FISHERIES REPORT

Warmwater Streams and Rivers

Tennessee Wildlife Resources Agency--Region IV

2011

FISHERIES REPORT
REPORT NO. 12-03
WARMWATER STREAM FISHERIES REPORT
REGION IV
2011

Prepared by

Bart D. Carter
Rick D. Bivens
Carl E. Williams
and
James W. Habera

TENNESSEE WILDLIFE RESOURCES AGENCY

Development of this report was financed in part by funds from Federal Aid in Fish and Wildlife Restoration (TWRA Project 4350)
(Public Law 91-503) as documented in
Federal Aid Project FW-6.

Cover: Cumberland arrow darter (*Etheostoma sagitta sagitta*) collected from No Business Branch, Campbell County.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHODS	2
Tennessee River System:	
Clinch River	9
Little River	18
Clinch River System:	
Titus Creek	33
Powell River	38
French Broad River System:	
Nolichucky River	45
Pigeon River	52
North Cumberland Habitat Conservation Plan	58
New River System:	
Montgomery Fork	59
Straight Fork	61
Jake Branch	63
Clear Fork Cumberland River System:	
Hudson Branch	65
Terry Creek	67
Stinking Creek	69
Unnamed Tributary to Big Branch	71
Louse Creek	74
SUMMARY	76
LITERATURE CITED	79

INTRODUCTION

The fish fauna of Tennessee is the most diverse in the United States, with approximately 307 species of native fish and about 30 to 33 introduced species (Etnier and Starnes 1993). Streams in Region IV, except for a few in Anderson, Campbell, Claiborne, and Scott counties (Cumberland River System streams) are in the Ridge and Valley and Blue Ridge physiographic provinces of the upper Tennessee River drainage basin. The main river systems in the region are the Clinch, Powell, Little Tennessee, mainstream Tennessee River, French Broad, Nolichucky, Holston and Big South Fork Cumberland River.

Streams and rivers across the state are of considerable value as they provide a variety of recreational opportunities. These include fishing, canoeing, swimming, and other riverine activities that are unmatched by other aquatic environments. Streams and rivers are also utilized as water sources both commercially and domestically. The management and protection of this resource is recognized by Tennessee Wildlife Resources Agency (TWRA) and has been put forth in the Strategic Plan (TWRA 2006) as a primary goal.

The main purpose of this project is to collect baseline information on game and non-game fish and macroinvertebrate populations in the region. This baseline data is necessary to update and expand our Tennessee Aquatic Database System (TADS) and aid in the management of fisheries resources in the region.

Efforts to survey the region's streams have led to many cooperative efforts with other state and federal agencies. These have included the Tennessee Department of Environment and Conservation (TDEC), Tennessee Valley Authority (TVA), U.S. Forest Service (USFS), Oak Ridge National Laboratory (ORNL), and the National Park Service (NPS).

The information gathered for this project is presented in this report as river and stream accounts. These accounts include an introduction describing the general characteristics of the survey site, a study area and methods section summarizing site location and sampling procedures, a results section outlining the findings of the survey(s), and a discussion section, which allows us to summarize our field observations and make management recommendations.

METHODS

The streams to be sampled and the methods required are outlined in TWRA field request No. 04-11. Five rivers and nine streams were sampled and are included in this report. Surveys were conducted from April to August 2011. A total of 48 (IBI, CPUE) fish and eight benthic macroinvertebrate samples were collected.

SAMPLE SITE SELECTION

Index of Biotic Integrity (IBI) sample sites were selected that would give the broadest picture of impacts to the watershed. We typically located our sample site in close proximity to the mouth of a stream to maximize resident species collection. However, we positioned survey sites far enough upstream to decrease the probability of collecting transient species. Large river sampling sites were selected based on historical sampling locations and available access points. Typically we selected sample areas in these rivers that represented the best available habitat for any given reach being surveyed. Sampling locations were delineated in the field utilizing hand held Geographical Positioning Units (GPS) and then digitally re-created using a commercially available software package.

WATERSHED ANALYSIS

Watershed size and/or stream order has historically been used to create relationships for determining maximum expected species richness for IBI analysis. This has been accomplished by plotting species richness for a number of sites against watershed areas and/or stream orders (Fausch et al. 1984). We chose to use watershed area (kilometer^2) to develop our relationships as this variable has been shown to be a more reliable metric for predicting maximum species richness. Watershed areas (the area upstream of the survey site) were determined from USGS 1:24,000 scale maps.

FISH COLLECTIONS

A percentage of the fish data collected in this report was collected by employing an Index of Biological Integrity (Karr et al. 1986). Fish were collected with standard electrofishing (backpack) and seining techniques. A 5 x 1.3 meter seine was used to make hauls in shallow pool and run areas. Riffle and deeper run habitats were sampled with a seine in conjunction with a backpack electrofishing unit (100-600 VAC). An area approximately the length of the seine^2 (i.e., 5 meters x 5 meters) was electrofished in a downstream direction. A person with a dipnet assisted the person electrofishing in collecting those fish, which did not freely drift into the seine. Timed (5-min duration) backpack electrofishing runs were used to sample shoreline habitats. In both cases (seining or shocking) an estimate of area (meter^2) covered on each pass was calculated. Fish collections were made in all habitat types within the selected

survey reach. Collections were made repeatedly for each habitat type until no new species was collected for three consecutive samples for each habitat type. All fish collected from each sample were enumerated. Anomalies (e.g., parasites, deformities, eroded fins, lesions, or tumors) were noted along with occurrences of hybridization. After processing, the captured fish were either held in captivity or released into the stream where they could not be recaptured. In larger rivers, a boat was used in conjunction with the backpack samples to effectively sample deep pool habitat. Timed (10-min duration) runs were used until all habitat types had been depleted.

Streams sampled for the Cumberland Habitat Conservation Plan (HCP) utilized two techniques for collecting fish data. Catch-per-unit-effort samples (CPUE) were calculated for all target species covered under the HCP. An additional population estimate was made for blackside dace following the model described by Black and Mattingly (2007). Site lengths for these streams were typically around 200 meters and were sampled by a one pass electrofishing run utilizing one backpack electrofishing unit.

Catch-per-unit-effort samples were conducted in four rivers during 2011. Timed boat electrofishing runs were made in pool and shallower habitat where navigable. Efforts were made to sample the highest quality habitat in each sample site and include representation of all habitat types typical to the reaches surveyed. Total electrofishing time was calculated and used to determine our catch-effort estimates (fish/hour).

Generally, fish were identified in the field and released. Problematic specimens were preserved in 10% formalin and later identified in the lab or taken to Dr. David A. Etnier at the University of Tennessee Knoxville (UTK) for identification. Most of the preserved fish collected in the 2011 samples will be catalogued into our reference collection or deposited in the University of Tennessee Research Collection of Fishes. Common and scientific names of fishes used in this report are after Nelson et al. (2004), Powers and Mayden (2007) and Etnier and Starnes (1993).

BENTHIC COLLECTIONS

Qualitative benthic samples were collected from each IBI fish sample site and at four other locations for a total of eight samples. These were taken with aquatic insect nets, by rock turning, and by selected pickings from as many types of habitat as possible within the sample area. Taxa richness and relative abundance are the primary considerations of this type of sampling. Taxa richness reflects the health of the benthic community and biological impairment is reflected in the absence of pollution sensitive taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Large particles and debris were picked from the samples and discarded in the field. The remaining sample was preserved in 70% ethanol and later sorted in the laboratory. Organisms were enumerated and attempts were made to identify specimens to species level when possible. Many were identified to genus, and most were at least identified to family. Dr. David A. Etnier (UTK) examined problematic specimens and either made the determination or confirmed our identifications. Comparisons with identified specimens in our aquatic invertebrate collection were also useful in making determinations. For

the most part, nomenclature of aquatic insects used in this report follows Brigham et al. (1982) and Louton (1982). Names of stoneflies (Plecoptera) are after Stewart and Stark (1988) and caddisflies are after Etnier et al. (1998). Benthic results are presented in tabular form with each stream account.

WATER QUALITY MEASUREMENTS

Basic water quality data were taken at most sites in conjunction with the fishery and benthic samples. The samples included temperature, pH, and conductivity. Data were taken from midstream and mid-depth at each site, using a YSI model 33 S-C-T meter. Scientific Products™ pH indicator strips were used to measure pH. Stream velocities were measured with a Marsh-McBirney Model 201D current meter. The Robins-Crawford "rapid crude" technique (as described by Orth 1983) was used to estimate flows. Water quality parameters were recorded and are included with each stream account.

HABITAT QUALITY ANALYSIS

Beginning in 2004, the stream survey unit introduced an experimental habitat assessment form that built on the existing method by incorporating biological impairment and metric modifications to the standardized form (Smith et al. 2002). The major advantages of this evaluation procedure include more concise metrics and categories that identify the stream or river based on size, gradient, temperature, ecoregion and alterations of flow based on groundwater or hydroelectric influences.

The other issue we wanted to address with this new evaluation was the development of our own biotic index for benthic macroinvertebrates. By assigning an overall value to the water quality, habitat, and biological impairment of a given reach of stream we can begin to assign tolerance values to associated benthic insect species collected during the survey. This will ultimately allow us to develop a more accurate biotic index for benthic macroinvertebrates for the Ridge and Valley and Blue Ridge Ecoregions of east Tennessee. The illustrations on the following page depict the layout of the experimental form including the 14 habitat/water quality metrics, the biotic index adjustment, ecoregion classification, and stream type.

We feel that this form allows us to be more precise in our evaluation of the stream habitat quality and gives us a more defined evaluation pertaining to stream morphology and location. We will continue to complete both habitat evaluations for each stream survey in order to fully evaluate the new form.

STREAM QUALITY ASSESSMENT FORM

FORM:SQA-09-2004

Tennessee Wildlife Resources Agency Stream Survey Unit

STREAM:_____ DATE:_____

INVESTIGATOR:_____ SITE CODE:_____

LAT/LONG:_____ ELEVATION:_____

Rate Each Of The Following 14 Metrics:
0(EXCELLENT) 1(GOOD) 2(FAIR) 3(POOR) 4(VERY POOR)
note: 0 = pristine condition and 4 = worst condition

SCORE

1 SILTATION ☐
(fine particles that blanket [smother] the substrate)

2 SUBSTRATE EMBEDDEDNESS ☐
(interstitial spaces between gravel, cobble and boulder have become filled with fine deposits such as sand making the underside habitat unsuitable to aquatic life)

3 BED-LOAD MOVEMENT ☐
(condition pertaining to excessive bed load movement, and frequent formation and destruction of sand and gravel bars)

4 STATE OF SMALL RIPARIAN VEGETATION ☐
(grasses, shrubs, etc. that stabilize the soil surface and serve as runoff filters)

5 STATE OF LARGE RIPARIAN VEGETATION ☐
(canopy trees that provide long-term bank stability and shade)

6 BANK STABILITY ☐
(signs of bank erosion)

7 PHYSICAL DAMAGE TO STREAM HABITAT BY DOMESTIC LIVESTOCK ☐
(obvious signs of damage within riparian zone and instream habitat from livestock traffic)

8 ALTERATIONS OF NATURAL PHYSICAL CHARACTERS OF STREAMBED ☐
(channelization, gravel dredging, channel relocation, bridges, culverts, dams, fords etc.)

9 TURBIDITY ☐
(suspended solids "muddy or cloudy")

10 POINT SOURCE POLLUTION ☐
(FACTORY, MINING SOURCE, etc.)
(pipes or ditches conveying contaminated effluent adversely affecting water quality), chemical odor and/or unusual water or substrate coloration. (reddish algae [organic] or iron oxide [inorganic] often associated with severe earth disturbance)

11 ENRICHMENT ☐
(agricultural livestock waste and/or crop fertilizers, poorly functioning municipal waste water treatment facility or residential septic systems often indicated by filamentous algae etc.)

12 ATYPICAL WATER QUALITY PARAMETERS (BASIC) ☐
(unusually high or low pH, conductivity, dissolved oxygen, or temperature)

13 ENVIRONMENTALLY HARMFUL TRASH ☐
(human refuse including oil filters, engines, batteries, tires, etc. that may be toxic to aquatic organisms)

14 ALTERED STREAM FLOW (CFS) ☐
(abnormal fluctuations in flow volume [e.g. hydroelectric dam regulation], or low flow due to water consumption for municipal water, bottled water, crop irrigation, or other water demands.)

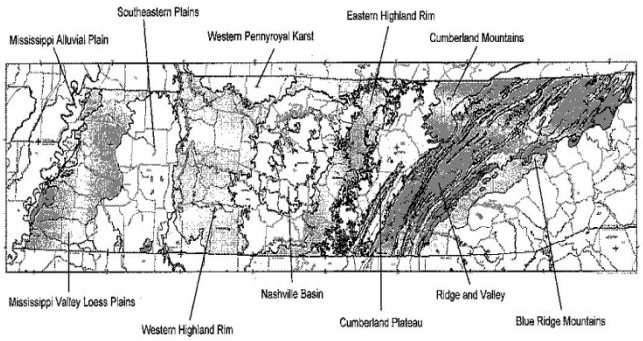
TOTAL ☐

BIOTIC INDEX ADJUSTMENT (BIA) + ☐
(does one or more of the previous 14 metrics seriously inhibit aquatic life?)
0 (no biological impairment) **5** (only the most sensitive taxa impaired)
10 (somewhat diverse but most intolerant forms absent) **15** (low diversity—tolerant forms only)
20 (little or no aquatic life present)

STREAM ASSESSMENT VALUE = TOTAL + BIA → ☐

0 - 10 (EXCELLENT) 11 - 21 (GOOD) 22 - 32 (FAIR) 33 - 43 (POOR) ≥44 (VERY POOR)

INDICATE (CIRCLE) ECOREGION:



STREAM TYPE:	GRADIENT LOW <0.01	GRADIENT MOD 0.01-0.05	GRADIENT HIGH >0.05	TEMPERATURE COLD <20°C	TEMPERATURE COOL <25°C	TEMPERATURE WARM >25°C	Maximum Summer Temp
HEADWATER (0 - 2 METERS)	☐	☐	☐	☐	☐	☐	
SMALL CREEK (2.1 -11.0 METERS)	☐	☐	☐	☐	☐	☐	
LARGE CREEK (11.1 -21.0 METERS)	☐	☐	☐	☐	☐	☐	
SMALL RIVER 1 (21.1 - 111 METERS)	☐	☐	☐	☐	☐	☐	
SMALL RIVER 2 (111.1 - 201 METERS)	☐	☐	☐	☐	☐	☐	
MEDIUM RIVER (202 METERS - 502 METERS)	☐	☐	☐	☐	☐	☐	
LARGE RIVER (>503 METERS)	☐	☐	☐	☐	☐	☐	

CHECK IF STREAM IS:

A SPRING RUN (near source) ☐
A CREEK WITH SIGNIFICANT SPRING INFLUENCE ☐
A TAILWATER ☐

Ecoregion designations follow Griffith (USEPA) et al. Stream Type, and Gradient definitions generally follow Smith, R.K., P.L. Freeman, J.V. Higgins, K.S. Wheaton, T.W. FitzHugh, K.J. Ernstrom, A.A. Das. Priority Areas for Freshwater Conservation: A Biodiversity of the Southeastern United States. The Nature Conservancy. 2002.

DATA ANALYSIS

Twelve metrics described by Karr et al. (1986) were used to determine an IBI score for each stream surveyed. These metrics were designed to reflect fish community health from a variety of perspectives (Karr et al. 1986). Given that IBI metrics were developed for the midwestern United States, many state and federal agencies have modified the original twelve metrics to accommodate regional differences. Such modifications have been developed for Tennessee primarily through the efforts of TWRA (Bivens et al. 1995), TVA, and Tennessee Tech University. In developing our scoring criteria for the twelve metrics we reviewed pertinent literature [North American Atlas of Fishes (Lee et al. 1980), The Fishes of Tennessee (Etnier and Starnes 1993), various TWRA Annual Reports and unpublished data] to establish historical and more recent accounts of fishes expected to occur in the drainages we sampled. Scoring criteria for the twelve metrics were modified according to watershed size. Watersheds draining less than 13 kilometer^2 were assigned different scoring criteria than those draining greater areas. This was done to accommodate the inherent problems associated with small stream samples (e.g., lower catch rates and species richness). Young-of-the-year fish and non-native species were excluded from the IBI calculations. After calculating a final score, an integrity class was assigned to the stream reach based on that score. The classes used follow those described by Karr et al. (1986).

Karr et al. (1986) criteria Total IBI score (sum of the 12 metric ratings)	Integrity Class	Attributes
58-60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of size classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundance or size distributions; trophic structure

		shows some signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites fin damage, and other anomalies regular.
	No fish	Repeated sampling finds no fish.

Catch-per-unit-effort analysis was performed for four large rivers sampled during 2011. Total time spent electrofishing at each site was used to calculate the CPUE estimates for each species collected. Length categorization analysis

(Gabelhouse 1984) was used to calculate Proportional Stock Density (PSD) and Relative Stock Density (RSD) for black bass and rock bass populations sampled. Catch per unit effort samples were also calculated for streams being monitored for the HCP. Additionally, a blackside dace population estimate was generated for those streams where this species was present. Estimates were derived following the model described by Black and Mattingly (2007).

Benthic data collected for the 2011 surveys were subjected to a biotic index that rates stream condition based on the overall taxa tolerance values and the number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa present. The North Carolina Division of Environmental Management (NCDEM) has developed a bioclassification index and associated criteria for the southeastern United States (Lenat 1993). This technique rates water quality according to scores derived from taxa tolerance values and EPT taxa richness values. The final derivation of the water quality classification is based on the combination of scores generated from the two indices. The criteria used to generate the biotic index values and EPT values are as follows:

Score	Biotic Index Values	EPT Values
5 (Excellent)	< 5.14	> 33
4.6	5.14-5.18	32-33
4.4	5.19-5.23	30-31
4 (Good)	5.24-5.73	26-29
3.6	5.74-5.78	24-25
3.4	5.79-5.83	22-23
3	5.84-6.43	18-21
2.6	6.44-6.48	16-17
2.4	6.49-6.53	14-15
2	6.54-7.43	10-13
1.6	7.44-7.48	8-9
1.4	7.49-7.53	6-7
1 (Poor)	> 7.53	0-5

The overall result is an index of water quality that is designed to give a general state of pollution regardless of the source (Lenat 1993). Taxa tolerance rankings were based on those given by NCDEM (2006) with minor modifications for taxa, which did not have assigned tolerance values.

Clinch River

Introduction

The Clinch River represents an important recreational resource for the state both in consumptive and non-consumptive uses. It provides critical habitat for threatened and endangered species and species of special concern. The river supports a diverse fish community and has been documented to host some 43 species of mussels (Ahlstedt 1986). Additionally, it supports one of east Tennessee's better warmwater sport fisheries. The Clinch River has been the focus of numerous surveys and investigations conducted by both state and federal agencies with the major purpose of assessing and monitoring the fish and benthic communities. The Agency has made limited surveys of the river that focused primarily on collecting basic fish, benthic, and water quality data (Bivens 1988, Carter et al. 2000, 2003, 2006). Our survey of the Clinch River focused on re-evaluating the sport fish population originally sampled in 1999. Our 2011 assessment was derived from nine sample sites located between river mile 202 and river mile 152. After our initial evaluation in 1999, the Clinch River was put into a 3-year rotational schedule with eight other rivers in the region. Sport fish sampling sites were reduced to those that would best characterize these populations. In March 2008, smallmouth bass regulations were changed to a protected slot limit (PLR) which prohibits the take of bass between 13 and 17 inches. The regulation allows anglers to keep one bass in excess of 17 inches as part of the five fish daily creel limit.

Study Area and Methods

The Clinch River originates in Virginia and flows in a southwesterly direction before emptying into Norris Reservoir near river mile 152. The river has a drainage area of approximately 3,838 kilometers^2 (upstream of the reservoir). In Tennessee, all of the Clinch River flows through the Ridge and Valley province of east Tennessee coursing by the town of Sneedville before emptying into Norris Reservoir just northwest of Thorn Hill. Public access along the river is primarily limited to bridge crossings and small "pull-outs" along roads paralleling the river. There are several primitive launching areas for canoes or small boats and three developed launching areas

managed by the Tennessee Wildlife Resources Agency (Kyles Ford, Sneedeville, Hwy. 25E Bridge).

Between May 5 and June 23, 2011, we conducted nine fish surveys between the Virginia state line and Norris Reservoir (Figure 1). In our survey sites, the riparian habitat consisted primarily of wooded shorelines with interspersed agricultural fields. Submerged woody debri was fairly common in most of our sample areas. The river substrate was predominately boulder/cobble in riffle areas and bedrock with interspersed boulder/cobble in the pool habitat. Measured mean channel widths ranged from 41.6 meters to 71.5 meters, while site lengths fell between 190 meters and 890 meters (Table 1). Water temperatures ranged from 15 C to 23.5 C and conductivity varied from 230 to 295 µs/cm (Table 1).

Figure 1. Site locations for samples conducted in the Clinch River during 2011.

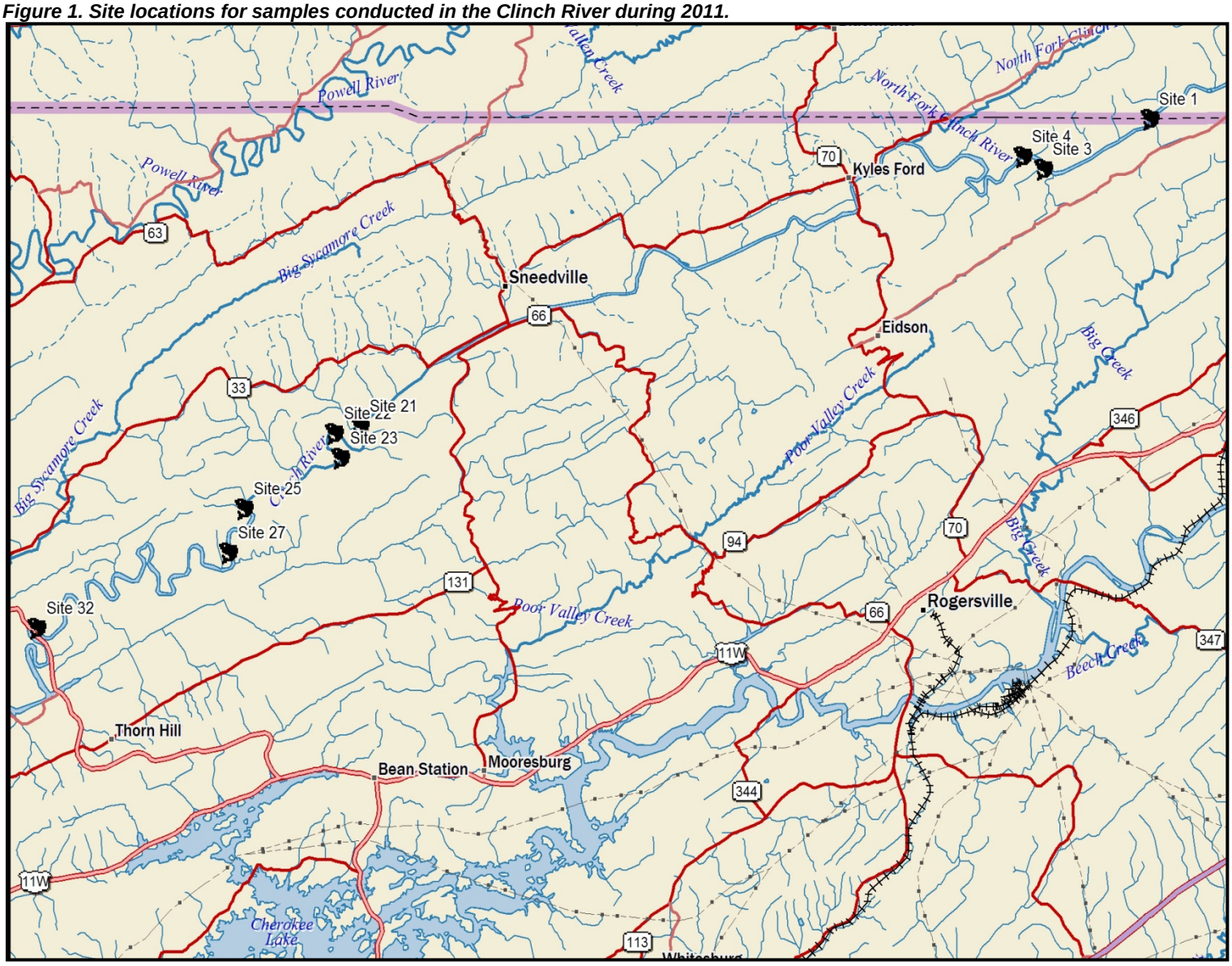


Table 1. Physiochemical and site location data for samples conducted in the Clinch River during 2011.

Site Code	Site	Quad	River Mile	Latitude	Longitude	Mean Width (m)	Length (m)	Temp. C	Cond. µs/cm	Secchi (m)
420111001	1	Looney Gap	202	36.59361	-82.88944	44.6	376	21.5	290	0.7
420111003	3	Looney Gap	199	36.57667	-82.94139	41.6	381	22.5	295	0.7
420111004	4	Looney Gap	197.8	36.58139	-82.95444	50.6	190	23.5	280	0.7
420111021	21	Swan Island	172.5	36.47722	-83.28917	53	718	15	220	0.8
420111022	22	Swan Island	170.7	36.47528	-83.30306	71.5	480	15	230	0.8
420111023	23	Swan Island	169.6	36.46500	-83.30083	50	217	16	235	0.8
420111025	25	Swan Island	166.6	36.44583	-83.34917	63	890	16.5	235	0.8
420111027	27	Swan Island	164.5	36.42917	-83.35778	68.5	520	15.5	240	0.8
420111032	32	Howard Quarter	152.2	36.40139	-83.45250	71.5	413	17	240	0.8

Fish were collected by boat electrofishing in accordance with the standard large river sampling protocols (TWRA 1998). Fixed-boom electrodes were used to transfer 4-5 amps DC at all sites. This current setting was determined effective in narcotizing all target species (black bass and rock bass). All sites were sampled during daylight hours and had survey durations ranging from 900 to 980 seconds. Catch-per-unit-effort (CPUE) values were calculated for each target species at each site. Length categorization indices were calculated for target species following Gabelhouse (1984).

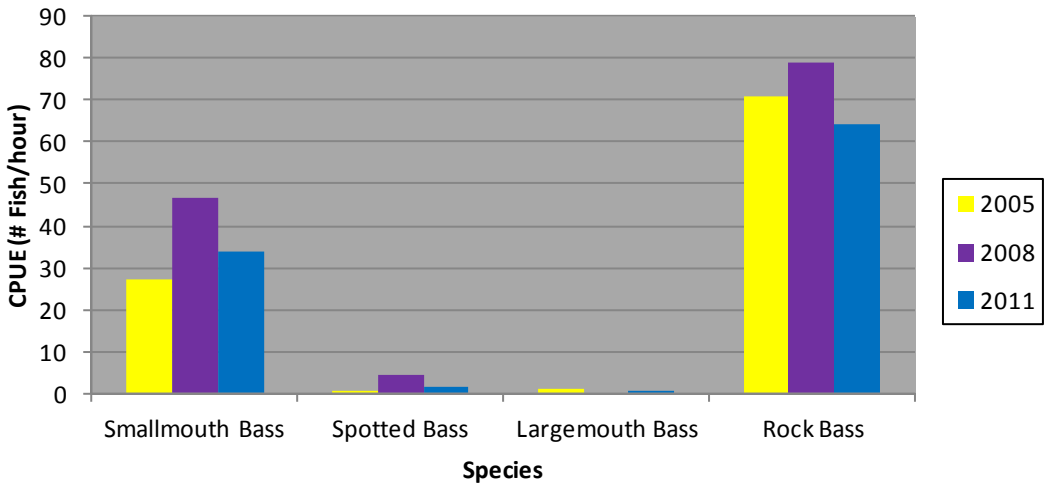
Results

CPUE estimates for smallmouth bass averaged 34/hour (SD 22.6), while the mean rock bass estimate was 64.1/hour (SD 58.4) (Table 2). We did collect one largemouth bass at site 32 in 2011 and very few spotted bass at sites 21 and 32. The CPUE estimate for spotted bass and largemouth bass were 1.3 (SD 2.8) and 0.4 (SD 1.3). Comparatively, there was an overall decrease in the mean catch rate of smallmouth bass from our survey in 2008 (Figure 2). The mean catch rate of smallmouth bass decreased 27% over the value observed in 2008. Likewise, the mean catch rate for rock bass decreased about 19% from our sample taken in 2008. Most the observed declines for smallmouth bass and rock bass were in the upper reaches of the river.

Table 2. Catch per unit effort and length categorization indices of target species collected in the Clinch River during 2011.

