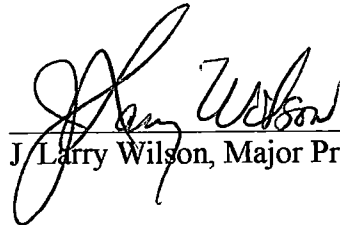
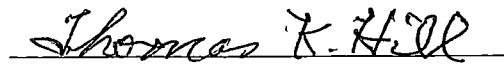


To the Graduate Council

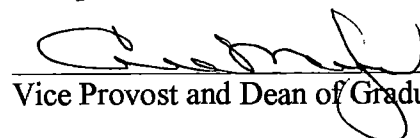
I am submitting herewith a thesis written by Joyce Coombs entitled "Tag Retention in Re-Introduced Species of Selected Darters in the Pigeon River, TN" I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science


J. Larry Wilson, Major Professor

We have read this thesis
And recommend its acceptance




Accepted for the Council


Vice Provost and Dean of Graduate Studies

**TAG RETENTION IN RE-INTRODUCED SPECIES
OF SELECTED DARTERS IN THE PIGEON RIVER, TN**

**A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville**

**Joyce A. Coombs
May 2003**

AQ-VET-MED.

Thesis

2003

1066

Dedication

This thesis is dedicated to my father, Richard A. Coombs, for fostering in me the love of learning.

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Abstract

The Pigeon River has historically suffered from the cumulative effect of years of pollution and hydrological alternation. TVA noted that the fish community consisted of pollution tolerant species such as gizzard shad (*Dorosoma cepedianum*), common carp (*Cyprinus carpio*), and goldfish (*Carassius auratus*). During the past 12-15 years, water quality improvements have brought about the return of some species of fish. Other species have not returned on their own due to population isolation, or non-migratory behavior. Water quality improvements in the river have led state, federal, and private agencies to re-introduce several species into the Pigeon River.

To assess the survival of the relocated species, a fluorescent visible implant elastomer (VIE) tagging technique was tested using a surrogate darter species (*Etheostoma rufilineatum*) in a laboratory setting. Fish were tagged with one of three colors of VIE and observed in aquaria for 125 days. A blue LED light and amber lens were used in conjunction to augment tag visibility. Tag retention after 125 days was 100%, and mortality was zero.

Clove oil was evaluated, as an alternative to MS-222, as a possible field anesthetic. The lowest effective concentrations producing knock down times under three minutes were 30 and 40 mg/L of clove oil. Statistical analysis found no significant differences between the mean induction times of these two concentrations.

The species considered for initial re-introduction were small, non-game, benthic fish. The first re-introductions were blueside (*E. jessiae*), bluebreast (*E. camurum*), and gilt darters (*Percina evides*). All fish were collected from area streams with similar

habitat within the French Broad River drainage. Fish were batch tagged with various colors of VIE before release at one of two re-introduction sites. From 14 March 2001 through 13 March 2003 at Tannery Island and McSween Memorial Bridge, 974 gilt darters, 329 bluebreast darters, and 619 blueside darters were released.

Snorkel surveys, during the summer of 2002, revealed substantial numbers of healthy gilt darters, a few bluebreast darters, and no blueside darters at the Tannery Island site. Representatives of all four re-introductions were seen. Additional snorkel surveys were conducted upstream and downstream of Tannery Island to locate fish, which may have moved from that re-introduction site. A number of tagged fish were observed in the riffle just upstream of Tannery Island. Possible blueside habitat has been identified downstream of the McSween Memorial Bridge site and will be sampled during the spring of 2003.

What appeared to be a young of the year gilt darter was collected during the annual IBI sampling of the Pigeon River. It was located approximately 26.5 km (8 mi) upstream of Tannery Island. If some gilt darters have migrated further upstream, this may be an indication of successful reproduction by the transplants.

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CHAPTER I

Introduction

The Pigeon River is located in the mountainous regions of western North Carolina and eastern Tennessee. The headwaters begin southwest of Asheville, NC, on the north slopes of Black Mountain in the Pisgah National Forest (Bartlett 1995). The origin of the Pigeon River is at the confluence of the East Fork Pigeon and West Fork Pigeon rivers near Woodrow, NC (Saylor et al. 1993). It flows 9.6 km (six miles) to the intake at the paper mill in Canton, NC, and subsequently, flows northwesterly emptying into the French Broad River. The French Broad is impounded by Douglas Dam, which empties its contents into the Tennessee River, the source of the city of Knoxville's water supply (Bartlett 1995).

Since 1908, the Pigeon River has endured environmental degradation by industrial discharge from the paper mill operation in Canton, NC (PRKM 102.1/PRM 63.2). The pulp and paper industry uses massive quantities of sulfur, chlorine, sodium hydroxide, sodium carbonate, sodium sulfate, sodium chlorate, titanium dioxide, aluminum sulfate, rosin sizing, and lime. Bleached kraft mill effluents (BKME) include tannin and lignin compounds the color of coffee and toxic chemicals, such as dioxins, furans, and chloroform (Bartlett 1995). It has been further degraded by altered hydrology as a result of impoundment for hydroelectric power from Walters Dam (PRKM 61.1/PRM 38.0), which was built in 1926 and commenced operation in 1930.

The Pigeon River in North Carolina and Tennessee has suffered from the cumulative effect of years of unabated pollution and hydrological alteration. In 1964, a

statewide fish management investigation by the North Carolina Wildlife Resources Commission found the main-stem Pigeon River so severely polluted by industrial and municipal pollution that a 32-kilometer section in the upper reach supported no fish life (Messer 1964). The state of North Carolina had assigned the river a sanitary classification of “E”, which meant the best use of water with this rating was for waste disposal (Messer 1964).

The Tennessee Department of Health and Environment, Division of Water Pollution Control (McKinney et al. 1978; Melgaard and McKinney 1980), found that the severe pollution arriving in the Tennessee segment of the river consisted of color, solids, and foam, which resulted in limitation of river productivity. This pollution impacted the whole aquatic food chain. BKME acts as a competitor with aquatic plants for trapping available light, suggesting photosynthesis was severely restricted (Kazyak and Dietz 1990). Studies by Adams et al. (1992) and Saylor et al. (1993) have documented the river’s decline in biodiversity. Saylor et al. (1993) commented that the fish community downstream of Canton, North Carolina, was “dominated by pollution tolerant fish such as gizzard shad (*Dorosoma cepedianum*), common carp (*Cyprinus carpio*), and goldfish (*Carassius auratus*), and an almost complete lack of non-game, riffle-dwelling fish species typical of streams in the region.” In historical times, it has been estimated that 95 species of native fish inhabited the Pigeon River (Etnier and Saylor 2001).

During the last 12-15 years, improvements in water quality have occurred. In 1988, the Tennessee Department of Health and Environment (TDEC), Tennessee Wildlife Resources Agency (TWRA), and the Tennessee Valley Authority (TVA) initiated annual biomonitoring on the Tennessee portion of the river to evaluate

environmental quality and to document recovery (Saylor et al. 1993). A summary of annual IBI data from 1988-2002 is found in Table A1.

The Index of Biotic Integrity (IBI) (Karr 1981) was modified by TVA (Tables B1-B3) and has been used annually to rate several sites on the Pigeon River and one reference site on the Little River, a direct tributary to the Tennessee River in Blount County, TN. Out of a possible 60 IBI index points, the Little River has rated a 54 or better since 1988, and the Pigeon River had consistently rated 38 points or less until 1993. One of the biggest improvements in water quality was brought about by change in the paper bleaching process. In 1992, the chlorine bleaching process was replaced by a chlorine dioxide and oxygen delignification system which virtually eliminated the toxic byproducts dioxins, furans, and chloroform in the waste chemical stream, and reduced water usage by 35 percent (Bartlett 1995). Subsequently, a decrease in nearly all pollutants and most notably a change in color has occurred, which was due in part to the paper mill's actions in response to public pressure. The annual average effluent color has decreased from 350,000 lbs/day (1988-89) to less than 50,000 lbs/day (2000-01). In 1997, the Environmental Protection Agency (EPA) issued a National Pollution Discharge Elimination System (NPDES) permit to Champion International Corporation (as of 1999, Blue Ridge Paper Products, Inc.) which called for significant pollution reductions. An IBI was conducted on the Pigeon River in Newport, TN, in April 2001; this score was 50 out of 60 and represented a significant recovery in the riverine habitat and the native fish communities.

Under the Tennessee Water Quality Control Act of 1977, the people of Tennessee have a right to unpolluted waters. The government of Tennessee has an obligation to take

all prudent steps to secure and preserve this right, as directed in section 69-3-102(a). It is further stated in section 69-3-102(b) that the Tennessee government must reclaim polluted waters. It is with this mandate to reclaim polluted waters that the Tennessee Department of Environment and Conservation initiated efforts to re-introduce native fish species into the Pigeon River.

A joint meeting between federal and state agency personnel was conducted in February 2001 to evaluate the possibility of re-introducing fish into the Pigeon River. There are no historical fish assemblage data for the Pigeon River downstream of Canton, NC, before it was degraded. However, based on the ecoregions it traverses and its similarity to other streams within the same watershed, many diverse fish species should have occurred. Etnier and Saylor (2001) developed a list of fish species that do occur and/or should have occurred in the Pigeon River (Appendix C). The fish species considered for re-introduction are believed to have occurred in the river but have not returned to the river on their own, because surviving populations are isolated from or within the Pigeon River drainage. Re-introduction was unanimously supported and project planning was initiated.

The species proposed for initial re-introduction by the Pigeon River Recovery Project (PRRP) included small, non-game, benthic fish. The first three fish chosen for re-introduction were *Etheostoma camurum* (bluebreast darter), *E. jessiae* (blueside darter), and *Percina evides* (gilt darter) (Figure 1). The overall goal of the PRRP is to increase fish species biodiversity in the Pigeon River through re-introduction by establishing viable, reproducing populations. Management for biodiversity requires monitoring for recovery (Saylor et al. 1993); therefore a plan to evaluate the success of the PRRP was



Figure 1. Bluebreast darter, blueside darter, and gilt darter (from top to bottom).

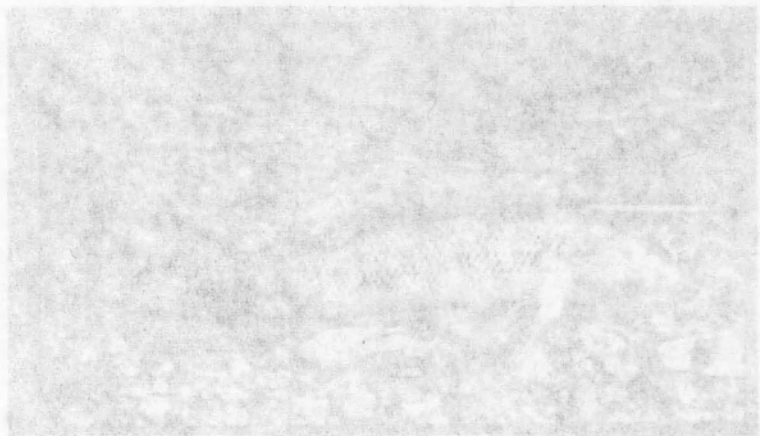


Figure 1. Blueberry darter, blueberry darter, and blueberry darter (from top to bottom).

needed.

The primary objective of the present study was to determine the survival of the re-introduced fish. To achieve this objective, laboratory and field studies were conducted. Two laboratory studies were conducted which: (1) evaluated tagging mortality and retention over time using a subcutaneous tag, Visible Implant Fluorescent Elastomer (Northwest Marine Technology, Inc.), and (2) assessed the effectiveness of an alternative anesthetic (clove oil) for field tagging by determining the lowest effective concentration and its effect on survivability. The field portion of the study was two-phased; the first step was to collect, tag and release darters into the Pigeon River, and the second step was to monitor their survival by conducting multiple snorkel surveys.

