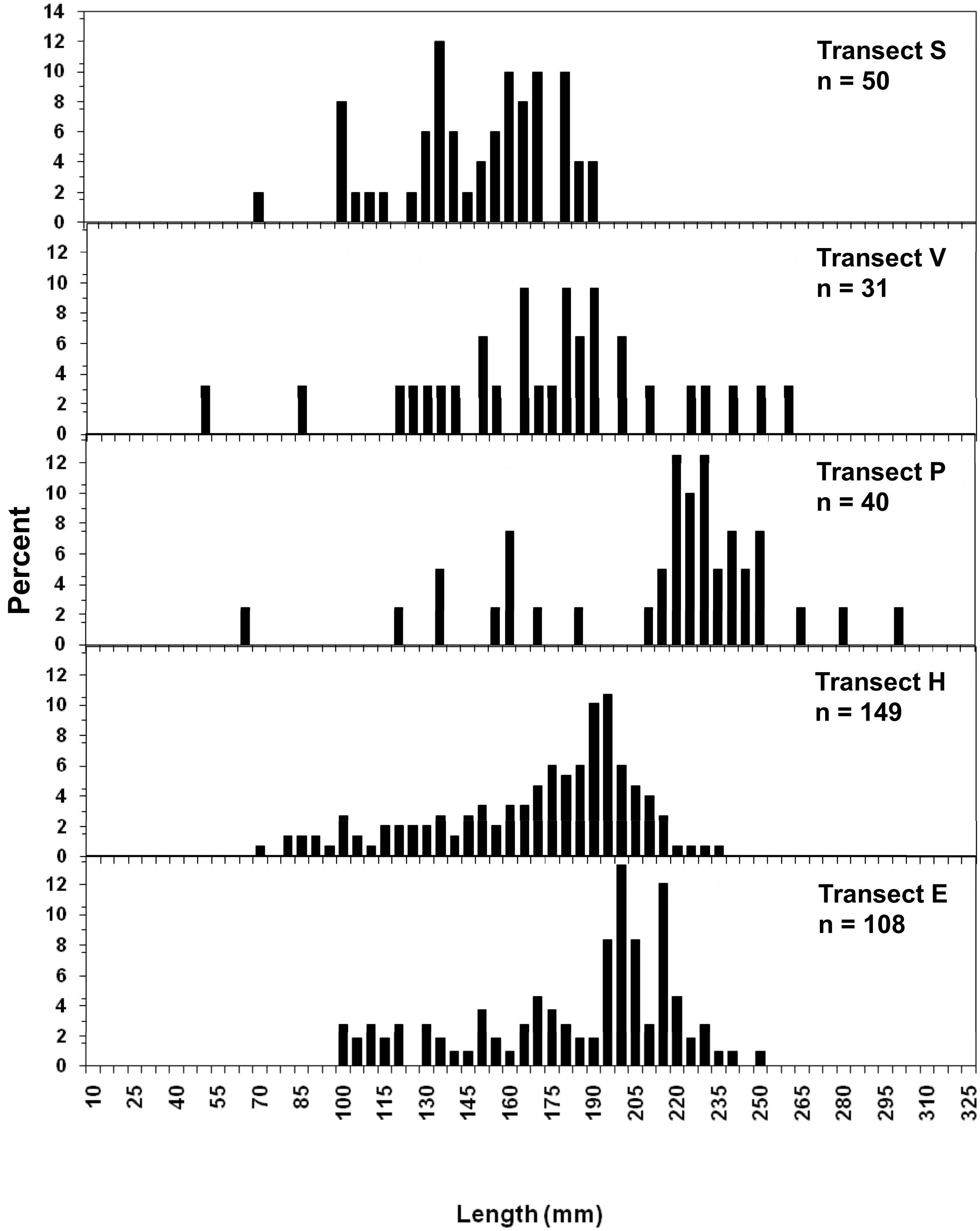
⁺One-way ANOVA was applied to analyze the 2002 database. Values with different superscript letters were significantly different. P values: * = 0.01 < P ≤ 0.05, ** = 0.001 < P ≤ 0.01, *** = P ≤ 0.001, and NS = nonsignificant. Fisher's least significant difference test ranking of transects was used to separate means. Analyses were performed on $\log_e$-transformed (catch-per-unit-effort + 1) data. Means are only presented for significant ANOVA results. Species tested include bluegill, chain pickerel, gizzard shad, green sunfish, largemouth bass, redbreast sunfish, redear sunfish, and warmouth.



