Yadkin Project
FERC No. 2197

YADKIN TAILWATER FISH AND AQUATIC BIOTA ASSESSMENT

JUNE 2005

YADKIN PROJECT
FERC NO. 2197

YADKIN TAILWATER FISH AND AQUATIC BIOTA ASSESSMENT

Prepared for
ALCOA GENERATING COMPANY, INC.
YADKIN DIVISION
293 NC 740 Highway
Badin, NC 28009-0576

Prepared by
NORMANDEAU ASSOCIATES, INC.
25 Nashua Road
Bedford, NH 03110

R-19556.001
June 2005

Table of Contents

Page

List of Figures

List of Tables

SUMMARY

The Tailwater Fish and Aquatic Biota Assessment Report presents the results of several surveys of fish and aquatic biota (e.g. mussels, benthic macroinvertebrates, etc.) in the tailwaters of the four developments that comprise the Yadkin Project: High Rock, Tuckertown, Narrows and Falls. The project tailwaters are generally those areas where moving water is clearly observable when water is being released from the powerhouses and/or dams. These areas are of particular interest to the resource management agencies because they may provide riverine habitat that can support aquatic species that are native to the free-flowing portions of the Yadkin-Pee Dee River.

The study was conducted in accordance with the Final Study Plan that was developed in consultation with Fish and Aquatics Issue Advisory Group (IAG). Specific objectives identified in the Final Study Plan included:

- Describe tailwater habitats in all four Yadkin development tailwater areas.
- Inventory and assess the resident fish community in the Project tailwaters on a seasonal basis to develop baseline data that can be used to detect changes over time. Evaluate the impacts of existing Project operations on the tailwater fish community, such as impacts associated with generation schedules and impacts due to the low dissolved oxygen found in the tailwaters during certain times of year.
- Search for RTE mussel species in Project tailwaters
- Search for RTE fish species, including the Robust and Carolina Rehorse species in the Project tailwaters during the spring (spawning period) and during the summary and fall fish surveys.

Tailwater aquatic surveys were conducted during the spring, summer and fall seasons. To ensure that the greatest number of species were being collected, fish sampling was done using a variety of methods and gear types including electrofishing and gill nets. Fish were sampled in many tailwater locations including both shallow and deep water habitats. Mussels and benthic macroinvertebrates were sampled along transects established in each of the tailwaters. Mussel searches were conducted by divers swimming along the length of each transect line. Divers searched at least two meters (approximately 6.3 ft) upstream and downstream of each transect line. Additional searches were conducted along the shoreline of each tailrace looking for mussel shells and by having divers search in areas identified by agencies as good mussel habitat that were not located along a transect line. Benthic macroinvertebrates were collected along each transect using an air lift. Benthic organisms were preserved in the field and returned to the laboratory for identification and counting.

The initial study effort included a detailed survey and description of the aquatic habitat found in each of the tailwaters. This work was accomplished by establishing transects in each tailwater and doing a detailed survey of substrate and other habitat characteristics along the transect. Another primary objective of the tailwater fish surveys was to develop a comprehensive list of fish species utilizing the tailwaters. The complete list of fish species found in each of the development tailwaters is provided in the table below.

Common Name	Scientific Name	High Rock Tailwater	Tucker-town Tailwater	Narrows Tailwater	Falls Tailwater
Blueback Herring	*Alosa aestivalis*	X	X	X	X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X	X
Threadfin Shad	*Dorosoma petenense*	X	X	X	X
Goldfish	*Carassius auratus*	X			
Common Carp	*Cyprinus carpio*	X	X	X	
Golden Shiner	*Notemigonus chrysoleucas*	X	X	X	X
Spottail Shiner	*Notropis hudsonius*	X			
Satinfin Shiner	*Cyprinella analostana*	X	X	X	X
Eastern Silvery Minnow	*Hybognathus regius*	X			
Quillback	*Carpiodes cyprinus*	X	X		X
Creek Chubsucker	*Erimyzon oblongus*	X	X		X
Shorthead Redhorse	*Moxostoma macrolepidotum*	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*	X	X	X	X
Flathead Catfish	*Pylodictus olivarus*	X	X	X	X
Blue Catfish	*Ictalurus furcatus*	X	X	X	X
Channel Catfish	*Ictalurus puntatus*	X	X	X	X
White Catfish	*Ameiurus catus*	X	X	X	X
Flat Bullhead	*Ameiurus platycephalus*			X	X
Yellow Bullhead	*Ameiurus natalis*				X
Snail Bullhead	*Ameiurus brunneus*				X
White Perch	*Morone americana*	X	X	X	X
Hybrid Bass (Striped x White)	*Morone saxatilis x chrysops*	X	X		
Striped Bass	*Morone saxatilis*	X	X	X	X
White Bass	*Morone chrysops*	X	X	X	X
Redbreast Sunfish	*Lepomis auritus*	X	X	X	X
Green Sunfish	*Lepomis cyanellus*	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Redear Sunfish	*Lepomis microlophus*	X	X	X	X
Warmouth	*Lepomis gulosus*	X	X	X	X
Smallmouth Bass	*Micropterus dolomieu*				X
Largemouth Bass	*Micropterus salmoides*	X	X	X	X
White Crappie	*Pomoxis annularis*	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X	X	X
Tesselated Darter	*Etheostome olmstedi*	X			X
Yellow Perch	*Perca flavescens*	X	X	X	X
Longnose Gar	*Lepisosteus osseus*	X	X	X	X
Smallmouth Buffalo	*Ictiobus bubalus*	X	X	X	
Bowfin	*Amia calva*			X	
White Sucker	*Catostomus commersoni*				X
Spotted Sucker	*Minytrema melanops*				X

Overall, the fish communities sampled in the tailwaters of High Rock, Tuckertown, Narrows and Falls developments were found to be very similar, but some differences in species captured were noted. Species diversity recorded in the tailwaters ranged from a high of thirty-four species in both High Rock and Falls tailwaters to a low of 29 species recorded in Tuckertown tailwater. Large numbers of bluegill, largemouth bass, gizzard shad and white perch dominated the catches in each tailwater. These four species are among the ten most abundant species captured within each tailwater, comprising 48% of the total catch in High Rock tailwater, 57% in Tuckertown tailwater, 64% in Narrows tailwater and 46% in Falls tailwater. These species are generally tolerant of low dissolved oxygen (DO) concentrations, a condition which can occur in the project tailwaters during the summer. Given the numbers of these species captured it also is apparent that these species are well adapted to hydro peaking operations, and routine changes in powerhouse discharges. Another popular sport fish, black crappies, were more abundant in both Tuckertown and High Rock tailwaters than either Narrows or Falls.

Common carp and quillback were both in the ten most abundant species sampled in the High Rock tailwater and were either not present or captured in low numbers in the other three tailwaters. The numbers of carp captured in High Rock tailwater were evenly distributed during all three seasons of sampling. Quillback were most abundant in the tailwater during the spring season and may have been using the tailwater area below High Rock dam for spawning. In the Falls tailwater, silver and shorthead redhorse were in the top ten species collected. The shorthead redhorse was captured at all four tailwaters during the study, but its numbers were lower at the other three tailwaters. The higher catches of shorthead redhorse in the Falls tailwater compared to upstream tailwaters may be due to better habitat and water quality conditions, especially dissolved oxygen levels. The shorthead redhorse (and the black redhorse) are considered to be intolerant to poor water quality, as are some darter species (Scott 1999).

In terms of the health of the tailwater fisheries, the relative weight values for bluegill and largemouth bass were either within or near the ideal ranges for these species in each of the four tailwaters. Average proportional stock density (PSD) and relative stock density (RSD-P) values for largemouth bass were greater then the ideal range within each of the four tailwaters. Bluegill PSD values were within (High Rock and Narrows) or close to (Tuckertown and Falls) the ideal range for the species in all four tailwaters, suggesting a balanced population. However, RSD-P values for bluegill were well below the ideal range for the species in all four tailwaters and this indicated that few large, quality sized fish were available for harvest. Relative weights for black crappie were within or very close to the ideal range in both Narrows and Tuckertown tailwaters, indicating that the fish are in good condition. However, black crappie relative weights in High Rock tailwater (Tuckertown Reservoir) were lower than both the ideal range, suggesting possible problems finding adequate food sources. The PSD and RSD-P values for black crappie were either within or greater then the ideal range for the species in High Rock, Tuckertown, and Narrows tailwaters, suggesting a balanced population with most size classes represented.

Striped bass are currently present within all of the reservoirs and tailwaters, but the numbers captured in the High Rock tailwater (n=11) and Falls tailwater (n=18), were low compared to the numbers capture in the Tuckertown (n=65) and Narrows (n=39) tailwaters. The North Carolina Wildlife Resources Commission (NCWRC) stocks striped bass in all the project reservoirs except Falls (Narrows tailwater). Striped bass captured in the Narrows tailwater (upper Falls reservoir) most likely have dropped down from Narrows Reservoir. Those collected in Falls tailwater (upper Tillery Reservoir) may have originated from stockings into Tillery Reservoir or may have dropped down from Falls Reservoir. Striped bass are known to be relatively sensitive to water temperature and DO conditions, and striped bass in Narrows Reservoir (Tuckertown tailwater) are currently the target of cooperative bioenergetic studies by NCWRC and North Carolina State University to evaluate growth in relation to available habitat, particularly the thermal environment.

Two federal fish species of concern, the Carolina redhorse and robust redhorse, were of particular interest to the fishery agencies during this study. Both species have been collected previously in the Pee-Dee River below the Blewett Falls project, and Carolina redhorse individuals have been collected below Tillery dam and in Tillery Reservoir. For the Yadkin Project study, focused searches for these two species were made in all four tailwaters, with sampling concentrated on Falls tailwater at the upper end of Lake Tillery. Despite the intensive surveys, neither the Carolina redhorse nor the robust redhorse was found in any of the Yadkin Project tailwaters.

The study also survey mussels in the four Project tailwaters. A total of seven species of freshwater mussels were found within the four tailwaters. A summary of the mussel species found within each of the four Project tailwaters is provided in the table below.

Mussels Found in the Yadkin Project Tailwaters 2003-2004.

Species	Falls Dam Tailwater	Badin Dam (Narrows) Tailwater	Tuckertown Tailwater	High Rock Tailwater
Anodonta implicata	R	1		
Alewife floater				
Elliptio complanta	328	16		
Eastern Elliptio				
Elliptio cf. lanceolata	113	1		
Pee Dee Lance				
Lampsilis radiata	117	R		
Eastern lamp mussel				
Pyganodon cataracte	1	2		
Eastern floater				
Utterbackia imbecillis	8	2	4	1
Paper pond shell				
Villosa delumbis	8			
Eastern creekshell				
Total No. Of Unionidae Species	7	6	1	1
Total No. Of Individuals	575	22	4	1
Corbicula fluminea	A	A	A	A
Cipangopalucdinea chinensis				231
Chinese mystery snail				

- R = represented by relics only
- A = abundant

Falls tailwater had the greatest mussel diversity with seven species and 575 total individuals. In Falls tailwater, *Elliptio complanta* (Eastern Elliptio) was the most abundant (57%) mussel species, while *Elliptio cf. lanceolata* (Pee Dee Lance)(20%) and *Lampsilis radiata* (Eastern lamp mussel)(20%) were common. Narrows tailwater had 6 species with 22 total individuals. *Elliptio complanta* (73%) was the most abundant species within the Narrows tailwater. *Elliptio complanata* was present in both the Falls and Narrows tailwaters. One specimen of *Anodonta implicata* (Alewife floater) was found within the Narrows tailwater. The only mussel species found in the Tuckertown and High Rock tailwaters was the *Utterbackia imbecillis* (Paper pond shell) with four individuals found in

Tuckertown and one in High Rock. *Corbicula fluminea*, the Asiatic clam, is an invasive species that was abundant throughout all four tailwaters. No state or federally listed rare mussel species were found in any of the four Project tailwaters.

The study also examined benthic macroinvertebrate communities in each of the tailwaters. Because of their limited mobility, benthic macroinvertebrates are often used as indicators of water quality and aquatic habitat quality. Generally speaking, a more diverse benthic community is indicative of better water quality. At the Yadkin Project, 6 phyla, 24 orders, and 41 families represented by the 99 benthic macroinvertebrates species were found in the four Project tailwaters. Spring sampling in Falls tailwater yielded the highest number of species with 53 found and the summer sampling in High Rock yielded the lowest number of species collected with 29. The spring sampling in Narrows (12,008/12m^2) and Falls (10,172/12m^2) yielded the highest densities of individuals. The lowest numbers of individuals per sample were recorded in Falls (1,420/12m^2) and Narrows (1,333/12m^2) during the fall sampling. The table below summarizes the percent composition of the most abundant benthic macroinvertebrate species within each of the four tailwaters during the three seasons of sampling.

Percent composition of the dominant benthic macroinvertebrate species by sampling season.

	September 2003				***November 2003***				***June 2004***			
SPECIES	**Falls Dam**	**Narrows Dam**	**Tucker Town**	**High Rock**	**Falls Dam**	**Narrows Dam**	**Tucker Town**	**High Rock**	**Falls Dam**	**Narrows Dam**	**Tucker Town**	**High Rock**
Dugesia tigrina		9.3		7.6			6.2	12.5				
Corbicula fluminea	**26.7**				**48.0**	**43.5**			11.0	9.3		
Musculium transversum	15.1	9.6	**38.2**	**43.7**	6.2		**53.2**	28.3			18.6	**35.2**
Physella sp.									8.2			
Menetus dilatatus			6.3									
Dero sp.											14.1	
Slavina appendiculata										14.6		9.1
Lumbriculidae										10.0		
Caecidotea sp.	11.1	17.0	10.0	12.6	6.8	17.9	13.8	**28.8**	**17.3**	**16.3**	**29.7**	6.8
Hyalella azteca					11.1				8.2	6.8		
Cyrnellus fraternus		7.3										
Cricotopus sp.										15.0		
Dicrotendipes simpsoni			24.5	22.3				11.7				
Glyptotendipes sp.							9.2					9.2
Rheotanytarsus sp.		**22.5**										

The EPT index is the total number of species found in an area within the pollution sensitive groups Ephemeroptera, Plecoptera, and Trichoptera and is considered a measure of water quality. As the EPT value increases, water quality will tend to do the same. The EPT values computed for all four of the Yadkin Project tailwaters, in all seasons, fell within the fair to poor water quality range.

1.0 INTRODUCTION

Alcoa Power Generating Inc. (APGI) is applying to the Federal Energy Regulatory Commission for a new license for the Yadkin Hydroelectric Project. The Project consists of four reservoirs (High Rock, Tuckertown, Narrows, and Falls), dams, and powerhouses located on a 38-mile stretch of the Yadkin River in central North Carolina (Figure 1-1). The Project generates electricity to support the power needs of Alcoa's Badin Works and its other aluminum operations, or is sold on the open market.

To address concerns over potential impacts of Project operations on aquatic biota in the tailwater reaches of the four developments, a comprehensive, seasonal survey of fish and macroinvertebrates (aquatic insects and mussels) was undertaken in each of the four Project tailwaters. These surveys also included searches for rare, threatened and endangered (RTE) fish and mussel species.

2.0 BACKGROUND

As part of the relicensing process, APGI prepared and distributed, in September 2002, an Initial Consultation Document (ICD), which provided a general overview of the Project (APGI 2002). Agencies, municipalities, non-governmental organizations and members of the public were given an opportunity to review the ICD and identify information and studies that were needed to address relicensing issues. To further assist in the identification of issues and data/study needs, APGI formed several Issue Advisory Groups (IAGs) to advise APGI on resource issues throughout the relicensing process. Through meetings, reviews and comments, the Fish and Aquatics IAG assisted in developing the Study Plans for the various resource issues, and will further review and comment on the findings resulting from the implementation of the study plans. The Fish and Aquatics IAG was interested in the effects of Yadkin reservoir releases on tailwater fish, macroinvertebrates and aquatic habitat. They were also interested in the current status of RTE aquatic species in the Project tailwaters that could be impacted by Project operations. This report presents the findings of the tailwater fish and aquatic biota studies, following implementation of the Final Study Plan, dated June 2003. The Final Study Plan, entitled Tailwater Fish and Aquatic Biota Assessment is attached to this report as Appendix 1.

3.0 STUDY OBJECTIVES

On March 12 and April 9, 2003 the Fish and Aquatics IAG met to discuss study objectives for the Tailwater Fish and Aquatic Biota study. Through those discussions and written comments on the draft study plan received after the April 9, 2003 IAG meeting, the following objectives were identified for the final study plan.

1. Describe tailwater habitats in all four Yadkin development tailwater areas.
2. Inventory and assess the resident fish community in the Project tailwaters on a seasonal basis (spring, summer, and fall) to develop baseline data that can be used to detect changes over time. Evaluate the impacts of existing Project operations on the tailwater fish community, such as impacts associated with generation schedules (generation on/off), and impacts due to the low dissolved oxygen (DO) found in the tailwaters during certain times of the year.

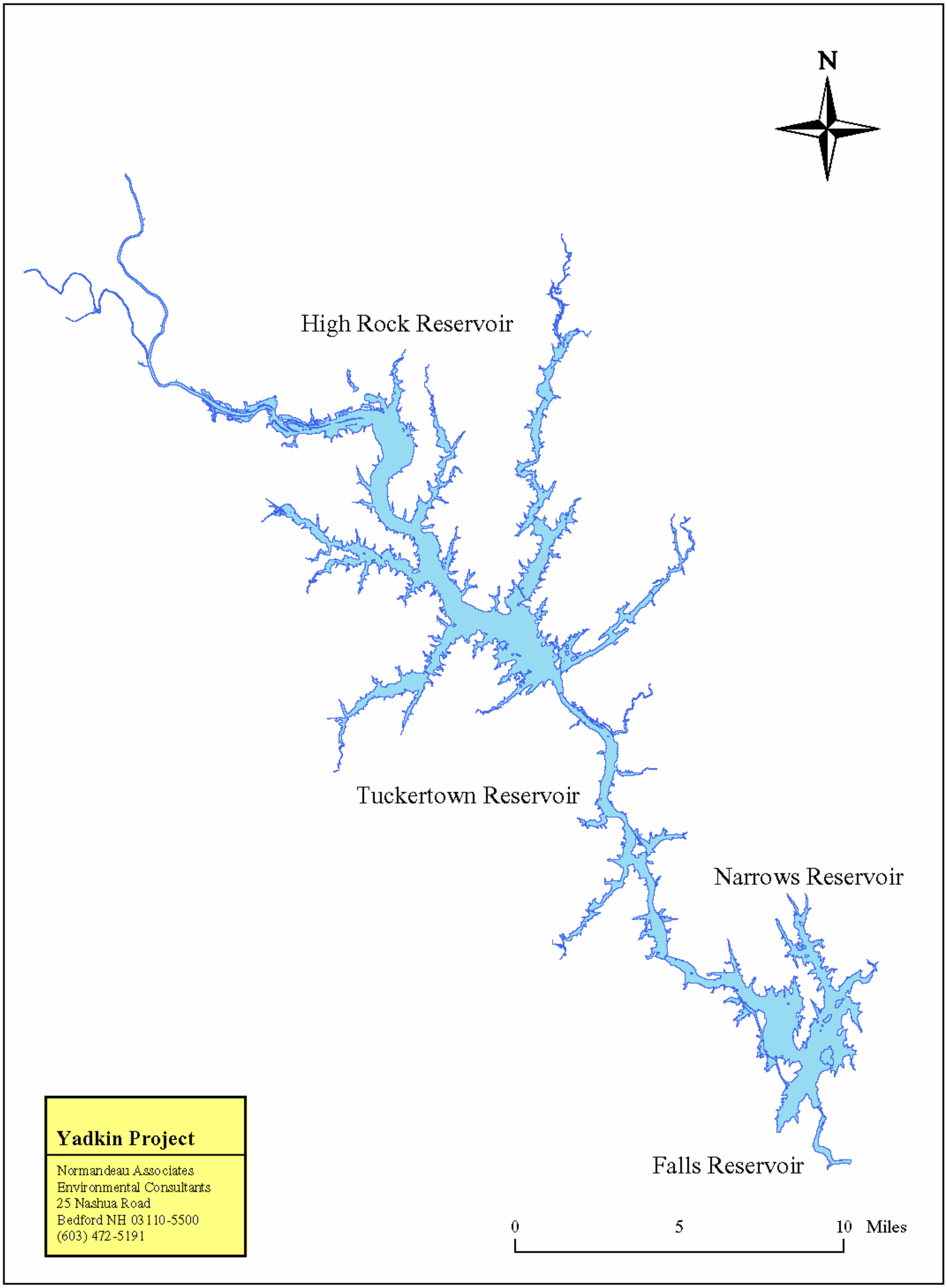

Figure 1-1. Yadkin Project

3. Inventory and assess the macroinvertebrate and mussel species in the Project tailwaters on a seasonal basis to develop baseline data that can be used to detect changes in these communities over time. Evaluate the impacts of existing project operations on the tailwater macroinvertebrate community and describe tailwater habitats.
4. Search for rare, threatened and endangered mussel species in Project tailwaters.
5. Search for rare, threatened and endangered fish species, including the Robust and Carolina redhorse species, in the Project tailwaters during the spring (spawning period), summer, and fall fish surveys.

4.0 METHODS

4.1 TAILWATER FISH SAMPLING

Normandeau personnel intensively sampled for fish during the summer (August and September, 2003), fall (November 2003) and spring (May 2004) in the Falls, Narrows, Tuckertown, and High Rock tailwater areas. Sampling gear included gill nets, boat electroshocking equipment, backpack electrofishing gear, and a forty foot seine net. Sampling focused on the immediate tailwater areas within each of the four reservoirs. The goal was to capture the maximum number of fish species to develop a comprehensive species list of the resident fish community on a seasonal basis in each tailwater. This list would then become a baseline that could be used to detect changes in the fish community over time. Fisheries sampling in each tailwater was planned to include periods when the projects were generating and during periods of no generation or reduced generation (this depended on the season and river flows). Part of this effort included sampling during low dissolved oxygen (DO) and normal DO levels during each season to determine effects of oxygen on fish catches. To accomplish these objectives, sampling in each tailwater generally continued for three to four consecutive days each season, so that different generation (on/off) and normal and low DO periods were sampled.

Two sets of experimental, monofilament gill nets, 100 ft long by 8 ft deep, were used to sample each of the tailwaters. The nets were constructed of four 25 ft panels of 1, 2, 3, and 4-inch stretch mesh. The second set of gillnets were of the same construction with 2, 3, 4, and 5 inch stretch mesh. The numbers of nets fished per tailwater varied based upon suitable conditions for setting the gear. Six nets were fished in the Highrock tailwater, seven in Tuckertown, six in Narrows and eight in Falls. Most gill nets were set to fish 24-hour periods and after they were hauled and the fish removed they were usually reset in the same location. However some gill nets were moved to other locations within the tailwater to avoid catching high numbers of repeat species and to expand the species list.

Electrofishing in the four tailwaters was conducted from two 16 ft aluminum boats equipped with a 4500W, 230V gasoline-powered generator. A four-electrode array was mounted on a boom and suspended in the water approximately 2 m in front of the boat; the cathode boom was secured to the bow of the boat. Direct current (DC) discharge was controlled by a Smith-Root Model IV electrofisher set to deliver 672V at 5-6 amps at a frequency of 60 pulses/sec. Current to the electrodes was pulsed by a foot switch operated by a netter at the bow. Both shock boats would work opposite shorelines simultaneously to expedite sampling and to ensure that fish were collected from all areas during both generation and non-generation periods. Most of the electrofishing effort in each tailwater concentrated on the shoreline because the mid-channel areas were too deep to effectively fish with anything but gill nets. Electrofishing was conducted during both daytime and nighttime to maximize catches and to sample during potential low DO periods in order to assess fish community reaction to the oxygen conditions in each tailwater. Each shore was electrofished multiple times to ensure that most fish species were captured. The Smith-Root systems logged the number of seconds each boat applied electricity to the water and this was used to calculate the number of fish captured per minute or the catch per unit effort (CPUE).

A backpack electroshocker was used to sample shallow water areas in each tailwater that could not be accessed with the electrofishing boats. A 40 ft seine was also used in appropriate habitat in each of the four tailwaters.

All fish were identified to species, measured to the nearest mm, and representative samples were weighed to the nearest gm. Most of the fish captured with electrofishing gear were released alive after they were processed except for a few individuals retained for further ID and reference specimens. Most of the fish captured with gill nets were dead or in poor condition, however, any live fish was released after it was measured and weighed.

4.2 TAILWATER FISH ANALYSIS

Percent composition and catch per unit effort (CPUE)was calculated for all fish. Proportional stock density (PSD), relative stock density (RSD) and relative weight (Wr) values were calculated for selected species. Boat electrofishing CPUE was obtained by dividing the total number of captured individuals within species by the number of hours (obtained from the Smith Root log detailing the seconds of electricity applied to the water) to calculate a value representing the number of fish captured per hour of actual shock time. Gill net CPUE was obtained by dividing the total number of captured individuals within each species by the total number of 24 hour net sets to calculate a value representing the number of fish captured per 24 hour period. Proportional stock densities (PSD) and relative stock densities (RSD-P) were calculated for selected game and forage fish. As described by Anderson (1980), PSD is the percentage of the stock that is of quality size and is calculated by:

$$\text{PSD}(\%) = \frac{\text{Number} > \text{quality size}}{\text{Number} > \text{stock size}} \times 100$$

where: stock size = 25 percent of maximum length

quality size = 37 percent of maximum length

RSD is the percentage of the stock that fits one of several size categories; preferred (RSD-P), memorable (RSD-M), or trophy (RSD-T), and is calculated based on the management strategy for the given stock (Gabelhouse 1984).

$$\text{RSD-P}(\%) = \frac{\text{Number} > \text{preferred size}}{\text{Number} > \text{stock size}} \times 100$$

where: stock size = 25 percent of maximum length

preferred size = 45-55 percent of maximum length

In addition to calculating PSD and RSD-P values for the dominant fish species captured in the tailwaters, relative weight was also determined. Relative weight gives an indication of a fish's body condition at the time of capture. As described by Anderson (1980) and Anderson and Neumann (1996), relative weight (W_r) is an index of body condition and is calculated by:

W_r = (W/Ws) x 100

where: W = the weight of an individual

W_s = a length specific standard weight predicted by a weight-length regression designed to represent a given species

Species-specific slope and intercept values are available to fisheries managers to assist in the calculation of relative weight values for a number of sport and non-game fish species (Neumann and Murphy 1991; Muoneke and Pope 1999; Anderson and Neumann 1996; Bister et al. 2000).

Standard ranges of PSD and RSD-P values to define a balanced fish population are available to aid fisheries managers. A balanced fish population has been defined as one that is intermediate between large numbers of small fish and small numbers of large fish and it indicates that the rates of growth, recruitment and mortality may be satisfactory (Anderson and Weithman 1978). Largemouth bass PSD values between 40 and 70 and RSD-P values between 10 and 40 are reported as ideal ranges for this species. Bluegill PSD values between 20 and 60 and RSD-P values between 5 and 20 are ideal for this fish. Crappie PSD values between 30 and 60 and RSD-P values between 5 and 20 are indicative of balanced populations (Anderson 1980; Anderson and Newman 1996). In general, an average relative weight of 100 over a broad range of size groups may reflect the optimum ecological and physiological conditions for a given species. Relative weight values well below the optimum range may be indicative of a problem with food or feeding for the species of concern. Ideal ranges of 95 to 100 for largemouth bass, bluegill, and redear sunfish (Murphy et al. 1991) and 95 to 105 for black and white crappie (Neumann and Murphy 1991) have been suggested. Of important note to fisheries managers, it has been suggested that populations of bass with low or no annual reproduction or low or indeterminate mortality of quality-sized fish may have PSD values greater then 80, RSD-P values greater then 40, and relative weight values exceeding 110. Populations of bluegill associated with above described bass populations typically have PSD values less then 20 and RSD-P values around zero (Anderson 1980).

4.3 CAROLINA AND ROBUST REDHORSE SEARCHES

The robust redhorse (*moxostoma robustum*) and Carolina redhorse (undescribed *moxostoma* species) are both listed as a Federal Species of Concern by the U.S. Fish and Wildlife Service (USFWS) and in recent years small numbers of both species have been captured in the Pee Dee River downstream of the Yadkin Project (RRCC 2003). Field crews were prepared to collect and hold these fish alive during all three seasons of tailwater fish capture. During the spring 2004 tailwater fish sampling, an additional effort was expended at all four tailwaters to try and capture the two redhorse species. Most of the available spawning habitat for the redhorse species at the Yadkin Project exists in the rocky, shoal habitat present in the four tailwaters, therefore the spring fish sampling was expanded to try and capture spawning redhorse species. Spring (2004) fish sampling began in the Falls tailwater when water temperatures reached 18 ºC (robust redhorse spawn between 18 and 24ºC). Additional gill net sets and electrofishing transects were fished in Falls tailwater during the spring sampling period, mainly because Falls has more of the redhorses preferred riverine habitat compared to the other Project tailwaters. Carolina redhorse have been captured in the Pee Dee River below the Yadkin Project around woody debris, therefore field crews also targeted this habitat type, when present, with both gill nets and electroshocking gear. Gill net locations at all four tailwaters were moved frequently during the spring sample period in an effort to cover more area. Gill nets were fished and checked within 8-hour periods during the spring survey to avoid any potentially negative effects on the rare redhorse species.

4.4 TAILWATER MACROINVERTEBRATE SAMPLING AND MUSSEL SEARCHES

Normandeau and Pennington and Associates, Inc. (PAI) personnel set-up permanent mussel transects and macroinvertebrate sampling stations in each of the four Project tailwaters. Agency personnel and interested participants from the Fish and Aquatics IAG assisted in picking out the transect locations at each tailwater site during the site visits in July 2003. Once the transect locations were selected, a GPS reading was taken on each shoreline so all macroinvertebrate sampling and mussel searches would be taken from the same transects.

Two transects were setup in each of the four tailwaters, with one transect located near each powerhouse and the other located downstream in the lower tailwater. Along each transect, three permanent macroinvertebrate stations were established at approximately 25%, 50% and 75% of the distance along each transect. Sampling was conducted at the macroinvertebrate stations during summer (September 2003), fall (November, 2003), and spring (May, 2004). A total of six 2 m^2 macroinvertebrate samples were collected from each tailwater per sample period. In deep water (>4 ft), an underwater airlift was used by a diver to collect the 2 m^2 macroinvertebrate samples at each station and in shoal water, a kick net was used. Macroinvertebrates collected were preserved on-site and returned to PAI's lab for sorting and identification of species.

Mussel searches were also conducted each season in each of the four tailwaters by divers swimming along the length of each transect line (length dependent on the wetted width of each tailwater at time of sampling). Divers searched at least one meter upstream and downstream of each transect line (2 m wide band along the entire transect) when visibility permitted. Additionally, mussel searches were done by walking along the shoreline of each tailwater looking for mussel shells and by having divers search in areas identified by participants during the July 2003 site visit as good mussel habitat that was not located along a transect line. Any live RTE mussel species located during the searches were to be identified, returned to where it was found (if it was removed from the water), and its location recorded with GPS. The location of any relic mussel shells found would be recorded and the shells collected and identified. The benthic macroinvertebrate communities were assessed and compared using taxa richness, percent contribution of dominant taxon, EPT index, Jaccards Coefficient, Percent Similarity and a modified Hilsenhoff Biotic Index.

During the macroinvertebrate sampling and mussel searches planned for August/September 2003, Normandeau and PAI biologists collecting the samples described the habitat found in each tailwater area along the transect lines.

5.0 TAILWATER FISH ASSESSMENT RESULTS

5.1 HIGH ROCK TAILWATER FISHERIES

This section presents results of all the fish captured in Highrock tailwater during the three sampling periods. Figure 5-1 shows the seasonal gill net locations, the extent of the area that was electrofished by boat, and the locations of backpack electrofishing and beach seining stations.

Figure 5-1. High Rock Tailwater Fisheries Sampling Locations.

A total of 2,275 fish (all gear types and seasons combined) representing 33 species and one hybrid were captured in the High Rock tailwater during the study period (Tables 5-1 & 5-2). Bluegill (15.7%), white perch (14.2%) and channel catfish (10%) were the three most common fish species collected (Table 5-2; Appendix 5). A total of 1,171 fish were captured by electrofishing during all three seasons of sampling (Table 5-3). Bluegills were the dominant species electrofished, with a CPUE of 47.7 fish/hr. Gill nets captured a total of 942 fish (Table 5-4). White perch (CPUE = 3.9 fish) were the most common fish captured using this gear. A total of 154 individuals representing five species (golden shiner, largemouth bass, satinfin shiner, spottail shiner and threadfin shad) were captured by beach seine (all seasons combined) and backpack shocking yielded eight individuals representing six species (bluegill, flathead catfish, green sunfish, pumpkinseed, satinfin shiner, and white crappie).

5.1.1 High Rock Tailwater Summer Sample Period

A total of 706 fish, representing 25 species were captured in High Rock tailwater (all gear types combined) between September 15 and September 18, 2003 (Table 5-2). Bluegill were the dominant fish species collected (18.8%) followed by white perch (16.0 %), channel catfish (13.0 %) and common carp at 9.4 % (Table 5-2; Appendix 5). These four fish accounted for more than 57 % of all the fish captured during the summer period.

Electrofishing in High Rock tailwater during the summer sample period resulted in 20 species being captured. Total electrofishing CPUE (all species combined) was 281 fish per hour with a total of 318 individual fish captured (Table 5-3). Bluegills were the most abundant fish species captured with a CPUE of 109.7 fish per hour followed by largemouth bass (42.5 fish per hour), black crappie (32.7 per hour) and gizzard shad (30.1 per hour). Combined, these four species represent 76 % of all the fish captured by electrofishing during the summer period.

Total CPUE for fish (all species combined) collected in gill nets deployed in High Rock tailwater during the summer sample period was 11.3 fish per net, and this consisted of 338 fish representing 20 species (Table 5-3). White perch were the dominant gill net fish captured, with a CPUE of 3.3 fish per net followed by channel catfish (2.9 per net) and common carp (1.8 per net). These three fish combined made up 71% of the summer gill net catches.

Beach seining in the High Rock tailwater during the summer sample period yielded 50 total fish, representing three species (44 satinfin shiner, 4 golden shiner, and 2 threadfin shad). No fish were captured during backpack electrofishing.

Values for PSD and RSD-P were calculated for largemouth bass, black crappie and bluegill captured in High Rock tailwater during the summer period (Table 5-5). The average PSD and RSD-P values for largemouth bass were 89 and 58, respectively, and both these values exceeded the ideal range reported. This means some of the large quality sized fish are experiencing low mortality and this may be due to catch and release fishing practices. Black crappie had an average PSD of 24, which is lower than the ideal range of 30 to 60 reported for a balanced population, but the RSD-P value of 10 is within the ideal range reported, suggesting that some large fish are available (Table 5-5). A low sample size prevented the calculation of PSD and RSD-P values for white crappie during the summer season. The average bluegill PSD (22) was within the range for a balanced population, but the average RSD-P (2) was below, indicating few large bluegills were present.

Table 5-1. Species composition for High Rock Tailwater by season.

Common Name	Scientific Name	Sampling Periods			
		Summer 2003	Fall 2003	Spring 2004	All Seasons
Blueback Herring	*Alosa aestivalis*		X		X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X	X
Threadfin Shad	*Dorosoma petenense*	X	X	X	X
Goldfish	*Carassius auratus*			X	X
Common Carp	*Cyprinus carpio*	X	X	X	X
Golden Shiner	*Notemigonus chrysoleucas*	X	X	X	X
Spottail Shiner	*Notropis hudsonius*			X	X
Satinfin Shiner	*Cyprinella analostana*	X	X	X	X
Eastern Silvery Minnow	*Hybognathus regius*			X	X
Quillback	*Carpiodes cyprinus*	X	X	X	X
Creek Chubsucker	*Erimyzon oblongus*			X	X
Shorthead Redhorse	*Moxostoma macrolepidotum*	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*	X	X		X
White Catfish	*Ameiurus catus*	X			X
Channel Catfish	*Ictalurus puntatus*	X	X	X	X
Flathead Catfish	*Pylodictus olivarus*	X	X	X	X
White Perch	*Morone americana*	X	X	X	X
Hybrid Bass (Striped x White)	*Morone saxatilis x chrysops*	X	X		X
Striped Bass	*Morone saxatilis*	X	X	X	X
White Bass	*Morone chrysops*			X	X
Redbreast Sunfish	*Lepomis auritus*	X	X	X	X
Green Sunfish	*Lepomis cyanellus*	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X	X
White Crappie	*Pomoxis annularis*	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X	X	X
Tesselated Darter	*Etheostome olmstedi*			X	X
Yellow Perch	*Perca flavescens*		X	X	X
Longnose Gar	*Lepisosteus osseus*	X	X	X	X
Warmouth	*Lepomis gulosus*		X	X	X
Smallmouth Buffalo	*Ictiobus bubalus*	X			X
Blue Catfish	*Ictalurus furcatus*	X	X		X
Redear Sunfish	*Lepomis microlophus*	X	X	X	X
	Total Taxa	**25**	**26**	**28**	**34**

Table 5-2. Percent Composition of Fish Species Captured within High Rock Tailwater, all gear types combined.

	Summer 2003		Fall 2003		Spring 2004		All Seasons	
Species	**# Individuals**	**% Composition**	**# Individuals**	**% Composition**	**# Individuals**	**% Composition**	**# Individuals**	**% Composition**
Bluegill	133	18.84%	150	19.53%	75	9.36%	358	15.74%
White Perch	113	16.01%	152	19.79%	58	7.24%	323	14.20%
Channel Catfish	92	13.03%	73	9.51%	63	7.87%	228	10.02%
Largemouth Bass	55	7.79%	63	8.20%	89	11.11%	207	9.10%
Gizzard Shad	55	7.79%	46	5.99%	103	12.86%	204	8.97%
Common Carp	66	9.35%	48	6.25%	51	6.37%	165	7.25%
Black Crappie	51	7.22%	34	4.43%	63	7.87%	148	6.51%
Golden Shiner	5	0.71%	54	7.03%	66	8.24%	125	5.49%
Satinfin Shiner	54	7.65%	27	3.52%	16	2.00%	97	4.26%
Quillback	10	1.42%	1	0.13%	68	8.49%	79	3.47%
Threadfin Shad	8	1.13%	40	5.21%	19	2.37%	67	2.95%
Pumpkinseed	4	0.57%	22	2.86%	14	1.75%	40	1.76%
White Crappie	5	0.71%	6	0.78%	27	3.37%	38	1.67%
Shorthead Redhorse	4	0.57%	11	1.43%	19	2.37%	34	1.49%
Flathead Catfish	10	1.42%	4	0.52%	9	1.12%	23	1.01%
Green Sunfish	10	1.42%	8	1.04%	3	0.37%	21	0.92%
Yellow Perch	0	0.00%	1	0.13%	16	2.00%	17	0.75%
Longnose Gar	3	0.42%	2	0.26%	9	1.12%	14	0.62%
Blue Catfish	13	1.84%	0	0.00%	0	0.00%	13	0.57%
Silver Redhorse	1	0.14%	11	1.43%	0	0.00%	12	0.53%
Striped Bass	3	0.42%	6	0.78%	2	0.25%	11	0.48%
White Bass	0	0.00%	0	0.00%	8	1.00%	8	0.35%
Redear Sunfish	1	0.14%	2	0.26%	4	0.50%	7	0.31%
Redbreast Sunfish	2	0.28%	0	0.00%	4	0.50%	6	0.26%
Creek Chubsucker	0	0.00%	0	0.00%	5	0.62%	5	0.22%
Warmouth	1	0.14%	1	0.13%	3	0.37%	5	0.22%
White Catfish	3	0.42%	2	0.26%	0	0.00%	5	0.22%
Goldfish	0	0.00%	0	0.00%	3	0.37%	3	0.13%
Hybrid Bass (Striped x White)	1	0.14%	2	0.26%	0	0.00%	3	0.13%
Blueback Herring	0	0.00%	2	0.26%	0	0.00%	2	0.09%
Smallmouth Buffalo	2	0.28%	0	0.00%	0	0.00%	2	0.09%
Tesselated Darter	0	0.00%	0	0.00%	2	0.25%	2	0.09%
Eastern Silvery Minnow	0	0.00%	0	0.00%	1	0.12%	1	0.04%
Spottail Shiner	0	0.00%	0	0.00%	1	0.12%	1	0.04%
White Sucker	1	0.14%	0	0.00%	0	0.00%	1	0.04%
TOTALS	**706**	**100.00%**	**768**	**100.00%**	**801**	**100.00%**	**2275**	**100.00%**

Table 5-3. Electrofishing CPUE (#of fish per hour of shock time) for fish captured in High Rock Tailwater.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE
Bluegill	124	109.65	146	47.31	72	24.35	342	47.67
Largemouth Bass	48	42.45	60	19.44	81	27.39	189	26.34
Gizzard Shad	34	30.07	40	12.96	28	9.47	102	14.22
Black Crappie	37	32.72	28	9.07	34	11.50	99	13.66
Common Carp	11	9.73	36	11.67	19	6.42	66	9.20
Threadfin Shad	5	4.42	40	12.96	17	5.75	62	8.64
Satinfin Shiner	10	8.84	25	8.10	14	4.73	49	6.83
Pumpkinseed	4	3.54	21	6.80	14	4.73	39	5.44
Quillback	0	0.00	0	0.00	29	9.81	29	4.04
Golden Shiner	1	0.88	8	2.59	16	5.41	25	3.48
White Perch	14	12.38	2	0.65	5	1.69	21	2.93
Channel Catfish	6	5.31	8	2.59	5	1.69	19	2.65
Green Sunfish	10	8.84	6	1.94	3	1.01	19	2.65
Yellow Perch	0	0.00	1	0.32	16	5.41	17	2.37
Silver Redhorse	1	0.88	11	3.56	0	0.00	12	1.67
White Crappie	4	3.54	4	1.30	4	1.35	12	1.67
Flathead Catfish	1	0.88	3	0.97	7	2.37	11	1.53
Striped Bass	2	1.77	6	1.94	2	0.68	10	1.39
Shorthead Redhorse	2	1.77	2	0.65	4	1.35	8	1.12
Redear Sunfish	1	0.88	2	0.65	4	1.35	7	0.98
Redbreast Sunfish	2	1.77	0	0.00	4	1.35	6	0.84
Longnose Gar	0	0.00	0	0.00	5	1.69	5	0.70
White Bass	0	0.00	0	0.00	5	1.69	5	0.70
Creek Chubsucker	0	0.00	0	0.00	4	1.35	4	0.56
Warmouth	0	0.00	1	0.32	3	1.01	4	0.56
Blueback Herring	0	0.00	2	0.65	0	0.00	2	0.28
Hybrid Bass (Striped x White)	0	0.00	2	0.65	0	0.00	2	0.28
Tesselated Darter	0	0.00	0	0.00	2	0.68	2	0.28
Eastern Silvery Minnow	0	0.00	0	0.00	1	0.34	1	0.14
Goldfish	0	0.00	0	0.00	1	0.34	1	0.14
White Catfish	1	0.88	0	0.00	0	0.00	1	0.14
TOTALS	**318**	**281.2**	**454**	**147.09**	**399**	**134.91**	**1171**	**163.1**

Table 5-4. Gillnet CPUE (# of fish per 24 hour set) for fish captured in High Rock Tailwater.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE
White Perch	99	3.30	150	8.33	53	1.77	302	3.87
Channel Catfish	86	2.87	65	3.61	58	1.93	209	2.68
Gizzard Shad	21	0.70	6	0.33	75	2.50	102	1.31
Common Carp	55	1.83	12	0.67	32	1.07	99	1.27
Quillback	10	0.33	1	0.06	39	1.30	50	0.64
Black Crappie	14	0.47	6	0.33	29	0.97	49	0.63
Shorthead Redhorse	2	0.07	9	0.50	15	0.50	26	0.33
White Crappie	1	0.03	1	0.06	23	0.77	25	0.32
Bluegill	9	0.30	2	0.11	3	0.10	14	0.18
Largemouth Bass	7	0.23	1	0.06	6	0.20	14	0.18
Blue Catfish	13	0.43	0	0.00	0	0	13	0.17
Flathead Catfish	9	0.30	1	0.06	1	0.03	11	0.14
Longnose Gar	3	0.10	2	0.11	4	0.13	9	0.12
White Catfish	2	0.07	2	0.11	0	0.00	4	0.05
Threadfin Shad	1	0.03	0	0.00	2	0.07	3	0.04
White Bass	0	0.00	0	0.00	3	0.10	3	0.04
Goldfish	0	0.00	0	0.00	2	0.07	2	0.03
Smallmouth Buffalo	2	0.07	0	0.00	0	0.00	2	0.03
Creek Chubsucker	0	0.00	0	0.00	1	0.03	1	0.01
Hybrid Bass (Striped x White)	1	0.03	0	0.00	0	0.00	1	0.01
Striped Bass	1	0.03	0	0.00	0	0.00	1	0.01
Warmouth	1	0.03	0	0.00	0	0.00	1	0.01
White Sucker	1	0.03	0	0.00	0	0.00	1	0.01
TOTALS	**338**	**11.25**	**258**	**14.34**	**346**	**11.54**	**942**	**12.08**

Table 5-5. Proportional stock density (PSD), Relative stock density (RSD-P) and Relative Weight (Wr)Values for selected species within High Rock Tailwater during all three sampling seasons.

