ASSESSMENT OF BALANCED AND INDIGENOUS POPULATIONS IN THE YADKIN RIVER AND HIGH ROCK LAKE NEAR BUCK STEAM STATION

NC0004774

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EXECUTIVE SUMMARY

Per agreement with the North Carolina Department of Environment and Natural Resources (NCDENR), annual monitoring of macroinvertebrates and fish at selected locations in the Yadkin River commenced in 1990. These monitoring data are used to evaluate potential impacts of the Buck Steam Station (BSS) discharge on balanced and indigenous populations in the Yadkin River and High Rock Lake.

The operation of BSS was in compliance with permitted thermal limits from January 2003 through December 2008. Additionally, water withdrawal limits based on the 10-ft drawdown of High Rock Lake were never exceeded. Since July 1993, BSS has operated per the EPA nomograph and within guidelines approved by NCDENR. Previous balanced and indigenous population evaluations have determined operation per these guidelines, and permit discharge limits have ensured protection of the downstream biota.

The Yadkin River near BSS experienced considerable variability in flows from January 2003 to December 2008. The annual mean flow for the 2003 calendar year was the second highest annual mean flow over the 46-year span of the USGS Yadkin College gauge. Conversely, the 2008 calendar year experienced the second lowest annual mean flow on record for the Yadkin River at the same gauge. Water quality in the Upper Yadkin River and High Rock Lake remains substantially impacted by turbidity, sedimentation, and nutrient enrichment.

During 2003 – 2008, annual macroinvertebrate densities varied substantially among years and locations, but were generally higher than those from the previous reporting period (1998 – 2002). Overall densities decreased from 2003 to 2004 and then increased at most locations through 2008. Densities at the BSS discharge were the lowest for this reporting period in 2008. Conversely, one of the highest annual densities for the reporting period also occurred at the BSS discharge in 2005. Densities at the most upstream location were lower than the densities from the location downstream of BSS each year, except 2004.

Generally the number of taxa collected during 2003 – 2008 varied very little between locations, with the exceptions of 2003 and 2008. Taxa abundance varied somewhat by year and ranged from 9 to 36 taxa, with higher numbers generally collected uplake. All taxa numbers were within those historically reported.

The fish community in the Piedmont region of the Yadkin River upstream and downstream of the BSS heated discharge has been monitored since 1977. Despite its situation in a region of highly erodible soils and downstream of various point and nonpoint pollution sources, the fish community has remained diverse and viable throughout the years. Electrofishing samples in both winter and summer have shown a persistent fish community at locations upstream, downstream, and in the heated discharge of BSS. The fish species present in the river are consistent with those documented by other sources for this river and include no threatened or endangered species.

The fish community is dominated by species with a pollution tolerance rating of Intermediate, with negligible Intolerant species. The trophic structure is dominated by insectivores, followed by piscivores and omnivores, with very few herbivores. Based on the evaluation of electrofishing data and various analysis metrics, during both winter and summer months, the present operating conditions at BSS are not negatively impacting the fish community in the Yadkin River. Based on the diversity and sustainability of the fish community through time, it is concluded that a balanced indigenous fish community exists in the Yadkin River in the vicinity of BSS.

Analyses of BSS operation and environmental monitoring data support that balanced and indigenous populations continue to exist in the Yadkin River in the vicinity of BSS and that the current limits should be maintained when the Station NPDES permit is renewed.

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CHAPTER 1

INTRODUCTION

Per agreement with the North Carolina Department of Environment and Natural Resources (NCDENR), annual monitoring of macroinvertebrates and fish at selected locations in the Yadkin River was initiated in 1990 and continues to the present. The objective of this on-going monitoring program is to provide data to assess balanced and indigenous populations in the vicinity of Buck Steam Station (BSS) [National Pollution Discharge Elimination System (NPDES) permit NC0004774].

> The term "balanced, indigenous community" [40CFR125.71(c)] is synonymous with the term "balanced, indigenous population" in the Clean Water Act, and refers to a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications (USEPA 1977).

Buck Steam Station operates under a monthly and daily thermal discharge limit to optimize generation while protecting biota. The monthly limit allows BSS to discharge condenser cooling water (CCW) into the Yadkin River at no more than 35 °C (95 °F) as a monthly average (NCDENR 2000, 2004, 2008). The daily thermal limit, per the EPA nomograph, is a dynamic value dependent upon influent temperatures and station operational conditions. The daily CCW effluent thermal limit appears in the BSS permit as follows:

> The daily average temperature of the effluent shall be such as not to exceed 10 °C (50 °F) if the daily average intake temperature is below 2.5 °C (36.5 °F), and shall not exceed two times the intake temperature (°F) minus 23 if the daily average intake temperature ranges from 2.5 °C (36.5 °F) to 12.8 °C (55 °F) when only units with the same control system are operating (NCDENR 2000, 2004, 2008).

Previous assessments accepted by regulators have demonstrated the thermal limits imposed on BSS CCW effluent ensured a balanced and indigenous biological community in the vicinity of BSS. This report utilizes plant operational, macroinvertebrate population, and fish community data collected from January 2003 through December 2008 to verify BSS operations during this time-frame were protective of balanced and indigenous biological communities near BSS.

CHAPTER 2

YADKIN RIVER BACKGROUND DATA AND STATION OPERATION

HIGH ROCK LAKE BASIN PHYSICAL CHARACTERISTICS

High Rock Lake, impounded in 1927, is the largest reservoir on the Yadkin River, with a surface area of 6,429 ha (15,886 acres). At the inflow of the river into High Rock Lake, the Yadkin River Basin comprises a drainage area of 8,961 km^2 (3,459 mi^2) (Weiss et al. 1981). Full pool elevation for the reservoir is listed as 190.2 m msl (624 ft) with a mean depth of 5.2 m (17 ft) and a maximum depth of 19 m (62 ft) in the forebay of the dam (Tetra Tech, Inc. 2004).

Past land cover analyses indicate a diversity of land usage within the North Carolina portion of the Yadkin River Basin (Tetra Tech, Inc. 2004). The basin at the time of analysis was 65% forested and roughly 25% was dedicated to agricultural use. The remaining usage was divided mainly among residential, urban, and commercial usages. Drainage from urban centers, suburban development, and agricultural usage, coupled with the highly erodible soils within the basin, provide large quantities of sediment for transport in the basin.

STATION BACKGROUND

Buck Steam Station (BSS) is located on the Yadkin River near Salisbury in Rowan County, NC, near the upper end of High Rock Lake in an area where the Yadkin River transitions from riverine to a more lacustrine system (Figure 2-1). Station operation began in 1926 with Units 1 and 2 (35 MW each). Unit 3 (80 MW) and Unit 4 (40 MW) began operation in 1941 and 1942, respectively. The station was completed in 1953, with the operation of Units 5 and 6 (125 MW each). In 1979, Units 1 and 2 were retired from service, resulting in a gross station capacity of 370 MW. Units 3, 4, and 5 were removed from operation in March of 1984 and placed in Duke Energy's Plant Modernization Program (PMP). Unit 5 returned to

service in 1991, Unit 3 returned in 1994, and Unit 4 returned in 1995. Unit 6 did not undergo PMP and is still in operation.

Each steam generating unit has two once-through condenser cooling water (CCW) pumps. One or two pumps operate per unit, depending on intake water temperature, discharge temperature limits, including seasonal limits set by the United States Environmental Protection Agency (USEPA) nomograph (USEPA 1976), and operational efficiency. The maximum pumping capacity of the CCW system is 18.1 m^3/s (638.0 cfs).

Operation per the EPA nomograph guidelines was initiated in July 1993. The most significant impact on plant operations occurs when only one control unit is operating during cold winter months. In this scenario, multiple CCW pumps may have to operate to reduce the ΔT between ambient water and station thermal discharge. Lowering the ΔT protects downstream biota from possible cold shock should rapid shutdown of all generating units occur at once.

An additional requirement limits Yadkin River withdrawals based on draw down conditions within High Rock Lake. In particular, when High Rock Lake is drawn down 3.05 m (10 ft) or greater, BSS must, on a daily average basis:

> Use no more than two thirds of the stream flow for condenser cooling; and
>
> ensure that the minimum unheated daily average stream flow does not fall below one third of the seven-day ten-year low flow (7Q10) (NCDENR 2000, 2004, 2008).

In this instance, 7Q10 is equivalent to 29.2 m^3/s (1,030 cfs). (NCDENR, 2007a)

FLOW CHARACTERIZATION OF THE YADKIN RIVER

On an annual basis, the Yadkin River Basin near BSS [United States Geological Survey (USGS) Cataloging Unit 03040101] experienced considerable variability in flows from January 2003 to December 2008 (USGS 2010). In 2003 and 2004, the annual mean Yadkin River flows for the USGS Yadkin College gauge (02116500) were above the mean period-of-record flow for the gauge. In fact, the average daily flow for the 2003 calendar year was the second highest annual mean flow over the 46-year record for the gauge. Conversely, annual

mean flows for 2005, 2006, 2007, and 2008 were below average for the Yadkin College gauge. Flows for the 2007 and 2008 calendar years were extremely low due to drought conditions present throughout the basin. The 2008 calendar year, in particular, experienced the second lowest annual mean flow on record for the Yadkin River at the Yadkin College gauge.

On a monthly basis, median Yadkin River flows (Figure 2-2) show the extent of drought conditions in the basin from May 2007 to December 2008. All monthly median flows for this time period were below the average of the monthly median flows for the period of record. The lowest monthly median flow encountered from 2003 – 2008 was 17.0 m^3/s (599 cfs) in August 2008. Further discussion of the 2003 – 2008 hydrograph (Figure 2-3) and its relation to biological sampling events follows in subsequent chapters.

WATER QUALITY

Historically, water quality in the upper Yadkin River and High Rock Lake has been substantially impacted by both sedimentation and nutrient enrichment (NCDENR 2007a). The river near BSS is influenced by heavily nutrient-enriched tributaries with inputs from upstream agriculturally-derived non-point sources and urban centers such as Statesville, Salisbury, and Winston-Salem, NC.

Recent water quality assessments of High Rock Lake utilizing data collected from August 2004 to September 2006 were reported by the Intensive Survey Unit of the NCDENR Division of Water Quality (DWQ) (NCDENR 2007b). Monitoring within the High Rock Lake assessment was split into four units. The northern unit comprised the upper Yadkin River mainstem (where BSS is located) and Towns Creek, the eastern unit included the Abbotts Creek arm, the western unit included the Second Creek arm and the southern unit incorporated the lower mainstem Yadkin and High Rock Lake forebay. At least one sampling location was situated within each unit.

According to the assessment, nutrient and sediment loading continued to be problematic in High Rock Lake. All units of the reservoir were listed as impaired due to excessive turbidity and chlorophyll *a* concentrations during the 2004 – 2006 sampling events. Severe to extreme algal blooms were evident throughout High Rock Lake in the summer months of 2004 – 2006, with exception of the most upstream Yadkin River DWQ location (YAD1391A).

Elevated surface pH and super-saturated dissolved oxygen (DO) concentrations generally concurrent with algal blooms were observed during these specific summer sampling events.

STATION OPERATION

Buck Steam Station operated 1,968 out of 2,192 days from January 2003 through December 2008, or 90% of the available days (Table 2-1). In previous years, BSS was described as a peaking facility with periods of heavier generation in the summer and winter months. From 2003 – 2008, BSS continued to operate in this capacity with slightly more operational days during spring and fall months than in previous years.

During operation, BSS records hourly thermal data and determines daily average temperatures for upstream ambient waters and CCW discharge waters as required by the NPDES permit. Daily average upstream ambient temperatures in the 2003 – 2008 monitoring period ranged from 1.1 °C (34 °F) in January of 2003 and 2004 to 34.4 °C (94 °F) in July of 2008. Daily average discharge temperatures were typical of previously reported data and ranged from 3.9 °C (39 °F) in December of 2004 to 42.8 °C (109 °F) in August of 2007 (Figure 2-4 and Figure 2-5). Monthly average intake water temperatures ranged from a minimum of 3.9 °C (39 °F) in the winters of 2003 and 2005 to a maximum of 30.6 °C (87 °F) in the summer of 2007 (Figure 2-5). The monthly average discharge water temperature ranged from 11.7 °C (53 °F) in the winter of 2003 to 35 °C (95 °F) in the summers of 2006, 2007, and 2008.

Operation of BSS from January 2003 through December 2008 resulted in no NPDES permit thermal violations. Also, from a water usage standpoint, BSS water withdrawal limits, based on the 3.05-m (10-ft) drawdown of High Rock Lake, were never exceeded from January 2003 through December 2008. In fact, from 2003 to 2008, daily average lake levels for High Rock Lake never met the 3.05-m (10-ft) drawdown criteria for activation of withdrawal limits (Figure 2-6).

SAMPLING LOCATIONS

Biological samples were collected from four locations in the vicinity of BSS. Temperature and DO were also measured at each location in conjunction with biological samples.

Sampling locations are labeled A through D, with A being the most upstream location and D the most downstream location (Table 2-2 and Figure 2-1). Fish collections at each sampling location (A – D) contain biota from ascending left and right banks of the river as indicated by an L or R following the sample location. Benthic sampling locations consist of transects corresponding to the fish collection locations (A – D). Each location sample consists of five discrete substrate grabs from across the transect.

Table 2-1. Operational data for Buck Steam Station from 2003 – 2008.

Year	Number of operating days	% of year operating
2003	363	99.5
2004	333	91.2
2005	325	89.3
2006	313	85.8
2007	337	92.3
2008	297	81.4

Table 2-2. Designation and description of biological sampling locations in the Yadkin River, NC, in the vicinity of Buck Steam Station. Location A is the most upstream site on the Yadkin River and Location D is at the most downstream site. Benthic macroinvertebrate samples collected from stations A – D are collected in transects. Fish samples are collected from the left and right banks of the river as indicated by an L or R following the station designation.

Report designation*	County	Relation to BSS	Description
A-L and A-R	Davidson/ Rowan	Upstream	Upstream of historical textile plant
B-L and B-R	Davidson/ Rowan	Upstream	Just downstream of the Interstate 85 bridge crossing
C-L and C-R	Rowan	Plant Discharge	BSS discharge
D-L and D-R	Davidson/ Rowan	Downstream	Just upstream of the transmission line crossing, 0.9 km downstream of BSS

* L and R designations indicate fish sampling locations on the left and right ascending banks of the Yadkin River. Benthic samples are collected in transects at locations (A – D).

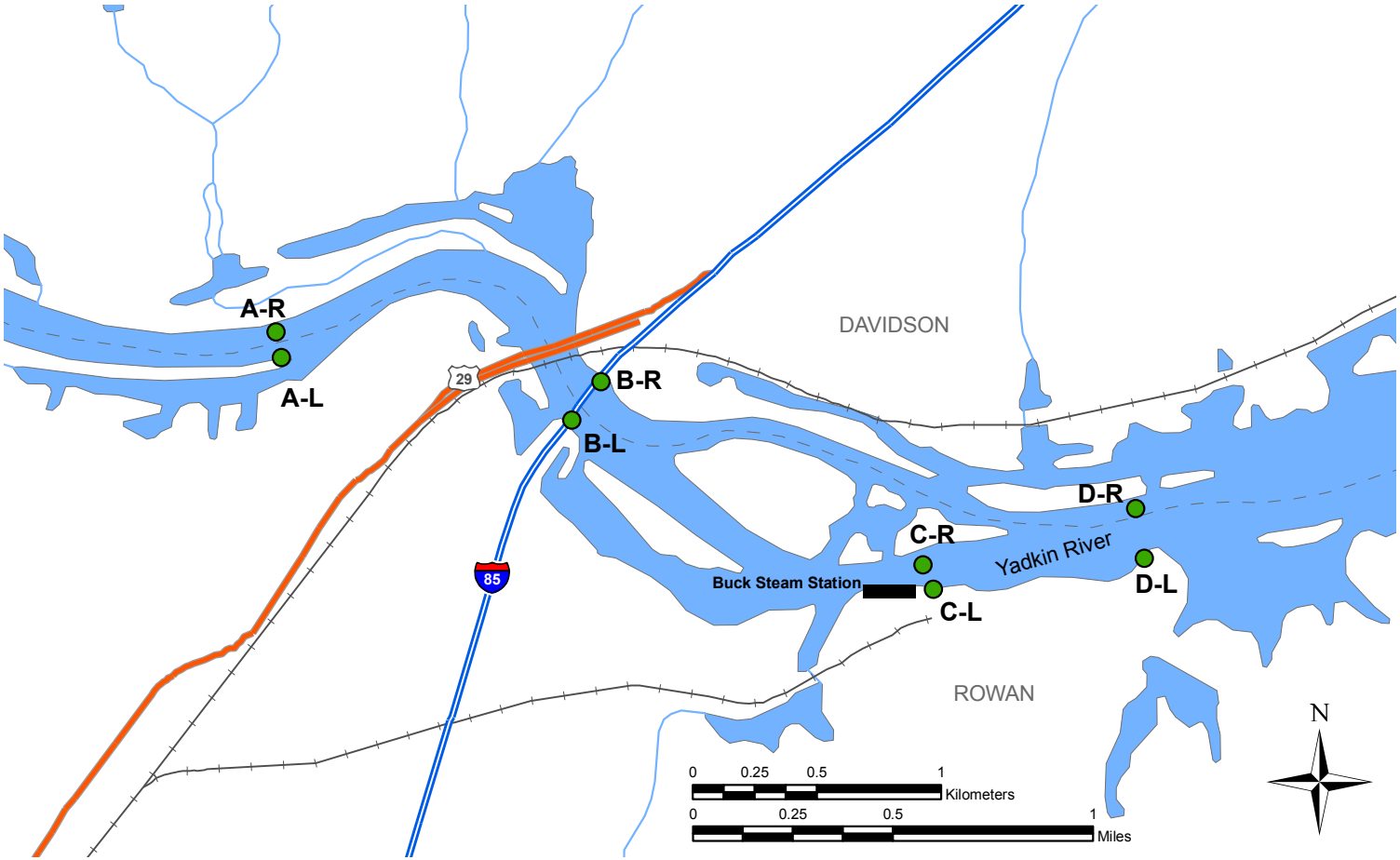

Figure 2-1. Biological sampling locations (A - D) on the Yadkin River and upper High Rock Lake, NC in the vicinity of BSS. Fish sampling locations are divided among left and right ascending banks of the river as indicated by L or R following location identifiers.

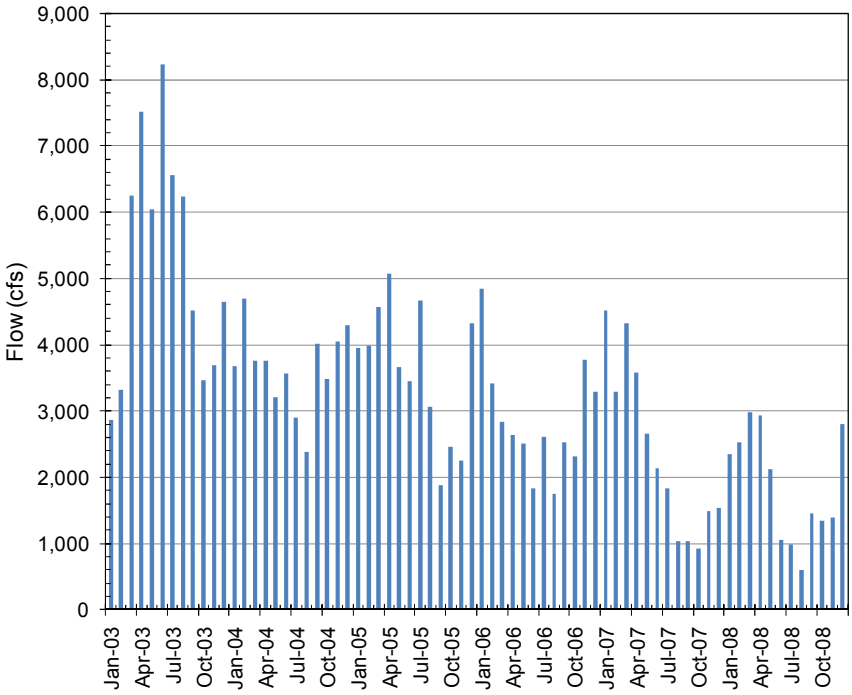

Figure 2-2. Monthly median flows for the Yadkin River near BSS. Yadkin River flows at the USGS Yadkin College gauge (02116500) were adjusted for the increased drainage area at BSS.