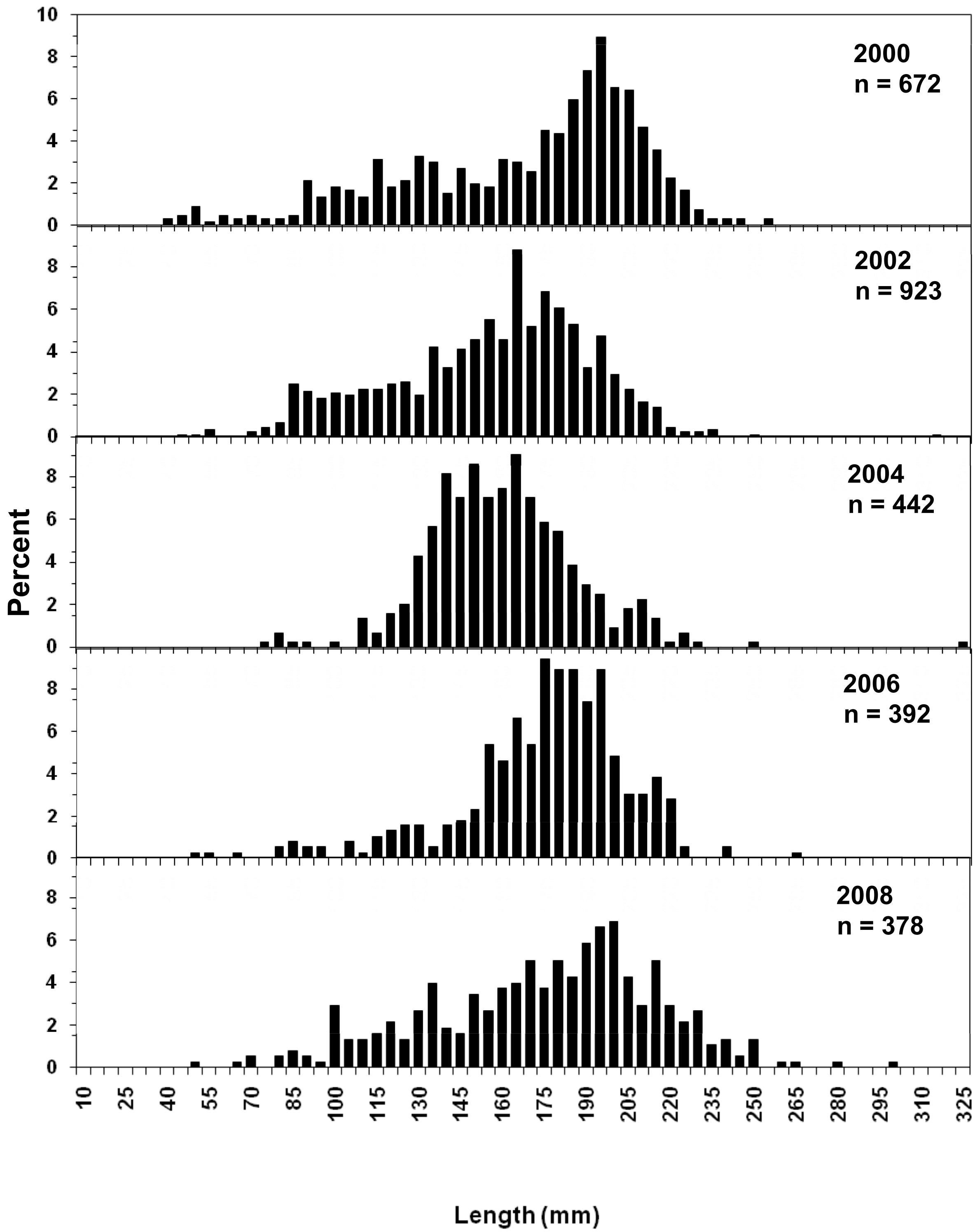
Appendix 13. Length-frequency distributions for bluegill by transect collected with electrofishing sampling from Harris Reservoir during 2008.