Species	PSD				
	Summer	Fall	Spring	All Seasons	Ideal Range
Black crappie	24	42	24	27	30 to 60*
Bluegill	22	40	25	26	20 to 60*
Largemouth bass	89	83	87	87	40 to 70*

Species	RSD-P				
	Summer	Fall	Spring	All Seasons	Ideal Range
Black crappie	10	9	8	8	5 to 20*
Bluegill	2	0	1	1	5 to 20*
Largemouth bass	58	69	55	58	10 to 40*

Species	Wr				
	Summer	Fall	Spring	All Seasons	Ideal Range
Black crappie	82	80	80	80	95 to 105**
Bluegill	95	98	94	95	95 to 100***
Channel catfish	87	88	90	89	90 to 100*
Largemouth bass	104	110	104	102	95 to 100***

[*(Anderson and Neumann 1996) **(Neumann and Murray 1991) ***(Murphy et al. 1991)

Table 5-5 shows the average relative weights (Wr) for four fish species captured in High Rock tailwater by season. Black crappie had an average relative weight of 82 during the summer sampling season, which is lower than the recommended values of 95 to 105 reported for that species, indicating a problem securing enough food. The average bluegill relative weight for the summer sampling period was 95 and this was within the acceptable range (95-100) for the species. Average largemouth bass relative weights (104) for the summer period were slightly higher than the recommended range of 95 to 100 reported in the literature. Channel catfish (Wr = 87) were slightly below the recommended range of 90 to 100 reported for the species.

5.1.2 High Rock Tailwater Fall Sample Period

A total of 768 fish, representing 26 species were captured in High Rock tailwater (all gear types combined) between November 6 and November 8, 2003 (Table 5-1). White perch (19.8 %) and bluegill (19.5 %) were the two most abundant species during the fall sampling followed by channel catfish (9.5 %) and largemouth bass (8.2 %) (Table 5-2; Appendix 5). Together, these four fish species comprised 57 % of all the fish captured. Golden shiners were the fifth most abundant fish within the tailwater area during the fall and the majority of these were captured by beach seine in shallow, low-flow areas with sandy substrate.

Electrofishing CPUE in High Rock tailwater averaged 147 fish per hour during the fall sampling period and from this effort, 454 fish, representing 22 species were captured by electrofishing (Table 5-3). Bluegills were the dominant fish captured electrofishing, with a CPUE of 47.3 fish per hour, followed by largemouth bass (19.4 per hour), gizzard shad (13.0 per hour), threadfin shad (13.0 per hour) and common carp (11.7 per hour).

Gillnet CPUE for the fall sampling, all species combined, averaged 14.3 fish per net (Table 5-4). Two hundred fifty-eight fish representing 13 species were captured in the gill nets. White perch dominated the gill net catch with a CPUE of 8.3 fish per net, comprising 58% of the total fish caught.

During the fall sampling, a total of 50 fish representing three species were captured by beach seining (46 golden shiner, 2 satinfin shiner, 2 largemouth bass). An additional six fish representing 4 species were captured by backpack electrofishing (2 green sunfish, 2 bluegills, 1 pumpkinseed and 1 white crappie).

Values for PSD and RSD-P were calculated for largemouth bass, black crappie and bluegills collected during the fall sample period (Table 5-5). The average PSD and RSD-P for largemouth bass was 83 and 69, respectively, and both these values exceeded the ideal range reported. This indicates some of the large quality sized bass are experiencing low mortality and this may be due to catch and release fishing practices. Black crappie had an average PSD of 42 and RSD-P of 9, suggesting a balanced population with some large fish available for harvest. A low sample size prevented the calculation of PSD/RSD-P values for white crappie during the fall season. The average bluegill PSD (40) was within the range for a balanced population, while the average RSD-P was zero, indicating no preferred size fish.

Table 5-5 shows the average relative weights for four fish species captured in High Rock tailwater by season. Black crappie had an average relative weight of 80 during the fall sampling season, which is lower than the recommended values of 95 to 105 reported for that species. This indicates that the black crappies may have a problem securing enough food. The average bluegill relative weight for the fall sampling period was 98 and is within the acceptable range (95-100) for the species. Average largemouth bass relative weights (110) for the fall period were slightly higher than the recommended range of 95 to

100 reported in the literature. Channel catfish (Wr = 88) were just below the recommended range for the species.

5.1.3 High Rock Tailwater Spring Sample Period

A total of 801 fish, representing 28 species were captured in High Rock tailwater (all gear types combined) between May 4 and May 6, 2003 (Tables 5-1). Gizzard shad (12.9%), largemouth bass (11.1%), and bluegill (9.4%) were the three most abundant species captured in the tailwater during spring sampling (Table 5-2; Appendix 5). Quillback were the fourth most abundant species captured, making up 8.5% of the fish caught, and field notes suggest the gear was not completely effective at capturing quilback. Large numbers of quillback were observed escaping capture by moving out of the field generated by the electrofishing boats. Golden shiners were the fifth most abundant species collected during the spring season, comprising 8.3% of the total catch. The majority of these fish were captured by beach seine in shallow, sandy, low-flow areas of the tailwater.

Spring electrofishing CPUE averaged 135 fish per hour, with a total of 399 fish (27 species) captured (Table 5-3). Largemouth bass (CPUE=27.4 per hour) and bluegill (24.4 per hour) were the dominant species and comprised over 38% of all the fish caught. Black crappie (11.5 per hour), quillback (9.8 per hour) and gizzard shad (9.5 per hour) were also regularly captured by electrofishing.

Total CPUE for gill nets fished during the spring season averaged 11.5 fish per net, per 24-hour set (Table 5-4). A total of 346 fish representing 16 species were captured, and of these, gizzard shad (2.5 per net), channel catfish (1.9 per net), white perch (1.8 per net) and quillback (1.3 per net) were the dominant species.

During the spring sampling, a total of 54 fish representing four species were captured by beach seining (50 golden shiners, 2 largemouth bass, 1 satinfin shiner and 1 spottail shiner). An additional two fish (1 satinfin shiner and 1 flathead catfish) were captured by backpack electrofishing

The average PSD and RSD-P values for largemouth bass were 87 and 55, respectively, and both these values exceeded the ideal range reported (Table 5-5). This indicates that some of the large quality sized fish are experiencing low mortality and this may be due to catch and release fishing practices. Black crappie had an average PSD of 24, which is lower than the ideal range of 30 to 60 reported for a balanced population, but the RSD-P value of 8 is within the ideal range reported, suggesting that some large fish are available.

Table 5-5 shows the average relative weights for four fish species captured in High Rock tailwater by season. Black crappie had an average relative weight of 80 during the spring sampling season, which is lower than the recommended values of 95 to 105 reported for that species. Relative weights for black crappie were low during all three seasons in High Rock tailwater, suggesting a problem securing enough food. The average bluegill relative weight for the spring sampling period was 94, near the acceptable range (95-100) for the species. Average largemouth bass relative weights (104) for the spring period were slightly higher than the recommended range of 95 to 100 reported in the literature. Channel catfish (Wr = 90) were within the recommended range for the species.

5.1.4 Seasonal Differences in High Rock Tailwater

Species abundance was highest in High Rock tailwater during the spring sampling period. Bluegill, largemouth bass, channel catfish and gizzard shad were among the top seven species collected in each of the three sampling periods. Quillback abundance showed a dramatic increase during the spring sampling period when compared to the summer and fall periods. Quillback in Tennessee have been shown to spawn from late April through May (Etnier and Starnes 1993). Quillback may be using the area below the dam as a spawning ground. The PSD and RSD-P values for black crappie, largemouth bass, and bluegill followed the same pattern through all three sampling events. Using criteria from Anderson (1980), the High Rock PSD, RSD-P and Wr values for largemouth bass from all seasons combined were suggestive of a population with low mortality among quality-sized fish. The relative weights calculated for black crappie were consistently below ideal ranges, suggesting a feeding problem. Bluegill and channel catfish relative weights were either in the ideal range or just below, indicating these fish are in good condition. Largemouth bass consistently exceeded Wr values, indicating these fish are in very good condition, with no problems securing food.

Appendix 2 (Figures 1-1 through 1-9) show the length frequency distributions for several important game and forage fish found in High Rock tailwater during all three sampling seasons. Largemouth bass are spawning successfully within High Rock tailwater or the upper reach of Tuckertown reservoir. The length-frequency figures for this species show a bimodal distribution with peaks for juvenile and adult sized fish. Small numbers of striped bass were present in the tailwater during all three sampling periods. Striped bass are stocked by NCWCR to enhance the sport fishery and as a management tool to consume shad. Channel catfish ranging in size from ≤5cm to ≥60 cm were present in the tailwater during all three seasons. Channel catfish are maintaining a population with some large-sized individuals within the tailwater and are a popular sport fish. Bluegills are spawning successfully with a large number of individuals in the 12-15 cm size-classes, but there are few large quality fish. Black crappies were captured in all three seasons in the tailwater and those individuals represented a wide range of size classes, from juvenile to adult fish. White crappies were less abundant but individuals from both adult and juvenile size classes were captured. Large numbers of forage species such as white perch, gizzard shad, and threadfin shad indicate these fish are spawning successfully

5.2 TUCKERTOWN TAILWATER FISHERIES

This section presents results of all the fish captured in the Tuckertown tailwater during the three sampling periods. Figure 5-2 shows the seasonal gill net locations, the extent of the area that was electrofished by boat, and the locations of backpack electrofishing and beach seining stations.

A total of 3,296 fish (all gear types and seasons combined) representing 28 species and one hybrid were captured in the Tuckertown tailwater during the study (Tables 5-6 & 5-7). Bluegill (18.2%), gizzard shad (18.1) and white perch (13.7%) were the top three species captured (Table 5-7; Appendix 5).

A total of 1,836 fish were captured by electrofishing during all three seasons of sampling, and of these, bluegill were the most commonly captured species with a CPUE of 48.2 fish captured per hour of electroshocking (Table 5-8).

A total of 1,438 fish were captured by gill nets during the three seasons of sampling. White perch were the most common species with a CPUE of 4.3 per net (Table 5-9). A total of 13 fish representing two species (bluegill and largemouth bass) were captured by beach seine during all three sampling seasons. Backpack shocking yielded nine individuals representing five species (bluegill, channel catfish, flathead catfish, golden shiner, largemouth bass).

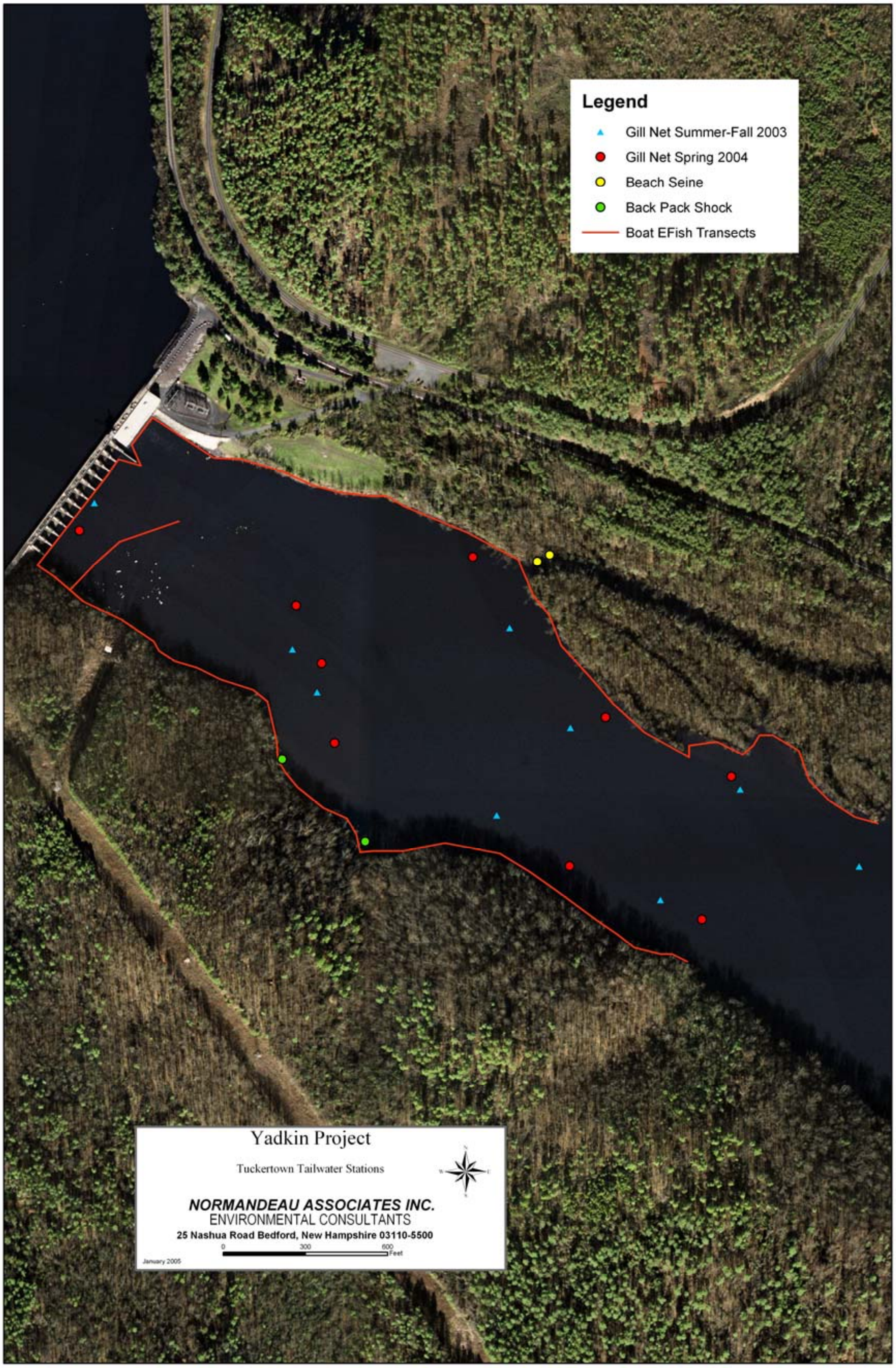

Figure 5-2. Tuckertown Tailwater Fisheries Sampling Locations.

Table 5-6. Species composition for Tuckertown Tailwater by season.

Common Name	Scientific Name	Sampling Periods Summer 2003	Fall 2003	Spring 2004	All Seasons
Blueback Herring	*Alosa aestivalis*	X	X	X	X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X	X
Threadfin Shad	*Dorosoma petenense*	X	X	X	X
Common Carp	*Cyprinus carpio*	X	X	X	X
Golden Shiner	*Notemigonus chrysoleucas*		X	X	X
Satinfin Shiner	*Cyprinella analostana*		X	X	X
Quillback	*Carpiodes cyprinus*		X	X	X
Creek Chubsucker	*Erimyzon oblongus*		X		X
Shorthead Redhorse	*Moxostoma macrolepidotum*	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*	X	X		X
White Catfish	*Ameiurus catus*	X	X	X	X
Channel Catfish	*Ictalurus puntatus*	X	X	X	X
Flathead Catfish	*Pylodictus olivarus*	X	X	X	X
White Perch	*Morone americana*	X	X	X	X
Hybrid Bass (Striped x White)	*Morone saxatilis x chrysops*	X	X		X
Striped Bass	*Morone saxatilis*	X	X	X	X
White Bass	*Morone chrysops*			X	X
Redbreast Sunfish	*Lepomis auritus*	X	X	X	X
Green Sunfish	*Lepomis cyanellus*	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X	X
White Crappie	*Pomoxis annularis*	X	X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X	X	X
Yellow Perch	*Perca flavescens*	X	X	X	X
Longnose Gar	*Lepisosteus osseus*	X	X	X	X
Warmouth	*Lepomis gulosus*	X			X
Blue Catfish	*Ictalurus furcatus*	X		X	X
Redear Sunfish	*Lepomis microlophus*	X	X	X	X
	Total Taxa	**24**	**26**	**25**	**29**

Table 5-7. Percent Composition of Fish Species Captured within Tuckertown Tailwater, all gear types combined.

	Summer 2003		Fall 2003		Spring 2004		All Seasons	
Species	**# Individuals**	**% Composition**	**# Individuals**	**% Composition**	**# Individuals**	**% Composition**	**# Individuals**	**% Composition**
Bluegill	267	18.76%	244	20.75%	88	12.63%	599	18.17%
Gizzard Shad	426	29.94%	116	9.86%	53	7.60%	595	18.05%
White Perch	224	15.74%	164	13.95%	63	9.04%	451	13.68%
Channel Catfish	100	7.03%	141	11.99%	73	10.47%	314	9.53%
Largemouth Bass	78	5.48%	79	6.72%	79	11.33%	236	7.16%
Threadfin Shad	53	3.72%	76	6.46%	69	9.90%	198	6.01%
Black Crappie	37	2.60%	83	7.06%	27	3.87%	147	4.46%
White Crappie	43	3.02%	29	2.47%	20	2.87%	92	2.79%
Pumpkinseed	5	0.35%	9	0.77%	62	8.90%	76	2.31%
Flathead Catfish	26	1.83%	4	0.34%	35	5.02%	65	1.97%
Striped Bass	15	1.05%	43	3.66%	7	1.00%	65	1.97%
Yellow Perch	2	0.14%	21	1.79%	37	5.31%	60	1.82%
White Catfish	34	2.39%	6	0.51%	18	2.58%	58	1.76%
Redear Sunfish	19	1.34%	31	2.64%	6	0.86%	56	1.70%
Blueback Herring	41	2.88%	10	0.85%	4	0.57%	55	1.67%
Shorthead Redhorse	15	1.05%	38	3.23%	1	0.14%	54	1.64%
Common Carp	16	1.12%	16	1.36%	21	3.01%	53	1.61%
Hybrid Bass (Striped x White)	2	0.14%	20	1.70%	0	0.00%	22	0.67%
Golden Shiner	0	0.00%	18	1.53%	3	0.43%	21	0.64%
Blue Catfish	8	0.56%	1	0.09%	8	1.15%	17	0.52%
Quillback	1	0.07%	7	0.60%	7	1.00%	15	0.46%
Silver Redhorse	2	0.14%	9	0.77%	0	0.00%	11	0.33%
Longnose Gar	3	0.21%	1	0.09%	5	0.72%	9	0.27%
Satinfin Shiner	0	0.00%	7	0.60%	1	0.14%	8	0.24%
Redbreast Sunfish	2	0.14%	1	0.09%	3	0.43%	6	0.18%
White Bass	0	0.00%	0	0.00%	5	0.72%	5	0.15%
Green Sunfish	1	0.07%	1	0.09%	2	0.29%	4	0.12%
Warmouth	3	0.21%	0	0.00%	0	0.00%	3	0.09%
Creek Chubsucker	0	0.00%	1	0.09%	0	0.00%	1	0.03%
TOTALS	**1423**	**100.00%**	**1176**	**100.00%**	**697**	**100.00%**	**3296**	**100.00%**

Table 5-8. Electrofishing CPUE (# of fish per hour of shock time) for fish captured in Tuckertown Tailwater.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE
Bluegill	256	58.42	233	74.44	73	17.60	562	48.20
Gizzard Shad	283	64.58	47	15.02	53	12.78	383	32.85
Largemouth Bass	66	15.06	77	24.60	73	17.60	216	18.52
Threadfin Shad	42	9.58	56	17.89	19	4.58	117	10.03
Pumpkinseed	5	1.14	9	2.88	62	14.95	76	6.52
White Perch	32	7.30	21	6.71	5	1.21	58	4.97
Black Crappie	16	3.65	26	8.31	7	1.69	49	4.20
Redear Sunfish	11	2.51	30	9.58	6	1.45	47	4.03
Blueback Herring	41	9.36	2	0.64	0	0.00	43	3.69
Yellow Perch	2	0.46	21	6.71	17	4.10	40	3.43
Channel Catfish	8	1.83	9	2.88	17	4.10	34	2.92
White Crappie	1	0.23	12	3.83	20	4.82	33	2.83
Common Carp	9	2.05	13	4.15	10	2.41	32	2.74
Striped Bass	15	3.42	15	4.79	2	0.48	32	2.74
White Catfish	9	2.05	3	0.96	11	2.65	23	1.97
Golden Shiner	0	0.00	18	5.75	2	0.48	20	1.72
Shorthead Redhorse	6	1.37	10	3.19	0	0.00	16	1.37
Hybrid Bass (Striped x White)	2	0.46	13	4.15	0	0.00	15	1.29
Satinfin Shiner	0	0.00	7	2.24	1	0.24	8	0.69
Redbreast Sunfish	2	0.46	1	0.32	3	0.72	6	0.51
Silver Redhorse	2	0.46	3	0.96	0	0.00	5	0.43
Green Sunfish	1	0.23	1	0.32	2	0.48	4	0.34
Longnose Gar	0	0.00	0	0.00	4	0.96	4	0.34
Quillback	0	0.00	0	0.00	4	0.96	4	0.34
White Bass	0	0.00	0	0.00	4	0.96	4	0.34
Flathead Catfish	0	0.00	1	0.32	2	0.48	3	0.26
Warmouth	2	0.46	0	0.00	0	0.00	2	0.17
TOTALS	**811**	**185.08**	**628**	**200.64**	**397**	**95.7**	**1836**	**157.44**

Table 5-9. Gillnet CPUE (# of fish per 24 hour set) for fish captured in Tuckertown Tailwater.

	Summer 2003		Fall 2003		Spring 2004		All Seasons	
Species	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE
White Perch	192	5.49	143	5.11	58	2.07	393	4.32
Channel Catfish	91	2.60	132	4.71	56	2.00	279	3.07
Gizzard Shad	143	4.09	69	2.46	0	0.00	212	2.33
Black Crappie	21	0.60	57	2.04	20	0.71	98	1.08
Threadfin Shad	11	0.31	20	0.71	50	1.79	81	0.89
Flathead Catfish	26	0.74	3	0.11	32	1.14	61	0.67
White Crappie	42	1.20	17	0.61	0	0.00	59	0.65
Shorthead Redhorse	9	0.26	28	1.00	1	0.04	38	0.42
White Catfish	25	0.71	3	0.11	7	0.25	35	0.38
Striped Bass	0	0.00	28	1.00	5	0.18	33	0.36
Common Carp	7	0.20	3	0.11	11	0.39	21	0.23
Bluegill	11	0.31	7	0.25	2	0.07	20	0.22
Yellow Perch	0	0.00	0	0.00	20	0.71	20	0.22
Largemouth Bass	11	0.31	1	0.04	6	0.21	18	0.20
Blue Catfish	8	0.23	1	0.04	8	0.29	17	0.19
Blueback Herring	0	0.00	8	0.29	4	0.14	12	0.13
Quillback	1	0.03	7	0.25	3	0.11	11	0.12
Redear Sunfish	8	0.23	1	0.04	0	0.00	9	0.10
Hybrid Bass (Striped x White)	0	0.00	7	0.25	0	0.00	7	0.08
Silver Redhorse	0	0.00	6	0.21	0	0.00	6	0.07
Longnose Gar	3	0.09	1	0.04	1	0.04	5	0.05
Creek Chubsucker	0	0.00	1	0.04	0	0.00	1	0.01
Warmouth	1	0.03	0	0.00	0	0.00	1	0.01
White Bass	0	0.00	0	0.00	1	0.04	1	0.01
TOTALS	**610**	**17.43**	**543**	**19.42**	**285**	**10.18**	**1438**	**15.81**

5.2.1 Tuckertown Tailwater Summer Sample Period

A total of 1,423 fish, representing 24 species were captured in the Tuckertown tailwater (all gear types combined) between September 1 and September 4, 2003 (Tables 5-7). Gizzard shad (29.9%), bluegill (18.8%), and white perch (15.7%) were the three most abundant species, comprising over 60% of the fish captured (Table 5-7; Appendix 5). Channel catfish, largemouth bass, and threadfin shad combined made up another 15% of the fish captured.

Summer electrofishing CPUE in the Tuckertown tailwater averaged 185 fish per hour (Table 5-8). A total of 811 fish representing 21 species were captured by boat electrofishing during this effort. Gizzard shad (64.5 per hour) and bluegill (58.4 per hour) were the two most abundant fish collected in the tailwater, followed by largemouth bass (15.1 per hour), threadfin shad (9.6 per hour), and blueback herring (9.4 per hour).

Gill net CPUE in Tuckertown tailwater during the summer sample period was 17.4 fish per net (Table 5-9). Six hundred and ten fish representing 17 species were captured by gill net and of these, white perch (5.5 fish per net), gizzard shad (4.1 per net), channel catfish (2.6 per net) and white crappie (1.2 per net) were the dominant species captured in the gill nets.

During the summer sampling, one largemouth bass was captured by beach seining and one channel catfish was collected with the backpack electrofishing unit.

The average PSD and RSD-P for largemouth bass was 86 and 63, respectively, and both these values exceeded the species ideal range (Table 5-10). Black crappie had an average PSD of 57 and RSD-P of 16, suggesting a balanced population with some large quality fish available. White crappie had a summer PSD of 23, slightly lower than the ideal range and an RSD-P of 9 within the ideal range, indicating some large fish are available for harvest. The average bluegill PSD (18) was slightly below the range for a balanced population, as was the average RSD-P (0). All redear sunfish captured during the summer that were greater than the minimum “stock” length for calculation of PSD values were also greater than the lower end of the “quality” size class. This resulted in a summer season PSD value of 100, which exceeded the ideal range of 20 to 60 reported for this species. The RSD-P value for redear was 32, higher than the ideal ranges, and this was due to the number of larger individuals captured.

Black crappie had an average relative weight of 91 during the summer sampling season, which is slightly lower than the recommended values of 95 to 105 reported for that species (Table 5-10). The average white crappie relative weight for the summer sampling period was 86, also below the acceptable range (95-105) for the species. The average bluegill relative weight for the summer sampling period was 101, slightly higher than the acceptable range (95-100) for the species, indicating they are in very good condition. The average relative weight for redear sunfish during the summer sampling was 78, lower then the ideal range for the species, indicating a potential problem securing food. Average largemouth bass relative weights (106) for the summer period were higher than the recommended range of 95 to 100 reported in the literature. Channel catfish (W_r = 92) were within the recommended range for the species.

5.2.2 Tuckertown Tailwater Fall Sample Period

A total of 1,176 fish, representing 26 species were captured in the Tuckertown tailwater (all gear types combined) between November 9 and November 11, 2003 (Table 5-7). Bluegill (20.8%), white perch (14.0%), and channel catfish (12.0%) were the three most abundant fish captured (Table 5-7; Appendix 5). Along with gizzard shad (9.9%), black crappie (7.1%) and largemouth bass (6.7%), these six species combined to represent over 70% of the total number of fish captured.

Total electrofishing CPUE (all fish combined) in the Tuckertown tailwater was 201 fish per hour and from this effort, 628 fish, representing 23 species were captured during the fall period (Table 5-8). Bluegills were the most abundant fish captured with a CPUE of 74.4 fish per hour, followed by largemouth bass (24.6 per hour), threadfin shad (17.9 per hour), and gizzard shad (15.0 per hour).

Gill net CPUE for fish collected during the fall period in Tuckertown tailwater was 19.4 fish per net (Table 5-9). A total of 543 fish, representing 21 species were captured. White perch (5.1 per net) and channel catfish (4.7 per net) comprised over 50 % of the fish caught in the gill nets. Gizzard shad (2.5 per net) and black crappie (2.0 per net) were the third and fourth most commonly captured fish.

Table 5-10. Proportional stock density (PSD), Relative stock density (RSD-P) and Relative Weight (Wr)Values for selected species within Tuckertown Tailwater during all three sampling seasons.

	PSD				
Species	**Summer**	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Black crappie	57	71	65	66	30 to 60*
Bluegill	18	5	15	15	20 to 60*
Largemouth bass	86	85	83	84	40 to 70*
Redear sunfish	100	N/A	100	100	20 to 60*
White crappie	23	54	34	35	30 to 60*

	RSD-P				
	Summer	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Black crappie	16	19	35	27	5 to 20*
Bluegill	0	0	0	0	5 to 20*
Largemouth bass	63	54	56	57	10 to 40*
Redear sunfish	32	N/A	30	30	5 to 20*
White crappie	9	25	16	16	5 to 20*

	Wr				
	Summer	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Black crappie	91	97	92	93	95-105**
Bluegill	101	92	98	98	90-100***
Channel catfish	92	87	93	92	90-100*
Largemouth bass	106	102	104	101	95-100***
Redear sunfish	78	N/A	77	78	95-100***
White crappie	86	92	87	87	95-105**

*(Anderson and Neumann 1996) **(Neumann and Murray 1991) ***(Murphy et al. 1991)

During the fall sampling, four bluegills and one largemouth bass were captured by backpack electrofishing. There were no fish captured by beach seine in Tuckertown tailwater during the fall sampling period.

The average fall PSD and RSD-P for largemouth bass was 85 and 54, respectively, exceeding the ideal range for both values (Table 5-10). Black crappies also exceeded the ideal values for PSD (71) and RSD-P (19) indicating some large fish were available for harvest. White crappie had a fall PSD of 54 and an RSD-P of 25, also exceeding ideal values reported in the literature. The average bluegill PSD (5) was below the range for a balanced population, as was the average RSD-P (0).

Black crappie had an average relative weight of 97 during the fall sampling season, which is within the recommended values of 95 to 105 reported for that species and the average white crappie relative weight for the fall sampling period was 92, just below the acceptable range (95-105). The average bluegill relative weight for the fall sampling period was 92, near the acceptable range (95-100) for the species. Average largemouth bass relative weights (102) for the fall period were slightly higher than the recommended range of 95 to 100 reported in the literature and channel catfish (Wr = 87) were just below the recommended range for the species.

5.2.3 Tuckertown Tailwater Spring Sample Period

A total of 697 individuals, representing 25 species were captured in the Tuckertown tailwater (all gear types combined) between May 9 and May 12, 2004 (Tables 5-7). Bluegill (12.6%), largemouth bass (11.3%), channel catfish (10.5%), threadfin shad (9.9%) and white perch (9.0%) comprised the top five species captured in the tailwater during the spring and accounted for 53.3 % of the individuals caught (Table 5-7; Appendix 5).

Total electrofishing CPUE averaged 95.7 fish per hour of effort during the Tuckertown spring sampling event and a total of 397 individuals representing 22 species were captured (Table 7-8). Bluegill (17.6 per hour), largemouth bass (17.6 per hour), pumpkinseed (15.0 per hour) and gizzard shad (12.8 per hour) were the four most abundant species collected, comprising 66% of the fish captured electrofishing.

Total CPUE (all fish combined) for gill nets fished during May of 2004 was 10.2 fish per net (Table 5-9). A total of 285 individuals representing 17 species were caught in gill nets and of these, white perch (2.1 per net), channel catfish (2.0 per net), threadfin shad (1.8 per net), and flathead catfish (1.1 per net) were the dominant fish.

During the spring sampling, 1 golden shiner, 1 flathead catfish and 1 bluegill were captured by backpack electrofishing and 12 bluegills were captured by beach seine in Tuckertown tailwater.

The average PSD and RSD-P for largemouth bass was 83 and 56, respectively, exceeding the ideal range for both values (Table 5-10). Black crappie had an average PSD of 65 and RSD-P of 35 and white crappie had a PSD of 34 and an RSD-P of 16. Both crappie species exceeded the ideal ranges for these values, indicating balanced fish populations with some quality sized fish available. The average bluegill PSD (15) was below the range for a balanced population, as was the average RSD-P (0). All redear sunfish captured during the spring that were greater than the minimum "stock" length for calculation of PSD values were also greater than the lower end of the "quality" size class. This resulted in a spring season PSD value of 100, well over the ideal range, and an RSD-P value of 30, also greater than the ideal range of 5 to 20 recommended for this fish, indicating some large quality fish are available for harvest.

Black crappie had an average relative weight of 92 during the spring sampling season, which is slightly lower than the recommended values of 95 to 105 reported for that species. The average white crappie relative weight for the spring sampling period was 87, also below the acceptable range (95-105) for the species. The average bluegill relative weight for the spring sampling period was 98, within the acceptable range (95-100) for the species. The average relative weight for redear sunfish during the spring sampling was 77, lower then the ideal range for the species. Average largemouth bass relative weights (104) for the spring period were slightly higher than the recommended range of 95 to 100 reported in the literature and channel catfish (Wr = 93) were within the recommended range for the species.

5.2.4 Seasonal Differences in Tuckertown Tailwater

Species richness was highest in the Tuckertown tailwater during the November sampling period. Bluegill, largemouth bass, channel catfish, threadfin shad, white perch and gizzard shad were consistently within the top seven species collected (all gear types combined) for each of the three sampling periods. The PSD, RSD-P and Wr values of largemouth bass were similar to values suggested by Anderson (1980) to be representative of a population that either has low or no annual reproduction or low rates of mortality on quality-sized fish. Since multiple size classes of largemouth bass were present (see Appendix 2 Figure 1-10), the data suggests that large, quality sized fish have low mortality and this may be a result of catch and release fishing. The PSD and RSD-P values for Tuckertown tailwater bluegills suggest a population that is not balanced due to few large fish, however, the bluegills captured had relative weights within the ideal range, suggesting the fish were in good condition. Redear sunfish were not present in the tailwater in great enough numbers during the fall season to calculate PSD/RSD-P values. The Wr values for this species (<78) were lower than optimum in both the spring and summer periods and this may be suggestive of a problem with food or feeding in this species. Relative weights for all six species looked at were consistent throughout the three seasons.

Appendix 2 (Figures 1-10 through 1-21) show the length frequency distributions for several important game and forage fish found in the Tuckertown tailwater. Largemouth bass representing all the size classes from 2-50 cm were captured during all three sampling periods in Tuckertown, demonstrating that successful spawning is occurring. Adult and juvenile sized striped bass were present in Tuckertown tailwater during all three sampling seasons. Fingerling striped bass are currently stocked by NCWRC into Narrows Reservoir (Tuckertown tailwater) at a rate of 62,000 fish per year. Blueback herring were present in Tuckertown tailwater during all three seasons sampled as a result of stockings into Narrows Reservoir (Tuckertown tailwater) during the 1970's. The presence of juvenile sized fish in the fall sampling suggests that this species is spawning successfully and continues to maintain a small land-locked population. Black and white crappies of different size classes were present in the tailwater during all three sampling events, indicating these fish are successfully spawning in Narrows reservoir (Tuckertown tailwater). Bluegills were present in large numbers and over a range of size classes demonstrating that they are successfully spawning. While PSD and RSD-P values are low for bluegill, suggesting an abundance of small individuals, the average relative weight value of all fish captured during the three seasons of sampling is within the ideal range for the species suggesting feeding is not a problem. The presence of small redear sunfish during the fall sampling period suggests that these fish are spawning and maintaining a population within Tuckertown tailwater. Channel and blue catfish are maintaining populations in the tailwater with some individuals reaching large size. Large numbers of forage species such as white perch, gizzard shad and threadfin shad demonstrate that these fish are spawning successfully.

5.3 NARROWS TAILWATER FISHERIES

This section presents results of all the fish captured in the Narrows tailwater during the three sampling periods. Figure 5-3 shows the seasonal gill net locations, the extent of the area that was electrofished by boat, and the locations of backpack electrofishing and beach seining stations.

A total of 3,667 fish (all gear types and seasons combined) representing 30 species were captured in the Narrows tailwater over the three seasons of sampling (Tables 5-11 & 5-12). White perch (20.3%), gizzard shad (19.6%) and bluegill (12.6%) were the top three fish species captured in Narrows during the study. Most of these fish (2,417 individuals) were captured by electrofishing during all three seasons of sampling. Gizzard shad (CPUE=39.2 fish/hr) were the most commonly captured species (Table 5-13). A total of 1,217 fish were captured by gill nets during the three seasons of sampling and of these, white perch were the dominant species with a CPUE of 6.9 per net (Table 5-14). A total of 25 individuals representing six species (bluegill, black crappie, golden shiner, largemouth bass,

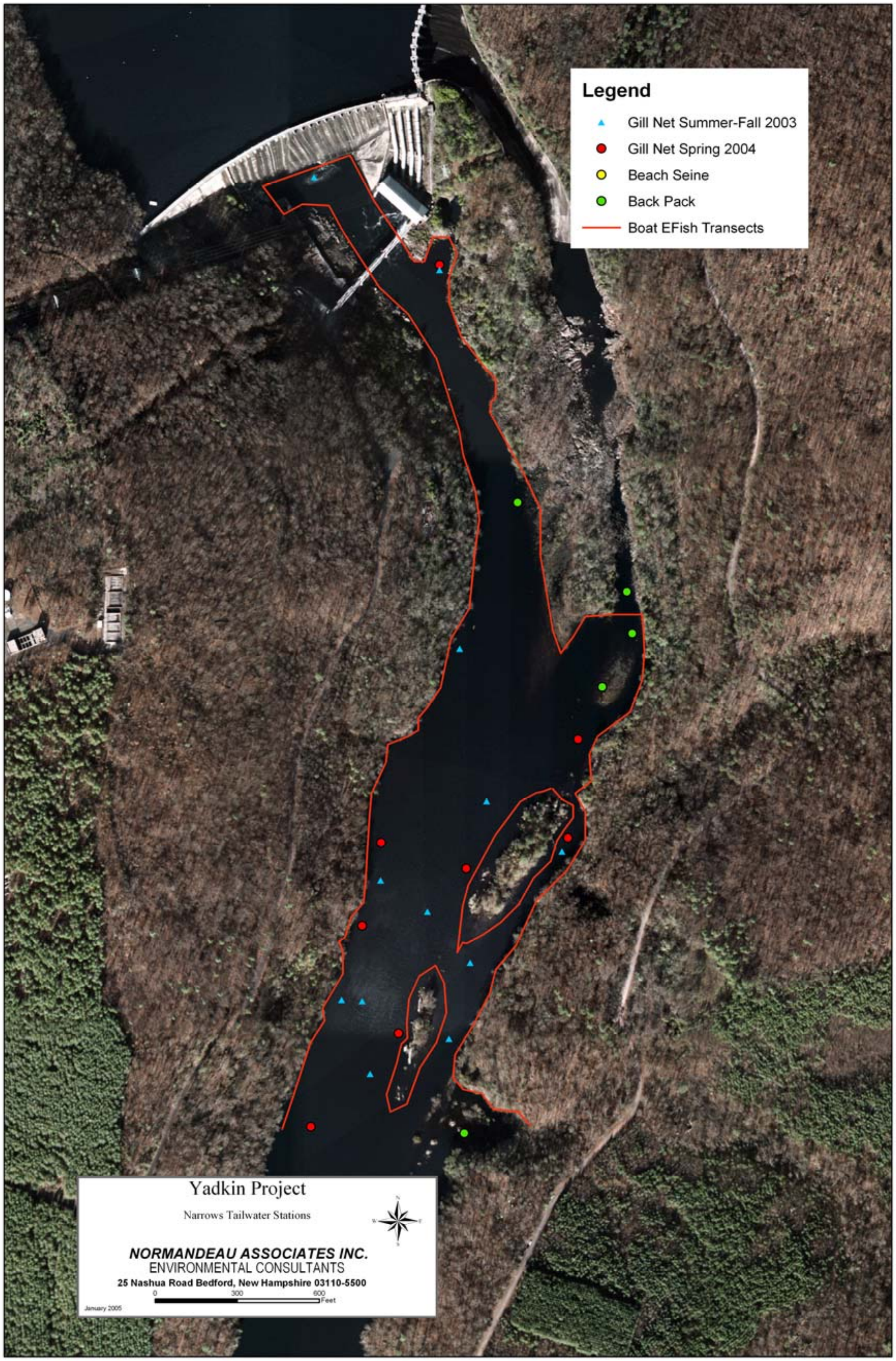

Figure 5-3. Narrows Tailwater Fisheries Sampling Locations.

Table 5-11. Species composition for Narrows Tailwater by season.