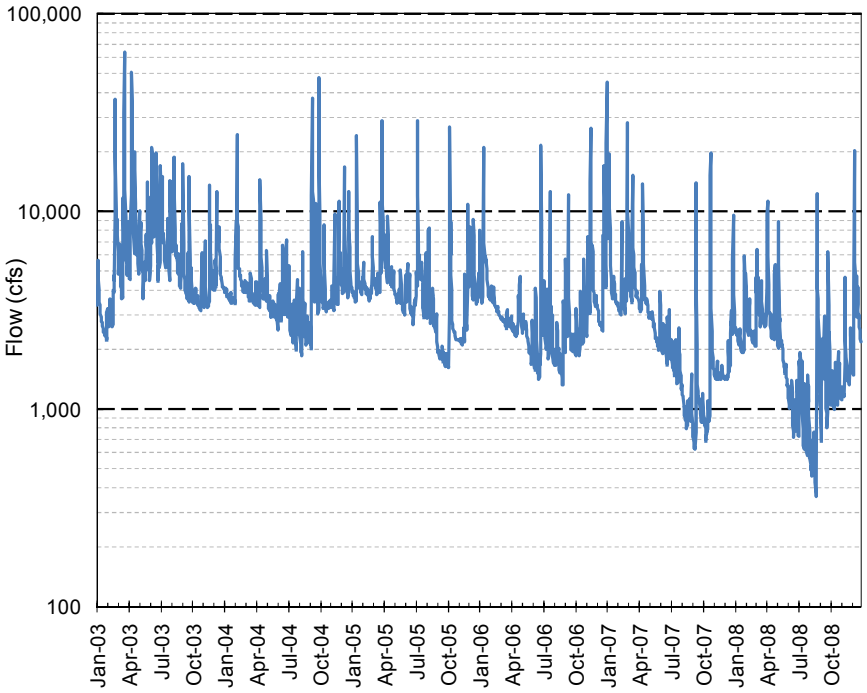

Figure 2-3. Yadkin river hydrograph at the Yadkin College gauge (USGS 02116500) from January 2003 to December 2008.

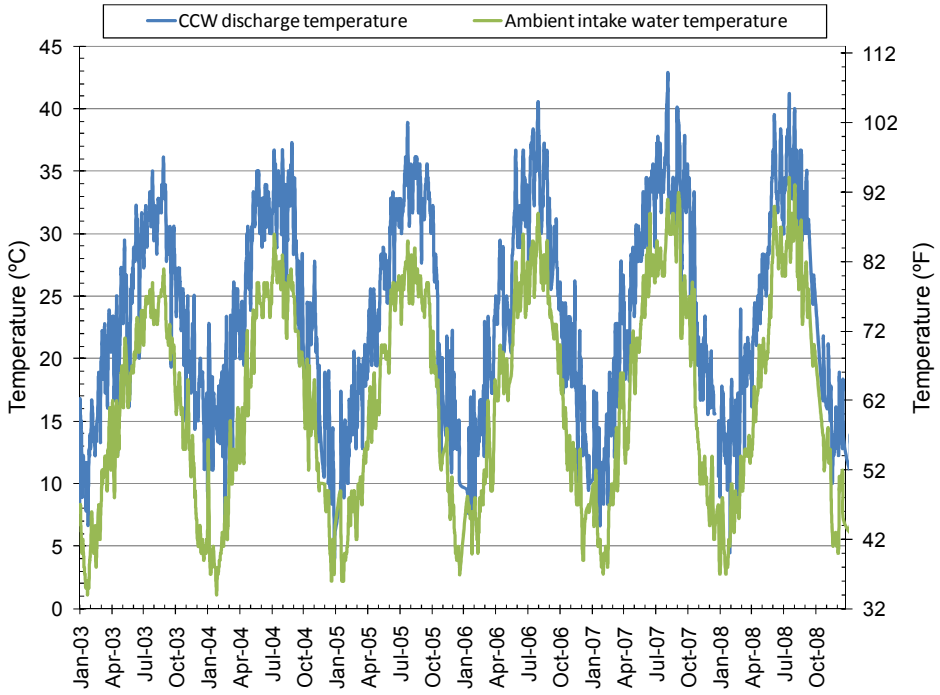

Figure 2-4. CCW intake and discharge water temperatures from January 2003 to December 2008.

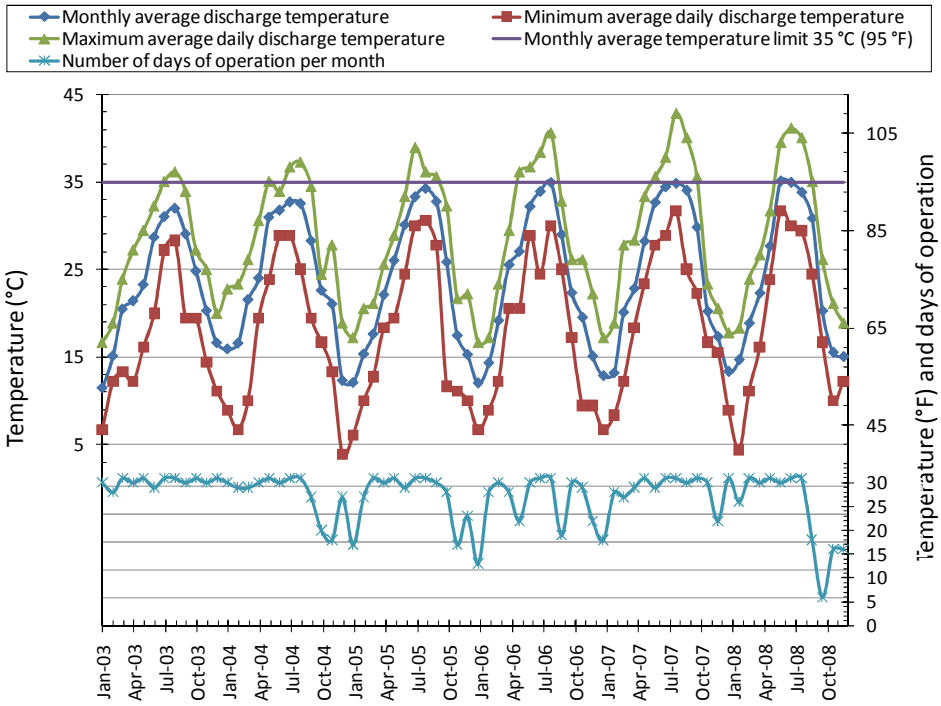

Figure 2-5. Buck Steam Station operational and thermal data from January 2003 to December 2008.

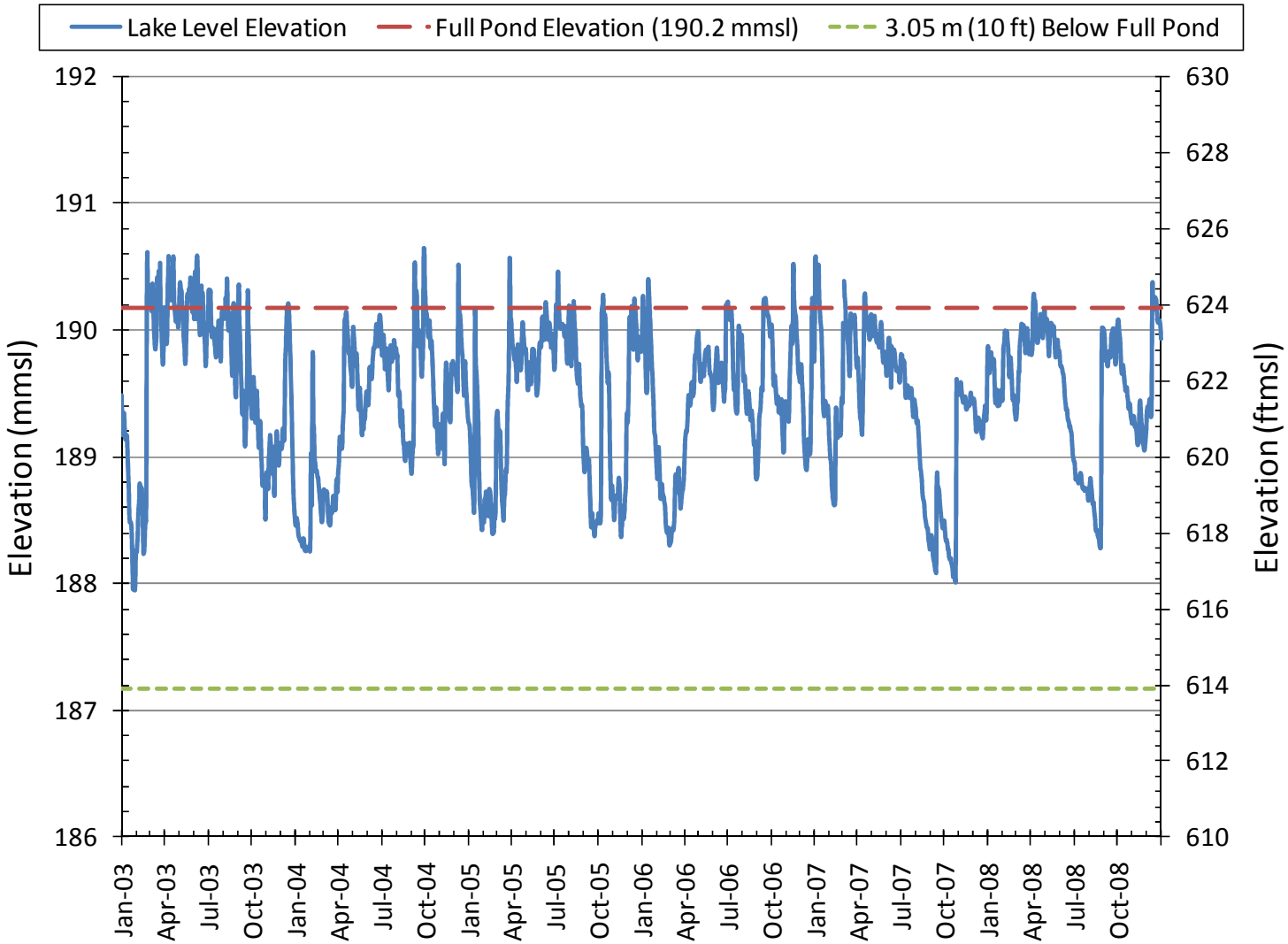

Figure 2-6. Lake level elevations for High Rock Lake from January 2003 to December 2008.

CHAPTER 3

MACROINVERTEBRATES

METHODS AND MATERIALS

Benthic macroinvertebrate sampling was conducted annually in late July 2003 – 2008 as part of the continuing monitoring program for Buck Steam Station (BSS). As in previous years, samples were collected from four locations (A, B, C, and D) in the Yadkin River (Table 2-2 and Figure 2-1). A petite ponar dredge (15.3 x 15.3 cm) was used to collect five sample replicates at each location. Samples were collected from depths ranging from two to six m at different points across the river to account for variability in substrate and benthic densities. Brinkhurst (1974) states that peak benthic abundance occurs at depths ranging from two to three meters. Samples were washed through a 500-µm mesh sieve and individually preserved with 70% ethanol containing rose bengal stain. The substrate at each location was identified and recorded, based on a visual analysis of substrate types during the sieving process. Organisms were sorted in the laboratory and identified to the lowest practicable taxon. Macroinvertebrate densities were calculated by extrapolating ponar densities to a standard one-square meter bottom area. The assessment of the balanced and indigenous nature of the benthic community in the vicinity of BSS was determined by comparing macroinvertebrate densities and taxa abundance among the sample locations.

Beginning in 2005 in conjunction with macroinvertebrate sampling, water temperature and dissolved oxygen (DO) were measured just above the substrate at each location using a pre-calibrated YSI Model 55 handheld DO meter. Starting in 2008, water temperatures and DO values were measured *in situ* using a pre-calibrated Hach®HQ40d water quality meter.

RESULTS AND DISCUSSION

Substrate

Typically the substrates at Locations A, B, and D were generally similar each year and comprised primarily of silt, sand, and organic matter. The sediment at Location C also had these substrate matrices, but generally also had varying amounts of gravel (Table 3-1).

Water Quality

Water temperatures observed during sampling from 2005 to 2008 (no water quality data were collected in 2003 and 2004) ranged from 26.0 to 38.0 °C (Table 3-2). With the exception of 2007, the lowest water temperature occurred uplake each year at Location A and ranged from 26.0 to 29.6 °C. The highest temperature each year occurred at Location C, the BSS discharge, ranging from 28.1 to 38.0 °C. Water temperatures recorded at Location D ranged from 26.4 to 31.0 °C, were very similar to those collected at Location B (26.2 to 29.6 °C) each year, and were several degrees cooler than those collected at Location C, except in 2005 when the temperature at Location D was actually one degree higher.

The DO concentrations observed from 2005 to 2008 ranged from 3.3 to 7.2 mg/L (Table 3-2). The lowest DO concentration at each location was observed in 2005. Each year the lowest DO generally occurred downstream at Location D ranging from 3.3 to 6.4 mg/L. These low concentrations may be due to the fact that these observations are taken just a few inches off the substrate at each location. Dissolved oxygen concentrations just above the substrate-water interface especially in lakes and slow moving waters can be influenced heavily by oxygen depletion via microbial respiration in the sediments (Hutchinson 1975). Extremely low DO concentrations can develop immediately above the sediment surface of these lentic waters with higher DO concentrations in the waters just above. As a result, measuring DO in this zone can vary greatly depending upon the distance from the sediment that the measurement is taken.

The BSS study reach is also unique in that it is situated in an area of transition from lentic to lotic waters. The sample locations inevitably experienced riverine flows and, at times, the quiescence of a reservoir. These flows from rainfall run-off and periodic hydropower releases as well as the variability in other conditions, including, but not limited to sediment

bacterial populations and inputs of organic material into the river would heavily influence the severity of depletion within the water column during these summer sampling events.

The highest DO each year varied between locations ranging from 4.0 to 7.2 mg/L. Both temperature and DO values were generally similar at the uplake and downlake locations each year.

Density

During 2003 – 2008, overall annual macroinvertebrate densities varied substantially among years and locations ranging from 483/m² to 11,032/m² (Tables 3-3 to 3-6 and Figure 3-1). Overall densities decreased from 2003 to 2004 and then increased at most locations through 2008. Maximum and minimum densities varied spatially from year to year. Annual maximum densities were observed at Location A in 2004, Location B in 2003 and 2006, Location C in 2005, and Location D in 2007 and 2008 (Figure 3-1). The maximum density (11,032/m²) at Location D in 2008 was the highest density reported from any of the four locations since this monitoring program began in 1990 (Duke Power Company 1994, 1998; Duke Power 2003). The minimum annual densities occurred at Location A in 2005 and 2007, Location C in 2003, 2006, and 2008, and Location D in 2004. Note that the annual macroinvertebrate densities at Location D (below the BSS discharge) for this reporting period were higher each year, except in 2004, than the annual densities at Location A (the control location farthest uplake) which has generally been the case since 1994 (Duke Power 2003). However, in comparison to densities at Location B (upstream of the BSS intake), densities at Location D were lower from 2003 to 2006, but were considerably higher in 2007 and 2008. Location C (discharge) had the lowest annual density (483/m²) in 2008, but had the highest density (4,788/m²) in 2005. The annual density at Location C in 2007 was also higher than the annual density uplake at Location A. Densities at each location from 2003 to 2008 were generally higher than those reported from 1998 to 2002, with the exception of 2001, and were more similar to the densities reported from 1994 to 1997 (Duke Power 2003). The lower annual densities from 1998 to 2002 may have resulted from a prolonged drought which occurred during this time period (Duke Power 2003).

Total densities were dominated each year at each location by either Oligochaeta, ranging from 181/m² (4%) to 7,078/m² (91%), or *Corbicula*, ranging from 0/m² (0%) to 3,280/m² (81%), except in 2004 when the "Other" category (all organisms except for *Corbicula*, Diptera, and Oligochaeta) was dominant at Location B and represented 31% (689/m²) of the

population (Tables 3-3 to 3-7 and Figures 3-3 to 3-6). The highest annual Oligochaeta density 8,395/m² (76%) was collected in 2008 from Location D. The percent of total Diptera densities collected at each location ranged between 5% (544/m²) in 2008 and 36% (439/m²) in 2004 (Tables 3-3 through 3-7 and Figures 3-3 through 3-6). The highest densities collected in the Other's category (all organisms except for *Corbicula*, Diptera, and Oligochaeta) were collected at Location B from 2003 to 2006, ranging from 439/m² to 809/m² and Location C in 2007 and 2008 with densities of 1,302/m² and 95/m², respectively (Tables 3-4 to 3-5 and Figures 3-4 to 3-5). The Other's category collected at Location B in 2004 represented 31% of the total number of organisms collected (689/m²) and was comprised mostly of Ephemeroptera *Hexagenia spp*. (Table 3-4; Table 3-7; and Figure 3-4). In 2007, the "Other" category also represented a high percentage (33%) of the total density collected at Location C (mostly Planariidae *Dugesia spp*., 1,137/m²), but *Corbicula* represented 52% (2,058/m²) of the total density that year at that location (Table 3-5; Table 3-7; and Figure 3-4).

Taxa

The number of macroinvertebrate taxa collected at a location is typically a good indicator of the overall diversity and the presence of a balanced indigenous population. Taxa abundance from 2003 to 2008 varied somewhat by year and location ranging from 9 to 36 taxa (Tables 3-3 to 3-6 and Figure 3-2) but was all within historically reported numbers, except in 2006 when the number of taxa (36) collected at Location B was the highest recorded since the monitoring program started in 1990 (Duke Power 1994 and 2003). The number of taxa collected generally decreased from 2003 to 2004, increased in 2005at each location, and were generally similar at each location through 2008. The only exceptions occurred in 2006 when the number of taxa collected at Locations A and B were the highest recorded for this reporting period (31 and 36, respectively) and in 2008 when only nine taxa were collected at Location C.

Spatially, the maximum and minimum numbers of taxa varied annually, as was the case with densities. Generally, the higher numbers were collected upstream of either Location A or B. The number of taxa collected from 2003 to 2008 from Locations A and B (17-36 taxa) were generally similar to those collected at Locations C and D (9-30 taxa). Although the lowest number of taxa collected during this six-year period occurred at the discharge location (Location C), generally the number of taxa collected from the discharge location each year was similar to those collected from the other locations. The Order Diptera and Class

Oligochaeta represented most of the taxa collected at each location from 2003 to 2008 (Tables 3-3 to 3-6).

SUMMARY

Buck Steam Station is located at the upper end of High Rock Lake in the transition zone from lotic to lentic habitat which may contribute to the variation in densities and number of taxa collected among locations each year (Duke Power 2003). Locations A and B tend to have more lotic characteristics, Location C can be considered to be more lotic when the station is operating, but lentic when the station is not operating, and Location D would be considered lentic. Baxter (1977), as cited in Soballe et al., 1992, reported that the maximum abundance of benthic macroinvertebrates is usually found in the upper end of a reservoir near the river inflow. The higher densities in the upper area of reservoirs are possibly due to the relatively higher concentrations of organic material (James et al. 1987). Densities at Location A each year, except in 2004, were lower than the downstream densities at Location D, but this may be due to the substrate matrix at Location A, which was primarily sand. Reid and Wood 1976 reported that substrate made up primarily of sand is not usually favored by benthic organisms. Densities reported each year at Location B, also uplake, were generally higher than those reported at Location A most likely due to more favorable substrate, which generally consisted of more silt and organic material. Milligan (1997) stated that benthic populations in habitats that are composed of silt and organically enriched substrate tend to have higher densities. The substrate collected at Location D was similar to that collected at Location B, but contained less organic material. Annual densities at Location D were also higher than those collected at Locations A and C each year, except for 2004.