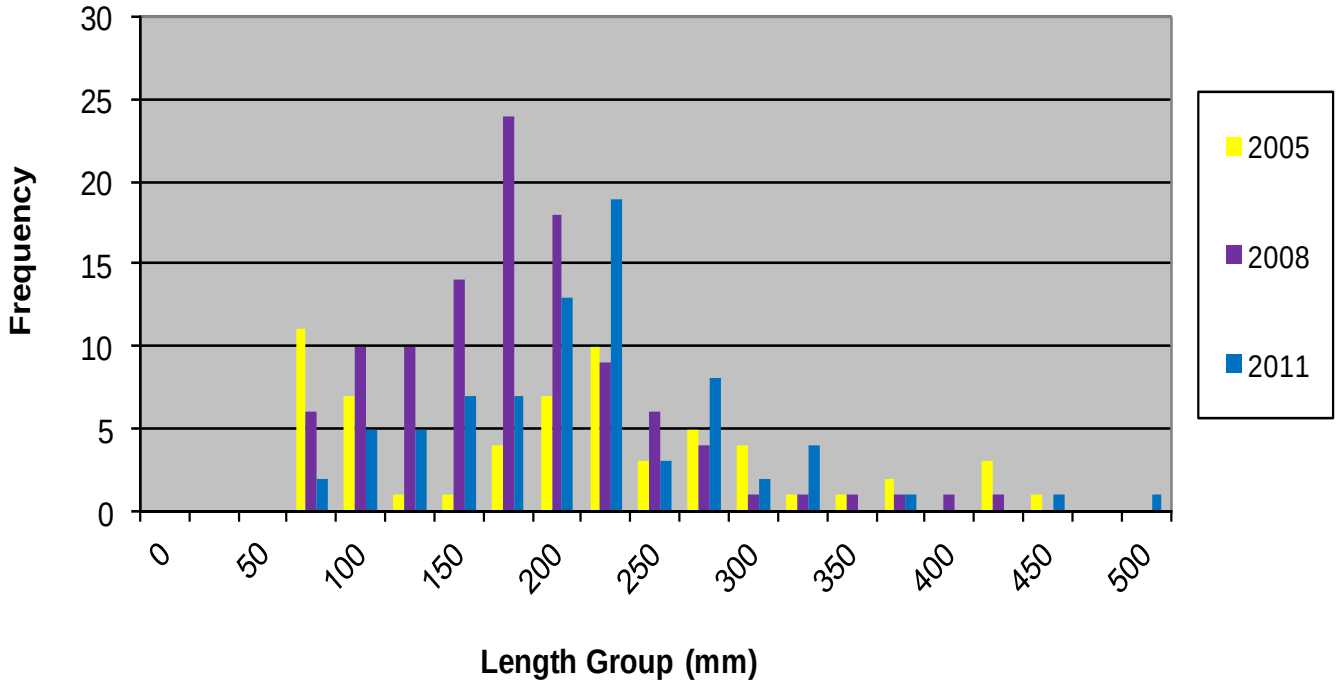
Site Code	Smallmouth Bass CPUE	Spotted Bass CPUE	Largemouth Bass CPUE	Rock Bass CPUE
420111001	16	-	-	52
420111003	16	-	-	12
420111004	24	-	-	16
420111021	24	8	4	24
420111022	35	-	-	77
420111023	36	-	-	152
420111025	84	-	-	92
420111027	55	-	-	152
420111032	16	4	-	-
MEAN	34	1.3	0.4	64.1
STD. DEV.	22.6	2.8	1.3	58.4
	Length-Categorization Analysis	**Length-Categorization Analysis**	**Length-Categorization Analysis**	**Length-Categorization Analysis**
	PSD = 33.9 RSD-PREFERRED = 5.3 RSD-MEMORABLE = 3.5 RSD- TROPHY = 1.7	PSD = 0 RSD-PREFERRED = 0 RSD-MEMORABLE = 0 RSD- TROPHY = 0	PSD = 0 RSD-PREFERRED = 0 RSD-MEMORABLE = 0 RSD- TROPHY = 0	PSD = 28.3 RSD-PREFERRED = 2.1 RSD-MEMORABLE = 0 RSD- TROPHY = 0

Figure 2. Trends in mean catch rate of black bass and rock bass collected from 2005 to 2011 in the Clinch River.



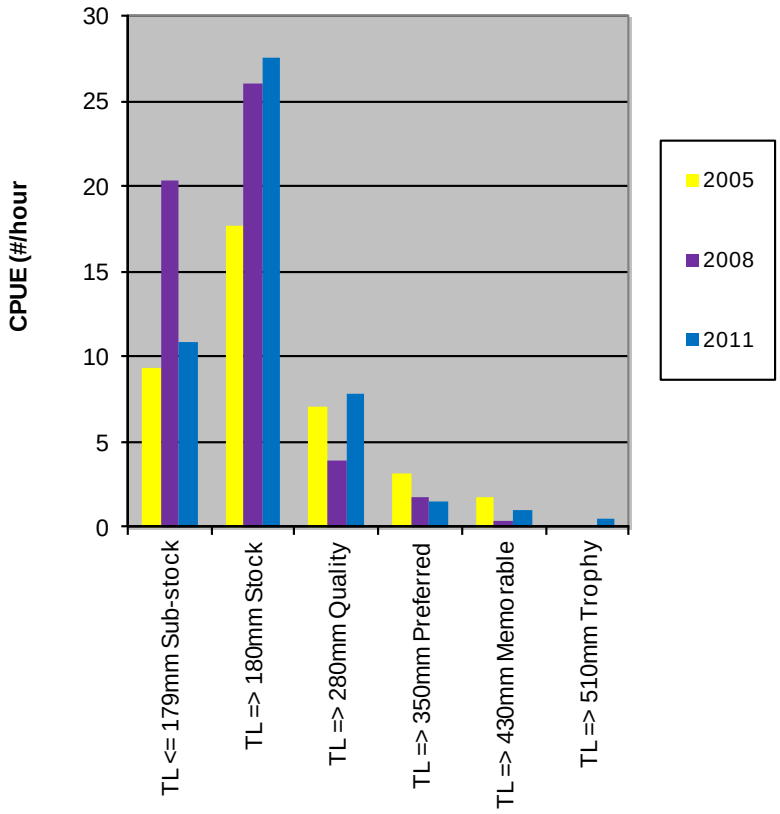
The size distribution of smallmouth bass between 1999 and 2011 has varied somewhat among our nine sampling stations (Figure 3). We observed good representation in the 100 to 225 size range although the numbers were lower than the previous sample. The occurrence of quality size bass 280 mm and larger was somewhat higher in 2011 when compared to 2008. The majority of smallmouth bass fell within the 100 and 250 mm size range with the highest frequency of fish in the 125 to 200 mm size class. Given the high frequency of fish between 175 and 250 mm, there should be bass recruiting to quality size over the next 2 to 4 years.

Figure 3. Length frequency distributions for smallmouth bass collected in the Clinch River from 2005 to 2011.



Length categorization analysis indicated the relative stock density (RSD) of preferred smallmouth bass (TL ≥ 350 mm) was 5.3 (Table 2). This was a small 19% decrease from the value recorded in 2008. RSD for memorable (TL ≥ 430 mm) size bass increased to 3.5 in 2011 from 1.6 in 2008. One trophy (TL ≥ 510 mm size bass was collected in 2011 resulting in an RSD value of 1.7 for this category. This was the second trophy size bass we have collected from the river since sampling began in 1999. The PSD of smallmouth bass (ratio of quality size bass to stock size bass) was 33.9, which is very close to the statewide average of 34 (Fiss et al. 2001). This observation rebounded substantially from the value of 15 observed in 2008. Catch per unit effort estimates by RSD category depicted general increases for most size groups with the exception of the sub-stock category. Overall, we observed good recruitment into the stock and quality categories. This trend persisted throughout the larger size groups although at a lower frequency (Figure 4). Based on the abundance of smaller fish in the population, recruitment should be good into the larger size categories for the next few years.

Figure 4. Relative stock density (RSD) catch per unit effort for smallmouth bass collected in the Clinch River from 2005 to 2011.

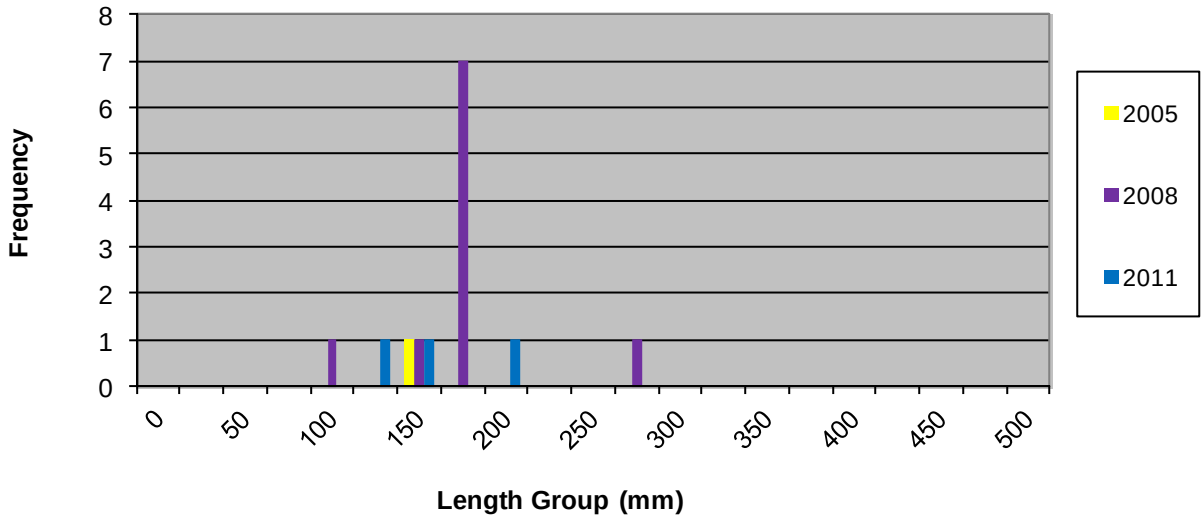


Age and growth characteristics for the smallmouth bass population in the Clinch River were characterized in 1999 (Carter et al. 2000). For the most part, the Clinch River has had growth rates similar to other large river populations with the same age structure.

We did not collect otoliths from smallmouth bass in 2011, assuming that the values generated from the 1999 survey typify the general growth characteristics of this population. In general it takes a smallmouth bass in the Clinch River about 4.7 years to reach 305 mm (12 inches), and about 7.8 years to attain a length of 406 mm (16 inches).

There were three spotted bass collected from the Clinch River in 2011. This was a decrease from the value observed in 2008 (10). The fish were collected from sites 21 and 32 which are in the mid to and lower reaches of the river. Given the scarcity of spotted bass in the Clinch, no real inferences about their contribution to the fishery can be made. However, they do persist in the river and may offer some opportunity to anglers. Figure 5 portrays the distribution of lengths for spotted bass collected from the Clinch River between 1999 and 2011. Catch rate for spotted bass in 2011 averaged 1.3/hour (SD 2.8).

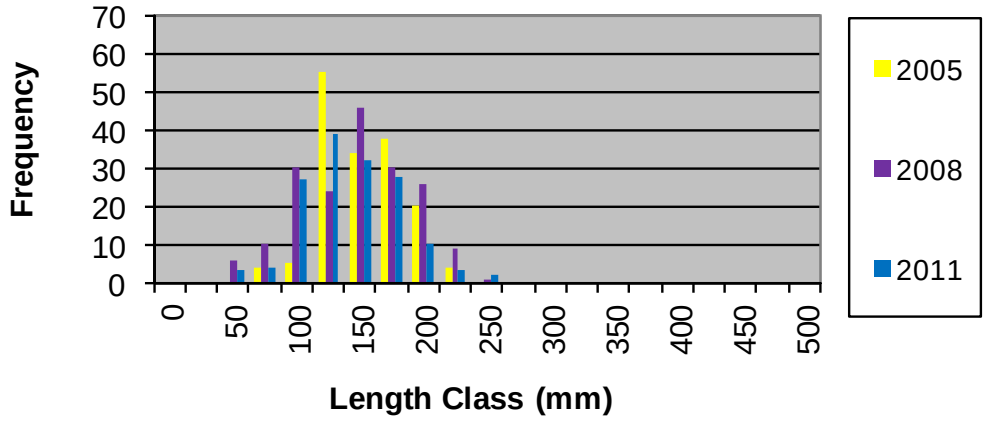
Figure 5. Length frequency distributions for spotted bass collected in the Clinch River from 2005 to 2011.



Although largemouth bass have been present on occasion (1999 and 2002, 2011), their numbers have been extremely low and quite inconsequential to the overall fishery. Our collection of one largemouth bass in 2011 was the first since 2002.

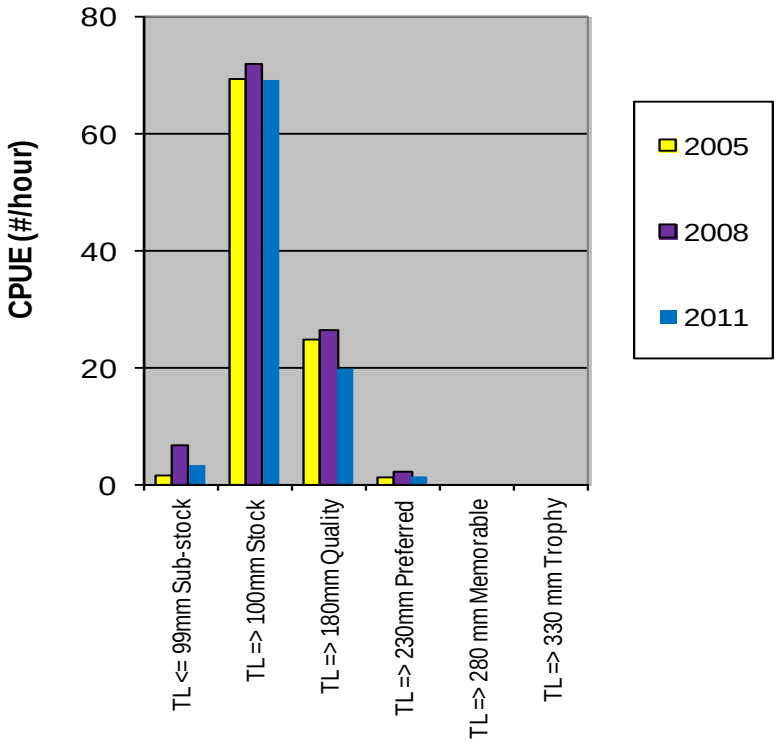
Individuals in the 100 to 225 mm range represented the majority of rock bass in our samples between 1999 and 2011 (Figure 6). For the most part, we observed decreases in all size classes over 150 mm, although we did have a higher number of fish in the 125 mm size group. The highest catches of rock bass were observed in lower reaches of the river.

Figure 6. Length frequency distributions for rock bass collected in the Clinch River from 2005 to 2011.



Relative stock density (RSD) analysis indicated the RSD for preferred rock bass (TL ≥ 230 mm) was 2.1 (3.0 in 2008). RSD for both memorable (TL ≥ 280 mm) and trophy (TL ≥ 330 mm) size rock bass was 0. The PSD of rock bass decreased over our 2008 survey (36.7) to 28.3. Our catch values by RSD category decreased slightly over the value observed in 2008 (Figure 7).

Figure 7. Relative stock density (RSD) catch per unit effort for rock bass collected in the Clinch River from 2005 to 2011.



Because of our confidence in determining age and growth characteristics (based on previous samples) we did not collect any otolith samples from rock bass in 2011. Therefore, no mortality or potential population growth statistics could be calculated. Age and growth and mortality of rock bass in the Clinch River are assumed to be similar to those reported from our 1999 assessment (Carter et al. 2000).

Discussion

The Clinch River provides anglers with the opportunity to catch all species of black bass along with rock bass. Because of the low numbers of spotted and largemouth bass in the Clinch River, angling opportunities for these species will be limited.

The popularity of this riverine fishery has grown over the last few years and now hosts a good percentage of anglers from Kentucky. Currently we have no angler use/harvest data on the river to aid in evaluating the effects that angler use may or may not have on the sport fishery. It is imperative that we obtain this

data in order to answer fisheries management questions, public inquiries, and aid in the development of regulations.

The occurrence of musky in the river warrants continued investigations. The consistent stockings made by the Virginia Department of Game and Inland Fisheries upstream of the state line could lead to the development of a fishery in the Tennessee portion of the Clinch River. According to Tom Hampton (VAGF) their stockings have been quite successful and have resulted in the establishment of a sport fishery. Recent Index of Biotic Integrity surveys by TVA have indicated that the Clinch River is in “good” condition based on data from two long-term monitoring stations.

Surveys on the Clinch River will be conducted on a three-year rotation in order to assess any changes in the fishery. Our return trip in 2014 will in all likelihood focus on the sample sites surveyed in 2011, providing no new or more efficient sampling scheme is developed.

Management Recommendations

1. Initiate an angler use and harvest survey.

2. Develop a fishery management plan for the river.

Little River

Introduction

Little River originates in Sevier County on the north slope of Clingmans Dome, in the Great Smoky Mountains National Park. It flows in a northwesterly direction for about 95 kilometers, past Elkmont in the National Park, and Townsend, Walland, and Maryville in Blount County, and joins the Tennessee River near river mile 635.6. Fort Loudoun Reservoir, impounds the lower 6.8 miles of Little River with another 1.5 miles being impounded by the low head dam at Rockford (located at the backwaters of Fort Loudoun). In all, a little over eight river miles are impounded. Another 0.75 mile or so is impounded by Perrys Milldam downstream of Walland, near river mile 22. A third low head dam is located in Townsend near river mile 33.6. The river has a drainage area of approximately 982 km^2 at its confluence with the Tennessee River. The upper reach of the river (upstream of Walland) is located in the Blue Ridge physiographic province, and then transitions into the Ridge and Valley province from Walland to Fort Loudoun Reservoir. Little River is a very scenic stream in the Great Smoky Mountains National Park. There, it drains an area containing some of the most spectacular scenery in the southeastern United States. The Little River fishery within the National Park boundary is primarily wild rainbow and brown trout with smallmouth bass in the lower reaches. An excellent trout fishery exists, and is managed by the National Park Service. Little River's gradient becomes moderate as it leaves the National Park and flows through the Tuckaleechee Valley from Townsend to Walland. Excellent populations of smallmouth bass and rock bass exist there, and rainbow trout are stocked in spring and fall as water temperatures allow. This portion of the river has many developed campgrounds and is a popular recreation destination for tourists. While not as developed as Pigeon Forge, the Townsend area has grown significantly over the past two decades. Downstream of Walland, Little River leaves the mountains and no longer displays the extreme clarity and attractive rocky bottom of its upper reaches. Here it enters the Ridge and Valley province

Little River at Perrys Mill

and resembles the more typical large river habitat with lower gradient and large deep pools interspersed with shallow shoal areas. Downstream of Perrys Milldam, the fishery, while still primarily smallmouth bass and rock bass, declines in quality relative to the upstream reach. This is probably related to limited availability of preferred smallmouth bass habitat. Near the small community of Rockford, Little River flows into a surprisingly large (given the size of the stream) embayment of Fort Loudon Lake. The Little River forms the boundary between Blount County and Knox County for the last few miles of its course.

Little River represents an important recreational resource for the state both in consumptive and non-consumptive uses. It supports an active tubing/rafting industry and is an important recreational resource for local residents and tourists alike. It is also the municipal water source of the cities of Alcoa and Maryville. It provides critical habitat for species of special concern and is home to over 50 species of fish (four listed federally). Additionally, its upper reach supports one of east Tennessee's better warm water sport fisheries. It provides anglers with the opportunity to catch all species of black bass, rock bass, and even stocked rainbow trout when water temperatures allow.

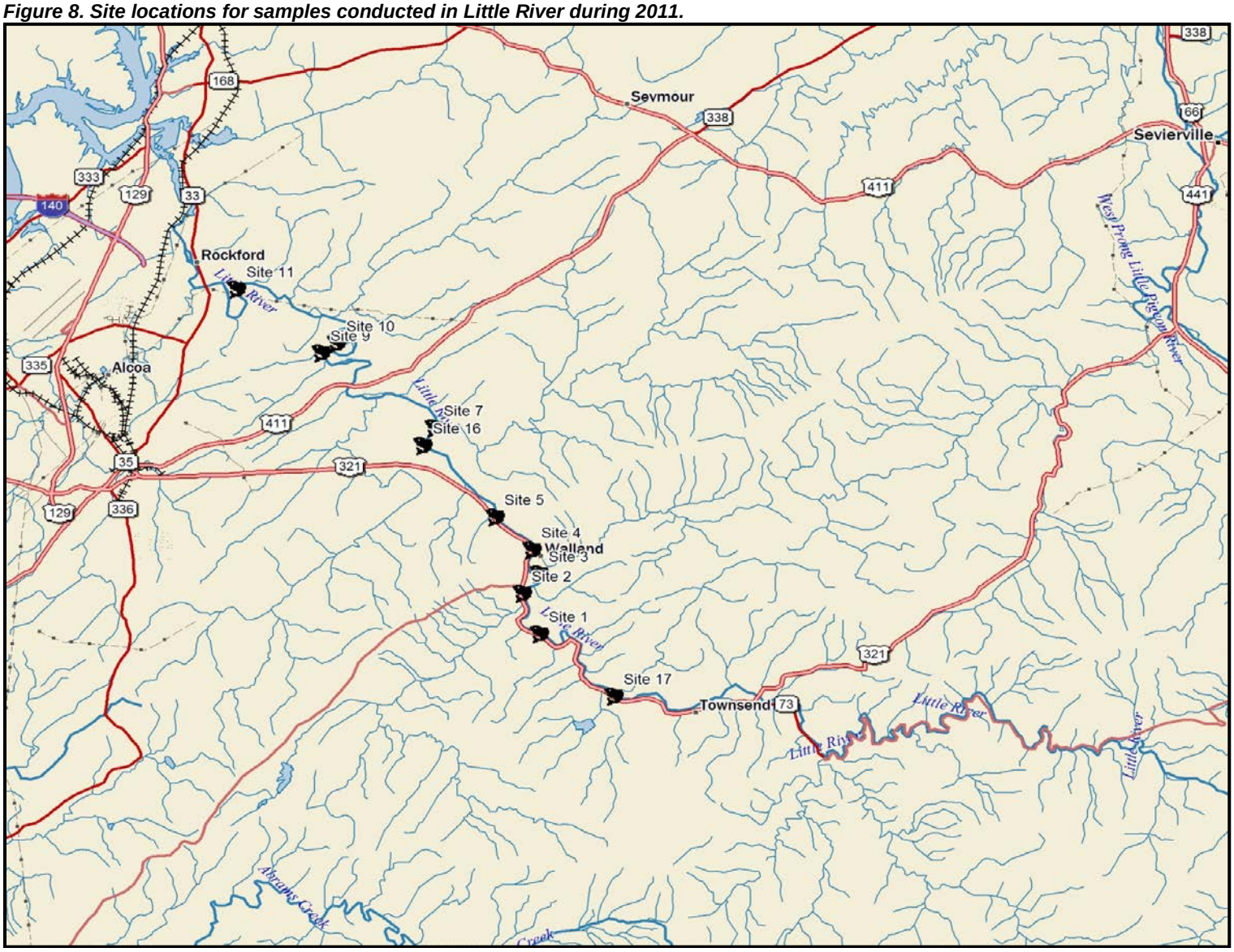
Study Area and Methods

Our 2011 survey of Little River consisted of two IBI sites (Coulters Bridge and Townsend) and nine CPUE black bass/rock bass samples. We cooperated with several agencies in conducting the two IBI samples between July 12 and 15. CPUE samples were conducted on May 4 and June 17. The Coulters Bridge site (16) is located in the Ridge and Valley Province of Blount County while the Townsend site (17) lies in the transitional zone between the Blue Ridge and the Ridge and Valley Provinces (Figure 8).

Public access along the river is primarily limited to bridge crossings and small "pull-outs" along roads paralleling the river. There are several primitive

launching areas for canoes or small boats and one developed access area managed by the Agency (Perrys Mill).

Figure 8. Site locations for samples conducted in Little River during 2011.



Fish were collected by boat electrofishing in accordance with the standard large river sampling protocols (TWRA 1998). Fixed-boom electrodes were used to transfer 2-3 amps DC at all sites. This current setting was determined effective in narcotizing all target species (black bass and rock bass). All sites were sampled during daylight hours and had survey durations ranging from 630 to 2009 seconds. Catch-per-unit-effort (CPUE) values were calculated for each target species at each site. Length categorization indices were calculated for target species following Gabelhouse (1984). For IBI sites, fish were collected according to the criteria described in the methods section of this report. Both backpack and boat electrofishing were used to collect samples at both stations. Qualitative benthic macroinvertebrates samples were collected at both stations

and analyzed to produce a biotic index score similar to those derived for the fish IBI.

In our survey sites, the riparian habitat consisted primarily of wooded shorelines with interspersed agricultural fields. Submerged woody debri was fairly common in most of our sample areas along with large boulder in the upper reaches. The river substrate was predominately boulder/cobble in riffle areas and bedrock with interspersed boulder/cobble in the pool habitat. The prevalence of boulders decreased somewhat as we proceeded downstream and the abundance of gravel and cobble increased. Water temperatures ranged from 15 C to 22 C and conductivity varied from 50 to130 µs/cm for those stations where values were recorded (Table 3).

Table 3. Physiochemical and site location data for black bass and rock bass samples conducted in Little River during 2011.

Site Code	Site	Quad	River Mile	Latitude	Longitude	Mean Width (m)	Length (m)	Temp. C	Cond. µs/cm	Secchi (m)
420110901	1	Kinzel Springs	26.6	35.70190	-83.81320	-	-	20	50	2.0+
420110902	2	Kinzel Springs	25.1	35.71550	-83.81870	-	-	20	50	2.0+
420110903	3	Kinzel Springs	24.6	35.72240	-83.81280	-	-	21	50	2.0+
420110904	4	Kinzel Springs	23.8	35.73050	-83.81550	-	-	21	60	2.0+
420110905	5	Kinzel Springs	22.6	35.74160	-83.82940	-	-	22	65	2.0+
420110907	7	Wildwood	19.7	35.77180	-83.85190	-	-	15	70	-
420110909	9	Maryville	15.3	35.79710	-83.89400	-	-	16	100	-
420110910	10	Maryville	14.1	35.80020	-83.88840	-	-	16	112	-
420110911	11	Maryville	10.6	35.81880	-83.92520	-	-	16	130	-
420110916	16	Wildwood	20.0	35.76580	-83.85630	-	-	-	-	-
420110917	17	Kinzel Springs	29.8	35.68160	-83.78500	-	-	-	-	-

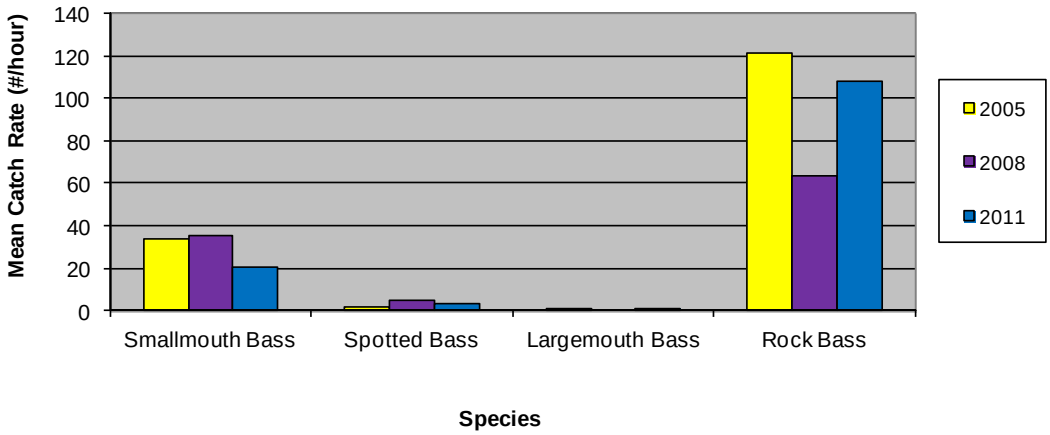
Results

CPUE estimates for smallmouth bass averaged 20.2/hour (SD 11.9) in 2011. This was down 43% from the 2008 value (35.5). Mean rock bass estimate was 108.4/hour (SD 32) which was a substantial increase of 71% from the previous sample (Table 4). This was a rebound from 2008 when effects of the drought were observed. In 2007, the U.S. Geological Survey documented the lowest flow (30 cfs) since the agency began recording data for Little River in 1951. The CPUE estimate for spotted bass was 3.1 (SD 6.3) which was down slightly from the value recorded in 2008 (Figure 9). Only two largemouth bass were collected in 2011. Both of these came from the upper reach of the river above the mill dam.