CHAPTER II

Literature Review

Re-introduction

Game fish have been reared and stocked in U. S. waters since the late 1800's (Kohler and Hubert 1993). It was not until the late 1900's, when science realized it was the whole ecosystem that defined the health of a particular forest, river, and prairie, that fisheries biologists began to look at the importance of native non-game species of fish. Re-introduction of native non-game fish species is a recent development in the ongoing battle to repair and replenish riverine ecosystems degraded by man.

Rakes and Shute (2002a) began their first native species re-introductions in 1986 with the federally threatened yellowfin madtom, *Noturus flavipinnis*, and federally endangered smokey madtom, *N. baileyi*, into Abrams Creek, Great Smoky Mountains National Park, Blount County, TN. Some 30 years earlier, Abrams Creek had been treated with rotenone to remove all native fish for fear that the stocked rainbow trout, *Oncorhynchus mykiss*, would have too much competition from the native species. Since that first re-introduction, Rakes and Shute (2002b) have expanded their re-introductions to include other federally listed species, such as the duskytail darter, *E. percunrum*, spotfin chub, *Erimonax monachus*, boulder darter, *E. wapiti*, and Barrens topminnow, *Fundulus julisia*.

Rakes and Shute began their re-introductions of the spotfin using propagated fish spawned and reared at their facility, Conservation Fisheries, Inc., since 1994 (Rakes and Shute 2002b). These fish were tagged with Visible Implant Fluorescent Elastomer (VIE) to determine survival and for future identification. There is evidence of reproduction and

recruitment in the wild for three of the four species. Minimal evidence of reproduction has been observed for the spotfin chub.

Schram et al. (1999) re-introduced lake sturgeon (*Acipenser fulvescens*) into the St. Louis River, a tributary of Lake Superior. Although lake sturgeon are considered a game species, this project sought to re-establish a native species into its historical home, not stocking game fish in a non-native stream. They were eliminated from the river during the 1900's due to the combined effects of overfishing, pollution, and habitat alteration (Schram et al. 1999). Water quality improved and by 1979 the states of Wisconsin and Minnesota became interested in re-establishing a spawning population of lake sturgeon. The concept of re-introduction of lake sturgeon was in harmony with the Wisconsin and Minnesota Departments of Natural Resources goals for re-establishing depleted stocks of native species (Schram et al. 1999). Lake sturgeon were stocked annually using hatchery reared fry, fingerlings, and yearlings from 1983 through 1994. Fisheries assessments were determined by sampling marked fish (coded wire tags, floy anchor tags) and with graded-mesh gill nets and bottom trawls (Schram et al. 1999).

In cases where a fish species is threatened or endangered, additional fish from other locations or from captive propagation could be introduced into other suitable habitat within that same water body. This augmentation would increase the distribution of species with restricted ranges (Johnston 2001).

Fish Movement

Gerking (1950) noted that certain stream fish species showed minimal or restricted movement within their stream area. Many studies since have come to similar conclusions. For the small percentage of fish found to travel great distances, Funk (1955)

proposed that fish populations consist of mobile or exploratory individuals and sedentary individuals. Smithson and Johnston (1999), using passive integrated transponder tags, showed that stream fish populations were comprised of a large static group and a smaller mobile group, that make round-trip movements outside of the home territory. Similar results showing the existence of resident and exploratory individuals were confirmed by Larson et al. (2002) in a study of fish movement in a mountain stream.

Little data are available about home ranges or movements of most darters, yet this information will be of great importance for locating and monitoring re-introduced species into a river. Early studies by Reed (1968) were conducted to determine population stability of certain darters of the genus *Etheostoma* in riffle habitats. He discovered that the rainbow darter *E. caeruleum*, the greenside darter *E. blennioides*, the fantail darter *E. fabellare*, and the banded darter *E. zonale*, restricted their movements within the stream. Scalet's (1973) study of the orangebelly darter, *E. radiosum cyanorum*, also supported the theory of minimal stream movement.

Upstream movement of fish was noted by Hall (1972). He investigated fish migration and found annual peak movement closely correlated with annual peaks in primary production, community respiration, and the end of winter floods (Hall 1972). No preference for upstream versus downstream movement was exhibited by the two darters (johnny darter, *E. nigrum*, and piedmont darter, *P. crassa*) in Hall's study. Mundahl and Ingersoll (1983) observed autumn movements and densities of the johnny and fantail darters, which indicated that most movements were restricted to areas near the initial point of capture. The average distance traveled (60 m) by darters was similar to the distance between habitats (two pools or two riffles), which suggested that most darter

movements occurred between similar adjacent habitats. Therefore, distance of movements was dependent upon the riverine morphology of the stream (Mundahl and Ingersoll 1983). Over 75% of all movements were in an upstream direction. Their results suggested that population density and habitat quality may influence seasonal movements.

In a more recent study, movements by adult black banded darter, *P nigrofasciata*, and juvenile redbreast sunfish, *Lepomis auritus*, were studied over an 18-month period (Freeman 1995). Most darters were recaptured within 33 m of their original capture location, which conforms to recent movement studies (Smithson and Johnston 1999, Johnston 2000) documenting limited movement by the larger proportion of the population. Recapture data demonstrated that only 12% of darters moved considerable distances (> 100 m) (Freeman 1995). These movements were among three distinct mesohabitats within the site (boulder riffle, sand pool, and gravel riffle). Darters appeared most likely to move long distances during winter and spring, and movements occurred in upstream and downstream directions equally (Freeman 1995).

Tagging

There has been a long-standing need for a tagging method that is inexpensive, biocompatible, permanent and capable of field application, especially for small (<100 mm) fish. Chemical marking or tagging has evolved from the need to eliminate the negative effects of non-chemical marks or tags. To conduct more precise studies such as population dynamics and life histories, a tag must have no effect on the fish's behaviors, reproduction, life span, growth, feeding, movement or vulnerability to predation.

Various chemicals that have been used to tag fish include metallic compounds, fluorescent compounds, radioactive isotopes, latex and plastic, inks and paints, and dyes and stains (Arnold 1966). These may be applied by immersion, spraying, tattooing, and injecting (needle or pressure) (Murphy and Willis 1996). Inert materials or pigments are embedded in or under the epidermis of the fish, thereby creating an internal mark. As such, these pigment tags can be considered the precursor to the visible implant tag (Murphy and Willis 1996). Pigment tags are relatively inexpensive and easy to apply. A disadvantage of chemical marking is that it lends itself to batch tagging. However, small numbers of fish can be individually tagged by using a combination of several tag locations and various tag colors. Pigment marking is a method in which inert colored material is embedded in or placed beneath the animal's skin or exoskeleton (Nielsen 1992). This technique holds great promise in addressing the problem of long-term tagging of small fish.

Davis (1955) was the first to use liquid latex rubber to mark fish. He injected colored latex subcutaneously into green sunfish, *L. cyanellus*, producing a mark that was retained for 6 to 10 months. Of the chemicals he tested, he believed liquid latex to be the most promising because it remained flexible and produced no harmful physiological effects. However, there were some problems with latex. Because it is air-cured, there were problems with clogged needles and variable curing times (within the fish tissue) that was subject to size and location of the tag and air temperatures.

Hill et al. (1969) did an evaluation of several marking methods on channel catfish, *Ictalurus punctatus*, using dyes and pigments that were injected or tattooed, and hot and cold brands. They determined that blue latex injections, hot brands, and cold brands were

the most effective for tagging in this study. The blue liquid latex was found to be superior to all other injected materials and was visible on 100 percent of the fish for 28 weeks.

Hill and Grossman (1987) developed a method using the subcutaneous injection of acrylic paint in one of nine body areas of six small species of fish using several different colors. Mark longevity varied among species and was affected by mark position. Their results suggested that this tagging method does not adversely affect fish survival and can be long lasting (> one year) (Hill and Grossman 1987). This same method was used by Freeman to tag adult *P. nigrofasciata* and juvenile *L. auritus* in her 18-month movement study.

Haines and Modde (1996) did a comparison study of three marking methods: tattoo ink injection, visible implant fluorescent elastomer, and fin clipping, using age-0 Colorado squawfish, *Ptychocheilus lucius*. Their studies indicated that fish marked with the elastomer had a mortality of less than 1% and a mark retention rate (85%) substantially higher than either of the other two methods after 142 days. No differences in vulnerability to predation were observed among fish with any of these marks or between marked and unmarked fish. In a field test of the elastomer, they found it was easy to use, produced low mortality, and exhibited highly visible marks.

Visible Implant Fluorescent Elastomer (VIE) is a two-part material consisting of medical grade fluorescent silicone rubber and a curing agent. This new tagging system was developed by Northwest Marine Technology, Inc. (NMT, Shaw Island, WA) in 1991. The tagging material was developed primarily for fish, and especially small fish,

but is now being used for marking many small organisms, including juvenile shrimp (Godin et al. 1996) and terrestrial salamanders (Jung et al. 2000).

The VIE for tagging small fish has been used on various species. Frederick (1997) tagged Hawaiian coral reef fishes (8-56 mm SL) successfully in the laboratory and in the field. Bonneau et al. (1995) used snorkelers to identify and count VIE tagged bull trout, *Salvelinus confluentus*, and cutthroat trout, *O. clarki*, during the day and night without the need for recapture. Bailey et al. (1998) tested mass marking of coho salmon, *O. kitsutch*, smolts. They found ocean retention of the VIE tag to range between 90-98%. Olsen and Vollestad (2001) compared growth in tagged and untagged age-0 brown trout (26-70 mm), *Salmo trutta*, released in the wild. They found no significant differences in mean fork length between tagged and untagged individuals captured on the same date. They also noted a low mortality rate associated with the VIE tagging method (0.5%) and could easily identify recaptured individuals.

Dewey and Zigler (1996) evaluated the fluorescent elastomer for tagging of adult and juvenile bluegills, *L. macrochirus*. The marks were visible for a minimum of six months and did not affect growth or survival of either adults or juveniles. Catalano et al. (2001) used age-0 largemouth bass, *Micropterus salmoides*, and bluegill (50-100 mm) to evaluate the retention rate of injectable photonic dyes (IPDs) versus VIEs, and the effect of colorless versus brightly colored marks, on prey selectivity by adult largemouth bass. Their results revealed that only VIE marks had retention rates long enough for use in small centrarchids (<150 mm). They also suggested that highly colored marks should be avoided in conspicuous locations because they may increase susceptibility of the tagged fish to predation.

This is not to say that all VIE tagging has always been successful. Some earlier studies resulted in much lower tag retention time, but the cause was unclear. Close and Jones (2002) evaluated VIE mark retention in fingerling (29 months) and yearling (35 months) rainbow trout. Fish were marked in the post ocular adipose eyelid and on the ventral surface of the lower jaw using yellow and green VIE. After recapture, it was concluded that, with a visual detection rate that ranged from 29% to 33%, the marking locations were problematic (heavy pigmentation) for this strain of rainbow trout. Dissection of fish revealed rates of tag loss to be 18% (yellow) and 12% (green), and of the green tags lost, 25% had been injected too deeply to be detected with either the naked eye or the blue light (Close and Jones 2002).

The first VIE tagging of a darter species was conducted by Conservation Fisheries, Inc., (CFI) of Knoxville, TN. Rakes and Shute (2002a) tagged five species (yellowfin madtom, spotfin chub, channel darter *P. copelandi*, blue shiner *Cyprinella caerulea*, and boulder darter *E. wapiti*) with red VIE. They also tagged mountain madtoms, *N. eleutherus*, and boulder darters with acrylic paint. At the end of one month, two fish tagged with acrylic paint had died but none of the fish tagged with VIE had died. Since that time, the only losses of any of these marked fish has been due to old age, euthanasia or transport, and the tags are still readily visible. In another part of that study, approximately 430 sub-adult (captive bred) boulder darters were tagged using yellow VIE. One mortality occurred as a result of an air embolism. Without the use of the blue light, however, the yellow VIE tags were not highly visible. Within two weeks time, the majority of the darters had shed their tags, and pieces of elastomer were seen in the tank.

The cause of this tag loss was unknown. These fish were retagged with red VIE and no tag losses were noted in the following two weeks (Rakes and Shute 2002a).