The numbers of macroinvertebrate taxa collected each year at each location did vary somewhat, but not to the same extent as the densities. Higher numbers of taxa were generally collected uplake each year at either Location A or B, which is possibly due to those locations being more lotic in nature. In 2008, only nine taxa were collected at Location C (BSS discharge), but it was the only year, which the lowest number of taxa was collected at this location. Generally, the number of taxa collected each year, with the exceptions of 2003 and 2008, varied very little between locations.

The water quality parameters (temperature and DO) taken at the time of macroinvertebrate collections from 2005 to 2008 were sufficient to support life and did not indicate any

negative impact to the benthic communities. Water temperatures were slightly higher and DO slightly lower each year at Location D, in comparison to those at Location B, possibly due to Location D being lentic and Location B being more lotic and not necessarily due to any effects from BSS operations. Based on macroinvertebrate densities and taxa diversity observed during 2003 – 2008, the macroinvertebrate communities at these locations in the vicinity of BSS represent balanced and indigenous populations.

Table 3-1. General descriptions of the substrate found at Locations A, B, C, and D in the vicinity of BSS during July of 2003 – 2008. Substrates are listed with the most prevalent type first. Organic matter is typically composed of small sticks, leaf, and/or grass fragments.

DATE	A	B	C	D
7/25/03	sand organic matter	silt sand organic matter	silt sand organic matter	silt sand organic matter
7/30/04	sand silt organic matter	silt organic matter sand	gravel sand	silt sand organic matter
7/28/05	sand silt organic matter	sand silt organic matter	silt sand	silt sand organic matter
7/27/06	sand silt organic matter	silt sand organic matter	gravel sand	silt sand organic matter
7/20/07	silt organic matter sand	silt sand organic matter	gravel organic matter	silt sand organic matter
7/23/08	sand silt organic matter	organic matter sand silt	sand gravel organic matter	silt sand organic matter

Table 3-2. Dissolved oxygen (mg/L) concentrations and temperatures (°C) recorded from Locations A, B, C, and D at the time of macroinvertebrate collections. Measurements were recorded for the first time in 2005.

DATE	A	B	C	D
7/28/05	4.0 mg/L 27.1 °C	4.0 mg/L 27.8 °C	3.6 mg/L 28.1 °C	3.3 mg/L 29.1 °C
7/27/06	4.1 mg/L 26.0 °C	6.0 mg/L 26.2 °C	5.6 mg/L 34.5 °C	5.5 mg/L 26.4 °C
7/20/07	5.2 mg/L 27.6 °C	4.8 mg/L 27.3 °C	5.0 mg/L 34.5 °C	4.7 mg/L 27.8 °C
7/23/08	7.2 mg/L 29.6 °C	7.1 mg/L 29.6 °C	6.7 mg/L 38.0 °C	6.4 mg/L 31.0 °C

Table 3-3. Densities (No./m^2) of macroinvertebrates collected from Location A (upstream of BSS) from 2000 to 2008.

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Annelida									
Hirudinea									
Rhynchobdellida									
Glossiphoniidae									
Helobdella spp.						60			
Oligochaeta	1,283	3,814							
Branchiobdellida									
Branchiobdellidae							9		
Haplotaxida									
Naididae									
Nais communis							9		95
Pristina aequiseta			9						
Pristinella acuminata							9		
Pristinella jenkinae									34
Pristinella osborni							69	17	95
Pristinella sima					9		34		26
Uncinais uncinata				138					
Tubificidae		2,471	1,429	43	491	52	758	336	1,533
Aulodrilus limnobius					482		215	534	3,694
Aulodrilus pigueti					43			146	327
Bothrioneurum vejdovskyanum							9		
Branchirua sowerbyi								69	129
Limnodrilus hoffmeisteri		9			34	86	9	34	43
Potamothrix vejdovskyi					17		103	525	
Rhyacodrilus coccineus					9		34		
Tubifex harmani					26				1,102
Tubifex tubifex							43	310	
Lumbriculida									
Lumbriculidae									
Lumbriculus spp.							9		
Arthropoda									
Acari		17							
Crustacea									
Amphipoda									
Talitridae									
Hyalella azteca							9		
Insecta									
Coleoptera									
Elmidae									
Dubiraphia vittata					17				

Table 3-3. (Continued).

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Macronychus glabratus						9			9
Diptera									
Ceratopogonidae									
Dasyhelea spp.		9							
Palpomyia-Bezzia complex		17	17			121	17		
Chaoboridae									
Chaoborus spp.						17	17		
Chironomidae-Chironominae									
Cladotanytarsus spp.				26		9	52		
Cryptochironomus spp.		17	138	17	9	34	43	17	52
Demicryptochironomus spp.				34					
Dicrotendipes neomodestus									9
Harnischia spp.						60		43	17
Nilothauma spp.							9		
Paracladopelma spp.			17	26					
Paralauterborniella nigrohalterale		17	17		9	17		9	
Paratendipes spp.				26					
Polypedilum flavum	9			17			17		9
Polypedilum halterale		9	43	164	43	17	9		
Polypedilum illinoense									34
Polypedilum scalaenum			17	17		26	26		
Rheotanytarsus spp.						9			
Robackia claviger				155			9		
Robackia demeijerei			9	17	9		17		
Saetheria spp.				17		9			
Stictochironomus spp.	172	181	284	9			17		
Tanytarsus spp.							9		9
Chironomidae-Orthocladiinae									
Cricotopus bicinctus					9				
Rheosmittia spp.				52					
Thienemanniella spp.			17						
Chironomidae-Tanypodinae									
Ablabesmyia spp.	26					9		9	
Ablabesmyia annulata		9						17	9
Ablabesmyia simpsoni	9								
Coelotanypus spp.	189	198	17		181	34	43	60	267
Procladius spp.	9	60		9		17	9	121	215
Procladius bellus	9								
Simuliidae									
Simulium spp.					9				
Ephemeroptera									

Table 3-3. (Continued).

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Caenidae									
Caenis spp.	9		95		9	9	9		
Ephemeridae									
Hexagenia spp.	34		17		370	319	69	77	26
Heptageniidae									
Heptagenia spp.		121							
Odonata-Anisoptera									
Gomphidae									
Gomphus spp.	9				17	17			
Gomphus spiniceps								9	
Odonata-Zygoptera									
Coenagrionidae									
Argia spp.			9						
Trichoptera									
Leptoceridae									
Oecetis spp.		9			9	9		9	
Polycentropodidae									
Polycentropus spp.		9							
Mollusca									
Pelecypoda									
Heterodontida									
Corbiculidae									
Corbicula fluminea	138	26	499	3,280	499	1,145	809	198	
Nematoda			9						26
Total density for year (No./m ^{2})	**1,896**	**6,993**	**2,643**	**4,047**	**2,301**	**2,085**	**2,500**	**2,540**	**7,760**
Total taxa for year	**12**	**17**	**17**	**17**	**21**	**22**	**31**	**19**	**22**

Table 3-4. Densities (No./m^2) of macroinvertebrates collected from Location B (upstream of BSS below I-85 bridge) from 2000 to 2008.

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Annelida									
Hirudinea									
Rhynchobdellida									
Glossiphoniidae									
Placobdella spp.									17
Oligochaeta	1,464	2,970							
Haplotaxida									
Naididae									
Nais communis								17	
Pristina synclites							9		
Pristinella acuminata							17		
Pristinella osborni							77		43
Pristinella sima					17		52		146
Stylaria lacustris									34
Uncinais uncinata				17					
Tubificidae		2,437	1,240	189	370	577	861	1,886	1507
Aulodrilus limnobius				9	17	9	680	913	387
Aulodrilus pigueti					26		155	164	121
Branchirua sowerbyi			34		95	9	121	482	95
Limnodrilus hoffmeisteri				86	69	34		9	
Limnodrilus udekemianus			9						
Potamothrix vejdovskyi							17		
Rhyacodrilus coccineus							103		
Spirosperma nikolskyi							34		
Tubifex harmani					52		9		
Tubifex tubifex							103	956	1,050
Arthropoda									
Crustacea									
Isopoda									
Asellidae									
Caecidotea spp.		9							
Insecta									
Coleoptera									
Elmidae									
Dubiraphia spp.	9					17	9		
Macronychus glabratus						17	9		
Optioservus spp.	9								
Stenelmis spp.				17					
Diptera									
Ceratopogonidae	17								
Palpomyia-Bezzia complex	9			43		121			

Table 3-4 (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Chaoboridae									
Chaoborus spp.		112		9		138	9	9	17
Chironomidae-Chironominae									
Cladotanytarsus spp.				17			9		
Cryptochironomus spp.	9	17		52	9	43	60	17	9
Cryptotendipes spp.						9			
Demicryptochironomus spp.				17					
Harnischia spp.	9			103				17	9
Microchironomus spp.									9
Paracladopelma spp.				26				9	
Paralauterborniella nigrohalterale	17			34		34			
Paratendipes spp.				9					
Polypedilum flavum	17			26					
Polypedilum halterale		17		60	17	43	77	138	17
Polypedilum illinoense		9					26		
Polypedilum scalaenum				34		60			
Polypedilum simulans/ digitifer	9								
Pseudochironomus spp.				9					
Stenochironomus spp.	9			9					
Stictochironomus spp.	60	17		26		129	60	17	9
Tanytarsus spp.	17	17					17		26
Tribelos spp.		9					95		
Chironomidae-Orthocladiinae									
Parametriocnemus spp.	9								
Chironomidae-Tanypodinae									
Ablabesmyia spp.	9	52	9	34			26		
Ablabesmyia annulata	34		60		43	34		69	
Ablabesmyia mallochi				9		9			
Ablabesmyia janta					9		26		
Coelotanypus spp.	172	284	138		319	86	336	164	258
Natarsia spp.							9		
Procladius spp.	9	26			86	69	69	77	198
Procladius bellus	17	52							
Procladius (Holotanypus)		9							
Zavrelimyia gp.		9							
Ephemeroptera									
Caenidae									
Caenis spp.	138		9	327	17	9	103		9
Ephemeridae									
Hexagenia spp.	9	9	370		629	740	491	69	

Table 3-4. (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Heptageniidae									
Heptagenia spp.	9								
Maccaffertium modestum							26		
Tricorythodes spp.				17					
Odonata-Anisoptera									
Gomphidae			9						
Gomphus spp.	34			34	26		9		
Gomphus spiniceps								9	
Stylurus spp.		9							
Odonata-Zygoptera									
Coenagrionidae									
Argia spp.					17				
Enallagma spp.							9		
Plecoptera		9							
Trichoptera									
Hydropsychidae									
Cheumatopsyche spp.				9					
Hydropsyche phalerata				9					
Leptoceridae									
Oecetis spp.	9							17	
Triaenodes spp.				17					
Polycentropodidae									
Neureclipsus spp.				9					
Mollusca									
Gastropoda									
Basommatophora									
Physidae									
Physella spp.	9								
Pelecypoda									
Heterodontida									
Corbiculidae									
Corbicula fluminea	112	52	9	4,029	379	1,438	542	112	69
Veneroida									
Sphaeriidae									
Sphaerium spp.							9	9	
Nematoda		17				26	9	26	
Platyhelminthes									
Turbellaria									
Tricladida									
Planariidae									
Dugesia spp.	9							17	

Table 3-4. (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Density for Year (No./m^2)	2,234	6,142	1,887	5,286	2,197	3,651	4,273	5,203	4,030
Total Taxa for Year	27	21	10	30	18	22	36	23	20

Table 3-5. Densities (No./m^2) of macroinvertebrates collected from Location C (BSS discharge) from 2000 to 2008.

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Annelida									
Hirudinea									
Rhynchobdellida									
Glossiphoniidae									
Helobdella spp.								9	
Oligochaeta		43							
Haplotaxida									
Naididae							9		
Dero trifida				17					
Nais variabilis								9	
Pristinella osborni						17			
Tubificidae		43	86	1,438	17	2,316	258	207	69
Aulodrilus limnobius				138		422	77		
Aulodrilus pigueti				43		155	17	9	
Aulodrilus pluriseta				9					
Branchirua sowerbyi					9	26			
Ilyodrilus templetoni				9					
Limnodrilus spp.				9					
Limnodrilus hoffmeisteri				138	9				
Tubifex tubifex							43	9	
Polychaeta									
Sabellida									
Sabellidae									
Manayunkia speciosa								26	9
Arthropoda									
Insecta									
Coleoptera									
Elmidae			26						
Dubiraphia spp.				9					
Dubiraphia vittata									9
Macronychus glabratus		17			9	9	9		
Stenelmis spp.		77	129	26				52	60
Diptera									
Ceratopogonidae									
Alluaudomyia spp.		26							
Palpomyia-Bezzia complex			9	34				9	
Chaoboridae									
Chaoborus spp.						52			
Chironomidae-Chironominae									
Chironomus spp.						17			
Cladotanytarsus spp.							9	189	

Table 3-5. (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cryptochironomus spp.			34	34		43	34	26	
Dicrotendipes neomodestus		9					9		
Glyptotendipes spp.		9							
Harnischia spp.				34		17			
Nilothauma spp.								26	
Paracladopelma spp.								17	
Paralauterborniella nigrohalterale						77			
Paratendipes spp.				43					
Polypedilum fallax			9	9					
Polypedilum halterale				129		26		17	
Polypedilum illinoense				146	9		17		
Polypedilum scalaenum				250		34	9	26	
Robackia demeijerei					9		17		
Stenochironomus spp.		9		9	26				
Stictochironomus spp.		9	26	34	43	224	9		112
Tanytarsus spp.		26				26		9	
Tribelos spp.		17		95					
Chironomidae-Orthocladiinae									
Rheocricotopus spp.		9							
Chironomidae-Tanypodinae									
Ablabesmyia mallochi								9	
Coelotanypus spp.					17	215	17		
Conchapelopia gp.		9			9				
Procladius spp.						9			9
Rheopelopia spp.		9							
Simuliidae									
Simulium spp.									9
Ephemeroptera									
Baetidae	9								
Caenidae									
Caenis spp.	17		9			52	17		
Ephemeridae									
Hexagenia spp.						17			
Heptageniidae									
Maccaffertium spp.	43	60							
Maccaffertium modestum					9		60	52	
Odonata-Anisoptera									
Corduliidae									
Neurocordulia spp.					17				
Gomphidae									
Gomphus spp.				17	34		9		

Table 3-5. (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Trichoptera									
Leptoceridae									
Oecetis spp.							9	9	
Triaenodes spp.						9			
Polycentropodidae									
Polycentropus spp.					9				
Mollusca									
Gastropoda									
Basommatophora									
Physidae									
Physella spp.							9		17
Pulmonata									
Planorbidae		26							
Helisoma spp.					9				
Heterodontida									
Corbiculidae									
Corbicula fluminea	121	250	43	1,352	982	1,025	1,205	2,058	189
Veneroida									
Sphaeriidae									
Sphaerium spp.							17	17	
Nematoda									
Platyhelminthes									
Turbellaria									
Tricladida									
Planariidae									
Dugesia spp.		26			17		69	1,137	
Total Density for Year (No./m^2)	**190**	**674**	**371**	**4,022**	**1,234**	**4,788**	**1,929**	**3,922**	**483**
Total Taxa for Year	**4**	**18**	**9**	**23**	**17**	**21**	**22**	**21**	**9**

Table 3-6. Densities (No./m^2) of macroinvertebrates collected from Location D (downstream of BSS) from 2000 to 2008.

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Annelida									
Oligochaeta	2,058	3,986							
Haplotaxida									
Naididae							34		
Nais communis								155	103
Nais variabilis								155	86
Pristina breviseta								52	
Pristinella osborni								77	
Pristinella sima							52		284
Tubificidae		3,151	52	112	293	568	1,240	2,583	2,480
Aulodrilus limnobius				9	207		706	2,247	2,437
Aulodrilus pigueti				9	34		172	77	1,016
Aulodrilus pluriseta							17		
Branchirua sowerbyi		9				34	69	181	69
Limnodrilus hoffmeisteri				26		491	86	26	
Potamothrix vejdovskyi							9	129	
Tubifex tubifex							327	1,317	1,920
Arthropoda									
Insecta									
Coleoptera									
Elmidae			9						
Dubiraphia vittata									9
Macronychus glabratus						17			
Stenelmis spp.				17					
Diptera									
Ceratopogonidae									
Alluaudomyia spp.		9							
Palpomyia-Bezzia complex		9		43		77		17	
Chaoboridae									
Chaoborus spp.		43		9			26	121	
Chironomidae-Chironominae									
Chironomus spp.								9	26
Cladopelma spp.		9							
Cladotanytarsus spp.	9	77		9		9	9		
Cryptochironomus spp.	9	17	17	34		43	34	69	52
Demicryptochironomus spp.				9					
Harnischia spp.				17	9	9		26	
Microchironomus spp.									17
Nilothauma spp.				17					
Pagastiella ostansa			17						
Paracladopelma spp.				34					

Table 3-6. (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Paralauterborniella nigrohalterale				9		60		9	
Paratanytarsus spp.			9						
Paratendipes spp.			9	9					
Phaenopsectra spp.	9								
Polypedilum flavum	9			17					
Polypedilum halterale		17		241		60		69	
Polypedilum illinoense					17				
Polypedilum laetum						9			
Polypedilum scalaenum				17		112	9	9	
Rheotanytarsus spp.				9		9			
Robackia demeijerei				9					
Saetheria spp.				9					
Stenochironomus spp.				17		9			
Stictochironomus spp.	17	52	34	138	17	215	17	86	26
Tanytarsus spp.	86	17		26		9			69
Chironomidae-Orthocladiinae									
Orthocladius spp.			26						
Chironomidae-Tanypodinae									
Ablabesmyia spp.		9							
Ablabesmyia annulata							9	69	
Ablabesmyia mallochi				9		17			9
Coelotanypus spp.	43	86			387	9	155	103	224
Conchapelopia gp.				9					
Procladius spp.		9			9		52	112	121
Procladius (Holotanypus)		9							
Ephemeroptera									
Caenidae									
Caenis spp.	17	9		17	9				60
Ephemeridae									
Hexagenia spp.						17	112	60	9
Odonata-Anisoptera									
Gomphidae									
Gomphus spp.				9					
Trichoptera									
Hydropsychidae									
Hydropsyche venularis				207					
Leptoceridae									
Oecetis spp.	9	9						26	
Mollusca									
Pelecypoda									
Heterodontida									

Table 3-6. (Continued)

Taxa	2000	2001	2002	2003	2004	2005	2006	2007	2008
Corbiculidae									
Corbicula fluminea	232	310	982	3,100	232	1,576	465	456	2,015
Veneroida									
Sphaeriidae									
Sphaerium spp.								34	
Nematoda						26	26		
Platyhelminthes									
Turbellaria									
Tricladida									
Planariidae									
Dugesia spp.						9			
Total Density for Year (No./m^2)	**2,498**	**7,837**	**1,155**	**4,197**	**1,214**	**3,385**	**3,626**	**8,274**	**11,032**
Total Taxa for Year	**11**	**19**	**9**	**30**	**10**	**22**	**21**	**27**	**20**

Table 3-7. Densities (No./m^2) and percent composition (in parentheses), of each major macroinvertebrate category collected from High Rock Lake in the vicinity of BSS from 2000 to 2008.

