

## **PREFACE**

This final report is submitted to the United States Fish and Wildlife Service, the Tennessee Wildlife Resources Agency, and the Center for the Management, Utilization, and Protection of Water Resources for their support of this research project. Detailed results obtained from this project are outlined in two Master of Science theses. An executive summary describing the project and a conclusions section have been added to concisely relate research findings.

The author would like to thank the many individuals involved with this project. Valuable information and experience has been gained over the course of this research effort, and it has provided a mechanism for students to further their education. Hopefully, results will benefit the agencies that supported the project, as well as professionals in the fields of fisheries and benthic macroinvertebrate ecology.

## EXECUTIVE SUMMARY

Although impacted by various pollutants and isolated by Watts Bar Reservoir, the Emory River Watershed remains one of the most natural and diverse systems in the Tennessee River drainage. Home to five rare fish species and numerous imperiled aquatic species, this predominantly Cumberland Plateau system is a valuable remnant of what free-flowing rivers in the upper Tennessee River drainage historically represented (TDEC 2000). Endemic to the Tennessee River drainage, the spotfin chub, *Erimonax monachus* (Cope 1868), is among the most rare and extraordinary minnows in the Emory River Watershed.

The spotfin chub, also known as the turquoise shiner, is a small, uncommon minnow, restricted to the Tennessee River drainage (Jenkins and Burkhead 1994). Although once widespread in 12 tributary systems distributed over five states, this species is now isolated into six small populations. Remaining refuges for spotfin chubs appear to be the Little Tennessee River, North Carolina, the North and Middle Fork Holston rivers, Virginia, and the Emory, Buffalo, and Duck rivers, Tennessee (Etnier and Starnes 1993, Jenkins and Burkhead 1994, Boschung and Mayden 2004). Due to anthropogenic effects, many extant populations are in various states of jeopardy.

Within the Emory River Watershed, many streams are listed by Jenkins and Burkhead (1984) as adversely affecting the river: upper Emory River, Crooked Fork, Crab Orchard, White and Daddys Creeks, and upper Obed River. They attributed declines in spotfin chub abundance to diminished habitat resulting from impoundment, which creates cool to cold tailwaters and inundates former spotfin chub riverine habitat. River impoundment, deforestation, and poor agricultural practices have increased sedimentation and siltation, which further restricts spotfin

chub range since this species avoids silt-laden habitats.

Conservative estimates predict that spotfin chubs have probably been extirpated from 90% or more of the original range (Ed Scott, pers. comm. TVA). Therefore, the spotfin chub was recognized as a threatened species in 1977 by the United States Fish and Wildlife Service (USFWS) (Federal Register 1977). In Tennessee, the spotfin chub is considered endangered (Etnier and Starnes 1993). A federal recovery plan was established in 1983, and restoration efforts are currently underway in Tellico River and Abrams Creek, TN. Due to water dilution, current water quality restoration projects (Crab Orchard Creek and Crooked Fork), and firm regulations, the Emory River spotfin chub population may be expanding. Population expansion of a federally threatened minnow could help lead to delisting. As a result, the United States Fish and Wildlife Service and the Tennessee Wildlife Resources Agency (TWRA) strive to know the current distribution and further understand the life history of the spotfin chub in this watershed.

Relatively few studies, aside from Jenkins and Burkhead (1984), have been conducted on the Emory River Watershed, and none have focused solely on fish communities and the spotfin chub population. Presence/absence data have been collected fairly recently by USFWS, Tennessee Valley Authority, TWRA, and United States Geological Survey (USGS) biologists. Seasonal habitat use by spotfin chubs within this watershed has never been documented, and extensive distribution patterns of this fish date back to the early 1980s. Therefore, data regarding current range and seasonal habitat use are important for the USFWS to resolve problems associated with this rare minnow. Fish community analyses further help predict the health of a watershed and confirm assumptions of a healthy Emory River Watershed. In addition, macroinvertebrate surveys further document the ecological status of this watershed.