Anesthesia

The U. S. Food and Drug Administration (FDA) has approved only two anesthetics for use on fish consumed by humans or fish released into public waters, tricaine methanesulfonate (MS-222) and carbon dioxide. MS-222 is the most effective and commonly used but is toxic to humans and costly. Carbon dioxide is considered safe but produces insufficient anesthesia and fish may react violently after its application (Taylor and Roberts 1999).

Clove oil has been found to be an effective alternative to MS-222 by Soto (1995), Anderson et al. (1997), Keen et al. (1998), Peake (1998), Taylor et al. (1999), Waterstrat (1999), Prince and Powell (2000), Cho and Heath (2000), and Cooper (2001). Besides its simplicity of use and low cost, clove oil has been widely tested in humans and has been generally regarded as safe by the FDA for both fish and humans (Waterstrat 1999).

Most research has tested the anesthetic efficacy of clove oil on salmonids and other game fish. A few studies have examined the effect of clove oil on small fish, Anderson et al. (1997) and Keene et al. (1998) studied the effects on juvenile rainbow trout, and Waterstrat (1999) examined its use on channel catfish, *I. punctatus*, fingerlings. Soto (1995) used juvenile rabbitfish, *Siganus ineatus*, a saltwater species, ranging in size from 5 to 23 cm in total length. All of these studies have found clove oil to be a highly effective alternative fish anesthetic. When compared with MS-222, induction times generally showed no significant differences; however, recovery times for clove oil were significantly longer in these studies.

Only one research article was found that examined the effect of clove oil on a small fish species. Munday and Wilson (1997) compared the efficacy of quinaldine, benzocaine, MS-222, 2-phenoxyethanol, and clove oil for anesthetizing the coral reef fish, *Pomacentrus amboinensis* (maximum size 80 mm SL). Clove oil was observed to have a calming effect on fish during induction and also produced excellent survival rates. Recovery time with clove oil was two to three times longer than recovery from other chemicals, which was suggested as a beneficial characteristic for use in fieldwork.

Survey Methods

Visual observation of fish has commonly been deemed the best method to estimate abundance of reintroduced species. Direct underwater observations have proven to be the most efficient method for the collection of life history data, microhabitat use, and census collection of rare benthic non-schooling species (Dinkins and Shute 1996). CFI has used snorkel surveys to monitor all of their re-introduced federally listed species. In a river fighting its way back to a healthy state, the sampling method must produce minimal injury and, hopefully, no mortality to any aquatic organisms. Although seining produces a minimum of injuries and mortalities, it provides only point samples, not a continuous sample throughout the survey area (Goldstein 1978).

The only other option for sampling benthic fish is electroshocking, which may cause short term and long term injury or death to fish and other aquatic species. Nielsen (1998) reviewed many studies that dealt with the lethal and sub-lethal effects of electrofishing. One study suggested that sub-lethal injuries might accumulate through time in fish populations exposed repeatedly to electroshocking (Nielsen 1998). Whaley et al. (1978) examined the mortality of fantail darters, *E flabellare*, exposed to variations

in pulse frequency and duration of exposure during electrofishing and suggested ways of minimizing injury. Nielsen (1998), in her review of electrofishing literature, stated that many researchers have suggested snorkel surveys as an alternative to electroshocking. Snorkeling does not harm fish and usually does not require as much time, equipment or personnel (Hankin and 1988). Snorkeling is an effective underwater observation technique that works in many environments including small streams and rivers, providing underwater visibility is adequate (Murphy and Willis 1996).

As noted by Hankin and Reeves (1988), correlations between diver counts and accurate estimates of fish abundance can be high ($R > 0.90$) for fish in the water column (coho salmon) but low for fish (steelhead trout, *Salmo gairdneri*) more closely associated with bottom substrate. Therefore, water depth, water clarity, and coloration (cryptic, non-cryptic) of the target species become major issues in the sampling design.

Underwater visual enumeration of stream salmonids using strip transect sighting models has become a common technique (Ensign et al. 1995). Surveys using visual estimation of other species, specifically benthic fish, have been infrequent. Benthic species are frequently small, cryptically colored, and living under and around rock substrate, debris, or vegetation. Therefore, it may not be possible to see all targets with equal certainty within a sample site. Ensign et al. (1995), in their estimation study of abundance of benthic stream fishes, indicated that sampling models that assume decreased sighting probability with increased distance of the target from the line of travel provide a more appropriate approach for abundance estimation of benthic riffle fish than strip transect models. The level of precision and reliability of a line transect survey for tagged benthic fish is unknown.

CHAPTER III

Methods

Study Area

The Pigeon River is a high gradient, 5th order stream 111.8 km (69.5 mi) in length, one of 4,200 5th order streams in the United States (Cushing and Allan 2001). The river's source originates in the Blue Ridge physiographic province of western North Carolina. As the river enters Tennessee, the gradient decreases, flowing into the Valley and Ridge physiographic province. The Pigeon becomes a classic floodplain stream initially underlain with deposits consisting of mud and sand derived from the rocks of the Blue Ridge Mountains. The alluvium is underlain with dolomite and limestone of the Knox Group (Cambro-Ordovician), and near Newport the river crosses into Sevier Shale (Middle Ordovician), which overlies the Knox Group. All three rivers (Little Pigeon, Pigeon, and Nolichucky Rivers) utilized in this study are part of the French Broad River drainage system.

Pigeon River receives paper mill effluents at PRKM 102 (PRM 63.3), Canton, NC, and then flows approximately 92 km (57 mi.) to Newport, TN (Figure 2). Two locations were utilized for re-introductions (Figure 3). The main release site was at Tannery Island PRKM 13.2 (PRM 8.2) with a secondary site just downstream at the McSween Memorial Bridge at PRKM 8.7 (PRM 5.4) in downtown Newport. Both sites are characterized as riffle habitat with predominately cobble, boulder, and some sand substrate. Vegetation within the river is predominately river weed (*Podostemum ceratophyllum*) and, in the littoral zone, water willow weed (*Justicia americana*).

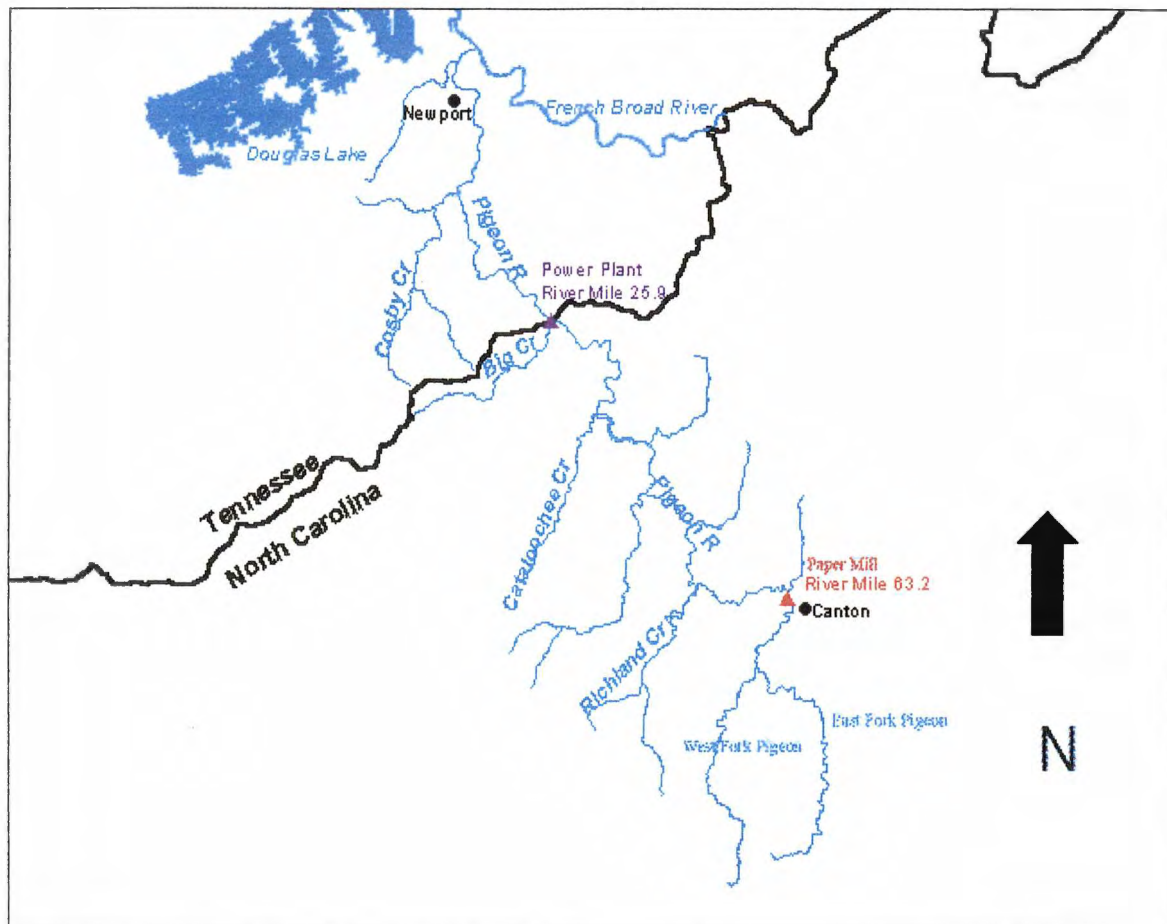


Figure 2. The Pigeon River: Origin to mouth.

Source: <http://www.state.tn.us/environment/epo/pigeon/pigeon.gif> (20 January 2002)

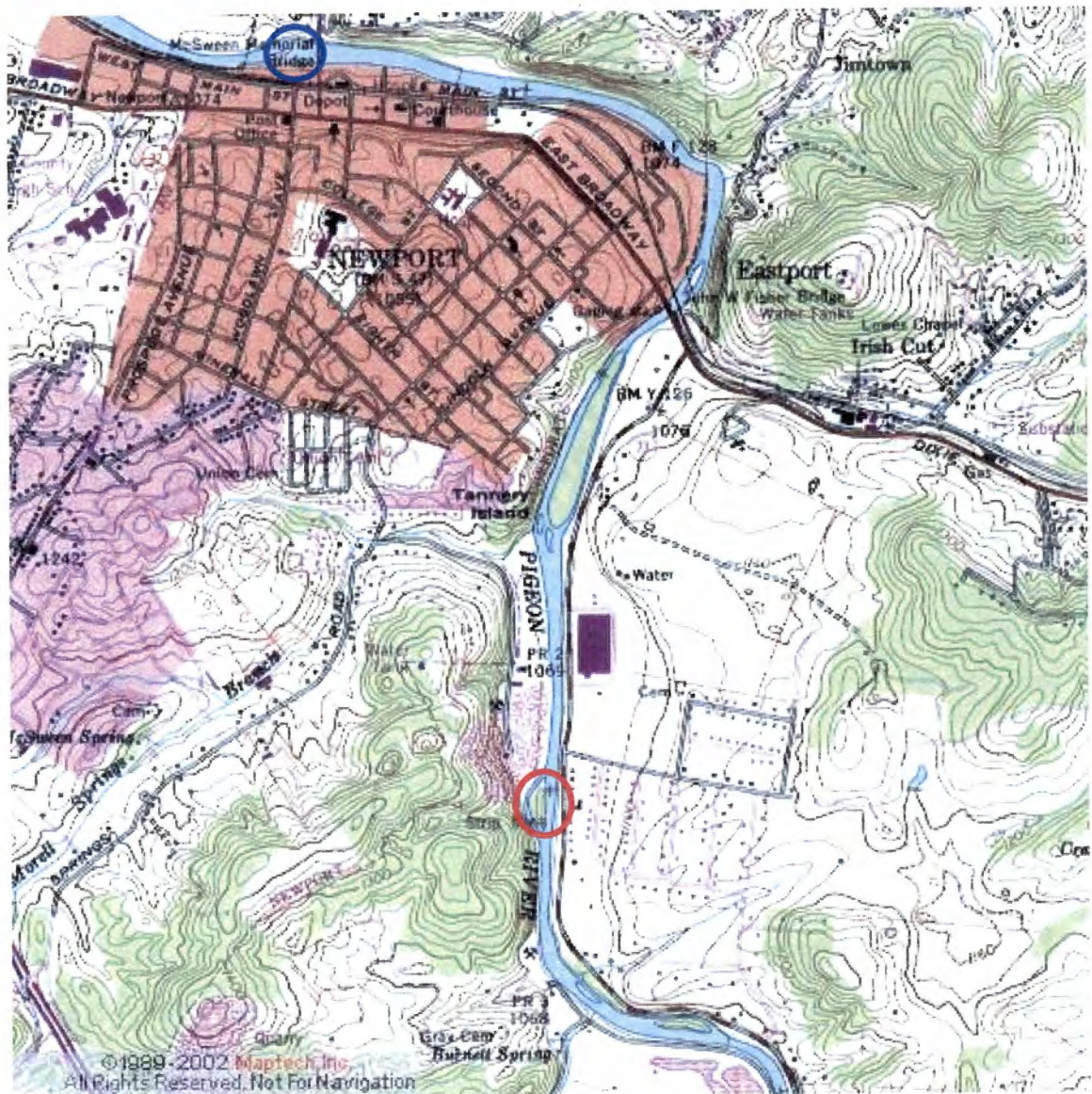


Figure 3. Re-introduction sites for three native darters: Tannery Island (red circle) and McSweeney Memorial Bridge (blue circle).