Location A

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Other	52 (3)	156 (2)	130 (5)	0 (0)	422 (18)	423 (20)	87 (3)	95 (4)	61 (1)
Diptera	423 (22)	517 (7)	576 (22)	586 (14)	269 (12)	379 (18)	294 (12)	276 (11)	621 (8)
Corbicula	138 (7)	26 (<1)	499 (19)	3,280 (81)	499 (22)	1,145 (55)	809 (32)	198 (8)	0 (0)
Oligochaeta	1,283 (68)	6,294 (90)	1,438 (54)	181 (4)	1,111 (48)	138 (7)	1,310 (52)	1,971 (78)	7,078 (91)

Location B

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Other	235 (11)	53 (1)	388 (21)	439 (8)	689 (31)	809 (22)	674 (16)	147 (3)	26 (1)
Diptera	423 (19)	630 (10)	207 (11)	517 (10)	483 (22)	775 (21)	819 (19)	517 (10)	552 (14)
Corbicula	112 (5)	52 (1)	9 (<1))	4,029 (76)	379 (17)	1,438 (39)	542 (13)	112 (2)	69 (2)
Oligochaeta	1,464 (66)	5,407 (88)	1,283 (68)	301 (6)	646 (29)	629 (17)	2,238 (52)	4,427 (85)	3,383 (84)

Location C

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Other	69 (36)	206 (31)	164 (44)	52 (1)	104 (8)	87 (2)	199 (10)	1302 (33)	95 (20)
Diptera	0 (0)	132 (20)	78 (21)	817 (20)	113 (9)	740 (15)	121 (6)	328 (8)	130 (27)
Corbicula	121 (64)	250 (37)	43 (12)	1,352 (34)	982 (80)	1,025 (21)	1,205 (62)	2,058 (52)	189 (39)
Oligochaeta	0 (0)	86 (13)	86 (23)	1,801 (45)	35 (3)	2,936 (61)	404 (21)	234 (6)	69 (14)

Table 3-7. (Continued).

Location D

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Other	26 (1)	18 (<1)	9 (1)	250 (6)	9 (1)	69 (2)	138 (10)	120 (1)	78 (1)
Diptera	182 (7)	363 (5)	112 (10)	691 (16)	439 (36)	647 (19)	311 (9)	699 (8)	544 (5)
Corbicula	232 (9)	310 (4)	982 (85)	3,100 (74)	232 (19)	1,576 (47)	465 (13)	456 (6)	2,015 (18)
Oligochaeta	2058 (82)	7,146 (91)	52 (5)	156 (4)	534 (44)	1,093 (32)	2,712 (75)	6,999 (85)	8,395 (76)

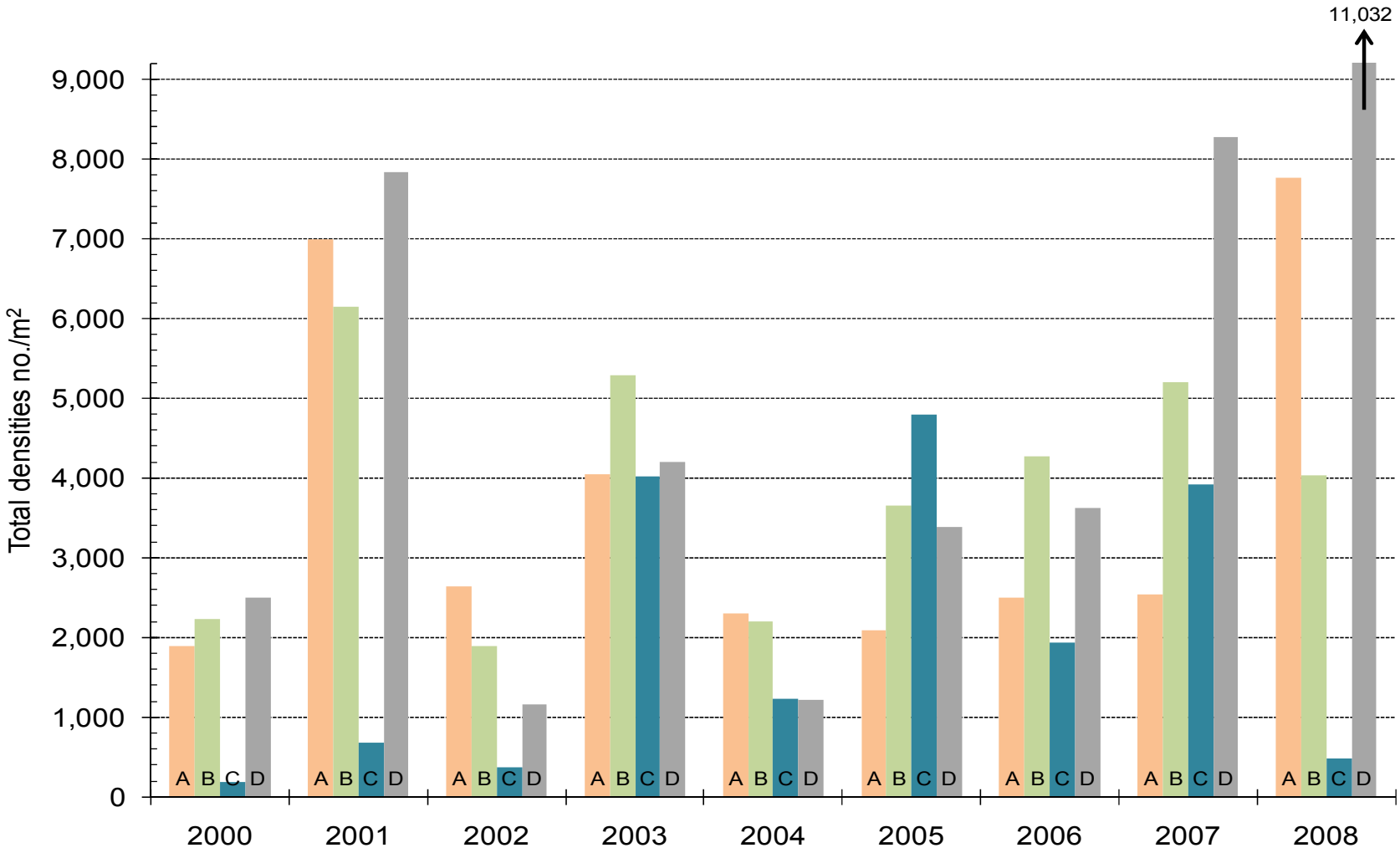

Figure 3-1. Density (No./m^2) of macroinvertebrates collected annually from the Yadkin River near BSS from 2000 to 2008.

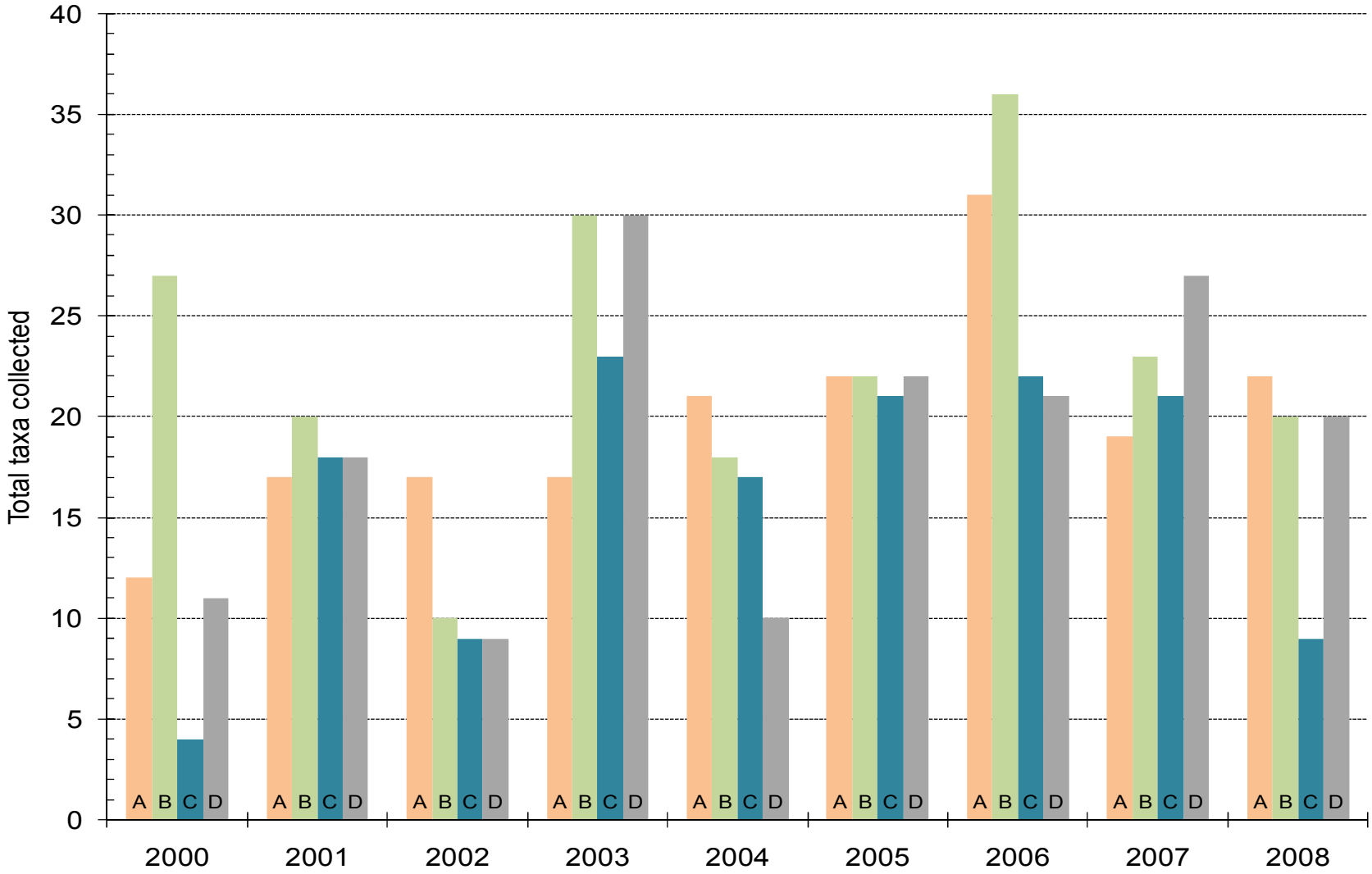

Figure 3-2. Total number of taxa collected annually from the Yadkin River near BSS from 2000 to 2008.

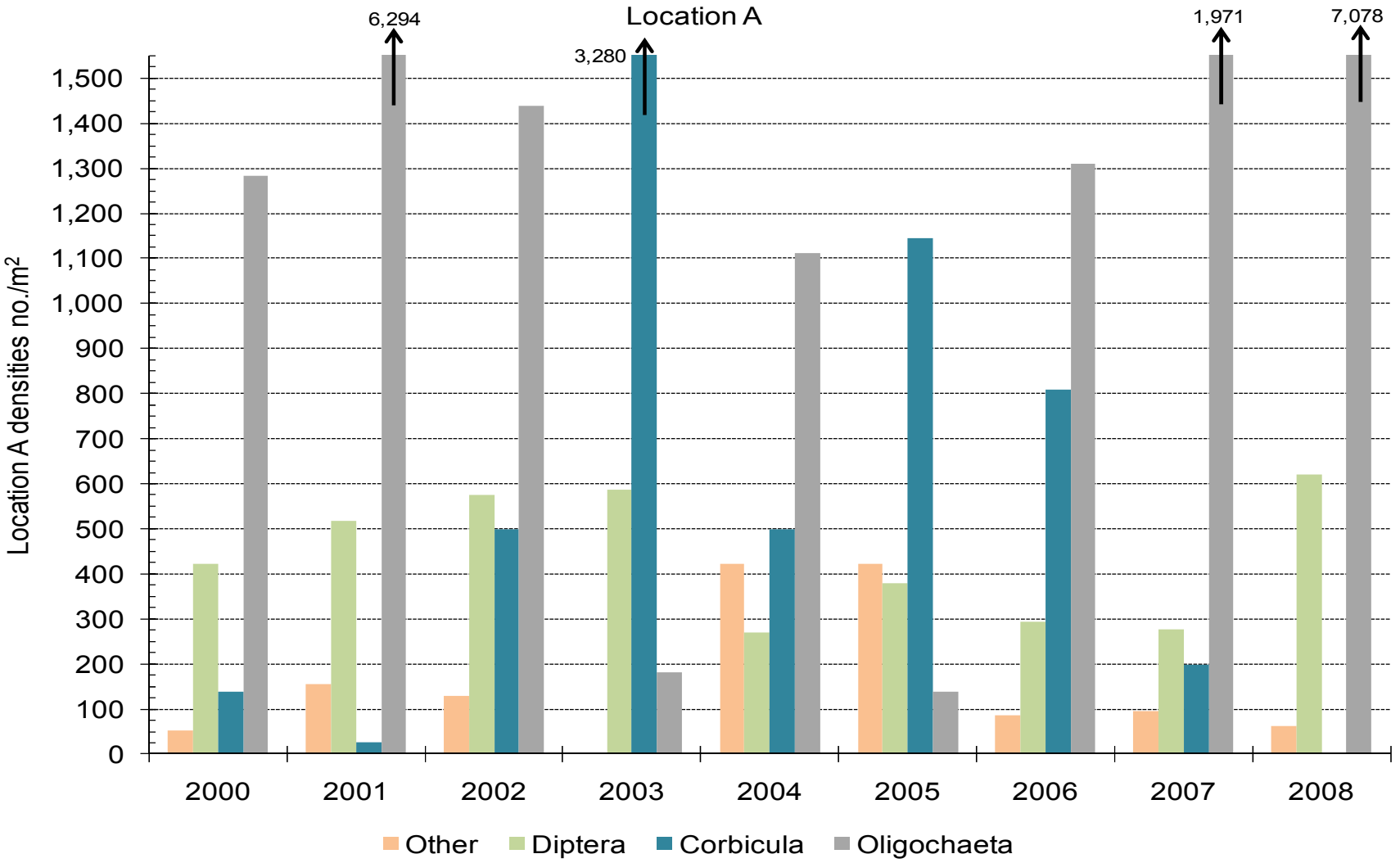

Figure 3-3. Density (No./m^2) of Other, Diptera, *Corbicula*, and Oligochaeta collected annually from Location A (upstream of BSS) from 2000 to 2008.

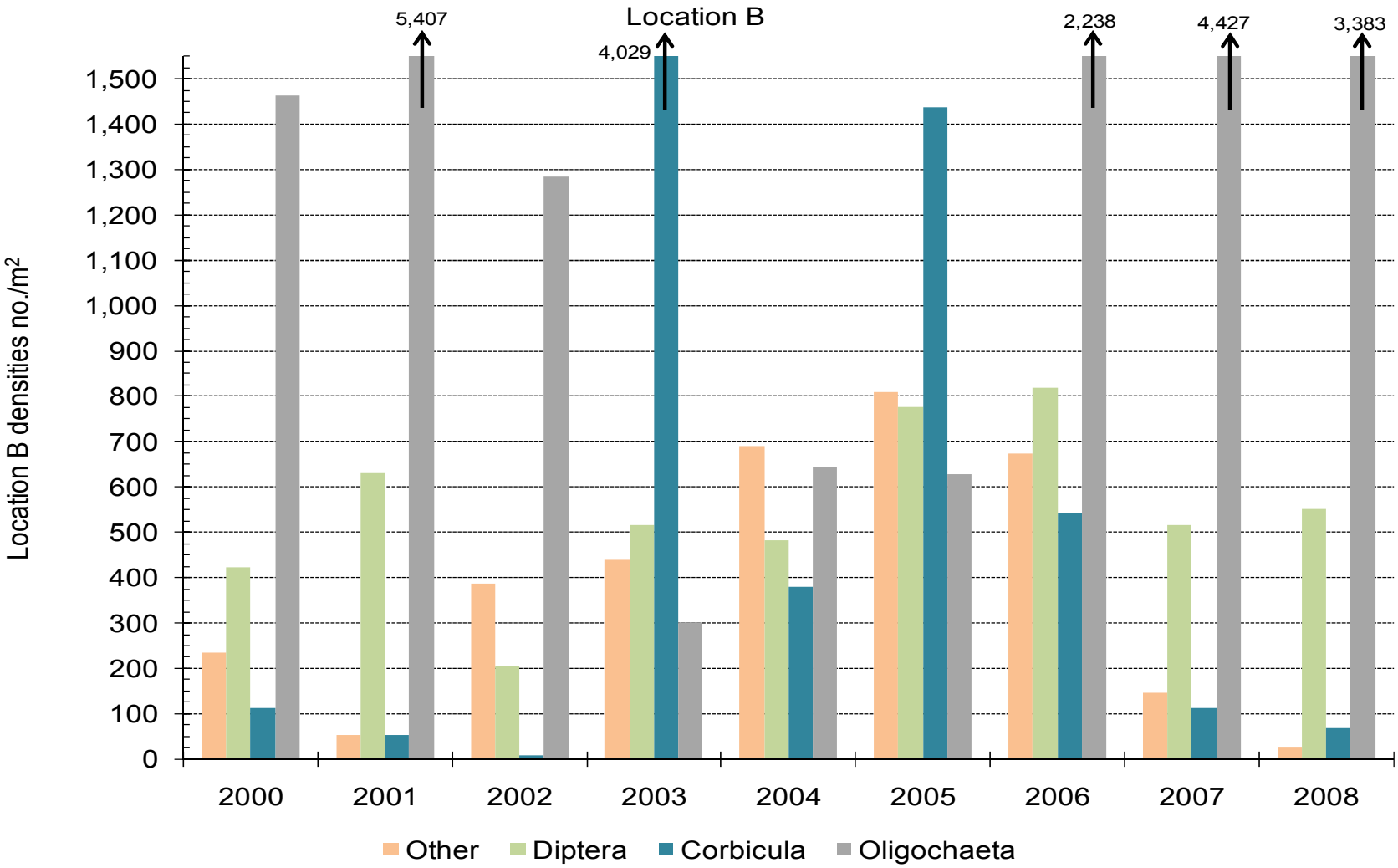

Figure 3-4. Density (No./m^2) of Other, Diptera, *Corbicula*, and Oligochaeta collected annually from Location B (upstream of BSS below I-85 bridge from 2000 to 2008.

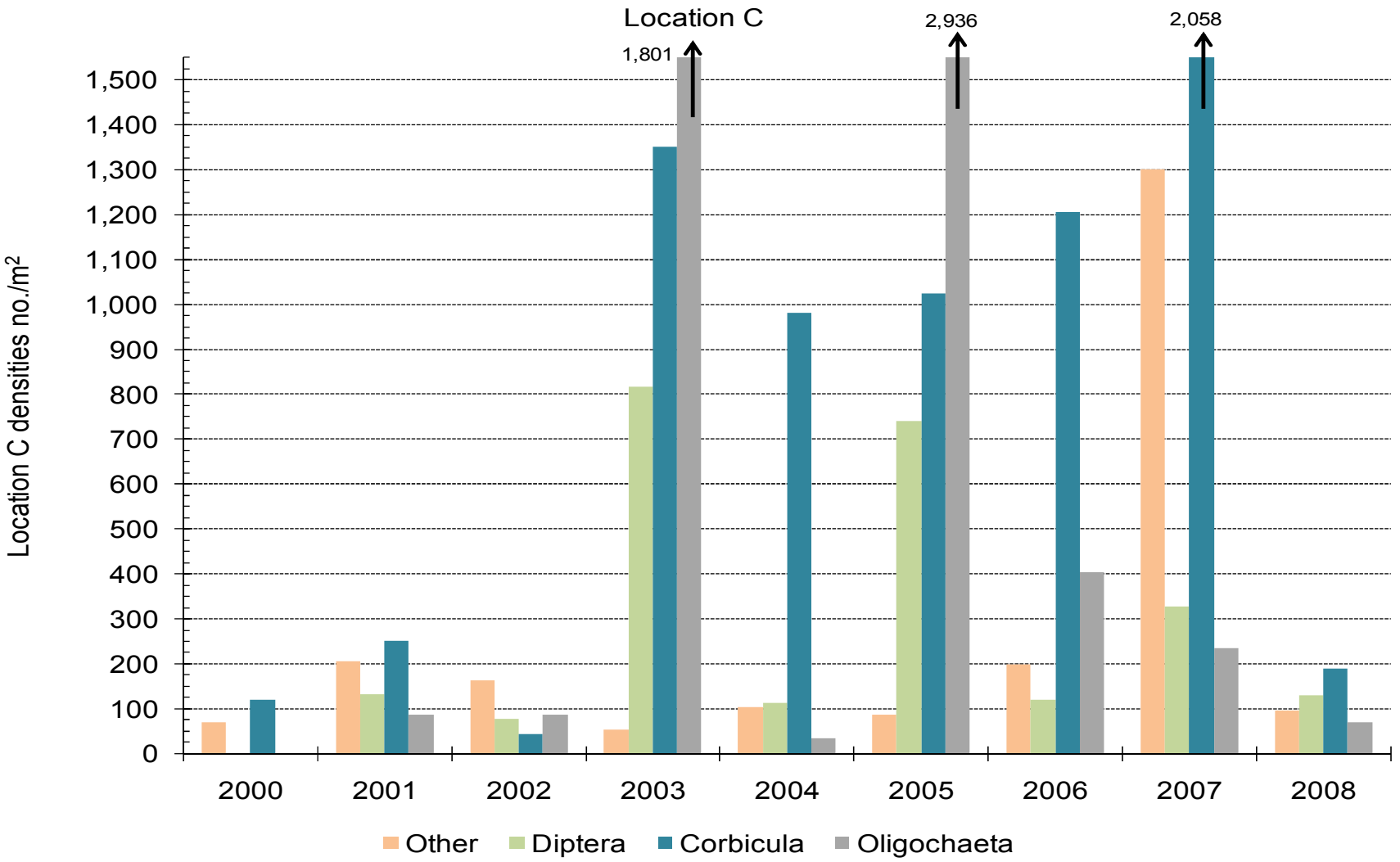

Figure 3-5. Density (No./m^2) of Other, Diptera, *Corbicula*, and Oligochaeta collected annually from Location C (BSS discharge) from 2000 to 2008.