Five objectives of this study were to: (1) determine current distribution and model presence/absence of spotfin chubs throughout the Emory River Watershed, (2) characterize fish communities of the Emory River Watershed, (3) describe spotfin chub seasonal habitat use within its known distribution, (4) determine how habitat conditions and land use practices within the Emory River Watershed influence benthic macroinvertebrate communities, and (5) evaluate seasonal variation in benthic communities at select locations.

Spotfin chub distribution and fish communities of the Emory River Watershed were sampled by electrofishing predetermined 200-m sites that were selected with the assistance of U.S. Fish and Wildlife Service, Tennessee Wildlife Resources Agency, Tennessee Valley Authority, and National Park Service personnel. In addition, snorkeling drifts were performed between sample sites to obtain precise spotfin chub distribution. Logistic regression analysis was used to predict variables significant to spotfin chub presence. Fish communities were characterized by percent composition, species richness, and the Index of Biotic Integrity (IBI). Multiple regression analysis was used to determine degree of association between fish communities and environmental variables. Seasonal spotfin chub habitat preferences were determined by quarterly snorkeling eight 200-m sites, within the historic range, and measuring habitat when fish were located. Descriptive statistics and Chi-Square analysis were used to determine if differences existed in spotfin chub seasonal habitat use.

Benthic macroinvertebrate samples were collected at 56 200-m sites throughout the ERW using semi-quantitative riffle kick (SQKICK) techniques. Biotic index scores were determined for all sites. The eight quarterly snorkel sites were also sampled using SQKICK techniques on a quarterly basis, and data were analyzed using ANOSIM (Analysis of Similarity) and SIMPER

(Similarity Percentages) routines within PRIMER software to identify variation in communities by site and/or time. Habitat and water quality variables were measured at all sites. In addition, habitat variables were evaluated using multiple linear regression to determine their influence on benthic communities among all 56 samples. Land use data also were evaluated using regression analysis to determine land use influences on benthic communities.

Spotfin chubs were collected in 12 of 57 sites sampled from 31 May 2004 through 25 August 2005. All 12 sites were within the historic spotfin chub distribution. Eleven of 12 sites were located in main tributaries of the four sub-watersheds (Daddys Creek, Clear Creek, Obed River, and Emory River), and one site was located in Clifty Creek (3<sup>rd</sup> order stream included in Emory River sub-watershed). Current spotfin chub distribution differed from the historical distribution. In Daddys Creek and Clear Creek sub-watersheds, distribution decreased a total of 8.7 km; Obed River distribution remained the same, and upper Emory River distribution increased 5.5 km (3.2 km net loss). Drainage area (km<sup>2</sup>) significantly predicted and was positively correlated to spotfin chub presence ( $P=0.0057$ ).

Emory River Watershed fish communities demonstrated stable conditions despite varying environmental factors. Throughout the Emory River Watershed, a total of 60 fish species were collected (52 native to the drainage). Overall, fishes encountered were from 12 families and 30 different genera (9 native families and 24 native genera). Within the Emory River Watershed, a total of 11,447 fish were encountered (Daddys Creek = 2,072; Obed River = 2,909; Clear Creek = 2,806; and Emory River = 3,660). Within each of the four sub-watersheds, largescale stonerollers consistently comprised the highest percent composition (Daddys Creek = 25.0%, Obed River = 17.7%, Clear Creek = 26.5%, and Emory River = 24.3%). Several rare fish

species were encountered in the Emory River Watershed, including the following species recognized by TDEC/Tennessee Natural Heritage Program as rare and in need of special concern: ashy darter *Etheostoma cinereum*, spotfin chub *Erimonax monachus*, tangerine darter *Percina aurantiaca*, longhead darter *Percina macrocephala*, and the olive darter *Percina squamata*. Drainage area was positively correlated ( $P < 0.001$ ) and turbidity was negatively correlated ( $P = 0.0173$ ) to species richness.