Laboratory Trials

Two separate laboratory experiments were conducted at the facilities of CFI. The first study was a tag retention study using a surrogate species, the redline darter, *E. rufilineatum*. The redline darter was chosen because it was plentiful, was co-located with the other species of darters in this study (at collection and release sites), and is considered a very hardy species. The second experiment used clove oil to anesthetize these same redline darters to compare the knockdown and recovery times with that of MS-222. The objective was to determine if clove oil could be used as an alternative to MS-222.

Tag Retention

The redline darters used in the laboratory studies were collected from the Little Pigeon River (LPR) just above its confluence with the West Prong, Little Pigeon River (WPLPR) (Figure 4). Fish were collected by kick seining using a 4.6-m seine (5 mm mesh). The net was held in place in the fast current of a riffle, then 4 or 5 people upstream of the net moved in a line towards the net, kicking and dislodging the rock substrate, thereby herding the fish towards the net. Once the kickers reach the net, the anchor line was lifted to a horizontal position so that the catch could be examined. Those specimens to be collected were placed in buckets containing river water and transported to the holding area. The darters were placed in oxygenated insulated holding tanks (coolers) containing ambient river water until ready for transport to the laboratory. Dissolved oxygen content and temperature were monitored continuously. The fish were placed in plastic bags, filled approximately 1/3 with river water, and then the bags were oxygenated and sealed for transport. The bags were placed in sealed coolers, placing the fish in the dark to minimize transport stress and temperature change (Williams et al.

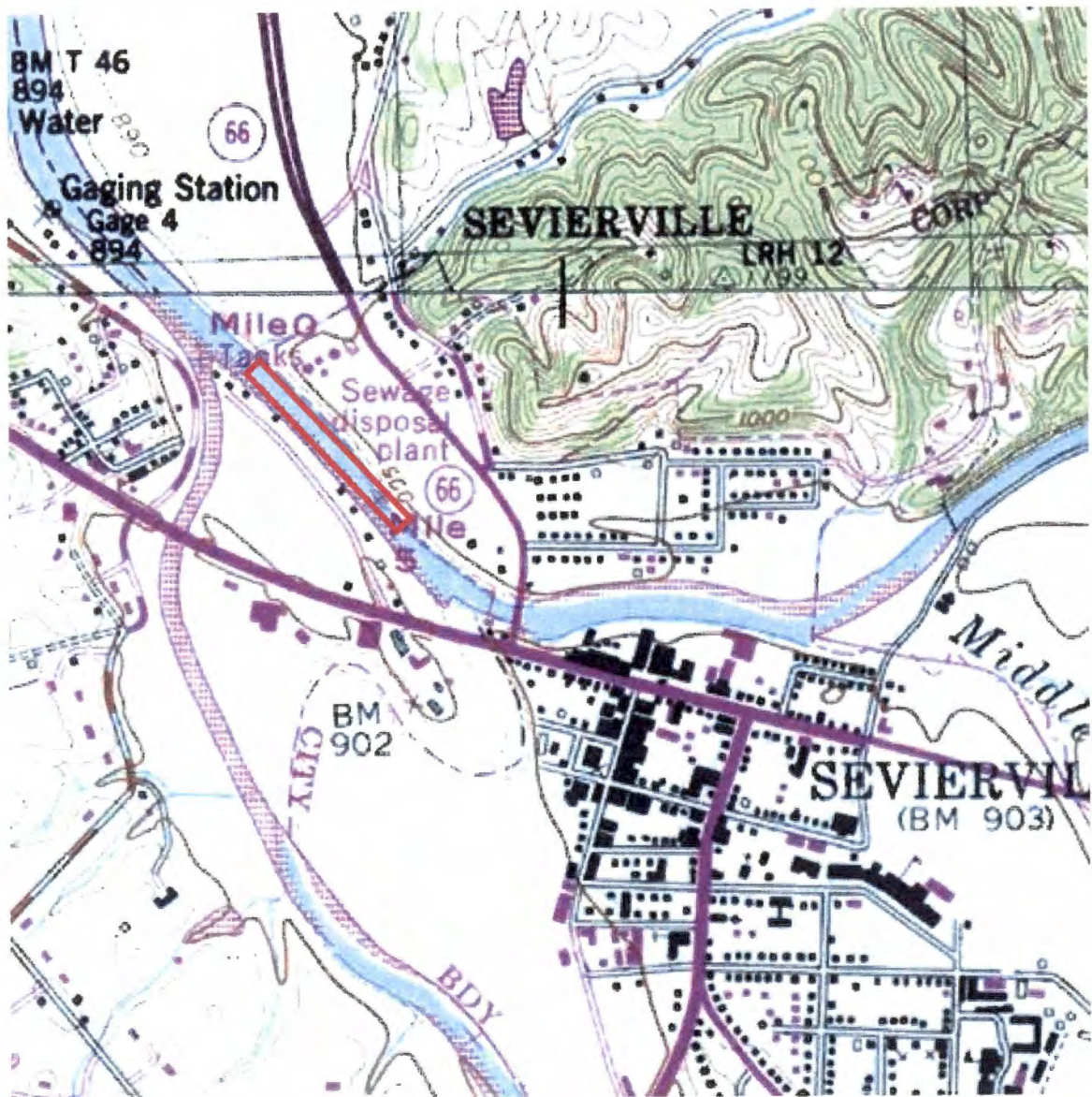


Figure 4. The Little Pigeon River collection area was located just upstream of its confluence with the West Prong of the Little Pigeon River. The site is denoted by the red rectangle.

1988), and transported to the University of Tennessee fisheries laboratory, Johnson Animal Research and Teaching Unit (JARTU), where they were held overnight. Subsequently, they were taken to CFI, acclimated to the new environment, and then placed into one of three 189-L aquaria that were part of a larger recirculating aquaria system. Initial feeding consisted of live *Daphnia* for two days, followed by *Daphnia* and live black worms (*Lumbriculus variegatus*). By week three, most were eating frozen bloodworms (*Chironomidae* larvae) and had adjusted to the aquaria; no mortalities occurred during the acclimation period.

After four weeks of acclimation, all fish were removed from the three aquaria and placed in aerated holding buckets in preparation for the tag retention study. Water temperature was monitored throughout the procedure. Immediately before tagging, three or four fish were placed in a clear plastic shoebox with 100 mg of MS-222 in 1.0 L of ambient water. Once anesthetized to a Stage 4 level (Table 1), each fish was removed from the shoebox and tagged with VIE using a 0.3-cc insulin syringe with an ultra-fine 29-gauge needle. These same methods had been used successfully by CFI to tag and reintroduce endangered boulder darters in the Elk River, TN (Rakes and Shute 2002a)

The tagging material, Visible Implant Fluorescent Elastomer (VIE), is a bio-compatible, medical grade silicone that, when injected as a liquid, cures to a pliable solid. VIE comes in five fluorescent colors (red, green, yellow, orange, pink). These colors are easily seen in ordinary light; in reduced light conditions, a blue LED light enhances visibility. Curing time is temperature dependent. VIE is a two-part compound of elastomer and curing agent at a 10:1 ratio. It is mixed just prior to use and generally has a working time of two hours at room temperature, although a longer time if cooler and a

Table 1. Stages of fish anesthesia induction and recovery.

Stage of Induction	Description
1	<i>Sedation</i> : Partial or total lack of reaction to external stimuli.
2	<i>Subtranquility</i> : Partial loss of equilibrium, uncoordinated movement followed by active, erratic swimming.
3	<i>Tranquility</i> : Inverted swimming with intermittent resting on bottom, but react to vibrational stimuli.
4	<i>Anesthesia</i> : Loss of reflex activity with slow erratic opercular movement.
5	<i>Medullary collapse</i> : Respiratory movement ceases. Fish are pale. Death.

Source: Plumb, J.A., and T.E. Schwedler, and C. Limsuan (1983)

Stage of Recovery	Description
1	Reappearance of opercular movement.
2	Partial recovery of equilibrium with partial recovery of swimming motion.
3	Total recovery of equilibrium.
4	Reappearance of avoidance swimming motion and reaction in response to external stimuli, but still behavioral response is stolid.
5	Total behavioral recovery; normal swimming.

Source: Cho, G.K., and D.D. Heath (2000)

shorter time if warmer. If the temperature of the water in which the tagged fish is placed is $<10^{\circ}\text{C}$, it may take up to 24 hours for the tag to cure (Northwest Marine Technology, Inc).

Needle technique is very critical to the visibility and retention of the mark. The needle pierced the skin of the fish, bevel up, to just below the dermis and was inserted 5-6 mm, parallel to the skin (Figure 5). The goal was to place the tag between the skin and the muscle layer to maximize tag visibility through the skin layer. Ideally, each tag was 3-5 mm in length. VIE was injected as the needle was withdrawn, filling the cavity made by the needle. Injection was halted just prior to removal of the needle. Any excess elastomer exuded from the entry wound was wiped off to minimize tag loss after curing. Ninety redline darters (36-83 mm TL) were double tagged just off the midline, parallel to the dorsal fin; 30 each were marked with red, yellow, and green VIE. After tagging, the total length (mm) and sex of the fish was recorded and they were placed in a recovery tank with oxygen aeration. Fish settled on the bottom of the recovery tank where they remained for 1-4 minutes before reaching recovery Stage 4 (Table 1). Upon recovery, ten fish of each color were placed in each of three aquaria for a total of 30 fish per aquarium.