Table 4. Catch per unit effort and length categorization indices of target species collected in Little River during 2011.

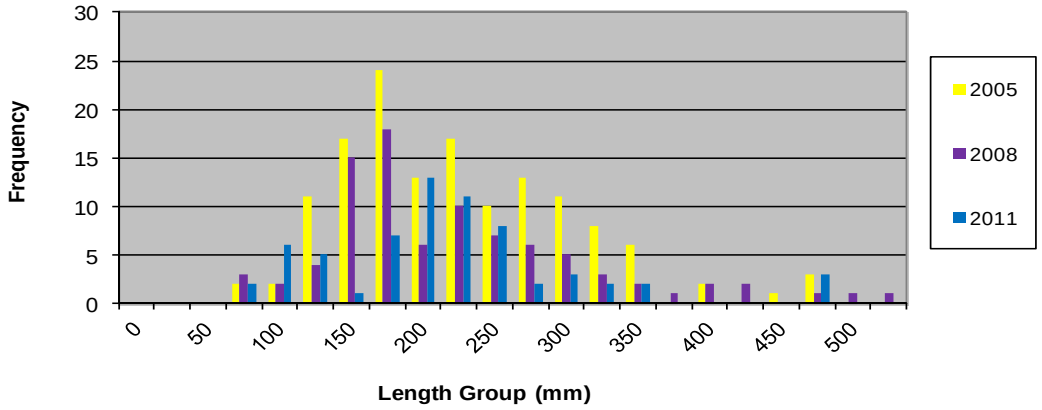
Site Code	Smallmouth Bass CPUE	Spotted Bass CPUE	Largemouth Bass CPUE	Rock Bass CPUE
420110901	36	-	2	113
420110902	28	-	-	120
420110903	15	-	-	158
420110904	36	-	3	105
420110905	28	-	-	52
420110907	15	11	-	111
420110909	6	17	-	72
420110910	12	-	-	104
420110911	6	-	-	141
MEAN	20.2	3.1	0.5	108.4
STD. DEV.	11.9	6.3	1.1	32
	Length-Categorization Analysis	**Length-Categorization Analysis**	**Length-Categorization Analysis**	**Length-Categorization Analysis**
	PSD = 22.9	PSD = 0	PSD = 0	PSD = 22.7
	RSD-PREFERRED = 10.4	RSD-PREFERRED = 0	RSD-PREFERRED = 0	RSD-PREFERRED = 0.4
	RSD-MEMORABLE = 6.2	RSD-MEMORABLE = 0	RSD-MEMORABLE = 0	RSD-MEMORABLE = 0
	RSD- TROPHY = 0	RSD- TROPHY = 0	RSD- TROPHY = 0	RSD- TROPHY = 0

Figure 9. Trends in mean catch rate of black bass and rock bass collected in Little River from 2005 to 2011.



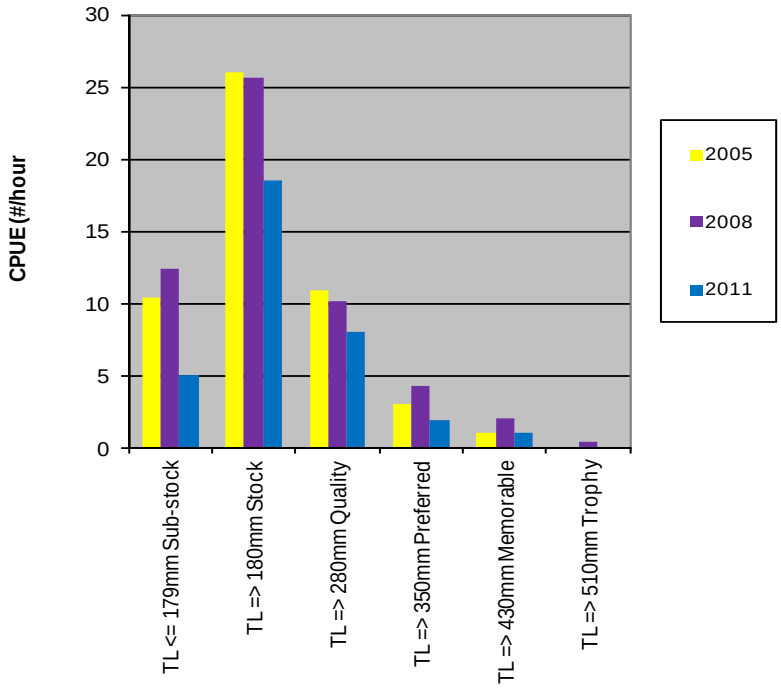
Our observation of mean catch for sport species was not untypical for east Tennessee rivers. Our highest catches were associated with two species, smallmouth bass and rock bass. Spotted bass and largemouth bass followed suit with much lower densities and typical ranking (spotted bass usually higher than largemouth bass). The size distribution was somewhat similar in 2011 when compared to 2008. Representation was fairly consistent across size classes but the overall frequency was generally lower in most size groups. We did not observe any bass in excess of 500 mm in the 2011 sample (Figure 10). The trends observed in 2008 and 2011 most likely reflect initial effects of the drought in 2007 and sustained impacts that have carried forward to 2011.

Figure 10. Length frequency distributions for smallmouth bass collected in Little River from 2005 to 2011.



Length categorization analysis indicated the relative stock density (RSD) of preferred smallmouth bass (TL ≥ 350 mm) was 10.4 (Table 4). RSD for memorable (TL ≥ 430 mm) and trophy (TL ≥ 510 mm) size bass were 6.2 and 0, respectively. The PSD of smallmouth bass (ratio of quality size bass to stock size bass) was 22.9. Our highest catch for the reported RSD categories was for bass of stock size (length ≥ 180mm). Overall, we observed declines in the catch rate of all RSD categories when compared to 2008 (Figure 11).

Figure 11. Relative stock density (RSD) catch per unit effort for smallmouth bass collected in Little River from 2005 to 2011.



We did not sample otoliths from smallmouth bass collected in Little River. Since we have no information pertaining to the age and growth of this population,

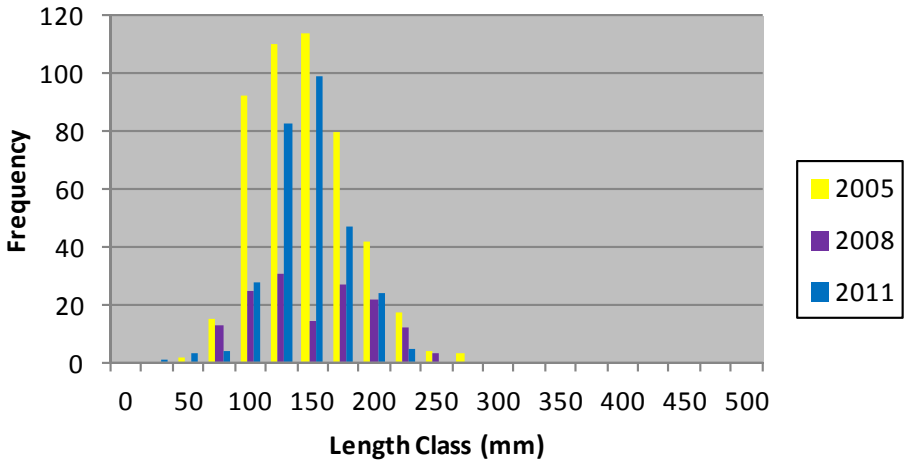
subsequent samples need to include a sub-sample of fish for age and growth analysis.

There were only six spotted bass collected from the Little River in 2011 (8 in 2008). These fish ranged in from 127 to 257 mm in length and were collected in the lower reaches of the river. Given the scarcity of spotted bass in Little River, no real inferences about their contribution to the fishery can be made. However, they do persist in the river and may offer some opportunity to anglers.

There were two largemouth bass collected during the 2011 survey (0 in 2008). Due to the low abundance of largemouth bass in this river, little can be said about population density and size structure. However, they do persist in the river and may offer some opportunity to anglers.

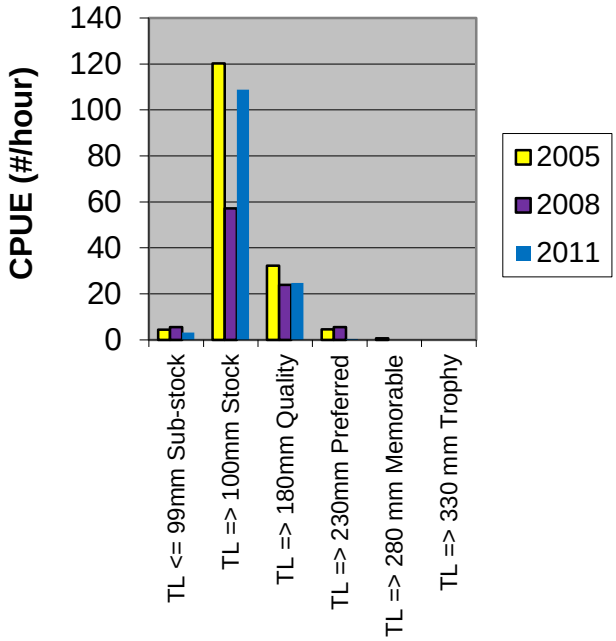
Individuals in the 100 to 225 mm range represented the majority of rock bass in our Little River sample during 2011 (Figure 12). The most dramatic observation we had in 2011, was the rebound in our catch for this species. In 2008, we observed a dramatic decline in the total number of rock bass collected due to drought conditions. Although not as strong as the 2005 survey we did notice a nice recovery in most size groups in 2011. It is apparent that the drought conditions between 2005 and 2008 have had a more dramatic effect on rock bass than smallmouth bass. The dewatering of critical shoreline habitat is most likely the cause for this observed decline.

Figure 12. Length frequency distributions for rock bass collected in Little River from 2005 to 2011.



Relative stock density (RSD) analysis indicated the value for preferred rock bass (TL ≥ 230 mm) was 0.4. This was down considerably from the value recorded in 2008. RSD for both memorable (TL ≥ 280 mm) and trophy (TL ≥ 330 mm) size rock bass was 0. The PSD (ratio of quality size to stock size) of rock bass was 22.7. Catch by RSD category illustrated nice recovery from the 2008 sample, but did not surpass those values recorded in 2005 (Figure 13).

Figure 13. Relative stock density (RSD) catch per unit effort for rock bass collected in Little River from 2005 to 2011.



Like smallmouth bass, we did not take any otoliths from rock bass collected in Little River. Future surveys of this river should include a sub-sample of otoliths from this species in order to evaluate the age and growth characteristics of the population.

Collaborative community assessments of Little River have been ongoing since the 1980's. These surveys have primarily focused on evaluating relative health changes in the fish community. Two Index of Biotic Integrity surveys were conducted in July 2011, one at Coulters Bridge (river mile 20) and one at Townsend (river mile 29.8). A total of 48 fish species were collected at the Coulters Bridge site while 29 were observed at Townsend. Overall, the IBI analysis indicated the fish community was in excellent condition at Coulters Bridge (IBI score 58). The condition of the fish community decreased slightly from the value observed in 2010. At the upper most station, Townsend, the stream rated good receiving a score of 50 which was a decrease of eight points from the previous sample. (Figure 14). Several rare or endangered species of fish inhabit Little River, and thus, the protection of the watershed is a high priority of managing agencies and local conservation groups. Table 5 lists the species and number of fish collected at the two IBI stations.

Figure 14. Trends in the Index of Biotic Integrity (IBI) at two stations in Little River (1987-2011).

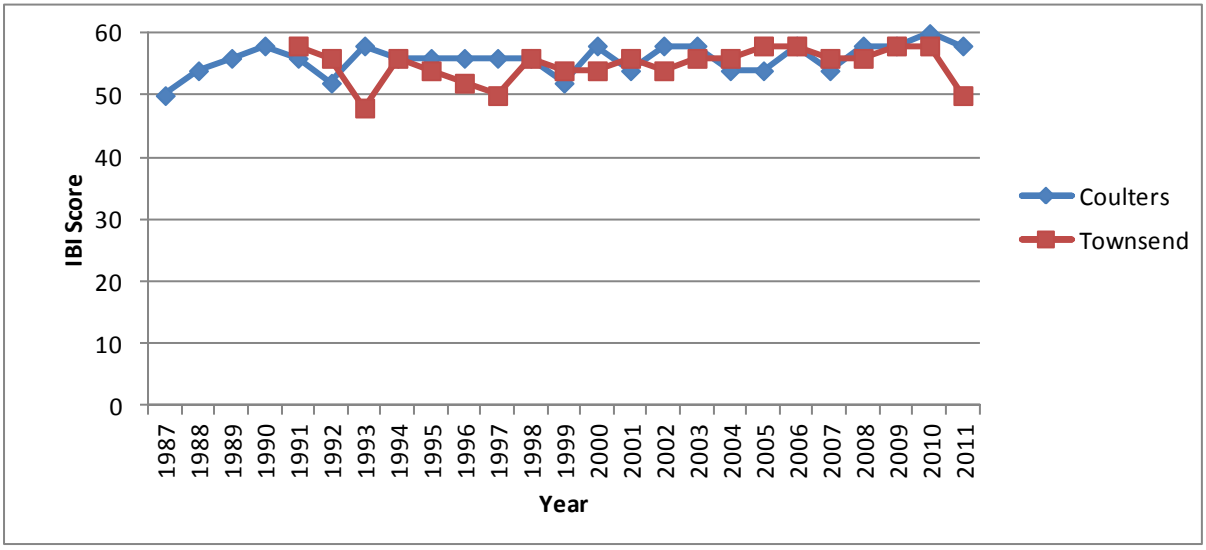


Table 5. Fish species collected at two Little River IBI stations 2011.

Site	Species	Number Collected
420110916 (Coulters Bridge)	*Ambloplites rupestris*	25
420110916 (Coulters Bridge)	*Aplodinotus grunniens*	7
420110916 (Coulters Bridge)	*Campostoma oligolepis*	71
420110916 (Coulters Bridge)	*Cottus carolinae*	16
420110916 (Coulters Bridge)	*Cyprinella galactura*	35
420110916 (Coulters Bridge)	*Cyprinella spiloptera*	31
420110916 (Coulters Bridge)	*Cyprinus carpio*	6
420110916 (Coulters Bridge)	*Dorosoma cepedianum*	5
420110916 (Coulters Bridge)	*Erimystax insignis*	13
420110916 (Coulters Bridge)	*Etheostoma blennioides*	21
420110916 (Coulters Bridge)	*Etheostoma camurum*	2
420110916 (Coulters Bridge)	*Etheostoma jessiae*	8
420110916 (Coulters Bridge)	*Etheostoma rufilineatum*	210
420110916 (Coulters Bridge)	*Etheostoma tennesseense*	4
420110916 (Coulters Bridge)	*Etheostoma zonale*	20
420110916 (Coulters Bridge)	*Fundulus catenatus*	8
420110916 (Coulters Bridge)	*Hybopsis amblops*	44
420110916 (Coulters Bridge)	*Hybrid Lepomis spp.*	2
420110916 (Coulters Bridge)	*Hypentelium nigricans*	26
420110916 (Coulters Bridge)	*Ictalurus punctatus*	2
420110916 (Coulters Bridge)	*Lampetra appendix*	1
420110916 (Coulters Bridge)	*Lepisosteus osseus*	2
420110916 (Coulters Bridge)	*Lepomis auritus*	88
420110916 (Coulters Bridge)	*Lepomis cyanellus*	2
420110916 (Coulters Bridge)	*Lepomis macrochirus*	22
420110916 (Coulters Bridge)	*Lepomis microlophus*	2
420110916 (Coulters Bridge)	*Luxilus chrysocephalus*	12
420110916 (Coulters Bridge)	*Luxilus coccogenis*	29
420110916 (Coulters Bridge)	*Lythrurus lirus*	26
420110916 (Coulters Bridge)	*Micropterus dolomieu*	9
420110916 (Coulters Bridge)	*Micropterus punctulatus*	1
420110916 (Coulters Bridge)	*Micropterus salmoides*	3
420110916 (Coulters Bridge)	*Minytrema melanops*	1
420110916 (Coulters Bridge)	*Moxostoma anisurum*	3
420110916 (Coulters Bridge)	*Moxostoma carinatum*	11
420110916 (Coulters Bridge)	*Moxostoma duquesneii*	111
420110916 (Coulters Bridge)	*Moxostoma erythrurum*	37
420110916 (Coulters Bridge)	*Nocomis micropogon*	28
420110916 (Coulters Bridge)	*Notropis leuciodus*	91
420110916 (Coulters Bridge)	*Notropis micropteryx*	79
420110916 (Coulters Bridge)	*Notropis photogenis*	45
420110916 (Coulters Bridge)	*Notropis telescopus*	22
420110916 (Coulters Bridge)	*Notropis volucellus*	34
420110916 (Coulters Bridge)	*Noturus eleutherus*	14
420110916 (Coulters Bridge)	*Percina caprodes*	7
420110916 (Coulters Bridge)	*Percina evides*	5
420110916 (Coulters Bridge)	*Percina williamsi*	3
420110916 (Coulters Bridge)	*Phenacobius uranops*	6
420110916 (Coulters Bridge)	*Semotilus atromaculatus*	1
420110917 (Townsend)	*Ambloplites rupestris*	26
420110917 (Townsend)	*Campostoma anomalum*	52
420110917 (Townsend)	*Cottus carolinae*	52
420110917 (Townsend)	*Cyprinella galactura*	87
420110917 (Townsend)	*Erimystax insignis*	5
420110917 (Townsend)	*Etheostoma blennioides*	11
420110917 (Townsend)	*Etheostoma rufilineatum*	134
420110917 (Townsend)	*Etheostoma tennesseeense*	16

Table 5. Continued.

Site	Species	Number Collected
420110917 (Townsend)	*Etheostoma zonale*	3
420110917 (Townsend)	*Fundulus catenatus*	3
420110917 (Townsend)	*Hybopsis amblops*	37
420110917 (Townsend)	*Hypentelium nigricans*	22
420110917 (Townsend)	*Ichthyomyzon greeleyi*	2
420110917 (Townsend)	*Lampetra appendix*	4
420110917 (Townsend)	*Lepomis auritus*	6
420110917 (Townsend)	*Lepomis macrochirus*	10
420110917 (Townsend)	*Luxilus chrysocephalus*	5
420110917 (Townsend)	*Luxilus coccogenis*	116
420110917 (Townsend)	*Lythrurus lirus*	4
420110917 (Townsend)	*Micropterus dolomieu*	22
420110917 (Townsend)	*Moxostoma duquesneii*	35
420110917 (Townsend)	*Moxostoma erythrurum*	3
420110917 (Townsend)	*Nocomis micropogon*	54
420110917 (Townsend)	*Notropis leuciodus*	130
420110917 (Townsend)	*Notropis micropteryx*	6
420110917 (Townsend)	*Notropis photogenis*	15
420110917 (Townsend)	*Notropis telescopus*	253
420110917 (Townsend)	*Notropis volucellus*	2
420110917 (Townsend)	*Percina burtoni*	1

Benthic macroinvertebrates collected in our sample at Townsend comprised 40 families representing 59 identified genera (Table 6). The most abundant group in our collection was the mayflies comprising 33% of the total sample. Overall, a total of 75 taxa were identified from the sample of which 39 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Good" (4.3).

Table 6. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from Little River at Townsend 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
AMPHIPODA				0.3
	Crangonyctidae		1	
ANNELIDA				1.1
	Oligochaeta		4	
COLEOPTERA				12.5
	Elmidae	*Ancyronyx variegatus* adult	1	
		Dubiraphia adults	5	
		Macronychus glabratus adults	10	
		Microcylloepus pusillus adult	1	
		Optioservus larva	1	
		Optioservus trivitattus adults	3	
		Promoresia elegans larva and adults	11	
	Gyrinidae	*Gyrinus* adults	3	
	Hydrophilidae	*Enochrus* larvae	1	
	Psephenidae	*Psephenus herricki*	11	
DIPTERA				9.3
	Athericidae	*Atherix lantha*	2	
	Chironomidae		21	
	Simuliidae		4	
	Tanyderidae	*Protoplasa fitchii*	2	
	Tipulidae	*Tipula*	6	
EPHEMEROPTERA				33.2
	Baetidae	*Acentrella*	4	
		Baetis	6	
		Barbaetis benfieldi	2	
		Centroptilum	3	
		Labiobaetis	2	
		Procloeon	1	
	Caenidae	*Caenis*	1	
	Ephemerellidae	*Serratella* early instars	2	
		Serratella deficiens	6	
		Serratella serratoides	3	
	Heptageniidae	*Epeorus rubidus/subpallidus*	2	

Table 6. Continued.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
		Leucrocuta	13	
		Maccaffertium early instars	9	
		Maccaffertium ithaca	7	
		Maccaffertium mediopunctatum	3	
		Maccaffertium modestum	2	
		Rithrogena	1	
		Stenacron pallidum	1	
	Isonychiidae	*Isonychia*	25	
	Leptohyphidae	*Tricorythodes*	10	
	Leptophlebiidae	*Habrophlebiodes*	2	
	Neoephemeridae	*Neoephemera purpurea*	20	
GASTROPODA				8.0
	Hydrobiidae relic		1	
	Pleuroceridae	*Leptoxis*	15	
		Pleurocera pretty striped form	10	
		Pleurocera yellow form	4	
HETEROPTERA				2.4
	Gerridae	*Metrobates hesperius* females	2	
		Rheumatobates rileyi male	1	
		Rheumatobates trulliger male	1	
	Nepidae	*Ranatra buenoi*	1	
	Veliidae	*Rhagovelia obesa* nymph, females and male	4	
HYDRACARINA			1	0.3
MEGALOPTERA				1.6
	Corydalidae	*Corydalus cornutus*	2	
		Nigronia serricornis	4	
ODONATA				11.2
	Aeshnidae	*Boyeria vinosa* mostly early instars	24	
	Calopterygidae	*Hetaerina americana*	3	
	Coenagrionidae	*Argia translata*	1	
	Corduliidae	*Helocordulia uhleri*	1	
	Gomphidae	*Gomphus (*Genus A *rogersi)*	2	
		Hagenius brevistylus	6	
		Stylogomphus albistylus	2	
	Macromiidae	*Macromia*	3	
PELECYPODA				0.8
	Corbiculidae	*Corbicula fluminea*	3	
PLECOPTERA				2.4
	Leuctridae	*Leuctra*	4	
	Perlidae	*Acroneuria abnormis*	1	
		Perlesta	2	
	Pteronarcidae	*Pteronarcys (Allonarcys)*	1	
		Pteronarcys dorsata	1	
TRICHOPTERA				17.0
	Brachycentridae	*Brachycentrus lateralis*	6	
		Micrasema wataga	2	
	Hydropsychidae	*Ceratopsyche morosa*	6	
		Ceratopsyche sparna	1	
		Cheumatopsyche pupa and larvae	11	
		Hydropsyche franclemonti	2	
		Hydropsyche venularis	4	
	Leptoceridae	*Oecetis* early instar	1	
		Oecetis avara	1	
		Triaenodes ignitus	9	
		Triaenodes perna	9	
	Limnephilidae	*Pycnopsyche divergens*	1	
		Pycnopsyche guttifer/scabripennis groups	1	
		Pycnopsyche luculenta	1	
	Polycentropodidae	*Polycentropus*	9	
		Total	**376**	

TAXA RICHNESS = 75 EPT TAXA RICHNESS = 39 BIOCLASSIFICATION = 4.3 (GOOD)

Benthic macroinvertebrates collected in our sample at Coulters Bridge comprised 40 families representing 56 identified genera (Table 7). The most abundant group in our collection was the mayflies comprising 28.6% of the total sample. Overall, a total of 70 taxa were identified from the sample of which 24 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as “Good” (4.3).

Table 7. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from Little River at Coulters Bridge 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
ANELLIDA				2.2
	Oligochaeta		8	
COLEOPTERA				7.6
	Dryopidae	*Helichus* adults	3	
	Dytiscidae	*Celina hubbelli* adult	1	
		Laccophilus maculosus maculosus adult	1	
		Liodessus affinis adult	1	
	Elmidae	*Macronychus glabratus* adults	2	
		Optioservus larvae	2	
		Optioservus trivittatus adults	2	
		Promoresia elegans larvae and adult	3	
		Stenelmis larva	1	
	Gyrinidae	*Dineutus discolor* adult male	1	
	Haliplidae	*Peltodytes duodecimpunctatus* adult	1	
		Peltodytes muticus adult	2	
	Hydrophilidae	*Enochrus ochraceus* adult	1	
		Tropisternus natator adults	3	
	Pshenidae	*Psephenus herricki* larvae	4	
DECAPODA				3.0
	Cambaridae	*Orconectes erichsonianus* juvenile	1	
		Orconectes forceps juveniles	10	
DIPTERA				12.5
	Athericidae	*Atherix lantha*	1	
	Chironomidae		26	
	Culicidae		1	
	Simuliidae		13	
	Tabanidae	*Chrysops*	1	
	Tipulidae	*Tipula*	4	
EPHEMEROPTERA				28.6
	Baetidae	early instars undetermined	6	
		Acentrella	1	
		Baetis	11	
		Centroptilum	1	
		Heterocloeon	2	
	Ephemerellidae	*Serratella deficiens*	6	
		Serratella serratoides	1	
	Ephemeridae	*Ephemera*	1	
	Heptageniidae	*Leucrocuta*	1	
		Maccaffertium early instars	22	
		Maccaffertium mediopunctatum	8	
		Maccaffertium modestum	3	
		Stenacron interpunctatum	1	
	Isonychiidae	*Isonychia*	32	
	Leptohyphidae	*Tricorythodes*	9	
GASTROPODA				10.4
	Physidae		1	
	Planorbidae		2	
	Pleuroceridae	*Leptoxis*	15	
		Pleurocera sp. with stripes	18	
		Pleurocera sp. yellow	2	
HYDRACARINA			2	0.5
ISOPODA				0.3
	Asellidae	*Caecidotea*	1	
MEGALOPTERA				1.4
	Corydalidae	*Corydalus cornutus*	5	
ODONATA				12.3
	Aeshnidae	*Basiaeshna janata*	4	
		Boyeria vinosa	9	
	Calopterygidae	*Calopteryx*	2	
		Hetaerina americana	8	
	Coenagrionidae	*Argia*	1	
	Cordulegastridae	*Cordulegaster* early instar	1	
	Gomphidae	*Dromogomphus spinosus*	1	
		Gomphus lividus	4	
		Gomphurus lineatifrons	1	
		Hagenius brevistylus	2	
		Lanthus vernalis	3	
		Stylogomphus albistylus	4	
	Macromiidae	*Macromia*	5	
PELECYPODA				4.4
	Corbiculidae	*Corbicula fluminea*	16	
PLECOPTERA				1.1
	Perlidae	*Perlesta*	2	
	Pteronarcyidae	*Pteronarcys dorsata*	2	

Table 7. Continued.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
TRICHOPTERA				15.5
	Brachycentridae	*Brachycentrus lateralis*	3	
		Micrasema wataga	4	
	Hydropsychidae	*Ceratopsyche morosa*	3	
		Cheumatopsyche	19	
		Hydropsyche early instars	5	
		Hydropsyche venularis	5	
	Leptoceridae	*Oecetis avara*	2	
		Triaenodes ignitus	1	
	Philopotamidae	*Chimara*	14	
	Polycentropodidae	*Polycentropus*	1	
TURBELLARIA			1	0.3
		Total	**367**	
TAXA RICHNESS = 70	**EPT TAXA RICHNESS = 24**	**BIOCLASSIFICATION = (4.3) GOOD**		

Discussion

Little River provides anglers with the opportunity to catch all species of black bass along with rock bass. Because of the low numbers of spotted and largemouth bass in Little River, it should not be considered a viable sport fishery for these species.

The river represents an outstanding resource in the quality of the water and the species that inhabit it. With the growing development in the watershed it will be imperative to monitor activities such that mitigation measures can be taken to ensure that the river maintains its outstanding water quality and aesthetic value. Continued efforts by the watershed group will continue to play an important role in the management of the watershed and serve as a "watchdog" for unregulated activities.

Trout stocking during suitable months is very popular for residents and non-residents visiting the area. This program should continue at the current level unless use dictates the need for program expansion.

TWRA should continue to be involved with the cooperative community assessment surveys each year. The results of these surveys are important indicators of the health of one of the region's best streams and serves as a benchmark in evaluating other streams of similar size and character. Effective March 1, 2009, smallmouth bass regulations in Little River from Rockford Dam upstream to the Great Smoky Mountains National Park boundary will protect bass 13 to 17 inches in length. One fish of the five fish daily creek limit can exceed 17 inches. Sport fishery surveys on Little River will be conducted on a three-year rotation in order to assess any changes in the fishery. Our return trip in 2014 to look at the sport fish will in all likelihood focus on the sample sites surveyed in 2011, providing no new or more efficient sampling scheme is developed.