Index of Biotic Integrity (IBI) scores varied throughout the Emory River Watershed. Six sites had upstream drainage areas of less than 25 km<sup>2</sup> and were not used in this analysis; 51 sites were used in IBI analysis. Average IBI score for the Emory River Watershed was 47, which scored in the fair to good classification. Nine sites fell within the poor class, five sites fell within the fair class, and 37 sites fell within the good or excellent class. Average IBI scores for each sub-watershed were as follows: Daddys Creek = 48, Obed River = 43, Clear Creek = 49, and Emory River = 48. Most IBI scores were similar to those historically obtained by TVA. Drainage area was positively correlated ( $P = 0.0013$ ) and conductivity was negatively correlated ( $P < 0.001$ ) to IBI scores. Multiple means testing, via the Tukey procedure, found two significantly different variables among the four sub-watersheds. Mean conductivity for Clear Creek was significantly lower than those for Obed River and Emory River sub-watersheds. Mean pH for the Obed River was significantly higher than that for Emory River and Clear Creek sub-watersheds.

A total of 2,991 spotfin chubs were observed from 1 May 2004 through 21 September 2005. Numbers of spotfin chubs observed during each season were: spring = 374, summer = 797, fall = 1,796 and winter = 24. Numbers observed in each sub-watershed were: Daddys

Creek = 133, Obed River = 39, Clear Creek = 158 and Emory River = 2,661. Spotfin chubs were predominately found in run habitats over bedrock and boulder substrates. During spring, summer, and fall, 96% of spotfin chubs were found in run habitats (N = 2,967). Spotfin chubs were only found in pools during winter 2005 (N= 24). During spring, summer, and fall, 48% of spotfin chubs were observed over bedrock substrate, and 36% were observed over boulder substrate (N = 2,967). During winter 2005, 79% were found over sand substrate (N=24). Spotfin chubs disproportionately used run habitats over riffles and pools, and bedrock over more available boulder and cobble substrates.

Quality of macroinvertebrate communities varied within the Emory River Watershed. However, 47 of 56 sites had biotic scores indicative of healthy benthic communities ( $\geq 32$ ). Taxa richness (TR) varied among sub-watersheds; however, highest values were observed within Clear Creek. EPT richness (EPT) fluctuated among sub-watersheds, with highest values found within Clear Creek. Percentage EPT (% EPT) also varied among sub-watersheds with highest values found within Obed River. Oligochaetes and chironomids were not abundant, and % OC values were generally low for all sub-watersheds; however, lowest values were observed within Daddys Creek. North Carolina Biotic Index (NCBI) scores generally were low among sub-watersheds, indicating that macroinvertebrates reflected good water quality. Lowest scores were observed within Clear Creek sub-watershed. Percent dominant (% Dominant) values varied among sub-watersheds, with lowest values shown within Clear Creek. Clinger organisms (% Clingers) generally were in high abundance; however, highest values were observed among Obed River sub-watershed sites. High percentages of clingers are indicative of healthy benthic communities.

Mean biotic scores for all sub-watersheds were indicative of non-impaired conditions (biotic score  $\geq 32$ ). Highest scores were shown within Clear Creek sub-watershed, where all scores indicated non-impaired conditions. Three habitat variables (conductivity, turbidity, and dissolved oxygen) significantly influenced benthic community quality among watershed sites. Conductivity ( $p = 0.0001$ ) and turbidity ( $p = 0.0001$ ) negatively influenced biotic scores; thus, increases in these parameters lowered biotic scores. A positive relationship was identified with dissolved oxygen ( $p = 0.0001$ ). Therefore, increases in this parameter increased biotic scores. Biotic condition scores also significantly increased with increasing stream order ( $p = 0.06$ ). Both percent forest ( $p = 0.08$ ) and percent stream/lake ( $p = 0.05$ ) coverage positively influenced biotic scores; thus, increased coverage by these land uses improved macroinvertebrate community health. Conductivity was neither influenced by percent forest ( $p = 0.62$ ) nor percent stream/lake ( $p = 0.54$ ) among watershed sites. However, significant positive relationships existed between both percent forest ( $p = 0.0001$ ) and percent stream/lake ( $p = 0.02$ ) land use coverage and dissolved oxygen, indicating that dissolved oxygen concentrations were higher in forested areas with numerous stream/lake drainages. Significant negative relationships were found with percent forest ( $p = 0.002$ ) and percent stream/lake ( $p = 0.01$ ) land use coverage and turbidity. Therefore, turbidity was higher at watershed sites less forested with fewer stream/lake drainages.