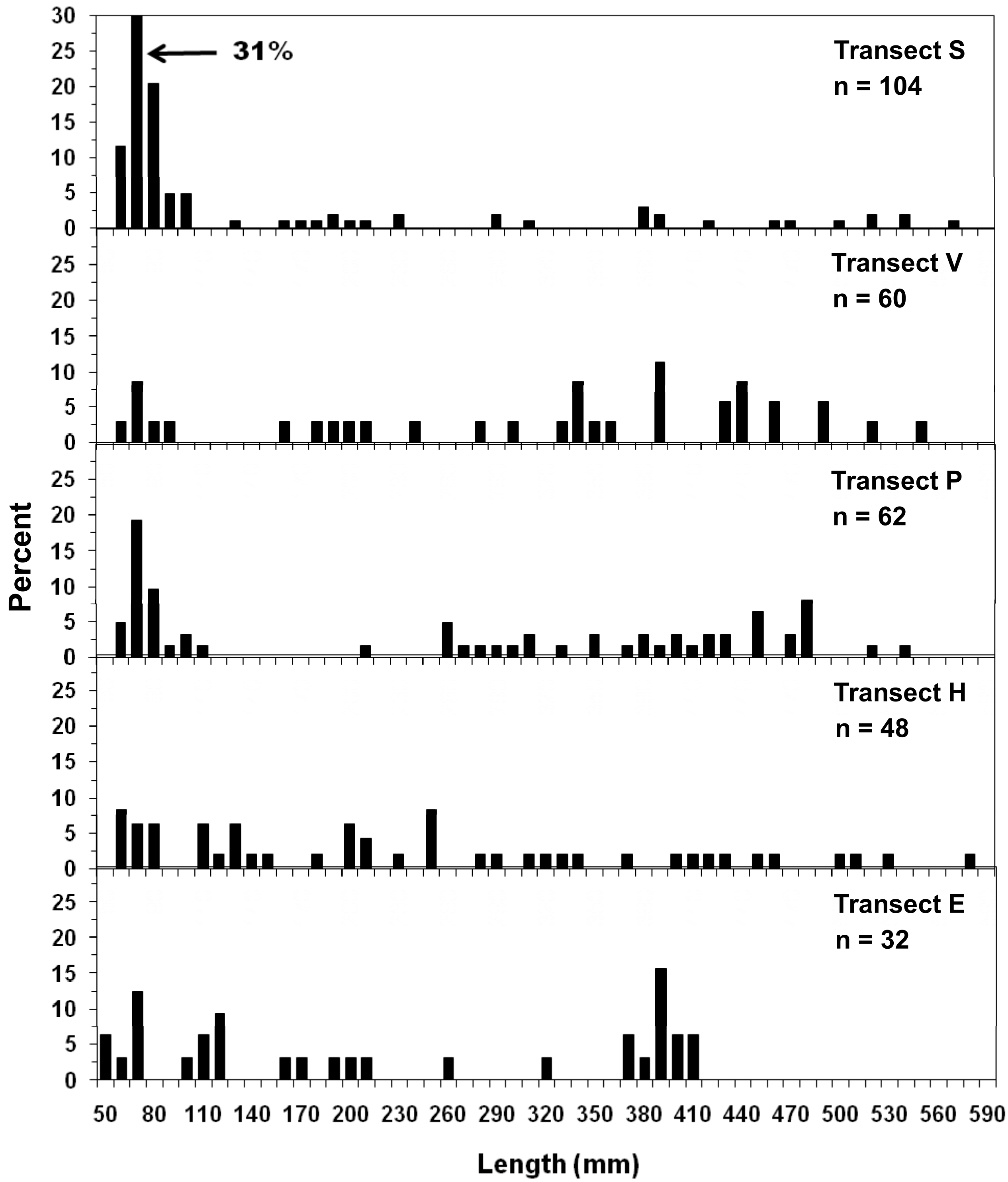
Appendix 14. **Length-frequency distributions for bluegill collected with electrofishing sampling from Harris Reservoir, 2000-2008 (electrofishing sampling was conducted bi-annually).**