Management Recommendations

1. Initiate an angler use and harvest survey.

2. Develop a fishery management plan for the river.

3. Cooperate with the local watershed organization to protect and enhance the river and its tributaries.

Titus Creek

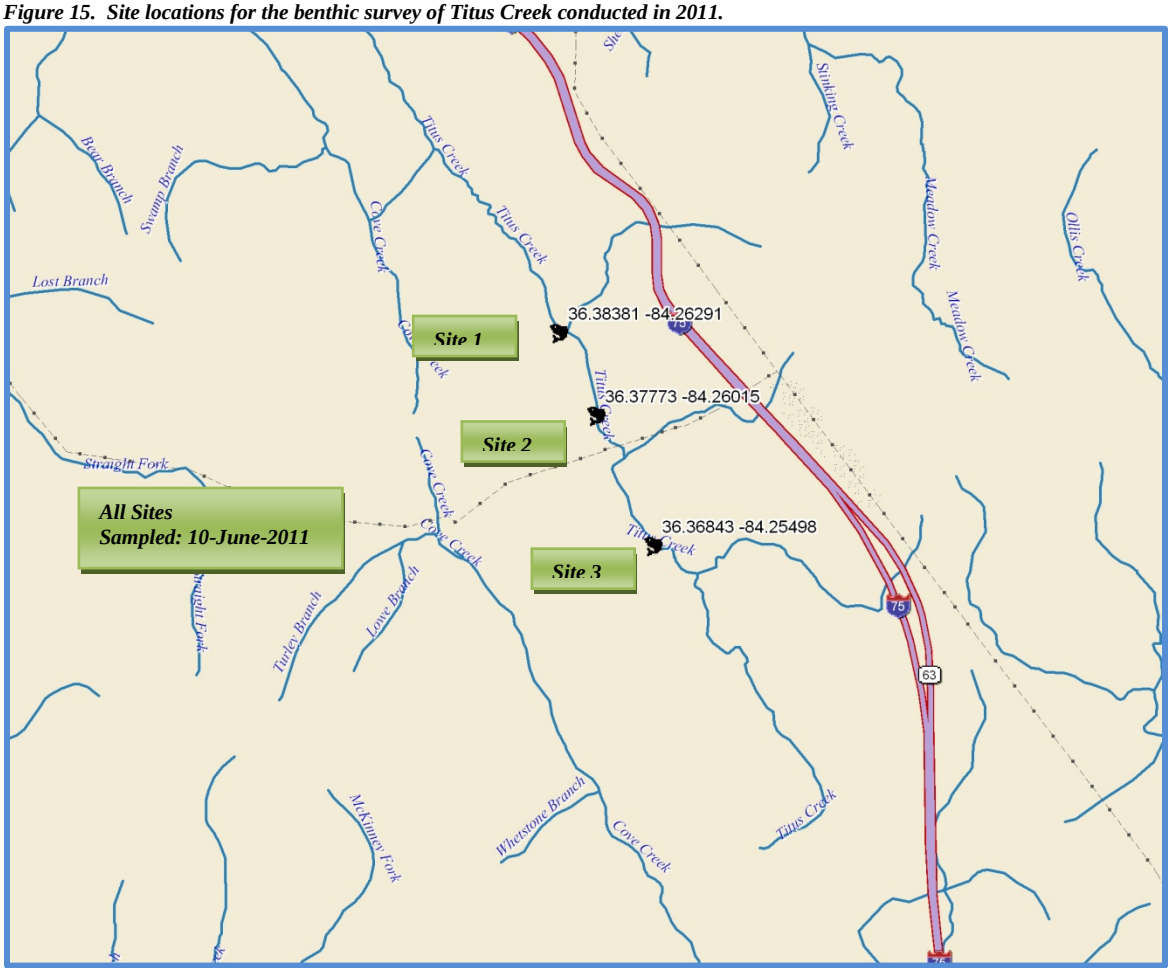
Introduction

The recent invasion of Hemlock Woolly Adelgid (HWA) into the Eastern U.S. has resulted in a unified effort by many natural resource management agencies to develop strategies to manage this exotic insect. Tennessee has been no exception to this effort, creating a HWA taskforce in 2005 to develop a management plan for the state's forest resources. This insect, when established in sufficient densities, attack hemlocks ultimately killing trees in a stand or the whole stand depending on the infestation level.

Study Area and Methods

In the spring of 2010, we were asked by TWRA's Forestry Division and the U.S. Forest Service to conduct a benthic macroinvertebrate survey of Titus Creek. Specifically, the request wanted us to characterize the benthic community before the release of an insect killing fungus targeted at controlling HWA in an experimental stand of hemlocks. On June 10, 2011 we reassessed three areas selected in Titus Creek during 2010 to evaluate the effects of the aerial application of the fungal agent Mycotal (Figure 15).

Figure 15. Site locations for the benthic survey of Titus Creek conducted in 2011.



The stream at these locations averaged about 3-4 meters in width and had a low to moderate grade. There was a prevalence of sand and bedrock in the sample. Beaver activity was prevalent at the middle site and had altered much of the stream habitat. Cobbles were fairly abundant with gravels being the least

abundant substrate component in our sample areas. Riffles were infrequent, but where they did occur, provided adequate habitat for collecting benthic organisms.

Results

We collected aquatic insects from Titus Creek (site 1) during a combined two hour effort. Benthic macroinvertebrates collected at the site comprised 24 families representing 32 identified genera (Table 8). The most abundant group in our collection was the caddisflies comprising 33.6% of the total sample. Overall, a total of 37 taxa were identified from the sample of which 18 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Good" (4.0).

Table 8. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from Titus Creek (Site 1) June 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
COLEOPTERA				10.4
	Dryopidae	*Helichus* adults	15	
	Elmidae	*Optioservus ovalis*	2	
		Optioservus trivittatus	2	
		Stenelmis adults	9	
	Hydrophilidae	*Hydrobius*	1	
DIPTERA				13.9
	Chironomidae	Larvae	27	
	Tlipulidae	*Dricanota*	1	
		Hexatoma	4	
		Tipula	7	
EPHEMEROPTERA				6.1
	Ephemeridae	*Ephemera*	1	
	Heptageniidae	*Maccaffertium* early instars	3	
		Maccaffertium pudicum	2	
		Maccaffertium vicarium	2	
		Stenacron pallidum	4	
	Isonychiidae	*Isonychia*	4	
	Leptophlebiidae	*Habrophlebiodes*	1	
HETEROPTERA				19.3
	Gerridae	*Aquarius remigis* males & female	5	
		Aquarius nymphs	3	
	Veliidae	*Rhagovelia obesa* nymph, males & females	46	
MEGALOPTERA				3.9
	Corydalidae	*Nigronia fasciatus*	1	
		Nigronia serricornis	8	
	Sialidae	*Sialis*	2	
ODONATA				6.8
	Aeshnidae	*Boyeria grafiana*	2	
	Cordulegastridae	*Cordulegaster maculate*	2	
	Gomphidae	*Gomphus lividus*	5	
		Gomphus rogersi	3	
		Stylogomphus sigmastylus	7	
PLECOPTERA				6.1
	Leuctridae	*Leuctra*	1	
	Peltoperlidae	*Peltoperla*	1	
	Perlidae	*Acroneuria abnormis*	5	
		Eccoptura xanthenes	1	
		Perlesta	8	
	Perlodidae	*Malirekus/Yugus*	1	
TRICHOPTERA				33.6
	Hydropsychidae	*Ceratopsyche sparna*	1	
		Cheumatopsyche	87	

Table 8. Continued.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
TRICHOPTERA	Limnephilidae	*Pycnopsyche luculenta* group	1	
	Philopotamidae	*Chimarra*	2	
		Dolophilodes distincta	2	
	Rhyacophilidae	*Rhyacophila* pupa	1	

TAXA RICHNESS = 35 EPT TAXA RICHNESS = 18 BIOCLASSIFICATION = 4.0 (GOOD)

We collected aquatic insects from Titus Creek (site 2) during a combined two hour effort. Benthic macroinvertebrates collected at the site comprised 26 families representing 31 identified genera (Table 9). The most abundant group in our collection was the caddisflies comprising 27.8% of the total sample. Overall, a total of 35 taxa were identified from the sample of which 18 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Good" (4.0).

Table 9. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from Titus Creek (Site 2) June 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
ANNELIDA				1.0
	Oligochaeta		2	
COLEOPTERA				5.1
	Dryopidae	*Helichus* adults	9	
	Dytiscidae	*Hydroporus* adult	1	
DIPTERA				9.6
	Athericidae	*Atherix lantha*	9	
	Chironomidae	larvae	9	
	Tabanidae	*Chrysops*	1	
EPHEMEROPTERA				10.6
	Baetidae	*Baetis*	2	
		Acentrella	6	
	Heptageniidae	*Maccaffertium ithaca*	8	
		Stenacron pallidum	4	
	Isonychiidae	*Isonychia*	1	
HETEROPTERA				28.3
	Gerridae	*Aquarius* nymph	6	
		Aquarius remigis adults	9	
	Veliidae	*Rhagovelia obesa* adults	41	
MEGALOPTERA				2.5
	Corydalidae	*Corydalus cornutus*	2	
		Nigronia fasciatus	1	
		Nigronia serricornis	1	
	Sialidae	*Sialis*	1	
ODONATA				3.5
	Aeshnidae	*Boyeria grafiana*	1	
	Calopterygidae	*Calopteryx dimidiata*	1	
	Cordulegastridae	*Cordulegaster maculata*	3	
	Gomphidae	*Gomphus lividus*	1	
		Gomphus rogersi	1	
PLECOPTERA				11.6
	Chloroperlidae	*Sweltsa* early instar	1	
	Peltoperlidae	*Peltoperla*	2	
	Perlidae	*Perlesta*	16	
	Perlodidae	*Malirekus/Yugus* early instars	4	
TRICHOPTERA				27.8
	Glossosomatidae	*Glossosoma nigrior*	5	
	Hydropsychidae	*Ceratopsyche sparna*	3	
		Cheumatopsyche	21	
		Hydropsyche betteni/depravata	8	
		undetermined pupa	1	
	Philopotamidae	Chimarra	7	
		Dolophilodes distincta larvae & pupa	3	
		Wormaldia	2	
	Polycentropodidae	*Polycentropus* larva & pupae	4	
	Rhyacophilidae	*Rhyacophila carolina*	1	

TAXA RICHNESS = 35 EPT TAXA RICHNESS = 18 BIOCLASSIFICATION = 4.0 (GOOD)

We collected aquatic insects from Titus Creek (site 3) during a combined two hour effort. Benthic macroinvertebrates collected at the site comprised 28 families representing 38 identified genera (Table 10). The most abundant group in our collection was the caddsiflies comprising 26.4% of the total sample. Overall, a total of 46 taxa were identified from the sample of which 21 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Good" (4.0).

Table 10. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from Titus Creek (Site 3) June 2011.

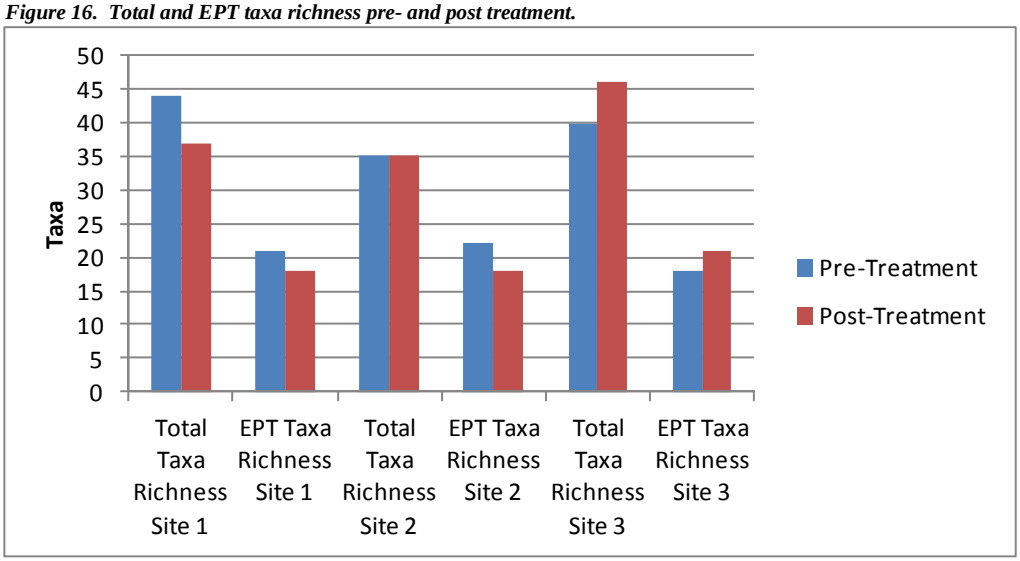
ORDER	FAMILY	SPECIES	NUMBER	PERCENT
COLEOPTERA				3.7
	Dryopidae	*Helichus* adults	6	
	Dytiscidae	*Acilius mediatus*	1	
	Elmidae	*Optoservus trivittatus*	1	
DIPTERA				9.3
	Athericidae	*Atherix lantha*	4	
	Chironomidae	larvae	11	
	Tipulidae	*Tipula*	5	
EPHEMEROPTERA				10.6
	Baetidae	*Baetis*	1	
	Caenidae	*Caenis*	2	
	Ephemerellidae	*Eurylophella*	1	
	Heptageniidae	*Heptagenia*	1	
		Maccaffertium ithaca	8	
		Maccaffertium vicarium	2	
		Stenacron interpunctatum	3	
	Isonychiidae	*Isonychia*	5	
GASTROPODA				0.5
	Planorbidae		1	
HETEROPTERA				12.0
	Belostomatidae	*Lethocerus*	1	
	Gerridae	*Aquarius* nymphs	8	
		Aquarius conformis males & female	5	
	Veliidae	*Rhagovelia obesa* adults	12	
MEGALOPTERA				4.6
	Corydalidae	*Corydalus cornutus*	2	
		Nigronia fasciatus	1	
		Nigronia serricornis	1	
	Sialidae	*Sialis*	6	
NEMATOMORPHA				0.5
		Nematomorpha sp.	1	
ODONATA				14.8
	Aeshnidae	*Boyeria grafiana*	1	
		Boyeria vinosa	1	
	Calopterygidae	*Calopteryx dimidiata*	3	
	Cordulegastridae	*Cordulegaster erronea*	1	
		Cordulegaster maculata	1	
	Gomphidae	*Gomphus lividus*	16	
		Hagenius brevistylus	1	
		Lanthus vernalis	7	
		Stylogomphus sigmastylus	1	
PLECOPTERA				17.6
	Perlidae	*Acroneuria abnormis*	2	
		Perlesta	35	
	Perlodidae	*Malirekus/Yugus*	1	
TRICHOPTERA				26.4
	Glossosomatidae	*Glossosoma nigrior*	1	
	Hydropsychidae	*Cheumatopsyche*	35	
		Ceratopsyche sparna	1	
		Diplectrona modesta	5	
		Hydropsyche betteni/depravata	2	
	Limnephilidae	*Pycnopsyche guttifer/scabripennis* group	2	
		Pycnopsyche luculenta group	1	
	Philopotamidae	*Chimarra*	8	
		Wormaldia	1	
	Polycentropodidae	*Polycentropus*	1	

TAXA RICHNESS = 46 EPT TAXA RICHNESS = 21 BIOCLASSIFICATION = 4.0 (GOOD)

Discussion

Our pre- and post treatment surveys revealed very little change in the benthic community. The observed differences were within the amount of sampling variability associated with these types of surveys. Total and EPT taxa richness was very similar between the samples indicating that there was most likely no effect from the application of the HWA control agent (Figure 16).

Figure 16. Total and EPT taxa richness pre- and post treatment.



Management Recommendations

1. Conduct surveys as prescribed to evaluate future application of Mycotal.

Powell River

Introduction

The remoteness of the Powell River makes it one of the premier warmwater rivers in east Tennessee. It offers the opportunity to take float trips without seeing another individual during the course of a day. The surroundings are appealing which makes a trip to the Powell well worth the drive. It is an important recreational resource for the state both in consumptive and non-consumptive uses. It provides critical habitat for threatened and endangered species and species of special concern. The river supports a diverse fish community and has been documented to host some 37 species of mussels (Ahlstedt 1986). It is one of only two rivers in the region having reaches designated as mussel sanctuaries. Additionally, it supports one of east Tennessee's better warmwater sport fisheries. The Powell River has been the focus of numerous surveys and investigations conducted by other state and federal agencies with the major purpose of assessing and monitoring the fish and benthic communities. The Agency has made limited surveys of the river that focused primarily on collecting basic fish, benthic, and water quality data (Bivens 1988, Carter et al. 2000, 2003, 2004, 2006). Our survey of the Powell River focused on re-evaluating the sport fish population originally sampled in 1999. Our 2011 assessment was derived from nine sample sites located between river mile 115 and river mile 75. We were unable to sample our two most downstream sites to due to boat problems and low water flows. After our initial evaluation in 1999, the Powell River was put into a 3-year rotational schedule with eight other rivers in the region. Sport fish sampling sites were reduced to those that would best characterize these populations. In March 2008, smallmouth bass regulations were changed to a protected slot limit (PLR) which prohibits the take of bass between 13 and 17 inches. The regulation allows anglers to keep one bass in excess of 17 inches as part of the five fish daily creel limit.

Study Area and Methods

The Powell River originates in Virginia and flows in a southwesterly direction before emptying into Norris Reservoir near river mile 54. The river has a drainage area of approximately 1,774 kilometers^2. In Tennessee, all of the Powell River flows through the Ridge and Valley province of east Tennessee coursing by the town of Harrogate before emptying into Norris Reservoir near the community of Arthur. Public access along the river is primarily limited to bridge crossings and small "pull-outs" along roads paralleling the river. There are several primitive launching areas for canoes or small boats and one developed launching area

managed by the Tennessee Wildlife Resources Agency (Mulberry Creek).

Between April 25 and 26, 2011, we conducted nine fish surveys between the Virginia state line and Norris Reservoir (Figure 17). In our survey sites, the riparian habitat consisted primarily of wooded shorelines with interspersed agricultural fields. Submerged woody debri and water willow were fairly common in most of our sample areas. The river substrate was predominately boulder/cobble in riffle areas and bedrock with interspersed boulder/cobble in the pool habitat. Measured mean channel widths ranged from 29.5 meters to 52.0 meters, while site lengths fell between 290 meters and 649 meters (Table 11). Water temperatures ranged from 18 C to 20 C and conductivity varied from 330 to 370 µs/cm (Table 11).

Figure 17. Site locations for samples conducted in the Powell River during 2011.

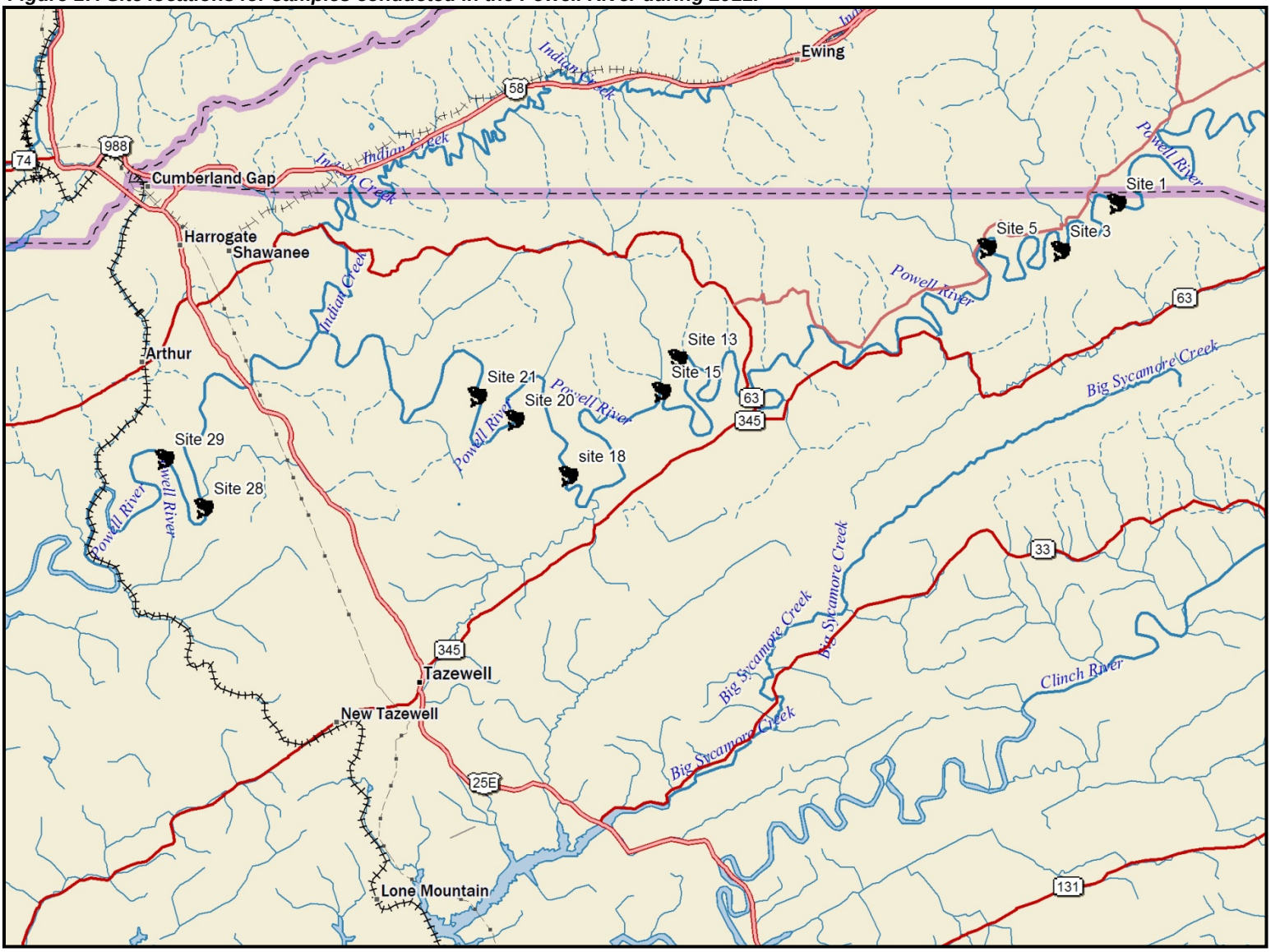


Table 11. Physiochemical and site location data for samples conducted in the Powell River during 2011.

Site Code	Site	Quad	River Mile	Latitude	Longitude	Mean Width (m)	Length (m)	Temp. C	Cond. µs/cm	Secchi (m)
420110801	1	Back Valley	115	36.59472	-83.31444	29.5	290	20	370	1.6
420110803	3	Back Valley	112.1	36.58111	-83.33472	30	577	18	350	1.6
420110805	5	Back Valley	107.6	36.58194	-83.36194	33.5	480	18	370	1.6
420110813	13	Coleman Gap	91	36.54917	-83.47417	38.5	537	18	332	1.6
420110815	15	Coleman Gap	87.1	36.53972	-83.48028	39	649	18.8	340	1.6
420110818	18	Wheeler	81	36.51500	-83.51444	40	383	19.5	330	1.6
420110820	20	Wheeler	77.3	36.53139	-83.53389	38	570	20	340	1.6
420110821	21	Wheeler	75	36.53833	-83.54750	38.5	467	20	340	1.6
420110828	28	Middlesboro South	61	36.50528	-83.64861	52	452	20	330	1.6
420110829	29	Middlesboro South	59	36.51981	-83.66189	41.5	479	-	-	-
(no sample)										

Fish were collected by boat electrofishing in accordance with the standard large river sampling protocols (TWRA 1998). Fixed-boom electrodes were used to transfer 4-5 amps DC at all sites. This current setting was determined effective in narcotizing all target species (black bass and rock bass). All sites were sampled during daylight hours and had survey durations ranging from 900 to 911 seconds. Catch-per-unit-effort (CPUE) values were calculated for each target species at each site. Length categorization indices were calculated for target species following Gabelhouse (1984).

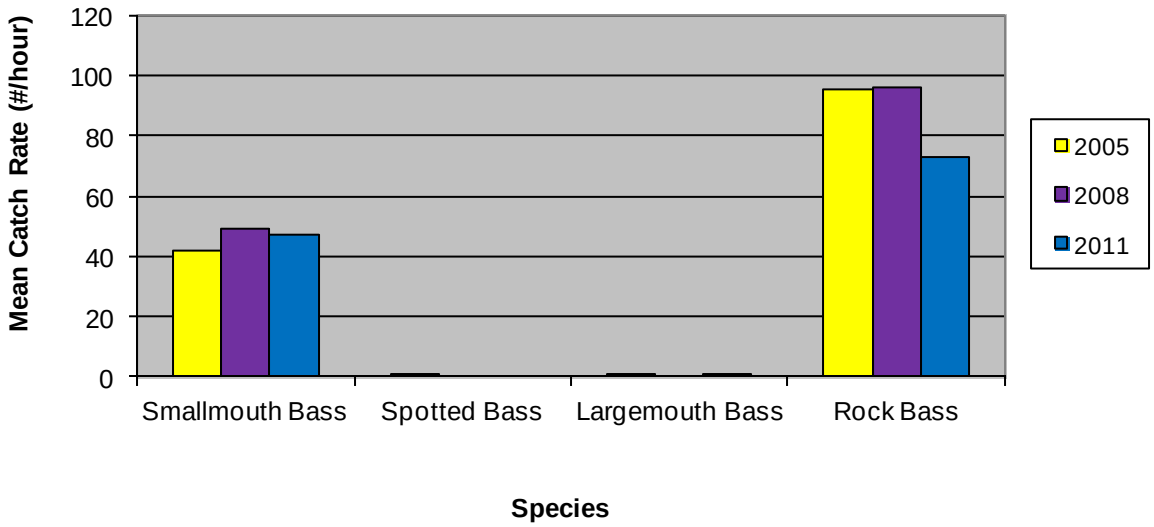
Results

CPUE estimates for smallmouth bass averaged 47.1/hour (SD 45.7), while the mean rock bass estimate was 73.3/hour (SD 65.9) (Table 12). Comparatively, there was a slight decline (5%) in the catch of smallmouth bass from the 2008 sample. The decline was more substantial with rock bass (23%) (Figure 18). There were no spotted bass and only one largemouth bass collected in the 2011 sample. Overall, the contribution of largemouth bass and spotted bass to the overall fishery has been insignificant in this and past surveys.

Table 12. Catch per unit effort and length categorization indices of target species collected in the Powell River during 2011.

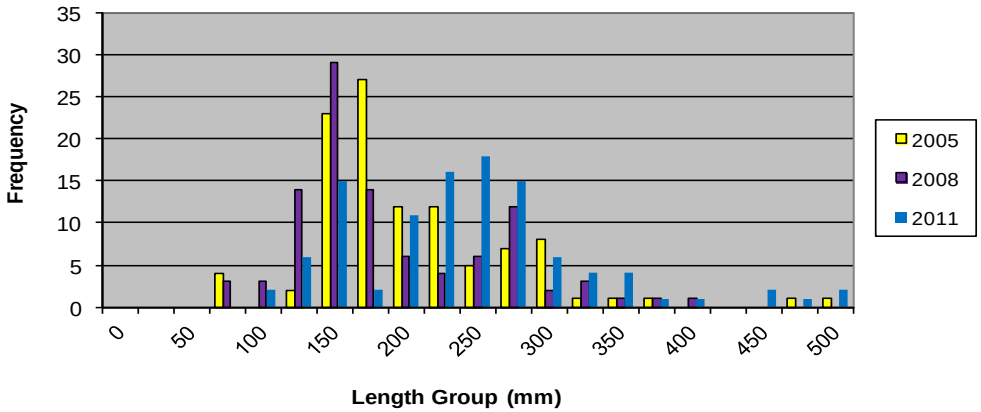
Site Code	Smallmouth Bass CPUE	Spotted Bass CPUE	Largemouth Bass CPUE	Rock Bass CPUE
420110801	24	-	-	24
420110803	24	-	4	68
420110805	32	-	-	60
420110813	164	-	-	240
420110815	52	-	-	48
420110818	32	-	-	48
420110820	20	-	-	92
420110821	20	-	-	24
420110828	56	-	-	56
420110829	-	-	-	-
MEAN	47.1	0	0.4	73.3
STD. DEV.	45.7	0	1.3	65.9
	Length-Categorization Analysis	**Length-Categorization Analysis**	**Length-Categorization Analysis**	**Length-Categorization Analysis**
	PSD = 40.2	PSD = 0	PSD = 0	PSD = 34.3
	RSD-PREFERRED = 13.4	RSD-PREFERRED = 0	RSD-PREFERRED = 0	RSD-PREFERRED = 2.4
	RSD-MEMORABLE = 6.0	RSD-MEMORABLE = 0	RSD-MEMORABLE = 0	RSD-MEMORABLE = 0
	RSD- TROPHY = 2.4	RSD- TROPHY = 0	RSD- TROPHY = 0	RSD- TROPHY = 0

Figure 18. Trends in mean catch rate of black bass and rock bass collected from 2005 to 2011 in the Powell River.