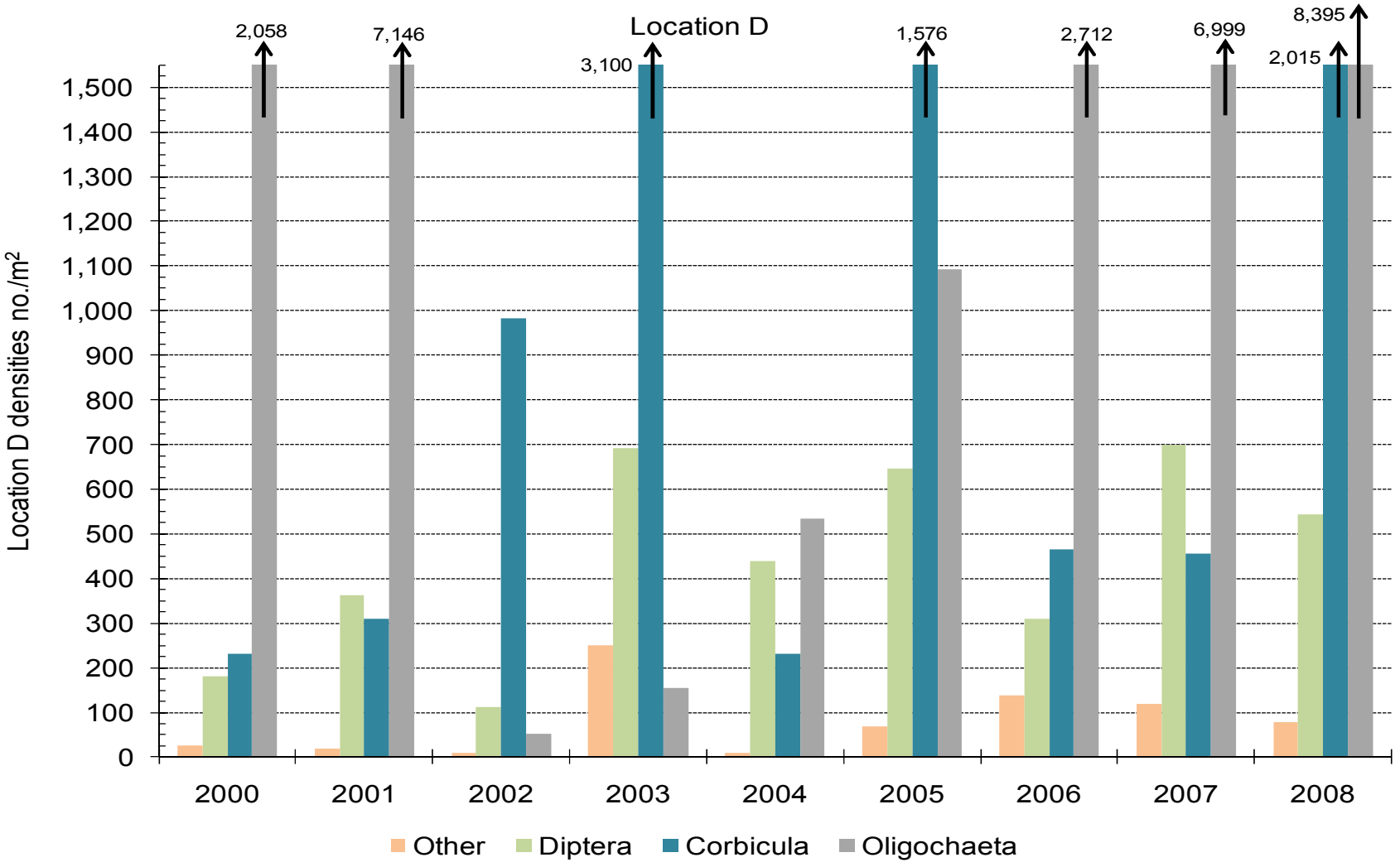

Figure 3-6. Density (No./m^2) of Other, Diptera, *Corbicula*, and Oligochaeta collected annually from Location D (downstream of BSS) from 2000 to 2008.

CHAPTER 4

FISH

MATERIALS AND METHODS

Fish collections were made in the Yadkin River near Buck Steam Station (BSS) during January and July/August, 2003 – 2009. Boat-mounted electrofishing equipment and methods were consistent with those used during previous study periods (Duke Power Company 1998 and Duke Power 2003). All netted fish were measured (total length in mm), weighed (g), and returned to the river, with the exception of a few fish that were preserved in formalin and returned to the laboratory for taxonomic identification. Fish identification followed Menhinick (1991).

Sampling locations consisted of two locations upstream from the BSS intake (A and B), a discharge location (C), and a location downstream (D) of the BSS discharge (Figure 2-1). Sampling locations were identical to those used during past study periods. Shoreline segments of 100 m were electrofished on the left and right ascending banks at each of these locations, yielding the designations A-L, A-R, B-L, B-R, C-L, C-R, D-L, and D-R.

As much as practical, electrofishing was conducted during periods of relatively low river flow to make fish collection as efficient as possible and to minimize variability due to sampling conditions. Water temperature (°C) and dissolved oxygen (DO) concentration (mg/L) were measured at each location, with a calibrated thermistor and DO probe, respectively. Water samples for specific conductance (µS/cm) were also collected at each segment, refrigerated, and returned to the laboratory where the samples were measured with a calibrated Hydrolab® Datasonde.

RESULTS AND DISCUSSION

Water Quality

Continuous in-river monitoring indicated that water temperature, in general, increased from 2003 to 2009 tracking ambient air temperature (Figure 2-4). Water temperatures measured during fish collections ranged from 1.8 ºC (Location A, both sides) in 2009 to 35.3 ºC (C-L) in 2006 (Appendix Tables A-1 to A-14). The annual mean flows of 2003 and 2004 were above the historical mean flow while 2005 – 2009 were below the historical mean flow (Figure 2-2). The annual mean flows for 2003 and 2008 were the second highest and second lowest, respectively, over the 46-year span of the gauge.

Water temperatures at A-L averaged 0.4 ºC warmer than A-R, and B-R averaged 0.4 ºC warmer than B-L, both differences within thermister tolerance ranges (+/- 2.0 ºC). However, shoreline segment water temperatures differed within and between discharge and downstream locations due to BSS operation. When BSS was operating during fish collections, the left side segments at Locations C and D averaged 4.9 ºC and 1.3 ºC higher, respectively. Although Location D segment averages are within tolerance ranges of the thermisters, the trend reveals the limited thermal influence of BSS operation.

Dissolved oxygen concentrations measured during fish collections ranged from 5.6 mg/L (C-L) in 2004 to 13.9 mg/L (C-R) in 2004. No DO concentrations were measured below the instantaneous water quality standard (4.0 mg/L) or the daily average water quality standard of 5.0 mg/L (NCDENR 2007c). The lowest DO value (5.6 mg/L) was recorded during summer 2005 at C-L.

Fish Community

A total of 44 species has been recorded from this reach of the Yadkin River near BSS since 1977 (Table 4-1), with the bowfin being collected for the first time in January 2004 (C-L). No threatened or endangered species have been collected during our studies. Variation in the abundance of individual species has long been noted. Analysis of Yadkin River fish collected by Duke Energy over the last 20 years (19,028 individuals captured from 1990 to 2009) indicates that the five most abundant species are bluegill *Lepomis macrochirus* (39.78%), red shiner *Cyprinella lutrensis* (11.75%), pumpkinseed *L. gibbosus* (8.11%), gizzard shad *Dorosoma cepedianum* (7.98%), and largemouth bass *Micropterus salmoides*

(5.15%). These five species would be considered the Representative Important Species (RIS) in the Yadkin River near BSS. Multiple species (n = 35) constituted less than 1.0% of the total number collected from 1990 to 2009.

A diverse fish community was present from 2003 to 2009 representing 38 species, 10 families, and totaling 7,260 individuals (Table 4-2). Sunfish (Centrarchidae = 65.50%), minnows (Cyprinidae = 20.11%), and shad (Clupeidae = 10.17%) numerically dominated catches. The remaining fish families each contributed less than 3% of the total catch as follows: temperate bass (Moronidae = 1.67%), catfish (Ictaluridae = 1.45%), livebearers (Poeciliidae = 0.45%), gar (Lepisosteidae = 0.33%), darters and perch (Percidae = 0.19%), suckers (Catostomidae = 0.12%), and bowfin (Amiidae = 0.01%).

Electrofishing Catch

Fish collections during January and July/August, 2003 – 2009, were made to assess fish distributions near BSS during the winter and summer. Fish attraction to warm thermal effluents during winter could be detrimental to populations if the power plant shutdown occurred rapidly. This phenomenon is known as cold shock.

Electrofishing catch rates (number of fish and number of species/100 m of shoreline) for all locations, from 2003 to 2009, varied and ranged from 0 to 388 fish/100 m and from 0 to 15 species/100 m of shoreline, respectively (Figures 4-1 and 4-2; and Appendix Tables A-1 to A-14). Data were generally similar to those collected during past study periods (Duke Power Company 1998 and Duke Power 2003). Monthly data were grouped by location relative to BSS (i.e., Locations A and B represent the Upstream area, Location C represents the Discharge area, and Location D is the Downstream area) to facilitate upstream to downstream comparisons and potential impacts of BSS.

Number of fish/100 m

Numbers of fish/100 m collected in January (2003 – 2009) were typically variable and ranged from 0 to 388 fish/100 m. The highest average value was observed at discharge segment C-L (152.14). Segments D-L (61.71), A-L (61.57), and B-R (59.29) values were similar, with D-L having some influence from the BSS discharge. The lowest average value was observed at C-R (24.29), with similar values at B-L (27.43), D-R (30.00), and A-R (33.29). Historical

data (1994 – 2002) also indicated a strong attraction of fish to the BSS discharge (C-L average = 195.33).

Numbers of fish/100 m collected in July/August (2003 – 2009) were typically variable and ranged from 12 to 270 fish/100 m. The highest average value was observed at D-L (131.67). Segment C-L had the second highest average value (113.00), although observed water temperature at the discharge location averaged 4.9 ºC higher than C-R, and was the highest overall. The remaining segment averages ranged from 42.00 to 96.33, segments D-R and A-L, respectively. These averages were similar to 1990 – 2002 values that ranged from 27.23 to 92.07.

Heterogeneous substrates, rocky outcrops, and submerged structure (tree branches) likely contributed to the general trend of more fish collected at discharge segment C-L since surveys began in 1990. However, A-L and D-L have similar heterogeneous habitat characteristics with lower numbers of fish. There was no indication of reduced numbers of fish at locations influenced by the BSS at the Discharge and Downstream areas relative to the Upstream area.

Number of species/100 m

Number of fish species collected in January (2003 – 2009) ranged from 0 to 15 species/100 m, segments A-L in 2009 and C-L in 2003, respectively (Figure 4-3). Analysis of the data indicated that C-L (10.86) and C-R (3.71) averaged a relatively high and low number of species, respectively. Overall, the average number of species collected at the remaining locations was slightly lower relative to 1994 – 2002 values.

Number of fish species collected in July/August (2003 – 2009) ranged from 4 to 16 species/100 m (Figure 4-4). Analysis of the data indicated that segments A-L (12.14) and C-R (7.14) averaged a relatively high and low number of species, respectively. Overall, the average number of species collected was similar at the remaining locations and also similar to 1994 – 2002 values.

Heterogeneous habitat likely contributed to the general trend of more fish species collected at discharge segment C-L since surveys began in 1990. However, segments A-L and D-L have similar heterogeneous habitat characteristics with lower numbers of fish species than C-L.

There was no indication of reduced numbers of fish species at locations influenced by BSS (i.e., Discharge and Downstream areas) relative to the Upstream area.

Pollution Tolerance

The presence or absence of various fish species may be indicative of conditions in a specific water body. These conditions can include physical habitat quality, water quality (including thermal influences), biotic interactions, and energy supply. To evaluate conditions in a waterbody, or at particular locations within a waterbody, each fish species has been assessed for its ability to withstand pollution and then assigned a pollution tolerance rating of Intolerant, Intermediate, or Tolerant (NCDENR 2006 and Table 4-3). The more species considered Intolerant of pollution that are encountered in a sample, the less the likelihood that the waterbody is impacted by pollutants. The majority of fish species have an Intermediate pollution tolerance rating; however, Tolerant species are typically encountered in most fish surveys. A water course is considered stressed when Tolerant individuals numerically dominate the sample. For this pollution tolerance evaluation, fish collected at each shoreline segment from 2003 to 2009 were pooled and characterized by area relative to the BSS thermal discharge.

The only Intolerant species encountered in the Yadkin River (2003 – 2009) was a single fieryblack shiner *Cyprinella pyrrhomelas* collected at segment A-R, January 2008. Fish with an Intermediate pollution tolerance rating comprised the majority of individuals collected from 2003 to 2009, with segment composition ranging from 51.36 (A-R) to 90.52% (B-R). The Discharge and Downstream areas had the highest composition of Tolerant fish, mostly red shiners, and Intermediate fish, mostly bluegill, respectively.

Intermediate species far outnumbered Tolerant species in all three areas. The Discharge area had the highest percentage of Tolerant species (30.36%) and, conversely, the lowest percentage of Intermediate species (69.64%). Pollution tolerance data did not identify the Discharge or Downstream areas near BSS as impaired.

Trophic Structure

Just as tolerance ratings provide clues to fish distributions and pollution impacts, trophic ratings reflect the effects of biotic interactions and energy supply (NCDENR 2006). For example, a stream receiving excessive nutrient enrichment may be expected to show an

increased abundance of omnivores and herbivores. The NCDENR (2006) rates wadeable North Carolina Piedmont streams by three trophic metrics and classifies streams as undisturbed if the total percentage of omnivores and herbivores is between 10% and 35%, the percentage of insectivores is between 60% and 90%, or the percentage of piscivores is ≥ 1%. It is noted that these metrics were developed for wadeable streams and not the larger river habitat that typifies the Yadkin River near BSS; these metrics are provided for guidance only.

Trophic guild data from 2003 to 2009 were summarized for each segment and area (Table 4-3). The only herbivorous species collected was the eastern silvery minnow *Hybognathus regius* and it was generally found throughout the river in low percentages comprising 0.65% of all fish collected. The total percentage of omnivores and herbivores was between 10.0% and 35% only at the Discharge area while insectivorous and piscivorous species composed 60-90% and ≥ 1%, respectively, at all areas. Only the Discharge area met the criterion for an undisturbed wadeable stream, although the Upstream and Downstream areas were similar. Trophic rating data did not identify the Discharge or Downstream areas near BSS as impaired.

Reproduction and Growth of Representative Important Species

Representative Important Species (RIS) in the Yadkin River near BSS represent those species collected in the highest numbers and amenable to an analysis of length frequency histograms. Species demonstrating successful spawning and growth over time should have length frequency histograms characterized by a species-specific range of lengths and possibly several peaks (i.e., small fish recruit into the community and increase in size between years, depending on species longevity). Differences in size distributions within a year should be demonstrated by an increase in modal lengths between fish collected in January and July/August. Additionally, differences in modal lengths, if present, should also be discernable among the Upstream, Discharge, and Downstream areas. To simplify analysis and provide adequate sample size for the histograms, 2003 – 2009 data were combined by season for each of the three RIS (bluegill, largemouth bass, and red shiner) and categorized by area.

Bluegill

A wide variety of bluegill sizes was collected in January and July/August. Bluegill total lengths ranged from 24 to 195 and from 21 to 184 mm in January and July/August, respectively (Figure 4-5 and 4-6). In January overwintering juvenile bluegill were collected at a modal TL class of 55 mm in the Upstream area, 60 mm in the Discharge area, and 55 mm in the Downstream area. In July/August juvenile bluegill were collected at a modal TL class of 40 mm in the Upstream area, 40 mm in the Discharge area, and 35 mm in the Downstream area. Second, and to a lesser extent, third winter and summer peaks were apparent. There was no discernable difference in growth rates among the three areas as modal TL classes for January and July/August were either the same or adjacent. Growth and reproduction of bluegill were not impacted by BSS operations.

Largemouth bass

A wide variety of largemouth bass sizes was collected in January and July/August. Largemouth bass total lengths ranged from 44 to 471 and from 28 to 520 mm in January and July/August, respectively (Figures 4-7 and 4-8). In January overwintering juvenile largemouth bass were collected at a modal TL class of 100 mm in the Upstream area, 125 mm in the Discharge area, and 100 mm in the Downstream area. In July/August juvenile largemouth bass were collected at a modal TL class of 75 mm in all three areas. Second, and to a lesser extent, third winter and summer peaks were apparent. There was no discernable difference in growth rates among the three areas as modal TL classes for January and July/August were either the same or adjacent. Growth and reproduction of largemouth bass were not impacted by BSS operations.

Red Shiner

A wide variety of red shiner sizes was collected in January and July/August. Red shiner total lengths ranged from 17 to 77 and from 33 to 86 mm in January and July/August, respectively (Figures 4-9 and 4-10). In January overwintering juvenile red shiner were collected at a modal TL class of 35 mm in the Upstream area, 35 mm in the Discharge area, and 40 mm in the Downstream area. In July/August juvenile red shiner were collected at a modal TL class of 65 mm in the Upstream area, 60 mm in the Discharge area, and 70 mm in the Downstream area in July/August. A second winter peak was apparent. Although there was no discernable difference in growth rates between Upstream and Discharge areas, Downstream red shiner

appear to have a higher growth rate as modal TL classes for January and July/August were higher. Growth and reproduction of red shiner were not negatively impacted by BSS operations.

SUMMARY

Overall, a diverse fish community was present in the Yadkin River near BSS from 2003 to 2009, and this community has been generally consistent for the last 30 years, with minor exceptions. This collection is represented by a total of 38 species and ten families, dominated by sunfish (Centrarchidae), minnows (Cyprinidae), and shad (Clupeidae). Similar species compositions have been reported in fish collections from the same area near BSS in 1977 (Wingo and Adair 1981), 1991 – 1993 (Duke Power Company 1993), 1994 – 1997 (Duke Power Company 1998), and 1998 – 2002 (Duke Power 2003).

Fish sampling metrics associated with species composition, catch (number of individuals and species/100m), and ecological function (pollution tolerance, trophic status, and the reproduction and growth of RIS) failed to indicate negative impacts associated with BSS. Although the Yadkin River fish community experiences thermal loading from BSS, nutrient inputs from point sources within the watershed, excessive sediment impacts from tributaries and upstream dams, occasional multi-year droughts, and predation pressures from introduced exotic predators (i.e., flathead catfish), it continues to maintain a diverse and self-sustaining population.

Table 4-1. Pollution tolerance rating, trophic guild of adults, and fish species collected during studies of the Yadkin River near BSS, 1997 – 2009.