Visual observation of all fish was conducted after 24 and 48 hours to check for mortalities. No tagged fish were handled again until day 14. Fish were not handled: (1) to minimize stress, (2) to allow the VIE to cure, and (3) to ensure that the tissue injection site had time to heal. For observations conducted at 14, 30, 60, 90, and 125 days, fish were netted from the aquaria and observed individually for general health and tag retention. Each tank was emptied individually, and then fish were netted and placed in an aerated container. From there, five fish at a time were placed in an aerated plastic

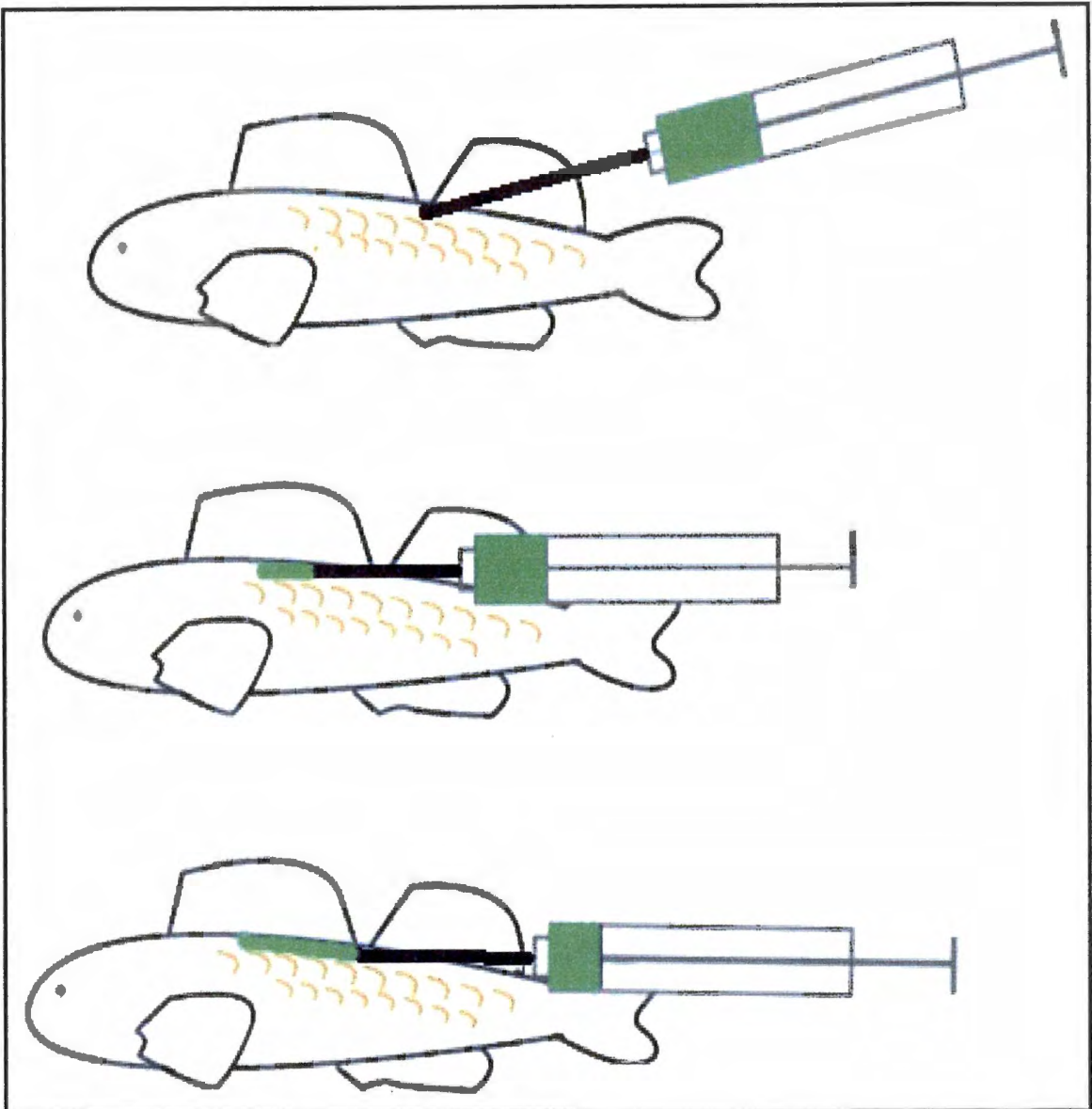


Figure 5. Needle technique schematic.

shoebox for observation by a fisheries biologist. The parameters used to determine the health of the fish included clarity of eyes, condition of the fins, and activity level. These same parameters were used for all subsequent observations. VIE tags were checked for visibility with the naked eye only on day 14. All subsequent observations were checked for tag visibility with the eye and if not readily visible, a LED blue light flashlight and amber glasses were used to locate the tag. Starting with the day 30 observation, the size and shape of the tag were also recorded.

Anesthesia

Due to clove oil's low solubility in water at temperatures below 15°C, it was dissolved in ethanol at a ratio of 9:1 (ethanol:clove oil) and added to dechlorinated tap water to make a 1.0-L solution. This stock solution was made on the day of the experiment to limit photo-degradation (Keene et al. 1998). The fish used for this experiment were the previously tagged redline darters that had been acclimated to aquaria for 125 days; food was withheld for 24 hours before the experiment began. One liter of ambient water was placed in a clear plastic shoebox (30.5 cm x 16.5 cm x 11 cm). The stock solution was shaken vigorously; the appropriate quantity was measured for the test concentration, which was then poured into the shoebox. This clove oil mixture was stirred before the fish were introduced. Each fish was monitored individually to determine time to induction and time to recovery using a stopwatch. Induction was considered complete when Stage 4 occurred, i.e., loss of equilibrium. This was defined as the point when the fish could no longer right itself. Three darters were netted from the holding tank and when placed in the shoebox, the stopwatch was started for each fish. Once anesthetized, the fish was netted and placed in the recovery container, at which time

the stopwatch was started. Recovery was considered complete (Stage 4) with the reappearance of avoidance behavior, being defined, as when the fish was touched, it would swim away. Both anesthesia and recovery tanks were aerated and temperatures monitored throughout the experiment. These same procedures were followed for each concentration tested.

Preliminary trials using 40, 60, 80, and 100 mg/L of clove oil were conducted to narrow the number of concentrations to be tested to those most promising. Twelve fish from tank #1 were used for the trial, with three different fish for each concentration. After recovering from the anesthesia, all fish were returned to tank #1. These concentrations were chosen based on a prior study by Cooper (2001), which tested the efficacy of clove oil on non-salmonid species. During the tagging procedure using MS-222, ten random induction times were recorded. Based on Marking and Meyer's (1985) criteria for an ideal anesthetic, the goal was to find the lowest effective concentration of clove oil to induce anesthesia at three minutes or less, recovery in 10 minutes or less, and no fish mortalities. As a result of the preliminary trials, concentrations of 30, 40, and 50 mg/L were chosen for the experiment. Twenty fish were tested at each concentration. After recovering from the anesthesia, all fish were returned to tanks, which were observed for abnormalities and mortalities for four weeks.

At the completion of both laboratory studies, the fish in tanks #2 and #3 were returned to the collection site on the Little Pigeon River. The redlines were released at latitude 35°52'25"N and longitude 83°34'21"W. The fish in tank #1 were held indefinitely to determine how long the VIE tag would remain visible.

Field Study

From 14 March 2001 to 13 March 2003, the three target darter species were collected from two sites for re-introduction. The first site was located on the Little Pigeon River (LPR) from below the Highway 66 bridge to just upstream of its confluence with the West Prong, Little Pigeon River (WPLPR) in Blount County, near Sevierville, TN (Figure 4). At this location, blueside and gilt darters were collected. The second site was located on the Nolichucky River (NRM 28) just downstream of the bridge at Bewley's Chapel in Greene County, TN (Figure 6). This location was one of a few locations where bluebreast darters are common (Charles Saylor, TVA, personal communication). Gilt darters were also collected from this site.

All collection and tagging operations were conducted in the spring, fall, or winter, when water temperatures were low, minimizing heat stress. The collection method for all three darters was conducted in the same manner as the collection for redline darters (see page 22). River water temperature, dissolved oxygen, and pH data were recorded at the start of each collection effort to be used as a reference point for the water in the holding and tagging tanks, and for acclimation at the release sites.

Field tagging procedures were modified from the lab study. The holding and recovery tanks consisted of individual 34-L coolers. Each species collected had its own recovery cooler to help minimize temperature change. Fresh river water was added and replaced as needed. Coolers were kept in the shade, when possible, and with the lids, open just enough for aeration hoses. This minimized heat, sound, and light transfer, which would minimize additional stress on the fish. All tanks were aerated using oxygen from portable tanks. To maintain the temperature of the anesthetizing solution on warm

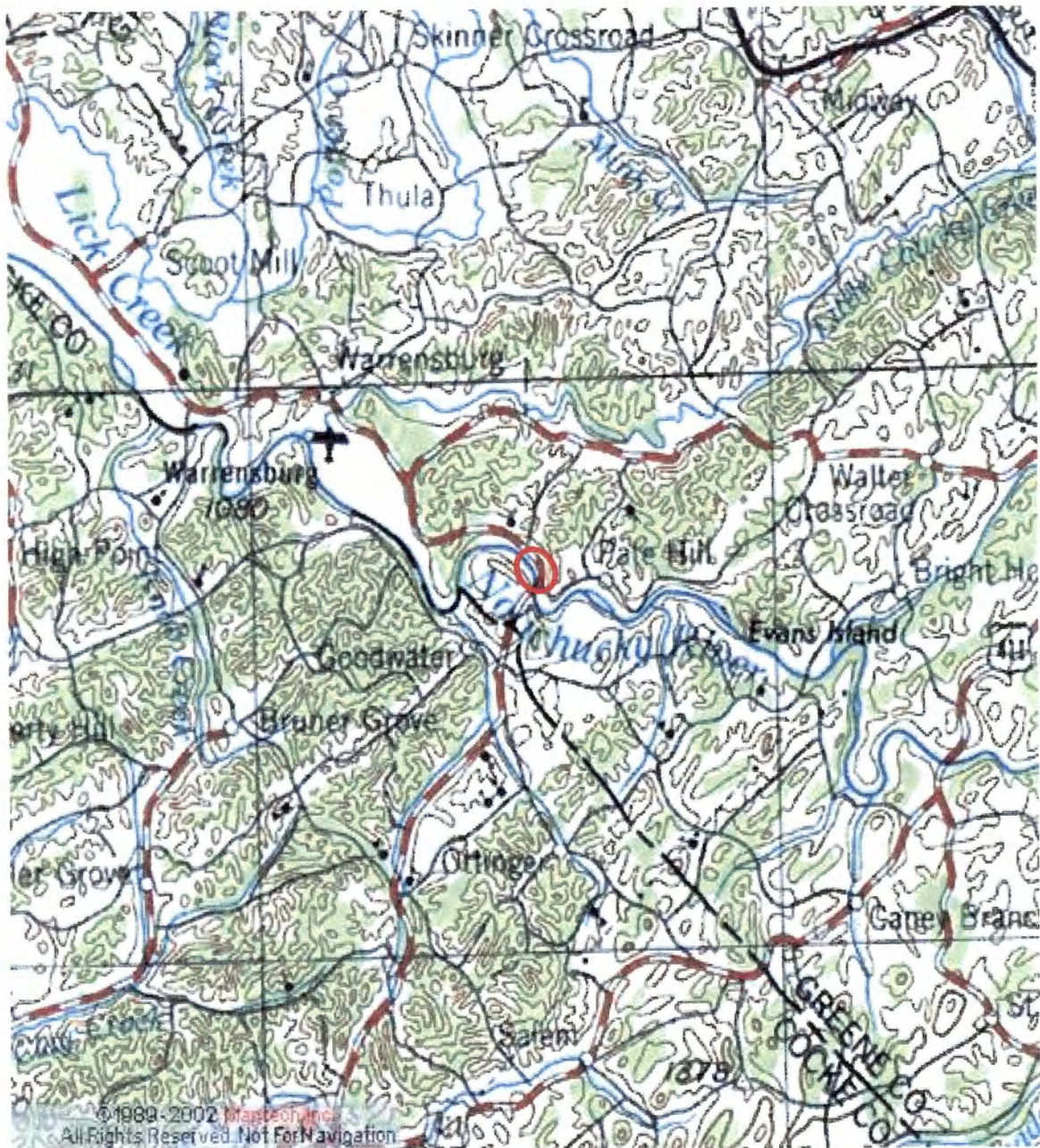


Figure 6. The Nolichucky River (NRM28) collection site (red circle).

days, ice was placed in sealed plastic bags and floated in the container. Temperature and oxygen were monitored in all fish containers.

The VIE color used in each batch tagging effort represented the river source, the season (spring or fall), and the year of collection (Table 2). Tagging of individual fish and transport were conducted using the same procedures as described previously on pages 22-26. After tagging, fish were transported to the appropriate release site, where they were acclimated to river temperature. Acclimation was required for any temperature difference between the fish transport bag and the Pigeon River exceeding 2°C; the tempering process should not exceed 5°C/h (Murphy and Willis 1996). The sealed bags of fish were floated in the river, and only opened after the river and bag temperatures were nearly equalized. River water was added to the bags in small increments to acclimate the fish to water quality variables.

On three occasions, a variation of the tagging procedure was necessary. In one instance, sunlight diminished before all fish could be tagged, and in the other case, it was too cold to complete the field tagging process. In both situations, untagged fish were transported to JARTU, and held for 2-6 days during which time the holding tank was aerated, temperature was monitored, and water was exchanged as needed. They were tagged and transported to the re-introduction sites for acclimation and release.