Common Name	Scientific Name	Sampling Periods			
		Summer 2003	Fall 2003	Spring 2004	All Seasons
Blueback Herring	*Alosa aestivalis*	X	X	X	X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X	X
Threadfin Shad	*Dorosoma petenense*	X	X	X	X
Common Carp	*Cyprinus carpio*	X	X	X	X
Golden Shiner	*Notemigonus chrysoleucas*	X		X	X
Satinfin Shiner	*Cyprinella analostana*	X		X	X
Shorthead Redhorse	*Moxostoma macrolepidotum*	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*			X	X
White Catfish	*Ameiurus catus*	X	X	X	X
Channel Catfish	*Ictalurus puntatus*	X	X	X	X
Flathead Catfish	*Pylodictus olivarus*	X	X	X	X
White Perch	*Morone americana*	X	X	X	X
Striped Bass	*Morone saxatilis*	X	X	X	X
White Bass	*Morone chrysops*			X	X
Redbreast Sunfish	*Lepomis auritus*	X	X	X	X
Green Sunfish	*Lepomis cyanellus*	X	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X	X
White Crappie	*Pomoxis annularis*		X	X	X
Black Crappie	*Pomoxis nigromaculatus*	X	X		X
Yellow Perch	*Perca flavescens*	X	X	X	X
Bowfin	*Amia calva*		X		X
Longnose Gar	*Lepisosteus osseus*		X	X	X
Flat Bullhead	*Ameiurus platycephalus*	X	X	X	X
Warmouth	*Lepomis gulosus*	X	X	X	X
Smallmouth Buffalo	*Ictiobus bubalus*			X	X
Snail Bullhead	*Ameiurus brunneus*			X	X
Blue Catfish	*Ictalurus furcatus*	X	X	X	X
Redear Sunfish	*Lepomis microlophus*	X	X	X	X
Total Taxa		**23**	**24**	**28**	**30**

Table 5-12. Percent Composition of Fish Species Captured within Narrows Tailwater, all gear types combined.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	% Composition	# Individuals	% Composition	# Individuals	% Composition	# Individuals	% Composition
White Perch	505	23.36%	217	24.27%	23	3.76%	745	20.32%
Gizzard Shad	553	25.58%	90	10.07%	77	12.60%	720	19.63%
Bluegill	273	12.63%	90	10.07%	100	16.37%	463	12.63%
Largemouth Bass	245	11.33%	125	13.98%	52	8.51%	422	11.51%
Redbreast Sunfish	198	9.16%	111	12.42%	89	14.57%	398	10.85%
Channel Catfish	92	4.26%	38	4.25%	73	11.95%	203	5.54%
White Catfish	67	3.10%	24	2.68%	42	6.87%	133	3.63%
Blue Catfish	90	4.16%	7	0.78%	24	3.93%	121	3.30%
Threadfin Shad	17	0.79%	58	6.49%	6	0.98%	81	2.21%
Blueback Herring	2	0.09%	41	4.59%	18	2.95%	61	1.66%
Warmouth	23	1.06%	10	1.12%	23	3.76%	56	1.53%
Striped Bass	14	0.65%	18	2.01%	7	1.15%	39	1.06%
Flathead Catfish	19	0.88%	4	0.45%	12	1.96%	35	0.95%
Redear Sunfish	16	0.74%	5	0.56%	14	2.29%	35	0.95%
Black Crappie	15	0.69%	16	1.79%	1	0.16%	32	0.87%
Pumpkinseed	6	0.28%	11	1.23%	15	2.45%	32	0.87%
Yellow Perch	11	0.51%	5	0.56%	11	1.80%	27	0.74%
Common Carp	5	0.23%	5	0.56%	6	0.98%	16	0.44%
Shorthead Redhorse	1	0.05%	7	0.78%	2	0.33%	10	0.27%
Longnose Gar	0	0.00%	6	0.67%	2	0.33%	8	0.22%
Golden Shiner	6	0.28%	0	0.00%	1	0.16%	7	0.19%
Flat Bullhead	2	0.09%	1	0.11%	3	0.49%	6	0.16%
Green Sunfish	1	0.05%	2	0.22%	1	0.16%	4	0.11%
Snail Bullhead	0	0.00%	0	0.00%	3	0.49%	3	0.08%
Satinfin Shiner	1	0.05%	0	0.00%	1	0.16%	2	0.05%
Silver Redhorse	0	0.00%	0	0.00%	2	0.33%	2	0.05%
Smallmouth Buffalo	0	0.00%	0	0.00%	2	0.33%	2	0.05%
White Bass	0	0.00%	1	0.11%	1	0.16%	2	0.05%
Bowfin	0	0.00%	1	0.11%	0	0.00%	1	0.03%
White Crappie	0	0.00%	1	0.11%	0	0.00%	1	0.03%
TOTALS	**2162**	**100.00%**	**894**	**100.00%**	**611**	**100.00%**	**3667**	**100.00%**

Table 5-13. Electrofishing CPUE (# of fish per hour of shock time) for fish captured in Narrows Tailwater.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE
Gizzard Shad	386	64.76	62	15.72	77	22.12	525	39.22
Bluegill	258	43.29	83	21.04	100	28.72	441	32.95
Redbreast Sunfish	197	33.05	108	27.38	89	25.56	394	29.43
Largemouth Bass	228	38.25	112	28.40	51	14.65	391	29.21
White Perch	85	14.26	12	3.04	23	6.61	120	8.96
White Catfish	51	8.56	23	5.83	36	10.34	110	8.22
Channel Catfish	39	6.54	14	3.55	46	13.21	99	7.40
Threadfin Shad	17	2.85	41	10.40	6	1.72	64	4.78
Blueback Herring	2	0.34	41	10.40	1	0.29	44	3.29
Warmouth	18	3.02	7	1.77	16	4.60	41	3.06
Redear Sunfish	14	2.35	5	1.27	14	4.02	33	2.47
Yellow Perch	11	1.85	5	1.27	10	2.87	26	1.94
Pumpkinseed	5	0.84	5	1.27	15	4.31	25	1.87
Striped Bass	10	1.68	12	3.04	2	0.57	24	1.79
Black Crappie	9	1.51	6	1.52	1	0.29	16	1.20
Blue Catfish	13	2.18	1	0.25	0	0.00	14	1.05
Common Carp	3	0.50	4	1.01	5	1.44	12	0.90
Flathead Catfish	2	0.34	2	0.51	6	1.72	10	0.75
Golden Shiner	4	0.67	0	0.00	1	0.29	5	0.37
Green Sunfish	1	0.17	2	0.51	1	0.29	4	0.30
Flat Bullhead	2	0.34	0	0.00	1	0.29	3	0.22
Shorthead Redhorse	0	0.00	2	0.51	1	0.29	3	0.22
Snail Bullhead	0	0.00	0	0.00	3	0.86	3	0.22
Longnose Gar	0	0.00	0	0.00	2	0.57	2	0.15
Satinfin Shiner	1	0.17	0	0.00	1	0.29	2	0.15
Smallmouth Buffalo	0	0.00	0	0.00	2	0.57	2	0.15
Bowfin	0	0.00	1	0.25	0	0.00	1	0.07
Silver Redhorse	0	0.00	0	0.00	1	0.29	1	0.07
White Bass	0	0.00	0	0.00	1	0.29	1	0.07
White Crappie	0	0.00	1	0.25	0	0.00	1	0.07
TOTALS	**1356**	**227.52**	**549**	**139.19**	**512**	**147.07**	**2417**	**180.55**

Table 5-14. Gillnet CPUE (# of fish per 24 hour set) for fish captured in Narrows Tailwater.

	Summer 2003		Fall 2003		Spring 2004		All Seasons	
Species	**# Individuals**	**CPUE**	**# Individuals**	**CPUE**	**# Individuals**	**CPUE**	**# Individuals**	**CPUE**
White Perch	420	8.75	205	8.54	0	0.00	625	6.94
Gizzard Shad	167	3.48	27	1.13	0	0.00	194	2.16
Blue Catfish	77	1.60	6	0.25	24	1.33	107	1.19
Channel Catfish	53	1.10	24	1.00	27	1.50	104	1.16
Flathead Catfish	17	0.35	2	0.08	6	0.33	25	0.28
Largemouth Bass	10	0.21	13	0.54	0	0.00	23	0.26
White Catfish	16	0.33	1	0.04	6	0.33	23	0.26
Blueback Herring	0	0.00	0	0.00	17	0.94	17	0.19
Threadfin Shad	0	0.00	17	0.71	0	0.00	17	0.19
Black Crappie	5	0.10	10	0.42	0	0.00	15	0.17
Striped Bass	4	0.08	6	0.25	5	0.28	15	0.17
Warmouth	5	0.10	3	0.13	7	0.39	15	0.17
Bluegill	3	0.06	7	0.29	0	0.00	10	0.11
Shorthead Redhorse	1	0.02	5	0.21	1	0.06	7	0.08
Longnose Gar	0	0.00	6	0.25	0	0.00	6	0.07
Common Carp	2	0.04	1	0.04	1	0.06	4	0.04
Flat Bullhead	0	0.00	1	0.04	2	0.11	3	0.03
Redbreast Sunfish	0	0.00	3	0.13	0	0.00	3	0.03
Redear Sunfish	1	0.02	0	0.00	0	0.00	1	0.01
Silver Redhorse	0	0.00	0	0.00	1	0.06	1	0.01
White Bass	0	0.00	1	0.04	0	0.00	1	0.01
Yellow Perch	0	0.00	0	0.00	1	0.06	1	0.01
TOTALS	**781**	**16.24**	**338**	**14.09**	**98**	**5.45**	**1217**	**13.54**

pumpkinseed, and redear sunfish) were captured by beach seine during all three sampling seasons. Backpack shocking yielded eight individuals representing five species (bluegill, gizzard shad, largemouth bass, pumpkinseed, and redbreast sunfish).

5.3.1 Narrows Tailwater Summer Sample Period

A total of 2,162 fish, representing 23 species were captured in the Narrows tailwater (all gear types combined) between August 28 and September 1, 2003 (Table 5-12). Gizzard shad and white perch were the dominant fish, and together they represented 50% of the individuals captured (Table 5-12; Appendix 5). Bluegill (12.6%), largemouth bass (11.3%), redbreast sunfish (9.2%) and channel catfish (4.3%) rounded out the top six species captured.

Total summertime electrofishing CPUE in Narrows tailwater was 227.5 fish per hour, with a total of 1,356 fish collected (Table 5-13). Gizzard shad were the most frequently captured fish in the summer electrofish samples, with a CPUE of 64.8 fish caught per hour, followed by bluegill (43.3 per hour), largemouth bass (38.3 per hour) and redbreast sunfish (33.1 per hour). The above four species along with white perch (14.3 per hour) and white catfish (8.6 per hour) comprised the top six fish captured by electrofishing.

Total CPUE for fish (all species combined) collected in the Narrows gill nets during the summer of 2003 was 16.2 fish per 24 hour set (Table 5-14). White perch were the most abundant fish in the gill nets with a CPUE of 8.8 fish per net followed by gizzard shad with 3.5 fish per net. Four catfish species, blue (CPUE=1.6), channel (1.1), flathead (0.4) and white (0.3), rounded out the six most frequently captured species in the gillnets.

During the summer sampling period in Narrows tailwater, a total of 19 fish representing five species were captured by beach seine (9 bluegill, 6 largemouth bass, 2 golden shiner, 1 black crappie, 1 redear sunfish). Backpack electrofishing captured a total of 6 fish representing four species (3 bluegill, 1 redbreast sunfish, 1 pumpkinseed, 1 largemouth bass).

The average PSD and RSD-P for largemouth bass was 84 and 41 respectively and these exceed the species ideal range (Table 5-15). Black crappie had an average PSD of 93 and RSD-P of 57, both values being higher then the optimum ranges for the species. The average bluegill PSD (17) was just below the range for a balanced population, as was the average RSD-P (0). Redear sunfish captured during the summer had an average PSD value of 33 and RSD-P value of 33. The PSD value was within the optimum range for the species whereas the RSD-P value was above, indicating some large fish were captured.

Table 5-15. Proportional stock density (PSD), Relative stock density (RSD-P) and Relative Weight (Wr) Values for selected species within Narrows Tailwater during all three sampling seasons.

	PSD				
Species	**Summer**	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Black crappie	93	100	N/A	97	30 to 60*
Bluegill	17	24	21	20	20 to 60*
Largemouth bass	84	70	79	78	40 to 70*
Redear sunfish	33	N/A	61	53	20 to 60*

	RSD-P				
	Summer	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Black crappie	57	93	N/A	76	5 to 20*
Bluegill	0	0	0	0	5 to 20*
Largemouth bass	41	38	39	39	10 to 40*
Redear sunfish	33	N/A	35	35	5 to 20*

	Wr				
	Summer	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Black crappie	91	99	96	95	95 to 105**
Blue catfish	108	N/A	106	107	90 to 100*
Bluegill	93	89	92	92	95 to 100***
Channel catfish	99	98	100	99	90 to 100*
Largemouth bass	104	108	104	102	95 to 100***
Redear sunfish	83	N/A	79	80	95 to 100***

*(Anderson and Neumann 1996) **(Neumann and Murray 1991) ***(Murphy et al. 1991)

Table 5-15 shows the average relative weights for six fish species captured in Narrows tailwater by season. Black crappie had an average relative weight of 91 during the summer sampling season, which is lower than the recommended values of 95 to 105 reported for that species. The average bluegill relative weight for the summer sampling period was 93, near the acceptable range (95-100) for the species. The average relative weight for redear sunfish during the summer sampling was 83, lower than the ideal range for the species. Average largemouth bass relative weights (104) for the summer period were slightly higher than the recommended range of 95 to 100 reported in the literature. Channel catfish (Wr = 99) were within the recommended range for the species whereas blue catfish (Wr = 108) were higher then the range suggested for that species.

5.3.2 Narrows Tailwater Fall Sample Period

A total of 894 fish, representing 24 species were captured in the Narrows tailwater (all gear types combined) between November 6 and November 8, 2003 (Table 5-12). White perch were the most frequently caught, comprising 24 % of the catch , followed by largemouth bass (14.0 %), redbreast sunfish (12.4 %), bluegill (10.1 %) and gizzard shad (10.1 %) (Table 5-12; Appendix 5). These five species made up over 70 % of the fish caught during the fall period.

Electrofishing CPUE in Narrows tailwater averaged 139.2 fish per hour, with a total of 549 fish collected (Table 5-13). Largemouth bass (28.4 per hour), redbreast sunfish (27.4 per hour) and bluegill (21.0 per hour) were the most abundant fish captured by electrofishing.

Total CPUE for fish collected in the Narrows gill nets during November of 2003 was 14.1 fish per 24 hour set (Table 5-14). A total of 338 individuals were captured and of these, white perch were the dominant fish captured in the gillnets, with CPUE of 8.5 fish per net. Gizzard shad (1.1 per net), channel catfish (1.0 per net), threadfin shad (0.7 per net) and largemouth bass (0.5 per net) rounded out the five most commonly captured fish in gillnets.

During the fall sampling in Narrows tailwater, a total of six pumpkinseed were captured by beach seine. A single gizzard shad was captured by backpack electrofishing.

The average PSD and RSD-P for largemouth bass was 70 and 38 respectively and black crappie had an average PSD of 100 and RSD-P of 93 (Table 5-15). These values are higher than the optimum ranges for both species. The average bluegill PSD (24) was within the range for a balanced population, whereas the average RSD-P (0) was below. Redear sunfish were not captured in high enough numbers during the fall sampling period to calculate stock densities or relative weights.

Black crappie had an average relative weight of 99 during the fall sampling season, which is within the recommended range of 95 to 105 reported for that species (Table 5-15). The average bluegill relative weight for the fall sampling period was 89, slightly below the acceptable range (95-100) for the species. Average largemouth bass relative weights (108) for the fall period were slightly higher than the recommended range of 95 to 100 reported in the literature. Channel catfish (Wr = 98) were within the recommended range for the species.

5.3.3 Narrows Tailwater Spring Sample Period

A total of 611 fish, representing 28 species were captured in the Narrows tailwater (all gear types combined) between May 12 and May 14, 2004 (Table 5-12). The five dominant fish captured in the Narrows tailwater during the spring sample period were bluegill (16.4 %), redbreast sunfish (14.6 %), gizzard shad (12.6 %), channel catfish (12.0 %) and largemouth bass (8.5 %) (Table 5-12; Appendix 5).

Electrofishing CPUE in Narrows tailwater averaged 147 fish per hour, with a total of 512 fish collected (Table 5-13). Similar to the fall season, bluegill (28.7 per hour) and redbreast sunfish (25.6 per hour) were the two dominant species, followed by gizzard shad (22.1 per hour) largemouth bass (14.7 per hour), and channel catfish (13.2 per hour).

Total CPUE for fish collected from gillnets during the spring season was 5.44 fish per net and from this effort, 98 fish, representing twelve species were captured (Table 5-14). Channel catfish (1.5 per net), blue catfish (1.3 per net), and blueback herring were the three most frequently captured species in gillnets.

During the spring sampling in Narrows tailwater, one largemouth bass was captured by backpack electrofishing. There were no fish captured by beach seine in Narrows tailwater during the spring sampling.

The average PSD and RSD-P for largemouth bass was 79 and 39 respectively, exceeding the species optimum range (Table 5-15). The average bluegill PSD (21) was within the range for a balanced population, but the average RSD-P was zero due to no large fish. Channel catfish had a spring season PSD of 58 and an RSD-P of 2. Blue catfish had a spring season PSD of 26 and an RSD-P of 1. Redear sunfish captured during the spring had an average PSD value of 61 and RSD-P value of 35, with both values exceeding the optimum range. Black crappie sample size for the spring season was too small for calculation of average stock densities.

The average bluegill relative weight for the spring sampling period was 100, within the acceptable range (95-100) for the species, while the average relative weight for redear sunfish during the spring sampling was 79, lower then the ideal range for the species (Table 5-15). Average largemouth bass relative weight (104) for the spring period was slightly higher than the recommended range of 95 to 100 reported in the literature. Channel catfish (Wr = 100) were within the recommended range for the species whereas blue catfish (Wr = 106) were higher then the range suggested for that species.

5.3.4 Seasonal Differences in Narrows Tailwater

Species abundance was highest in Narrows tailwater during the spring season. Largemouth bass, bluegill, redbreast sunfish, white perch, and gizzard shad were consistently among the five most abundant species sampled during all three seasons. Blueback herring were represented in the catch during all three seasons. These fish have not been officially stocked into Falls reservoir (Narrows tailwater) but have most likely been recruited from the land-locked population found upstream in Narrows reservoir. The PSD and RSD values for largemouth bass and bluegill in Narrows tailwater are consistent through all three sampling periods. Overall, largemouth bass and bluegill were within or near the suggested ranges, indicating a balanced population. Redear sunfish were not present in the tailwater in great enough numbers during the fall season to calculate PSD/RSD-P values. The values for this species were lower than suggested in both the spring and summer and this could be suggestive of a problem with food or feeding in this species. Relative weights for all six species calculated were consistent throughout the three seasons.

Appendix 2 (Figures 1-22 through 1-32) show length frequency distributions for several important game and forage fish found in Narrows tailwater during all three sampling seasons. Largemouth bass are successfully spawning as they show a bimodal length frequency distribution with both young fish and older spawning age adults represented in the catches. Adult and juvenile sized striped bass were present in the Narrows tailwater during all three seasons. The NCWRC does not currently stock striped bass into Falls Reservoir (Narrows tailwater) and the presence of these fish in Falls reservoir is most likely due to successful recruitment from upstream sources. Small numbers of blueback herring were captured in the Narrows tailwater during all three seasons and their presence could be explained by recruitment from the established population upsystem in Narrows Reservoir. Redear sunfish appear to be successfully spawning in the tailwater as shown by the variety of size classes present. They are not as abundant in Narrows tailwater as they were in the Falls tailwater. Bluegills in Narrows tailwater seem to be dominated by small fish in the 12 – 14 cm range. Black crappie were captured in small numbers in the Narrows tailwater and the presence of juvenile size classes could suggest some spawning taking place in Falls Reservoir (Narrows tailwater) or possible recruitment from the upstream population in Narrows Reservoir. The presence of individuals in many size classes indicates that both channel and blue catfish are spawning and achieving large sizes within the Falls reservoir. Three major forage species, gizzard shad, threadfin shad and white perch were abundant in the tailwater demonstrating successful spawning.

5.4 FALLS TAILWATER FISHERIES

This section presents results of all the fish captured in the Falls tailwater during the three sampling periods. Figure 5-4 shows the seasonal gill net locations, the extent of the area that was electrofished by boat, and the locations of backpack electrofishing and beach seining stations.

A total of 2,906 individuals (all gear types and seasons combined) representing 34 species were captured in the Falls tailwater over the three seasons of sampling (Table 5-16 & 5-17). Over all three seasons of sampling, gizzard shad (13.7 %), redbreast sunfish (13.5 %), and bluegill (12.5 %) were the top three fish species captured (Table 5-17; Appendix 5). A total of 2,395 fish were captured by electrofishing during all three seasons of sampling. Redbreast sunfish were the most commonly captured species with 23.9 fish captured per hour (Table 5-18). A total of 357 fish were captured by gillnets during all three seasons of sampling and of these white perch were dominant with 1.1 captured per 24 hour set (Table 5-19). A total of seven individuals representing four species were captured by backpack electrofishing during all three sampling seasons (bluegill, largemouth bass, redbreast sunfish, and tessellated darter). Beach seining yielded three individuals representing two species (bluegill and redbreast sunfish).

5.4.1 Falls Tailwater Summer Sample Period

A total of 834 fish representing 23 species were captured in Falls tailwater (all gear types combined) between August 26 and August 27, 2003 (Table 5-17). Bluegill (16 %) were the dominant fish species, followed by white perch (13 %), threadfin shad (10 %), gizzard shad (10 %), and redbreast sunfish (10 %). Two game species, the redear sunfish and largemouth bass, each comprised between 7 and 8 % of the capture. These top seven fish species represented more then 75 % of the catch in Falls tailwater.

Electrofishing CPUE in the Falls tailwater averaged 168.4 fish per hour, with a total of 676 fish collected (Table 5-18). Bluegills were the dominant species with 32.1 fish per hour followed by white perch (21.9 per hour), redbreast sunfish (19.9 per hour), redear sunfish (15.4 per hour), gizzard shad, and threadfin shad (both at 15.2 per hour).

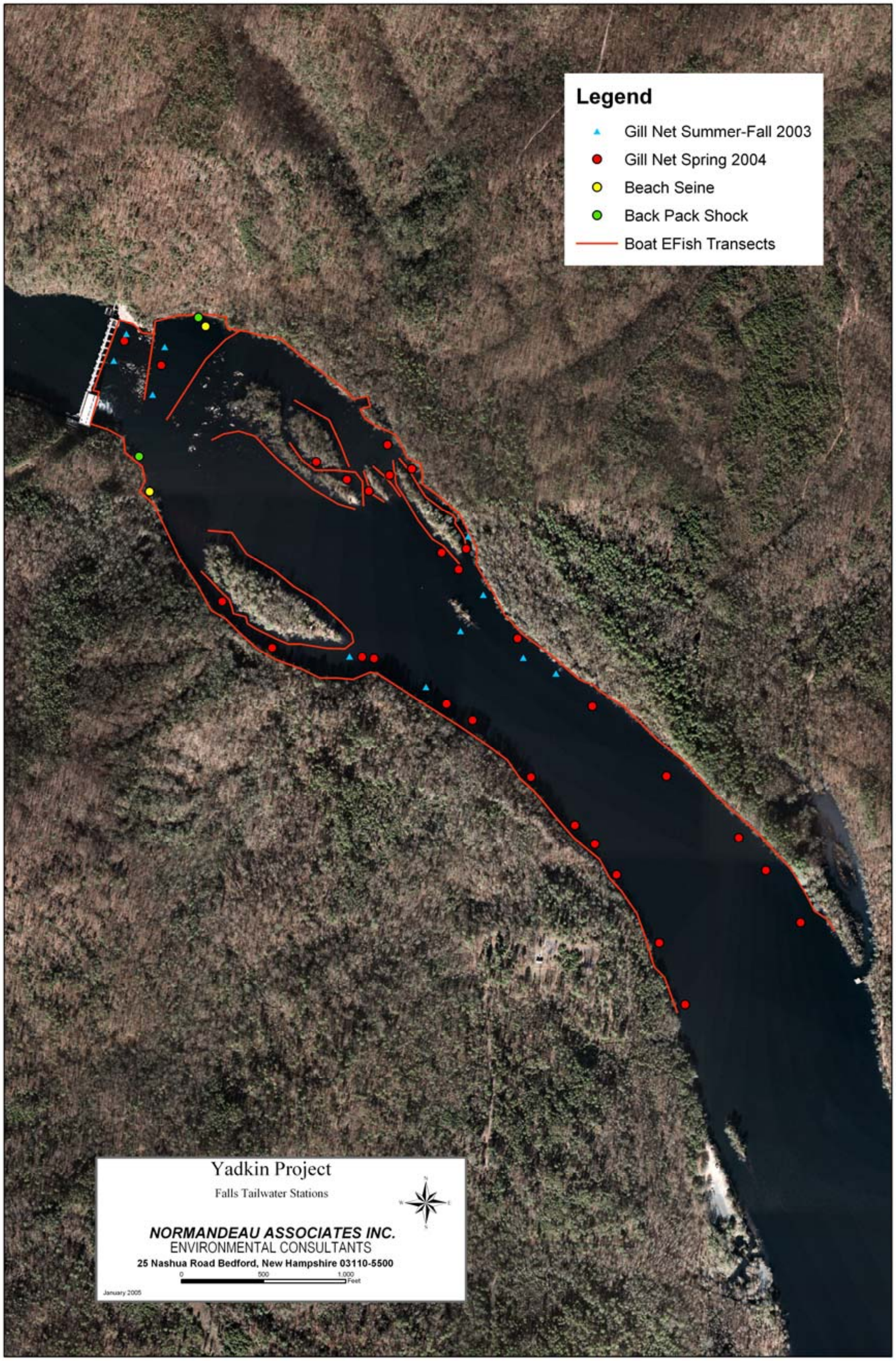

Figure 5-4. Falls Tailwater Fisheries Sampling Locations.

Table 5-16. Species composition for Falls Tailwater by season.

Common Name	Scientific Name	Sampling Periods			
		Summer 2003	Fall 2003	Spring 2004	All Seasons
Blueback Herring	*Alosa aestivalis*	X	X	X	X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X	X
Threadfin Shad	*Dorosoma petenense*	X	X	X	X
Golden Shiner	*Notemigonus chrysoleucas*			X	X
Satinfin Shiner	*Cyprinella analostana*	X	X	X	X
Quillback	*Carpiodes cyprinus*			X	X
White Sucker	*Catostomus commersoni*		X		X
Creek Chubsucker	*Erimyzon oblongus*		X	X	X
Shorthead Redhorse	*Moxostoma macrolepidotum*	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*	X	X	X	X
White Catfish	*Ameiurus catus*	X	X	X	X
Yellow Bullhead	*Ameiurus natalis*	X		X	X
Channel Catfish	*Ictalurus puntatus*	X	X	X	X
Flathead Catfish	*Pylodictus olivarus*	X	X		X
White Perch	*Morone americana*	X	X	X	X
Striped Bass	*Morone saxatilis*	X	X	X	X
White Bass	*Morone chrysops*			X	X
Redbreast Sunfish	*Lepomis auritus*	X	X	X	X
Green Sunfish	*Lepomis cyanellus*			X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Smallmouth Bass	*Micropterus dolomieu*		X		X
Largemouth Bass	*Micropterus salmoides*	X	X	X	X
White Crappie	*Pomoxis annularis*	X			X
Black Crappie	*Pomoxis nigromaculatus*		X	X	X
Tesselated Darter	*Etheostome olmstedi*		X	X	X
Yellow Perch	*Perca flavescens*	X	X	X	X
Longnose Gar	*Lepisosteus osseus*	X	X	X	X
Flat Bullhead	*Ameiurus platycephalus*			X	X
Warmouth	*Lepomis gulosus*	X	X	X	X
Spotted Sucker	*Minytrema melanops*	X	X	X	X
Snail Bullhead	*Ameiurus brunneus*		X	X	X
Blue Catfish	*Ictalurus furcatus*	X	X	X	X
Redear Sunfish	*Lepomis microlophus*	X	X	X	X
Total Taxa		**23**	**27**	**30**	**34**

Table 5-17. Percent Composition of Fish Species Captured within Falls Tailwater, all gear types combined.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	% Composition	# Individuals	% Composition	# Individuals	% Composition	# Individuals	% Composition
Gizzard Shad	86	10.31%	220	18.55%	92	10.38%	398	13.70%
Redbreast Sunfish	84	10.07%	205	17.28%	102	11.51%	391	13.45%
Bluegill	137	16.43%	146	12.31%	81	9.14%	364	12.53%
White Perch	107	12.83%	130	10.96%	76	8.58%	313	10.77%
Largemouth Bass	59	7.07%	95	8.01%	102	11.51%	256	8.81%
Redear Sunfish	67	8.03%	87	7.34%	55	6.21%	209	7.19%
Threadfin Shad	87	10.43%	23	1.94%	74	8.35%	184	6.33%
White Catfish	22	2.64%	33	2.78%	69	7.79%	124	4.27%
Silver Redhorse	16	1.92%	28	2.36%	58	6.55%	102	3.51%
Shorthead Redhorse	13	1.56%	68	5.73%	18	2.03%	99	3.41%
Yellow Perch	28	3.36%	33	2.78%	34	3.84%	95	3.27%
Blue Catfish	40	4.80%	19	1.60%	10	1.13%	69	2.37%
Channel Catfish	13	1.56%	12	1.01%	19	2.14%	44	1.51%
Satinfin Shiner	9	1.08%	11	0.93%	21	2.37%	41	1.41%
Flathead Catfish	14	1.68%	13	1.10%	12	1.35%	39	1.34%
Snail Bullhead	0	0.00%	7	0.59%	25	2.82%	32	1.10%
Spotted Sucker	19	2.28%	1	0.08%	1	0.11%	21	0.72%
Pumpkinseed	8	0.96%	7	0.59%	3	0.34%	18	0.62%
Striped Bass	2	0.24%	15	1.26%	1	0.11%	18	0.62%
Yellow Bullhead	12	1.44%	0	0.00%	1	0.11%	13	0.45%
Black Crappie	2	0.24%	8	0.67%	1	0.11%	11	0.38%
Blueback Herring	1	0.12%	3	0.25%	7	0.79%	11	0.38%
Warmouth	4	0.48%	5	0.42%	1	0.11%	10	0.34%
Tesselated Darter	0	0.00%	7	0.59%	3	0.34%	10	0.34%
Longnose Gar	3	0.36%	2	0.17%	2	0.23%	7	0.24%
Golden Shiner	0	0.00%	0	0.00%	6	0.68%	6	0.21%
Creek Chubsucker	0	0.00%	2	0.17%	2	0.23%	4	0.14%
Quillback	0	0.00%	0	0.00%	3	0.34%	3	0.10%
White Bass	0	0.00%	0	0.00%	3	0.34%	3	0.10%
White Sucker	0	0.00%	3	0.25%	0	0.00%	3	0.10%
White Crappie	1	0.12%	1	0.08%	0	0.00%	2	0.07%
Flat Bullhead	0	0.00%	0	0.00%	2	0.23%	2	0.07%
Green Sunfish	0	0.00%	0	0.00%	2	0.23%	2	0.07%
Smallmouth Bass	0	0.00%	2	0.17%	0	0.00%	2	0.07%
TOTALS	**834**	**100.00%**	**1186**	**100.00%**	**886**	**100.00%**	**2906**	**100.00%**

Table 5-18. Electrofishing CPUE (# of fish per hour of shock time) for fish captured in Falls Tailwater.

	Summer 2003		Fall 2003		Spring 2004		All Seasons	
Species	**# Individuals**	**CPUE**	**# Individuals**	**CPUE**	**# Individuals**	**CPUE**	**# Individuals**	**CPUE**
Redbreast Sunfish	80	19.93	203	48.26	101	12.82	384	23.85
Bluegill	129	32.13	140	33.28	81	10.28	350	21.74
Gizzard Shad	61	15.19	178	42.32	81	10.28	320	19.88
Largemouth Bass	48	11.96	90	21.40	100	12.69	238	14.78
Redear Sunfish	62	15.44	87	20.68	55	6.98	204	12.67
White Perch	88	21.92	30	7.13	51	6.47	169	10.50
Threadfin Shad	61	15.19	22	5.23	54	6.85	137	8.51
Yellow Perch	28	6.97	33	7.85	34	4.32	95	5.90
Silver Redhorse	15	3.74	16	3.80	55	6.98	86	5.34
White Catfish	17	4.23	17	4.04	46	5.84	80	4.97
Shorthead Redhorse	12	2.99	50	11.89	17	2.16	79	4.91
Satinfin Shiner	9	2.24	11	2.62	21	2.67	41	2.55
Snail Bullhead	0	0.00	5	1.19	24	3.05	29	1.80
Flathead Catfish	9	2.24	12	2.85	7	0.89	28	1.74
Channel Catfish	3	0.75	5	1.19	12	1.52	20	1.24
Blue Catfish	10	2.49	0	0.00	8	1.02	18	1.12
Spotted Sucker	17	4.23	1	0.24	0	0.00	18	1.12
Pumpkinseed	7	1.74	7	1.66	3	0.38	17	1.06
Striped Bass	2	0.50	10	2.38	1	0.13	13	0.81
Yellow Bullhead	12	2.99	0	0.00	1	0.13	13	0.81
Blueback Herring	1	0.25	3	0.71	7	0.89	11	0.68
Tesselated Darter	0	0.00	5	1.19	3	0.38	8	0.50
Black Crappie	2	0.50	4	0.95	1	0.13	7	0.43
Golden Shiner	0	0.00	0	0.00	6	0.76	6	0.37
Warmouth	2	0.50	2	0.48	1	0.13	5	0.31
Creek Chubsucker	0	0.00	2	0.48	2	0.25	4	0.25
Green Sunfish	0	0.00	0	0.00	2	0.25	2	0.12
Longnose Gar	0	0.00	0	0.00	2	0.25	2	0.12
Quillback	0	0.00	0	0.00	2	0.25	2	0.12
Smallmouth Bass	0	0.00	2	0.48	0	0.00	2	0.12
White Bass	0	0.00	0	0.00	2	0.25	2	0.12
White Crappie	1	0.25	1	0.24	0	0.00	2	0.12
White Sucker	0	0.00	2	0.48	0	0.00	2	0.12
Flat Bullhead	0	0.00	0	0.00	1	0.13	1	0.06
TOTALS	**676**	**168.37**	**938**	**223.02**	**781**	**99.13**	**2395**	**148.74**

Table 5-19. Gillnet CPUE (# of fish per 24 hour set) for fish captured in Falls Tailwater.

Species	Summer 2003		Fall 2003		Spring 2004		All Seasons	
	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE	# Individuals	CPUE
White Perch	19	0.40	100	4.17	25	0.39	144	1.06
Gizzard Shad	25	0.52	42	1.75	11	0.17	78	0.57
Blue Catfish	30	0.63	19	0.79	2	0.03	51	0.38
Threadfin Shad	26	0.54	1	0.04	20	0.31	47	0.35
White Catfish	5	0.10	16	0.67	23	0.36	44	0.32
Channel Catfish	10	0.21	7	0.29	7	0.11	24	0.18
Shorthead Redhorse	1	0.02	18	0.75	1	0.02	20	0.15
Largemouth Bass	11	0.23	5	0.21	1	0.02	17	0.13
Silver Redhorse	1	0.02	12	0.50	3	0.05	16	0.12
Flathead Catfish	5	0.10	1	0.04	5	0.08	11	0.08
Bluegill	8	0.17	2	0.08	0	0.00	10	0.07
Longnose Gar	3	0.06	2	0.08	0	0.00	5	0.04
Redear Sunfish	5	0.10	0	0.00	0	0.00	5	0.04
Striped Bass	0	0.00	5	0.21	0	0.00	5	0.04
Warmouth	2	0.04	3	0.13	0	0.00	5	0.04
Black Crappie	0	0.00	4	0.17	0	0.00	4	0.03
Redbreast Sunfish	3	0.06	0	0.00	1	0.02	4	0.03
Snail Bullhead	0	0.00	2	0.08	1	0.02	3	0.02
Spotted Sucker	2	0.04	0	0.00	1	0.02	3	0.02
Flat Bullhead	0	0.00	0	0.00	1	0.02	1	0.01
Pumpkinseed	1	0.02	0	0.00	0	0.00	1	0.01
Quillback	0	0.00	0	0.00	1	0.02	1	0.01
White Bass	0	0.00	0	0.00	1	0.02	1	0.01
White Sucker	0	0.00	1	0.04	0	0.00	1	0.01
TOTALS	**157**	**3.26**	**240**	**10.00**	**104**	**1.66**	**501**	**3.72**

CPUE for fish collected by the gillnets in the Falls tailwater during August of 2003 was 3.3 fish per net, with a total of 157 fish captured (Table 5-19). Blue catfish CPUE was 0.6 per net, followed by threadfin shad (0.5 per net), gizzard shad (0.5 per net) and white perch (0.4 per net).

There were no fish captured by backpack electrofishing in the Falls tailwater during the summer sampling period. One redbreast sunfish was collected by beach seine.

The PSD and RSD-P values were calculated for largemouth bass, bluegill, and redear sunfish (Table 5-20). The average PSD and RSD-P for largemouth bass was 90 and 64 respectively. The average bluegill PSD (10) was below the range for a balanced population, as was the average RSD-P (0). Redear sunfish had a summer season PSD of 71 and an RSD-P of 34 and both values were greater then the optimal range for a balanced population.

The average bluegill relative weight for the summer sampling period was 100, within the acceptable range (95-100) for the species (Table 5-20). The average relative weight for redear sunfish during the summer sampling was 83, lower then the ideal range for the species. Average largemouth bass relative weights (98) for the summer period were within the recommended range of 95 to 100 reported in the literature. Relative weights for blue catfish (Wr = 109) and channel catfish (Wr = 115) were above the recommended range for the species indicating these fish are in good condition.

Table 5-20. Proportional stock density (PSD), Relative stock density (RSD-P) and Relative Weight (Wr) Values for selected species within Falls Tailwater during all three sampling seasons.

	PSD				
Species	**Summer**	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Bluegill	10	24	14	14	20 to 60*
Largemouth bass	90	83	89	88	40 to 70*
Redear sunfish	71	81	80	78	20 to 60*

	RSD-P				
	Summer	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Bluegill	0	0	0	0	5 to 20*
Largemouth bass	64	53	61	60	10 to 40*
Redear sunfish	34	17	22	24	5 to 20*

	Wr				
	Summer	**Fall**	**Spring**	**All Seasons**	**Ideal Range**
Blue catfish	109	99	107	106	90 to 100*
Bluegill	100	94	96	97	95 to 100**
Channel catfish	115	95	103	104	90 to 100*
Largemouth bass	98	100	98	97	95 to 100**
Redear sunfish	83	80	81	81	95 to 100**

*(Anderson and Neumann 1996) **(Neumann and Murray 1991)

5.4.2 Falls Tailwater Fall Sample Period

A total of 1,186 fish representing 27 species were captured in the Falls tailwater (all gear types combined) between November 4 and November 6, 2003 (Table 5-17). Gizzard shad were the dominant species, comprising 19% of the total catch. Redbreast sunfish, bluegill, white perch, largemouth bass, and redear sunfish each comprised between 7 and 17 % of the fish caught. Shorthead redhorse were more abundant in the tailwater during the fall season, and made up 6 % of the catch. These top seven fish species represented more then 80 % of the fish captured.

Electrofishing CPUE in Falls tailwater average 223 fish per hour, with a total of 938 fish collected (Table 5-18). Redbreast sunfish (48.3 per hour) and gizzard shad (42.3 per hour) were the dominant species. Bluegill (33.3 per hour), largemouth bass (21.4 per hour), redear sunfish (20.7 per hour) and shorthead redhorse (11.9 per hour) rounded out the top six species captured by electrofishing.

Gillnet CPUE for the Falls tailwater during the fall sampling period was 10.0 fish per net, with a total of 240 fish captured (Table 5-19). White perch were the dominant fish species captured by gillnet with a CPUE of 4.2 fish per net, followed by gizzard shad (1.8 per net), blue catfish (0.8 per net) and shorthead redhorse (0.8 per net).

One bluegill was captured by beach seine during the fall sampling period and a total of 6 fish representing 3 species were captured by backpack electrofishing (2 redbreast sunfish, 2 bluegill, 2 tessellated darter).

The average PSD and RSD-P for largemouth bass was 83 and 53 respectively, exceeding the optimal range (Table 5-20). The average bluegill PSD (24) was within the range for a balanced population, whereas the average RSD-P was zero. Redear sunfish had a fall season PSD of 81 and an RSD-P of 17. The PSD value is greater then the optimal range for a balanced population, however the RSD-P value is within the optimal range.

The average bluegill relative weight for the fall sampling period was 94, near the acceptable range (95-100) for the species (Table 5-20). The average relative weight for redear sunfish during the fall sampling was 80, lower then the ideal range for the species, indicating a feeding problem. Average largemouth bass relative weight (100) for the fall period was within the recommended range of 95 to 100 reported in the literature and relative weights for blue catfish (Wr = 99) and channel catfish (Wr = 95) were also within the recommended range for the species.

5.4.3 Falls Tailwater Spring Sample Period

A total of 886 fish representing 30 species were captured in Falls tailwater (all gear types combined) between May 7 and May 10, 2004 (Table 5-17). The top seven fish captured during the spring sampling included largemouth bass, redbreast sunfish, gizzard shad, bluegill, white perch and threadfin shad and together, they accounted for nearly 70 % of the fish collected. Each of these species made up between 8 and 11 % of the total number of fish captured during the spring. White catfish were more abundant in the tailwater during the spring season than either the summer or fall sampling periods and made up 8 % of the total spring catch. The spring sampling period in Falls yielded the highest species diversity of any of the three seasons sampled.

Electrofishing CPUE in the Falls tailwater average 99.1 fish per hour, with a total of 781 fish collected (Table 5-18). Redbreast sunfish (12.8 per hour) and largemouth bass (12.7 per hour) were the dominant species sampled by electrofishing. Gizzard shad (10.3 per hour), bluegill (10.3 per hour), silver redhorse (7.0 per hour), redear sunfish (7.0 per hour) and threadfin shad (6.9 per hour) made up the top seven species sampled.

Gillnet CPUE for the spring season was 1.63 fish per net, with 104 fish captured (Table 5-19). The lower spring gillnet CPUE values may be a reflection of the fact that nets were moved frequently and fished for only eight hour sets during the day. No night gillnets were set during the spring sampling period in Falls tailwater and nets were moved frequently in an attempt to sample as much endangered redhorse habitat as possible. Overnight sets were avoided in order to prevent the mortality of any endangered redhorse that may have been captured.

There were no fish captured by beach seine in the Falls tailwater during the spring sampling season. Backpack electrofishing yielded one largemouth bass.

The average PSD and RSD-P for largemouth bass was 89 and 61 respectively, and both values exceeded the optimum range (Table 5-20). The average bluegill PSD (14) was below the range for a balanced population, as was the average RSD-P (0). Redear sunfish had a spring season PSD of 80 and an RSD-P of 22. The PSD value is greater then the optimal range for a balanced population, however the RSD-P value is near the optimal range.

The average bluegill relative weight for the spring sampling period was 96, within the acceptable range (95-100) for the species (Table 5-20). The average relative weight for redear sunfish during the spring sampling was 81, lower then the ideal range for the species. Average largemouth bass relative weight (98) for the spring period was within the recommended range of 95 to 100 reported in the literature. Relative weights for blue catfish (Wr = 107) and channel catfish (Wr = 103) were both above the recommended range for the species.

5.4.4 Seasonal Differences in Falls Tailwater

Although the spring sampling period yielded higher species diversity than either the fall or summer, species composition and CPUE rates were similar for all three sampling periods in Falls tailwater. Largemouth bass, bluegill, redbreast sunfish, white perch, and gizzard shad were consistently among the seven most abundant species sampled for all three seasons. Shorthead redhorse were more abundant in the tailwater area during the fall season then either the spring or summer samplings. The PSD and RSD-P values for largemouth bass, bluegill, and redear sunfish in Falls tailwater were consistent through all three sampling periods. Similar to High Rock and Tuckertown tailwaters largemouth bass within Falls tailwater show high PSD, RSD-P and Wr levels, indicating a population with low or indeterminate mortality of quality-sized fish.

Appendix 2 (Figures 1-33 through 1-41) show length frequency distributions for several important game and forage fish found in Falls tailwater. Largemouth bass are successfully spawning as they show a bimodal length frequency distribution with young fish and older spawning age adults. Striped bass, another important game fish in the area, were present in Falls tailwater. These fish are present in Tillery Reservoir due to the current stocking program of the NCWRC. Redear sunfish length frequencies indicate consistent numbers through a variety of size classes suggesting that these fish are successfully reproducing. The low PSD values for bluegill in the Falls tailwater that were suggestive of an unbalanced population dominated by smaller fish, is supported by length frequency data that shows a unimodal distribution of bluegill with a peak in the 10 – 12 cm size classes. Channel and blue catfish length frequencies each show small numbers of quality sized fish present. The three major forage species captured, gizzard shad, threadfin shad and white perch were abundant in the tailwater and are successfully spawning.

5.5 TAILWATER FISH SUMMARY

The fish communities sampled in the tailwaters of High Rock, Tuckertown, Narrows and Falls developments were similar, but some differences in species captured are noted. Species diversity recorded during the NAI tailwater assessments ranged from a high of thirty-four species in both High Rock and Falls tailwaters to a low of 29 species recorded in Tuckertown tailwater. Large numbers of bluegill, largemouth bass, gizzard shad and white perch dominated the catches in each tailwater. These four species are among the ten most abundant species captured within each tailwater, comprising 48% of the total catch in High Rock tailwater, 57% in Tuckertown tailwater, 64% in Narrows tailwater and 46% in Falls tailwater. These species are tolerant of the low dissolved oxygen (DO) concentrations often found in the project tailwaters during the summer and given their numbers, they also appear well adapted to the hydro peaking operations that often occur at all four Yadkin Project developments.

Black crappies were more abundant in both Tuckertown and High Rock tailwaters than either Narrows or Falls. Common carp and quillback were both in the ten most abundant species sampled in the High Rock tailwater and were either not present or captured in low numbers in the other three tailwaters. The numbers of carp captured in High Rock tailwater were evenly distributed during all three seasons of sampling. Quillback were most abundant in the tailwater during the spring season and may have been using the tailwater area below High Rock dam for spawning. In the Falls tailwater, silver and shorthead redhorse were in the top ten species collected. The shorthead redhorse was captured at all four tailwaters during the study, but its numbers were lower at the other three tailwaters, where water quality conditions were not as good as those recorded at Falls. The higher catches of shorthead redhorse in the Falls tailwater compared to upstream tailwaters may be due to better habitat and water quality conditions, especially dissolved oxygen levels. The shorthead redhorse (and the black redhorse) are considered to be intolerant to poor water quality, as are some darter species (Scott 1999).

Bluegill and largemouth bass maintained consistent relative weights throughout all four tailwaters. Relative weight values were either within or near the ideal ranges for these species in each of the four tailwaters. Average proportional stock density (PSD) and relative stock density (RSD-P) values for largemouth bass were greater then the ideal range within each of the four tailwaters. Bluegill PSD values were within (High Rock and Narrows) or close to (Tuckertown and Falls) the ideal range for the species in all four tailwaters, suggesting a balanced population. However, RSD-P values for bluegill were well below the ideal range for the species in all four tailwaters and this indicated that few large, quality sized fish were available for harvest.