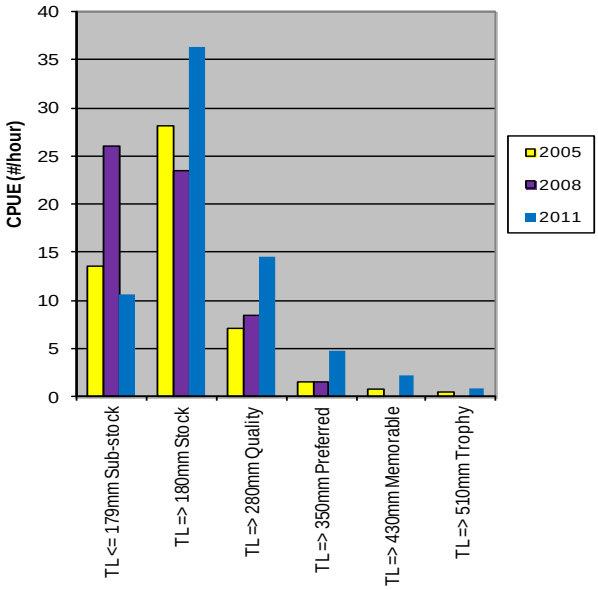
The size distribution of smallmouth bass between 2005 and 2011illustrated a substantial shift in the number of fish in larger size classes (Figure 19). The most dramatic increases were observed within the 225 to 350 mm size classes. The occurrence of bass 450 mm and larger was the highest we have observed in the river since sampling began in 1999. Generally, we observed good recruitment into most of the size classes with the exception of those less than 200 mm. In these cases, we generally observed fewer fish when compared to 2005 and 2008.

Figure 19. Length frequency distributions for smallmouth bass collected in the Powell River from 2005 to 2011.



Length categorization analysis indicated the relative stock density (RSD) of preferred smallmouth bass (TL ≥ 350 mm) was 13.4. This was double the value observed in 2008 (Table 4). RSD for memorable (TL ≥ 430 mm) and trophy (TL ≥ 510 mm) size bass was 6 and 2.4, respectively. The PSD of smallmouth bass (ratio of quality size bass to stock size bass) increased from 36.2 in 2008 to 40.2 in 2011. With the exception of the sub-stock category our catches in all other size categories increased considerably from the 2008 sample (Figure 20). There were no spotted bass or largemouth bass collected in the 2008 surveys. Historically, these species contribution to the overall fishery has been insignificant.

Figure 20. Relative stock density (RSD) catch per unit effort for smallmouth bass collected in the Powell River from 2005 to 2011.

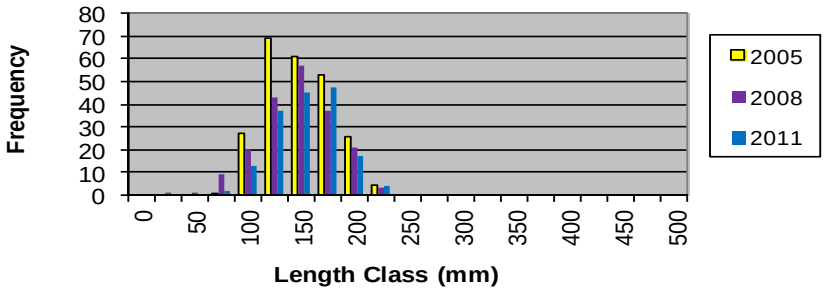


Age and growth characteristics for the smallmouth bass population in the Powell River were characterized in 1999 (Carter et al. 2000). For the most part,

the Powell River has had growth rates somewhat slower than other large river populations with the same age structure. We did not collect otoliths from smallmouth bass in 2011, assuming that the values generated from the 1999 survey typify the general growth characteristics of this population. In general, it takes a smallmouth bass in the Powell River about 5.2 years to reach 305 mm (12 inches), and about 9.5 years to attain a length of 406 mm (16 inches).

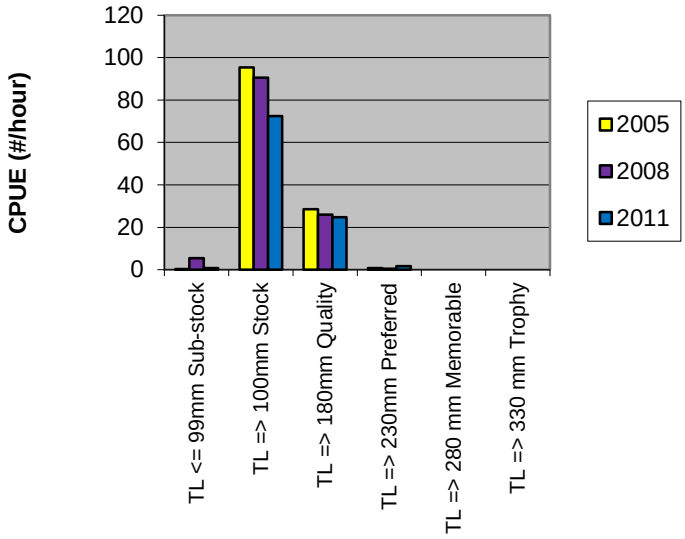
Individuals in the 100 to 200 mm range represented the majority of rock bass in our samples in 2011 (Figure 21). For the most part, the distributions among years were fairly similar, although there were fewer representatives in each size class during 2011 for most size groups.

Figure 21. Length frequency distributions for rock bass collected in the Powell River from 2005 to 2011.



Length categorization analysis indicated the RSD for preferred rock bass (TL $\underline{\geq}$ 230 mm) was 2.4, which was up from 0.5 in 2005. RSD for both memorable (TL $\underline{\geq}$ 280 mm) and trophy (TL $\underline{\geq}$ 330 mm) size rock bass was 0. The PSD of rock bass was 34.3 which was also an increase from the value observed in 2008. For the most part, we observed declines in all size categories with the exception of the RSD-preferred which increased slightly over the 2008 value. (Figure 22).

Figure 22. Relative stock density (RSD) catch per unit effort for rock bass collected in the Powell River from 2005 to 2011.



Discussion

The Powell River provides anglers with the opportunity to catch all species of black bass along with rock bass. Because of the low numbers of spotted and largemouth bass in the Powell River, it should not be considered a sport fishery for these species.

The popularity of this riverine fishery is continuing to grow as more anglers shift from reservoir habitats to rivers. This trend will undoubtedly continue as the use on reservoirs increases. This type of potential for exploitation of riverine fisheries requires angler use/harvest data collection in order to effectively manage the resource. It is imperative that we obtain this data in order to answer fish management questions, public inquiries, and aid in the development of regulations. Recent Index of Biotic Integrity surveys by TVA have indicated that the Powell River is in "good to excellent" condition based on data from one long-term monitoring station.

Overall the Powell River represents one of east Tennessee's premier warmwater river resources. It provides anglers with the opportunity to catch good numbers of smallmouth bass and rock bass and has the potential of producing memorable catches (both in number and size). The surrounding landscape is as eye appealing as the wildlife that lives in and around the river. It provides an excellent escape for recreationists (consumptive and non-consumptive) who are looking for a river that offers relatively undisturbed surroundings and a diverse community of wildlife.

Despite record drought in recent years, the smallmouth and rock bass populations in the river seem to have been able to persist at levels similar to pre-drought conditions, although we suspect that the situation was stressful to these segments of the fish community we have not observed any lasting impacts to the population. Surveys on the Powell River will be conducted on a three-year rotation in order to assess any changes in the fishery. Our return trip in 2014 will in all likelihood repeat those samples conducted in 2011.

Management Recommendations

1. Initiate an angler use and harvest survey.

2. Develop a fisheries management plan for the river.

Nolichucky River

Introduction

The Nolichucky River represents an important recreational resource for the state both in consumptive and non-consumptive uses. It provides critical habitat for species of special concern and is home to approximately 50 species of fish and has historically supported at least 21 species of mussels (Ahlstedt 1986). Additionally, it supports one of east Tennessee's better warmwater sport fisheries. The Nolichucky River and its tributaries have been the subject of numerous biological and chemical investigations that span some 40 years. These investigations have concentrated on evaluating pollution levels and documenting sources for mitigation. Much of the upper reach of the Nolichucky River has been consistently impacted by sand dredging and mica mining in North Carolina and extensive agricultural development along the entire length in Tennessee. However, in recent years, the Nolichucky River has improved in water quality as a result of mitigation and education conducted during these early studies. The Agency has made limited surveys of the river that focused primarily on collecting basic fish, benthic, and water quality data (Bivens 1988). Extensive sport fish population surveys were conducted in 1998 (Carter et al. 1999) from the North Carolina state line to the French Broad River. Our survey of the Nolichucky River focused on re-evaluating the sport fish populations and developing long-term community assessment sites. Our 2011 assessment of the sport fish populations was derived from 10 sample sites between river mile 27.9 and mile 99.1. Our 1998 survey consisted of 31 sample sites, falling between river mile 7.6 and mile 99.1. After our initial evaluation in 1998, the Nolichucky River was put into a 3-year rotational sampling schedule with eight other rivers. Sport fish sampling sites were reduced to those that would best characterize these populations. In March 2008, smallmouth bass regulations were changed to a protected slot limit (PLR) which prohibits the take of bass between 13 and 17 inches. The regulation allows anglers to keep one bass in excess of 17 inches as part of the five fish daily creel limit.

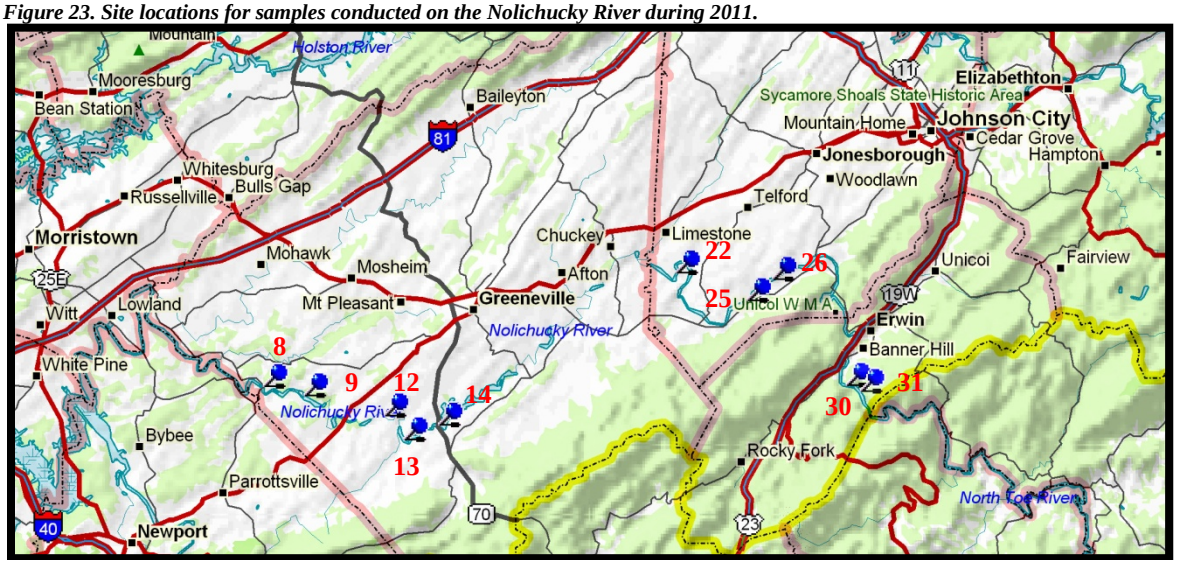
Study Area and Methods

The Nolichucky River originates in North Carolina and flows in a southwesterly direction before emptying into the French Broad River near river mile 69.0. The river has a drainage area of approximately 2,827 kilometers^2. In Tennessee, approximately 159 kilometers of the Nolichucky River flows through the Blue Ridge and Ridge and Valley provinces, coursing through or by the towns of Erwin, Greeneville, and Morristown before joining the French Broad River near the community of White Pine.

Public access (found in Unicoi, Washington, Greene, Cocke, and Hamblen counties) along the river is primarily limited to bridge crossings and small "pull-outs" along roads paralleling the river. There are several primitive launching areas for canoes or small boats and five developed launching areas managed by the Tennessee Wildlife Resources Agency (Easterly Bridge, Birds Bridge, and Davy Crocket State Park), the City of Greeneville (Kinser Park), and the U.S. Forest Service (Chestoa).

Between May 2 and June 3, 2011 we conducted 10 fish surveys between the North Carolina state line and the French Broad River (Figure 23).

Figure 23. Site locations for samples conducted on the Nolichucky River during 2011.



In our survey sites, the riparian habitat consisted primarily of wooded shorelines with interspersed agricultural fields. There were several reaches of the river where one or both sides of the river were confined within rock palisades. Submerged woody debri was fairly common in most of our sample areas. The river substrate was predominately boulder/cobble in riffle areas and bedrock with interspersed boulders/cobble in the pool habitat. Measured mean channel widths ranged from 50 meters to 100.6 meters, while site lengths fell between 241 meters and 1,224 meters (Table 13). Water temperatures ranged from 15.5 C to 29.5 C and conductivity varied from 50 to 225 (Table 13).

Table 13. Physiochemical and site location data for samples conducted on the Nolichucky River during 2011.

Site Code	Site	Quad	River Mile	Latitude	Longitude	Mean Width (m)	Length (m)	Temp. C	Cond.	Secchi (m)
420110708	8	Parrottsville 172SE	27.9	36.09707	-83.05132	87.3	1094	29.5	225	1.3
420110709	9	Parrottsville 172SE	30.9	36.09037	-83.00844	57.3	321	28	215	1.3
420110712	12	Cedar Creek 181SW	39.1	36.07348	-82.92312	59.6	663	23	165	-
420110713	13	Cedar Creek 181SW	42.5	36.05399	-82.90385	100.6	650	23.5	160	-
420110714	14	Davy Crockett Lake 181SE	45.7	36.06542	-82.86884	80.5	1224	23	150	-
420110722	22	Telford 190NE	71.4	36.19329	-82.62080	66.3	300	19	100	2.6
420110725	25	Telford 190NE	80.3	36.17006	-82.54678	57.7	890	18	80	2.6
420110726	26	Telford 190NE	82.9	36.18831	-82.51960	50	769	19	90	2.6
420110730	30	Chestoa 199SW	98	36.09918	-82.44337	53.3	241	15.5	50	-
420110731	31	Chestoa 199SW	99.1	36.09449	-82.42855	80.3	426	15.5	50	-

Fish were collected by boat electrofishing in accordance with the standard large river sampling protocols (TWRA 1998). Fixed-boom electrodes were used to transfer 4-5 amps DC at all sites. This current setting was determined effective in narcotizing all target species (black bass and rock bass). All sites were sampled during daylight hours and had survey durations ranging from 1,086 to 2,681 seconds. Catch-per-unit-effort (CPUE) values were calculated for each target species at each site. Length categorization indices were calculated for target species following Gabelhouse (1984).

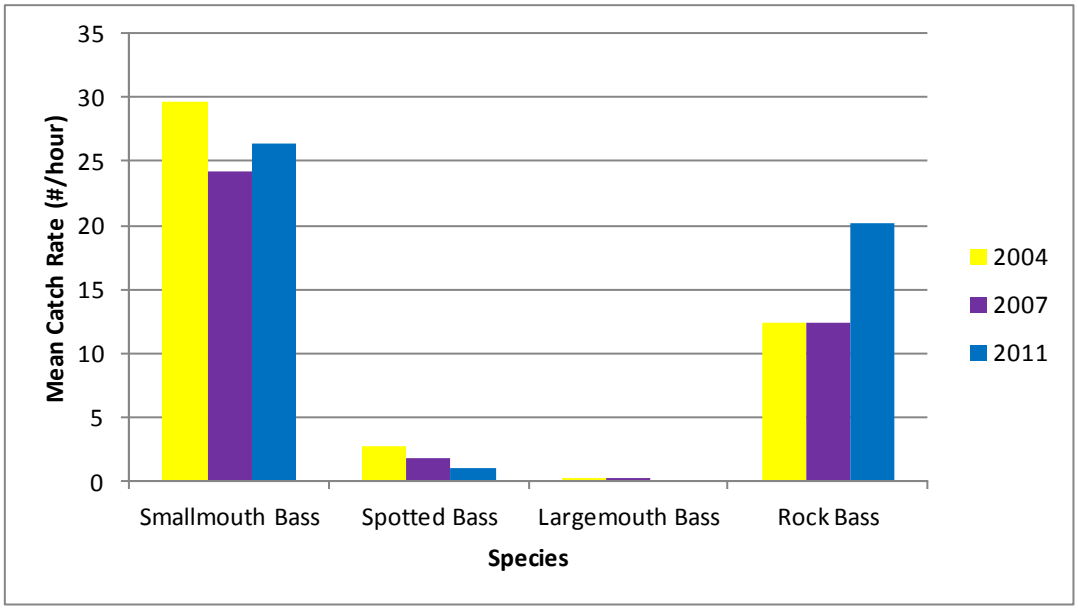
Results

CPUE estimates for smallmouth bass averaged 26.4 (SD 22.3). The rock bass estimate was 20.1 (SD 24). There were very few spotted bass and no largemouth bass collected during the survey (Table 14). Comparatively, the catch rate for smallmouth bass was very similar to the value observed in 2007 (24.2). The spotted bass and largemouth bass values remained low as in the previous sample, while rock bass catch improved considerable over the value observed in 2007 (Figure 24).

Table 14. Catch per unit effort and length categorization indices of target species collected at 10 sites in the Nolichucky River during 2011.

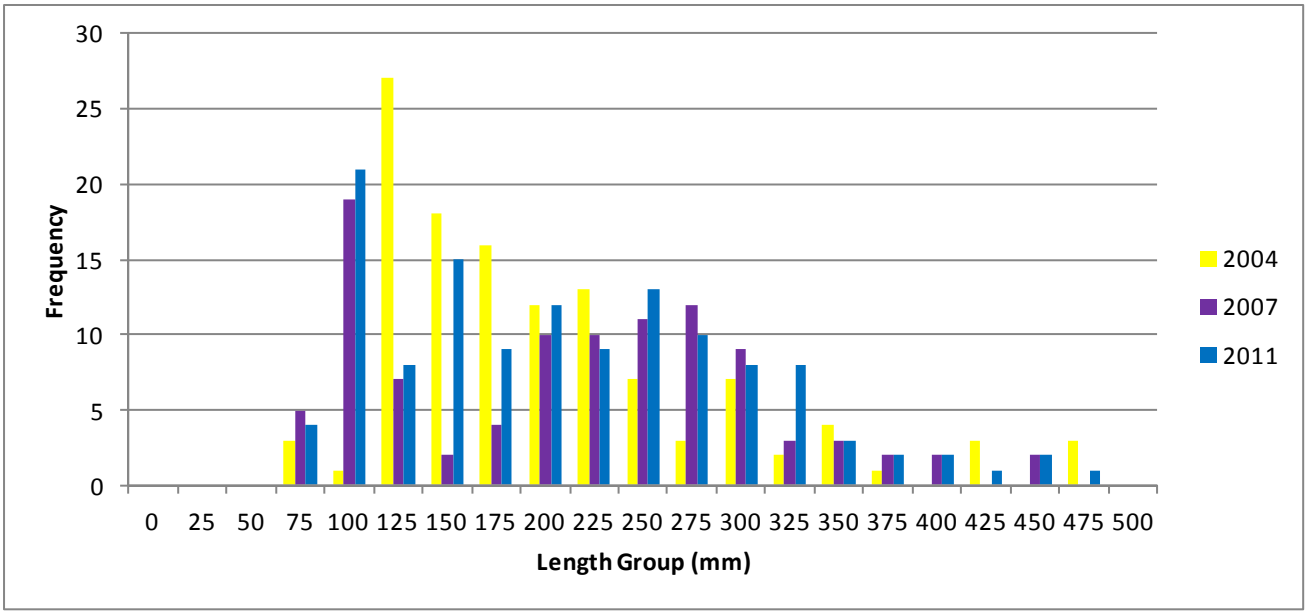
Site Code	Smallmouth Bass CPUE	Spotted Bass CPUE	Largemouth Bass CPUE	Rock Bass CPUE
420110708	14.2	-	-	-
420110709	14.7	-	-	29.4
420110712	16.6	2.7	-	33.3
420110713	2.9	2.9	-	17.6
420110714	7.2	3.6	-	-
420110722	38.8	-	-	13.8
420110725	19.4	-	-	2.7
420110726	25	-	-	9.6
420110730	50	-	-	80.5
420110731	75.6	-	-	14.8
MEAN	26.4	0.92	-	20.1
STD. DEV.	22.3	1.4	-	24.0
	Length-Categorization Analysis	**Length-Categorization Analysis**	**Length-Categorization Analysis**	**Length-Categorization Analysis**
	PSD = 43.4	PSD = 0	PSD = 0	PSD = 47.2
	RSD-PREFERRED = 14.4	RSD-PREFERRED = 0	RSD-PREFERRED = 0	RSD-PREFERRED = 0
	RSD-MEMORABLE = 3.9	RSD-MEMORABLE = 0	RSD-MEMORABLE = 0	RSD-MEMORABLE = 0
	RSD- TROPHY = 0	RSD- TROPHY = 0	RSD- TROPHY = 0	RSD- TROPHY = 0

Figure 24. Trends in mean catch rate of black bass and rock bass collected in the Nolichucky River from 2004 to 2011.



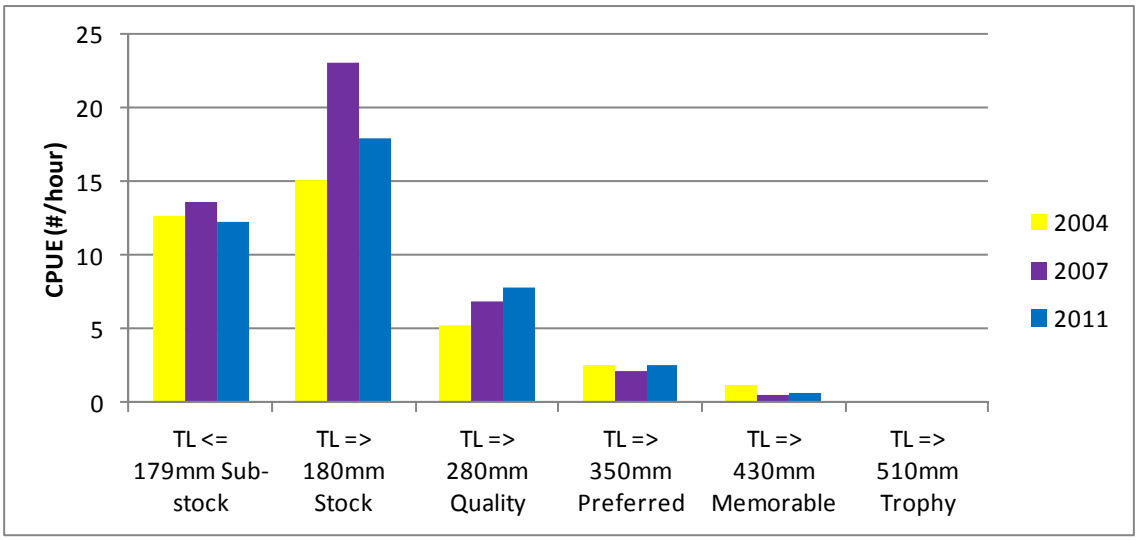
The size distributions of smallmouth bass between 2004 and 2011 changed somewhat among our 10 sampling stations (Figure 25). Generally, we observed a fairly substantial increase in the distribution of larger fish through time with the 2011 sample indicating a relatively higher frequency of bass above the 14 inch mark. Overall, we observed similar trends in the 2011 length distribution that were seen in 2007. There were good numbers of juvenile bass in the 2011 sample which will hopefully recruit to larger size classes in subsequent years.

Figure 25. Length frequency distributions for smallmouth bass collected in the Nolichucky River from 2004 to 2011.



Length categorization analysis indicated the relative stock density (RSD) of preferred smallmouth bass (TL ≥ 350 mm) was 14.4 (Table 14). RSD for memorable (TL ≥ 430 mm) and trophy (TL ≥ 510 mm) size bass were 3.9 and 0, respectively. The PSD of smallmouth bass (ratio of quality size bass to stock size bass) was 43.4. In comparison to the 2007 survey, we observed increases in the number of quality, preferred and memorable size bass, although the number of sub-stock and stock size bass all exhibited decreases (Figure 26). Although no trophy bass were collected during 2011, we are certain that there is a component to the fishery that comprises bass in excess of 508 mm (20 inches).

Figure 26. Relative stock density (RSD) catch per unit effort for smallmouth bass collected in the Nolichucky River from 2004 to 2011.

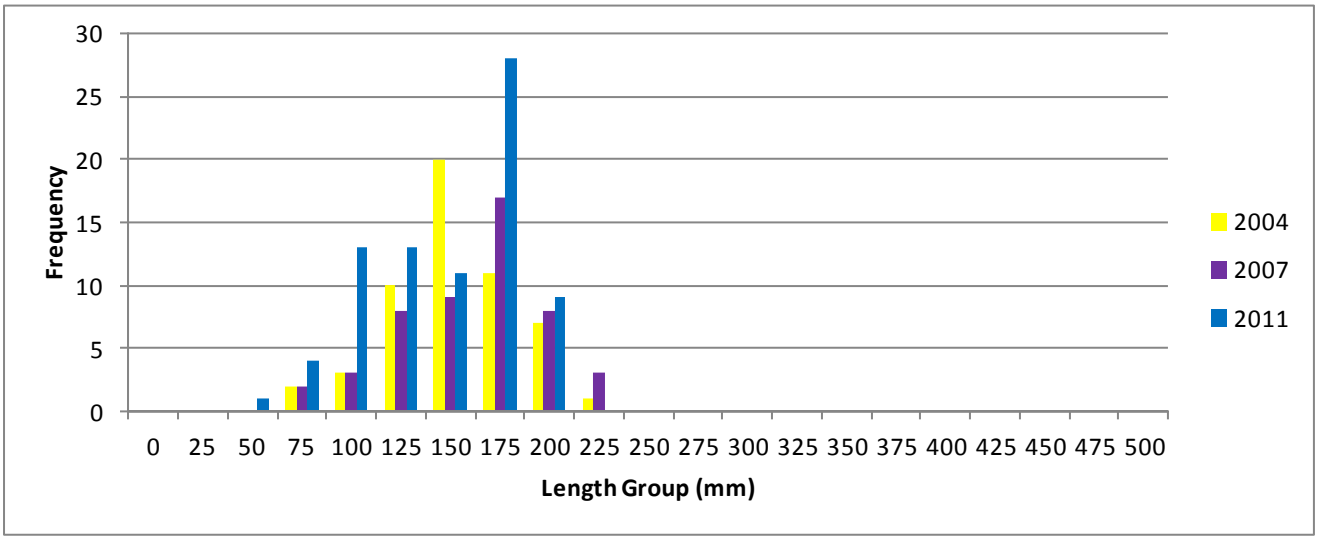


Age and growth characteristics for the smallmouth bass population in the Nolichucky River were characterized in 1998 (Carter et al. 1999). For the most part, the Nolichucky River has had growth rates similar to other large river populations with the same age structure. We did not collect otoliths from smallmouth bass in 2007, assuming that the values generated from the 1998 survey typify the general growth characteristics of this population. In general, it takes a smallmouth bass in the Nolichucky River about 3.8 years to reach 305 mm (12 inches), and about 7.8 years to attain a length of 406 mm (16 inches).

Only four spotted bass was collected in the 2011 sample. There were no largemouth bass collected in the survey. The spotted bass ranged from 81-209 mm. The collection of largemouth and spotted bass in the Nolichucky River has been sporadic and generally restricted to the lower reaches of the river where preferred habitat occurs. This is fairly typical of most large river systems in east Tennessee where these bass species contribute very little to the overall fishery.