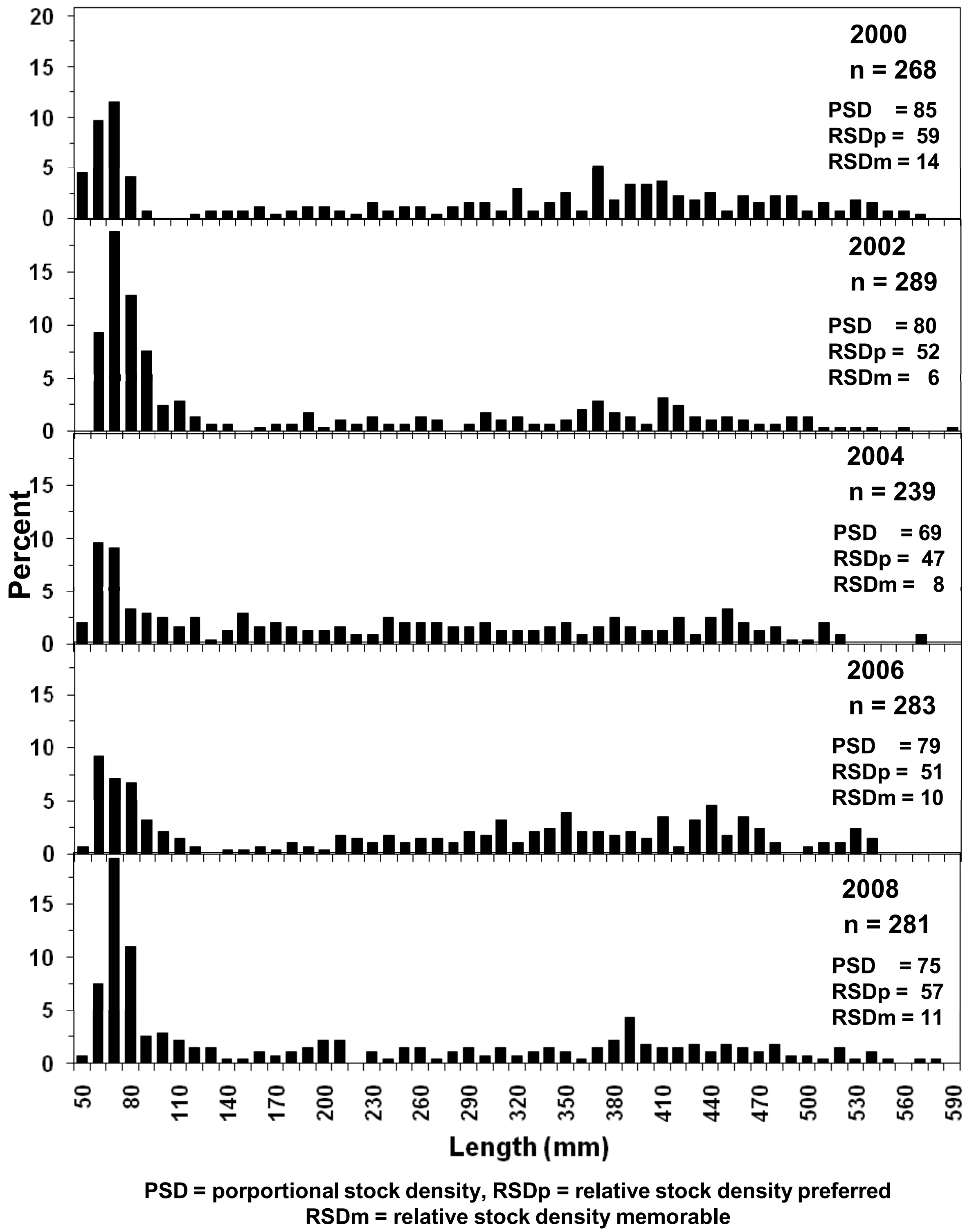
Appendix 15. Length-frequency distributions for redear sunfish by transect collected with electrofishing sampling from Harris Reservoir during 2008.