Relative weights for black crappie were within or very close to the ideal range in both Narrows and Tuckertown tailwaters, indicating that the fish are in good condition. However, black crappie relative weights in High Rock tailwater were lower than both the ideal range and the average values calculated for the downstream tailwaters, suggesting possible problems finding adequate food sources. The PSD and RSD-P values for black crappie were either within or greater then the ideal range for the species in High Rock, Tuckertown, and Narrows tailwaters, suggesting a balanced population with most size classes represented. Relative weights for redear sunfish in Tuckertown, Narrows and Falls tailwaters were low when compared to the ideal range suggested in the literature for that species suggesting a problem obtaining adequate food sources. The numbers of redear sunfish captured in the High Rock tailwater were too low to assess the population. Channel catfish relative weights were consistent among all four tailwaters and were either within or very close to the ideal range for that species.

Striped bass and blueback herring, both anadromous species, are currently present within all of the reservoirs. Striped bass were captured in all four tailwaters during the study, but numbers were low in High Rock (n=11) and Falls tailwaters (n=18), compared to Tuckertown (n=65) and Narrows (n=39). The NCWRC stocks striped bass in all the project reservoirs except Falls (Narrows tailwater). Striped bass captured in the Narrows tailwater (upper Falls reservoir) may have passed downstream through the turbines or spill gates. Those collected in Falls tailwater (upper Tillery Reservoir) may have originated from stockings into Tillery Reservoir or they dropped downstream from Falls Reservoir.

Low dissolved oxygen concentrations in southeastern reservoirs have received particular attention in regard to the effects on important game fish such as striped bass. Dissolved oxygen levels below 2 mg/l and temperatures greater than 25.0 ^{o}C constitute unsuitable habitat for striped bass (Coutant and Carroll 1980; Young and Isely 2002). DO conditions of 2 mg/l and less and water temperatures of greater than 25 ^{o}C have been recorded at certain times during the summer months in the High Rock, Tuckertown and Narrows tailwaters(NAI 2005a). Telemetry studies on adult striped bass in southeastern reservoirs have shown that habitat use, distribution and movements are all influenced by seasonal changes in temperature and dissolved oxygen (Schaffler et al. 2002). While long-term exposure to DO concentrations less then 2 mg/l can be detrimental to individual striped bass, short-term exposure to these conditions are tolerable and don't necessarily lead to high rates of mortality (Jackson and Hightower 2001). Striped bass in Narrows Reservoir (Tuckertown tailwater) are currently the target of cooperative bioenergetic studies by NCWRC and North Carolina State University to evaluate growth in relation to available habitat, particularly the thermal environment.

Blueback herring were captured in all four tailwaters during the study with the highest numbers captured in the Tuckertown (n=55) and Narrows (n=61) tailwaters and lesser numbers captured in the Falls (n=11) and High Rock (n=2) tailwaters. The NCWRC stocked blueback herring into Narrows Reservoir during the 1970's and the presence of adult and juvenile sized fish suggests that this population is continuing to maintain itself. Blueback herring captured in both the Narrows (upper Falls reservoir) and Falls (upper Tillery Reservoir) tailwaters may have passed downstream through the turbines or were flushed out of Narrows Reservoir during a spill event. The small numbers of blueback herring captured in High Rock tailwater may be the result of bait-bucket introductions. It should be noted that blueback herring and striped bass are both listed as species of interest in the Restoration Plan for the Diadromous Fishes of the Yadkin-Pee Dee River Basin North Carolina (USFWS 2004).

5.6 FISH SAMPLING DURING LOW AND NORMAL DISSOLVED OXYGEN CONDITIONS

One of the objectives of this study was the evaluation of the impacts from existing Project operations on the fish community with regard to the low dissolved oxygen (DO) levels found within the tailwaters during certain times of the year (NAI 2005a). Within the three seasons of fish sampling in the four tailwaters, two events occurred in the Narrows tailwater when both low DO (< 5 mg/l) and normal DO (>5 mg/l)levels were sampled within a 24 hour period. These two events were defined by a change in dissolved oxygen of 2 mg/L or greater within a 24 hour period and in both instances, this change was caused by going from full generation down to no generation. Unit four at Narrows is equipped with air injection valves that increase dissolved oxygen in the tailwater by 2-3 mg/l when unit four is operated alone (NAI 2005a). The other three units at Narrows do not have air injection. The influence of air injection at unit four on tailwater dissolved oxygen concentrations is diluted as the other units are brought online.

The first of the DO comparison sampling events occurred between 2300 hrs on August 30 and 2300 hrs on August 31, 2003. Dissolved oxygen readings taken in the Narrows tailwater by the field crew during electrofishing sampling ranged from 1.63 to 6.05 mg/l. Figure 5-5 presents the dissolved oxygen and total discharge relationship for the 24 hour time period. Fish sampling at normal dissolved oxygen levels took place within the tailwater from 2300 to 0200 and 1700-1800. Dissolved oxygen concentrations during this period ranged from 5.23 to 6.01 mg/l during those time periods (Appendix 3). Fish sampling at low dissolved oxygen levels took place during the hours of 1300 and 1500 and dissolved oxygen concentrations during this period were between 1.63 and 1.71 mg/l. Figure 5-5 shows the greatest DO values (6 mg/l) occurred when discharge was 500 cfs and this value decreased to around 3 mg/l when discharge increased to 3,500 cfs. The lowest DO levels (< 2mg/l) in the Narrows tailwater coincided with no discharge during the afternoon hours. When unit four began

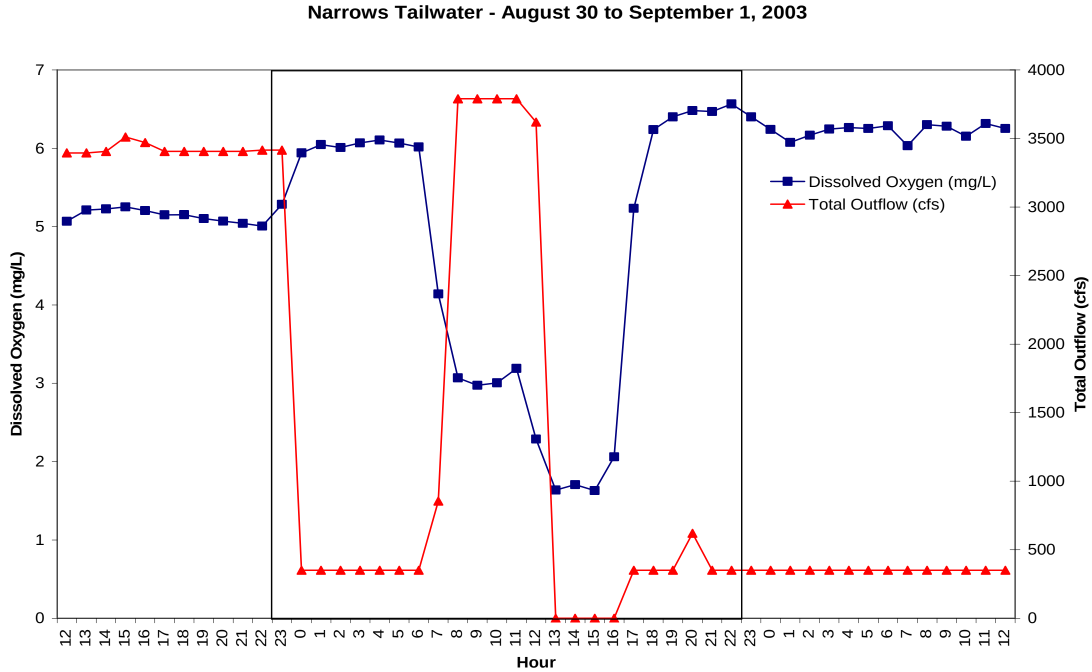

Figure 5-5. Dissolved oxygen (mg/L) and total outflow (cfs) for 24 hour period during which electrofish sampling in Narrows tailwater (summer 2003). Shaded area denotes 24 hour period of fish sampling.

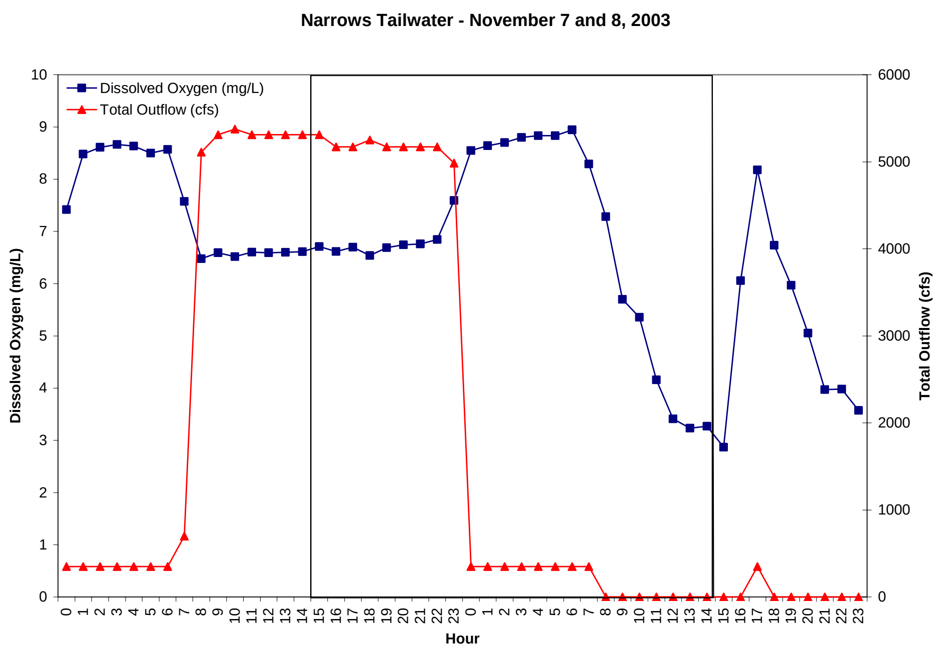

Figure 5-6. Dissolved oxygen (mg/L) and total outflow (cfs) for 24 hour period during electrofish sampling in Narrows tailwater (summer 2003). Shaded area denotes 24 hour period of fish sampling.

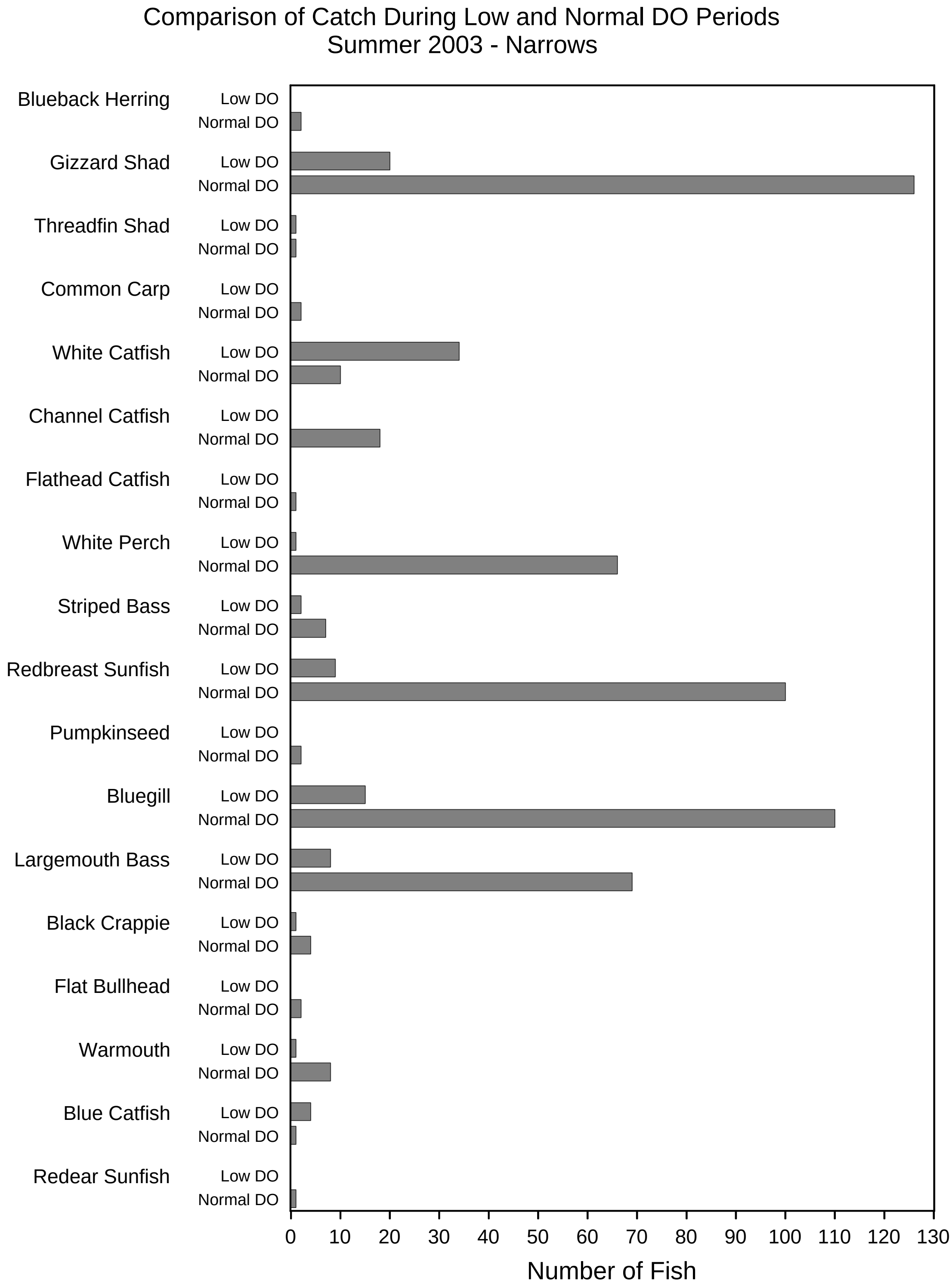

Figure 5-7. Species and number of fish of each captured during low and normal dissolved oxygen periods during the 24-hour sampling period in the Narrows tailwater during the summer season.

generating at 500 cfs around 1700 hrs, DO levels rapidly rose to above 6 mg/l. During the summer event in Narrows tailwater, no significant differences ($p = 0.5017$) were detected in the number of fish species using the tailwater areas during the low and normal DO periods, using a one-way ANOVA comparing the number of species between the low and normal DO periods (Figure 5-7). However, of the eighteen species captured in Narrows tailwater during the 24-hour summer sampling event, fifteen showed fewer individuals present in the tailwater during the low DO period. It is not known if these fish moved away from the tailwater area of if they slowed their movements down making them more likely to avoid capture.

The second event took place between 1500 on November 7, 2003 and 1500 on November 8, 2003. Dissolved oxygen concentrations taken in the tailwater during electrofishing sampling ranged from 3.23 to 6.75 mg/L. Figure 5-6 presents the dissolved oxygen and total discharge relationship for the above time period. Fish sampling at normal dissolved oxygen levels took place in the tailwater between the hours of 1800 and 2000. Dissolved oxygen readings from the long term monitors ranged from 6.54 to 6.74 mg/L during those time periods. Fish sampling at low DO levels took place during the hours of 1200 and 1400 with DO's between 3.27 and 3.41. The trend lines in Figure 5-6 show the lowest DO readings (< 4 mg/l) occurred in the afternoon during a no flow (generation off) period, similar to the summer event described above. The highest DO values were recorded when discharge was 500 cfs and this was due to unit four being operated with the air injection system. When discharge was high, DO readings dropped from approximately 8.5 mg/l to 6.5 mg/l. During the November 24-hour sampling period, the total number of species present during both low and normal DO periods was significantly different ($p = 0.0195$), with 16 species caught during the normal DO period and 12 species caught during the low DO period. Of the twenty-one species captured in the tailwater, thirteen had fewer individuals present during the low DO periods (Figure 5-8). Dissolved oxygen readings from the Narrows tailwater continuous monitor, along with generation data for the two periods is presented in Appendix 3.

5.7 FISH STRANDING DURING GENERATION ON/OFF CYCLES

Hydroelectric facilities often produce rapid changes of water level as turbines are turned on and off with generation demands. These rapid changes can lead to the stranding of fish that are unable or reluctant to move from habitats that become dewatered. Although generation schedules at all four Yadkin developments had periods of full and non-generation during the tailwater fish sample periods, the stranding of fish was not observed at any of the hydroelectric sites. During this study, drops in tailwater water levels were minor (1 ft or less) at each site after generation went from full or near full generation down to no generation. The lack of stranding at the four tailwaters after flows went from full generation down to no or low generation is because each tailwater is inundated, in part, by the downstream dam. In this sense, the project tailwaters do not operate as a true tailrace (riverine section downstream of the powerhouse) that is found at most hydroelectric projects, but instead become an extension of the downstream reservoir.

In addition to the short term changes in water levels that can be associated with project generation, seasonal drawdowns of reservoir levels can also lead to fish stranding. Under the existing project operations, there are no winter drawdowns at Narrows, Tuckertown or Falls Reservoirs. However, if the operation of Narrows were changed to allow for a greater drawdown (beyond 16 feet), it is possible that the potential for stranding below Tuckertown may increase. The NAI habitat survey in Narrows Reservoir took place during December of 2003. During the 16-ft drawdown associated with

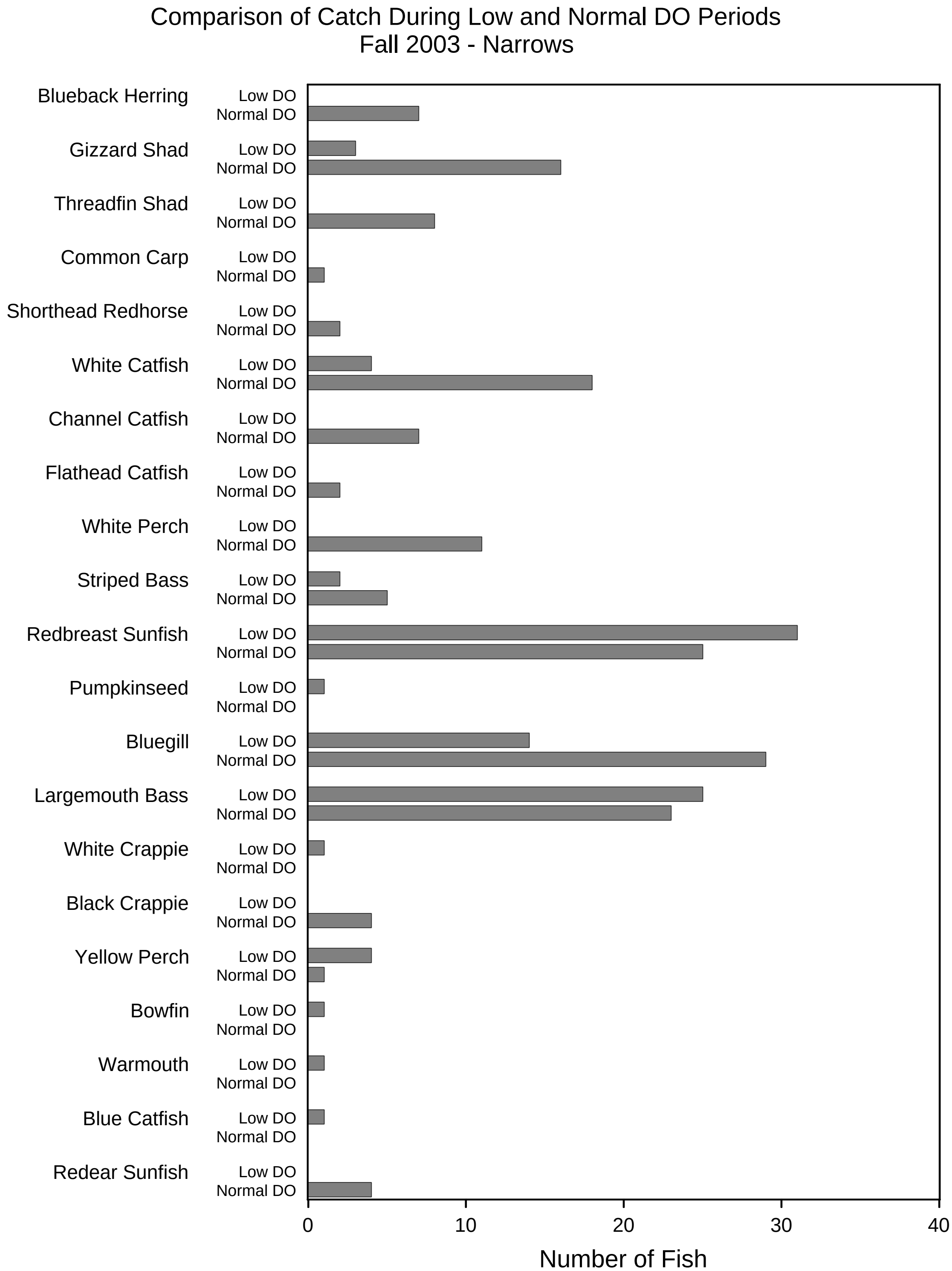

Figure 5-8. Species and number of fish each captured during low and normal dissolved oxygen periods during the 24-hour sampling period in the Narrows tailwater during the fall season.

this work, the Tuckertown tailwater area was surveyed and video-recorded (NAI 2005b). No stranded fish were found during the tailwater habitat surveys.

5.8 ROBUST AND CAROLINA REDHORSE SEARCHES

No robust or Carolina redhorse species were captured during the three seasons of fish sampling in the four project tailwaters. The robust redhorse, a Federal species of concern, has recently been collected from the Pee-Dee River, below the Blewett Falls project. The Carolina redhorse is an undescribed sucker species and is also a species of Federal concern. Carolina redhorse individuals have been collected from Blewett Falls Reservoir and the river reach directly below that impoundment. One specimen was also collected in Lake Tillery during November of 2002. NAI efforts, particularly during the spring season, focused on searching the tailwater reaches of the four developments thoroughly for both species. Although searches were conducted in all four tailwaters, sampling concentrated on Falls tailwater at the upper end of Lake Tillery. Spring sampling began when water temperatures were in the range of 18-24^{o}C, the temperature thought to trigger spawning in these fish. Gill nets were fished for 8-hour periods and moved frequently in order to cover as much redhorse habitat as possible. Electrofishing focused on areas of woody debris and in cobble/boulder shoal habitat. The search area extended from the base of Falls hydroelectric facility down to the mouth of the Uwharrie River. Despite the intensive surveys, neither redhorse species was found.

6.0 TAILWATER MACROINVERTEBRATE AND MUSSEL ASSESSMENT RESULTS

Macroinvertebrate sampling and mussel searches were conducted in the tailwaters of Falls, Narrows, Tuckertown and High Rock Reservoirs during September 2003 (summer sampling), November 2003 (fall sampling), and June 2004 (spring sampling), and the results are briefly summarized in this section. The full report, entitled *Benthic Macroinvertebrate Survey Yadkin River*, prepared by Pennington and Associates, Inc. (PAI 2005), details the results of this survey and is attached to this report as Appendix 4.

6.1 TRANSECT AND STATION LOCATIONS

Figures 6-1 through 6-4 show the locations of mussel search transects within the four tailwaters along with the macroinvertebrate sampling stations located at the quarter points of each transect. Table 6-1 shows the east and west bank endpoints for each transect within the four tailwaters. Within High Rock tailwater, transect 1 was located approximately 500 feet downstream from the dam while transect 2 was located approximately 900 feet downstream. Transect 1 in Tuckertown tailwater was approximately 900 feet downstream of the dam while transect 2 was around 1,300 feet below the dam. The two transects in Narrows tailwater were located approximately 700 and 1,700 feet respectively, below the dam. Transect 1 in Falls tailwater was located approximately 400 feet below the dam while transect 2 was located approximately 1,000 feet below the dam.

6.2 TAILWATER DESCRIPTIONS

Habitat (substrate) types along each transect were described during the collection of mussel and macrtoinvertebrate samples. For full descriptions, refer to the PAI report *Benthic Macroinvertebrate*

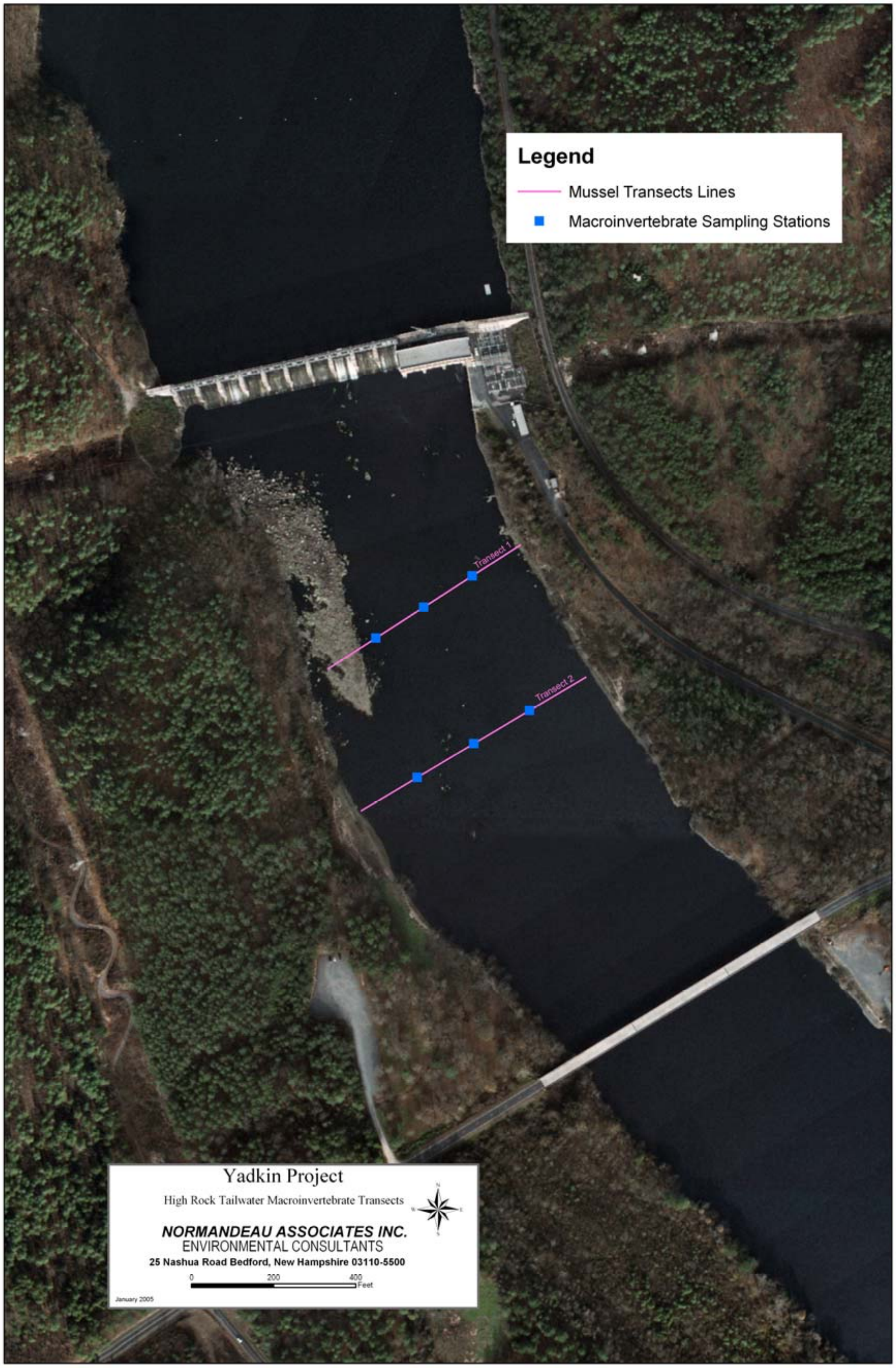

Figure 6-1. High Rock Macroinvertebrate Stations and Mussel Transects.

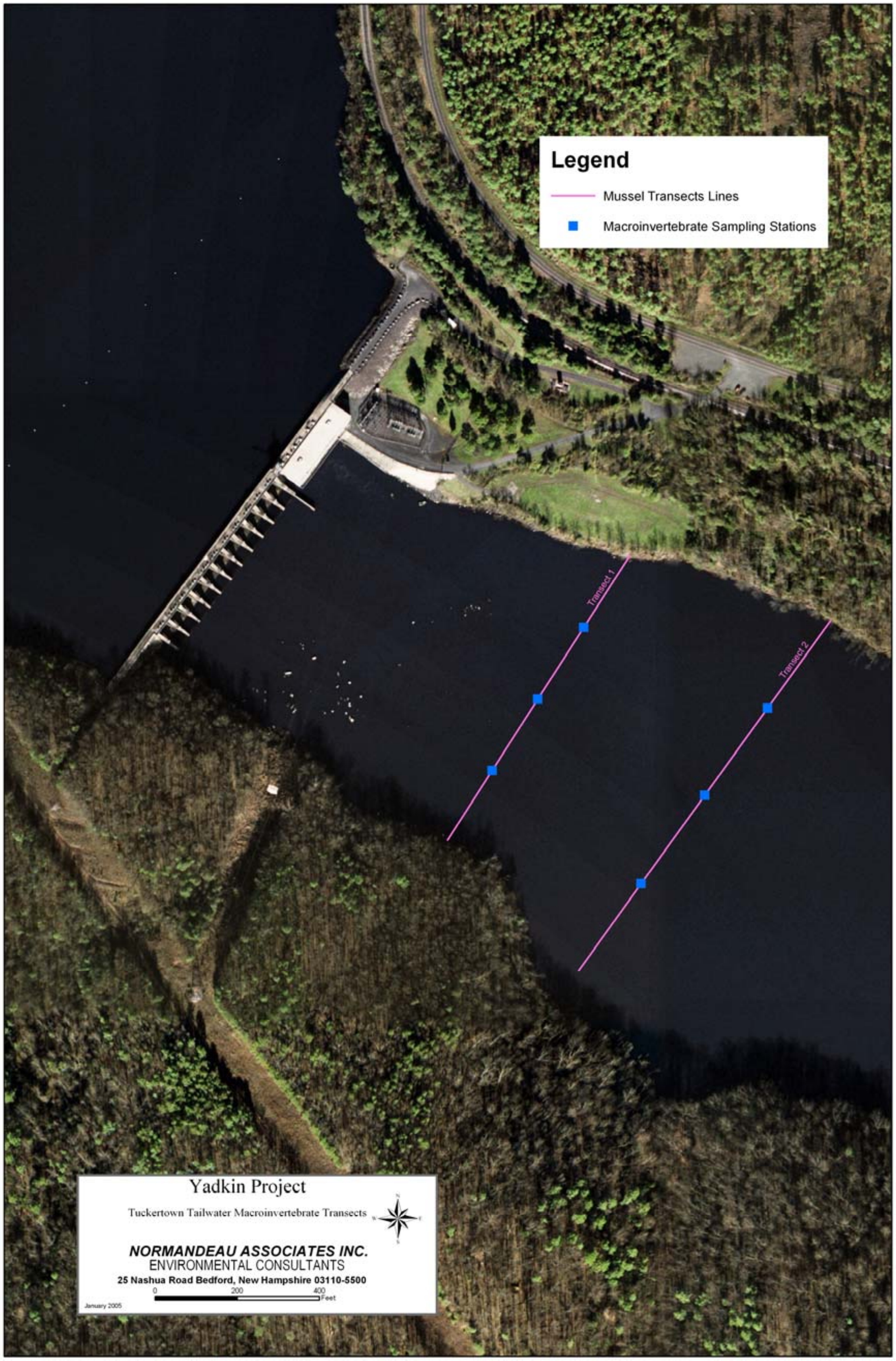

Figure 6-2. Tuckertown Macroinvertebrate Stations and Mussel Transects.

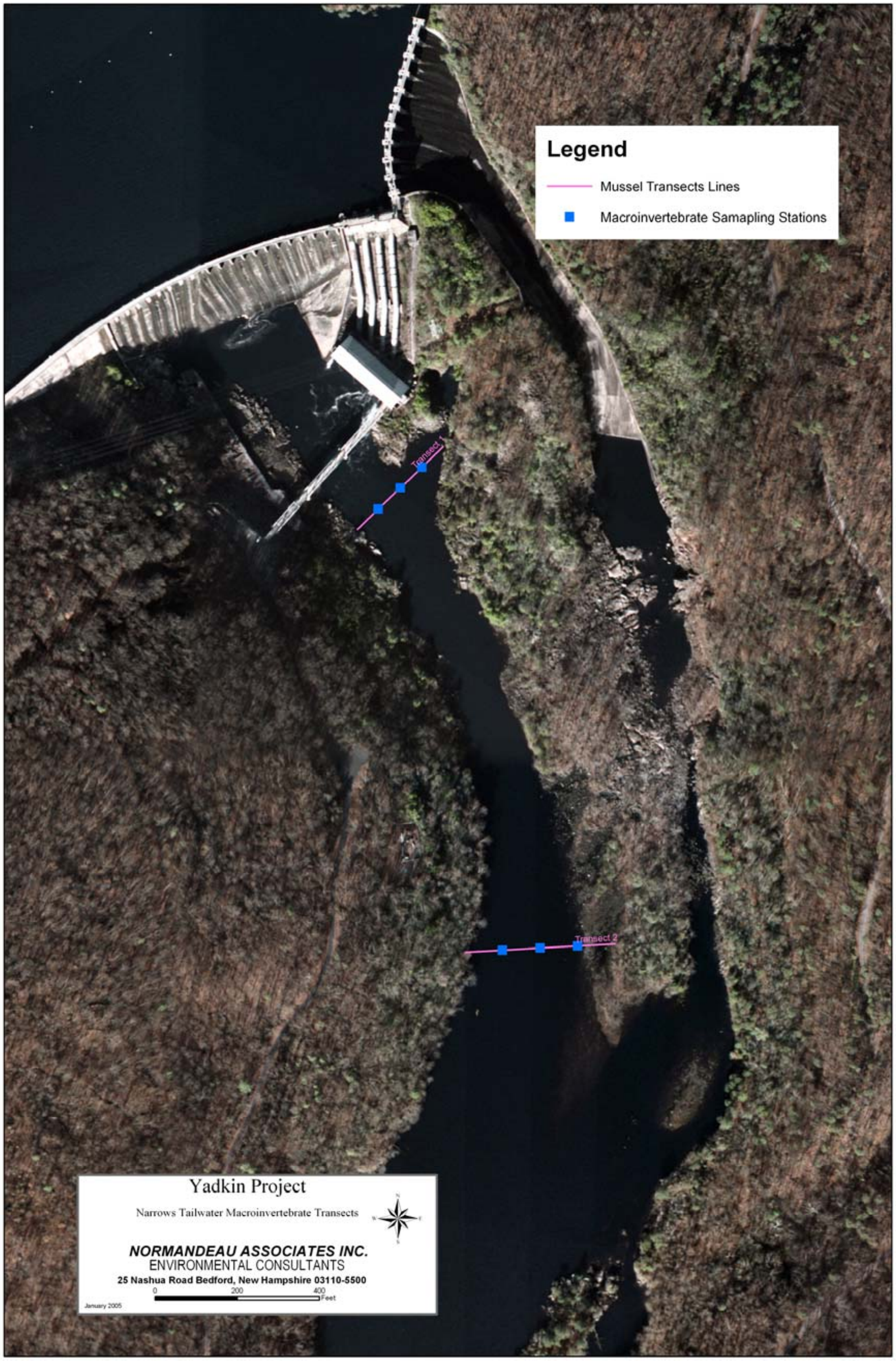

Figure 6-3. Narrows Macroinvertebrate Stations and Mussel Transects.

Figure 6-4. Falls Macroinvertebrate Stations and Mussel Transects.

Table 6-1. Transect locations for mussel and macroinvertebrate sampling, Yadkin tailwaters 2003.

Falls Dam Tailwater				
Transect No.	**East Bank**		**West Bank**	
	Lat.	**Long.**	**Lat.**	**Long.**
1	N35023’45.4”	W80004’22.5”	N35023’36.7”	W80004’28.1”
2	N35^{0}23’36.2”	W80^{0}04’15.9”	N35^{0}23’31.2”	W80^{0}04’21.3”

Badin Dam (The Narrows) Tailwater				
Transect No.	**East Bank**		**West Bank**	
	Lat.	**Long.**	**Lat.**	**Long.**
1	N35^{0}25’06.6”	W80^{0}05’28.0”	N35^{0}25’04.5”	W80^{0}05’30.6”
2	N35^{0}24’54.6”	W80^{0}05’22.8”	N35^{0}24’54.4”	W80^{0}05’27.3”

Tuckertown Tailwater				
Transect No.	**East Bank**		**West Bank**	
	Lat.	**Long.**	**Lat.**	**Long.**
1	N35^{0}29’05.2”	W80^{0}10’23.2”	N35^{0}28’58.3”	W80^{0}10’38.5”
2	N35^{0}29’02.2”	W80^{0}10’18.6”	N35^{0}28’55.1”	W80^{0}10’24.5”

High Rock Tailwater				
Transect No.	**East Bank**		**West Bank**	
	Lat.	**Long.**	**Lat.**	**Long.**
1	N35^{0}35’58.5”	W80^{0}13’59.1”	N35^{0}35’55.4”	W80^{0}14’04.8”
2	N35^{0}35’55.3”	W80^{0}13’57.2”	N35^{0}35’52.0”	W80^{0}14’03.8”

Table 6-2. Physical characteristics of mussel/macroinvertebrate sampling transects within the four project tailwaters.

	Falls Dam	**Narrows Dam**	**Tuckertown**	**High Rock**
Distance from Dam T1 (ft)	~400	~700	~900	~500
Width (ft) T1	976	~300	843	455
Distance from Dam T2 (ft)	~1000	~1,700	~1,300	~900
Width (ft) T2	671	~300	1,188	675
Depth (ft) T1	4-20	4-20	2-8	2-10
Depth (ft) T2	4-8	4-10	2-12	3-12
Substrate T1	Boulders, cobble and gravel	0`-200’ bedrock and boulders 200’-300’ Boulders with cobble, gravel and silt	Bedrock, boulders, silt	Boulders, few cobble and gravel covered with silt
Substrate T2	Boulders, cobble and gravel	Boulders, cobble with lesser amounts of gravel and silt	0-135’ mud on bedrock 135’-250’ boulders 500’-750’ boulders few cobble 750’-1188’ bedrock, cobble with silt	0-100’ mud 100’-675’ boulders few cobble and gravel covered with silt

Survey Yadkin River, attached to this report as Appendix 4 (PAI 2005). Summaries of tailwater habitats from PAI (2005) are provided here. Table 6-2 provides a summary of the physical characteristics of each transect within the four tailwaters. Transect descriptions begin on the right bank (looking downstream) and run across the channel to the left bank.

6.2.1 High Rock Tailwater

Figure 6-1 shows the locations of transect 1 and 2 within the High Rock tailwater. Transect 1 was 455 feet long and water depths across this transect ranged from 2 to 10 feet deep. Substrate within transect 1 was comprised mainly of silt covered boulders with lesser amounts of cobble and gravel. Transect 2 was 675 feet long and in water from 3 to 12 feet deep. The first 100 feet of transect 2 were comprised of mud and from 100 to 675 feet across the substrate consisted of silt covered boulders with lesser amounts of cobble and gravel. As seen in Figure 6-1, the power house and associated flow of water are located on the right side of the dam, looking upstream. A large field of boulders and slower water is located on the left side of the tailwater in the area below the spill gates.

6.2.2 Tuckertown Tailwater

Figure 6-2 shows the locations of transect 1 and 2 within the Tuckertown tailwater. Transect 1 was 843 feet wide and water depths along it ranged from 2 to 8 feet. Substrate along transect 1 consisted of bedrock, boulder and silt. Transect 2 was 1,188 feet long and depths ranged from 2 to 12 feet along the length of the transect. The substrate of transect 2 from 0 to 135 feet consisted of mud overlying bedrock, while boulders were the dominate substrate from 135 to 250 feet. A mixture of silt covered bedrock, boulder, and cobble comprised the rest of transect 2. As shown in Figure 6-2 and similar to High Rock tailwater, the power house and the associated water flow are located on the right side of the tailwater. A large field of boulders and slower moving water are located on the left side of the tailwater in the area below the spill gates.

6.2.3 Narrows Tailwater

Figure 6-3 shows the locations of transects 1 and 2 within the Narrows tailwater. Transect 1 was approximately 300 feet long and along its length, water depths ranged from 4 to 20 feet deep. Bottom substrate along transect 1 was characterized as bedrock and boulders from 0 to 200 feet and as boulder and cobble with lesser amounts of gravel and silt from 200 to 300 feet. Transect 2 was approximately 300 feet long with water depths ranging from 4 to 10 feet. Water depth along transect 1 was approximately 4 ft deep for most of its length, except for a deeper zone along the downstream looking right bank. Substrate along transect 2 was comprised of boulder and cobble with lesser amounts of gravel and silt. As shown in Figure 6-3, the turbine discharge is located along the right hand bank, above transect 1. The tailwater channel is very narrow until the area below transect 2, where the tailwater widens. A shallow overflow channel is located along the right side of the tailwater and rejoins the mainstem of the tailwater in the area below transect 1.

6.2.4 Falls Tailwater

Figure 6-4 shows the locations of transect 1 and 2 within the Falls tailwater. Transect 1 was 976 feet long and water depths along it ranged from 4 to 20 feet. The bottom substrate was comprised mostly of boulders and cobble with mixed lenses of gravel. Transect 2 was 671 feet long with water depths that ranged between 4 and 8 feet. Bottom substrate along transect 2 was similar to that of transect 1.

As shown in Figure 6-4, the endpoints of transect 2 were located on two islands on either side of the main channel within the Falls tailwater. The main flow from the turbines is located on the left side of the dam. A large area of boulders is located on the right side of the upper tailwater in the area below the spill gates.

6.3 MUSSEL SEARCHES

A total of seven species of freshwater mussels were found within the four tailwaters. Table 6-3, taken from PAI (2005) provides a summary of mollusca species found within the four tailwaters.

Falls tailwater had the greatest mussel diversity with seven species and 575 total individuals. In Falls tailwater, *Elliptio complanta* (Eastern Elliptio) was the most abundant (57%) mussel species, while *Elliptio cf. lanceolata* (Pee Dee Lance)(20%) and *Lampsilis radiata* (Eastern lamp mussel)(20%)

Table 6-3. Summary of Mollusca taken from Yadkin River, 2003-2004.

Species	Falls Dam Tailwater	Badin Dam (Narrows) Tailwater	Tuckertown Tailwater	High Rock Tailwater
Anodonta implicata	R	1		
Alewife floater				
Elliptio complanta	328	16		
Eastern Elliptio				
Elliptio cf. lanceolata	113	1		
Pee Dee Lance				
Lampsilis radiata	117	R		
Eastern lamp mussel				
Pyganodon cataracte	1	2		
Eastern floater				
Utterbackia imbecillis	8	2	4	1
Paper pond shell				
Villosa delumbis	8			
Eastern creekshell				
Total No. Of Unionidae Species	7	6	1	1
Total No. Of Individuals	575	22	4	1
Corbicula fluminea	A	A	A	A
Cipangopalucdinea chinensis				231
Chinese mystery snail				

- R = represented by relics only
- A = abundant

were common. Narrows tailwater had 6 species with 22 total individuals. *Elliptio complanta* (73%) was the most abundant species within the Narrows tailwater. *Elliptio complanata* was present in both the Falls and Narrows tailwaters. One specimen of *Anodonta implicata* (Alewife floater) was found within the Narrows tailwater. The only mussel species found in the Tuckertown and High Rock tailwaters was the *Utterbackia imbecillis* (Paper pond shell) with four individuals found in Tuckertown and one in High Rock. *Corbicula fluminea*, the Asiatic clam, is an invasive species that was abundant throughout all four tailwaters. For a detailed listing of mussels found within each tailwater by season, refer to Tables 1A, 2A, and 3A in PAI (2005).

In addition to inventorying the freshwater mussel species present in the four tailwaters, the presence of any rare, threatened or endangered mussel species was to be noted. There were no federally endangered mussel species found within any of the four tailwaters. *Elliptio cf. lancolata* (PeeDee Lance) is listed as endangered by the state of North Carolina. This species was found in the tailwaters of both Falls and Narrows. Two species, *Anodonta implicata* (alewife floater) and *Lampsilis radiata* (Eastern lamp mussel), are both listed as threatened by the state of North Carolina. *Anodonta implicata* was found in both Falls (relic shells only) and Narrows tailwaters. *Lampsilis radiata* was found in Falls and Narrows (relics only) tailwaters. *Villosa delumbis* (Eastern creekshell) is considered significantly rare by the North Carolina Heritage Program and 8 individuals were found within the Falls tailwater.