The Pigeon River Recovery Project determined the primary re-introduction site. It was believed that the area above Tannery Island (latitude 35°56'39"N, longitude 83°10'44"W) had good habitat characteristics for gilt, blueside, and bluebreast darters. It was later determined that this site had only marginal characteristics for blueside darter habitat. A new site was chosen downstream that contained more sand and vegetation

Table 2. Comprehensive list of species re-introduced into the Pigeon River during a 24-month period from March 2001-March 2003.

Date	Species	N	River Source	VIE	Release Site
3/14/01	BS	128	LPR	R	TI
5/23/01	G	120	LPR	R	TI
	BS	1	LPR	R	TI
10/02/01	G	132	LPR	G	TI
	BS	4	LPR	G	TI
10/09/01	G	41	N	Y	TI
	BB	121	N	Y	TI
11/06/01	G	52	N	Y	TI
	BB	122	N	Y	TI
	BS	6	N	Y	TI
2/08/02	BS	113	LPR	O	MMB
	G	51	LPR	O	TI
2/15/02	BS	107	LPR	O	MMB
	G	43	LPR	O	TI
3/15/02	BS	145	LPR	O	MMB
5/21/02	G	157	LPR	O	TI
5/28/02	G	136	LPR	O	TI
8/28/02	BB	86	N	P	TI
	G	28	N	P	TI
10/23/02	G	126	LPR	P	TI
3/13/03	BS	115	LPR	R	MMB
	G	61	LPR	R	TI

BS=Blueside darter

G = Gilt darter

BB = Bluebreast darter

TI = Tannery Island, Pigeon River

MMB = McSween Memorial Bridge

LPR = Little Pigeon River

NT = Not Tagged

R = Red

G = Green

Y = Yellow

O = Orange

P= Pink

adjacent to riffle and pool habitat. This re-introduction site was located 200 m downstream of the McSween Memorial Bridge at latitude 35°58'08"N and longitude 83°11'20"W. Site locations referenced by longitude and latitude was initially determined using a handheld Garmin GPS (Global Positioning System), eTrex Legend model. Subsequently, an online mapping service was used (Maptech Mapserver) to provide more accurate latitude and longitude reference points. Site elevations were also determined by GPS. Monitoring for the re-introduced species was accomplished by qualitative and quantitative underwater visual surveys and data from the annual IBIs conducted at the Denton and Tannery Island sites since 1988 (Figures 7 and 8). Fish species identified during the IBIs are recorded in Appendix A. The Denton location has also been considered a possible future re-introduction site.

The snorkel survey consisted of five parallel line transects, starting just above the pool-riffle transition zone at the Tannery Island site, surveying downstream a distance of 100 m. This surveyed an area of 600 m², measuring 6 m wide by 100 m long. The upper boundary was located at an approximate latitude 35°56'38"N and longitude 83°10'44"W, and the lower boundary at latitude 35°56'44"N and longitude 83°10'43"W. No block-nets were used to confine the fish within the survey site, since pools at the upstream and downstream ends of the census site were considered natural barriers. The transects ran roughly parallel to the midstream island, approximately 1 to 2 meters east from its bank, and encompassing the thalweg, i.e., the line defining the lowest points along the length of a river bed which corresponds to the swiftest water flow. The width of the lanes (1.2 m) had been determined prior to the survey. During several qualitative surveys at this release site, it was determined that the identity and tag of a target species could not be

Figure 7. Annual IBI scores for the Pigeon River at Denton and Tannery Island 1988-2002.

Source: TDEC 2002.

IBIs for the Pigeon River at Denton & Tannery, 1988 - 2002

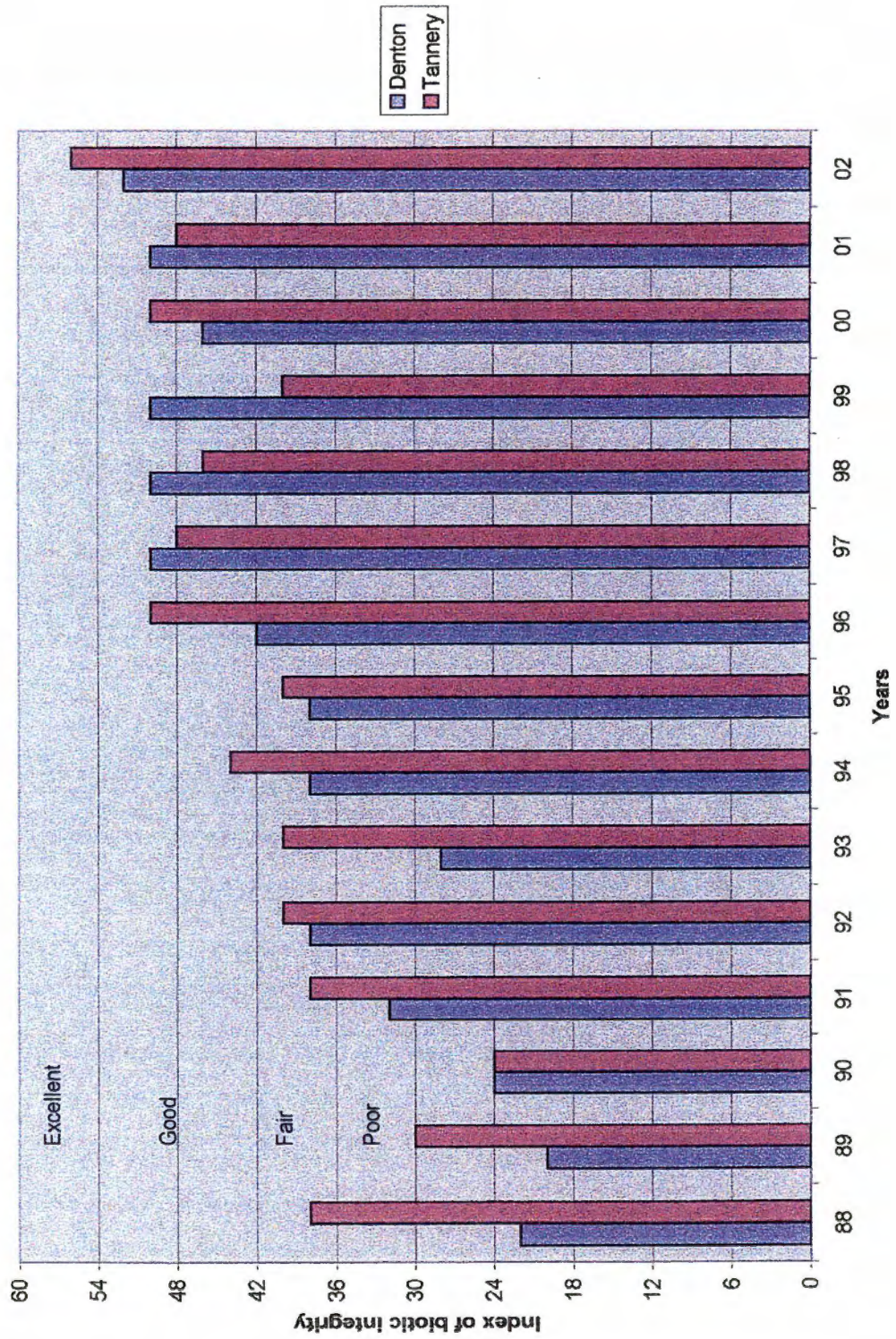
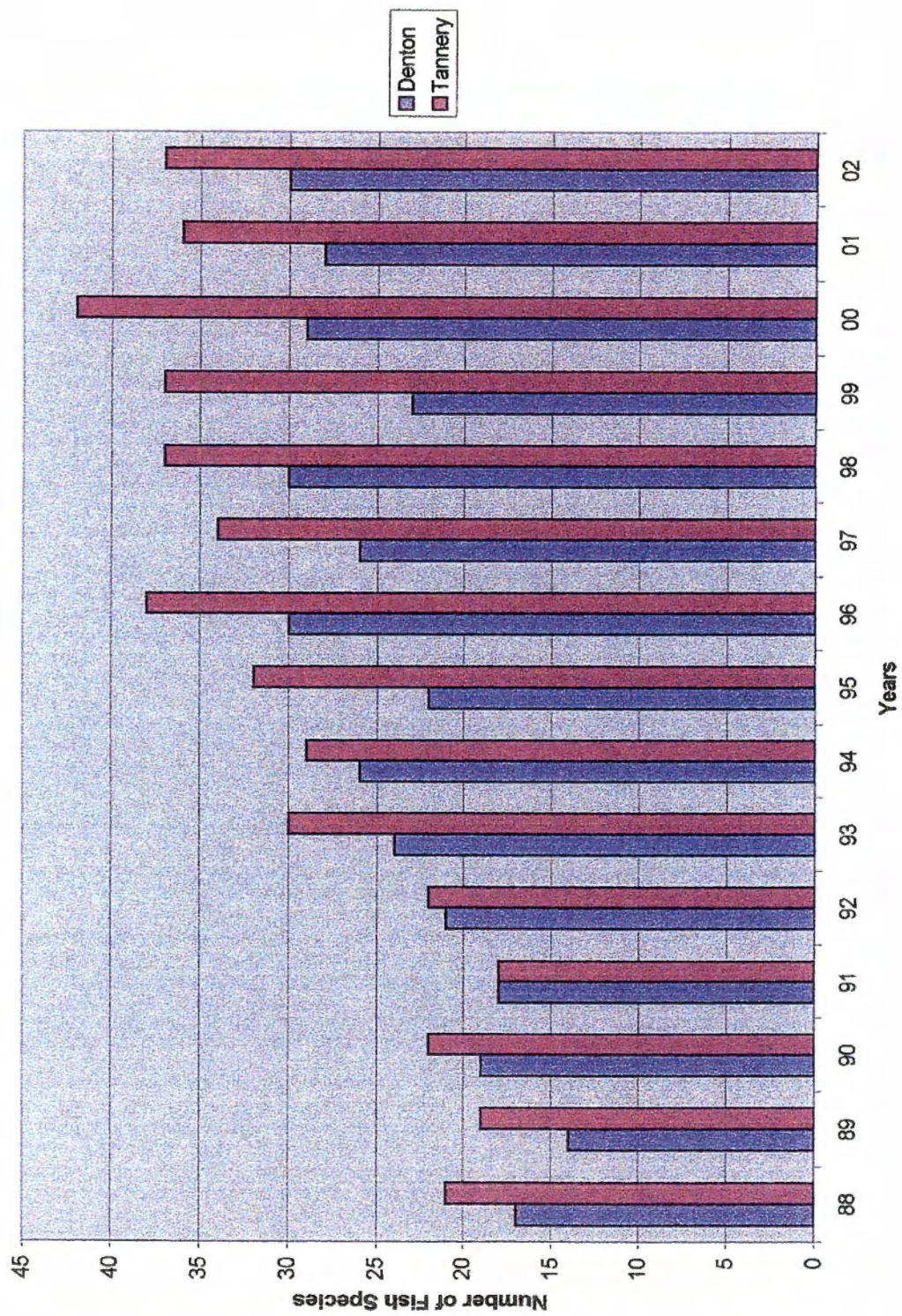


Figure 8. Number of fish species collected during the annual IBIs at Denton and Tannery Island 1988-2002.

Source: TDEC 2002.

Number of Fish Species for the Pigeon River at Denton & Tannery 1988 - 2002



confirmed at a distance greater than 60 cm (2 feet) in full sunlight and less than 45 cm (1.5 feet) in shade. Horizontal visibility was checked twice before the start of the survey using a Secchi disk with two different snorkelers, which confirmed a distance of 1.6 m. After the lead core ropes and their anchors were set and spaced, the area was vacated for one hour to let the fish resettle. The survey could not start until approximately noon, when all shade had receded from the river and the river was in full sun.