Scientific name	Common name	Tolerance rating	Trophic guild of adults	Wingo and Adair 1981	Duke Power Co. 1993	Duke Power Co. 1998	Duke Power 2003	**Duke Energy 2011**
Lepisosteidae								
Lepisosteus osseus	Longnose gar	Tolerant	Piscivore	X	X	X	X	**X**
Amiidae								
Amia calva	Bowfin	Tolerant	Piscivore					**X**
Clupeidae								
Alosa aestivalis	Blueback herring	Intermediate	Insectivore			X		**X**
Dorosoma cepedianum	Gizzard shad	Intermediate	Insectivore	X	X	X	X	**X**
Dorosoma petenense	Threadfin shad	Intermediate	Omnivore	X	X	X	X	**X**
Dorosoma hybrid	Gizzard x threadfin hybrid	Intermediate	Omnivore		X	X		
Cyprinidae								
Carassius auratus	Goldfish	Tolerant	Omnivore		X	X	X	**X**
Cyprinella analostanus	Thicklip chub	Intolerant	Insectivore				X	
Cyprinella labrosa	Satinfin shiner	Tolerant	Insectivore	X	X	X	X	**X**
Cyprinella lutrensis	Red shiner	Tolerant	Insectivore	X	X	X	X	**X**
Cyprinella nivea	Whitefin shiner	Intermediate	Insectivore	X		X		**X**
Cyprinella pyrrhomelas	Fieryblack shiner	Intolerant	Insectivore					**X**
Cyprinus carpio	Common carp	Tolerant	Omnivore	X	X	X	X	**X**
Hybognathus regius	Eastern silvery minnow	Intermediate	Herbivore			X	X	**X**
Nocomis leptocephalus	Bluehead chub	Intermediate	Omnivore			X		**X**
Notemigonus crysoleucas	Golden shiner	Tolerant	Omnivore	X	X	X	X	**X**
Notropis hudsonius	Spottail shiner	Intermediate	Omnivore		X			**X**
Notropis scepticus	Sandbar shiner	Intermediate	Insectivore				X	
C. auratus X C. carpio hybrid	Goldfish X carp hybrid	Tolerant	Omnivore		X	X		**X**
Catostomidae								
Carpiodes cyprinus	Quillback	Intermediate	Omnivore	X		X	X	
Catostomus commersonii	White sucker	Tolerant	Omnivore				X	**X**
Moxostoma collapsum	Notchlip redhorse	Intermediate	Insectivore		X	X		**X**
Moxostoma macrolepidotum	Shorthead redhorse	Intermediate	Insectivore		X	X	X	**X**
Moxostoma pappillosum	V-lip redhorse	Intermediate	Insectivore			X	X	
Scartomyzon sp.	Brassy jumprock	Intermediate	Insectivore				X	**X**
Ictaluridae								
Ameiurus catus	White catfish	Tolerant	Omnivore	X	X	X	X	**X**
Ameiurus melas	Black bullhead	Tolerant	Insectivore		X			
Ameiurus nebulosus	Brown bullhead	Tolerant	Omnivore	X		X	X	**X**
Ictalurus punctatus	Channel catfish	Intermediate	Omnivore	X	X	X	X	**X**
Pylodictis olivaris	Flathead catfish	Intermediate	Piscivore		X	X	X	**X**
Poeciliidae								
Gambusia holbrooki	Eastern mosquitofish	Tolerant	Insectivore	X	X	X	X	**X**
Moronidae								
Morone americana	White perch	Intermediate	Piscivore	X	X	X	X	**X**
Morone chrysops	White bass	Intermediate	Piscivore	X	X	X	X	**X**
Morone saxatilis	Striped bass	Intermediate	Piscivore	X	X		X	
Centrarchidae								
Lepomis auritus	Redbreast sunfish	Tolerant	Insectivore	X	X	X	X	**X**
Lepomis cyanellus	Green sunfish	Tolerant	Insectivore	X	X	X	X	**X**
Lepomis gibbosus	Pumpkinseed	Intermediate	Insectivore	X	X	X	X	**X**
Lepomis gulosus	Warmouth	Intermediate	Insectivore	X	X	X	X	**X**
Lepomis macrochirus	Bluegill	Intermediate	Insectivore	X	X	X	X	**X**
Lepomis microlophus	Redear sunfish	Intermediate	Insectivore	X	X	X	X	**X**
Lepomis hybrid	Hybrid sunfish	Tolerant	Insectivore	X	X	X	X	**X**
Micropterus punctulatus	Spotted bass	Intermediate	Piscivore				X	**X**
Micropterus salmoides	Largemouth bass	Intermediate	Piscivore	X	X	X	X	**X**
Micropterus hybrid	Hybrid black bass	Intermediate	Piscivore					**X**
Pomoxis annularis	White crappie	Intermediate	Piscivore	X	X	X	X	**X**
Pomoxis nigromaculatus	Black crappie	Intermediate	Piscivore	X	X	X	X	**X**
Percidae								
Etheostoma olmstedi	Tessellated darter	Intermediate	Insectivore					**X**
Perca flavescens	Yellow perch	Intermediate	Piscivore		X	X	X	**X**
		Total number of species		25	29	33	35	**38**

Table 4-2. Species composition of electrofishing samples collected from the Yadkin River near BSS 2003 – 2009.

Common name	Upstream				Discharge		Downstream		Total	Percent composition
	A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L		
Lepisosteidae										
Longnose gar		6	4	1	1	9	3		**24**	**0.33%**
Amiidae										
Bowfin						1			**1**	**0.01%**
Clupeidae										
Blueback herring	7						1		**8**	**0.11%**
Gizzard shad	24	53	40	39	24	185	22	32	**419**	**5.77%**
Threadfin shad	11	33	9	17	7	229	2	3	**311**	**4.28%**
Cyprinidae										
Goldfish	1			2	1	14	3	3	**24**	**0.33%**
Satinfin shiner	84	124	6	11	13	8	12	15	**273**	**3.76%**
Red shiner	180	94	38	87	110	280	91	48	**928**	**12.78%**
Whitefin shiner	5		1		1		1		**8**	**0.11%**
Fieryblack shiner	1								**1**	**0.01%**
Common carp	2	25	13	18	4	26	10	7	**105**	**1.45%**
Eastern silvery minnow	21	3	1	2	5	2	12	1	**47**	**0.65%**
Bluehead chub			1	1				1	**3**	**0.04%**
Golden shiner	26	1	6	6	2		16	2	**59**	**0.81%**
Spottail shiner	3			1		4			**8**	**0.11%**
Goldfish X carp hybrid				1		2	1		**4**	**0.06%**
Catostomidae										
White sucker	1			1					**2**	**0.03%**
Notchlip redhorse	1	2		1					**4**	**0.06%**
Shorthead redhorse				1	1				**2**	**0.03%**
Brassy jumprock		1							**1**	**0.01%**
Ictaluridae										
White catfish		2						1	**3**	**0.04%**
Brown bullhead					4	9	1	1	**15**	**0.21%**
Channel catfish	8	11	9	9	2	11	2	21	**73**	**1.01%**
Flathead catfish		1				4	1	8	**14**	**0.19%**
Poeciliidae										
Eastern mosquitofish	5		2	3	5	10	8		**33**	**0.45%**
Moronidae										
White perch	10	33	3	5	14	15	19	21	**120**	**1.65%**
White bass			1						**1**	**0.01%**
Centrarchidae										
Redbreast sunfish	1	13	13	1		28		27	**83**	**1.14%**
Green sunfish	2	3	10	2	1	151	3	94	**266**	**3.66%**
Pumpkinseed	12	76	127	30	43	144	25	138	**595**	**8.20%**
Warmouth		6	5	1			1	4	**17**	**0.23%**
Bluegill	170	330	502	234	148	542	188	740	**2,854**	**39.31%**
Redear sunfish	2	8	13	3	4	18	9	12	**69**	**0.95%**
Hybrid sunfish		2	1	1		6		3	**13**	**0.18%**
Spotted bass	4	11	18	11	4	11	3	14	**76**	**1.05%**
Largemouth bass	35	84	41	24	60	63	34	83	**424**	**5.84%**
Hybrid black bass						1			**1**	**0.01%**
White crappie		15	18	6		1	2		**42**	**0.58%**
Black crappie	5	137	97	17	3	22	14	20	**315**	**4.34%**
Percidae										
Tessellated darter	1	1	1	2		1		2	**8**	**0.11%**
Yellow perch	1		1	2	2				**6**	**0.08%**
Total number of individuals	**623**	**1,075**	**981**	**540**	**459**	**1,797**	**484**	**1,301**	**7,260**	**100.00%**
Total number of species	**27**	**25**	**26**	**29**	**23**	**25**	**25**	**24**	**38**	

Table 4-3. Pollution tolerance rating and trophic guild of adults of electrofishing samples collected from the Yadkin River near BSS, 2003 – 2009.

	Upstream				Discharge		Downstream		Percent
Tolerance rating	A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L	**composition**
Intolerant	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.01%**
Intermediate	51.36%	74.88%	90.52%	75.19%	69.28%	69.73%	69.42%	84.55%	**74.74%**
Tolerant	48.48%	25.12%	9.48%	24.81%	30.72%	30.27%	30.58%	15.45%	**25.25%**
Intolerant		**0.03%**			**0.00%**		**0.00%**		
Intermediate		**75.15%**			**69.64%**		**80.45%**		
Tolerant		**24.82%**			**30.36%**		**19.55%**		
Trophic guild of adults									
Omnivore	8.35%	6.70%	3.87%	10.37%	4.36%	16.42%	7.23%	3.00%	**8.36%**
Herbivore	3.37%	0.28%	0.10%	0.37%	1.09%	0.11%	2.48%	0.08%	**0.65%**
Insectivore	79.45%	66.33%	77.37%	77.04%	76.25%	76.41%	74.59%	85.70%	**76.89%**
Piscivore	8.83%	26.70%	18.65%	12.22%	18.30%	7.07%	15.70%	11.22%	**14.10%**
Omnivore		**6.77%**			**13.96%**		**4.15%**		
Herbivore		**0.84%**			**0.31%**		**0.73%**		
Insectivore		**74.03%**			**76.37%**		**82.69%**		
Piscivore		**18.36%**			**9.35%**		**12.44%**		

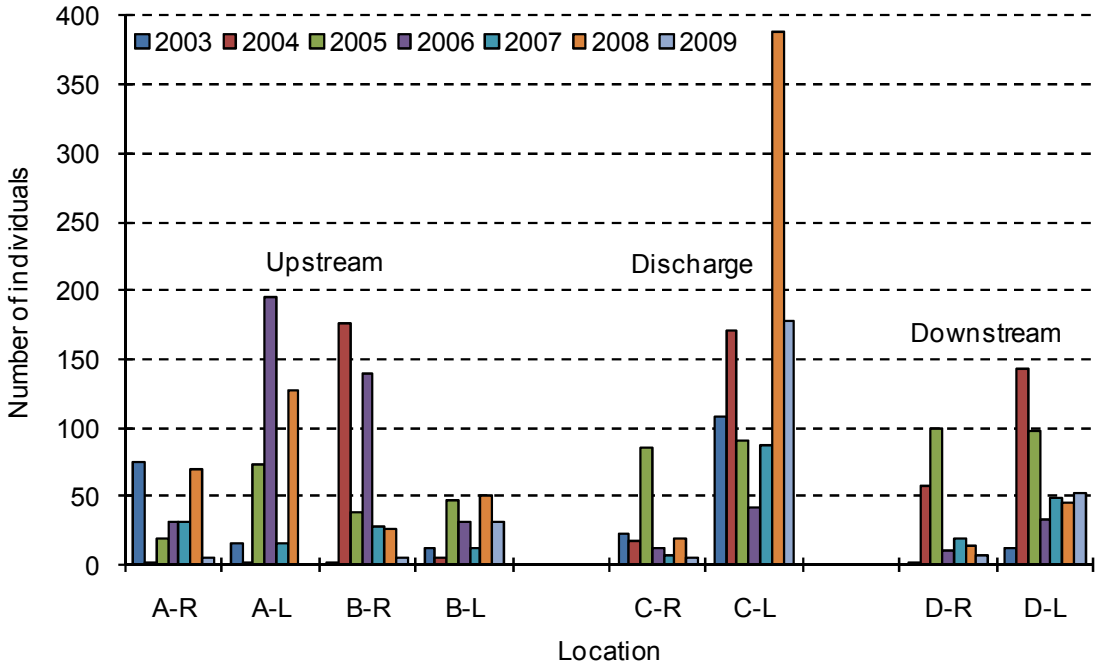

Figure 4-1. Number of fish collected by electrofishing during January, 2003 – 2009, at each Yadkin River sampling area near BSS.

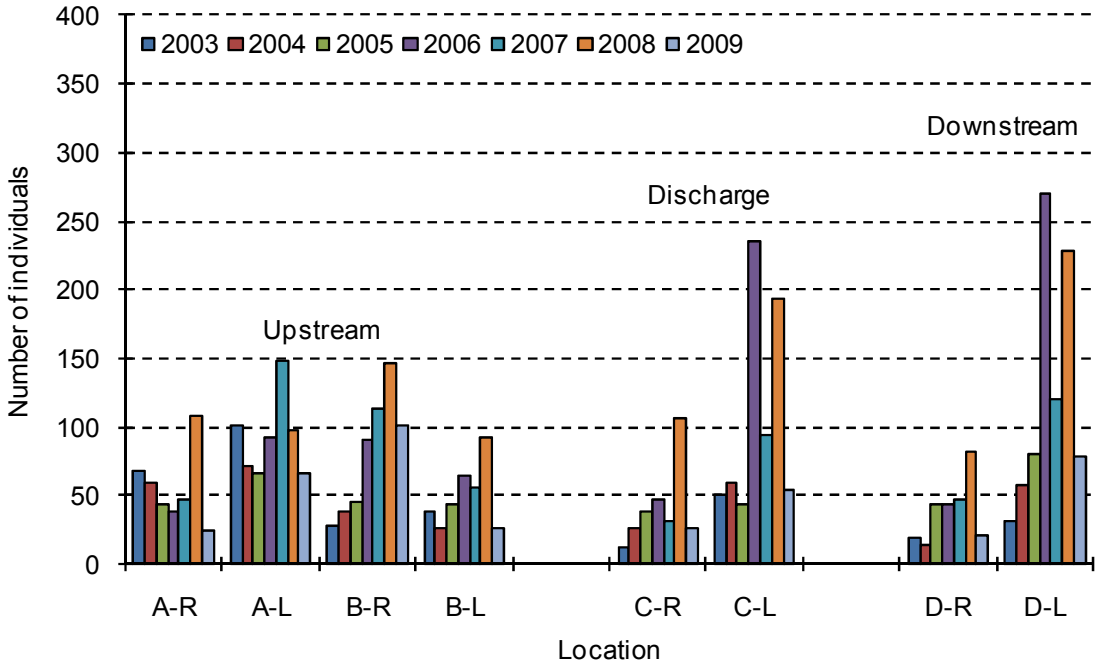

Figure 4-2. Number of fish collected by electrofishing during July/August, 2003 – 2009, at each Yadkin River sampling area near BSS.

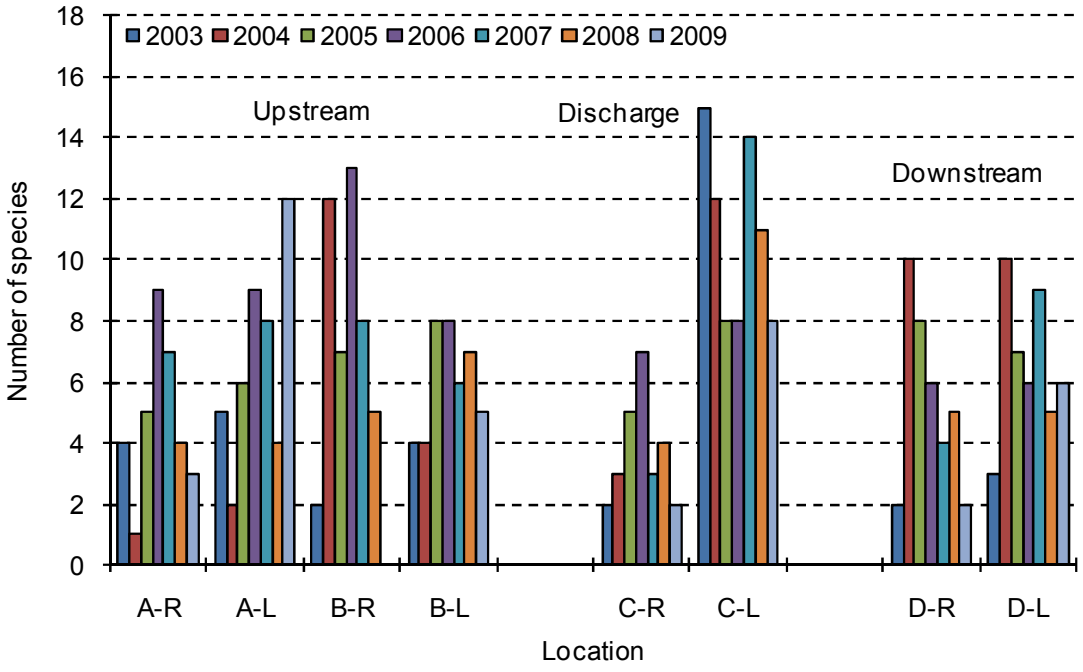

Figure 4-3. Number of fish species collected by electrofishing during January, 2003 – 2009, at each Yadkin River sampling area near BSS.

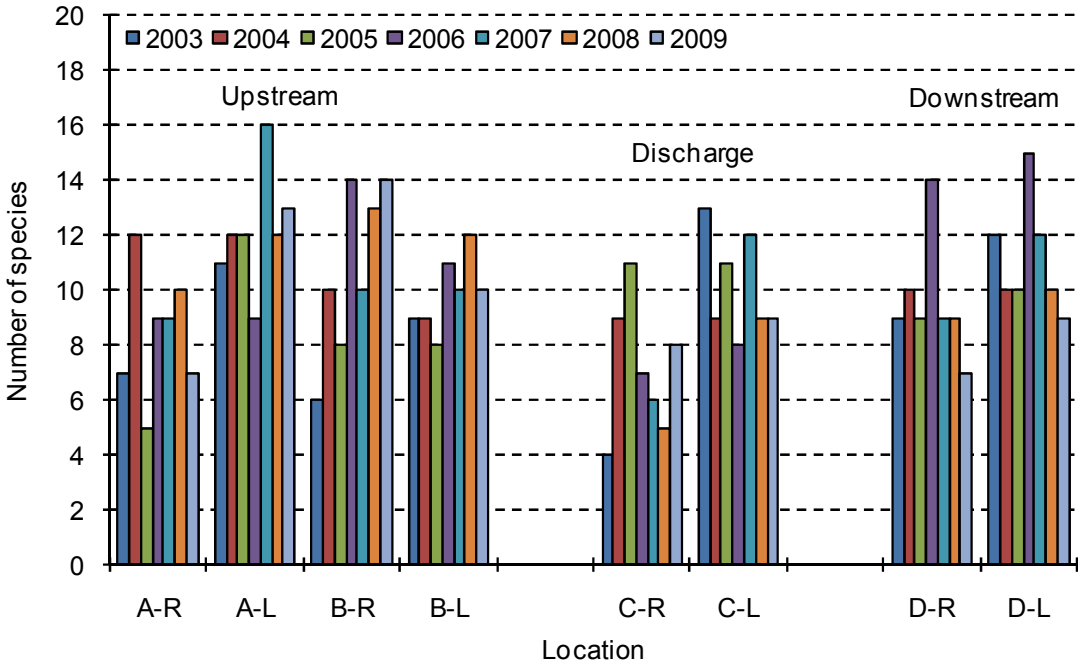

Figure 4-4. Number of species collected by electrofishing during July/August, 2003 – 2009, at each Yadkin River sampling area near BSS.