In High Rock Reservoir, mussel species were found and identified by state personnel during the severe drought of 2002. Three species, *Elliptio complanata* (Eastern Elliptio), *Anodonta implicate* (Alewife floater), and *Corbicula fluminea* (Asiatic clam) were identified from the shell samples collected in the main body of High Rock. The mussels were collected by Peter Diamond, of the North Carolina Zoological Park and were identified by Sarah McRae, freshwater ecologist with the North Carolina Natural Heritage Program.

6.4 MACROINVERTEBRATES

There were 6 phyla, 24 orders, and 41 families represented by the 99 benthic macroinvertebrates species found in the four tailwaters. Table 6-4, taken from PAI (2005) provides a list of the macroinvertebrates found within the four tailwaters. The spring sampling in Falls tailwater yielded the highest number of species with 53 found and the summer sampling in High Rock yielded the lowest number of species collected with 29. The spring sampling in Narrows (12,008/12m^2) and Falls (10,172/12m^2) yielded the highest densities of individuals. The lowest numbers of individuals per sample were recorded in Falls (1,420/12m^2) and Narrows (1,333/12m^2) during the fall sampling. Table 6-5 (taken from PAI macroinvertebrate survey report) presents the percent composition of the most abundant benthic macroinvertebrate species within each of the four tailwaters during the three seasons of sampling.

Dominant species in Falls tailwater during the three sampling periods included *Corbicula fluminea* (Asiatic clam; summer and fall) and *Caecidota sp*. (isopod sp.; spring). The three sampling periods in Narrows were dominanted by *Rheotanytarsus sp*. (midge sp.; summer), *Corbicula fluminea* (fall), and *Caecidotea sp*. (June). Tuckertown samplings were dominated by *Musculium transversum* (Fingernail clam; summer and fall) and *Caecidotea sp*. in the spring. *Musculium transversum* was the dominant species in High Rock during the summer and spring while *Caecidotea sp*. was dominant in the fall.

Although the EPT and Hilsenhoff Biotic Indices were used to assess the water quality condition of the four tailwaters, it is important to note that these indices should not be used in the direct comparison of these four tailwaters and of natural steam habitat. The scoring criteria developed for unregulated streams cannot fairly represent attainable conditions in the Project tailwaters. Due to the lack of nutrient and insect drift in the altered tailwater system, these habitats are not directly comparable using these methods. These indices were applied to the tailwaters to obtain a baseline water quality using a known method that will allow for future comparison should these studies be repeated.

The EPT index is the total number of species found in an area within the pollution sensitive groups Ephemeroptera, Plecoptera, and Trichoptera and is considered a measure of water quality. As the EPT value increases, water quality will tend to do the same. Table 6-6 shows the EPT Index score for standard collecting effort within the piedmont area of North Carolina. The Hilsenhoff Biotic Index uses arthropod populations to evaluate water quality. Species are assigned pollution tolerance values from 0 to 10. A value of 0 would be assigned to a species found only in unaltered streams with high water quality whereas a value of 10 would be assigned to a species know to occur in severely polluted areas. Table 6-6 presents the range of Hilsenhoff Biotic Index values and the associated water quality classifications for the piedmont area of North Carolina.

The EPT and Hilsenhoff Biotic Index values indicated that the benthic fauna in Falls tailwater exists under mostly "poor" water quality conditions during the spring sampling and no better than "fair" during the summer and fall sampling periods. Benthic fauna in Narrows tailwater follows the same pattern of "poor" water quality conditions during the spring period with "fair" water quality conditions during the summer and fall sampling periods. Water quality conditions for the benthic fauna of High Rock and Tuckertown tailwaters was determined to be "poor" for all three sampling periods based on the results of the EPT and Hilsenhoff Biotic Index. The "poor" value for the spring periods could be explained by the flushing of macroinvertebrates from the tailwater areas during the seasonal inflows associated with spring weather events and a decrease in abundance and diversity due to the colder temperatures during the winter months. For seasonal EPT Index and Hilsenhoff Biotic Index scores for all four tailwaters, refer to Table 6-4.

7.0 IMPACTS OF EXISTING PROJECT OPERATIONS ON FISH AND AQUATIC BIOTA IN THE TAILWATERS

One of the objectives of this study was to consider impacts from Project operations on aquatic biota in the Project tailwaters. Two types of impacts were considered potentially significant at the Yadkin Project; the effects of low tailwater dissolved oxygen conditions, and the effects of project peaking operations. Of these two, based on the aquatic biota surveys conducted in the Yadkin Project tailwaters it appears that the greatest impact of project operations to fish and other aquatic biota existing in the four Yadkin tailwaters is the low DO conditions that can occur in all four tailwaters. The low dissolved concentrations in the project tailwaters result from project operations. At each dam, both surface and bottom water from the upstream reservoir is entrained and mixed during passage through the turbines, which can cause lower dissolved oxygen concentrations in the tailwaters if the bottom water is oxygen depleted. Low dissolved oxygen concentrations can also occur when tailwater flows are reduced to near zero for a prolonged period.

Peaking impacts can also occur at hydropower projects and can affect fish communities by interrupting flows, feeding cycles, spawning and causing rapid changes in water quality, including DO and water temperatures in the tailwater areas. Fluctuating water levels in tailwaters due to hydro peaking operations can also impact aquatic biota by exposing habitat and in some cases stranding aquatic life when generation goes from high generation with subsequent high flows down to minimal or no generation in a short time period.

The occurrence of low DO levels in the Yadkin project tailwaters and the causes for these conditions are reported in detail in Normandeau's Yadkin Water Quality Report (NAI 2005a). For example,at the High Rock tailwater during 2004, an average-to-wet water year, average daily dissolved oxygen

Table 6-4. Benthic Macroinvertebrates collected from Yadkin River 2003-2004 (No./~2m^2)

SPECIES	T.V.	F.F.G.	Falls Dam Sep-03 TOTAL	Narrows Dam Sep-03 TOTAL	Tucker Town Sep-03 TOTAL	High Rock Sep-03 TOTAL	Falls Dam Nov-03 TOTAL	Narrows Dam Nov-03 TOTAL	Tucker Town Nov-03 TOTAL	High Rock Nov-03 TOTAL	Falls Dam Jun-04 TOTAL	Narrows Dam Jun-04 TOTAL	Tucker Town Jun-04 TOTAL	High Rock Jun-04 TOTAL
COELENTERATA														
Hydrozoa														
Hydroida														
Hydridae														
Hydra sp.														1
PLATYHELMINTHES														
Turbellaria														
Tricladida														
Planariidae														
Cura foremanii								1			2	12		
Dugesia tigrina	**7.2**		117	294	245	685	75	50	608	717	513	250	29	150
NEMATODA							1		10	2				1
MOLLUSCA														
Bivalvia														
Unionoida														
Unionidae														
Elliptio complanata	**5.1**	**FC**	1	2			1		5					
Utterbackia imbecillis									1				1	1
Veneroida														
Corbiculidae														
Corbicula fluminea	**6.1**	**FC**	542	207	18	3	682	580	205	28	1118	1122	64	119
Sphaeriidae	***8**	**FC**	13					5						
Eupera cubensis	**5.7**	**FC**	114	2			44	5			58			
Musculium transversum	***8**	**FC**	307	306	2461	3921	89	72	5239	1610	623	165	349	1406
Pisidium sp.	**6.5**	**FC**		6				1						
Gastropoda														
Mesogastropoda														
Hydrobiidae	***8**	**SC**												
Amnicola limosa			4	6	49		4	10	30		5	106	17	
Viviparidae														
Cipangopaludina chinensis						2								12
Basommatophora														
Ancylidae		**SC**												
Ferrissia rivularis	**6.6**	**SC**	49	19	198	2	33	14	26	8	9		2	

(continued)

Table 6-4. (Continued)

SPECIES	T.V.	F.F.G.	Falls Dam Sep-03 TOTAL	Narrows Dam Sep-03 TOTAL	Tucker Town Sep-03 TOTAL	High Rock Sep-03 TOTAL	Falls Dam Nov-03 TOTAL	Narrows Dam Nov-03 TOTAL	Tucker Town Nov-03 TOTAL	High Rock Nov-03 TOTAL	Falls Dam Jun-04 TOTAL	Narrows Dam Jun-04 TOTAL	Tucker Town Jun-04 TOTAL	High Rock Jun-04 TOTAL
Physidae														
Physella sp.	**8.8**	**CG**	12	35	20	17	27	12	42	43	839	404	35	58
Planorbidae	***6**	**SC**												
Helisoma anceps	**6.2**	**SC**	1								15		1	
Menetus dilatatus	**8.2**	**SC**	2	24	409	62	2	1	11	123	227	163	26	180
ANNELIDA														
Oligochaeta	***1**	**CG**												
Tubificida														
Naididae	***8**	**CG**	14	19							194	53	8	72
Dero sp.	**10.0**	**CG**	3	3	37	3	10		80	1			271	31
Nais sp.	**8.9**	**CG**	1	4										
Nais communis	**8.8**	**CG**			31	24			43	51	76	180	2	25
Nais bretscheri	***6**	**CG**									4			
Pristina sp.	**9.6**	**CG**								1				
Pristina leidyi	**9.6**	**CG**											2	
Pristinella sp.	**7.7**	**CG**				1								
Ripistes parasita	**2**	**FC**							90	87			2	1
Slavina appendiculata	**7.1**	**CG**								3	193	1758	25	364
Spirosperma sp.	**5.3**	**CG**			1									
Stylaria lacustris	**9.4**	**CG**		3						16	156	403		
Tubificidae w.o.h.c.	**7.1**	**CG**	2	7	98	30	11	22	7	3	266	321	60	23
Limnodrilus hoffmeisteri	**9.5**	**CG**									116		16	
Tubificidae w.h.c.	**7.1**	**CG**		6						1		40	1	8
Branchiura sowerbyi	**8.3**	**CG**			47									57
Quistadrilus multisetosus	**3.9**	**CG**											2	
Lumbriculida														
Lumbriculidae	**7.0**	**CG**	37	9	1		33	17		1	526	1197		8
Hirudinea	***8**	**P**	4	46	13	2			81	2	13	26	27	8
Erpobdellidae	***8**	**P**				1	2	8	14	5	6	20	25	6
Erpobdella punctata		**P**							2					
Rhynchobdellida														
Glossiphoniidae	***8**	**P**			6	20	1		4				27	10
Batrachobdella phalerata	**7.6**	**P**							1					
Helobdella sp.	***6**	**P**			9				70	5				
Helobdella stagnalis	**8.6**	**P**			72	41			53	4			52	149

(continued)

Table 6-4. (Continued)

SPECIES	T.V.	F.F.G.	Falls Dam Sep-03 TOTAL	Narrows Dam Sep-03 TOTAL	Tucker Town Sep-03 TOTAL	High Rock Sep-03 TOTAL	Falls Dam Nov-03 TOTAL	Narrows Dam Nov-03 TOTAL	Tucker Town Nov-03 TOTAL	High Rock Nov-03 TOTAL	Falls Dam Jun-04 TOTAL	Narrows Dam Jun-04 TOTAL	Tucker Town Jun-04 TOTAL	High Rock Jun-04 TOTAL
Helobdella triserialis	**9.2**	**P**		1	2	27	4	5	40	24			36	115
Placobdella translucens	**9.0**	**P**								2				
ARTHROPODA														
Crustacea														
Ostracoda				5	5						1			1
Candoniidae														
Candona sp.							4							
Cladocera														
Daphnidae														
Daphnia sp.				1										
Sididae														
Sida crystillina					15		1		20	9	9		2	
Copepoda					5						1		1	
Cyclopoida					5				10					
Isopoda														
Asellidae	***8**	**SH**												
Caecidotea sp.	**9.1**	**CG**	225	542	646	1130	97	238	1356	1641	1762	1952	557	272
Amphipoda														
Crangonyctidae														
Crangonyx sp.	**7.9**	**CG**		1		12	1	1		2				
Talitridae														
Hyalella azteca	**7.8**	**CG**	70	123	22		158	93	295	1	826	813	11	7
Decapoda														
Cambaridae	**7.5**		1								2			
Insecta														
Collembola														1
Ephemeroptera														
Caenidae	***7**	**CG**												
Caenis sp.	**7.4**	**CG**	1	3	11			1	4	58	10	5		
Heptageniidae	***4**	**SC**												
Stenacron interpunctatum	**6.9**	**SC**	4	1			9							
Stenonema sp.	***4**	**SC**				1				1				
Tricorythidae														
Tricorythodes sp.	**5.1**	**CG**								1				

(continued)

Table 6-4. (Continued)

SPECIES	T.V.	F.F.G.	Falls Dam Sep-03 TOTAL	Narrows Dam Sep-03 TOTAL	Tucker Town Sep-03 TOTAL	High Rock Sep-03 TOTAL	Falls Dam Nov-03 TOTAL	Narrows Dam Nov-03 TOTAL	Tucker Town Nov-03 TOTAL	High Rock Nov-03 TOTAL	Falls Dam Jun-04 TOTAL	Narrows Dam Jun-04 TOTAL	Tucker Town Jun-04 TOTAL	High Rock Jun-04 TOTAL
Odonata														
Coenagrionidae	***9**	**P**												
Argia sp.	**8.2**	**P**	2	1			1							
Corduliidae	***5**	**P**												
Neurocordulia sp.	**5.0**			1										
Gomphidae														
Gomphus sp.	**5.8**	**P**						1						
Neuroptera														
Sisyridae											1			
Trichoptera														
Hydropsychidae	***4**	**FC**												
Cheumatopsyche sp.	**6.2**	**FC**	68	146			1							
Hydroptilidae	***4**	**PI**									1			
Hydroptila sp.	**6.2**	**PI**	10	12			9	1		11	30	12	1	
Leptoceridae		**CG**												
Ceraclea sp.	**2**	**CG**									1			
Polycentropodidae	***6**	**FC**												
Cyrnellus fraternus	***8**	**FC**	134	231	32	7	55	13	47	38	27			
Neureclipsis sp.	**4.2**	**FC**	1											
Diptera												40		
Chaboridae														
Chaoborus punctipennis	**8.5**	**P**							8				10	19
Chironomidae					35	62				3	211	124	13	49
Ablabesmyia mallochi	**7.2**	**P**			20									1
Ablabesmyia rhamphe gp.	***6**	**P**	50	44	17	2			5	4	438	225	1	14
Chironomus sp.	**9.6**	**CG**							14	15			2	19
Clinotanypus sp.		**P**											1	
Coelotanypus sp.	**8**	**P**												36
Conchapelopia sp.	**8.4**	**P**	1											
Cricotopus sp.	***7**	**CG**		157			52	116			376	1806		2
Cricotopus bicinctus	**8.5**	**CG**	61	6	5				2	9	460	243	9	7
Cryptochironomus sp.	**6.4**	**P**											1	2
Diamesa sp.	**8.0**	**CG**	1											
Dicrotendipes lucifer	**8.0**	**CG**	1								29	41	17	31
Dicrotendipes neomodestus	**8.1**	**CG**	12	4			5	1		10	216	166		3

(continued)

Table 6-4. (Continued)

SPECIES	T.V.	F.F.G.	Falls Dam Sep-03 TOTAL	Narrows Dam Sep-03 TOTAL	Tucker Town Sep-03 TOTAL	High Rock Sep-03 TOTAL	Falls Dam Nov-03 TOTAL	Narrows Dam Nov-03 TOTAL	Tucker Town Nov-03 TOTAL	High Rock Nov-03 TOTAL	Falls Dam Jun-04 TOTAL	Narrows Dam Jun-04 TOTAL	Tucker Town Jun-04 TOTAL	High Rock Jun-04 TOTAL
Dicrotendipes simpsoni	**10.0**	**CG**	10	55	1579	1999	3	21	393	669	6	36	17	122
Dicrotendipes sp.	**8.1**	**CG**									7		3	8
Endochironomus sp.		**SH**						1	1					1
Einfeldia natchitocheae											108			
Eukiefferiella claripennis gp.	**5.6**	**CG**		1										
Glyptotendipes sp.	**9.1**	**FC**	3	24	220	576	1	16	912	276	14	35	97	367
Microtendipes pedellus gp.	**5.5**	**CG**									20	5		
Nanocladius distinctus	**7.1**	**CG**	6	28	40	271		6	12	107	5	22	3	5
Orthocladius (Euorthocladius) sp.	***4**	**CG**	2	25				1			1			
Parachironomus sp.	**9.4**	**CG**	1	16	30	59			110	18	133	165	3	214
Phaenopsectra sp.	**6.5**	**SC**				3								
Parakiefferiella sp.	**5.4**	**CG**					1	2			1			
Polypedilum flavum	**4.9**	**SH**									2	5		
Polypedilum illinoense	**9.0**	**SH**			5									
Procladius sp.	**9.1**	**P**		1			1		2				10	
Pseudochironomus sp.	**5.4**	**CG**		5					3			20		
Rheotanytarsus sp.	**5.9**	**FC**	137	715	10	13	1	15		77		20		
Stenochironomus sp.	**6.5**	**SH**	1		5									
Tanytarsus sp.	**9.2**	**FC**		1							177	35	39	9
Tribelos fuscicorne	**6.3**	**CG**	1								316			
Tribelos sp.	**6.3**	**CG**									1			
Tvetenia bavarica gp.	**3.7**	**CG**									1			
Xenochironomus xenolabis	**7.1**	**P**	4	27	21	5		2		8	20	18		5
Empididae	**7.6**	**P**												
Hemerodromia sp.	***6**	**P**		2				1						
Simuliidae	***6**	**FC**												
Simulium sp.	**6.0**	**FC**		2										
Tipulidae														
Tipula sp.	**7.3**	**SH**					1							
TOTAL NO. OF ORGANISMS			**2030**	**3179**	**6445**	**8981**	**1420**	**1333**	**9856**	**5695**	**10172**	**12008**	**1878**	**4000**
TOTAL NO. OF TAXA			**42**	**48**	**38**	**29**	**34**	**33**	**39**	**42**	**53**	**37**	**44**	**46**
EPT INDEX			**6**	**5**	**2**	**2**	**4**	**3**	**2**	**5**	**5**	**2**	**1**	
NC BIOTIC INDEX			**7.14**	**7.33**	**8.54**	**8.57**	**6.94**	**7.19**	**8.20**	**8.38**	**8.09**	**7.75**	**8.65**	**8.24**

Table 6-5. Percent composition of the dominant benthic macroinvertebrate species by sampling season.

	September 2003				*November 2003*				*June 2004*			
SPECIES	**Falls Dam**	**Narrows Dam**	**Tucker Town**	**High Rock**	**Falls Dam**	**Narrows Dam**	**Tucker Town**	**High Rock**	**Falls Dam**	**Narrows Dam**	**Tucker Town**	**High Rock**
Dugesia tigrina		9.3		7.6			6.2	12.5				
Corbicula fluminea	**26.7**				**48.0**	**43.5**			11.0	9.3		
Musculium transversum	15.1	9.6	**38.2**	**43.7**	6.2		**53.2**	28.3			18.6	**35.2**
Physella sp.									8.2			
Menetus dilatatus			6.3									
Dero sp.											14.1	
Slavina appendiculata										14.6		9.1
Lumbriculidae										10.0		
Caecidotea sp.	11.1	17.0	10.0	12.6	6.8	17.9	13.8	**28.8**	**17.3**	**16.3**	**29.7**	6.8
Hyalella azteca					11.1				8.2	6.8		
Cyrnellus fraternus		7.3										
Cricotopus sp.										15.0		
Dicrotendipes simpsoni			24.5	22.3				11.7				
Glyptotendipes sp.							9.2					9.2
Rheotanytarsus sp.		**22.5**										

Table 6-6. EPT Index and Hilsenhoff Biotic Index scores along with associated water quality for Piedmont area of North Carolina.

Bioclassification	**NC Piedmont EPT Value**	**NC Piedmont Biotic Index**
Excellent	>31	<5.19
Good	24-31	5.19-5.78
Good-Fair	16-23	5.79-6.48
Fair	8-15	6.49-7.48
Poor	0-7	>7.48

concentrations were below 5mg/l on 107 days (see NAI 2005a, Table 2.4-3). In Tuckertown tailwater in 2004, average daily DO concentrations were below 5 mg/l standards on 96 days and in Narrows, average daily DO concentrations were below 5 mg/l on 75 days. At Falls, there is a significant improvement in water quality and average daily DO concentrations fell below 5 mg/l on only 4 dates in 2004.

One of the primary impacts of project operations on macroinvertebrates in the tailwaters is caused by low DO levels. Macroinvertebrate rankings were poor for all seasons in High Rock and Tuckertown tailwaters, and this is related to the marginal water quality found at these two sites. At Narrows and Falls tailwaters, the macroinvertebrate communities ranked poor in the spring but fair during the summer and fall sample periods and this is likely due to the better water quality found in the tailwaters of the two lower developments. Similar water quality impacts were also evident for the mussel species. At High Rock and Tuckertown, only one mussel species was collected during all three sampling periods. At Narrows, six mussel species were collected (22 individuals) and at Falls, seven mussel species (575 individuals) were found. Falls tailwater has the most habitat available for mussels, but it also has the best water quality of the four Yadkin Project tailwaters.

Four RTE mussel species were found during the surveys, including the NC endangered species *Elliptio lancolata* (PeeDee lance), which was found in Falls and Narrows tailwaters. Two NC threatened mussel species were found, *Anodonta implicata* (alewife floater) and *Lampsilis radiate* (eastern lamp mussel). The alewife floater was found in Falls and Narrows and the eastern lamp mussel was also found in Falls and Narrows, but only relic shells were found of this species. Another mussel species listed as significantly rare by the NC Heritage Program, *Villosa delumbis* was found in the Falls tailwater (8 individuals).

During the tailwater fish collections in 2003 and 2004, the differences in fish catches during normal DO levels (5 mg/l or greater) and low DO periods (at least a 2mg/l drop from normal) over two 24 hour periods were analyzed (see Section 5.5). The first test occurred during the summer collections at Narrows and of the 18 fish species collected, 15 had fewer individuals captured during the low DO period. In the second test that occurred during the fall sampling at Narrows, there were significantly fewer species (P=0.019) captured during the low DO period, and of the 21 fish species, 17 had fewer individuals collected during the low DO period. It is not known if the fish ceased or slowed their movements during the low DO tests making them less available for capture or moved out of the tailwater area.

Low dissolved oxygen levels and the effects of minimum flows in the tailraces of two TVA hydro projects (Douglas and Cherokee) were studied between 1987 and 1996, including what improvements to the fish communities could be realized by providing minimum flows and by reaerating the turbine discharge to improve DO levels (Scott 1999). It was reported that just providing minimum flows did not substantially improve the fish community over time at Cherokee (1988-1995) and the reason may have been the low DO's recorded (<4 mg/l) at the project for 100 days or more each year. However, when reaeration equipment was put in place at the Douglas development to bring the DO concentrations up to 4 mg/l, steady improvement in the fish community was documented between 1988 and 1996 (Scott 1999).

The fish populations currently in the four Yadkin tailwaters have been shaped by the current project operations, including peaking flows and low DO concentrations that occur in three of the four tailwaters (all but Falls) between 20 and 29% of the year during a normal year. Many of the fish species present are tolerant of marginal water quality, such as gizzard shad, white perch and largemouth bass and this is why these species dominate the catches at Yadkin. Fish species that cannot tolerate marginal water quality (especially low DO), such as some of the darter and minnow species are generally absent from the catches.

Relative weights (Wr) are an indication of a fish's condition, and if these values fall below a range reported for the species, it can indicate a problem with feeding. Largemouth bass either exceeded or fell within the ideal range for Wr in all four tailwaters, indicating they are having no problem securing food. They also are successfully spawning in all four tailwaters (or the reservoir backing up to the tailwaters), given the various size classes captured. Many large sized fish are available for capture, suggesting that fishermen are releasing many of the quality fish. Largemouth bass and some other predators frequently do well in reservoirs with fluctuating water levels (see NAI 2005b) because they take advantage of young forage fish drawn from their cover when lake elevations drop. Black crappies captured in the High Rock tailwater during all three seasons had low relative weights, suggesting that this species may be having a problem securing enough food. These fish did not have a balanced population (PSD value slightly below ideal range), but they are successfully spawning. It is not clear if the problems with feeding are related to the marginal water quality. Relative weights for black crappies captured downstream in Tuckertown and Narrows tailwaters were either within or just below the recommended range for this species and their populations were balanced (PSD values in range).

Impacts to tailwater fish populations due to stranding are minor at all four tailwaters because the tailwater areas remain watered up when generation is shut down and discharge flow ceases. Tailwater water surface elevations do fluctuate 1 or 2 ft, but no pools or sections of the tailwater were isolated – there is connectivity to all areas of the four Project tailwaters when generation ceases.

No rare, threatened or endangered (RTE) fish were captured during the three seasons of sampling the project tailwaters. Habitat that the robust redhorse and Carolina redhorse are known to frequent were intensively sampled with gill nets and electrofishing gear, especially during the spring spawning season, but none were found in the project tailwaters.

8.0 CITED REFERENCES

Alcoa Power Generating, Inc. (APGI) Yadkin Division. 2002. Yadkin Hydroelectric Project FERC No. 2197-NC. Initial Consultation Document.

Anderson, R.O. 1980. Proportional stock density (PSD) and relative weight (Wr): interpretive indices for fish populations and communities. Pages 27 – 33 in S. Gloss and B. Shupp, editors. Practical fisheries management: doing more with less in the 1980's. Workshop proceedings, New York Chapter, American Fisheries Society, Ithaca, New York, USA.

Anderson, R.O. and R .M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 in B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Anderson, R.O. and A.S. Weithman. 1978. The concept of balance for coolwater fish populations. Pages 371-381 in R.L. Kendall, editor. Selected coolwater fishes of North America: proceedings of a symposium held in St. Paul, Minnesota March 7-9, 1978. Special Publication; no. 11. American Fisheries Society, Washington DC.

Bister, T.J., D.W. Willis, M.L. Brown, S.M. Jordan, R.M. Neumann, M.C. Quist, and C.S. Guy. 2000. Proposed standard weight (Ws) equations and standard length categories for 18 warmwater nongame and riverine fish species. North American Journal of Fisheries Management. 20: 570-574.

Coutant, C.C., and D.S. Carrol. 1980. Temperatures occupied by ten ultrasonic-tagged striped bass in freshwater lakes. Transactions of the American Fisheries Society. 109: 195-202.

Etnier, D. A. and W.C. Starnes. 1993. The fishes of Tennessee. University of Tennessee Press, Knoxville, TN.

Gabelhouse, D.W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management. 4:273-285.

Jackson, J.R. and J.E. Hightower. 2001. Reservoir striped bass movements and site fidelity in relation to seasonal patterns in habitat quality. North American Journal of Fisheries Management. 21:34-45.

Muoneke, M.I. and K.L. Pope. 1999. Development and evaluation of a standard weight (Ws) equation for blue catfish. North American Journal of Fisheries Management. 19: 878-879.

Murphy, B.R., D.W. Willis, T.A. Springer. 1991. The relative weight index in fisheries management: status and needs. Fisheries. 16(2): 30-38.

Neumann, R.M. and B.R. Murphy. 1991. Evaluation of the relative weight (Wr) index for assessment of white crappie and black crappie populations. North American Journal of Fisheries Management. 11: 543-555.

Normandeau Associates, Inc. 2005a. Draft Yadkin Water Quality Report. Prepared for Alcoa Power Generating, Inc. Yadkin Division.

Normandeau Associates, Inc. 2005b. Draft Yadkin Reservoir Fish and Aquatic Habitat Assessment. Prepared for Alcoa Power Generating Inc. Yadkin Division.

Pennington and Associates, Inc, 2005. Benthic Macroinvertebrate Survey Yadkin River. Produced for Alcoa Power Generating Inc. Yadkin Division.

Robust Redhorse Conservation Committee. 2003. Intensive Surveys for the Robust Redhorse (*Moxostoma robustum*) on the Pee Dee River below Blewett Hydroelectric Plant, 2003 Work Plan.

Schaffler, J.J., J.J. Isely and W.E. Hayes. 2002. Habitat use by striped bass in relation to seasonal changes in water quality in a southern reservoir. Transactions of the American Fisheries Society. 131:817-827.

Scott, E. M. 1999. Tailwater fish index (TFI) development for Tennessee river tributary tailwaters. Pages 507 – 522 in T. P. Simon, editor. Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press LLC, Boca Raton, FL.

USFWS, NMFS, NCWRC. 2004. Draft Restoration Plan for the Diadromous Fishes of the Yadkin-PeeDee River Basin North Carolina.

Young, S.P. and J.J. Isely. 2002. Striped bass annual site fidelity and habitat utilization in J. Strom Thurmond reservoir, South Carolina – Georgia. Transactions of the American Fisheries Society. 131:828-837

APPENDIX 1

Tailwater Fish and Aquatic Biota Assessment
Final Study Plan
June, 2003

Yadkin Project (FERC No. 2197)
Tailwater Fish and Aquatic Biota Assessment

Final Study Plan
June, 2003

Background

Alcoa Power Generating Inc. (APGI) is the licensee for the Yadkin Hydroelectric Project. The Yadkin Project is currently licensed by the Federal Energy Regulatory Commission (FERC) as Project No. 2197. This license expires in 2008 and APGI must file a new license application with FERC on or before April 30, 2006 to continue operation of the Project.

The Yadkin Project consists of four reservoirs, dams, and powerhouses (High Rock, Tuckertown, Narrows, and Falls) located on a 38-mile stretch of the Yadkin River in central North Carolina. The Project generates electricity to support the power needs of Alcoa's Badin Works, to support its other aluminum operations, or is sold on the open market.

As part of the relicensing process, APGI prepared and distributed, in September 2002, an Initial Consultation Document (ICD), which provides a general overview of the Project. Agencies, municipalities, non-governmental organizations and members of the public were given an opportunity to review the ICD and identify information and studies that are needed to address relicensing issues. To further assist in the identification of issues and data/study needs, APGI has formed several Issue Advisory Groups (IAGs) to advise APGI on resource issues throughout the relicensing process. IAGs will also have the opportunity to review and comment on Draft Study Plans. This Draft Study Plan has been developed in response to comments on the ICD and through discussions with the Fish and Aquatics IAG, to provide additional necessary information for consideration in the relicensing process.

Issues

The following issues were raised during initial consultation regarding tailwater fish and aquatic biota at the Yadkin Project:

- Effects of Yadkin Project reservoir releases on tailwater fish, macroinvertebrates and aquatic habitat

- Current status of rare, threatened and endangered (RTE) aquatic species at the Yadkin Project that could be impacted by Project operations

Objectives

On March 12, 2003 the Fish and Aquatics IAG met and discussed objectives for the tailwater fish and aquatic biota study. Over the course of those discussions the following objectives were identified for the study.

- Describe tailwater habitats in all four Yadkin development tailwater areas.
- Inventory and assess the resident fish community in the Project tailwaters on a seasonal basis (spring, summer & fall) to develop baseline data that can be used to detect changes over time. Evaluate the impacts of existing Project operations on the tailwater fish community, such as impacts associated with generation schedules (generation on/off), and impacts due to the low dissolved oxygen (DO) found in the tailwaters during certain times of the year.

- Inventory and assess the macroinvertebrate and mussel species in the Project tailwaters on a seasonal basis to develop baseline data that can be used to detect changes in these communities over time. Evaluate impacts of existing Project operations on the tailwater macroinvertebrate community and describe tailwater habitats.

- Search for RTE mussel species in Project tailwaters.

- Search for RTE fish species, including the Robust and Carolina Redhorse species, in the Project tailwaters during the spring (spawning period) and during the summer and fall fish surveys.

Following the March 12, 2003 IAG meeting, Normandeau prepared a draft study plan for the Yadkin Project Tailwater Fish and Aquatic Biota Assessment. This draft study plan was distributed electronically to the Fish and Aquatics IAG on April 4, 2003 for review prior to the next IAG meeting scheduled for April 9, 2003 in Badin, NC. Comments on the Draft Tailwater Fish and Aquatic Biota Assessment at the meeting included discussions on modifying the fish sampling plan in the Project tailwaters so that sampling would occur during generation and during no generation periods to see if it effects fish movement in and out of the tailwaters. It was also requested that more detail be provided in the study plan, including particulars on the sampling design and other parameters that will be collected during tailwater fish surveys, such as water quality sampling. Discussions also focused on sampling in the tailwaters during low DO and normal DO periods each season. It was requested that the extent of the low DO "plume" be determined, as well as its impacts to fish movements into and out of the tailwaters. Other comments included determining the change in the amount and quality of habitat in the tailwaters between peaking and non-peaking operations, especially if there is stranding due to fluctuating tailwater elevations. It was requested that the mussel searches in the tailwaters be expanded beyond the two transects proposed for each tailwater so that good mussel habitat that does not fall along a transect line would get searched. It was also requested that the mussel searches include walking the banks on both sides of each tailwater to identify fresh mussel shells/middens. It was agreed upon by the IAG participants that interested parties would meet during the summer, 2003 for a site visit to the four tailwaters to assist in establishing the permanent fish and mussel sampling stations (transects) proposed for each tailwater.

A revised draft study plan was distributed to the IAG in May, 2002. Minor comments received on the revised draft have been incorporated into this final study plan.

Methods

The tailwater fish and aquatic biota assessment will be conducted by Normandeau Associates Inc. (NAI) with assistance from Pennington and Associates, Inc. and will entail the following:

Tailwater Fish Sampling

Normandeau Associates will conduct intensive electrofishing, trap netting, seine netting and gill netting in the four tailwaters of the Yadkin Project during spring, summer and fall seasons. Spring sampling will be conducted in late April/May 2004 to document resident fish use of tailwater areas and to search for RTE redhorse species. Summer sampling will occur in August 2003 and fall sampling will be performed in November 2003. Permanent fish sampling stations (and electrofishing transects) will be established in each of the four Project tailwaters in June 2003 by agencies and interested participants from the Fish and Aquatics IAG.

The primary objective during the seasonal fish sampling in each of the four tailwaters will be to capture as many fish species as possible. This will be accomplished by intensive boat electrofishing, gill netting, seine netting and trap netting over a 3 to 4 day period in each tailwater per season. Many fish are habitat specialists, therefore efforts will be made to sample all habitats present in the tailwaters, including deeper runs, pools, undercut banks and shallow shoals. Other objectives will include sampling during generation on and generation off (or reduced generation – this will depend on the season and flows) in each tailwater and sampling during low DO compared to normal DO time periods each season to see if these project operations effects fish movement. DO levels are more apt to be low and fluctuate more each day during the summer sampling period, therefore sampling in the spring period may only focus on peaking generation (no generation/generation) if daily DO fluctuations are small.

During all tailwater fish sampling, temperature and DO profiles will be collected at selected stations in each tailwater under each operating scenario, such as during generation on, generation off (or reduced generation if higher flows) and low DO or not low DO time periods. Normandeau also plans on fishing each tailwater during daytime and nighttime periods over the four days of sampling planned for each tailwater during each season. Fishing at night can be very effective and at times can produce the largest catches and the most species.

In addition to the water quality data collection during fish sampling, Normandeau has installed YSI continuous DO/temperature water quality monitors in all four tailwaters in late April 2003 that will remain in place through November 2003. This data will also be analyzed to confirm changes in DO and temperature that will occur during each seasonal fish sampling period and to review seasonal conditions prior to sampling so that collections can be designed around daily changes in DO, temperature and flows (flow data will be provided by Yadkin). To evaluate the longitudinal and lateral extent of DO conditions in the tailwaters, in August and September 2003, beginning at each YSI continuous tailwater monitor, temperature and DO profiles will be taken at ¼ points along transects that will be spaced ¼ mile apart (going downstream from the monitor). Transects will be added until temperature and DO conditions at consecutive transects are mixed (this effort is included within the Yadkin Water Quality study plan).

Fish sampling methods for each tailwater (and each season) will be similar. The shock boat will be used to sample the shoreline (where water depth permits) and channel sections of the tailwaters traveling in a downstream direction. The shock boat uses Smith-Root electronics and will be set to pulsed DC current, >500v, 4 amps. Shocking runs will continue along chosen transects until two consecutive shocking runs fail to capture any new species for a given habitat (i.e. shoreline or channel habitat). The time for each boat shocking run will be recorded on the data sheets along with the number and species of fish collected. Total length (mm) and weight (gm) of fish captured will also be recorded on the field data sheets – a sub-sample of 50 randomly chosen individuals will be measured and weighted for abundant fish species captured.

Gill nets will also be fished at the same time the boat shocking is being conducted. Experimental gill nets measuring 30.5 m long and 2.4 m deep, and constructed with four 7.6 m panels with mesh sizes of 2.54 cm, 5.08 cm, 7.62 cm and 10.16 cm of stretch monofilament will be used – these are the same sized gill nets recently used in 2000 by Progress Energy to sample for fish in the Yadkin Project reservoirs. These gill nets will be set prior to electrofishing in various locations/habitat types in the tailwater and their location (GPS), depth and habitat type will be recorded for each station. It has been our experience that the boat shocker can be used to effectively "drive" fish into the gill nets, especially in deeper tailraces where the boat shocker may not be entirely effective. Our intent is to keep the gill nets mobile, moving them to different locations or habitat types frequently, in an effort to capture as many species as possible during each operational scenario (gen. on/ gen. off, etc). Some gill nets will be moved around to sample in concert with the shock boat, and others will be used to fish deeper areas that the shock boat cannot effectively fish. Gill nets will be fished at least every 4 to 6 hours and will not be left unattended or fished overnight.

Trap nets may also be used, but their use and number of traps deployed will depend on their success at capturing fish species not collected via the shock boat and gill net. If it is determined that this gear type does not help capture additional fish species, at least one net will be set-up in each tailwater as a holding pen to keep alive redhorse species or other uncommon species that may need to have their identity verified by other experts. Seine nets will also be used in all four tailwaters to try to collect smaller fish species that may be present.

Tailwater Macroinvertebrate Sampling

Normandeau and Pennington and Associates, Inc. will search for mussels and collect macroinvertebrates at permanent stations and transects set-up in the Project tailwaters during summer (August, 2003), fall (November, 2003), and spring (May, 2004). These permanent macroinvertebrate stations and mussel transects in each of the four tailwaters will be located in early June, 2003 by agency personnel and interested participants from the Fish and Aquatics IAG. Once a station or transect location is picked by the IAG, its position will be pinpointed with GPS and all future macroinvertebrate sampling or mussel searches will be taken from the same locations.

Normandeau and Pennington propose to set-up 2 transects in each of the developments tailwaters – one transect near each powerhouse and the other located downstream in the lower tailwater (to be determined in field by Normandeau and the IAG members). Three 2 m^2 macroinvertebrate samples will be collected from each transect at 25%, 50% and 75% of the distance along each transect (six samples from each tailwater per each sample period). However, these station locations will ultimately depend on the consensus from participants that attend the early June 2003 field trip to locate the stations. Mussel searches will also be conducted along these same transect lines.

In deep water (>4 ft), an underwater airlift will be used to collect macroinvertebrate samples (2 m^2 sample size) at each station along the transect line (in shoal water, a kick net will be used to collect the samples). Macroinvertebrates collected will be preserved on-site and returned to PAI's lab for sorting and identification of species. Mussel searches will also be conducted each season by divers swimming along the length of each transect line (length dependent on the wetted width of each tailwater at time of sampling). Divers will search at least one meter upstream and downstream of each transect line (2 m wide band along the entire transect), but this will greatly depend on visibility at the time of the search. Additionally, mussel searches will done by walking along the shoreline of each tailwater looking for mussel shells and by having divers search in areas identified by participants as good mussel habitat that is not located along a transect line. Any live RTE mussel species located during these searches will be identified, returned to where it was found (if it was removed from the water), and its location recorded with GPS. The location of any relic mussel shells found will also be recorded and the shells collected and identified.

During the fisheries and macroinvertebrate sampling and mussel searches planned for August 2003, the divers will also describe the habitat types found in each tailwater area. Depending on visibility, divers will take representative U/W pictures of the habitat found along each transect line and also pictures of the chosen macroinvertebrate sampling stations.

Carolina and Robust Redhorse Searches

During the seasonal tailwater fish sampling, Normandeau will attempt to capture the Carolina and Robust redhorse species that are known to occupy habitat in the Pee Dee River downstream of the Falls development and the Progress Energy dams. Normandeau will specifically target these fish in the Yadkin tailwaters during their spring spawning period in late April-early May, 2004, which is when the spring tailwater sampling begins. Electrofishing and gill nets will be used to try to capture these fish (see methods above in Tailwater Fish Sampling). Most of the available spawning habitat for the robust redhorse exists in the Project tailwaters. The shoal areas at each development will be targeted for spawning redhorse species when water temperatures are between 18º C and 24º C. The spring tailwater fish survey will begin at the Falls tailwater, and gradually (over a 2 week period) move up the river ending the spring fish sampling at the High Rock tailwater. Any robust or Carolina redhorse captured will be identified, measured, weighted and released unharmed. If identification is difficult, the fish will be safely held in a trap net until it can be properly identified by experts (Progress Energy personnel are willing to help with identification of these fish).

Data Collection and Reporting Schedule

Normandeau proposes to conduct the tailwater fish, macroinvertebrate and mussel field evaluations in each of the four Project tailwaters during spring (April/May 2004), summer (August 2003) and late fall (November 2003) sample periods. Searches for the Carolina and robust redhorse's will be conducted seasonally during the tailwater fish assessments. Locations of the proposed permanent fish, mussel and macroinvertebrate stations and transects will be selected in June 2003 by interested members of the Fish and Aquatics IAG. Results of the fish, macroinvertebrate and mussel evaluations will be reported in draft and final study reports. A draft study report for the Tailwater fish sampling will be prepared and distributed to the Fish and Aquatics IAG for review and comment by August 31, 2004, approximately three months after the completion of data collection. IAG comments will be addressed in a final study report that will be completed by November 30, 2004. A draft study report for the Tailwater macroinvertebrate and mussel evaluations will be prepared and distributed to the Fish and Aquatics IAG by the 3rd quarter of 2004 and after IAG comments are addressed, the final report will be distributed by the 4th quarter of 2004. Interim results, such as results of seasonal tailwater fish sampling, and mussel searches, may be shared with the IAG as such information becomes available, prior to completion of the draft study report.

APPENDIX 2

Length Frequency Distributions for Selected Species from High Rock, Tuckertown, Narrows, and Falls Tailwaters.

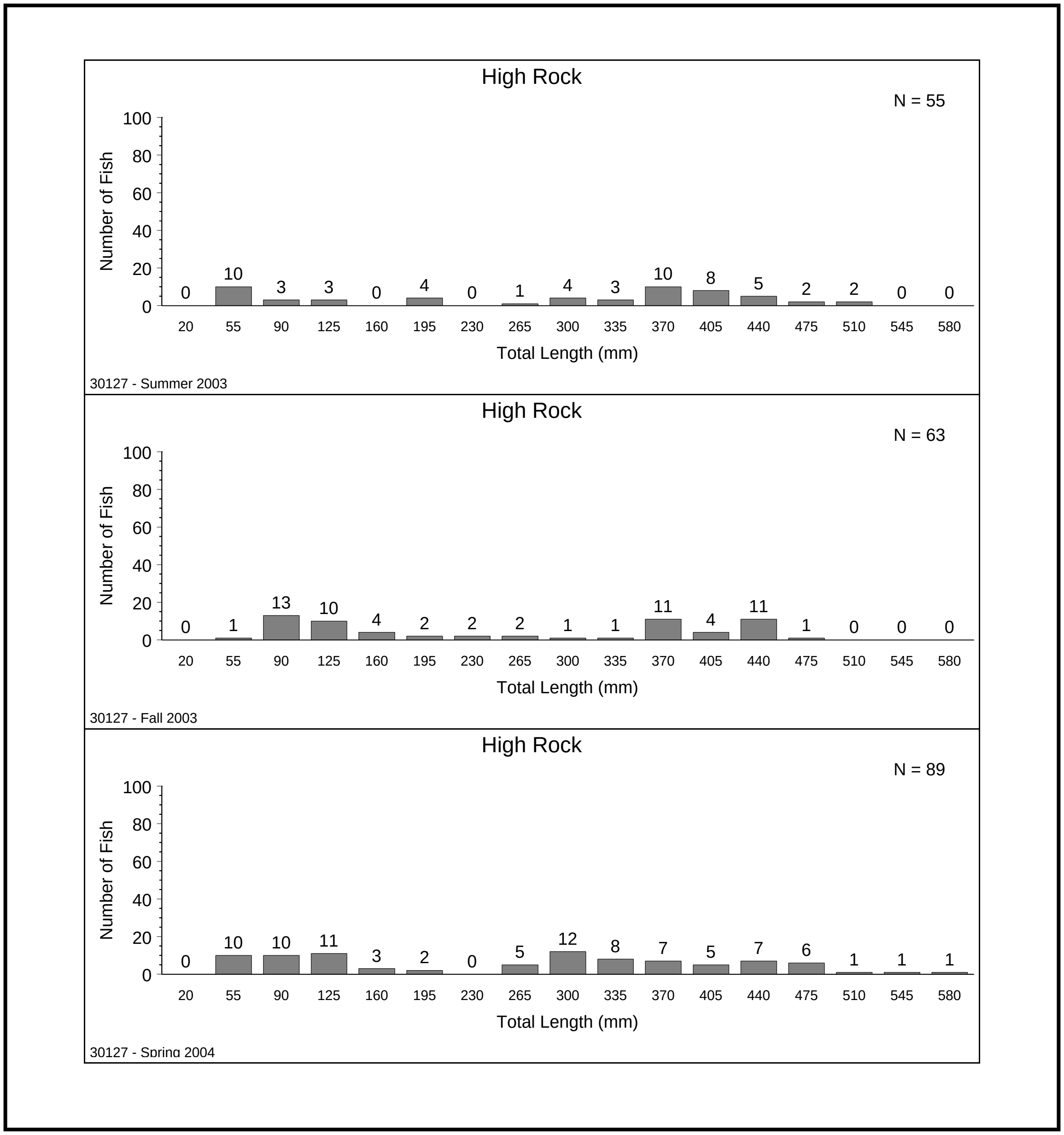

Figure 1-1. Length frequency distribution of largemouth bass captured in High Rock tailwater by season. All gear types combined.