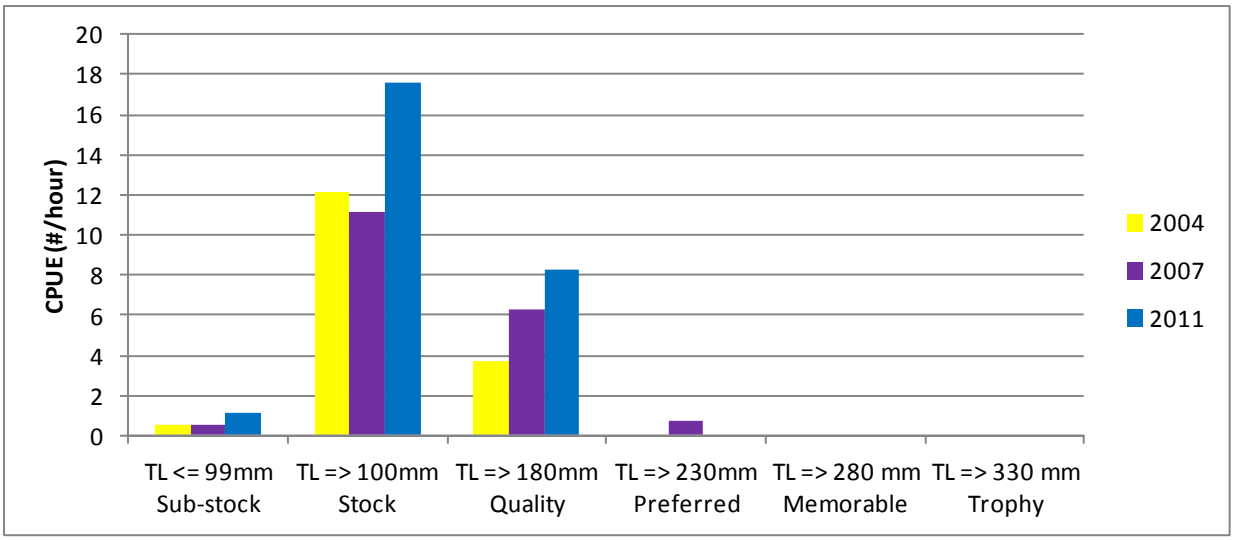
Individuals in the 100 to 200 mm range represented the majority of rock bass in our samples collected in 2011 (Figure 27). The length frequency distribution for 2011 was fairly similar to the previous samples. In almost all length classes we observed increase in the number of fish collected when compared to the 2007 sample.

Figure 27. Length frequency distributions for rock bass collected in the Nolichucky River from 2004 to 2011.



RSD analysis indicated the RSD for preferred rock bass (TL ≥ 230 mm) was 0. This was a considerable decrease from the 6.2 value recorded in 2007. RSD for both memorable (TL ≥ 280 mm) and trophy (TL ≥ 330 mm) size rock bass was 0. The PSD of rock bass was 47.2. Catch per unit effort estimates by RSD category indicated the majority of our catch was stock size fish (Figure 28). We did observe and increase in the catch of quality and preferred size rock bass in 2007. Compared to previous samples there were catch increases in all RSD categories with the exception of RSD-preferred. There were a few fish represented in the RSD-preferred category in 2007 but the number was low.

Figure 28. Relative stock density (RSD) catch per unit effort by category for rock bass collected in the Nolichucky River from 2004 to 2011.



Because of our confidence in determining age and growth characteristics (based on previous samples) we did not collect any otolith samples from rock bass in 2011. Therefore, no mortality or potential population growth statistics could be calculated. Age and growth and mortality of rock bass in the Nolichucky

River are assumed to be similar to those reported from our 1998 assessment (Carter et al. 1999).

Discussion

The Nolichucky River provides anglers with the opportunity to catch all species of black bass, rock bass, muskellunge, channel catfish, flathead catfish and other sunfish. During the winter months the upper reaches of the Nolichucky are stocked with rainbow trout from the U.S. Fish and Wildlife Service hatchery in Erwin. This provides additional recreational opportunities for winter anglers frequenting the river. In recent years, the river has seen an increase in use, with the establishment of several rafting companies and the increased recognition of the river's sport fishery.

The occurrence of musky in the river warrants continued stocking when fish become available. Based on our observations and information from anglers the stocking program has met with some success and there have been rumors of reproduction in the river although these claims have not been verified. We did not collect any musky during the 2011 surveys.

Surveys on the Nolichucky River will be conducted on a three-year rotation in order to assess any changes in the fishery. Our return trip in 2014, will in all likelihood repeat the surveys conducted in 2011.

Management Recommendations

1. Develop a fishery management plan for the river.

2. Continue to stock musky 203 to 254 mm at a rate of 27-40/mile (when available).

Pigeon River

Introduction

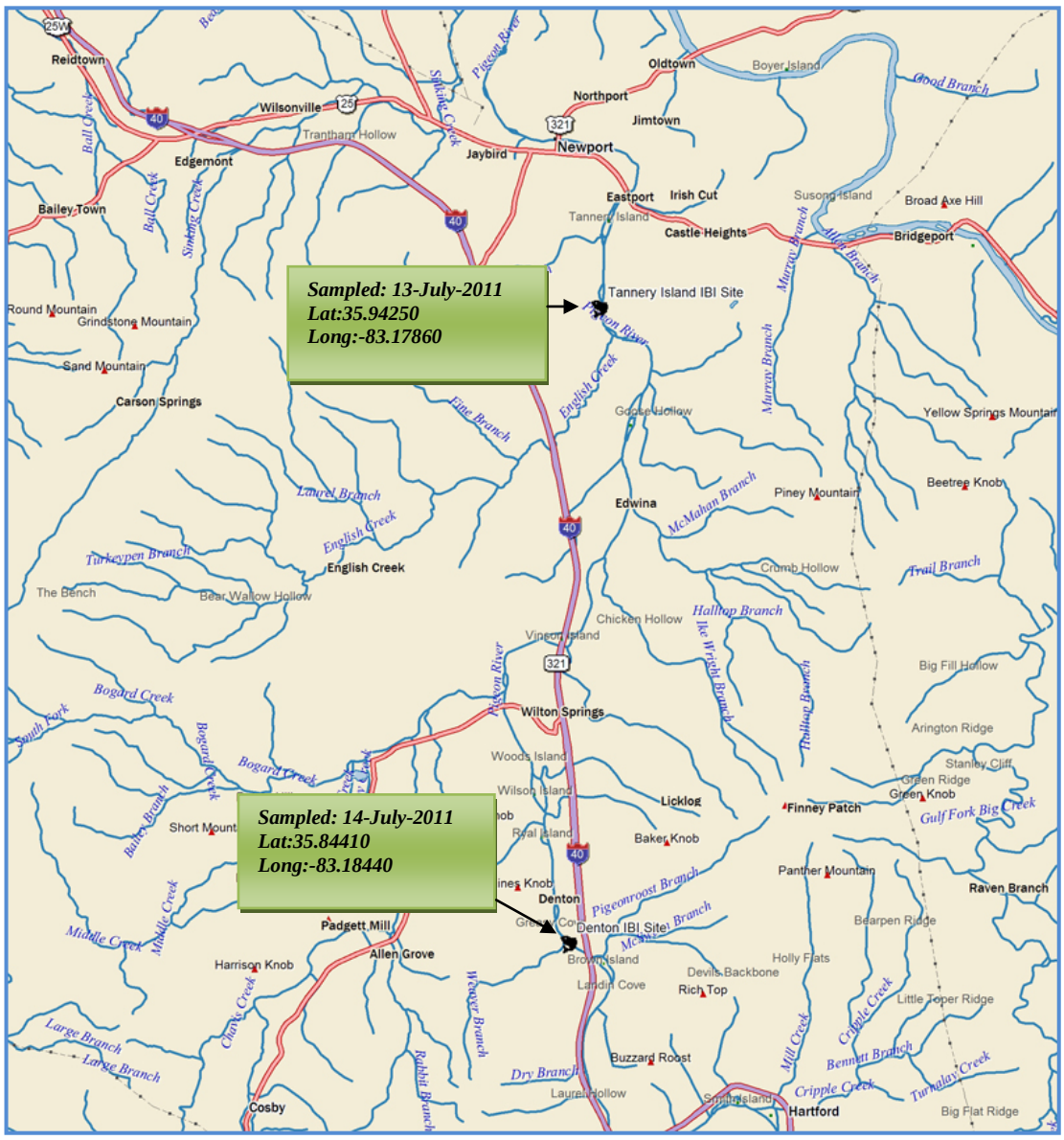
The Pigeon River has had a long history of pollution problems, stemming primarily from the discharge of wastewater from the Champion Paper Mill in Canton, North Carolina. This discharge has undoubtedly had a profound effect on the recreational use of the river and after the discovery of elevated dioxin levels in the 1980's raised concerns about public health (TDEC 1996). Although the river has received increased attention in recent years, the recreational use of the river has not developed its full potential. In terms of the fishery, consumption of all fish was prohibited up until 1996 when the ordinance was downgraded, limiting consumption of carp, catfish, and redbreast sunfish (TDEC 1996). In 2003, all consumption advisories were removed from the river. Since 1988, inter-agency Index of Biotic Integrity samples have been conducted at two localities, one near river mile 8.2 (Tannery Island) and one at river mile 16.6 (Denton).

Our 2011 surveys focused on continuing the evaluation of the fish community at two long-term IBI stations. Catch effort data along with otolith samples from rock bass and black bass were collected from three sites in 1997 (Bivens et al. 1998) and five sites in 1998 (Carter et al. 1999). Since 1999, data has been collected at five to six sites between river mile 4.0 and 20.5. During 1998, a 508 mm minimum (20-inch) length limit on smallmouth bass with a one fish possession limit was passed by the Tennessee Wildlife Resources Commission (TWRC). This regulation was implemented on March 1, 1999.

Study Area and Methods

The Pigeon River originates in North Carolina and flows in a northwesterly direction before emptying into the French Broad River near river mile 73.8. The river has a drainage area of approximately 1,784 km^2 at its confluence with the French Broad River. In Tennessee, approximately 35 kilometers of the Pigeon River flows through mountainous terrain with interspersed communities and small farms before joining the French Broad River near Newport. Public access along the river is primarily limited to bridge crossings and small "pull-outs" along roads paralleling the river. There are a few primitive launching areas for canoes or small boats and one moderately developed launch at Denton. On July 13 and 14, 2011, we conducted IBI fish surveys at Tannery Island (PRM 8.2) and Denton (PRM 16.6) (Figure 29).

Figure 29. Site locations for the IBI samples conducted in the Pigeon River during 2011.



Fish were collected according to the IBI criteria described in the methods section of this report. Both backpack and boat electrofishing were used to collect samples from both stations. Qualitative benthic macroinvertebrates were collected at both stations and analyzed to produce a biotic index score similar to those derived for the fish IBI.

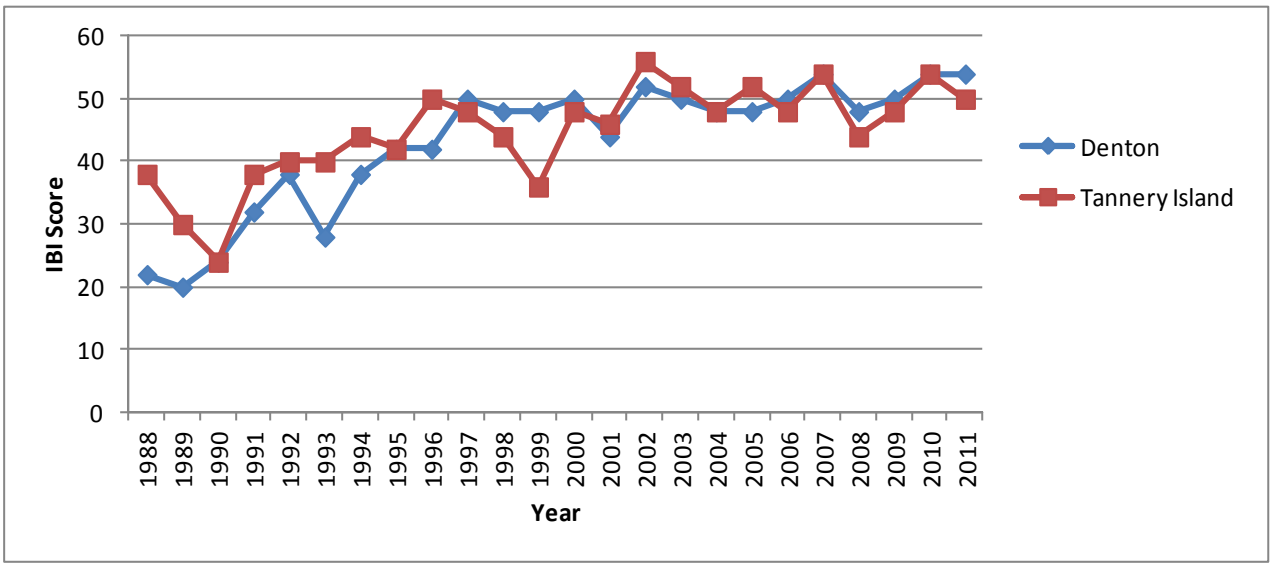
Results

Collaborative community assessments of Pigeon River have been ongoing since the late 1980's. These surveys have primarily focused on evaluating relative health changes in the fish community. A total of 36 fish species were collected at the Tannery Island site while 29 were observed at Denton (Table 15). Overall, The IBI analysis indicated the fish community was in good condition at Tannery Island (IBI score 50). This was a four point decrease from the 2010 score. The condition of the fish community assessed the same at the Denton site in 2011(54) as it did in 2010 (Figure 30).

Table 15. Fish species collected at the two Pigeon River IBI stations during 2011.

Pigeon River Mile	8.2 (Tannery Island)	Number Collected	16.6 (Denton)	Number Collected
	420113401		420113403	
	Ambloplites rupestris	6	*Ambloplites rupestris*	35
	Aplodinotus grunniens	1	*Aplodinotus grunniens*	4
	Campostoma oligolepis	32	*Campostoma oligolepis*	37
	Carpiodes cyprinus	2	*Cottus carolinae*	49
	Cottus carolinae	145	*Cyprinella galactura*	175
	Cyprinella galactura	32	*Dorosoma cepedianum*	63
	Cyprinella spiloptera	18	*Etheostoma blennioides*	6
	Cyprinus carpio	4	*Etheostoma rufilineatum*	323
	Dorosoma cepedianum	25	*Etheostoma tennesseense*	11
	Etheostoma blennioides	201	*Hybopsis amblops*	23
	Etheostoma rufilineatum	1057	*Hypentelium nigricans*	35
	Etheostoma tennesseense	20	*Ichthyomyzon sp.*	6
	Etheostoma zonale	5	*Ictalurus punctatus*	3
	Hypentelium nigricans	12	*Ictiobus bubalus*	10
	Ichthyomyzon castaneus	6	*Ictiobus niger*	4
	Ictalurus punctatus	4	*Lepomis auritus*	12
	Ictiobus bubalus	8	*Micropterus dolomieu*	25
	Ictiobus niger	3	*Moxostoma anisurum*	1
	Lepomis auritus	24	*Moxostoma breviceps*	2
	Lepomis macrochirus	8	*Moxostoma carinatum*	3
	Micropterus dolomieu	4	*Moxostoma duquesneii*	34
	Micropterus punctulatus	2	*Moxostoma erythrurum*	18
	Micropterus salmoides	7	*Notropis micropteryx*	4
	Moxostoma anisurum	3	*Notropis photogenis*	195
	Moxostoma breviceps	4	*Notropis telescopes*	74
	Moxostoma carinatum	1	*Oncorhynchus mykiss*	6
	Moxostoma duquesneii	18	*Percina caprodes*	12
	Moxostoma erythrurum	24	*Pomoxis annularis*	2
	Notropis micropteryx	214	*Sander vitreum*	13
	Notropis telescopus	8		
	Notropis volucellus	1		
	Noturus eleutherus	6		
	Percina caprodes	25		
	Percina evides	1		
	Rhinichthys obtusus	1		
	Sander vitreum	6		

Figure 30. Trends in Index of Biotic Integrity (IBI) at two stations on the Pigeon River (1988-2011).



Benthic macroinvertebrates collected at the Tannery Island site comprised 24 families representing 23 identified genera (Table 16). The most abundant group in our collection was the caddisflies comprising 45.5% of the total sample. Overall, a total of 30 taxa were identified from the sample of which 10 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Fair" (2.5).

Table 16. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from the Pigeon River at Tannery Island (river mile 8.2) July, 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
ANELLIDA				3.6
	Hirudinea		2	
	Oligochaeta		4	
COLEOPTERA				4.2
	Elmidae	*Promoresia elegans* adult	1	
	Gyrinidae	*Gyrinus* adults males	6	
DIPTERA				9.6
	Athericidae	*Atherix lantha*	1	
	Chironomidae		15	
EPHEMEROPTERA				9.6
	Baetidae	*Baetis*	3	
		Heterocloeon	1	
	Heptageniidae	*Maccaffertium* early instar	1	
		Maccaffertium ithaca	3	
		Maccaffertium mediopunctatum	2	
	Isonychiidae	*Isonychia*	6	
GASTROPODA				7.8
	Ancylidae	*Ferrissia*	1	
	Physidae		1	
	Pleuroceridae	*Leptoxis*	5	
		Pleurocera	6	
HETEROPTERA				0.6
	Belostomatidae	*Belostoma flumineum*	1	
MEGALOPTERA				3.0
	Corydalidae	*Corydalus cornutus*	5	
ODONATA				10.2
	Aeshnidae	*Boyeria vinosa*	1	
	Calopterygidae	*Hetaerina americana*	11	
	Coenagrionidae	*Argia moesta/translata*	1	
		Argia sedula	2	
	Cordulegastridae	*Cordulegaster maculata*	1	
	Gomphidae	*Hagenius brevistylus*	1	

Table 16. Continued.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
PELECYPODA				4.8
	Corbiculidae	*Corbicula fluminea*	8	
TRICHOPTERA				45.5
	Brachycentridae	*Brachycentrus lateralis*	1	
	Hydropsychidae	*Ceratopsyche morosa*	34	
		Cheumatopsyche	38	
	Hydroptilidae	*Hydroptila*	2	
	Lepidostomatidae	*Lepidostoma*	1	
TURBELLARIA			2	1.2
		Total	**167**	

TAXA RICHNESS = 30 EPT TAXA RICHNESS = 10 BIOCLASSIFICATION = 2.5 (FAIR)

Benthic macroinvertebrates collected at the Denton site comprised 39 families representing 51 identified genera (Table 17). The most abundant groups in our collection were the caddisflies and mayflies comprising about 35% of the total sample. Overall, a total of 51 taxa were identified from the sample of which 22 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Fair to Good" (3.3).

Table 17. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from the Pigeon River at Denton (river mile 17.1) July, 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
AMPHIPODA				1.8
	Crangonyctidae		9	
ANELLIDA				3.2
	Oligochaeta		16	
COLEOPTERA				7.0
	Dryopidae	*Helichus* adults	2	
	Elmidae	*Ancyronyx variegatus* adults	6	
		Macronychus glabratus adults	13	
		Microcylloepus pusillus adult	1	
		Promoresia elegans adults	2	
	Gyrinidae	*Dineutus discolor* adults	3	
		Dineutus larvae	2	
		Gyrinus adults	4	
	Hydrophilidae	*Cymbiodyta vindicata* adult	1	
	Psephenidae	*Psephenus herricki*	1	
DECAPODA				1.2
	Cambaridae	*Cambarus longirostris* juveniles male and female	2	
		Orconectes forceps juvenile males	2	
		Orconectes virilis juvenile males	2	
DIPTERA				10.6
	Athericidae	*Atherix lantha*	5	
	Chironomidae		42	
	Simuliidae		1	
	Tipulidae	*Antocha*	1	
		Tipula	4	
EPHEMEROPTERA				33.5
	Baetidae	*Acentrella*	12	
		Baetis	23	
		Heterocoloen	1	
	Caenidae	*Caenis*	2	
	Ephemerellidae	*Serratella deficiens*	20	
	Heptageniidae	*Maccaffertium* early instars	49	
		Maccaffertium ithaca	45	
		Maccaffertium modestum small instars	4	
	Isonychiidae	*Isonychia*	11	
GASTROPODA				0.6
	Physidae		1	
	Pleuroceridae	*Leptoxis*	2	

Table 17. Continued.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
HETEROPTERA				1.6
	Gerridae	*Metrobates hesperius* males and females	6	
	Veliidae	*Rhagovelia obesa* males	2	
ISOPODA				1.6
	Asellidae	*Caecidotea*	8	
MEGALOPTERA				5.2
	Corydalidae	*Corydalus cornutus*	19	
		Nigronia serricornis	5	
	Sialidae	*Sialis*	2	
ODONATA				5.0
	Aeshnidae	*Basiaeshna janata*	1	
		Boyeria vinosa	14	
	Calopterygidae	*Argia sedula*	1	
		Hetaerina americana	1	
	Corduliidae	*Neurocordulia obsoleta*	1	
	Gomphidae	*Gomphus lividus*	2	
		Hagenius brevistylus	1	
		Hylogomphus viridifrons	1	
	Macromiidae	*Macromia*	3	
PELECYPODA				3.8
	Corbiculidae	*Corbicula fluminea*	19	
PLECOPTERA				0.2
	Perlidae	*Perlesta* (freckled form)	1	
TRICHOPTERA				24.4
	Brachycentridae	*Brachycentrus lateralis*	9	
	Hydropsychidae	*Ceratopsyche morosa*	50	
		Ceratopsyche sparna	2	
		Cheumatopsyche	37	
		Hydropsyche venularis	1	
	Hydroptilidae	*Hydroptila*	1	
	Lepidostomatidae	*Lepidostoma*	3	
	Leptoceridae	*Oecetis avara*	2	
		Triaenodes ignitus	1	
	Limnephilidae	*Pycnopsyche scabripennis* group	1	
	Polycentropodidae	*Neureclipsis crepuscularis*	1	
		Polycentropus	13	
	Psychomyiidae	*Lype diversa*	1	
TURBELLARIA			1	0.2
		Total	**499**	

TAXA RICHNESS = 60 EPT TAXA RICHNESS = 22 BIOCLASSIFICATION = 3.3 (FAIR/GOOD)

Management Recommendations

1. Continue monitoring the sport fish population every three years.

2. Continue the cooperative IBI surveys at the two established stations (Denton and Tannery Island).

3. Develop a management plan for the river.

4. Continue cooperative efforts to reintroduce common species.

5. Closely monitor black fly control program being conducted by the University of Tennessee.

North Cumberland Habitat Conservation Plan (HCP) Monitoring

The development of a comprehensive forest resource Habitat Conservation Plan (HCP) has been an ongoing effort. This collaboration between TWRA, USFWS and several other governmental and academic groups has focused on developing a plan to determine “take” of species listed in the plan in relation TWRA’s forestry practices and formulate mitigation strategies. The goal of this plan is to allow the Agency to qualify for USFWS grant funding to purchase land within the project area. These funds are awarded to competing entities that have a USFWS approved HCP plan in place.

Our involvement with the development of the plan was to address aquatic issues and strategies regarding TWRA’s forest resource management and the means by which the Agency could evaluate “take” for listed fish species. The following stream accounts encompass preliminary monitoring efforts undertaken to evaluate TWRA’s forestry activities over the next ten years in relation to listed fish species. This data, and data collected over the next four years will be used to establish bench marks for these populations and serve as the standard by which changes can be determined.

Montgomery Fork

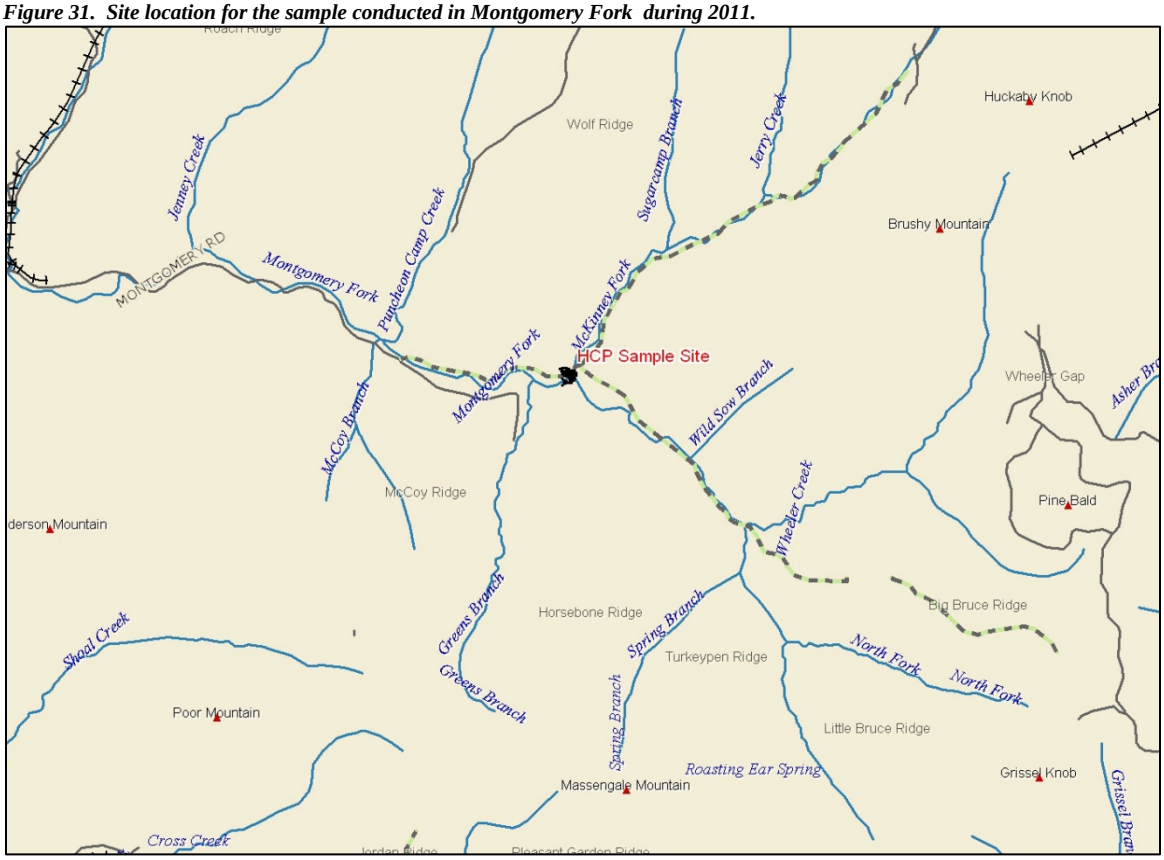
Introduction

Montgomery Fork was chosen for monitoring due it expansive forested watershed and the potential for the Agency to conduct timber harvest within the stream basin over the next several years. The emerald darter (state listed) is the species of concern in this system and was identified as one of the key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located near the confluence with McKinney Fork (Figure 31). We conducted the survey on July 26, 2011. The access road to the site was in very poor shape, and section of the road had almost been eliminated by high water events. We surveyed approximately 170 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one back electrofishing unit operating at 125 volts AC to stun fish which were collected by the backpack operator or the netter assisting with the survey. Basic water quality collected at the site indicated a conductivity of 290 µs/cm, a pH of 6.0, and water temperature of 22.5 C. Overall, the physical habitat and condition of the stream scored 125 (sub-optimal). The most influential metrics on the overall score were the amount of sediment deposition and the instability of the stream banks.

Figure 31. Site location for the sample conducted in Montgomery Fork during 2011.



Results

Our initial survey in 2011 focused on a reach of stream that had been surveyed previously near the mouth of McKinney Fork (Carter et al 2003). We had collected seven emerald darters from this location in 2002 and were hopeful that we would be able to locate the fish during this sample. We collected 12 fish species during our survey effort. Stoneroller, striped shiner, creek chub, rainbow darter and greenside darter were the most common species encountered (Table 18). We did not collect any emerald darters but did observe an increase in the number of smallmouth bass when compared to the 2002 sample.

Table 18. Fish species collected from Montgomery Fork 2011.

Species	Abundance
Ambloplites rupestris	Scarce
Campostoma anomalum	Common
Catostomus commersonii	Scarce
Etheostoma blenniodes	Common
Etheostoma caeruleum	Common
Hypentelium nigricans	Scarce
Luxilus chrysocephalus	Common
Micropterus dolomieu	Scarce
Notropis rubellus	Scarce
Notropis stramineus	Common
Percina maculate	Scarce
Semotilus atromaculatus	Common

Discussion

We did not collect any of the target species, however, we were encouraged to see the smallmouth bass which were not present in our 2002 survey. When emerald darters occur at low densities it is not uncommon for them to go undetected during a survey. We believe they still persist in this section of the stream at some level. Given the difficulty we encountered getting to this site, we will most likely move our monitoring station to our lower sample site at Norma to continue the monitoring for the HCP.