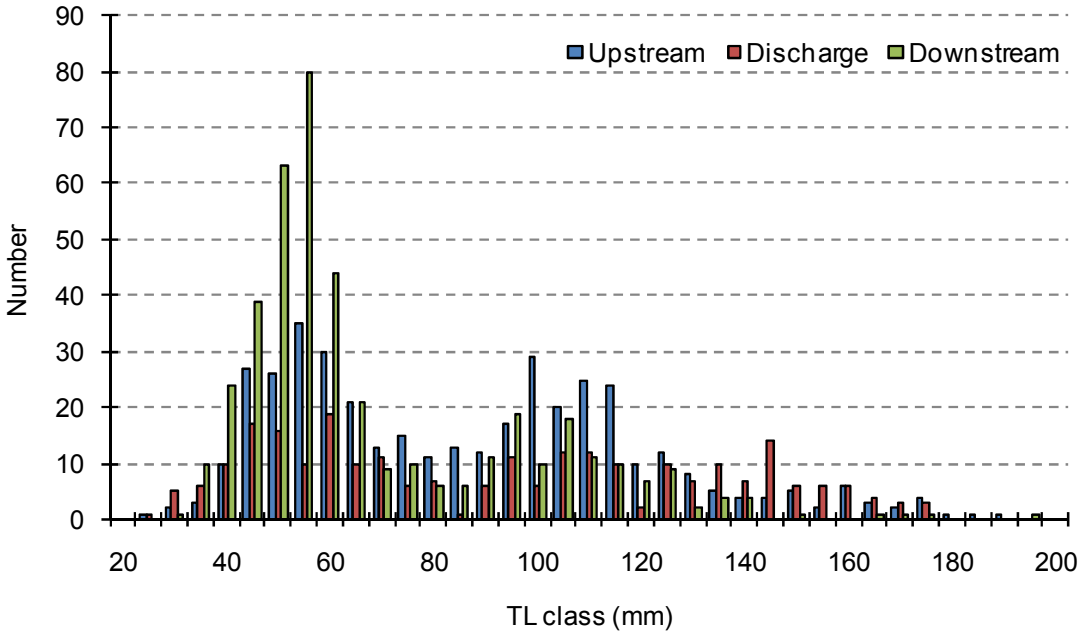

Figure 4-5. January bluegill length frequency distribution by Yadkin River area relative to BSS discharge, 2003 – 2009.

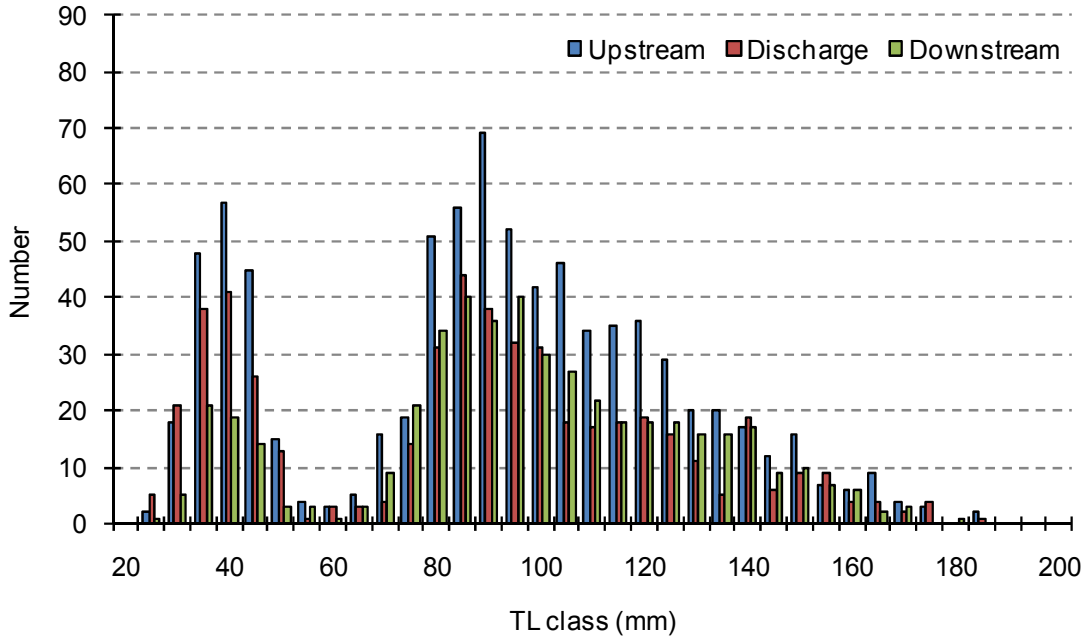

Figure 4-6. July/August bluegill length frequency distribution by Yadkin River area relative to BSS discharge, 2003 – 2009.

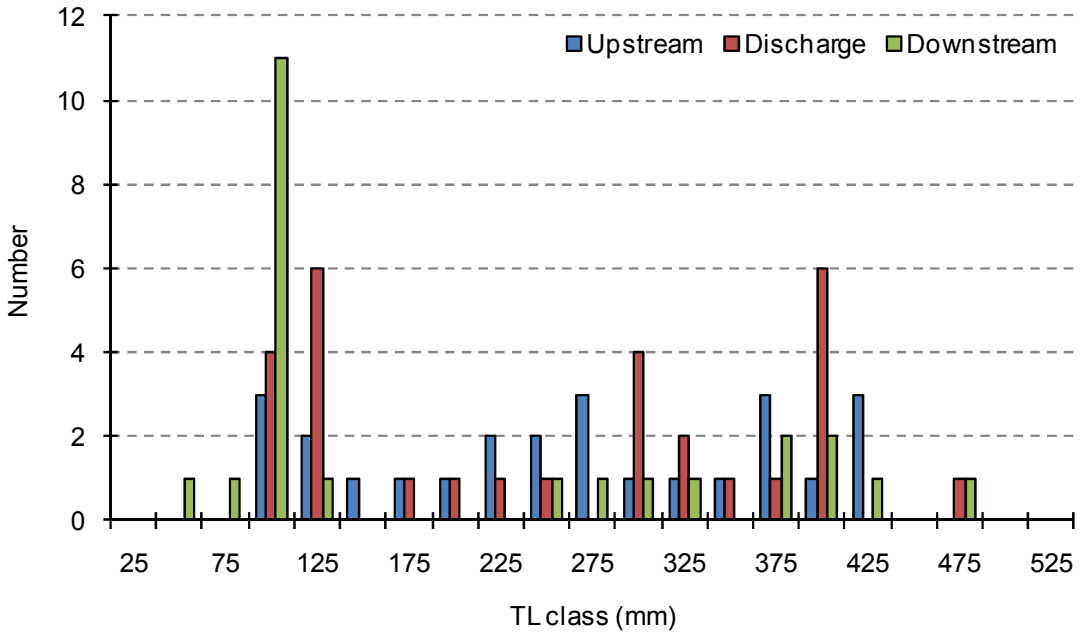

Figure 4-7. January largemouth bass length frequency distribution by Yadkin River area relative to BSS discharge, 2003 – 2009.

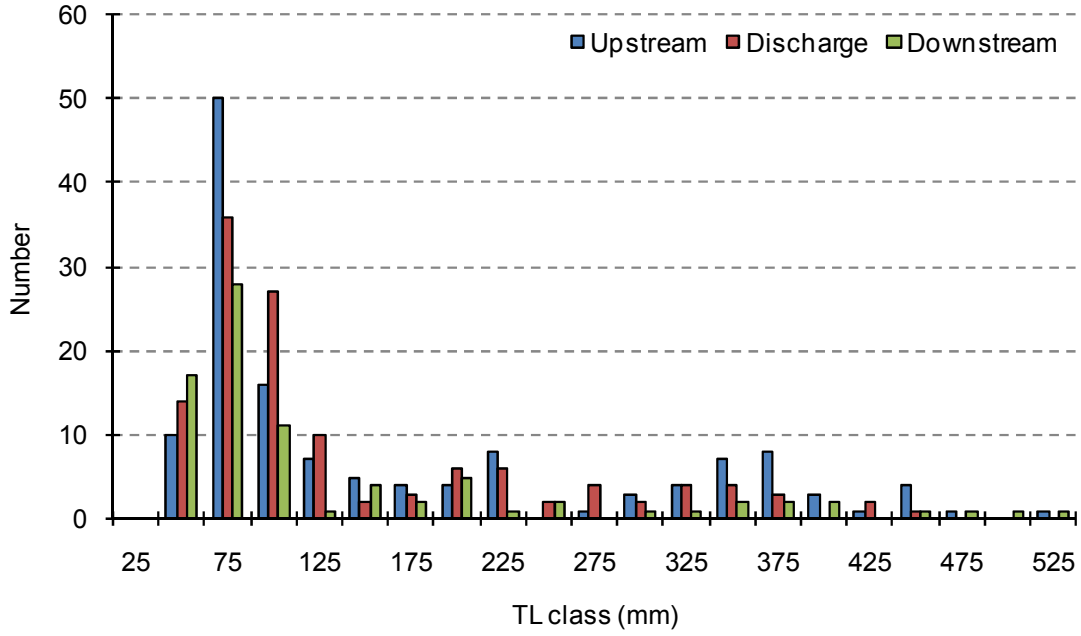

Figure 4-8. July/August largemouth bass length frequency distribution by Yadkin River area relative to BSS discharge, 2003 – 2009.

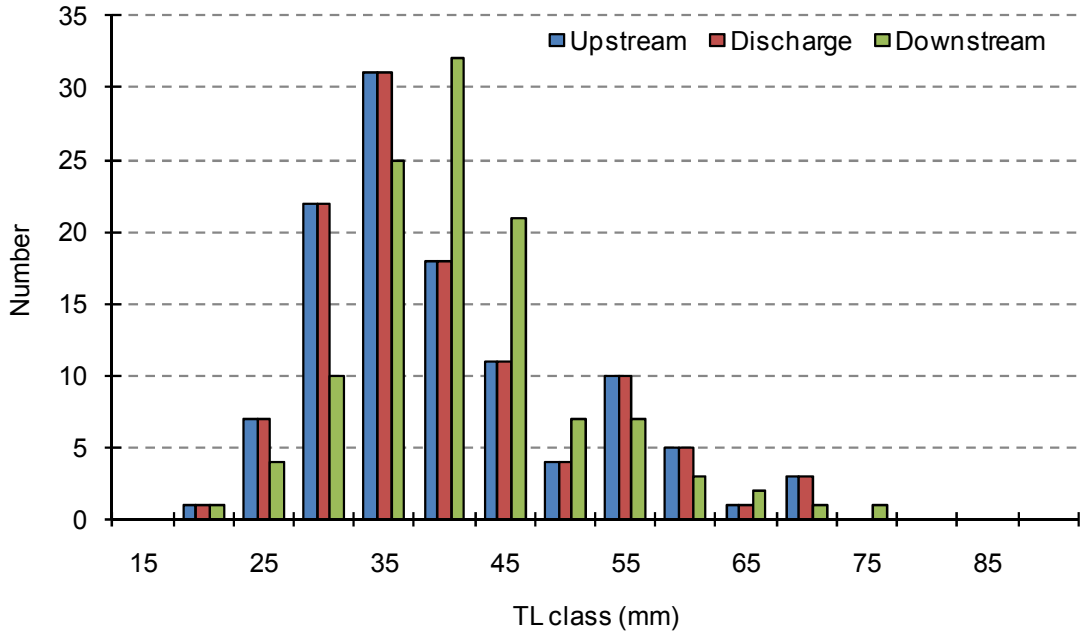

Figure 4-9. January red shiner length frequency distribution by Yadkin River area relative to BSS discharge, 2003 – 2009.

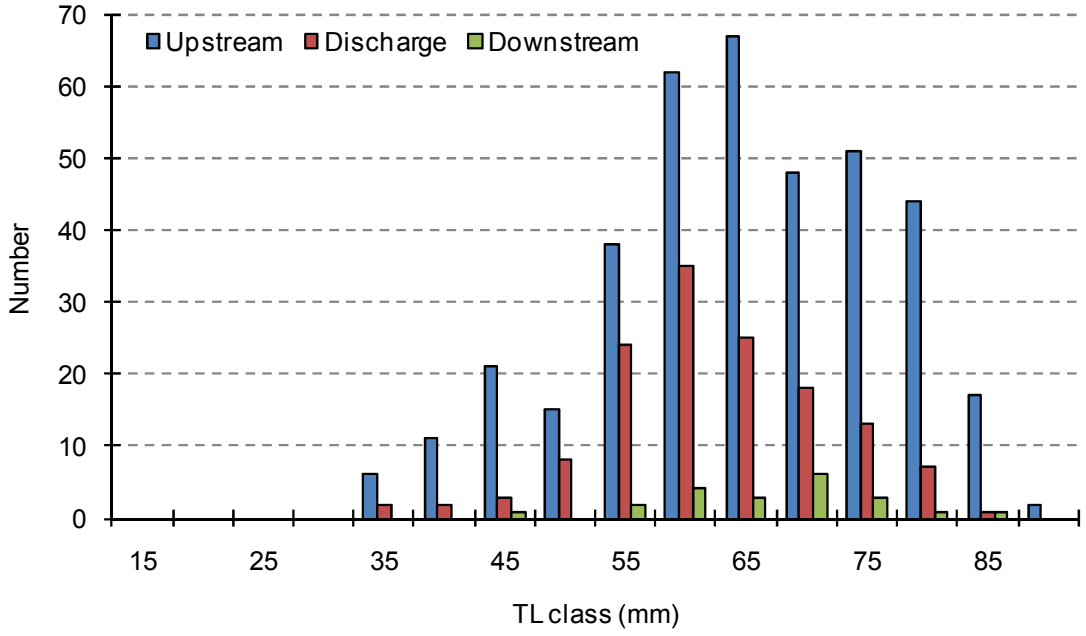

Figure 4-10. July/August red shiner length frequency distribution by Yadkin River area relative to BSS discharge, 2003 – 2009.

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APPENDIX TABLES

Appendix A-1. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 7 – 8, 2003.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Clupeidae									
Dorosoma cepedianum	Gizzard shad						17		
Dorosoma petenense	Threadfin shad						26		
Cyprinidae									
Carassius auratus	Goldfish						13		
Cyprinella analostanus	Satinfin shiner	16		1	4	13	1		
Cyprinella lutrensis	Red shiner	55			7	10	15	1	11
Cyprinus carpio	Common carp						4		
Notropis hudsonius	Spottail shiner						1		
Moronidae									
Morone americana	White perch						4		
Centrarchidae									
Lepomis auritus	Redbreast sunfish		2				1		
Lepomis cyanellus	Green sunfish						2		
Lepomis gibbosus	Pumpkinseed						1		
Lepomis macrochirus	Bluegill	3	4		1		6		1
Micropterus punctulatus	Spotted bass		2	1			2		
Micropterus salmoides	Largemouth bass						6		1
Micropterus hybrid	Hybrid black bass						1		
Pomoxis annularis	White crappie		2		1				
Pomoxis nigromaculatus	Black crappie	1	6				9	1	
Total number of individuals		75	16	2	13	23	109	2	13
Total number of species		4	5	2	4	2	15	2	3
Water temperature (°C)		5.0	5.1	5.1	5.4	4.7	12.1	5.1	7.2
Dissolved oxygen (mg/L)		11.4	11.6	11.4	11.6	12.3	11.6	12.3	12.0
Specific conductivity (uS/cm)		83.6	92.3	89.6	88.9	109.5	107.4	92.1	98.3

Appendix A-2. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, July 24 – 25, 2003.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar		3				3		
Clupeidae									
Dorosoma cepedianum	Gizzard shad		11	3	6	3		2	
Dorosoma petenense	Threadfin shad		1				1		2
Cyprinidae									
Carassius auratus	Goldfish				1			1	2
Cyprinella lutrensis	Red shiner	55	73	17	18		13	2	6
Cyprinus carpio	Common carp		1		2		2	1	
Notropis hudsonius	Spottail shiner	3			1		2		
Ictaluridae									
Ictalurus punctatus	Channel catfish	2	2		3		1		4
Pylodictis olivaris	Flathead catfish						2		1
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish							1	
Moronidae									
Morone americana	White perch				2	7		9	9
Centrarchidae									
Lepomis auritus	Redbreast sunfish		7	2			4		1
Lepomis cyanellus	Green sunfish						6		
Lepomis macrochirus	Bluegill	6	1	2	4	1	9	2	2
Lepomis microlophus	Redear sunfish	1					1		1
Lepomis hybrid	Hybrid sunfish						2		
Micropterus punctulatus	Spotted bass		1	1			1		2
Micropterus salmoides	Largemouth bass	1	1		2		4	1	1
Pomoxis annularis	White crappie		1						
Pomoxis nigromaculatus	Black crappie	1		3		1		1	1
Total number of individuals		69	102	28	39	12	51	20	32
Total number of species		7	11	6	9	4	13	9	12
Water temperature (°C)		23.2	23.4	23.3	23.3	22.7	27.9	24.5	25.6
Dissolved oxygen (mg/L)		7.2	6.7	7.4	7.2	7.3	6.9	7.0	7.1
Specific conductivity (uS/cm)		63.2	67.8	64.0	66.0	66.8	67.6	67.2	67.2

Appendix A-3. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 12 – 13, 2004.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Amiidae									
Amia calva	Bow fin						1		
Clupeidae									
Dorosoma cepedianum	Gizzard shad						13		2
Cyprinidae									
Carassius auratus	Goldfish						1		
Cyprinella analostanus	Satinfin shiner			1	1			3	
Cyprinella lutrensis	Red shiner	1				3		5	
Cyprinus carpio	Common carp						2		
Nocomis leptocephalus	Bluehead chub			1	1				1
Notemigonus crysoleucas	Golden shiner			1					
Catostomidae									
Scartomyzon sp.	Brassy jumprock		1						
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish			1				1	
Centrarchidae									
Lepomis auritus	Redbreast sunfish			4			7		7
Lepomis cyanellus	Green sunfish						24	2	10
Lepomis gibbosus	Pumpkinseed			2			9	4	1
Lepomis gulosus	Warmouth								3
Lepomis macrochirus	Bluegill			70		13	83	32	101
Lepomis microlophus	Redear sunfish			1			4	3	
Lepomis hybrid	Hybrid sunfish			1					2
Micropterus punctulatus	Spotted bass			2	1	1	3	1	1
Micropterus salmoides	Largemouth bass		1	1			20	3	9
Pomoxis annularis	White crappie			15					
Pomoxis nigromaculatus	Black crappie			76			4	3	6
Percidae									
Etheostoma olmstedi	Tessellated darter				2				
Total number of individuals		1	2	176	5	17	171	57	143
Total number of species		1	2	12	4	3	12	10	10
Water temperature (°C)		3.1	3.0	2.9	2.9	2.9	15.4	3.6	5.2
Dissolved oxygen (mg/L)		13.5	13.7	13.5	13.5	13.9	12.0	13.6	13.4
Specific conductivity (uS/cm)		94.9	97.1	94.8	97.7	91.8	92.7	91.7	91.9

Appendix A-4. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, July 12, 2004.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar		1		1	1		1	
Clupeidae									
Alosa aestivalis	Blueback herring	7						1	
Dorosoma cepedianum	Gizzard shad	5	4	9	1	1	2	2	9
Dorosoma petenense	Threadfin shad	5				2	3		
Cyprinidae									
Cyprinella lutrensis	Red shiner	5	8	1	8	1	23		
Cyprinus carpio	Common carp	1	2	1	2	1		1	1
Hybognathus regius	Eastern silvery minnow	19	2						
Notemigonus crysoleucas	Golden shiner				2				1
Ictaluridae									
Ictalurus punctatus	Channel catfish	3	1	4	3	1	5	1	3
Pylodictis olivaris	Flathead catfish								1
Moronidae									
Morone americana	White perch	2	4					1	
Centrarchidae									
Lepomis auritus	Redbreast sunfish		2	1	1		1		1
Lepomis cyanellus	Green sunfish			2			10		6
Lepomis gibbosus	Pumpkinseed	1					1	1	
Lepomis macrochirus	Bluegill	6	22	17	5	9	10	5	16
Lepomis hybrid	Hybrid sunfish		1						
Micropterus punctulatus	Spotted bass	3		1					3
Micropterus salmoides	Largemouth bass	2	6	1	3	9	5	1	17
Pomoxis annularis	White crappie		3						
Pomoxis nigromaculatus	Black crappie		16	2		2		1	
Total number of individuals		59	72	39	26	27	60	15	58
Total number of species		12	12	10	9	9	9	10	10
Water temperature (°C)		27.2	27.3	27.5	27.6	30.7	34.0	29.2	30.9
Dissolved oxygen (mg/L)		6.0	6.0	5.9	5.9	5.9	5.8	5.9	6.2
Specific conductivity (uS/cm)		91.4	91.1	92.1	90.5	92.4	94.5	94.2	91.8