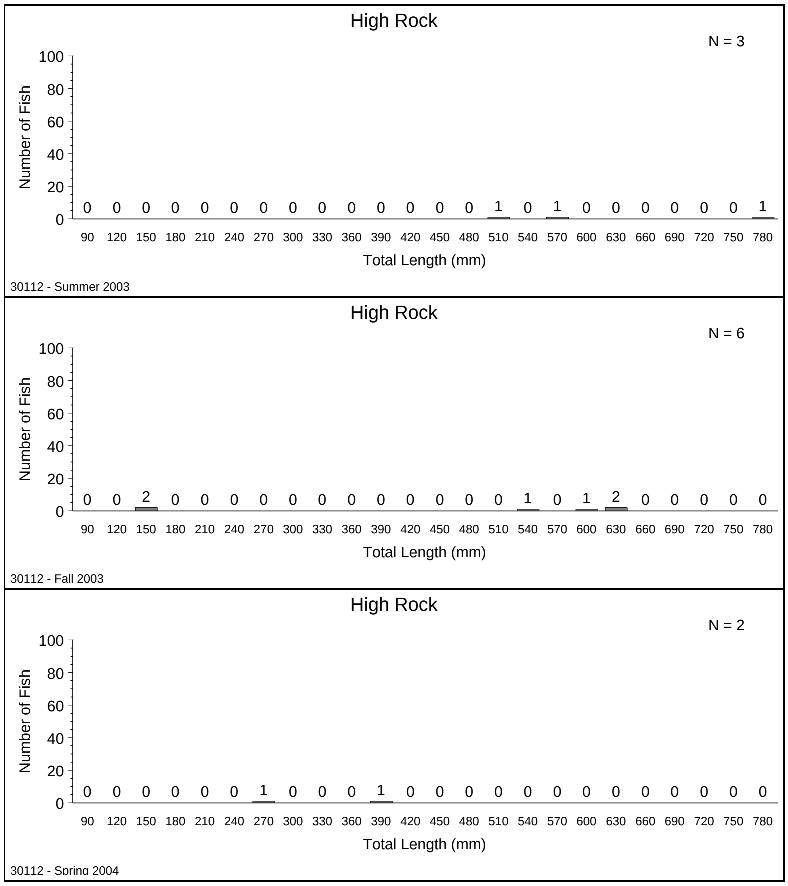

Figure 1-2. Length frequency distribution of striped bass captured in High Rock tailwater by season. All gear types combined.

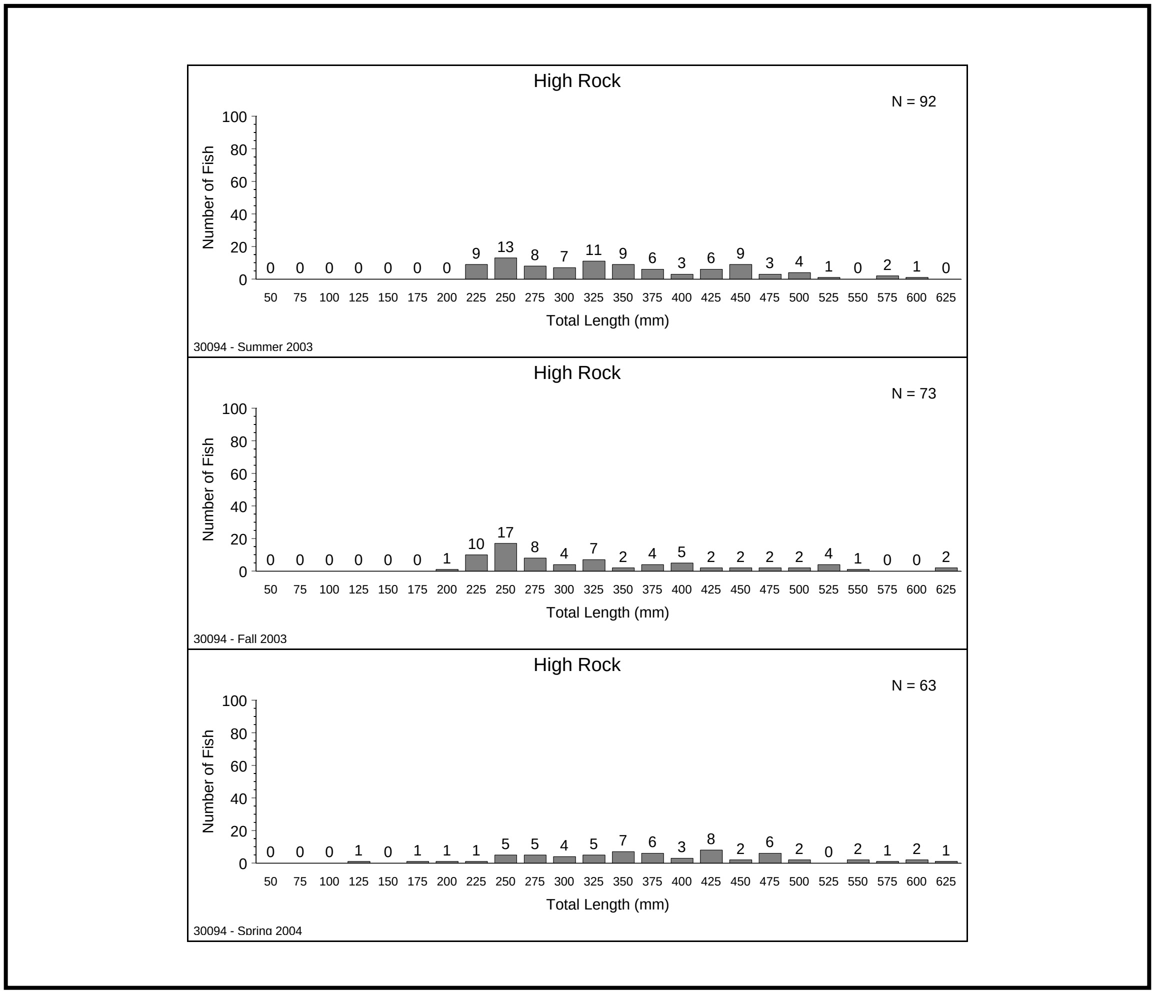

Figure 1-3. Length frequency distribution of channel catfish captured in High Rock tailwater by season. All gear types combined.

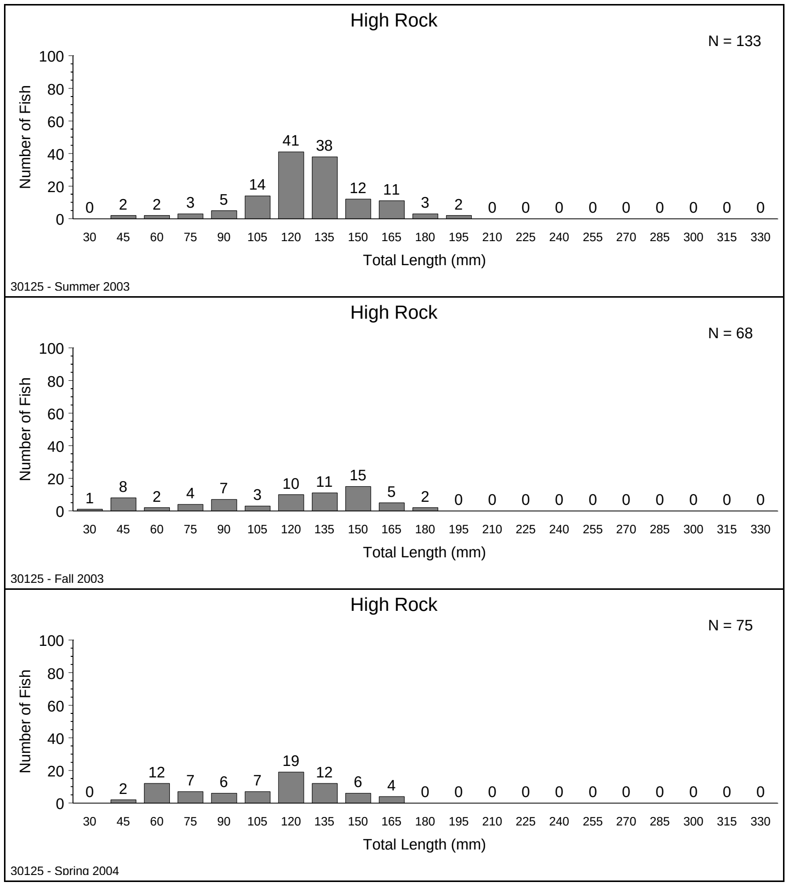

Figure 1-4. Length frequency distribution of bluegill captured in High Rock tailwater by season. All gear types combined.

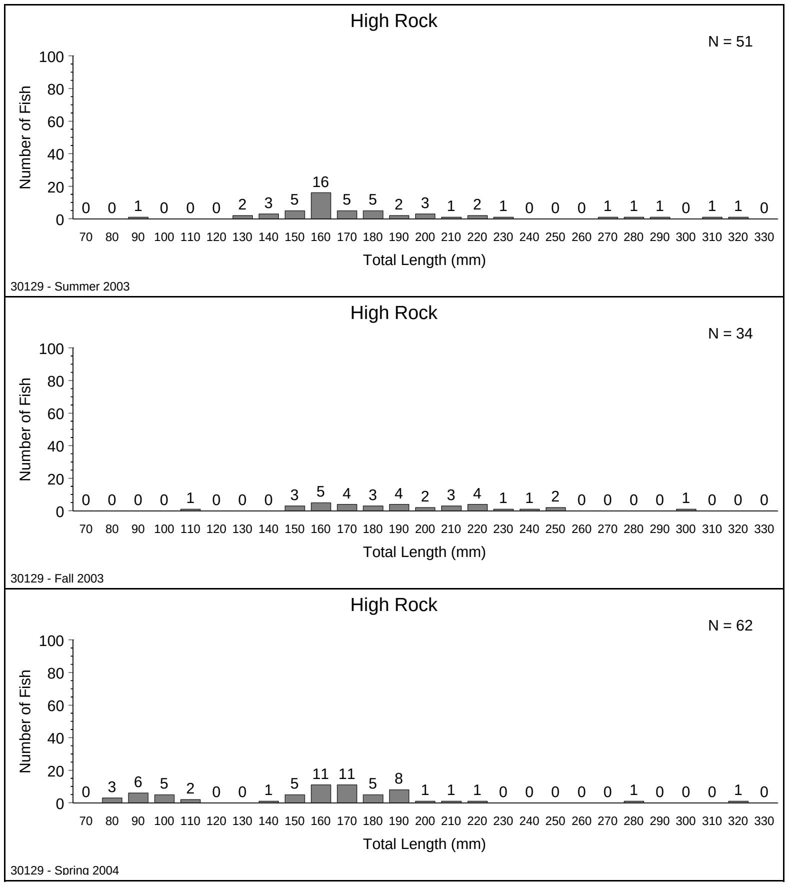

Figure 1-5. Length frequency distribution of black crappie captured in High Rock tailwater by season. All gear types combined.

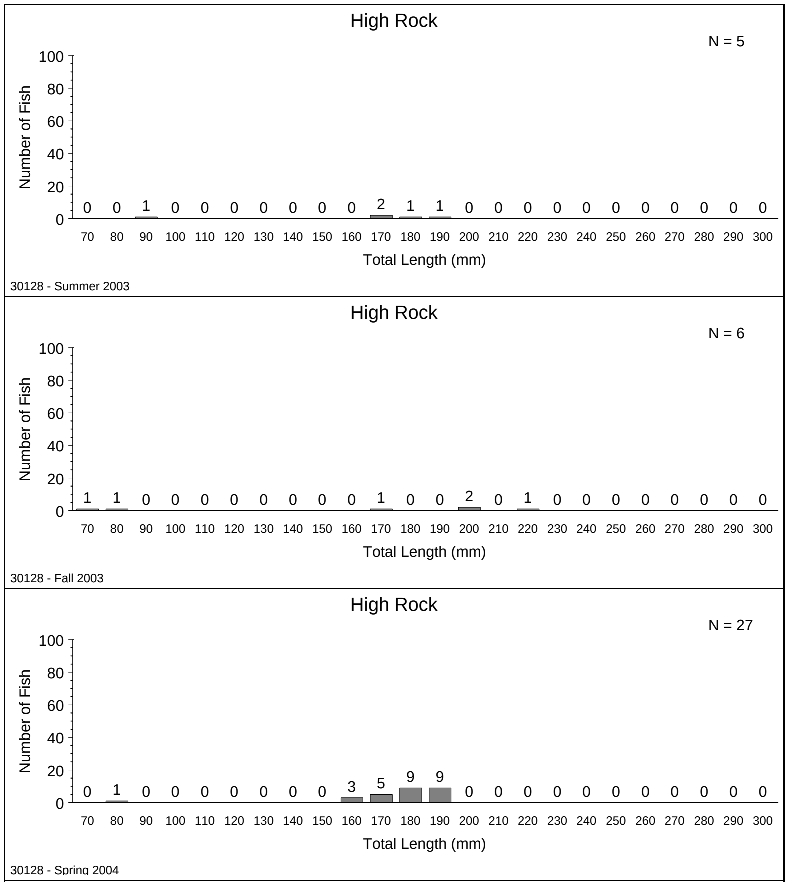

Figure 1-6. Length frequency distribution of white crappie captured in High Rock tailwater by season. All gear types combined.

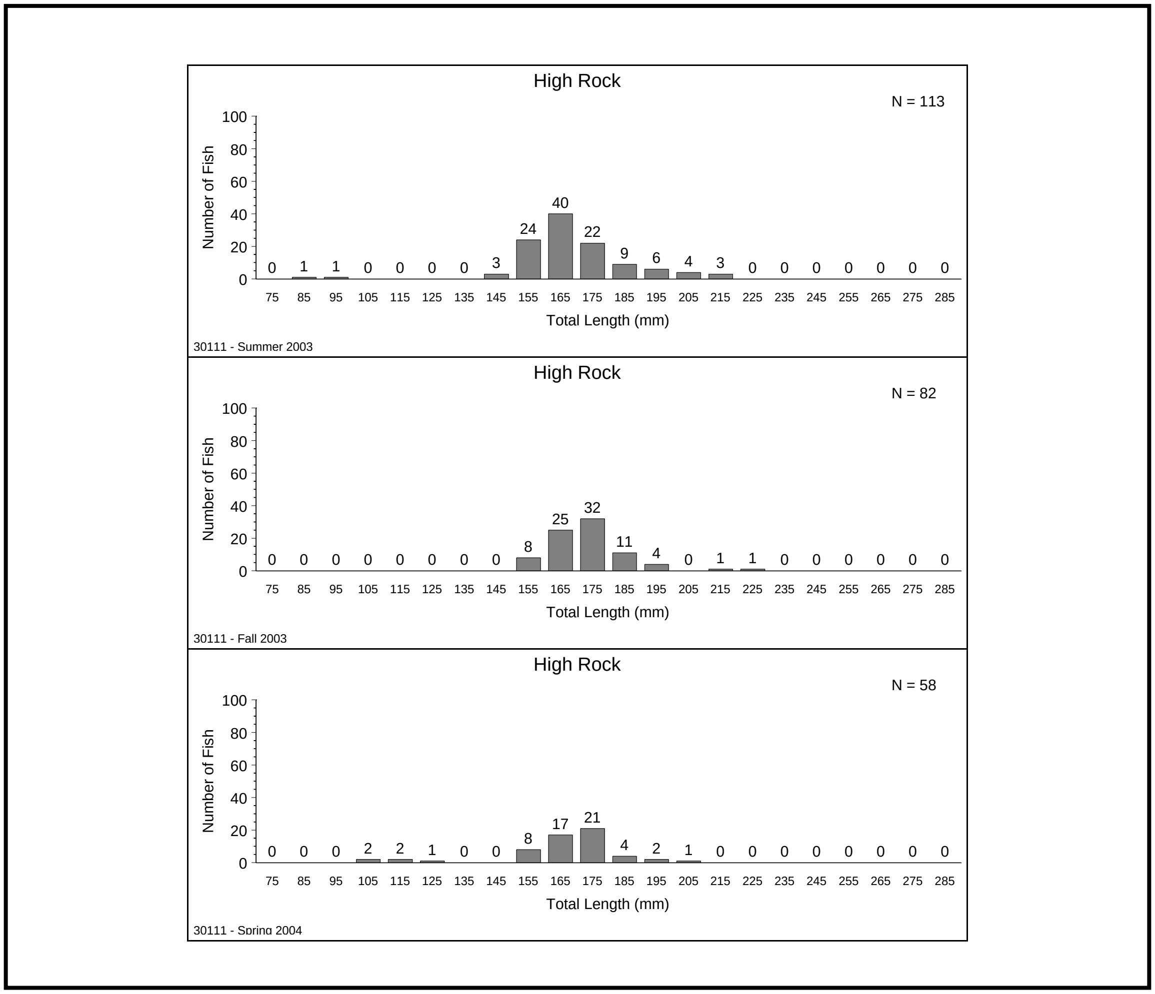

Figure 1-7. Length frequency distribution of white perch captured in High Rock tailwater by season. All gear types combined.

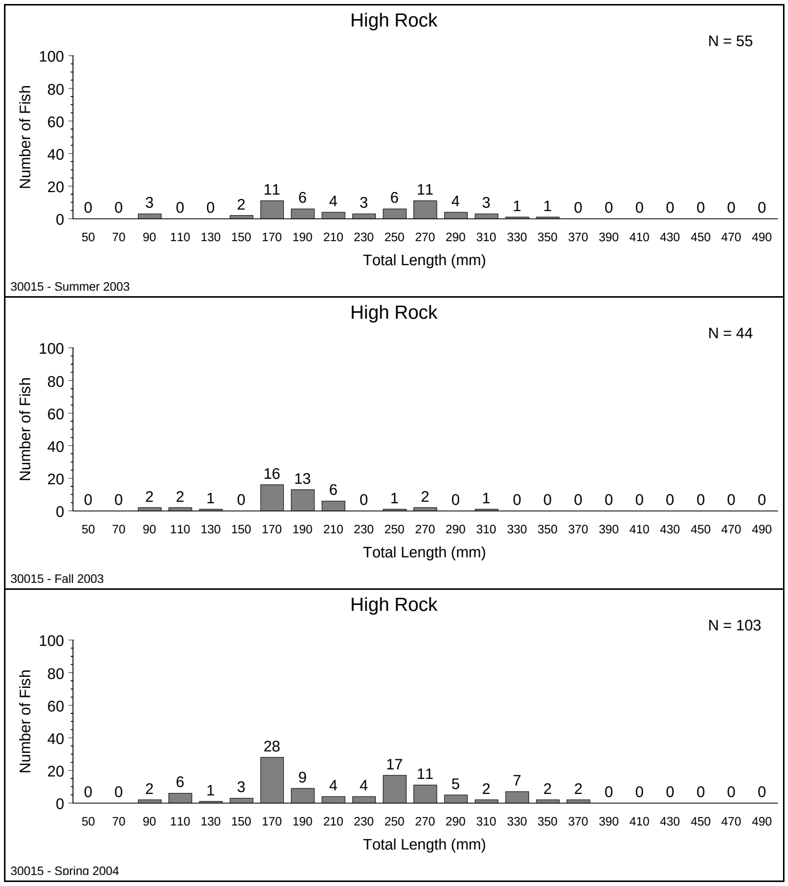

Figure 1-8. Length frequency distribution of gizzard shad captured in High Rock tailwater by season. All gear types combined.

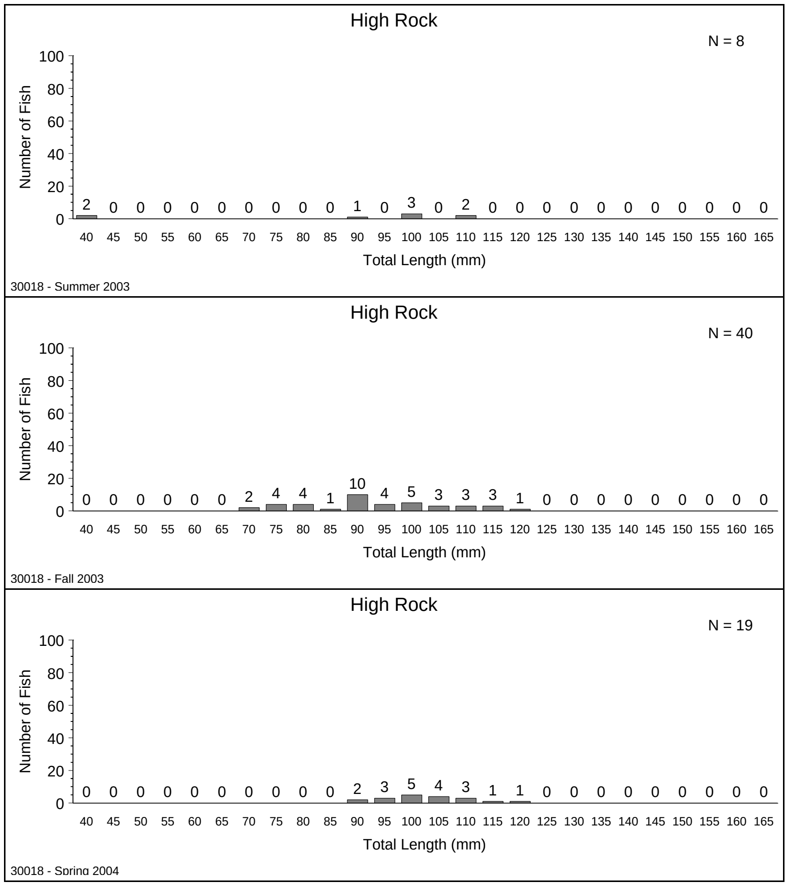

Figure 1-9. Length frequency distribution of threadfin shad captured in High Rock tailwater by season. All gear types combined.

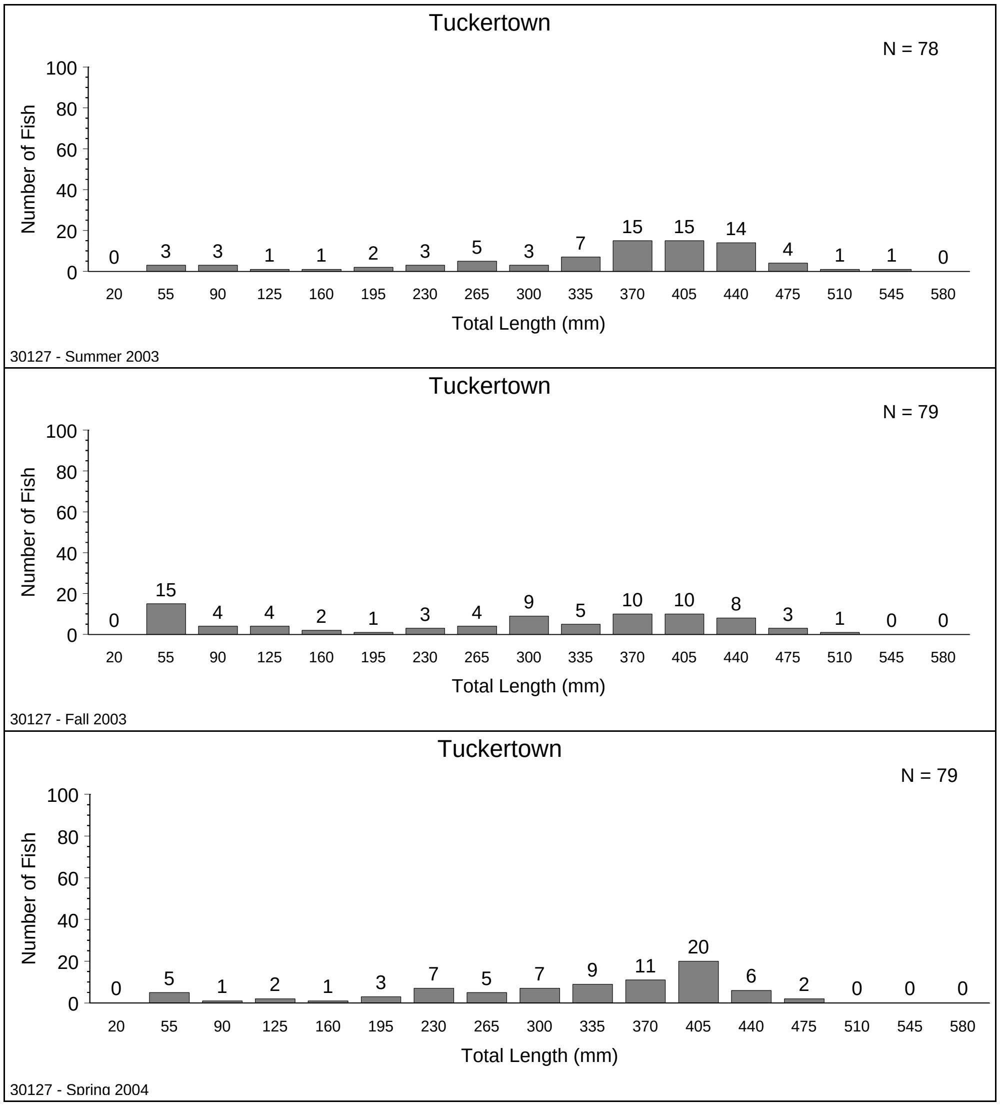

Figure 1-10. Length frequency distribution of largemouth bass captured in Tuckertown tailwater by season. All gear types combined.

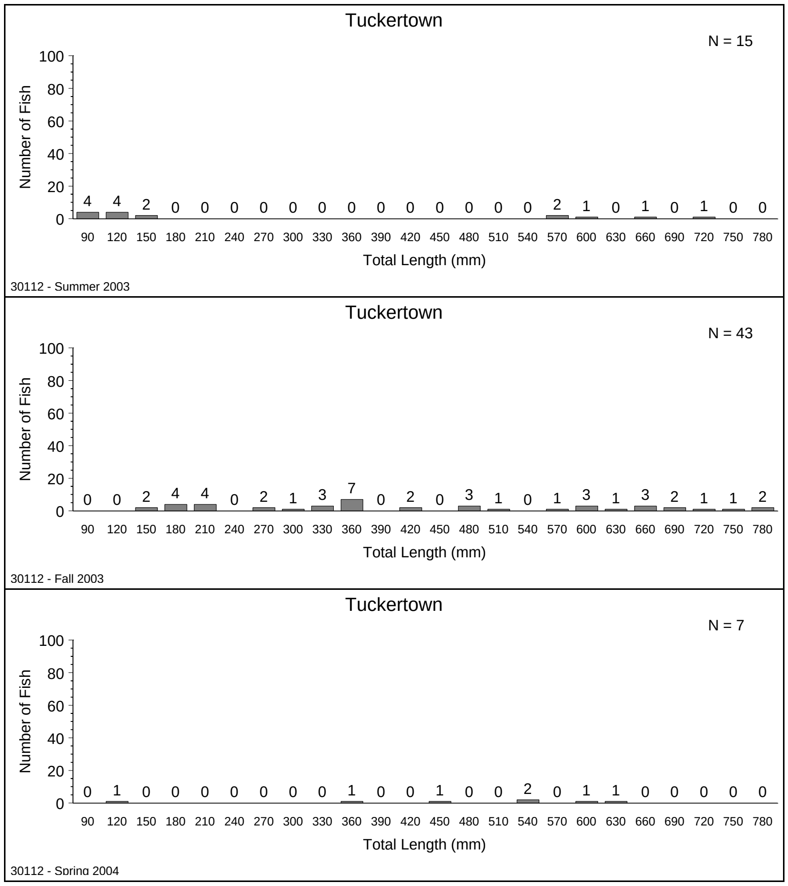

Figure 1-11. Length frequency distribution of striped bass captured in Tuckertown tailwater by season. All gear types combined.

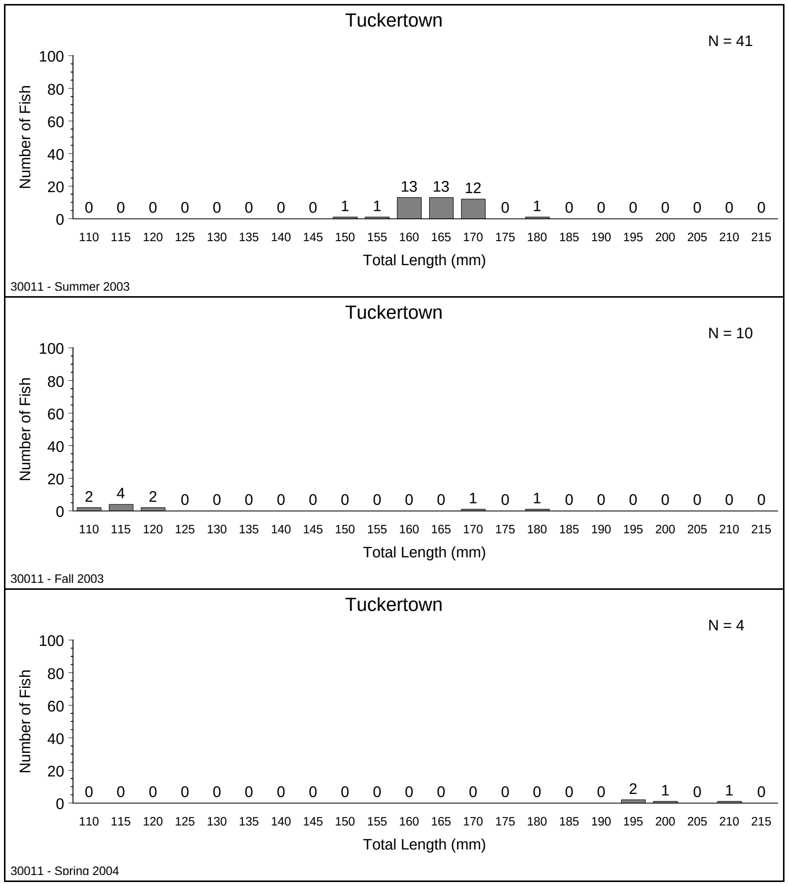

Figure 1-12. Length frequency distribution of blueback herring captured in Tuckertown tailwater by season. All gear types combined.

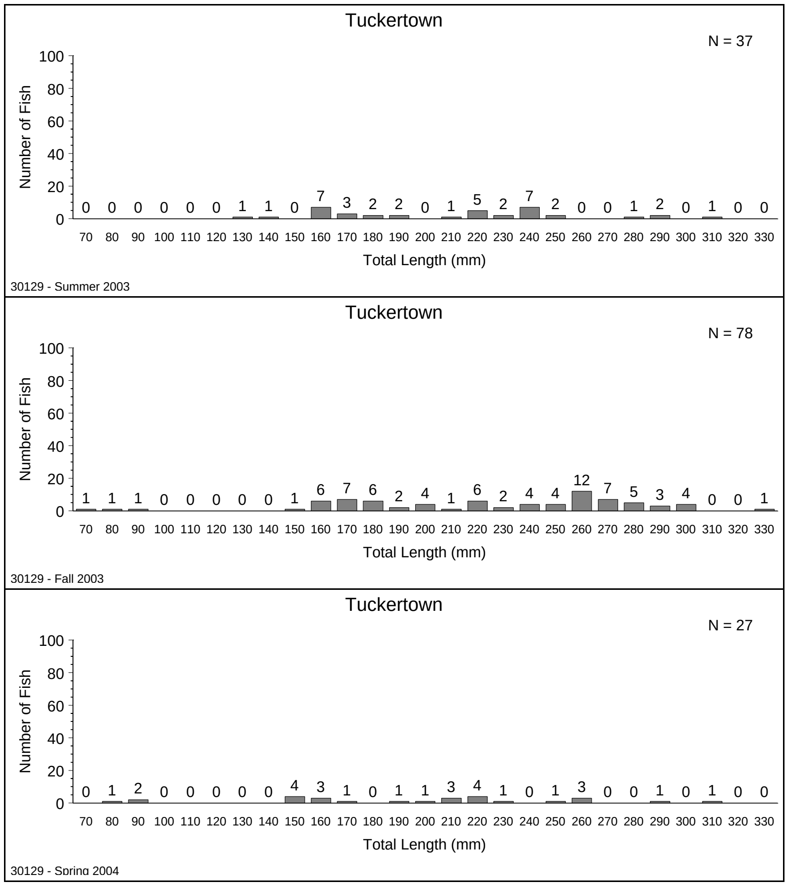

Figure 1-13. Length frequency distribution of black crappie captured in Tuckertown tailwater by season. All gear types combined.

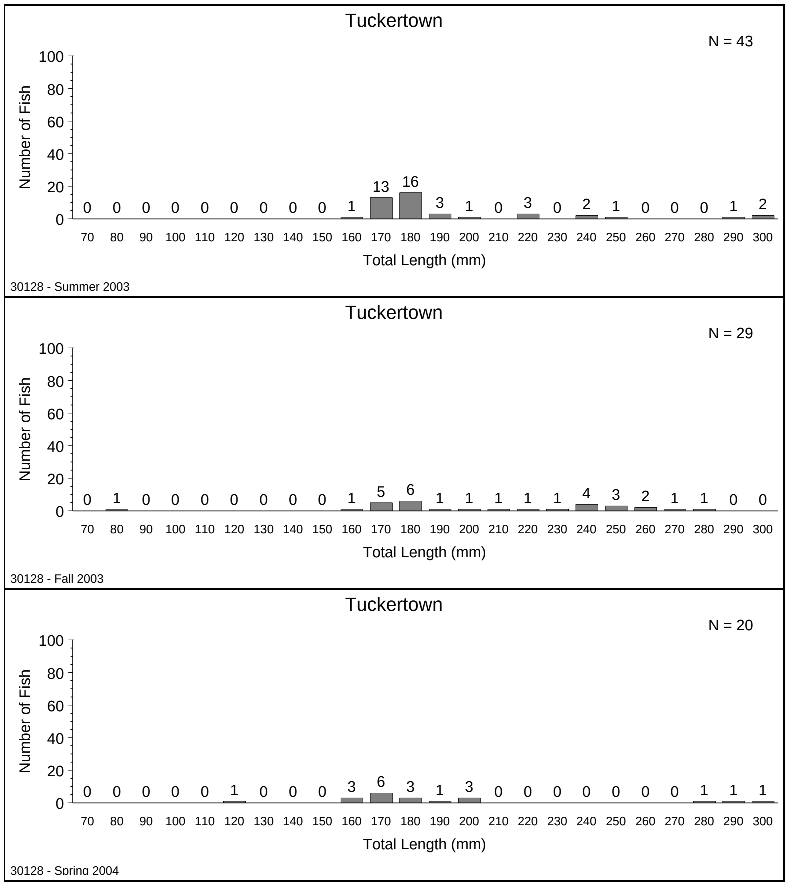

Figure 1-14. Length frequency distribution of white crappie captured in Tuckertown tailwater by season. All gear types combined.

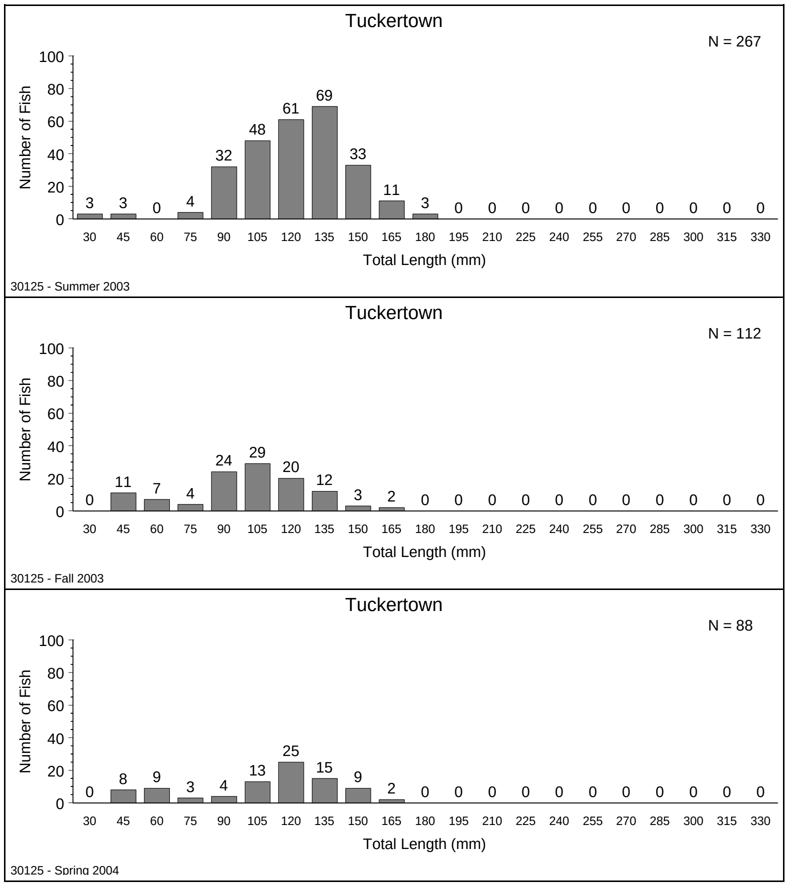

Figure 1-15. Length frequency distribution of bluegill captured in Tuckertown tailwater by season. All gear types combined.

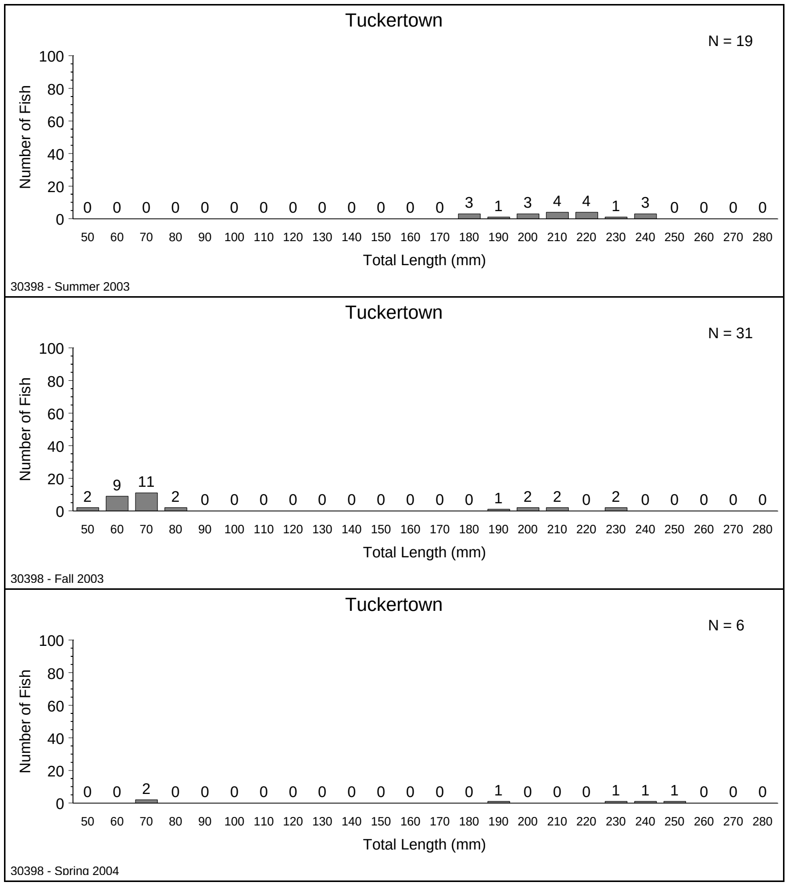

Figure 1-16. Length frequency distribution of redear sunfish captured in Tuckertown tailwater by season. All gear types combined.

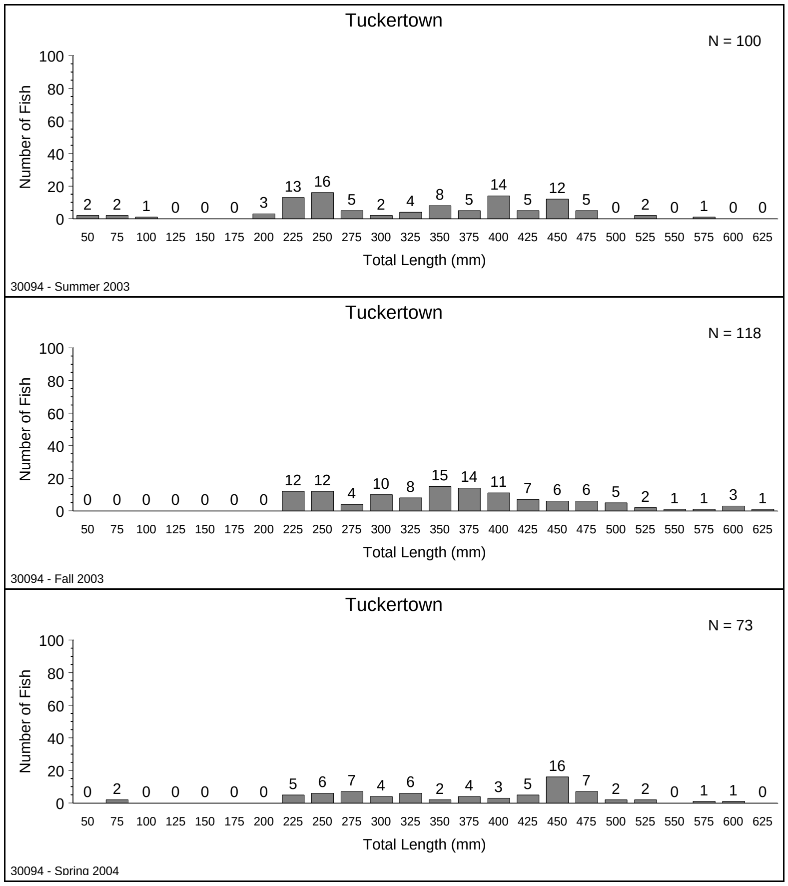

Figure 1-17. Length frequency distribution of channel catfish captured in Tuckertown tailwater by season. All gear types combined.