Entering the river upstream of the transect area, five experienced observers with masks, snorkels, and wetsuits conducted the surveys. Each snorkeler was tethered with a rope around one ankle (Figure 9). The rope was attached to a reel, which was operated by the tether person. The tetherer's job was to keep each snorkeler in a straight line and hold them in place while they counted darters and recorded the data. Snorkelers communicated with tetherers and adjacent snorkelers with hand signals. Fish observed along transect lane boundaries or fish passing between transects were discussed with adjacent snorkelers to reduce duplicate counts. The lead core rope marked the center of each lane or transect. The snorkeler kept his/her body centered over the rope as they drifted slowly downstream, scanning directly in front and to both sides of the line of travel (Figure 10). When one of the target species was sighted, the line of snorkelers was halted and the species and color of the VIE tag (or no tag) was recorded on the PVC slate of the individual observer. At each location that a darter(s) was observed, the snorkeler placed a weighted marker, attached to a float, on the stream bottom. All snorkelers would then proceed when the signal was given. At the lower end of the survey area, the snorkelers had to crawl and walk through some shallow places (<15 cm in depth) within the rapids. This was not preferred habitat for any of the three target species.



Figure 9. Snorkel survey conducted at Tannery Island, LPR, 26 July 2003.



Figure 10. Snorkel survey in progress.

Approximately 50 minutes was required to complete each survey, with three replicates being conducted. Snorkelers were assigned to different lanes on each pass. At the completion of each pass, the water depth (cm) was measured with a meter stick and current velocity (m/sec) was measured with a flow meter (Marsh-McBirney) as close to the bottom as possible at each marked location. Approximately 30 minutes was given between each replicate survey to allow the fish to resettle. Due to the hydroelectric dam upstream, the surveys had to be completed by 1600 hours, at which time the generated flow normally reached Tannery Island. The increase in water velocity made snorkeling impossible. The areas adjacent to the release site were checked for tagged fish on two occasions.

CHAPTER IV

Results and Discussion

Tag Retention

VIE tags have advantages over other types of fish tags. Elastomer tags are externally visible, but are entirely internal and biocompatible. After the injection site wound has healed, there are no long-term openings in the tissue that may lead to infection as with external tags. This small internal tag is less vulnerable to environmental damage and is less likely to alter fish behavior compared with mutilation methods (Hale and Gray 1998). The expense of extracting and reading of other types of tags is eliminated. VIE tags can be identified without sacrificing the fish and without handling or removing the fish from its environment.

During the tagging procedure in the laboratory, water temperature ranged from 12°C to 13°C. The aquaria were checked at 24 and 48 hours for mortalities, with no mortalities or abnormal behavior noted. On days 30, 60, 90, and 125, fish were observed for tag visibility and general health. Tag visibility data are located in Appendix D1-D9.

Thirty days after tagging, VIE tags on darkly pigmented fish were difficult to see, especially, the green and yellow tags. These tags both appeared as the same color under the blue light and were indecipherable (Figure 11). Amber glasses removed the blue tint of the blue LED light, allowing the true color to show. The amber glasses in conjunction with the blue light helped differentiate between larger yellow and green tags but did not help in identifying smaller yellow and green tags. At day 60, there was an increase in the number of tags visible only with the blue light. The problem of differentiating between yellow and green tags remained.

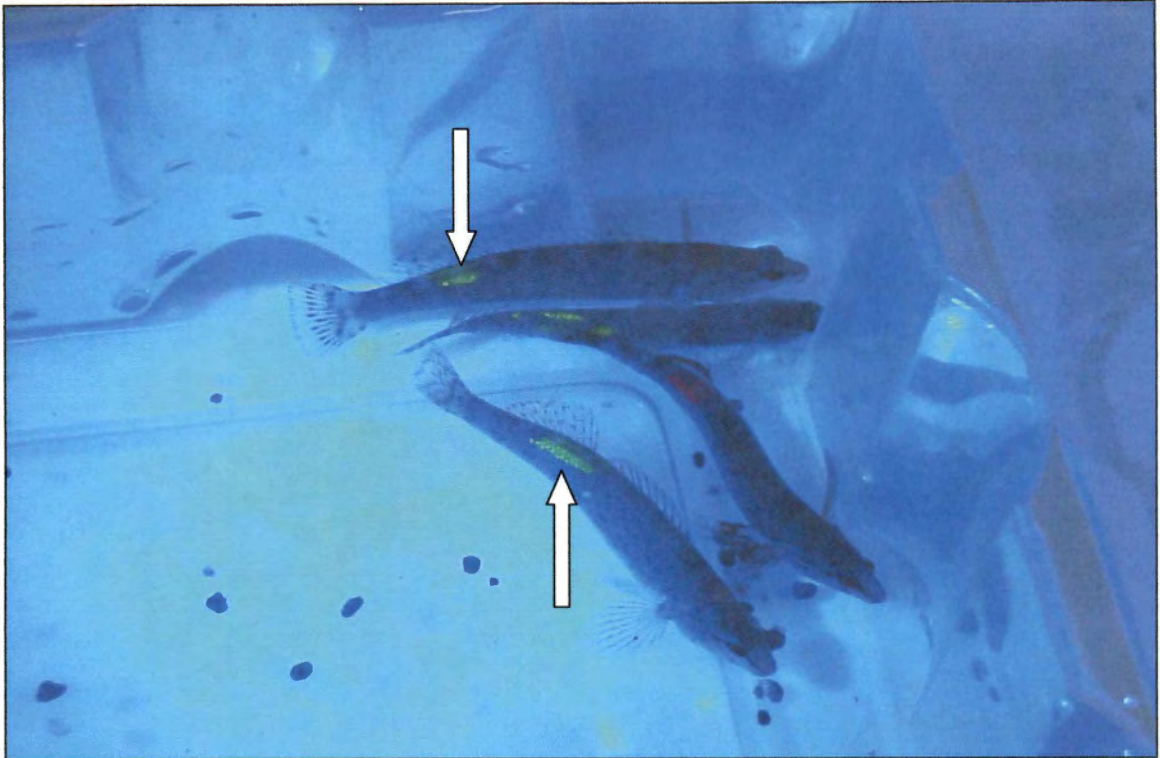


Figure 11. Tagged redlines under the blue LED light. Note fluorescent tags at the arrows.

A color reference block that was not part of the original VIE tagging kit was provided by CFI for the 90-day and final observations. This reference block of latex contained samples of all the VIE colors. When used in conjunction with the blue light and amber lenses, tag color identification became much more reliable. The more practice observing tagged fish, the more the ability increased to detect and identify the tag color.

During the 90-day laboratory observations, it was noted that only one darter in tank #2 was extremely dark; however, when all fish for this tank were returned to the aquarium, five extremely dark fish were noted. This also occurred with the fish in tank #3, with three fish appearing extremely dark during observations, but 10 extremely dark ones noted afterwards. This behavior was not noted during any of the other observations in this study. The CFI biologist stated that some fish darken their color in response to stress. During this observation, the water temperature $17.7^{\circ}\text{C} - 18.8^{\circ}\text{C}$ was the warmest during the entire study, which was substantially higher than the $10^{\circ}\text{C} - 13^{\circ}\text{C}$ temperatures during all other observations. Temperature changes outside of a species thermal optimum may lead to reduced tolerance of additional stressors, such as, capture and handling (Murphy and Willis 1996). Also, fish that are frightened may undergo rapid color changes (Moyle and Cech 2000). This finding suggested that the elevated temperature may have added to the stress level of the darters, resulting in a darkened color pattern.

Tag visibility was greatly affected by the depth at which the tag was placed. It was noted that inexperienced personnel were more likely to inject the elastomer too deeply into the tissue instead of just under the skin. A similar problem was noted by Frederick (1997), Bailey et al. (1998), and Close and Jones (2002). Kelly (1967) stated

that placement of the tagging material at the proper intracutaneous level is likely the most critical factor. He further suggested that the needle insertion may be judged as being at the correct depth if the needle shows as a dark line under the skin. Tag visibility in the present study was affected by fish coloration, tag color, the tagger's experience, and the observer's experience.

No pattern of tag loss can be concluded from these observations. The number of tags visible to the naked eye and the number visible with the blue light varied between observations. The yellow VIE was the least visible of the three tag colors throughout the study. However, on the final observation (day 125), nine tag sets were not visible to the naked eye, but were visible under the blue light; one set was red and the other eight sets were yellow. Based on the difficulty of differentiating between yellow and green in this study, it is not recommended to use both colors in a study using a single species. In this study, Visible Implant Fluorescent Elastomer resulted in no mortalities and 100% tag retention after 125 days.

Anesthesia

As noted in the Literature Review, there is substantial documentation of the effectiveness of clove oil as a fish anesthetic. However, fish species differ in the concentration of chemical required to achieve a given level of anesthesia, and in their recovery time (Summerfelt and Smith 1990). Therefore, the redline darter was chosen to be the first darter species anesthetized using clove oil.

Water temperature during anesthetization and recovery ranged from 10°–11.1°C, which was well below the recommended 15°C level. The mixture was shaken vigorously to facilitate emulsification of the clove oil and water solution. Many fish exhibited a

gasping behavior when initially placed in the clove oil solution. A similar behavior was observed by Keene et al. (1998). Even at the low temperatures experienced during this experiment, the clove oil performed well as a fish anesthetic. Stage 4 anesthesia (Table 1) is defined as the loss of equilibrium. To observe the initial loss of balance, fish often had to be gently pushed over because their pectoral fins became erect during anesthesia, keeping them from rolling over on their sides. Stage 4 recovery (Table 1) refers to the resumption of the fear or fright response, and was exhibited by avoidance or movement from the stimulus. To determine recovery, each fish was prodded and the stopwatch read when each individual began to swim away from the stimulus.

The clove oil preliminary trials narrowed the range and number of concentrations to be tested. Our parameters were to find the lowest effective concentration that induced Stage 4 anesthesia in three minutes (180 sec) or less. Based on the preliminary results, we chose to test the 40 mg/L concentration. Two additional concentrations were selected (30 and 50 mg/L) to bracket the chosen dosage.

Data were analyzed using ANOVA, i.e., one-way analysis of variance (SPSS Base 10.0). Induction times of the three concentrations (30, 40, 50 mg/L) of clove oil were compared with that of 100 mg/L of MS-222 (Table 3). ANOVA applied to the induction means determined that differences existed among the means. Based on the arbitrary criteria of three minutes or less, the likely choice would be 40 mg/L with an induction mean of 175 sec. (2:55min.). A post hoc range test was used to determine which means differed. A LSD (least significant difference) Test ($p = 0.05$) indicated that there was no significant difference between 30 mg/L and 40 mg/L concentrations. Therefore, there was no reason to reject the hypothesis that they are equal. ANOVA

Table 3. Descriptive statistics for the induction (Induct) times (sec) of 30, 40, and 50 mg/L of clove oil, and 100 mg/L of MS-222; and for the recovery (Recov) times (sec) of 30,40, and 50 mg/L of clove oil.

Induct	N	Mean	Std. Error	Minimum	Maximum
30	20	198.1	10.7	118	313
40	20	175.4	7.9	113	252
50	20	141.3	5.2	95	178
100	10	182.3	0.7	180	185

Recov	N	Mean	Std. Error	Minimum	Maximum
30	20	236.5	21.5	115	427
40	20	293.3	19.1	178	516
50	20	370.1	16.0	240	471

applied to the recovery means determined that differences existed among the three clove oil concentrations. An LSD Test indicated significant differences among all three. Therefore, the hypothesis that they are equal was rejected. Based on the above results, the lowest concentration (30 mg/L) was preferred to minimize recovery time and minimize exposure to an anesthetic.

Field Study

The use of underwater observation, i.e., the snorkel survey, to assess fish assemblages by counting numbers of fish, has several advantages. Equipment is affordable and easily portable. Snorkelers can directly observe the substrate, aquatic vegetation, and the entire riverine topography. Similarities and differences in life history among and within species may be observed first hand. Once the location and abundance is known, the species may be collected more efficiently by other sampling techniques.

A major advantage of snorkeling is the low number of personnel hours required to survey a stream, whereas, chemical, electrical, and mechanical sampling require more hours (Whitworth and Schmidt 1980). The major disadvantages are that there must be horizontal visibility of at least 1.5 – 2 m and a minimum depth of 15 cm.