Appendix A-5. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 4 – 5, 2005.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar							1	
Clupeidae									
Dorosoma cepedianum	Gizzard shad				1				
Cyprinidae									
Cyprinella analostanus	Satinfin shiner	11			2				
Cyprinella lutrensis	Red shiner	2		2	38	77		59	
Cyprinella nivea	Whitefin shiner	4							
Cyprinus carpio	Common carp							1	2
Catostomidae									
Moxostoma collapsum	Notchlip redhorse				1				
Ictaluridae									
Ictalurus punctatus	Channel catfish	1							
Pylodictis olivaris	Flathead catfish								2
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish						5	2	
Moronidae									
Morone americana	White perch		2			1			
Centrarchidae									
Lepomis auritus	Redbreast sunfish						1		1
Lepomis cyanellus	Green sunfish			1			25		17
Lepomis gibbosus	Pumpkinseed	1	5	19		2	28	3	6
Lepomis gulosus	Warmouth		1	1					
Lepomis macrochirus	Bluegill		53	13	3	4	27	29	68
Lepomis microlophus	Redear sunfish				1			1	
Lepomis hybrid	Hybrid sunfish						1		
Micropterus punctulatus	Spotted bass				1		1		
Micropterus salmoides	Largemouth bass		11	1			1		1
Pomoxis nigromaculatus	Black crappie		1					3	
Percidae									
Etheostoma olmstedi	Tessellated darter			1			1		
Perca flavescens	Yellow perch				1	1			
Total number of individuals		19	73	38	48	85	90	99	97
Total number of species		5	6	7	8	5	8	8	7
Water temperature (°C)		10.5	9.8	9.9	10.1	10.8	10.4	11.1	10.6
Dissolved oxygen (mg/L)		11.1	11.0	11.2	10.9	10.9	10.9	11.0	10.9
Specific conductivity (uS/cm)		79.1	79.3	76.6	78.2	79.9	79.8	78.9	79.2

Appendix A-6. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, August 8 – 10, 2005.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar		1				1		
Clupeidae									
Dorosoma cepedianum	Gizzard shad	2	12	7	2	9	1	1	9
Dorosoma petenense	Threadfin shad					1			
Cyprinidae									
Cyprinella lutrensis	Red shiner	15	6		5	2	6	1	1
Cyprinus carpio	Common carp					1	1	2	
Hybognathus regius	Eastern silvery minnow						1		1
Notemigonus crysoleucas	Golden shiner							1	
Notropis hudsonius	Spottail shiner						1		
Catostomidae									
Moxostoma macrolepidotum	Shorthead redhorse					1			
Ictaluridae									
Ictalurus punctatus	Channel catfish	2	1	1	1	1			
Pylodictis olivaris	Flathead catfish						2		
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish				1				
Moronidae									
Morone americana	White perch					1	2	4	10
Centrarchidae									
Lepomis auritus	Redbreast sunfish			3					
Lepomis cyanellus	Green sunfish		1	1			15		7
Lepomis gibbosus	Pumpkinseed		5		2	2		7	4
Lepomis macrochirus	Bluegill	17	31	29	29	14	11	22	35
Lepomis microlophus	Redear sunfish		2	2		4	2		8
Lepomis hybrid	Hybrid sunfish		1						
Micropterus punctulatus	Spotted bass		1		1				4
Micropterus salmoides	Largemouth bass	7	4	2	3	2			1
Pomoxis annularis	White crappie		1					2	
Pomoxis nigromaculatus	Black crappie		1	1				3	
Total number of individuals		43	67	46	44	38	43	43	80
Total number of species		5	12	8	8	11	11	9	10
Water temperature (°C)		26.6	27.0	27.0	27.0	23.9	29.8	23.8	24.2
Dissolved oxygen (mg/L)		6.2	6.2	6.1	6.1	5.9	5.6	5.8	5.8
Specific conductivity (uS/cm)		100.7	97.6	103.4	99.6	57.1	57.4	58.6	58.2

Appendix A-7. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 3 – 4, 2006.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar			1			3	1	
Clupeidae									
Dorosoma cepedianum	Gizzard shad	4		1		2	1	3	
Cyprinidae									
Carassius auratus	Goldfish					1		1	
Cyprinella analostanus	Satinfin shiner	3							
Cyprinella lutrensis	Red shiner	15		2	1			1	1
Cyprinella nivea	Whitefin shiner	1							
Cyprinus carpio	Common carp		5	1	2		2		
Hybognathus regius	Eastern silvery minnow					1			
Notemigonus crysoleucas	Golden shiner			1					
Ictaluridae									
Ictalurus punctatus	Channel catfish						1		
Moronidae									
Morone americana	White perch	5	4	1	1	5	8	2	1
Centrarchidae									
Lepomis cyanellus	Green sunfish						6		4
Lepomis gibbosus	Pumpkinseed		39	52	2	1	14		14
Lepomis gulosus	Warmouth		2	1					1
Lepomis macrochirus	Bluegill	1	46	69	21	2	7	3	12
Lepomis microlophus	Redear sunfish			2					
Micropterus punctulatus	Spotted bass	1	6	4	3				
Micropterus salmoides	Largemouth bass	1	5	3					
Pomoxis annularis	White crappie		4						
Pomoxis nigromaculatus	Black crappie		85	2	1				
Percidae									
Perca flavescens	Yellow perch	1			1	1			
Total number of individuals		32	196	140	32	13	42	11	33
Total number of species		9	9	13	8	7	8	6	6
Water temperature (°C)		7.1	7.2	7.7	7.5	7.8	7.9	7.9	7.8
Dissolved oxygen (mg/L)		12.1	12.0	12.0	12.0	10.6	10.7	10.9	10.9
Specific conductivity (uS/cm)		82.6	82.4	82.2	82.1	78.7	79.0	78.9	78.9

Appendix A-8. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, July 12 – 13, 2006.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Clupeidae									
Dorosoma cepedianum	Gizzard shad	9	14	4	24	6	6	11	4
Dorosoma petenense	Threadfin shad	3	17	9	12	3	3	1	
Cyprinidae									
Carassius auratus	Goldfish							1	1
Cyprinella analostanus	Satinfin shiner			2			6		
Cyprinella lutrensis	Red shiner	4	3	9	1		192		20
Cyprinus carpio	Common carp		1		1			2	2
Hybognathus regius	Eastern silvery minnow	2		1				2	
Notemigonus crysoleucas	Golden shiner							4	
C. auratus X C. carpio hybrid	Goldfish X carp hybrid							1	
Ictaluridae									
Ameiurus catus	White catfish								1
Ictalurus punctatus	Channel catfish			2	2		1		6
Pylodictis olivaris	Flathead catfish								2
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish	1		1	1	1		2	
Moronidae									
Morone americana	White perch		3	1	1			2	
Centrarchidae									
Lepomis auritus	Redbreast sunfish	1							2
Lepomis cyanellus	Green sunfish			1			11		17
Lepomis gibbosus	Pumpkinseed	3	6	9	1	9	6	2	47
Lepomis gulosus	Warmouth							1	
Lepomis macrochirus	Bluegill	9	27	43	16	10	10	10	157
Lepomis hybrid	Hybrid sunfish				1				1
Micropterus punctulatus	Spotted bass			4	2	2		2	2
Micropterus salmoides	Largemouth bass	6	12	1	2	16		2	5
Pomoxis nigromaculatus	Black crappie		9	4				1	2
Percidae									
Etheostoma olmstedi	Tessellated darter								1
Total number of individuals		38	92	91	64	47	235	44	270
Total number of species		9	9	14	11	7	8	14	15
Water temperature (°C)		25.3	25.6	25.4	25.7	31.7	35.3	30.2	30.6
Dissolved oxygen (mg/L)		6.6	6.6	6.5	6.1	6.3	6.0	6.6	6.3
Specific conductivity (uS/cm)		94.9	97.3	98.2	96.9	101.4	101.6	101.9	101.6

Appendix A-9. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 10 – 11, 2007.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Clupeidae									
Dorosoma cepedianum	Gizzard shad			2			8		
Dorosoma petenense	Threadfin shad						1		
Cyprinidae									
Cyprinella analostanus	Satinfin shiner	3			1				
Cyprinella lutrensis	Red shiner	15		2		4		16	6
Cyprinella nivea	Whitefin shiner							1	
Cyprinus carpio	Common carp		5	1	1		5		1
Hybognathus regius	Eastern silvery minnow						1		
C. auratus X C. carpio hybrid	Goldfish X carp hybrid						1		
Catostomidae									
Catostomus commersonii	White sucker	1							
Moxostoma collapsum	Notchlip redhorse	1							
Moxostoma macrolepidotum	Shorthead redhorse				1				
Ictaluridae									
Ictalurus punctatus	Channel catfish		1						
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish						3		
Moronidae									
Morone americana	White perch	1	2				1		1
Morone chrysops	White bass			1					
Centrarchidae									
Lepomis auritus	Redbreast sunfish						6		2
Lepomis cyanellus	Green sunfish		1				1		1
Lepomis gibbosus	Pumpkinseed	3	3	14	1	2	11	1	6
Lepomis gulosus	Warmouth			1					
Lepomis macrochirus	Bluegill	7		3	6	2	40		22
Lepomis microlophus	Redear sunfish		1						
Micropterus punctulatus	Spotted bass		1	4	2		3		
Micropterus salmoides	Largemouth bass						1	1	1
Pomoxis annularis	White crappie						1		
Pomoxis nigromaculatus	Black crappie		2				5		9
Total number of individuals		31	16	28	12	8	88	19	49
Total number of species		7	8	8	6	3	14	4	9
Water temperature (°C)		8.8	8.5	8.4	8.5	7.0	11.2	7.2	7.8
Dissolved oxygen (mg/L)		10.6	10.7	10.1	10.1	10.8	10.3	11.1	10.8
Specific conductivity (uS/cm)		62.5	63.4	62.5	64.1	63.8	91.4	63.4	64.6

Appendix A-10. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, July 23 – 24, 2007.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar						1		
Clupeidae									
Dorosoma cepedianum	Gizzard shad	1	8	8					7
Dorosoma petenense	Threadfin shad	2	13		4		5		1
Cyprinidae									
Cyprinella analostanus	Satinfin shiner						1		
Cyprinella lutrensis	Red shiner	2	2		1		3		
Cyprinus carpio	Common carp	1	4	4	5	1		2	
Notemigonus crysoleucas	Golden shiner							1	
C. auratus X C. carpio hybrid	Goldfish X carp hybrid				1		1		
Ictaluridae									
Ictalurus punctatus	Channel catfish		2	1			2	1	6
Pylodictis olivaris	Flathead catfish		1					1	1
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish				1		1		
Moronidae									
Morone americana	White perch	1	4	1					
Centrarchidae									
Lepomis auritus	Redbreast sunfish		2	2			3		2
Lepomis cyanellus	Green sunfish		1	3		1	27		7
Lepomis gibbosus	Pumpkinseed	4	8	17	7	1	10	3	12
Lepomis gulosus	Warmouth		1						
Lepomis macrochirus	Bluegill	26	68	65	27	19	33	34	63
Lepomis microlophus	Redear sunfish				1			1	
Micropterus punctulatus	Spotted bass					1	1		2
Micropterus salmoides	Largemouth bass	9	24	11	7	9	7	4	17
Pomoxis annularis	White crappie		1		1				
Pomoxis nigromaculatus	Black crappie		8	2	1			1	2
Percidae									
Etheostoma olmstedi	Tessellated darter	1	1						1
Total number of individuals		47	148	114	56	32	95	48	121
Total number of species		9	16	10	10	6	12	9	12
Water temperature (°C)		25.6	25.4	26.2	26.3	29.6	32.7	28.7	29.7
Dissolved oxygen (mg/L)		7.1	7.1	6.1	6.2	6.1	5.9	6.1	6.2
Specific conductivity (uS/cm)		125.9	121.5	120.9	121.0	121.7	121.8	121.8	121.3

Appendix A-11. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 8 – 9, 2008.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Clupeidae									
Dorosoma cepedianum	Gizzard shad		1				34		
Dorosoma petenense	Threadfin shad						182		
Cyprinidae									
Cyprinella analostanus	Satinfin shiner	49	124	2				3	
Cyprinella lutrensis	Red shiner	9		3	6	12	1	6	
Cyprinella nivea	Whitefin shiner			1		1			
Cyprinella pyrrhomelas	Fieryblack shiner	1							
Cyprinus carpio	Common carp						8		
Catostomidae									
Catostomus commersonii	White sucker				1				
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish						1		
Centrarchidae									
Lepomis auritus	Redbreast sunfish						1		1
Lepomis cyanellus	Green sunfish								4
Lepomis gibbosus	Pumpkinseed				2	2	34	1	10
Lepomis macrochirus	Bluegill	11	2	19	35	4	114	4	29
Lepomis microlophus	Redear sunfish			1			6		1
Lepomis hybrid	Hybrid sunfish						1		
Micropterus salmoides	Largemouth bass		1		1		5	1	
Pomoxis annularis	White crappie				2				
Pomoxis nigromaculatus	Black crappie				4		1		
Total number of individuals		70	128	26	51	19	388	15	45
Total number of species		4	4	5	7	4	11	5	5
Water temperature (°C)		5.0	4.7	4.8	4.8	6.3	10.7	7.3	7.7
Dissolved oxygen (mg/L)		12.9	13.1	13.0	13.4	13.5	11.8	12.4	13.0
Specific conductivity (uS/cm)		85.0	85.6	87.8	84.1	87.1	86.2	87.2	85.7

Appendix Table A-12. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, July 7 – 8, 2008.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar			3					
Clupeidae									
Dorosoma cepedianum	Gizzard shad		2	1	3		1		
Dorosoma petenense	Threadfin shad		2		1		6		
Cyprinidae									
Carassius auratus	Goldfish	1			1				
Cyprinella analostanus	Satinfin shiner	2							1
Cyprinella lutrensis	Red shiner	1	2	1			10		3
Cyprinus carpio	Common carp		6	5	3			1	1
Hybognathus regius	Eastern silvery minnow				1				
Notemigonus crysoleucas	Golden shiner	26	1	4	4	2		7	1
Ictaluridae									
Ameiurus nebulosus	Brown bullhead					4	9	1	1
Ictalurus punctatus	Channel catfish		1						
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish	3						2	
Moronidae									
Morone americana	White perch	1							
Centrarchidae									
Lepomis auritus	Redbreast sunfish						3		4
Lepomis cyanellus	Green sunfish	1					22	1	17
Lepomis gibbosus	Pumpkinseed		10	8	8	24	20	3	31
Lepomis gulosus	Warmouth		2	1	1				
Lepomis macrochirus	Bluegill	65	53	100	56	57	108	44	144
Lepomis microlophus	Redear sunfish			1				2	
Lepomis hybrid	Hybrid sunfish						2		
Micropterus salmoides	Largemouth bass	7	11	14	6	19	13	21	26
Pomoxis annularis	White crappie		2	2	1				
Pomoxis nigromaculatus	Black crappie	2	5	6	7				
Percidae									
Perca flavescens	Yellow perch			1					
Total number of individuals		109	97	147	92	106	194	82	229
Total number of species		10	12	13	12	5	9	9	10
Water temperature (°C)		25.6	25.8	25.3	25.6	31.0	35.2	29.6	30.5
Dissolved oxygen (mg/L)		6.1	6.3	6.1	6.0	6.3	6.2	5.8	6.1
Specific conductivity (uS/cm)		131.5	137.5	132.1	134.2	133.2	133.5	132.6	134.3

Appendix Table A-13. Species composition, number of individuals, number of species, temperature, dissolved oxygen concentration, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, January 19 – 20, 2009.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Clupeidae									
Alosa aestivalis	Blueback herring								
Dorosoma cepedianum	Gizzard shad						101		
Dorosoma petenense	Threadfin shad						2		
Cyprinidae									
Cyprinella analostanus	Satinfin shiner				3			6	14
Cyprinella lutrensis	Red shiner	1							
Cyprinus carpio	Common carp						1		
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish	1				2			
Centrarchidae									
Lepomis auritus	Redbreast sunfish								4
Lepomis cyanellus	Green sunfish								1
Lepomis gibbosus	Pumpkinseed				6		10		5
Lepomis gulosus	Warmouth								
Lepomis macrochirus	Bluegill	3		3	17	3	55	1	27
Lepomis microlophus	Redear sunfish			1	1		4		
Micropterus salmoides	Largemouth bass			1			1		1
Pomoxis nigromaculatus	Black crappie				4		3		
Total number of individuals		5	0	5	31	5	177	7	52
Total number of species		3	0	3	5	2	8	2	6
Water temperature (°C)		1.8	1.8	2.2	2.0	2.1	12.4	2.2	5.6
Dissolved oxygen (mg/L)		10.9	9.7	10.9	11.0	12.1	13.8	10.8	12.8
Specific conductivity (uS/cm)		98.9	101.4	98.1	100.1	101.2	99.8	100.1	100.7

Appendix Table A-14 Species composition, number of individuals, number of species, temperature, dissolved oxygen concentation, and specific conductivity at eight electrofishing locations on the Yadkin River near BSS, August 4 – 5, 2009.

		Upstream				Discharge		Downstream	
		A-R	A-L	B-R	B-L	C-R	C-L	D-R	D-L
Scientific name	Common name	433.1	433.2	432.1	432.2	430.1	430.2	430.7	430.6
Lepisosteidae									
Lepisosteus osseus	Longnose gar		1				1		
Clupeidae									
Alosa aestivalis	Blueback herring								
Dorosoma cepedianum	Gizzard shad	3	1	5	2	3	1	3	1
Dorosoma petenense	Threadfin shad	1				1		1	
Cyprinidae									
Cyprinella lutrensis	Red shiner			1	2	1	17		
Cyprinus carpio	Common carp		1	1	2	1	1		
Hybognathus regius	Eastern silvery minnow		1		1	4		10	
Notemigonus crysoleucas	Golden shiner							3	
Moxostoma collapsum	Notchlip redhorse		2						
Ictaluridae									
Ameiurus catus	White catfish		2						
Ictalurus punctatus	Channel catfish		3	1			1		2
Pylodictis olivaris	Flathead catfish								1
Poeciliidae									
Gambusia holbrooki	Eastern mosquitofish					2			
Moronidae									
Morone americana	White perch		14		1			1	
Centrarchidae									
Lepomis auritus	Redbreast sunfish			1			1		2
Lepomis cyanellus	Green sunfish	1		2	2		2		3
Lepomis gibbosus	Pumpkinseed			6	1				2
Lepomis gulosus	Warmouth			1					
Lepomis macrochirus	Bluegill	16	23	69	14	10	29	2	63
Lepomis microlophus	Redear sunfish	1	5	5			1	2	2
Micropterus punctulatus	Spotted bass			1	1				
Micropterus salmoides	Largemouth bass	2	8	6		5			3
Pomoxis annularis	White crappie		1	1	1				
Pomoxis nigromaculatus	Black crappie	1	4	1					
Total number of individuals		25	66	101	27	27	54	22	79
Total number of species		7	13	14	10	8	9	7	9
Water temperature (°C)		26.5	26.5	27.0	27.2	28.0	29.3	28.3	28.4
Dissolved oxygen (mg/L)		6.9	6.9	6.8	6.8	6.8	6.4	6.7	6.6
Specific conductivity (uS/cm)		79.2	74.6	78.5	77.5	79.5	79.3	79.6	80.0