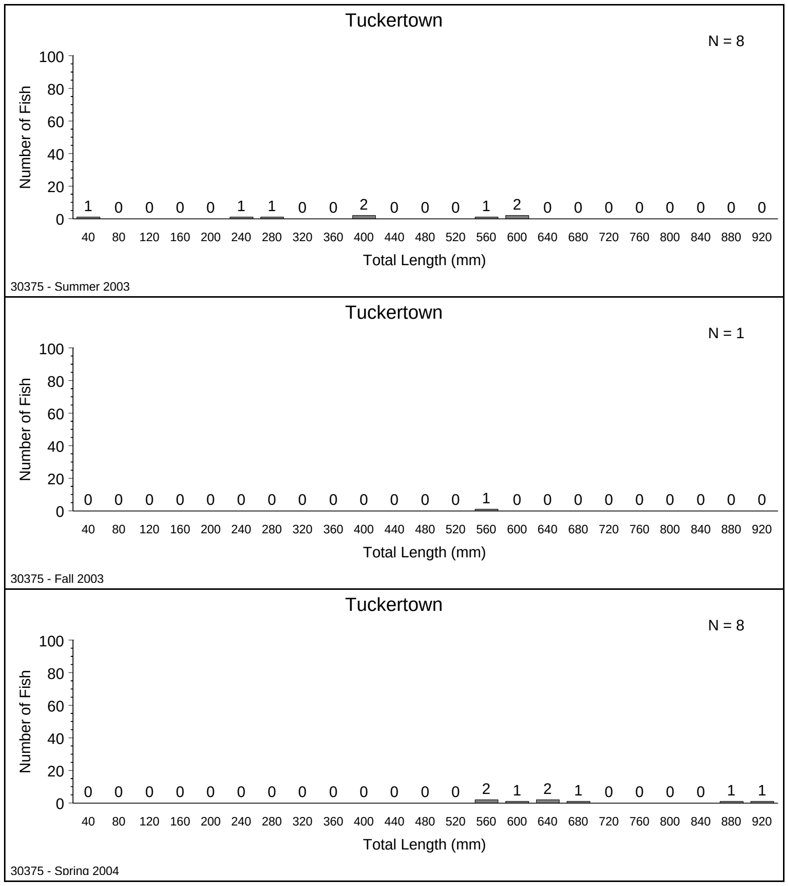

Figure 1-18. Length frequency distribution of blue catfish captured in Tuckertown tailwater by season. All gear types combined.

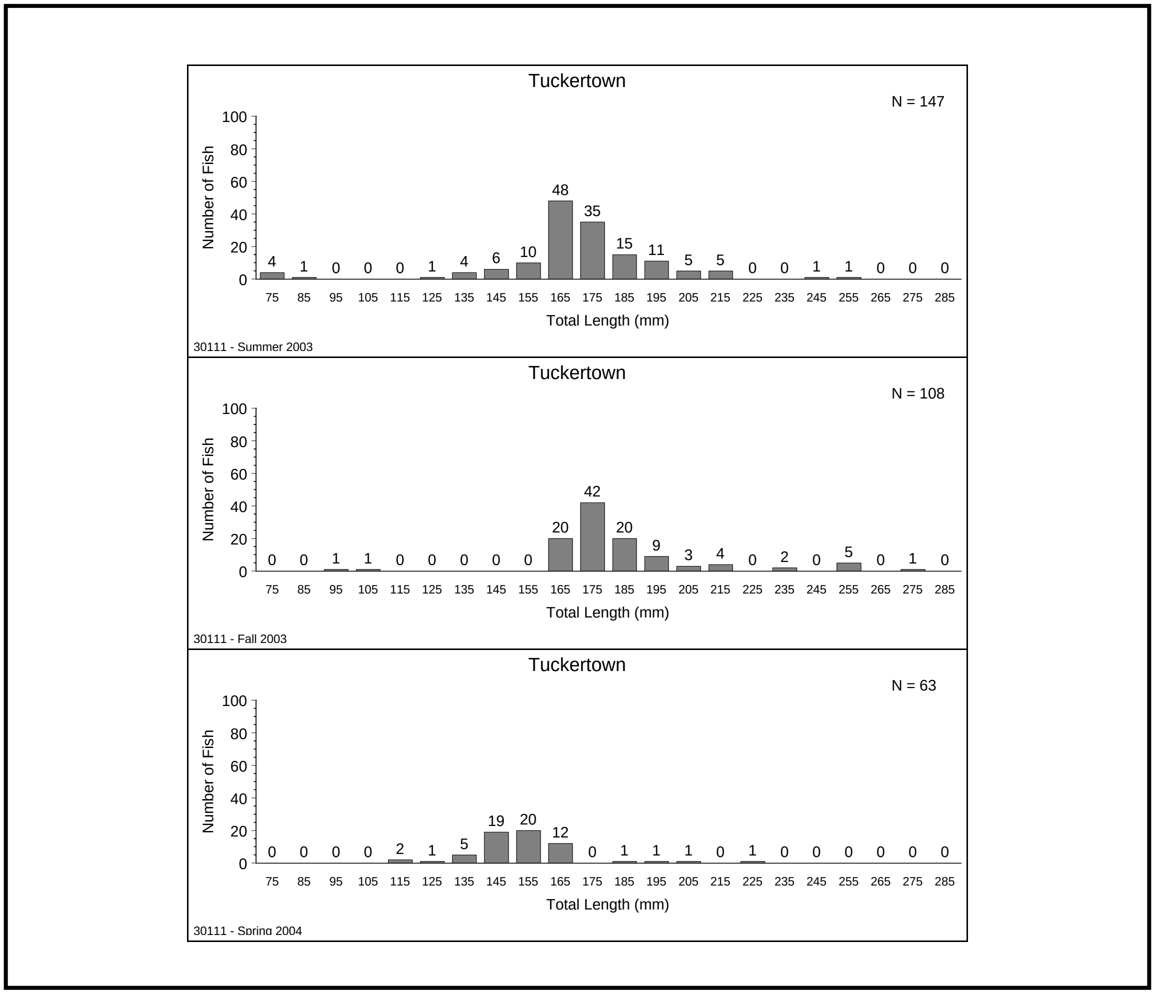

Figure 1-19. Length frequency distribution of white perch captured in Tuckertown tailwater by season. All gear types combined.

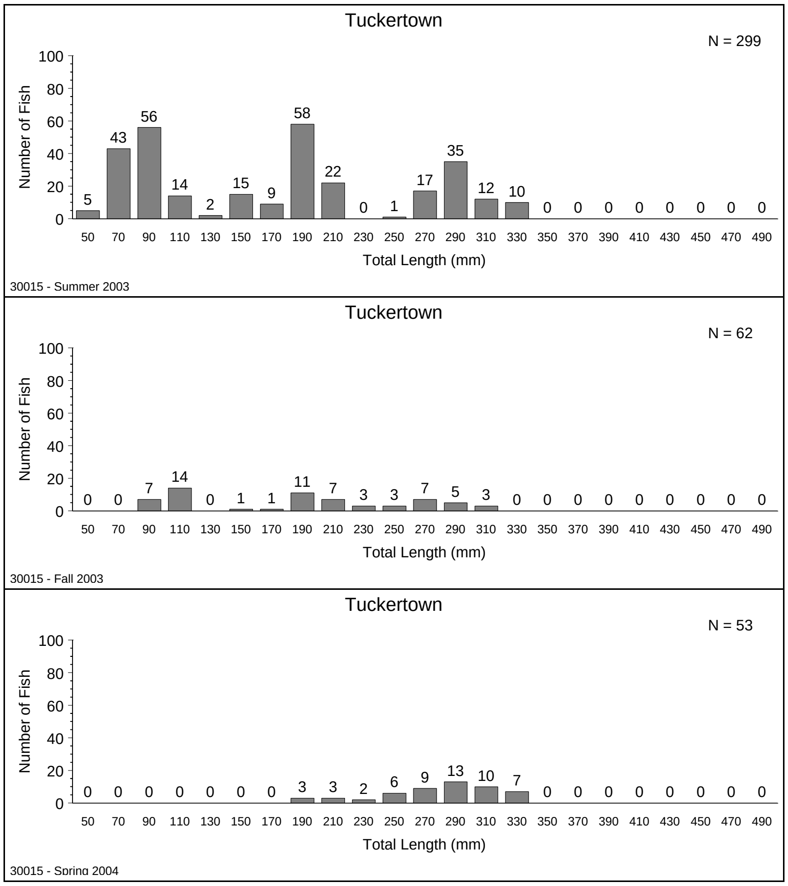

Figure 1-20. Length frequency distribution of gizzard shad captured in Tuckertown tailwater by season. All gear types combined.

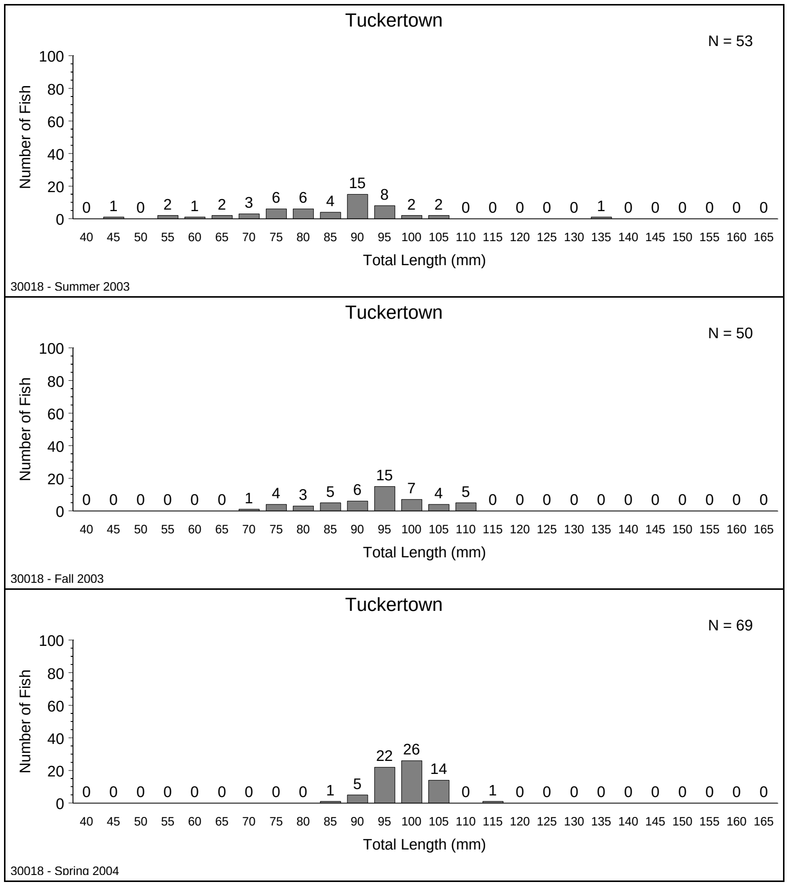

Figure 1-21. Length frequency distribution of threadfin shad captured in Tuckertown tailwater by season. All gear types combined.

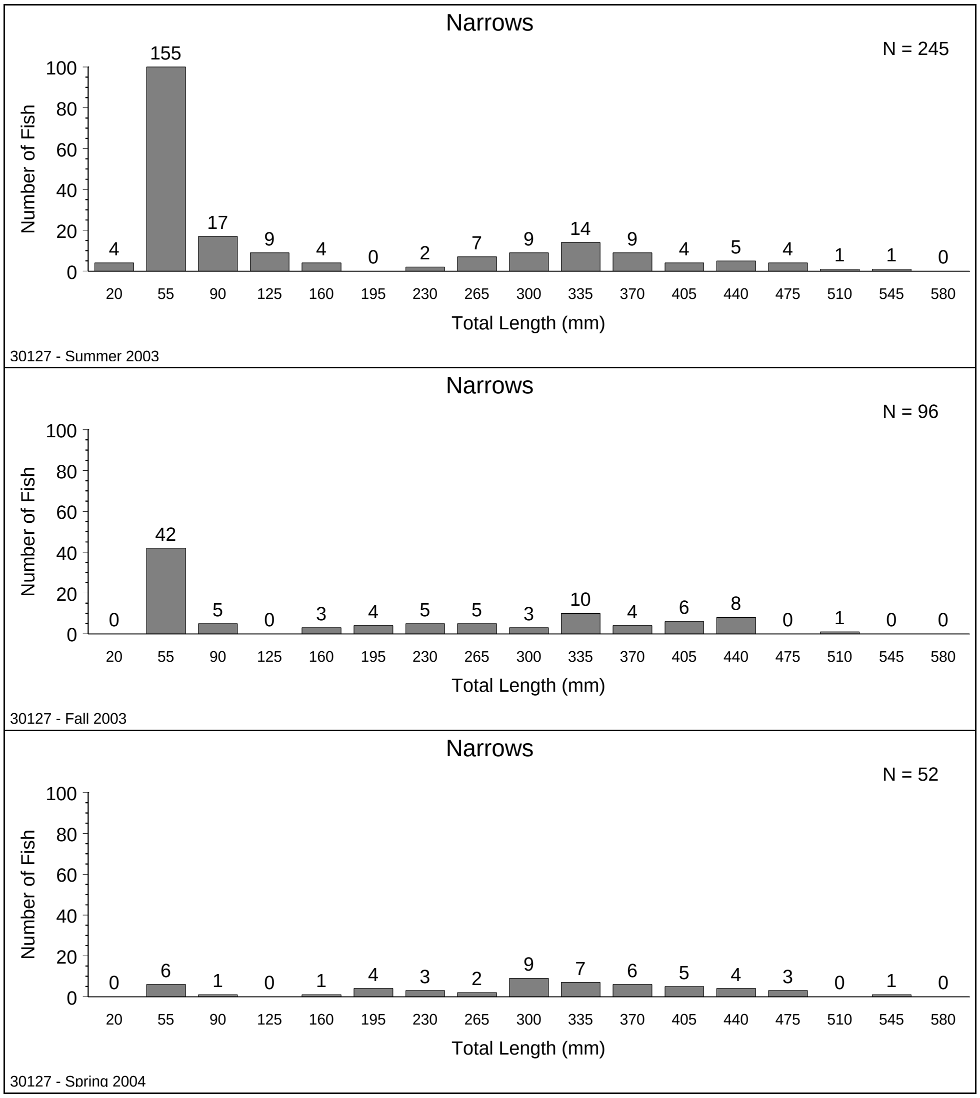

Figure 1-22. Length frequency distribution of largemouth bass captured in Narrows tailwater by season. All gear types combined.

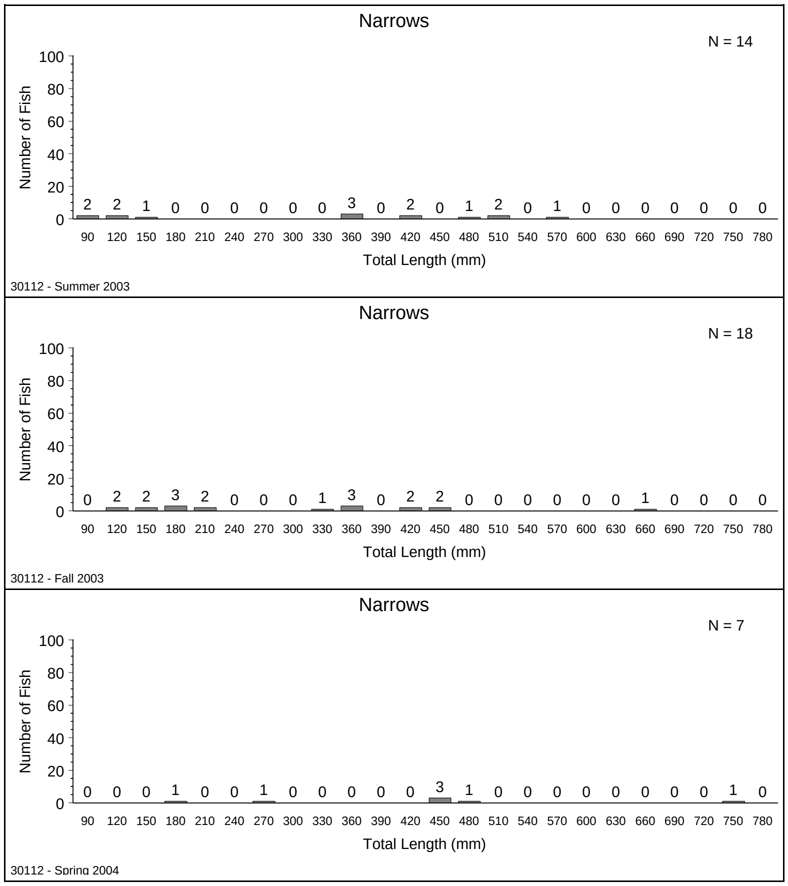

Figure 1-23. Length frequency distribution of striped bass captured in Narrows tailwater by season. All gear types combined.

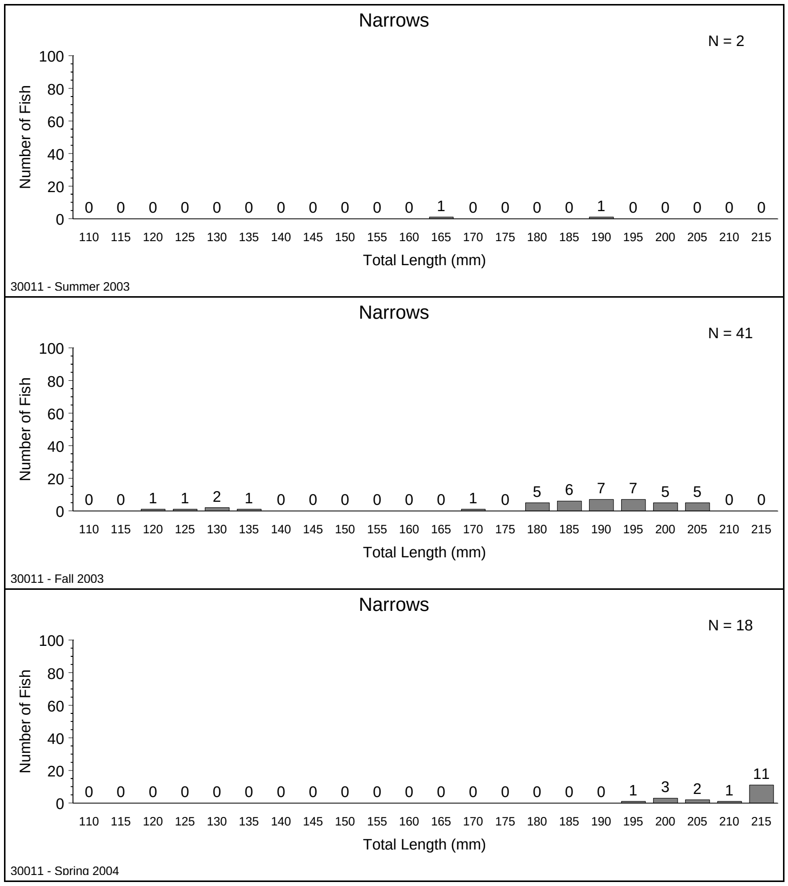

Figure 1-24. Length frequency distribution of blueback herring captured in Narrows tailwater by season. All gear types combined.

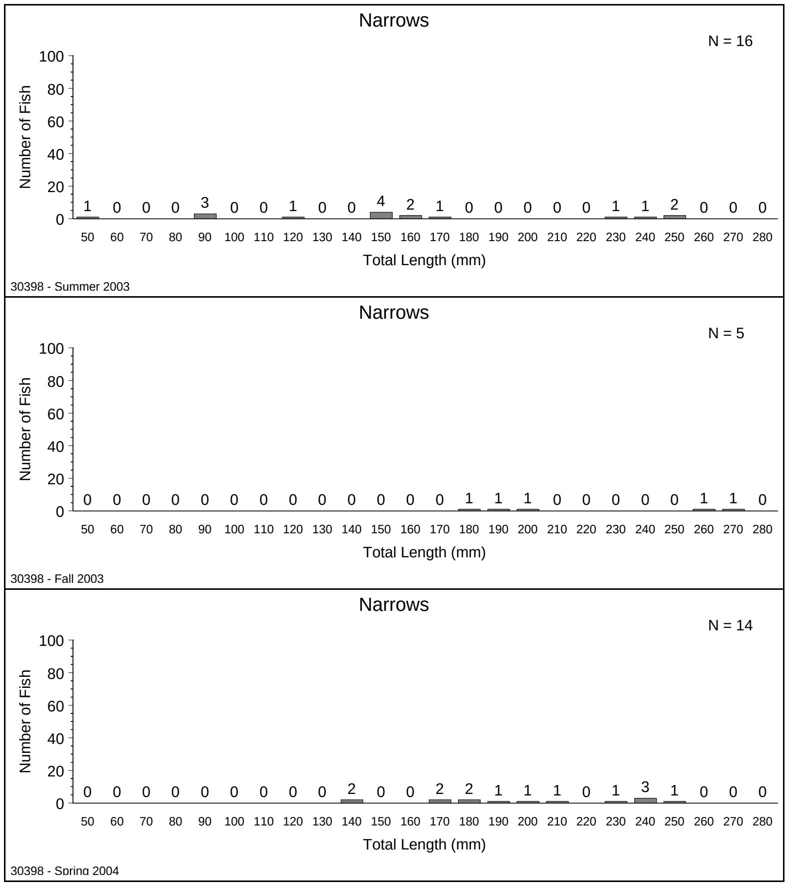

Figure 1-25. Length frequency distribution of redear sunfish captured in Narrows tailwater by season. All gear types combined.

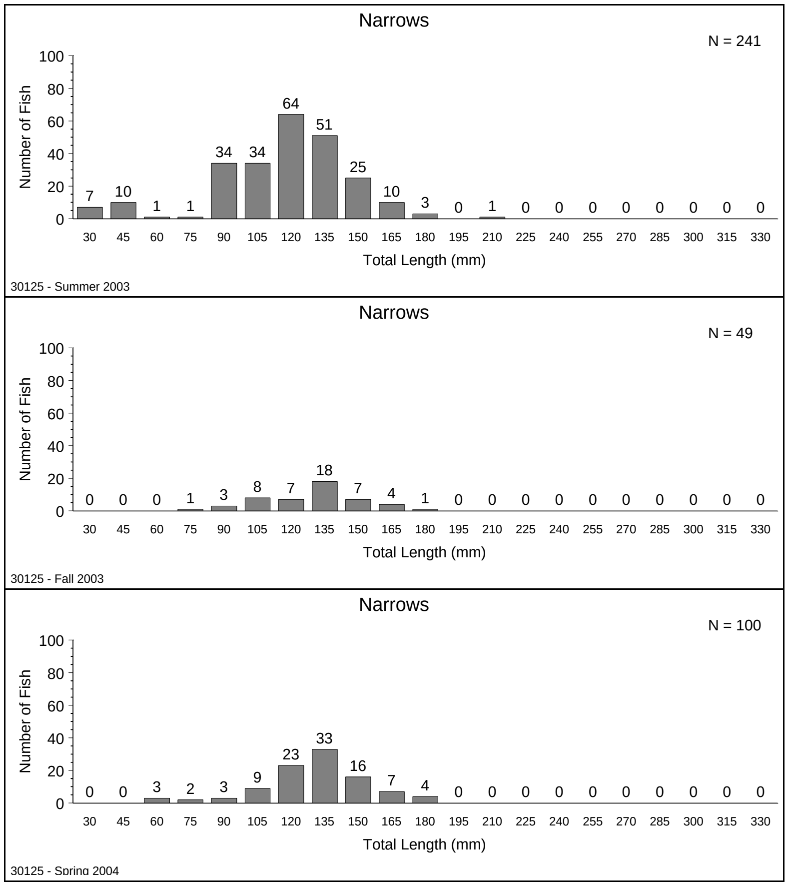

Figure 1-26. Length frequency distribution of bluegill captured in Narrows tailwater by season. All gear types combined.

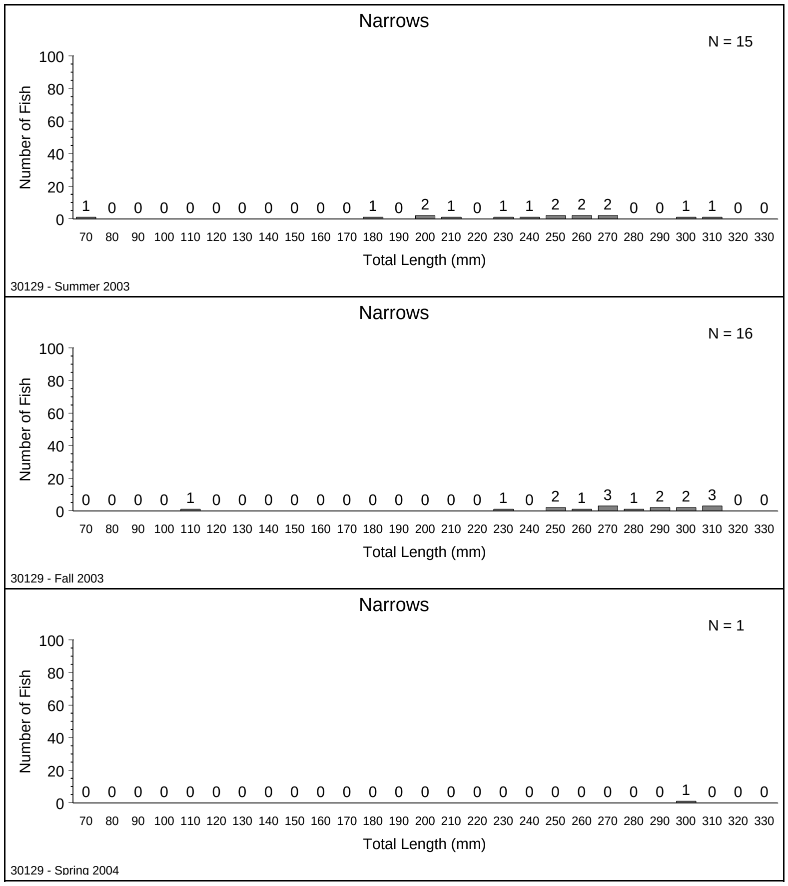

Figure 1-27. Length frequency distribution of black crappie captured in Narrows tailwater by season. All gear types combined.

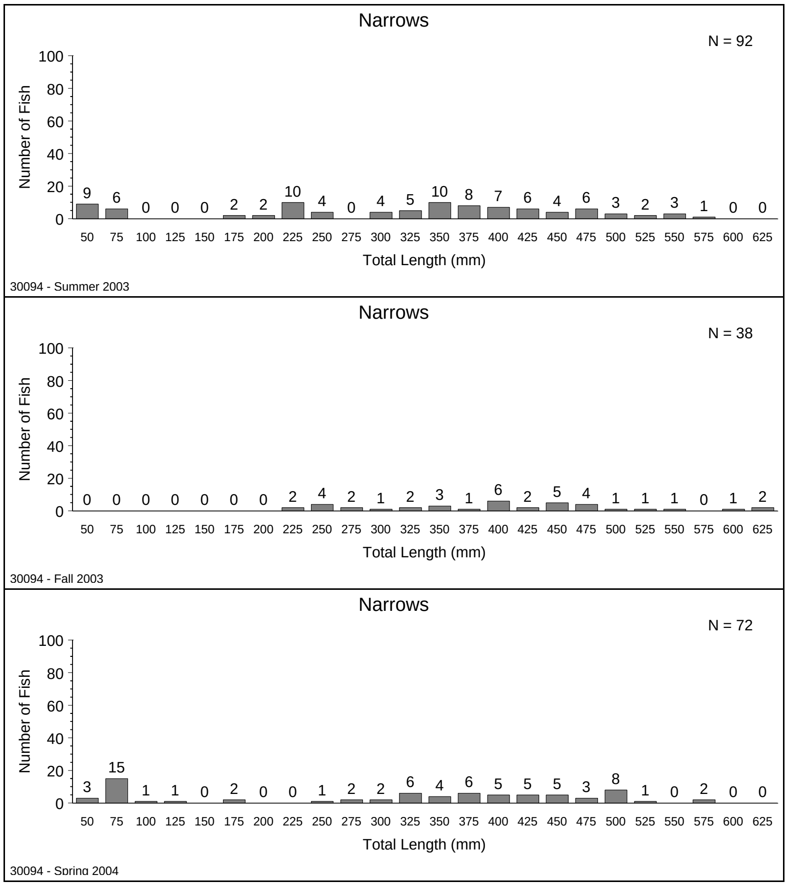

Figure 1-28. Length frequency distribution of channel catfish captured in Narrows tailwater by season. All gear types combined.

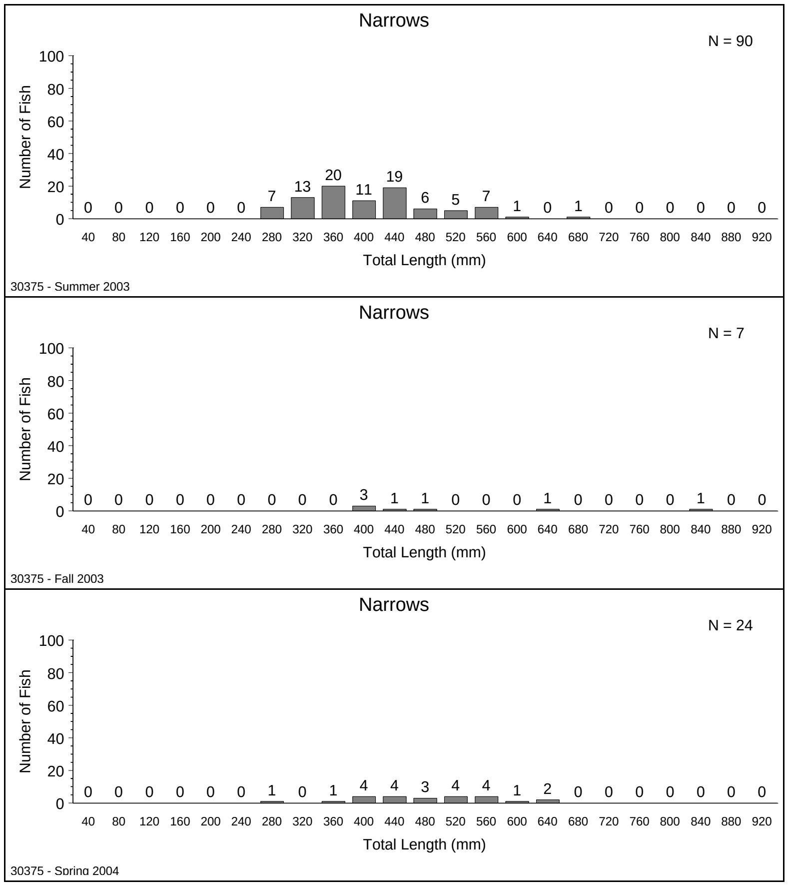

Figure 1-29. Length frequency distribution of blue catfish captured in Narrows tailwater by season. All gear types combined.

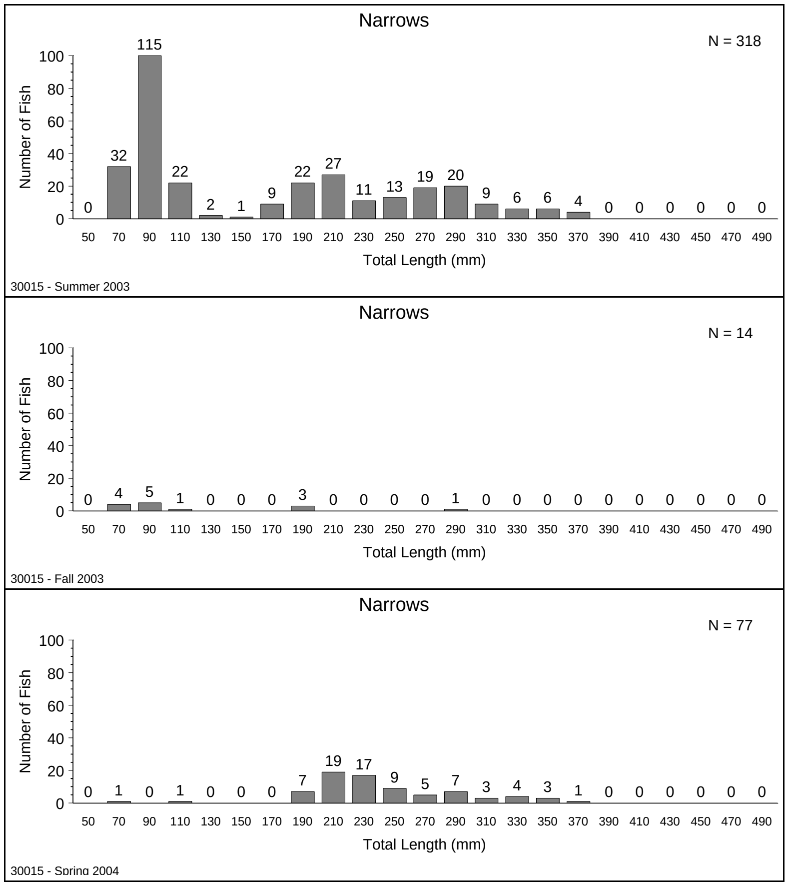

Figure 1-30. Length frequency distribution of gizzard shad captured in Narrows tailwater by season. All gear types combined.

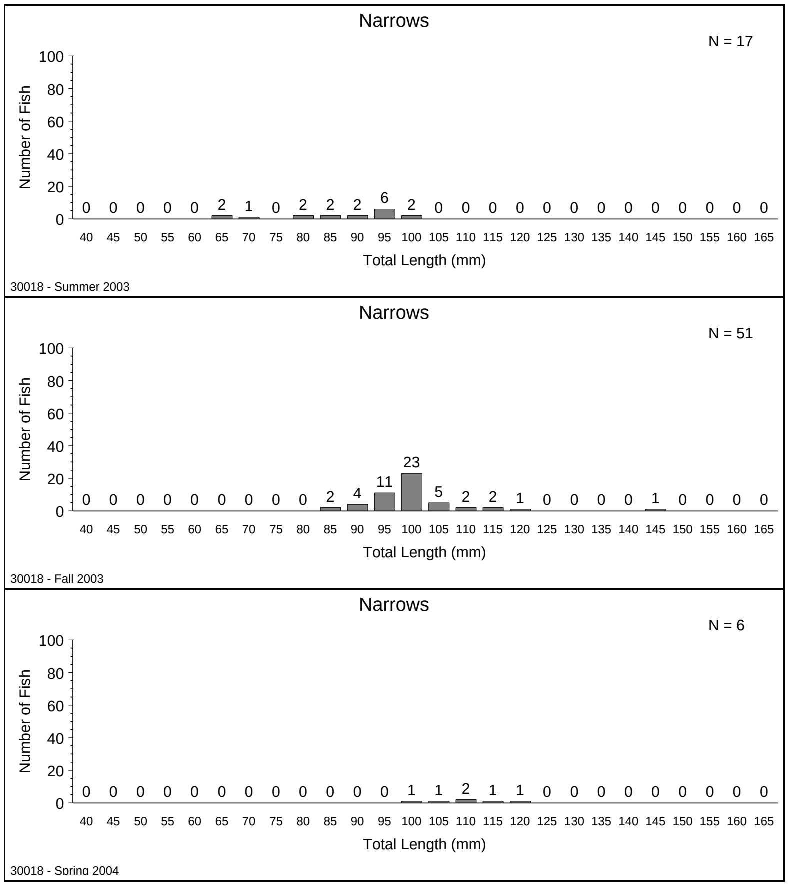

Figure 1-31. Length frequency distribution of threadfin shad captured in Narrows tailwater by season. All gear types combined.

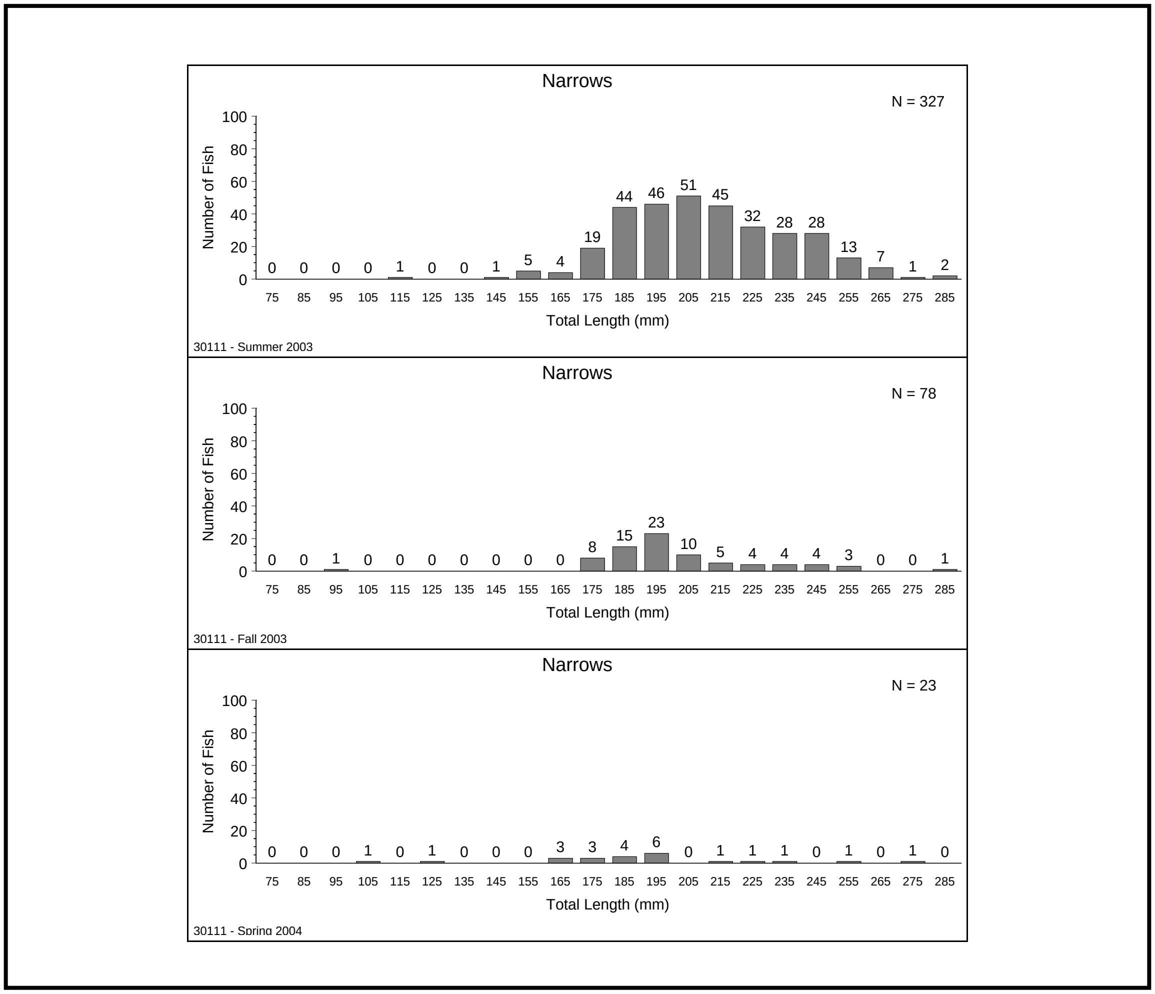

Figure 1-32. Length frequency distribution of white perch captured in Narrows tailwater by season. All gear types combined.

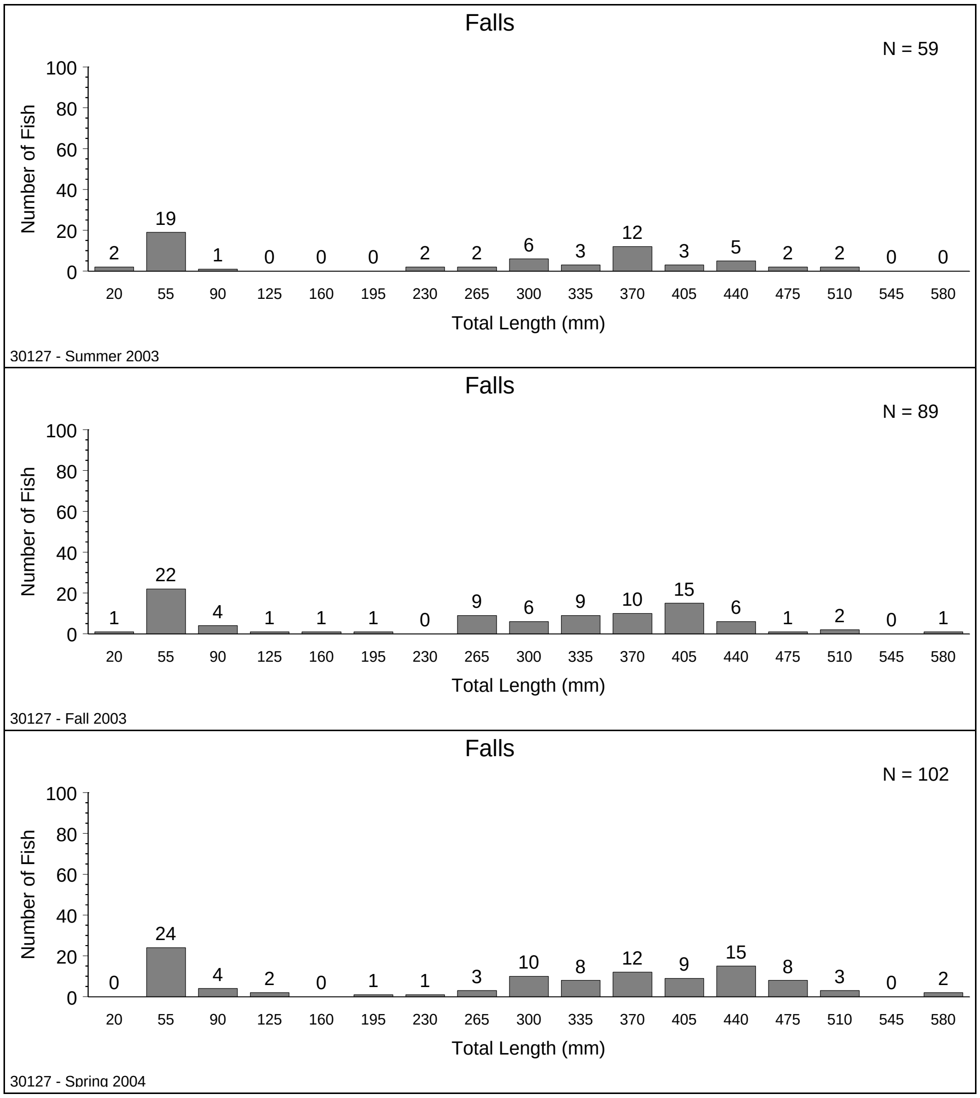

Figure 1-33. Length frequency distribution of largemouth bass captured in Falls tailwater by season. All gear types combined.

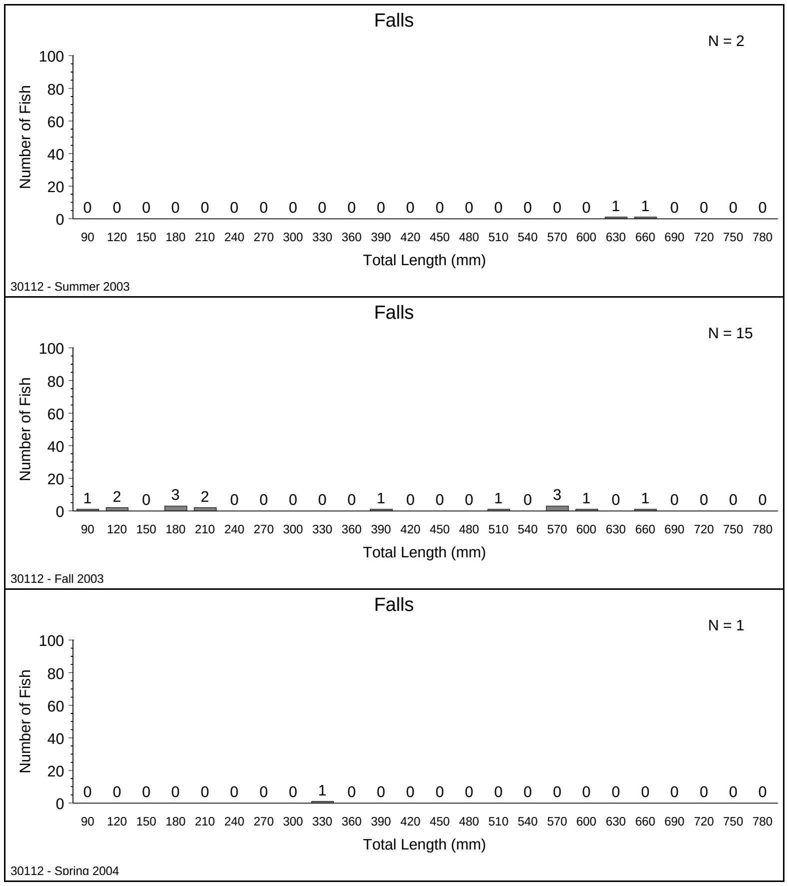

Figure 1-34. Length frequency distribution of striped bass captured in Falls tailwater by season. All gear types combined.