Management Recommendations

1. Relocate monitoring station to historical site at Norma.

2. Continue to monitor emerald darter annually for the next four years.

Straight Fork

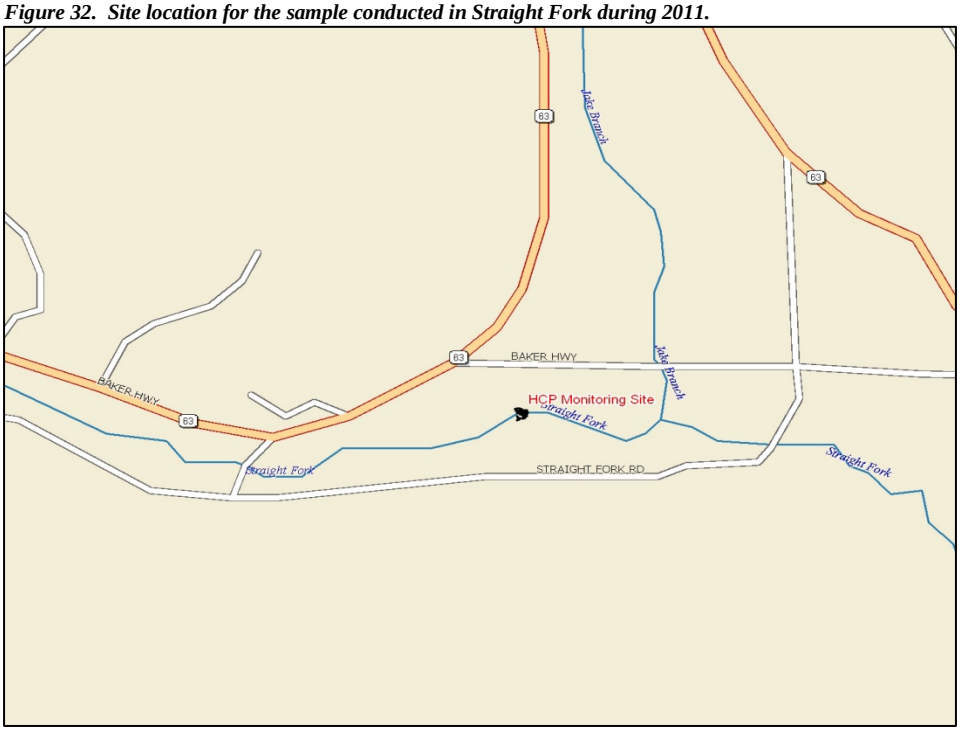
Introduction

Straight Fork was chosen for monitoring due to TWRA's planned forestry activity within the watershed and the occurrence of blackside dace in the stream. The blackside dace (federally listed) is the species of concern in this system and was identified as one of the key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located near the confluence with Jake Branch (Figure 32). We conducted the survey on July 26, 2011. Our survey was actually on private land but was at the upper extent of the blackside dace distribution. There is a substantial reach of the stream above our survey site that flows through private land that depending on use, could have impacts on the population we are monitoring. We were confined to the reach of stream below Jake Branch due to low pH above this confluence that limits the occurrence of blackside dace. We surveyed approximately 208 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one backpack electrofishing unit operating at 150 volts DC to stun fish which were collected by the backpack operator or the netter assisting with the survey. A population estimate was derived for blackside dace using a one pass electrofishing model developed by Black and Mattingly (2007). Basic water quality collected at the site indicated a conductivity of 170 µs/cm, a pH of 6.0, and water temperature of 25 C. Overall, the physical habitat and condition of the stream scored 108 (marginal/sub-optimal). The most influential metrics on the overall score were the amount of sediment deposition, instability of the stream banks and substrate embeddedness.

Figure 32. Site location for the sample conducted in Straight Fork during 2011.



Results

We collected five fish species during our survey of Straight Fork. The most common species were creek chub followed by blackside dace. Sixteen blackside dace were collected within our sample area (Table 19). Based on the one pass electrofishing catch, our estimate of the population size within our sample area was 52 dace/200m. This value will be used to develop trends over the next four years and serve as a benchmark for comparison should forestry practices take place within the watershed.

Table 19. Fish species collected from Straight Fork 2011.

Species	Abundance
Chrosomus cumberlandensis	16 (pop. est. 52)
Lepomis cyanellus	Scarce
Micropterus salmoides	Rare
Semotilus atromaculatus	Common
Rhinichthys obtusus	Rare

Discussion

Straight Fork is still under the influence of acid mine drainage and if not for the buffering effect of Jake Branch, recovery of stream would not be realized for some distance downstream of our sample location. In previous surveys of the stream, we have documented pH as low as 2.3 in tributaries to Straight Fork. We will return to repeat the sample in 2012 to add to the HCP database.

Management Recommendations

1. Continue to monitor blackside dace annually for the next four years.

Jake Branch

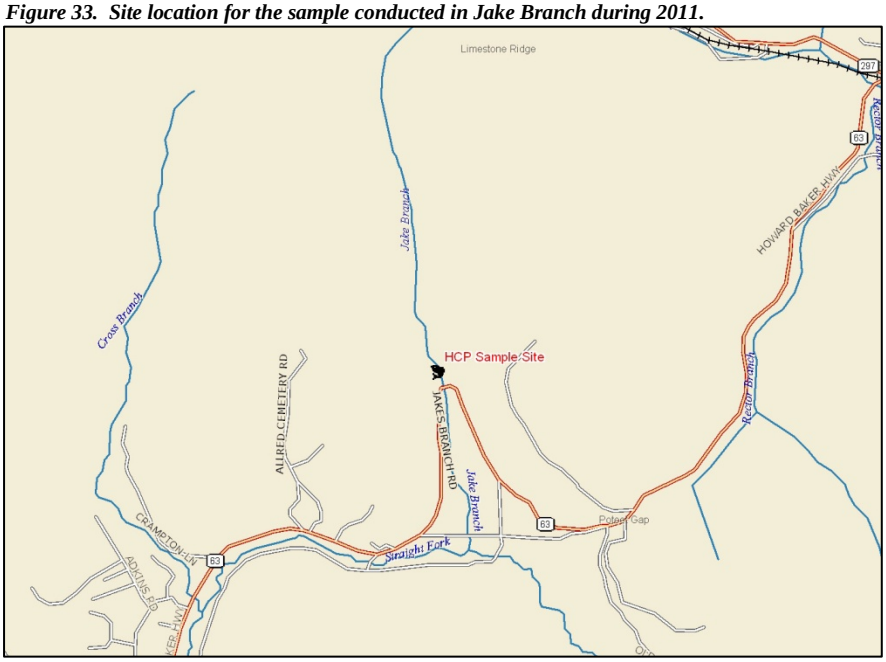
Introduction

Jake Branch was chosen for monitoring due to TWRA's planned forestry activity within the watershed and the occurrence of blackside dace in the stream. The blackside dace (federally listed) is the species of concern in this system and was identified as one of the key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located approximately 0.6 miles upstream from the confluence with Straight Fork on the Bridge's property (Figure 33). We conducted the survey on August 3, 2011. Our survey was actually on private land but was at the upper extent of the blackside dace distribution. We did some initial distribution work to identify the area of the stream that had the best population of blackside dace prior to establishing the monitoring site. We were confined to the reach of stream located at the downstream boundary of the private property and the first farm road crossing upstream from the landowner residence. We surveyed approximately 178 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one backpack electrofishing unit operating at 150 volts DC to stun fish which were collected by the backpack operator or the netter assisting with the survey. A population estimate was derived for blackside dace using a one pass electrofishing model developed by Black and Mattingly (2007). Basic water quality collected at the site indicated a conductivity of 267 µs/cm, a pH of 6.0, and water temperature of 21 C. Overall, the physical habitat and condition of the stream scored 112 (sub-optimal). The most influential metrics on the overall score were the bank vegetative protection and the width of the riparian zone.

Figure 33. Site location for the sample conducted in Jake Branch during 2011.



Results

We collected four fish species during our survey of Jake Branch. The most common species were creek chub followed by blackside dace. Twenty-two blackside dace were collected within our sample area (Table 20). Based on the one pass electrofishing catch, our estimate of the population size within our sample area was 72 dace/200m. This value will be used to develop trends over the next four years and serve as a benchmark for comparison should forestry practices take place within the watershed.

Table 20. Fish species collected from Jake Branch 2011.

Species	Abundance
Campostoma anomalum	Scarce
Chrosomus cumberlandensis	22 (pop. est. 72)
Lepomis cyanellus	Scarce
Semotilus atromaculatus	Common

Discussion

There is the potential to manage the Jake Branch watershed for early successional forest type as identified in the HCP plan. Therefore, we will monitor the blackside dace in this stream in order to document trends in relation to TWRA's activities. We will return to repeat the sample in 2012 to add to the HCP database.

Management Recommendations

1. Continue to monitor blackside dace annually for the next four years.

Hudson Branch

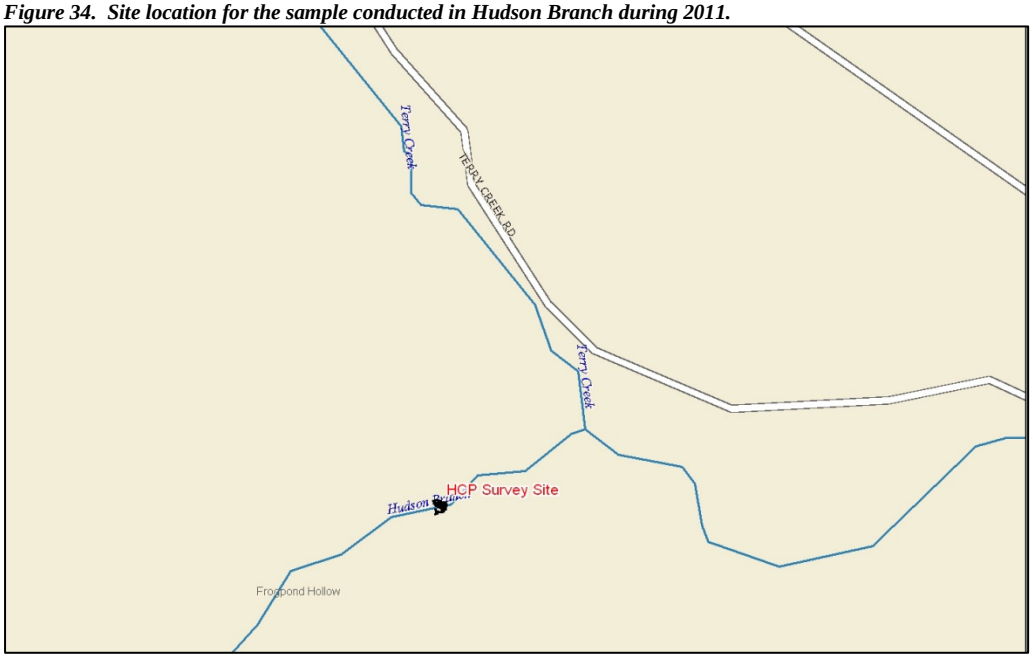
Introduction

Hudson Branch was chosen for monitoring due to TWRA's potential forestry activity within the watershed and the occurrence of blackside dace and Cumberland arrow darter in the stream. The blackside dace (federally listed) and Cumberland arrow darter (state listed) are species of concern in this system and were identified as key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located approximately 0.1 miles upstream from the confluence with Terry Creek on private property (Figure 34). We conducted the survey on August 3, 2011. We surveyed approximately 234 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one backpack electrofishing unit operating at 300 volts DC to stun fish which were collected by the backpack operator or the netter assisting with the survey. A population estimate was derived for blackside dace using a one pass electrofishing model developed by Black and Mattingly (2007). Catch per unit effort (fish/hour) was calculated for Cumberland arrow darter. Basic water quality collected at the site indicated a conductivity of 82 µs/cm, a pH of 6.2, and water temperature of 23 C. Overall, the physical habitat and condition of the stream scored 127 (sub-optimal). The most influential metrics on the overall score were sedimentation and the bank instability.

Figure 34. Site location for the sample conducted in Hudson Branch during 2011.



Results

We collected six fish species during our survey of Hudson Branch. The most common species were creek chub followed by stripetail darter. Five blackside dace were collected within our sample area (Table 21). Based on the one pass electrofishing catch, our estimate of the population size within our sample area was 16 dace/200m. Five Cumberland arrow darters were also collected during our survey. Based on our catch and the amount of electrofishing effort expended at the site we calculated a CPUE of 19.2/hour for this species. These values will be used to develop trends over the next four years and serve as a benchmark for comparison should forestry practices take place within the watershed.

Table 21. Fish species collected from Hudson Branch 2011.

Species	Abundance
Campostoma anomalum	Scarce
Chrosomus cumberlandensis	5 (pop. est. 16)
Etheostoma kennicotti	Common
Etheostoma sagitta sagitta	5 (CPUE = 19.2)
Lepomis cyanellus	Scarce
Semotilus atromaculatus	Common

Discussion

There are no plans by TWRA forestry to conduct activity within this watershed currently. However, given the occurrence of blackside dace and Cumberland arrow darter we wanted to begin building background data for activities that may take place in the future. We will return to repeat the sample in 2012 to add to the HCP database.

Management Recommendations

1. Continue to monitor blackside dace and Cumberland arrow darter annually for the next four years.

Terry Creek

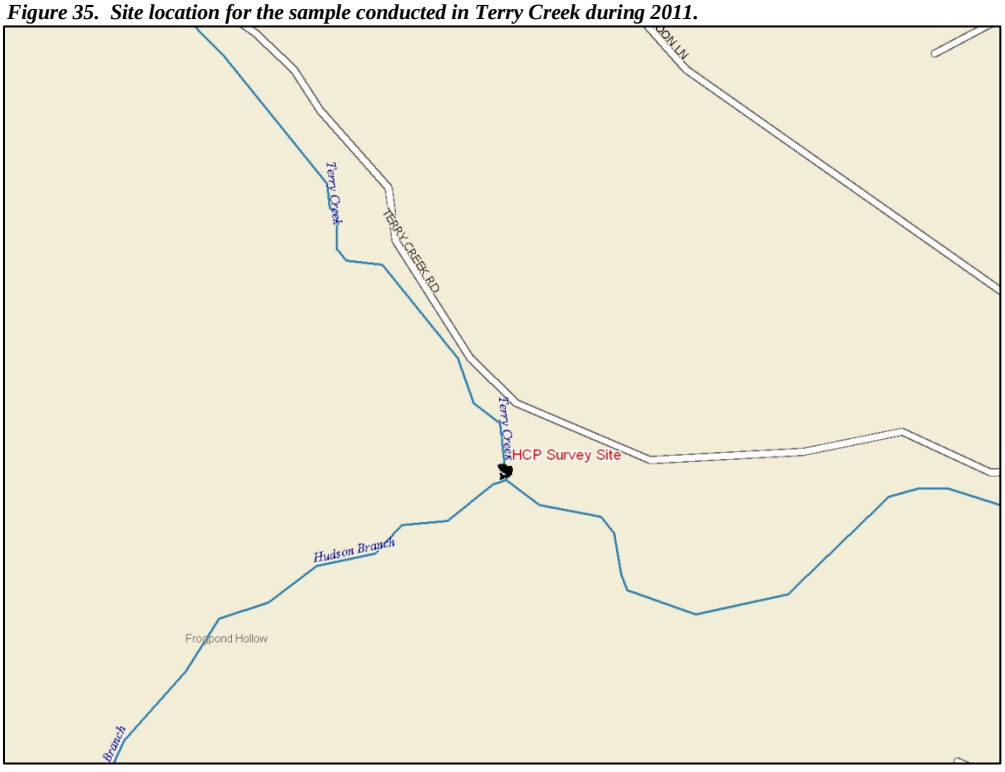
Introduction

Terry Creek was chosen for monitoring due to TWRA's potential forestry activity within the watershed and the occurrence of blackside dace and Cumberland arrow darter in the stream. The blackside dace (federally listed) and Cumberland arrow darter (state listed) are species of concern in this system and were identified as key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located just upstream from the confluence with Hudson Branch on private property (Figure 35). We conducted the survey on August 3, 2011. We surveyed approximately 113 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one backpack electrofishing unit operating at 250 volts DC to stun fish which were collected by the backpack operator or the netter assisting with the survey. A population estimate was derived for blackside dace using a one pass electrofishing model developed by Black and Mattingly (2007). Catch per unit effort (fish/hour) was calculated for Cumberland arrow darter. Basic water quality collected at the site indicated a conductivity of 101 µs/cm, a pH of 6.0, and water temperature of 22 C. Overall, the physical habitat and condition of the stream scored 133 (sub-optimal). The most influential metrics on the overall score were the bank vegetative protection and bank instability.

Figure 35. Site location for the sample conducted in Terry Creek during 2011.



Results

We collected 12 fish species during our survey of Terry Creek. The most common species were creek chub, redbreast sunfish, stripetail darter, rainbow darter, and blackside dace. Forty-three blackside dace were collected within our sample area (Table 22). Based on the one pass electrofishing catch, our estimate of the population size within our sample area was 142 dace/200m. One Cumberland arrow darter was collected during our survey. Based on our catch and the amount of electrofishing effort expended at the site we calculated a CPUE of 3.8/hour for this species. These values will be used to develop trends over the next four years and serve as a benchmark for comparison should forestry practices take place within the watershed.

Table 22. Fish species collected from Terry Creek 2011.

Species	Abundance
Campostoma anomalum	Scarce
Catostomus comersonii	Scarce
Chrosomus cumberlandensis	43 (pop. est. 142)
Chrosomus erythrogaster	Common
Etheostoma caeruleum	Common
Etheostoma kennicotti	Common
Etheostoma sagitta sagitta	1 (CPUE = 3.8/hour)
Hypentelium nigricans	Scarce
Lepomis auritus	Common
Lepomis cyanellus	Scarce
Luxilus chrysocephalus	Scarce
Semotilus atromaculatus	Common

Discussion

There are no plans by TWRA forestry to conduct activity within this watershed currently. However, given the occurrence of blackside dace and Cumberland arrow darter we wanted to begin building background data for activities that may take place in the future. We will return to repeat the sample in 2012 to add to the HCP database.

Management Recommendations

1. Continue to monitor blackside dace and Cumberland arrow darter annually for the next four years.

Stinking Creek

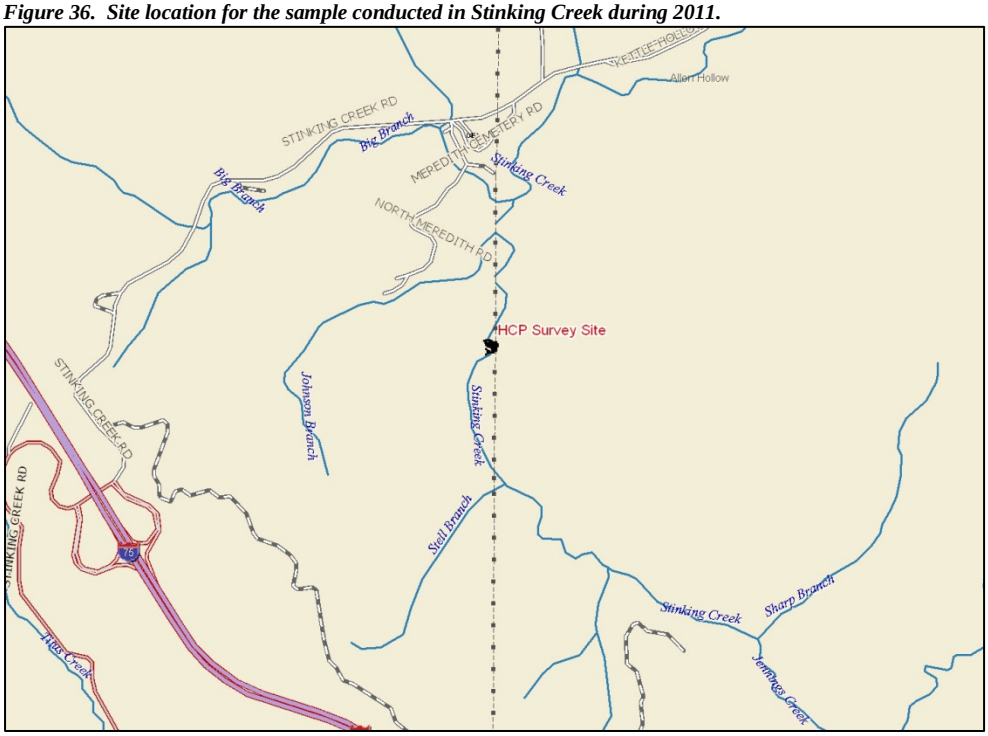
Introduction

Stinking Creek was chosen for monitoring due to TWRA's potential forestry activity within the watershed and the occurrence of Cumberland arrow darter in the stream. The Cumberland arrow darter (state listed) is a species of concern in this system and was identified as key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located about 200 m upstream from the first road crossing after entering North Cumberland WMA (Figure 36). We conducted the survey on August 12, 2011. We surveyed approximately 200 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one backpack electrofishing unit operating at 350 volts AC to stun fish which were collected by the backpack operator or the netter assisting with the survey. Catch per unit effort (fish/hour) was calculated for Cumberland arrow darter. Basic water quality collected at the site indicated a conductivity of 97 µs/cm, a pH of 6.0, and water temperature of 24.5 C. Overall, the physical habitat and condition of the stream scored 123 (sub-optimal). The most influential metric on the overall score was bank instability.

Figure 36. Site location for the sample conducted in Stinking Creek during 2011.



Results

We collected 18 fish species during our survey of Stinking Creek. There were several species in the survey that were common (Table 23). Six Cumberland arrow darters were collected during our survey. Based on our catch and the amount of electrofishing effort expended at the site we calculated a CPUE of 20/hour for this species. This value will be used to develop trends over the next four years and serve as a benchmark for comparison should forestry practices take place within the watershed.

Table 23. Fish species collected from Stinking Creek 2011.

Species	Abundance
Ambloplites rupestris	Scarce
Campostoma anomalum	Common
Catostomus commersonnii	Scarce
Cyprinella galactura	Scarce
Etheostoma sagitta sagitta	6 (CPUE = 20/hour)
Etheostoma blenniodes	Common
Etheostoma caeruleum	Common
Etheostoma kennicotti	Common
Hypentelium nigricans	Common
Lepomis auritus	Common
Lepomis macrochirus	Scarce
Luxilus chrysocephalus	Scarce
Lythrurus fasciolaris	Scarce
Micropterus dolomieu	Scarce
Micropterus punctatus	Scarce
Notropis rubellus	Common
Pimephales notatus	Scarce
Semotilus atromaculatus	Common

Discussion

There are no plans by TWRA forestry to conduct activity within this watershed currently. However, given the occurrence of Cumberland arrow darter we wanted to begin building background data for activities that may take place in the future. We will return to repeat the sample in 2012 to add to the HCP database.

Management Recommendations

1. Continue to monitor Cumberland arrow darter annually for the next four years.

Unnamed Tributary to Big Branch

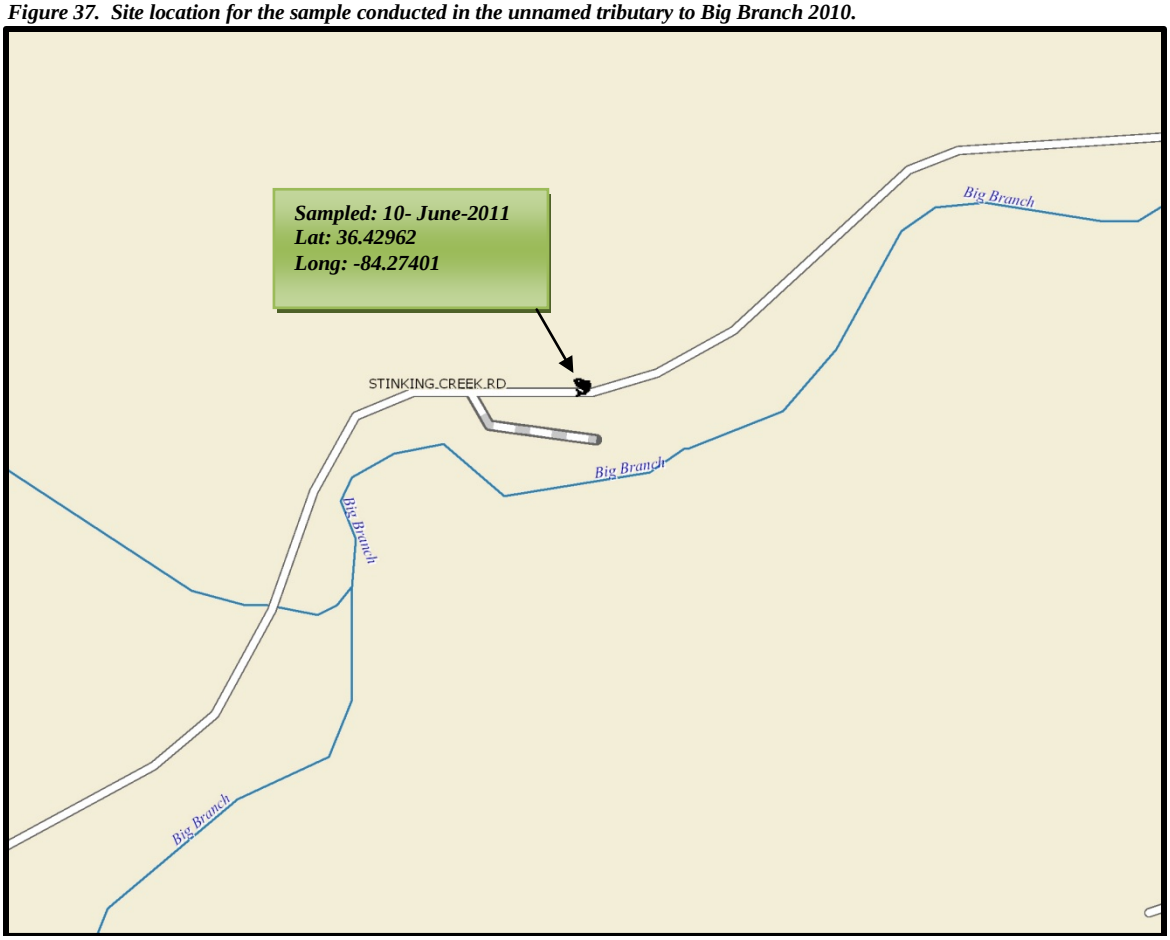
Introduction

The recent invasion of Hemlock Woolly Adelgid (HWA) into the Eastern U.S. has resulted in a unified effort by many natural resource management agencies to develop strategies to manage this exotic insect. Tennessee has been no exception to this effort, creating a HWA taskforce in 2005 to develop a management plan for the state's forest resources. This insect, when established in sufficient densities, attack hemlocks ultimately killing trees in a stand or the whole stand depending on the infestation level.

Study Area and Methods

In the spring of 2010 we were asked by TWRA's Forestry Division and the U.S. Forest Service to conduct a benthic macroinvertebrate survey of the tributary to Big Branch as a control stream that would be compared to Titus Creek which was subject to the HWA treatment. On June 10, 2011 we resurveyed a section of the tributary close to its confluence with Big Branch that was initially sampled in 2010 to evaluate any changes (Figure 37).

Figure 37. Site location for the sample conducted in the unnamed tributary to Big Branch 2010.



Results

We collected aquatic insects from the tributary during a combined three hour effort. Benthic macroinvertebrates collected at the site comprised 27 families representing 27 identified genera (Table 24). The most abundant group in our collection was the caddisflies comprising 51.5% of the total sample. Overall, a total of 35 taxa were identified from the sample of which 21 were EPT. Based on the EPT taxa richness and overall biotic index of all species collected, the relative health of the benthic community was classified as "Good" (4.0).

Table 24. Taxa list and associated biotic statistics for benthic macroinvertebrates collected from the unnamed tributary to Big Bran Branch June 2011.

ORDER	FAMILY	SPECIES	NUMBER	PERCENT
COLEOPTERA				2.2
	Elmidae	*Optioservus ovalis*	1	
	Eubriidae	*Ectopria*	1	
	Hydraenidae	undetermined larva	1	
	Staphylinidae	*Stenus* adults	2	
COLLEMBOLA				0.9
	Isotomidae		2	
DIPTERA				17.0
	Chironomidae	larvae	34	
	Dixidae	*Dixa*	1	
	Stratiomyidae	very early instar	1	
	Tipulidae	*Dicranota*	1	
		Hexatoma	2	
EPHEMEROPTERA				3.1
	Baetidae	*Baetis*	1	
	Heptageniidae	*Leucrocuta*	1	
		Maccaffertium meririvulanum	2	
		Maccaffertium vicarium	3	
HETEROPTERA				3.1
	Gerridae	*Aquarius* nymph	1	
	Veliidae	*Rhagovelia* nymphs	6	
ODONATA				4.8
	Aeshnidae	*Boyeria grafiana*	1	
	Gomphidae	*Lanthus vernalis*	10	
PLECOPTERA				17.0
	Leuctridae	*Leuctra*	3	
	Peltoperlidae	*Peltoperla*	28	
	Perlidae	*Acroneuria carolinensis*	6	
		Eccoptura xanthenes	1	
	Perlodidae	*Isoperla holochlora*	1	
TRICHOPTERA				51.5
	Hydropsychidae	*Diplectrona modesta* larvae & pupa	44	
		Ceratopsyche sparna	1	
	Glossosomatidae	*Glossosoma nigrior*	22	
	Lepidostomatidae	*Lepidostoma*	2	
	Limnephilidae	*Pycnopsyche luculenta* group	5	
	Philopotamidae	*Dolophilodes distincta* larvae & pupa	17	
	Polycentropodidae	*Polycentropus*	6	
	Rhyacophilidae	*Rhyacophila carolina*	2	
		Rhyacophila fuscula	1	
		Rhyacophila glaberrima	1	
	Uenoidae	*Neophylax aniqua*	14	
		Neophylax wigginsi	4	
		Total	**229**	

TAXA RICHNESS = 35 EPT TAXA RICHNESS = 21 BIOCLASSIFICATION = 4.0 (GOOD)

Discussion

This small tributary appears to be relatively unimpacted by logging or mining activities. The small size of the stream is most likely the reason for the lower insect diversity observed in this stream. We collected five additional taxa in the 2011 survey that were not observed in 2010. Overall, the EPT taxa richness remained unchanged as well as the bioclassification score.