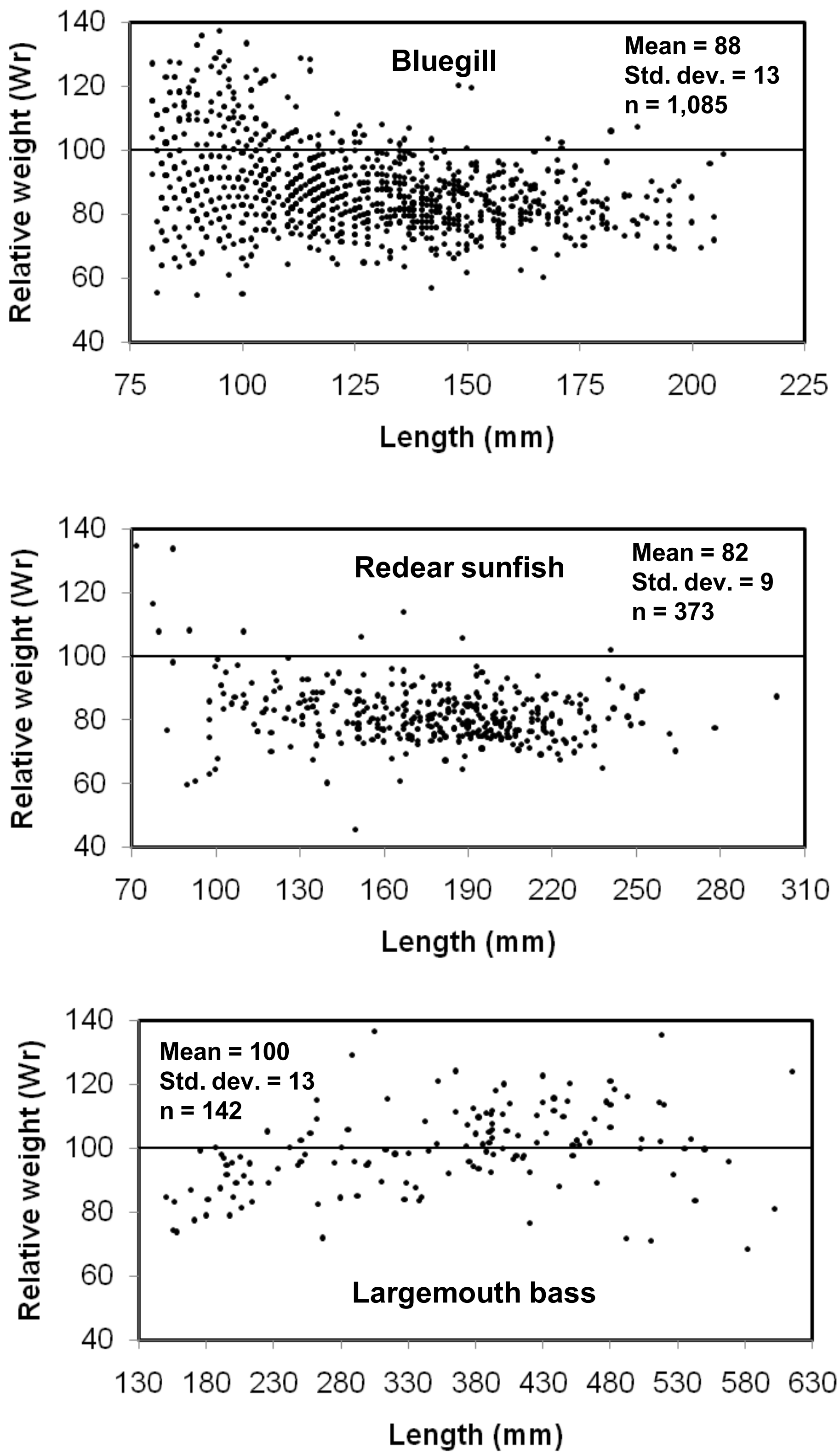
Appendix 16. **Length-frequency distributions for redear sunfish collected with electrofishing sampling from Harris Reservoir, 2000-2008 (electrofishing sampling was conducted bi-annually).**



Appendix 17. Length-frequency distributions for largemouth bass by transect collected with electrofishing sampling from Harris Reservoir during 2008.



Appendix 18. **Length-frequency distributions for largemouth bass collected with electrofishing sampling from Harris Reservoir, 2000-2008 (electrofishing sampling was conducted bi-annually).**



Appendix 19. Relative weight values for bluegill, redear sunfish, and largemouth bass collected with electrofishing sampling from Harris Reservoir during 2008.

Appendix 20. Mean relative weight (Wr), standard deviation (sd), and number (n) collected for bluegill, redear sunfish, and largemouth bass collected with electrofishing sampling from Harris Reservoir, 2000-2008. +

Taxon	Year				
	2000	**2002**	**2004**	**2006**	**2008**
Bluegill	84 ± 14 n = 660	82 ± 11 n = 983	83 ± 13 n = 829	86 ± 11 n = 1,015	88 ± 13 n = 1,085
Redear sunfish	78 ± 38 n = 634	77 ± 8 n = 895	79 ± 32 n = 436	83 ± 10, n = 379	82 ± 9 n = 373
Largemouth bass	94 ± 13 n = 180	97 ± 10 n = 126	95 ± 10 n = 150	101 ± 10, n = 192	100 ± 13 n = 142

+Sampling was conducted every other year since 2000.