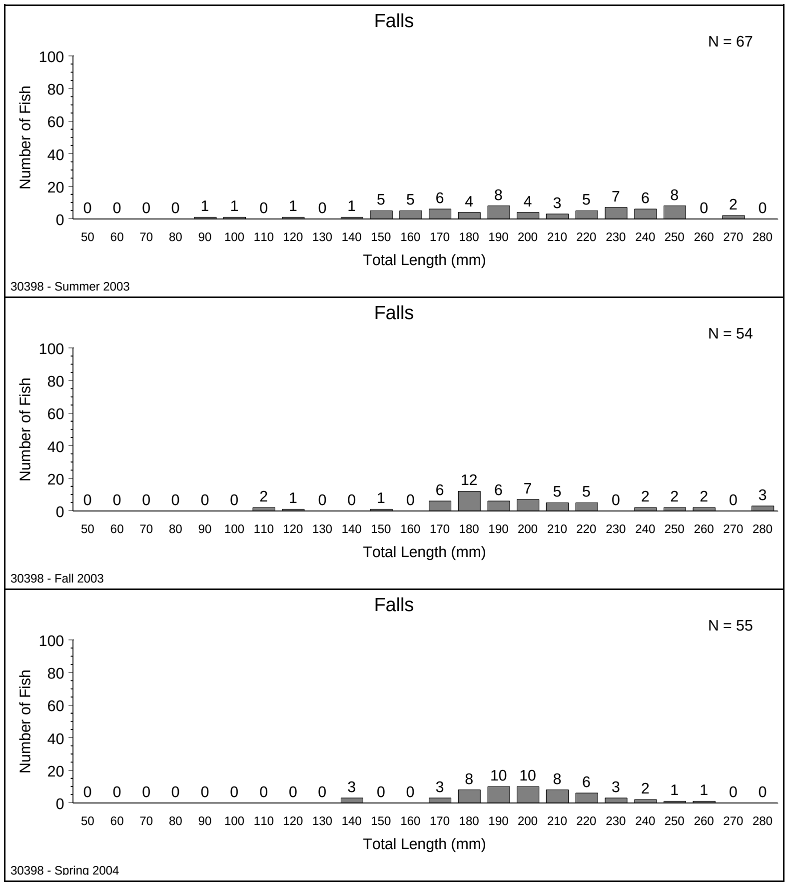

Figure 1-35. Length frequency distribution of redear sunfish captured in Falls tailwater by season. All gear types combined.

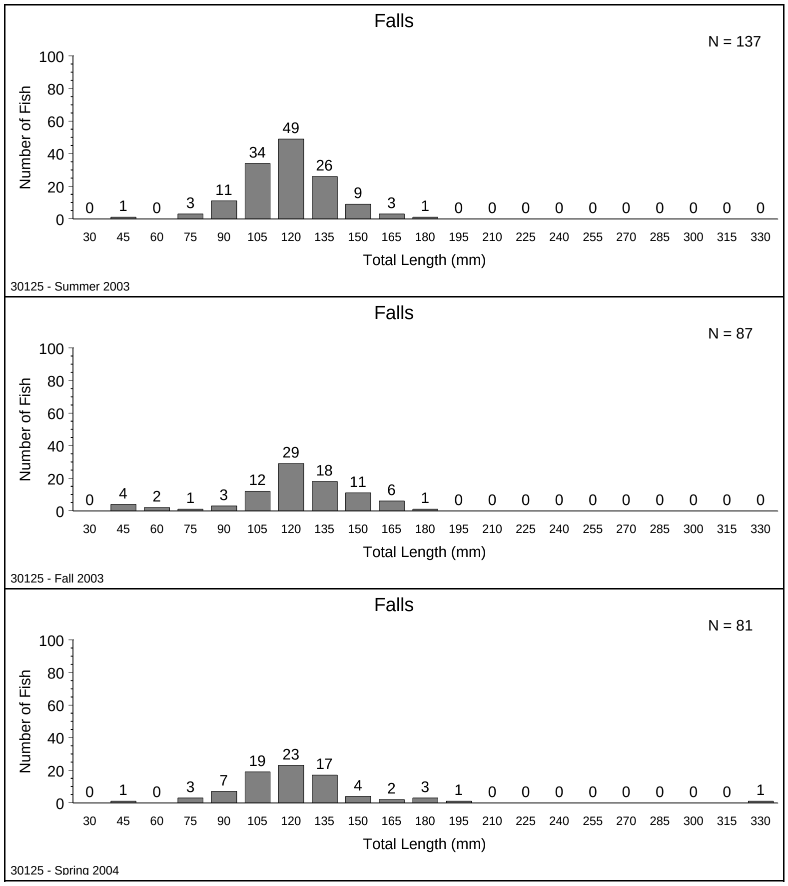

Figure 1-36. Length frequency distribution of bluegill captured in Falls tailwater by season. All gear types combined.

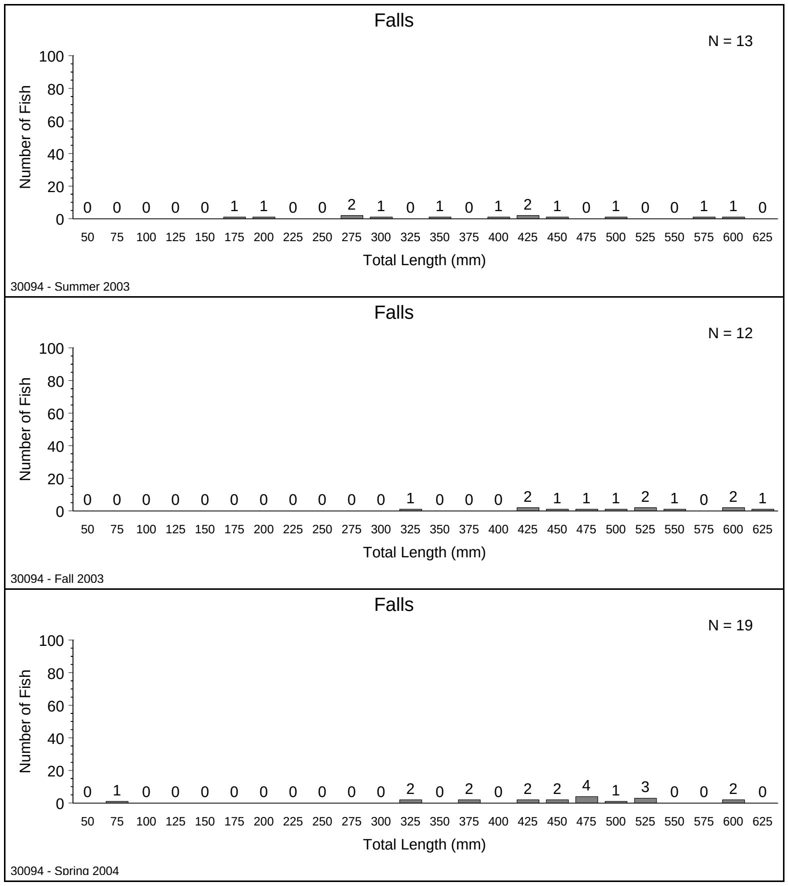

Figure 1-37. Length frequency distribution of channel catfish captured in Falls tailwater by season. All gear types combined.

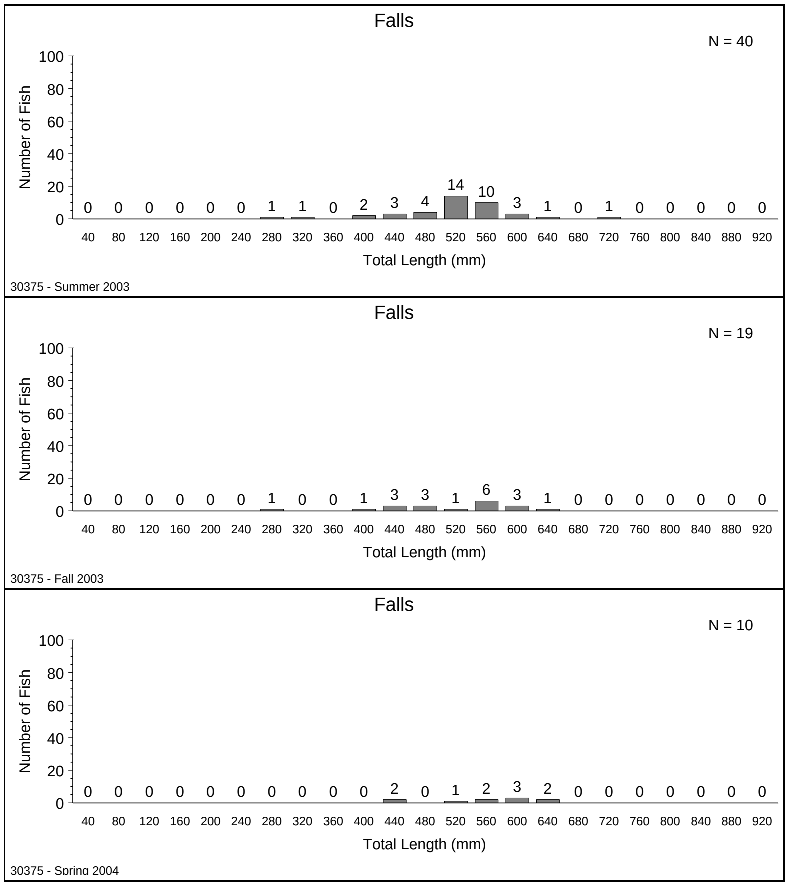

Figure 1-38. Length frequency distribution of blue catfish captured in Falls tailwater by season. All gear types combined.

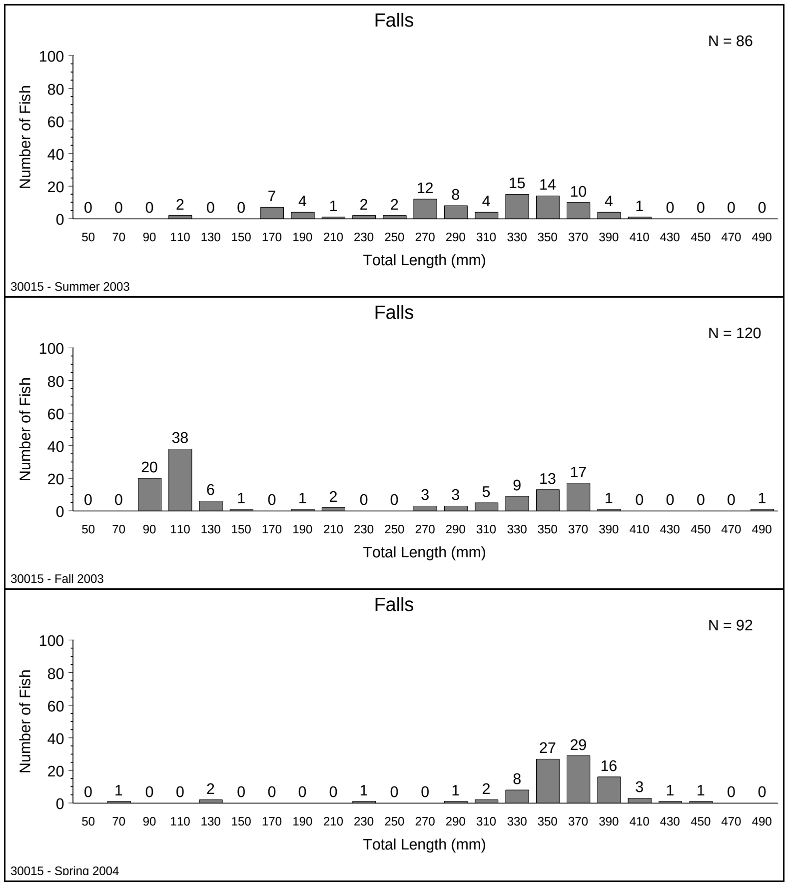

Figure 1-39. Length frequency distribution of gizzard shad captured in Falls tailwater by season. All gear types combined.

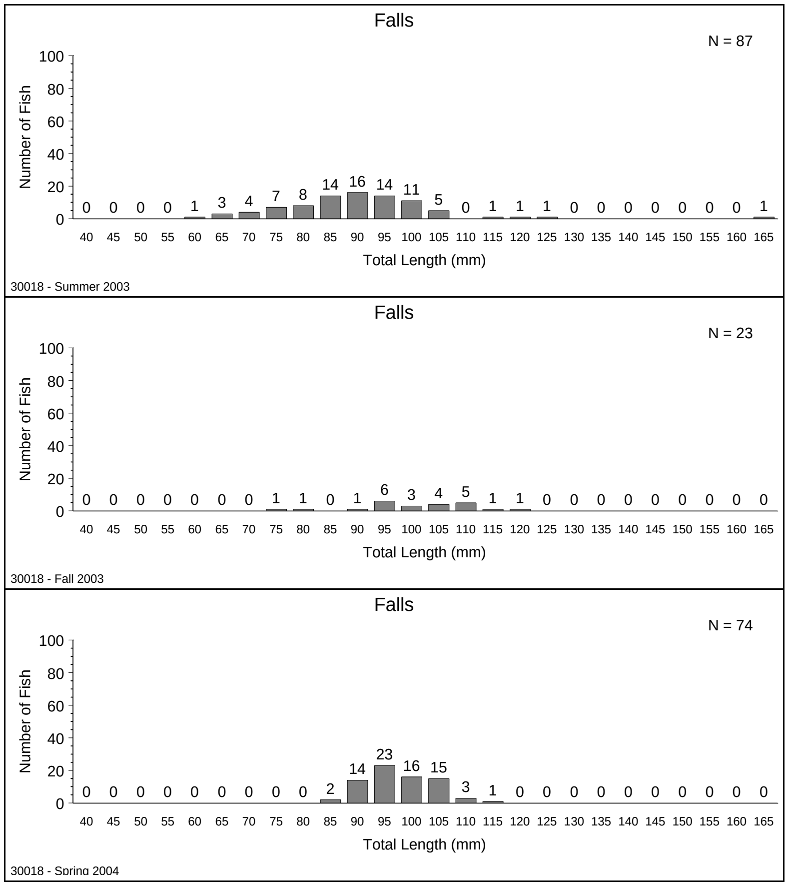

Figure 1-40. Length frequency distribution of threadfin shad captured in Falls tailwater by season. All gear types combined.

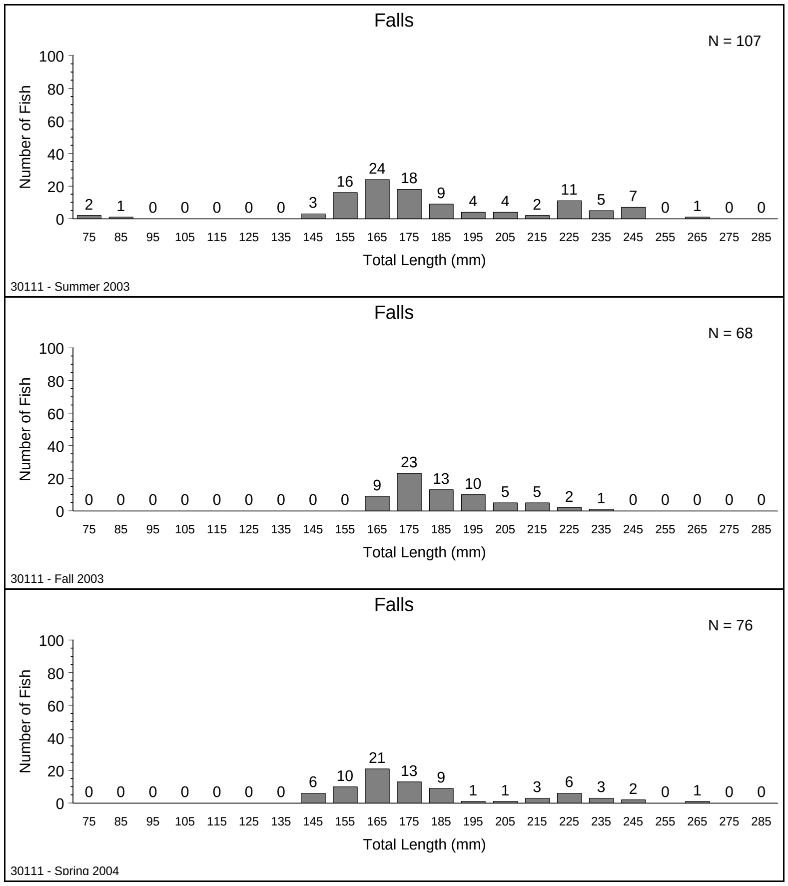

Figure 1-41. Length frequency distribution of white perch captured in Falls tailwater by season. All gear types combined.

APPENDIX 3

Narrows Tailwater Long Term Monitor and Plant Generation Data for 2 24-Hour Time Periods Investigating Fish Abundances and Diversity During Periods of Normal and Low Dissolved Oxygen Levels

August 31 – September 1, 2003

DATE	hour	MeanTemp	MeanDO	Total Generation (MWh)	Total Outflow (cfs)	Log (Mean DO)	Log (Total Outflow)
8/30/2003	23	26.495	5.285	44	3415	0.723044992	3.533390708
8/31/2003	0	26.34	5.94	4	350	0.773786445	2.544068044
8/31/2003	1	26.3175	6.0475	4	350	0.781575877	2.544068044
8/31/2003	2	26.3225	6.01	4	350	0.778874472	2.544068044
8/31/2003	3	26.34	6.0675	4	350	0.783009785	2.544068044
8/31/2003	4	26.34	6.105	4	350	0.785685668	2.544068044
8/31/2003	5	26.3275	6.065	4	350	0.782830805	2.544068044
8/31/2003	6	26.3	6.015	4	350	0.779235632	2.544068044
8/31/2003	7	26.545	4.14	8	855	0.617000341	2.931966115
8/31/2003	8	26.6975	3.07	44	3790	0.487138375	3.57863921
8/31/2003	9	26.7275	2.975	44	3790	0.47348697	3.57863921
8/31/2003	10	26.775	3.005	44	3790	0.477844476	3.57863921
8/31/2003	11	26.8125	3.19	44	3790	0.503790683	3.57863921
8/31/2003	12	26.795	2.2875	40	3620	0.359361103	3.558708571
8/31/2003	13	26.66	1.6375	0	0	0.214181309	0
8/31/2003	14	26.5575	1.705	0	0	0.231724383	0
8/31/2003	15	26.43	1.63	0	0	0.212187604	0
8/31/2003	16	26.3175	2.0625	0	0	0.314393957	0
8/31/2003	17	26.3675	5.2325	1	350	0.718709237	2.544068044
8/31/2003	18	26.505	6.2375	2	350	0.795010559	2.544068044
8/31/2003	19	26.525	6.4	4	350	0.806179974	2.544068044
8/31/2003	20	26.485	6.48	5	620	0.811575006	2.792391689
8/31/2003	21	26.435	6.47	4	350	0.810904281	2.544068044
8/31/2003	22	26.375	6.565	4	350	0.81723473	2.544068044
8/31/2003	23	26.37	6.4	4	350	0.806179974	2.544068044
9/1/2003	0	26.41	6.24	4	350	0.79518459	2.544068044
9/1/2003	1	26.4325	6.075	3	350	0.783546282	2.544068044
9/1/2003	2	26.4225	6.1675	2	350	0.790109158	2.544068044
9/1/2003	3	26.4525	6.245	2	350	0.795532443	2.544068044
9/1/2003	4	26.4775	6.265	2	350	0.796921075	2.544068044
9/1/2003	5	26.49	6.2525	2	350	0.7960537	2.544068044
9/1/2003	6	26.495	6.2875	2	350	0.798477998	2.544068044
9/1/2003	7	26.5025	6.0325	2	350	0.780497331	2.544068044
9/1/2003	8	26.4825	6.3025	2	350	0.799512854	2.544068044
9/1/2003	9	26.4825	6.28	2	350	0.797959644	2.544068044
9/1/2003	10	26.46	6.1525	3	350	0.789051622	2.544068044
9/1/2003	11	26.4425	6.315	2	350	0.800373355	2.544068044
9/1/2003	12	26.415	6.2525	2	350	0.7960537	2.544068044
9/1/2003	13	26.585	6.3175	2	350	0.800545251	2.544068044
9/1/2003	14	26.69	4.4375	37	2955	0.647138366	3.470557485
9/1/2003	15	26.6725	3.73	88	4800	0.571708832	3.681241237
9/1/2003	16	26.69	3.7925	89	4820	0.578925589	3.683047038
9/1/2003	17	26.6625	3.6325	88	4800	0.560205623	3.681241237
9/1/2003	18	26.655	3.5325	89	4840	0.548082171	3.684845362
9/1/2003	19	26.6025	3.355	88	4800	0.525692525	3.681241237
9/1/2003	20	26.54	3.2025	89	4840	0.505489138	3.684845362
9/1/2003	21	26.545	3.1675	88	4800	0.500716624	3.681241237
9/1/2003	22	26.5525	2.975	83	6855	0.47348697	3.836007459
9/1/2003	23	26.5625	3.315	82	6715	0.520483533	3.827046017

November 7 to 8, 2003

DATE	MeanTemp	MeanDO	MeanPctSat	hour	Total Generation ((MWh)	Total Outflow ((cfs)	Log DO	Log CFS
11/7/2003	17.96	7.4175	0.788003173	0	1	350	0.870258	2.544068
11/7/2003	17.8525	8.48	0.898997028	1	3	350	0.928396	2.544068
11/7/2003	17.8175	8.61	0.912116231	2	3	350	0.935003	2.544068
11/7/2003	17.835	8.665	0.918277104	3	3	350	0.937769	2.544068
11/7/2003	17.925	8.635	0.916801514	4	3	350	0.936262	2.544068
11/7/2003	18.0075	8.5	0.904006317	5	3	350	0.929419	2.544068
11/7/2003	18.0275	8.57	0.911826432	6	3	350	0.932981	2.544068
11/7/2003	18.0775	7.5725	0.806466872	7	3	700	0.879239	2.845098
11/7/2003	18.1075	6.4775	0.690326279	8	67	5110	0.811407	3.708421
11/7/2003	18.1175	6.5925	0.702726163	9	70	5310	0.81905	3.725095
11/7/2003	18.1225	6.5175	0.694802914	10	71	5375	0.814081	3.730378
11/7/2003	18.1775	6.6025	0.704662536	11	70	5310	0.819708	3.725095
11/7/2003	18.245	6.5925	0.704571787	12	70	5310	0.81905	3.725095
11/7/2003	18.3	6.6	0.706168754	13	70	5310	0.819544	3.725095
11/7/2003	18.36	6.6125	0.708373893	14	70	5310	0.820366	3.725095
11/7/2003	18.3925	6.71	0.719299258	15	70	5310	0.826723	3.725095
11/7/2003	18.375	6.6175	0.709130512	16	68	5170	0.820694	3.713491
11/7/2003	18.365	6.6975	0.717558286	17	68	5170	0.825913	3.713491
11/7/2003	18.3575	6.54	0.700573947	18	69	5250	0.815578	3.720159
11/7/2003	18.36	6.69	0.716678023	19	68	5170	0.825426	3.713491
11/7/2003	18.36	6.745	0.722571534	20	68	5170	0.828982	3.713491
11/7/2003	18.3525	6.76	0.724066242	21	68	5170	0.829947	3.713491
11/7/2003	18.375	6.845	0.733509268	22	68	5170	0.835373	3.713491
11/7/2003	18.325	7.595	0.81302076	23	65	4985	0.880528	3.697665
11/8/2003	18.2225	8.5475	0.913081238	0	2	350	0.931839	2.544068
11/8/2003	18.155	8.6425	0.921952011	1	3	350	0.936639	2.544068
11/8/2003	18.11	8.7025	0.927497321	2	3	350	0.939644	2.544068
11/8/2003	18.0875	8.8	0.93745553	3	3	350	0.944483	2.544068
11/8/2003	18.0875	8.835	0.941183524	4	4	350	0.946207	2.544068
11/8/2003	18.155	8.8325	0.942230086	5	3	350	0.946084	2.544068
11/8/2003	18.2175	8.945	0.955454653	6	3	350	0.95158	2.544068
11/8/2003	18.2425	8.29	0.885953435	7	2	350	0.918555	2.544068
11/8/2003	18.08	7.2825	0.775744608	8	0	0	0.86228	0
11/8/2003	17.9675	5.7	0.605727921	9	0	0	0.755875	0
11/8/2003	17.905	5.355	0.568320189	10	0	0	0.728759	0
11/8/2003	17.8975	4.1575	0.441160952	11	0	0	0.618832	0
11/8/2003	17.9625	3.4125	0.362579441	12	0	0	0.533073	0
11/8/2003	18.0675	3.2325	0.344205146	13	0	0	0.509539	0
11/8/2003	18.1575	3.27	0.348858889	14	0	0	0.514548	0
11/8/2003	18.2125	2.8675	0.306255861	15	0	0	0.457503	0
11/8/2003	18.1175	6.055	0.645269982	16	0	0	0.782114	0
11/8/2003	18.1125	8.1775	0.871588809	17	3	350	0.912621	2.544068
11/8/2003	18.0775	6.735	0.717339182	18	0	0	0.828338	0
11/8/2003	17.8925	5.97	0.633443383	19	0	0	0.775974	0
11/8/2003	17.8175	5.0525	0.535259303	20	0	0	0.703506	0
11/8/2003	17.785	3.97	0.420292286	21	0	0	0.598791	0
11/8/2003	17.7425	3.98	0.420979342	22	0	0	0.599883	0
11/8/2003	17.6775	3.5725	0.377365609	23	0	0	0.552972	0

APPENDIX 4

Benthic Macroinvertebrate Survey, Yadkin River, September 2003–June 2004 for Normandeau Associates, Inc. by Pennington and Associates, Inc.

APPENDIX 5

Percent Composition of All Species Captured in the Four Project Tailwaters by Season

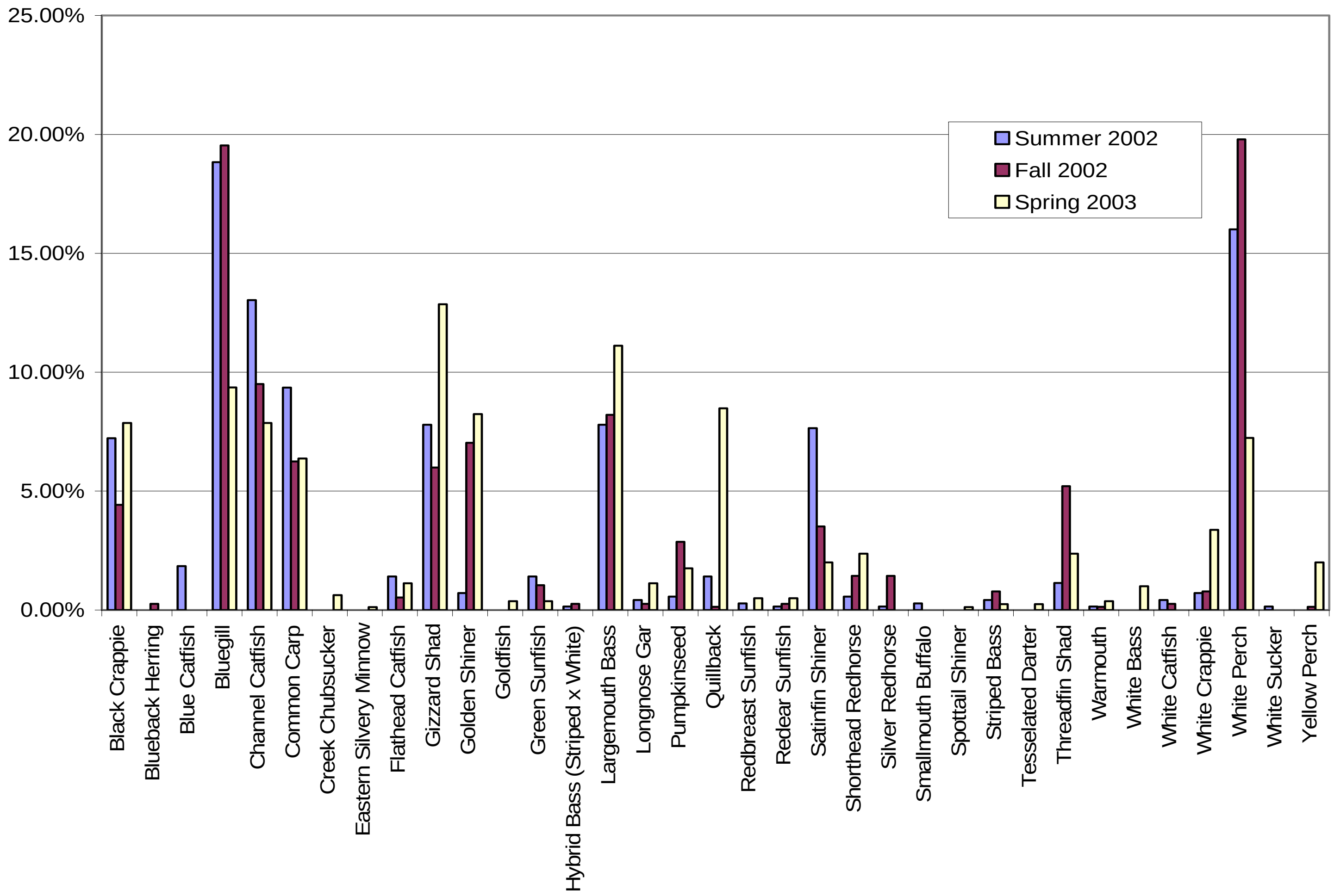

Figure 5.1 Percent Composition of Fish Species Captured in the High Rock Tailwater During Three Sampling Periods, 2002-2003. (All Sampling Methods Combined).

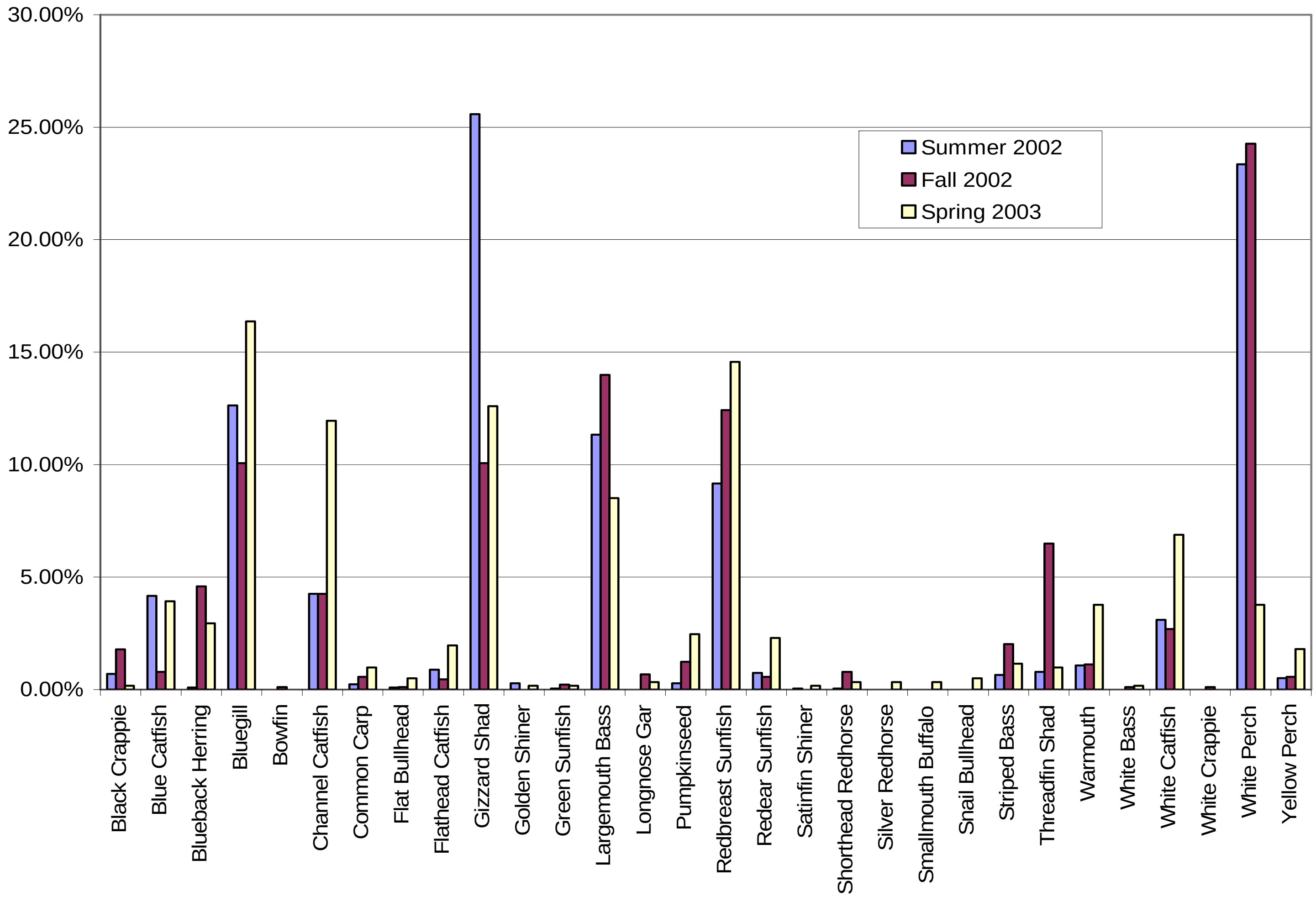

Figure 5.2 Percent Composition of Fish Species Captured in the Narrows Tailwater During Three Sampling Periods, 2002-2003. (All Sampling Methods Combined).

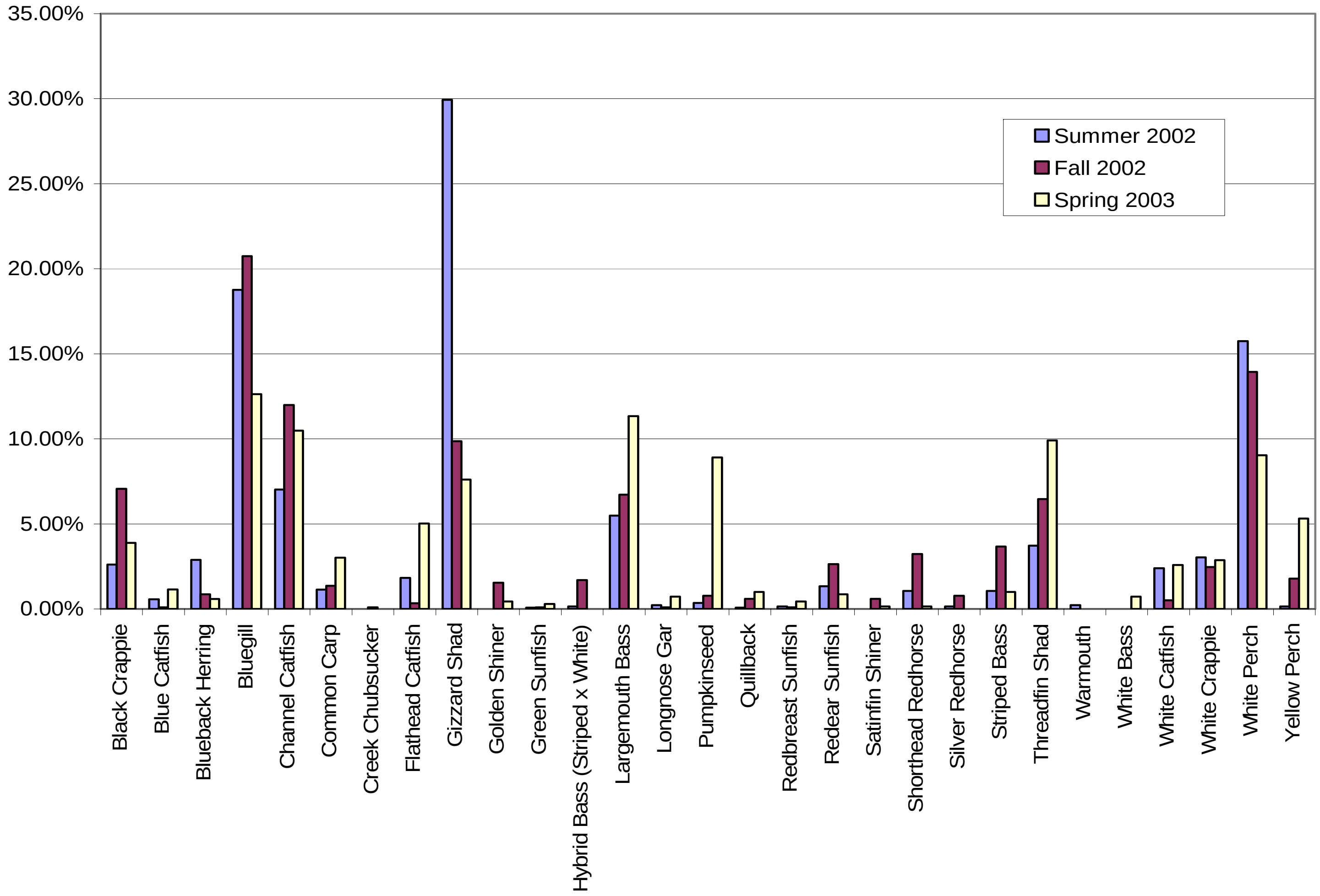

Figure 5.3 Percent Composition of Fish Species Captured in the Tuckertown Tailwater During Three Sampling Periods, 2002-2003. (All Sampling Methods Combined).

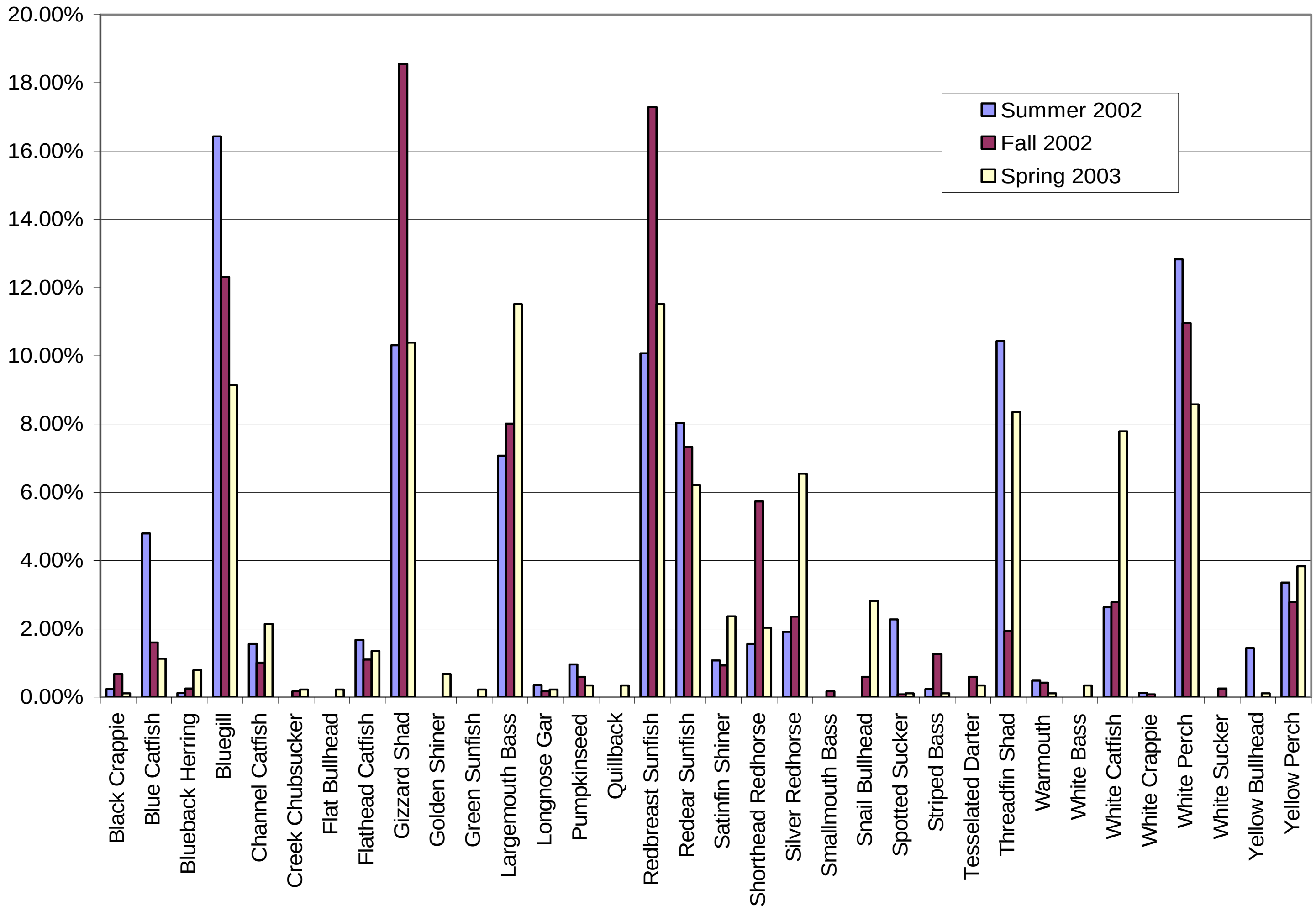

Figure 5.4 Percent Composition of Fish Species Captured in the Falls Tailwater During Three Sampling Periods, 2002-2003. (All Sampling Methods Combined).

APPENDIX 6

Comment Summary

Copies of the Yadkin Tailwater Fish and Aquatic Biota Assessment Draft Report were distributed to the Fish and Aquatics Advisory Group (IAG) in March, 2005. The Draft Report was then summarized and discussed at a Fish and Aquatics IAG meeting held April 5, 2005. Additionally, the IAG was given until May, 2005 to submit additional comments. Table 1 below is a summary of the comments received and responses to the comments.

Source of Comment	Comment	Response
Chris Goudreau, NC Wildlife Resources Commission, IAG meeting 4/5/05	Questioned if there was a typographical error on page 43, p=0.5017.	The noted error occurred in the powerpoint presentation given at the 4/5/05 IAG meeting. The correct p-value was provided in the draft report and indicates a non-significant relationship for the summer event in Narrows tailwater (Section 5.6).
Chris Goudreau, NC Wildlife Resources Commission, IAG meeting 4/5/05	Asked what type of statistical test was used in determining the differences in the number of species observed in the tailwaters during low and normal dissolved oxygen periods.	A one-way ANOVA (analysis of variance) test was used to detect differences in the number of species between low and normal DO periods. This clarification has been made in Section 5.6 of the final report.
Chris Goudreau, NC Wildlife Resources Commission, IAG meeting 4/5/05	Asked that Section 5.6 of the final report state that fish activity in the tailwater definitely slows during times of low DO.	In section 5.6 of the final report, NAI has proposed two possible explanations for lower fish numbers captured during the periods of low DO. Fish may have either slowed their movements down and avoided capture or fish may have moved out of the tailwater area in response to the lower DO conditions.
Todd Ewing, NC Wildlife Resources Commission, IAG meeting 4/5/05	Asked that graphs showing the percent composition of each species for each tailwater and sampling season be included in the final report.	Appendix 5 was added to the final report. It provides a graph for each tailwater with the percent composition of each species for each sampling period.
Chris Goudreau, NC Wildlife Resources Commission, 4/5/05	Noted that lack of winter tailwater sampling event may have caused NAI to miss the worst conditions for potential stranding below Tuckertown. Upon hearing that there is no winter drawdown at Narrows, Chris recommended that the final report make that clear and also that the report should note that if the operation of Narrows changed and more of a	Since there is no winter drawdown at Narrows reservoir, it was not necessary to conduct observations of tailwater stranding in the winter. The conditions under which stranding below Tuckertown were observed for this study are reflective of the "worst case" under existing project operations. However, if the operation of Narrows were changed to allow

	drawdown were allowed, there could be fish stranding below Tuckertown.	for a greater drawdown of that reservoir, it is possible that the potential for stranding below Tuckertown may increase. Section 5.7 of the Final Report has been modified to reflect this potential.
Darlene Kucken, NC Division of Water Quality, email dated 4/29/05	NCDWQ raised several questions regarding the macroinvertebrate analysis in the draft report and the “Poor” water quality rating for the Spring period.	A paragraph was added to Section 6.4 of the Final Report that discusses the potential limitations with using water quality indices developed for natural in a regulated tailwater environment.
Todd Ewing, NC Wildlife Resources Commission, IAG meeting 4/5/05	Recommended that the final report not use the qualitative descriptions of tailwater water quality based on the NCIBI.	See response to similar comment above.
Darlene Kucken, NC Division of Water Quality, email dated 4/29/05	Would like the final report to address the impacts/abundances of exotic fish species within the tailwaters.	NAI contacted NCDWQ about this issue and at the time the Final report was prepared was awaiting a reply from NCDWQ staff as to what exotic species are of interest.