Biotic scores varied among seasonal sites; however, highest scores were found during spring 2005, and mean scores for all seasons indicated non-impairment. All winter 2005, spring 2005, and summer 2005 benthic macroinvertebrate communities had biotic index scores indicative of a non-impaired condition ( $\geq 32$ ), regardless of sub-watershed. Two fall 2004



samples (Jett Bridge and Deermont) had biotic index scores indicative of slight- impairment. However, winter 2005, spring 2005, and summer 2005 biotic index scores for these sites improved due to increased EPT species. Community variation existed among seasons ( $p = 0.10$ ); however, no significant differences among the eight seasonal sites were identified across seasons. One-way pairwise test comparisons determined dissimilarities between fall and spring, winter and spring, and winter and summer communities using presence/absence transformation. Life history stages of three taxa (*Oemopteryx*, *Perlesta*, and *Isoperla*) influenced this variation. No individual water quality variable influenced biotic scores at seasonal sites. In addition, land use practices were not found to influence seasonal benthic community variation at the eight seasonal sites.

## CONCLUSIONS

The initial intent of this research was to provide increased understanding of the threatened spotfin chub in order to eventually de-list this species; also, additional knowledge of existing fish and benthic macroinvertebrate communities would allow managers to better evaluate ecological health of the Emory River Watershed. All remaining spotfin chub populations are isolated by impoundments and all occupy very different drainages; however, the Emory River Watershed is the only watershed within the spotfin chub range that consists primarily of sandstone bedrock. The unproductive and low buffering capacity of the Emory River Watershed is critical to survival of its native fish fauna. Slight alterations in this watershed could change macroinvertebrate communities and lead to extirpation of many

intolerant fishes, including the spotfin chub.

In the past, due to the extreme terrain of the upper Cumberland Plateau, human development has been limited; however, now a new surge is taking advantage of the scenic quality this region has to offer. Numerous developments and mining activities have increased in the watershed during this two year study. Coupled with the increase in need for forestry, agriculture, and mining products, the ecological health of the Emory River Watershed will be tested in the near future.

Currently, the spotfin chub and fish communities of the Emory River Watershed can be classified as stable. Macroinvertebrate communities are overall indicative of healthy aquatic ecosystems. Increases in spotfin chub range have not occurred and probably will not occur in the future due to the geological formations and limited water supply of the Emory River Watershed. Fish communities resembled historic populations; however, more exotic species were found in the watershed than during previous surveys. Variables found significant in this study (e.g. drainage area, conductivity, and turbidity) are definitely related to anthropogenic activities in the watershed. Increases in land use activities that increase productivity and sedimentation/siltation, and decreased water supply will undoubtedly affect the fish fauna and macroinvertebrate communities.

The ultimate goal of the U.S. Fish and Wildlife Service is to remove the spotfin chub from the threatened list and in order to accomplish this, sub-populations of this fish must first be examined. Taking all this into account, this two year study on the Emory River Watershed should be the first step in a continuous recovery plan. Additional understanding of the spotfin chub and the ecology of this watershed will increase its chance of survival. The predictive

model produced by this study should be used as a supportive tool when deciding to enhance habitat or re-introduce spotfin chubs into a system, not as a total predictive tool. Caution should be exercised because these models should be compared to other river systems and tested for validity prior to wholesale use.

As a result of this study, the spotfin chub should not be de-listed at the present, and studies associated with spotfin chub micro-habitat use in the Emory River Watershed should be conducted. Future studies comparing the remaining isolated spotfin chub populations are highly recommended to better understand the entire distribution of this rare fish and to further test, validate, and refine, if necessary, models developed in this study and in the ongoing micro-habitat study. Also, due to the unique nature of the Emory River Watershed, more land use regulations may be needed to protect water quality, macroinvertebrate communities, and native fishes of this watershed. Future watershed-based research will reveal if fish communities in the Emory River Watershed have been altered.

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