Management Recommendations

1. Conduct surveys as prescribed to evaluate future application of Mycotal.

Louse Creek

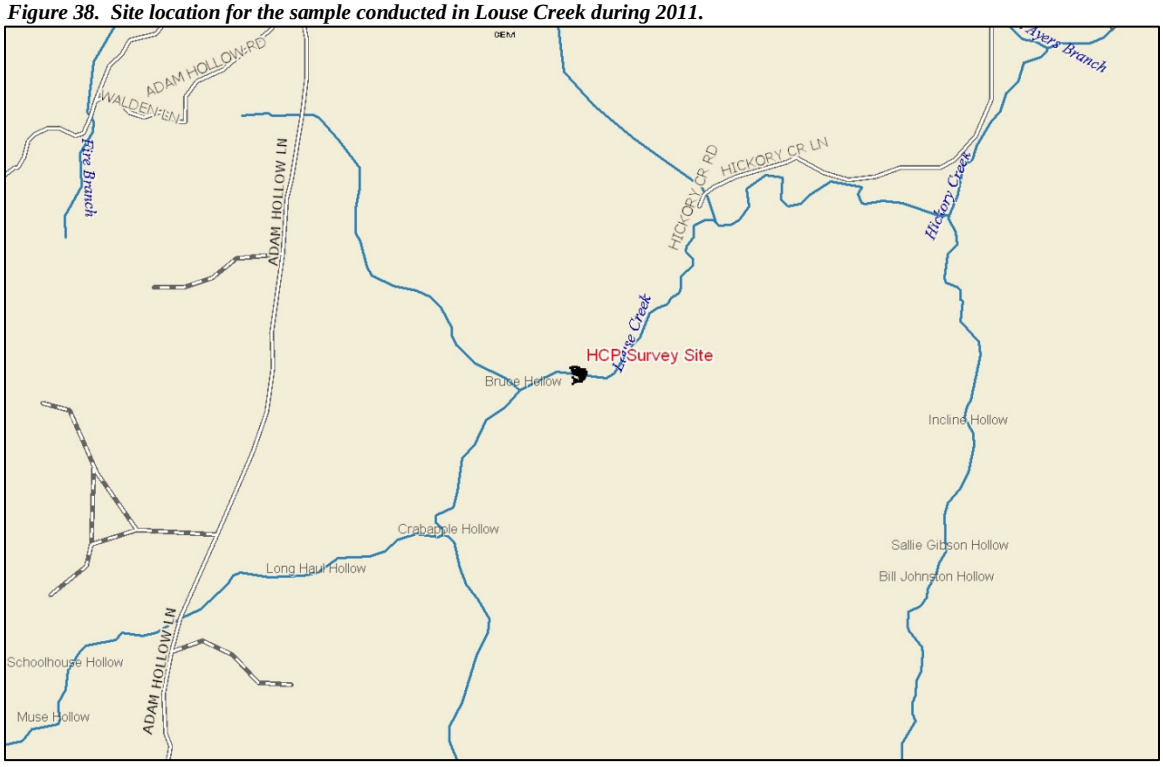
Introduction

Louse Creek was chosen for monitoring due to TWRA's potential forestry activity within the watershed and the occurrence of blackside dace and Cumberland arrow darter in the stream. The blackside dace (federally listed) and Cumberland arrow darter (state listed) are species of concern in this system and were identified as key species for monitoring under the HCP.

Study Area and Methods

The area we surveyed was located just upstream from the logging access road (Figure 38). We conducted the survey on August 12, 2011. We surveyed approximately 190 meters of stream, recording our total electrofishing time so that subsequent samples could be repeated with same amount of effort. We used one backpack electrofishing unit operating at 250 volts DC to stun fish which were collected by the backpack operator or the netter assisting with the survey. A population estimate using a one pass electrofishing model developed by Black and Mattingly (2007) is used to when blackside dace are present. Catch per unit effort (fish/hour) was calculated for Cumberland arrow darter. Basic water quality collected at the site indicated a conductivity of 110 µs/cm, a pH of 6.0, and water temperature of 21 C. Overall, the physical habitat and condition of the stream scored 127 (sub-optimal). The most influential metric on the overall score was bank instability.

Figure 38. Site location for the sample conducted in Louse Creek during 2011.



Results

We collected nine fish species during our survey of Louse Creek. The most common species were creek chub, stripetail darter, and rainbow darter (Table 25). There were no blackside dace collected in our survey site although they have been collected in previous surveys upstream of this site. Seven Cumberland arrow darters were collected during our survey. Based on our catch and the amount of electrofishing effort expended at the site we calculated a CPUE of 14.2/hour for this species. These values will be used to develop trends over the next four years and serve as a benchmark for comparison should forestry practices take place within the watershed.

Table 25. Fish species collected from Louse Creek 2011.

Species	Abundance
Campostoma anamolum	Scarce
Etheostoma caeruleum	Common
Etheostoma kennicotti	Common
Etheostoma sagitta sagitta	7 (CPUE = 14.2)
Hypentelium nigricans	Scarce
Lepomis macrochirus	Scarce
Micropterus dolomieu	Scarce
Rhinichthys obtusus	Scarce
Semotilus atromaculatus	Common

Discussion

There are no plans by TWRA forestry to conduct activity within this watershed currently. However, given the occurrence of blackside dace and Cumberland arrow darter we wanted to begin building background data for activities that may take place in the future. We will return to repeat the sample in 2012 to add to the HCP database.

Management Recommendations

1. Continue to monitor blackside dace and Cumberland arrow darter annually for the next four years.

Summary

During 2011, we collected 48 fish and eight benthic macroinvertebrate samples. These included samples from Little River, Nolichucky River, Clinch River River, Powell River and Pigeon River. Additionally, nine streams were also surveyed for Cumberland arrow darter, HCP, and benthic macroinvertebrate response to HWA treamtement.

Overall, CPUE estimates for black bass and rock bass looked relatively good despite several years of low water. In most instances, we observed declines in our smallmouth bass catch with the exception of the Nolichucky River which showed a slight increase. Rock bass catch was down in the Clinch and Powell rivers but showed some improvement in the Nolichucky and Little rivers. Muskellunge stocking within the region continued in 2011. Approximately 2,000 fingerling musky were released in the French Broad and Nolichucky rivers.

The IBI surveys for Little River and the Pigeon River either remained the same or illustrated declines when compared to the 2010 values. In Little River, the Townsend site decreased eight points from the 2010 value whereas the Coulters Bridge site decreased by two points from the previous year. The Pigeon River exhibited a decline of four points at the Tannery Island site when compared to 2010, while the score at the Denton site remained the same. Fish reintroductions continued on the Pigeon River with many of the introduced species collected in the 2011 IBI samples. Benthic macroinvertebrate diversity in Little River and the Pigeon rivers looked good during 2011.

Streams monitored for the HCP were completed and initial monitoring data for species covered under the plan were generated. We will continue to monitor these select streams over the next four years to establish benchmarks to relate to TWRA's forestry activities in these watersheds.

Our re-assessment of the fungal application to control HWA within the Titus Creek watershed illustrated no apparent impact on the aquatic benthic community. This was supported by the data collected in the control stream where similar fluctuations in the benthic community were observed.

Over the past 18 years the stream survey unit has been conducting Index of Biotic Integrity surveys in various watersheds within the region. These have been done in response to requests made by TWRA personnel, cooperative effort requests, and general interest in determining the state of certain streams. Our compilation of these surveys has given us a reference database for many streams in the region that can be used for comparison purposes should we return for a routine survey or responding to a water quality issue. Table 26 lists our results for various streams surveyed during this time period.

Table 26. Index of Biotic Integrity and Benthic Biotic Index scores for samples conducted between 1994 and 2010.

Water	Watershed	Year Surveyed	County	IBI Score	Benthic BI Score
Capuchin Creek	Cumberland River	1994	Campbell	44 (Fair)	3 (Fair/Good)
Trammel Branch	Cumberland River	1994	Campbell	36 (Poor/Fair)	3 (Fair/Good)
Hatfield Creek	Cumberland River	1994	Campbell	42 (Fair)	3 (Fair/Good)
Baird Creek	Cumberland River	1994	Campbell	38 (Poor/Fair)	3 (Fair/Good)
Clear Fork (Site 1)	Cumberland River	1994	Campbell	52 (Good)	3 (Fair/Good)
Clear Fork (Site 2)	Cumberland River	1994	Claiborne	40 (Fair)	N/A
Clear Fork (Site 3)	Cumberland River	1994	Claiborne	24 (Very Poor/Poor)	1 (Poor)
Elk Fork Creek	Clear Fork	1994	Campbell	40 (Fair)	2 (Fair)
Fall Branch	Clear Fork	1994	Campbell	28 (Poor)	1 (Poor)
Crooked Creek	Clear Fork	1994	Campbell	38 (Poor/Fair)	2 (Fair)

Table 26. Continued.

Water	Watershed	Year Surveyed	County	IBI Score	Benthic BI Score
Burnt Pone Creek	Clear Fork	1994	Campbell	38 (Poor/Fair)	2 (Fair)
Whistle Creek	Clear Fork	1994	Campbell	38 (Poor/Fair)	2 (Fair)
Little Elk Creek	Clear Fork	1994	Campbell	40 (Fair)	2 (Fair)
Lick Fork	Clear Fork	1994	Campbell	38 (Poor/Fair)	2 (Fair)
Terry Creek	Clear Fork	1994	Campbell	48 (Good)	2 (Fair)
Crouches Creek	Clear Fork	1994	Campbell	28 (Poor)	1 (Poor)
Hickory Creek (Site 1)	Clear Fork	1994	Campbell	46 (Fair/Good)	3 (Fair/Good)
Hickory Creek (Site 2)	Clear Fork	1994	Campbell	48 (Good)	2 (Fair)
White Oak Creek	Clear Fork	1994	Campbell	30 (Poor)	2 (Fair)
No Business Branch	Clear Fork	1994	Campbell	30 (Poor)	3 (Fair/Good)
Laurel Fork	Clear Fork	1994	Campbell	52 (Good)	3 (Fair/Good)
Lick Creek	Clear Fork	1994	Campbell	44 (Fair)	3 (Fair/Good)
Davis Creek	Clear Fork	1994	Campbell	38 (Poor/Fair)	2 (Fair)
Rock Creek	Clear Fork	1994	Campbell	54 (Good/Excellent)	3 (Fair/Good)
Little Tackett Creek	Clear Fork	1994	Claiborne	28 (Poor)	3 (Fair/Good)
Unnamed tributary to Little Tackett Creek	Clear Fork	1994	Claiborne	0 (No Fish)	3 (Fair/Good)
Rose Creek	Clear Fork	1994	Campbell	36 (Poor/Fair)	2 (Fair)
Rock Creek	Clear Fork	1994	Claiborne	28 (Poor)	2 (Fair)
Tracy Branch	Clear Fork	1994	Claiborne	34 (Poor)	2 (Fair)
Little Yellow Creek (Site 1)	Cumberland River	1994	Claiborne	38 (Poor/Fair)	N/A
Little Yellow Creek (Site 2)	Cumberland River	1994	Claiborne	38 (Poor/Fair)	N/A
Little Yellow Creek (Site 3)	Cumberland River	1994	Claiborne	36 (Poor/Fair)	N/A
Hickory Creek	Clinch River	1995	Knox	46 (Fair/Good)	3 (Fair/Good)
White Creek	Clinch River	1995	Union	34 (Poor) (SC)	4 (Good)
Little Sycamore Creek	Clinch River	1995	Claiborne	40 (Fair)	4.5 (Good/Excel).
Big War Creek	Clinch River	1995	Hancock	50 (Good)	4 (Good)
North Fork Clinch River	Clinch River	1995	Hancock	46 (Fair/Good)	4 (Good)
Old Town Creek (Site 1)	Powell River	1995	Claiborne	40 (Fair)	4 (Good)
Old Town Creek (Site 2)	Powell River	1995	Claiborne	42 (Fair)	4 (Good)
Indian Creek	Powell River	1995	Claiborne	N/A	4 (Good)
Sweetwater Creek	Tennessee River	1995	Loudon	30 (Poor)	3 (Fair/Good)
Burnett Creek	French Broad River	1995	Knox	46 (Fair/Good)	3 (Fair/Good)
Jockey Creek	Nolichucky River	1995	Greene	34 (Poor)	3 (Fair/Good)
South Indian Creek (Sandy Bottoms)	Nolichucky River	1995	Unicoi	38 (Poor/Fair)	4 (Good)
South Indian Creek (Ernestville)	Nolichucky River	1995	Unicoi	44 (Fair)	4 (Good)
Spivey Creek	Nolichucky River	1995	Unicoi	54 (Good/Excellent)	4 (Good)
Little Flat Creek	Holston River	1995	Knox	42 (Fair)	3 (Fair/Good)
Beech Creek	Holston River	1995	Hawkins	48 (Good)	4 (Good)
Big Creek	Holston River	1995	Hawkins	46 (Fair/Good)	4 (Good)
Alexander Creek	Holston River	1995	Hawkins	34 (Poor)	4 (Good)
Thomas Creek	South Fork Holston River	1995	Sullivan	54 (Good/Excellent)	4 (Good)
Hinds Creek	Clinch River	1996	Anderson	36 (Poor/Fair)	3 (Fair/Good)
Cove Creek	Clinch River	1996	Campbell	28 (Poor)	3 (Fair/Good)
Titus Creek	Clinch River	1996	Campbell	42 (Fair)	3 (Fair/Good)
Cloyd Creek	Tennessee River	1996	Loudon	36 (Poor/Fair)	4 (Good)
Sinking Creek	Little Tennessee River	1996	Loudon	34 (Poor)	4 (Good)
Baker Creek	Little Tennessee River	1996	Loudon	26 (Very Poor/Poor)	3 (Fair/Good)
Little Baker Creek	Little Tennessee River	1996	Blount	38 (Poor/Fair)	4 (Good)
Ninemile Creek	Little Tennessee River	1996	Blount	24 (Very Poor/Poor)	4 (Good)
East Fork Little Pigeon River	French Broad River	1996	Sevier	36 (Poor/Fair)	3 (Fair/Good)
Dunn Creek	French Broad River	1996	Sevier	32 (Poor)	4 (Good)
Wilhite Creek	French Broad River	1996	Sevier	44 (Fair)	4 (Good)
Watauga River (above Watauga Res.)	Holston River	1996	Johnson	42 (Fair)	4 (Good)
Stony Fork	Big South Fork	1996	Campbell	38 (Poor/Fair)	4 (Good)
Bullett Creek	Hiwassee River	1997	Monroe	50 (Good)	4.5 (Good/Excel.)
Canoe Branch	Powell River	1997	Claiborne	26 (V Poor/Poor) (SC)	4.7 (Excellent)
Town Creek	Tennessee River	1997	Loudon	34 (Poor)	2 (Fair)
Bat Creek	Little Tennessee River	1997	Monroe	30 (Poor)	1.5 (Poor/Fair)
Island Creek	Little Tennessee River	1997	Monroe	40 (Fair)	4 (Good)
Little Pigeon River	French Broad River	1997	Sevier	40 (Fair)	2 (Fair)
West Prong Little Pigeon River	French Broad River	1997	Sevier	46 (Fair/Good)	2 (Fair)
Flat Creek	French Broad River	1997	Sevier	30 (Poor)	3.8 (Good)
Clear Creek	French Broad River	1997	Jefferson	34 (Poor)	2.2 (Fair)
Richland Creek	Nolichucky River	1997	Greene	30 (Poor)	2.3 (Fair)
Middle Creek	Nolichucky River	1997	Greene	34 (Poor)	4 (Good)
Sinking Creek	Pigeon River	1997	Cocke	30 (Poor)	3.8 (Good)
Chestuee Creek	Hiwassee River	1998	Monroe	28 (Poor)	2.5 (Fair/Fair -Good)
Fourmile Creek	Powell River	1998	Hancock	36 (Poor/Fair)	4.5 (Good/Excel.)
Martin Creek	Powell River	1998	Hancock	50 (Good)	4 (Good)
Big Creek	Tellico River	1998	Monroe	46 (Fair/Good)	4 (Good)
Oven Creek	Nolichucky River	1998	Cocke	40 (Fair)	2.9 (Fair/Good)
Cherokee Creek	Nolichucky River	1998	Washington	36 (Poor/Fair)	2.8 (Fair/Good)
Bennetts Fork	Cumblerland River	2000	Claiborne	30 (Poor)	3.5 (Fair/Good)

Table 26. Continued.

Water	Watershed	Year Surveyed	County	IBI Score	Benthic BI Score
Gulf Fork Big Creek	French Broad River	2001	Cocke	42 (Fair)	4.0 (Good)
Nolichucky River	French Broad River	2001	Unicoi	56 (Good/Excellent)	4.0 (Good)
North Fork Holston River	Holston River	2001	Hawkins	50 (Good)	4.5 (Good)
Stinking Creek	Cumberland River	2002	Campbell	42 (Fair)	4.5 (Good)
Straight Fork	Cumberland River	2002	Campbell	18 (Very Poor)	3.0 (Fair/Good)
Montgomery Fork	Cumberland River	2002	Campbell	48 (Good)	3.5 (Fair/Good)
Turkey Creek	Holston River	2003	Hamblen	34 (Poor)	1.5 (Poor)
Spring Creek	Holston River	2003	Hamblen	34 (Poor)	2.2 (Fair)
Cedar Creek	Holston River	2003	Hamblen	30 (Poor)	3.5 (Fair/Good)
Fall Creek	Holston River	2003	Hamblen	32 (Poor)	2.3 (Fair)
Holley Creek	Nolichucky River	2003	Greene	30 (Poor)	2.4 (Fair)
College Creek	Nolichucky River	2003	Greene	36 (Poor/Fair)	2.2 (Fair)
Kendrick Creek	South Fork Holston River	2004	Sullivan	34 (Poor)	3.8 (Fair/Good-Good)
Sinking Creek	South Fork Holston River	2004	Sullivan	32 (Poor)	3.8 (Fair/Good-Good)
Mud Creek	Nolichucky River	2004	Greene	46 (Fair/Good)	4.0 (Good)
New River (Site 1)	Big South Fork Cumberland River	2004	Anderson	30 (Poor)	4.2 (Good)
New River (Site 2)	Big South Fork Cumberland River	2004	Campbell	42 (Fair)	3.5 (Fair/Good)
Indian Fork	Big South Fork Cumberland River	2004	Anderson	41 (Fair)	3.8 (Fair/Good-Good)
Unnamed Tributary to Taylor Branch	Hiwassee River	2005	Bradley	48 (Good)	4.0 (Good)
Little River (Coulters Bridge)	Tennessee River	2005	Blount	54 (Good/Excellent)	-
Little River (Townsend)	Tennessee River	2005	Blount	48 (Good)	-
Williams Creek	Clinch River	2005	Grainger	42 (Fair)	4.3 (Good)
Beaver Creek (Site 1)	Holston River	2005	Jefferson	38 (Poor/Fair)	2.8 (Fair/Fair-Good)
Beaver Creek (Site 2)	Holston River	2005	Jefferson	30 (Poor)	3.2 (Fair/Good)
Doe Creek	Holston River	2005	Johnson	46 (Fair/Good)	4.0 (Good)
Gap Creek	Nolichucky River	2005	Greene	36 (Poor/Fair)	3.5 (Fair/Good)
Pigeon River (Tannery Island)	French Broad River	2005	Cocke	52 (Good)	2.8 (Fair/Fair-Good)
Pigeon River (Denton)	French Broad River	2005	Cocke	48 (Good)	3.8 (Fair-Good/Good)
Little River (Coulters Bridge)	Tennessee River	2006	Blount	58 (Excellent)	4.2 (Good)
Little River (Townsend)	Tennessee River	2006	Blount	58 (Excellent)	4.7 (Good-Excellent)
Pigeon River (Tannery Island)	French Broad River	2006	Cocke	48 (Good)	3.5 (Fair-Good)
Pigeon River (Denton)	French Broad River	2006	Cocke	50 (Good)	3.8 (Fair-Good/Good)
Pigeon River (Hwy. 73 Bridge)	French Broad River	2006	Cocke	-	3.8 (Fair-Good/Good)
Little River (Coulters Bridge)	Tennessee River	2007	Blount	54 (Good)	3.8 (Fair-Good/Good)
Little River (Townsend)	Tennessee River	2007	Blount	56 (Good/Excellent)	4.0 (Good)
Pigeon River (Tannery Island)	French Broad River	2007	Cocke	54 (Good)	3.7 (Fair-Good/Good)
Pigeon River (Denton)	French Broad River	2007	Cocke	54 (Good)	3.5 (Fair/Good)
Little River (Coulters Bridge)	Tennessee River	2008	Blount	58 (Excellent)	3.8 (Fair-Good/Good)
Little River (Townsend)	Tennessee River	2008	Blount	56 (Good/Excellent)	3.0 (Fair/Good)
Pigeon River (Tannery Island)	French Broad River	2008	Cocke	44 (Fair)	2.0 (Fair)
Pigeon River (Denton)	French Broad River	2008	Cocke	48 (Good)	3.0 (Fair/Good)
Little River (Coulters Bridge)	Tennessee River	2009	Blount	58 (Excellent)	4.3 (Good)
Little River (Townsend)	Tennessee River	2009	Blount	58 (Excellent)	4.5 (Good)
Pigeon River (Tannery Island)	French Broad River	2009	Cocke	48 (Good)	3.0 (Fair/Good) July
Pigeon River (Denton)	French Broad River	2009	Cocke	50 (Good)	3.0 (Fair/Good) July
Pigeon River (Waterville)	French Broad River	2009	Cocke	-	4.5 (Good) March
Pigeon River (Denton)	French Broad River	2009	Cocke	-	4.3 (Good) March
Pigeon River (Tannery Island)	French Broad River	2009	Cocke	-	4.0 (Good) March
Poplar Creek	Clinch River	2009	Anderson	30 (Poor)	3.7 (Fair/Good-Good)
Titus Creek	Clinch River	2009	Campbell	-	4.5 (Good)
Pigeon River (Tannery Island)	French Broad River	2010	Cocke	54 (Good)	4.0 (Good)
Pigeon River (Denton)	French Broad River	2010	Cocke	54 (Good)	3.3 (Fair/Good)
Little River (Coulters Bridge)	Tennessee River	2010	Blount	60 (Excellent)	4.3 (Good)
Little River (Townsend)	Tennessee River	2010	Blount	58 (Excellent)	4.5 (Good/Excellent)
Smoky Creek	New River	2010	Scott	37 (Fair)	3.5 (Fair/Good)
Beech Fork	New River	2010	Campbell	47 (Good)	-
Pigeon River (Tannery Island)	French Broad River	2011	Cocke	50 (Good	2.5 (Fair)
Pigeon River (Denton)	French Broad River	2011	Cocke	54 (Good)	3.3 (Fair/Good)
Little River (Coulters Bridge)	Tennessee River	2011	Blount	58 (Excellent)	4.3 (Good)
Little River (Townsend)	Tennessee River	2011	Blount	50 (Good)	4.3 (Good)

Literature Cited

Ahlstedt, S.A. 1986. Cumberlandian mollusk conservation program. Activity 1: Mussel distribution surveys. Tennessee Valley Authority, Field Operations. Division of Services and Field Operations. 125pp.

Bivens, R.D. 1988. Region IV stream fishery data collection report: 1986-1987. Tennessee Wildlife Resources Agency. Nashville.

Bivens, R.D., B.D. Carter, and C.E. Williams. 1995. Region IV stream fishery data collection report: 1994. Fisheries Report 95-60. Tennessee Wildlife Resources Agency, Nashville.

Bivens, R.D., B.D. Carter, and C.E. Williams. 1998. Region IV stream fishery data collection report: 1997. Fisheries Report 98-1. Tennessee Wildlife Resources Agency, Nashville.

Black, T.R. and H.T. Mattingly. 2007. Conservation status of the threatened blackside dace in selected Cumberland River streams. Final Report submitted to U.S. Fish and Wildlife Service, Cookeville and Frankfort Field Offices. 51pp.

Brigham, A.R., W.U. Brigham, and A Gnilka, editors. 1982. Aquatic insects and oligochaetes of North and South Carolina. Midwest Enterprises, Mohomet, Illinois.

Carter, B.D., C.E. Williams, and R.D. Bivens. 1999. Region IV stream fishery data collection report: 1998. Fisheries Report 99-5. Tennessee Wildlife Resources Agency, Nashville.

Carter, B.D., C.E. Williams, and R.D. Bivens. 2000. Warmwater stream fisheries report: 1999. Fisheries Report 00-10. Tennessee Wildlife Resources Agency, Nashville.

Carter, B.D., C.E. Williams, R.D. Bivens, and J.W. Habera. 2002. Warmwater stream fisheries report. Region IV 2001. Fisheries Report 02-05. Tennessee Wildlife Resources Agency, Nashville.

Carter, B.D., C.E. Williams, R.D. Bivens, and J.W. Habera. 2003. Warmwater stream fisheries report. Region IV 2002. Fisheries Report 03-04. Tennessee Wildlife Resources Agency, Nashville.

Carter, B.D., C.E. Williams, R.D. Bivens, and J.W. Habera. 2005. Warmwater stream fisheries report. Region IV 2004. Fisheries Report 05-03. Tennessee Wildlife Resources Agency, Nashville.

Carter, B.D., C.E. Williams, R.D. Bivens, and J.W. Habera. 2006. Warmwater stream fisheries report. Region IV 2005. Fisheries Report 06-02. Tennessee Wildlife Resources Agency, Nashville.

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

Etnier, D.A, J.T. Baxter Jr., S.J. Fraley, and C.R. Parker. 1998. A checklist of the Trichoptera of Tennessee. Journal of the Tennessee Academy of Science. 73(1-2): 53-72.

Fausch, K.D., J.R. Karr, and P.R. Yant. 1984. Regional application of an index of biotic integrity based on stream fish communities. Transactions of the American Fisheries Society 113:39-55.

Fiss, F. C., T. A. Cleveland, B. D. Carter, R. D. Bivens, and J. M. Swearengin. 2001. Population characteristics of riverine smallmouth bass in Tennessee, simulated effects of length limits, and management recommendations. Tennessee Wildlife Resources Agency, Fisheries Report 01 - 19

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

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters, a method and its rationale. Illinois History Survey, Special Publication 5.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History. Publication #1980-12 of the North Carolina Biological Survey.

Lenat, D.R. 1993. A biotic index for the Southeastern United States: derivation and list of tolerance values, with criteria for assigning water quality ratings. Journal of the North American Benthological Society 12(3):279-290.

Louton, J.A. 1982. Lotic dragonfly (Anisoptera:Odonata) nymphs of the southeastern United States: identification, distribution, and historical biogeography. Doctoral dissertation. The University of Tennessee, Knoxville.

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

North Carolina Department of Environmental Management. 2006. Standard operating procedures- biological monitoring. North Carolina Department of Environment, Health, and Natural Resources. 42 pp.

Orth, D.J. 1983. Aquatic measurements. Pages 61-84 in L.A. Neilsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Powers, S.L. and R.L. Mayden. 2007. Systematics, evolution and biogeography of the *Etheostoma simoterum* species complex (Percidae: Subgenus *Ulocentra*). Bull. Alabama Mus. Nat. Hist. 25:1-23.

Smith, R.K., P.L. Freeman, J.V. Higgins, K.S. Wheaton, T.W. Fitzhugh, K.J. Ernstrom, and A.A. Das. 2002. Priority areas of freshwater conservation: A biodiversity of the southeastern United States. The Nature Conservancy.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of North America stonefly genera (Plecoptera). Entomological Society of America. Volume 12.

Tennessee Department of Environment and Conservation. 1996. The status of water quality in Tennessee 1996 305(b) report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville.

Tennessee Wildlife Resources Agency. 1998. Stream surveys protocols of the Tennessee Wildlife Resources Agency, Nashville. 21 pp.

Tennessee Wildlife Resources Agency. 2006. Tennessee Wildlife Resources Agency Strategic Plan 2006-2012. Tennessee Wildlife Resources Agency, Nashville.