A preliminary snorkel survey was conducted 1 October 2001 at Tannery Island. A random zigzag snorkel of the release site (surveying upstream and downstream) and the areas adjacent to the re-introduction site were completed. No blueside or gilt darters were found outside of the release site. Three tagged (red) gilt darters were observed while snorkeling downstream in the swiftest current, mid-riffle of the release site.

Snorkeling in an upstream direction had previously elicited immediate flight behavior from the gilt darters. When moving downstream and approaching head-on at a

very slow pace, a snorkeler could move to within inches of a gilt darter. Based on these findings, all later snorkel surveys were conducted in a downstream direction. It was determined, as a result of this survey, that Tannery Island had only marginal habitat for blueside darters. A new site was located for their re-introduction downstream of the McSween Memorial Bridge in Newport, TN.

Sixty VIE-tagged fish from the laboratory study were released at the collection site on the Little Pigeon River (latitude 35°52'25"N, longitude 83°23'21"W) on 15 March 2002. Seven days later, the release site and the area above and below it were seined. In 16 seining samples of 91.4 m² per effort, five tagged fish were collected, with only one tagged fish caught in any one effort. All fish were collected downstream of the release site.

Tagged redlines (from the earlier tag retention study) were caught incidentally during the collection of other target species: 21 May 2002, one tagged fish; 28 May 2002, three tagged fish; and 23 October 2002, three tagged fish. In all recaptured fish, the VIE tags were visible without artificial illumination. These redlines were tagged on 30 October 2001, indicating a tag retention time in the field of approximately one year.

Of the 1,917 blueside, bluebreast, and gilt darters field tagged, only 24 (1 bluebreast, 9 blueside, 14 gilt darters) expired before release, for a tagging mortality rate of 1.2%. These mortalities were most likely a result of multiple stress inducing factors. Stress results when fish experience fright, discomfort, or pain (Schreck 1981). Loss of mucus or scales, breaks in the skin, or damage to internal organs can lead to shock, increased susceptibility to infection, suppressed immune system, and/or delayed mortality (Schreck 1981). These fish were trapped in a net, carried in small buckets,

confined in a cooler, dropped into an anesthetizing bath, and stuck with a needle; some were confined in a strange environment for as many as six days, and six of these died in peak spawning condition. Based on these multiple stress factors, it is surprising that the mortality rate was not higher. On the other hand, no redline mortalities occurred in the laboratory study. This may indicate that the darters in the present study were hardier than originally perceived. However, there is room for improvement. Water temperature differentials should be watched more closely.

One of the most frequently used procedures for an underwater survey is the strip transect method (Watson et al. 1995). This concept involves a snorkeler moving a measured distance along the bottom of a waterbody while counting fish within a specific width or range. Our snorkelers required taxonomic knowledge of the target species as well as experience in recognizing tagged fish and differentiating between the VIE colors underwater. The effect of underwater magnification (1.33x) assisted us in identification. The blue LED was not utilized during any of the snorkel surveys. Our previous experience showed minimal, if any, enhancement to tag visibility in clear water. However, Rakes and Shute (2002a) noted that while searching for VIE tagged boulder darters in the turbid waters of the Elk River, the blue light illuminated marked fish, making the tags easily identified.

The first replicate of the snorkel survey was affected by the learning curve of the personnel involved. Only one person had tethered a snorkeler before and only one snorkeler had done a transect while tethered. This created problems getting and keeping the tension right on the tether and sometimes resulted in disturbances of the sediment. This first replicate was completed at a faster pace (45 min) than the second and third

replicates (50 min). This may explain the lower count of 42 fish on the first pass, while the second and third passes had 69 and 64 fish, respectively.

During the snorkel survey, the working visibility ranged from 60 cm in full sun to 45 cm or less when ambient light was reduced by passing clouds. Instream cover consisted primarily of cobble in the preferred habitat and boulders in the poorer habitat, which may have had a minimal effect on target species visibility. Minimal sediment was dislodged during the survey due to the tetherers holding the snorkelers in place and the buoyancy of the wetsuits kept the snorkelers off the bottom except in very shallow places.

A 100-m transect length was designed to pass through cobble riffle and boulder riffle habitat to confirm the habitat preference of bluebreast and gilt darters that was hypothesized to be two riffled-dwelling species. Nearly all target species were located in the upstream half of all five transects. Only one gilt darter was observed near the downstream end of the survey site. The upper half consisted of cobble, with some sand and gravel in fast water riffles and the lower half consisted of boulder, with some cobble and sand. Markers were placed on the river bottom at any site where a darter or several darter target species were observed. At each marker, velocity (m/sec) and depth (cm) measurements were taken in hopes of comparing relative microhabitat differences among re-introduced species. However, of the 175 fish counted during the survey, 172 were gilt darters; only three were bluebreast darters, and no blueside darters were observed. Incidentally, the measurements for the three bluebreast darters were similar to those for the gilt darters.

One hundred and seventy-five target species were identified and counted; representing a density of 58.3 fish in 600 m², however, preferred habitat only represented half of the survey site or 300 m². If the assumption is made that the passes were random, then it is possible to calculate an expanded density for the upper 50 m of 291.5 fish in 1,500 m², or 19.4 fish in 100 m².

Representatives of all four re-introductions were seen, in which the fish were batch tagged with red, green, yellow, or orange VIE. The three bluebreast were found on the margins of the cobble riffle habitat. One was found in the shallow littoral zone and two were located downstream in the deeper water at the cobble/boulder transition. Although there were fewer bluebreast than gilt darters re-introduced (243 / 724), there must be some other factor affecting their numbers. According to Stauffer et al. (1996), bluebreast darters tend toward habitat specialization. They prefer moderate to swift current in riffles like the gilt darter but prefer water at depths of 0.5 – 1.5 m (Etnier and Starnes 1993). Water depth within the transects ranged from 15 - 60 cm, suggesting they may have migrated to deeper, more suitable habitat.

The multi-agency annual IBI conducted on the Pigeon River in July 2002 collected six tagged darters at the Tannery Island site, which was the same area of the re-introductions. Three tagged gilts were also collected at the riffle area above the re-introduction site. A large, deep pool separated these two riffles. No other target species were collected at any other locations during the IBIs of 2001 or 2002.

Qualitative underwater observations were performed on 1 October 2001 and 10 June 2002 in the area immediately adjacent to the release site. No target species were observed in the pool above, in the west channel of the midstream island, or in the riffles

and side channel below the survey site. Several qualitative snorkel surveys were completed at riffle areas upstream and downstream of Tannery Island to attempt to locate other fish which may have moved from the re-introduction site. The survey conducted at the riffle above Tannery Island (latitude 35°56'19"N, longitude 83°10'39"W) produced 26 gilt darters and one bluebreast darter. Underwater surveys at the second and fifth riffle complex upstream, and the three riffle areas immediately downstream, found no target species. At the McSween Memorial Bridge site (latitude 35°58'08"N, longitude 83°11'20"W), sandy vegetated areas of the mid-stream island were circumnavigated, with no results. Possible blueside habitat has been identified downstream and will be sampled by seining and electroshocking during the spring of 2003.

What appeared to be a young of the year gilt darter (not tagged) was collected during the annual IBI at the Denton site, approximately 26.5 km (8 mi) upstream of Tannery Island. If tagged gilt darters have migrated further upstream, this may be an indication of successful reproduction by the transplants. Future plans include snorkel surveys of all riffle areas between Tannery Island and Denton to evaluate movements and reproductive success of the re-introduced species.

CHAPTER V

Summary and Recommendations

Visible implant fluorescent elastomer was evaluated as a tag for selected darters re-introduced into the Pigeon River. In the laboratory setting, VIE tags on surrogate redlines were retained for 125 days with no mortalities. Only 1.2% of the re-introduced species were lost due to tagging mortality. Tag visibility was affected most by two factors: (1) subcutaneous depth and, (2) skin pigmentation at the selected tagging site. Based on the difficulty of differentiating between yellow and green tags in this study, it is not recommended to use both colors in a study using a single species. Before using VIE in a study or research requiring marked fish, individuals should be trained and experienced in tagging fish to assure maximum tag retention and visibility. Tag location and VIE color should be assessed on a species-specific basis.

Clove oil was evaluated as an alternative field anesthetic for tagging. It was determined to be an effective alternative anesthetic for redline darters. There was no statistical difference between induction times for concentrations of 30 and 40 mg/L, but the use of 30 mg/L would provide a minimal economic savings. The 40 mg/L concentration provided a mean induction time of under three minutes (175 sec/2:55 min), and a mean recovery time of under five minutes (293 sec/4:53 min). The concentration of clove oil required to induce anesthesia varies by species. It is an effective anesthetic that is easily obtained, inexpensive, and non-toxic.

During a 24-month period, 974 gilt darters, 329 bluebreast darters and 619 blueside darters were re-introduced into the Pigeon River at two sites. A quantitative

snorkel survey resulted in 175 sightings of target species within a three-pass sampling effort. The vast majority were gilt darters, a few bluebreast darters, and no blueside darters. Qualitative surveys indicated darter movement in an upstream direction.

Whether this is a permanent migration of just the temporary movement of exploratory individuals, will require further study. Snorkel surveys provide an efficient, non-invasive sampling method to monitor re-introduced species. Accuracy and precision of visual census may vary according to riverine topography, time of the day or season, and the observers skill level.

There is much more to be gleaned from the waters of the Pigeon River about the complexities of this aquatic ecosystem. Greater knowledge of darter dynamics is needed to improve their chances of survival when relocated. More details of their life histories, habitat, and microhabitat preferences, and those factors influencing habitat partitioning among darter species is required. This information will assist in the determination of a minimum viable population size (MVP), which is an estimate of the number of individuals in a population deemed necessary for long-term survival. This population estimate will lead to a determination of a minimum viable metapopulation size (MVM). MVM, similar to a fish assemblage, is defined “as the minimum number of interacting local populations necessary for the long-term persistence of the metapopulation” (Hanski et al. 1996). This will lead to the long-term survival of a healthy ecosystem.

Literature Cited

Literature Cited

- Adams, M.A., W.D. Crumby, M.S. Greeley, L.R. Shugart, and C.F. Saylor. 1992. Responses of fish populations and communities to pulp mill effluents: a holistic approach. *Ecotoxicology and Environmental Safety* 24:347-360.
- Anderson, W.G., R.S. McKinley, and M. Colavecchia. 1997. The use of clove oil as an anesthetic for rainbow trout and its effects on swimming performance. *North American Journal of Fisheries Management* 17:301-307.
- Anonymous. 2003. Maptech Mapserver.
<http://mapserver.maptech.com/homepage/index.cfm> (18 February 2003).
- Arnold, D.E. 1966. Marking fish with dyes and other chemicals. Technical Papers of the Bureau of Sport Fisheries and Wildlife No. 10. 44 pp.
- Bailey, R.E., J.R. Irvine, F.C. Dalziel, and T.C. Nelson. 1998. Evaluation of visible implant fluorescent tags for marking coho salmon smolts. *North American Journal of Fisheries Management* 18:191-196.
- Bartlett, R.A. 1995. Troubled waters. University of Tennessee Press, Knoxville, TN. 329 pp.
- Bonneau, J.L., R.F. Thurow, and D.L. Scarnecchia. 1995. Capture, marking, and enumeration of juvenile bull trout and cutthroat trout in small, low conductivity streams. *North American Journal of Fisheries Management* 15:563-568.
- Catalano, M.J., S.R. Chipps, M.A. Bouchard, and D.H. Wahl. 2001. Evaluation of injectable fluorescent tags for marking centrarchid fishes: retention rate and effects on vulnerability to predation. *North American Journal of Fisheries Management* 21:911-917.
- Cho, G.K. and D.D. Heath. 2000. Comparison of Tricaine methanesulphonate (MS222) and clove oil anaesthesia effects on the physiology of juvenile Chinook salmon *Oncorhynchus tshawytscha* (Walbaum). *Aquaculture Research* 31:537-546.
- Close, T.L., and Jones, T.S. 2002. Detection of visible implant elastomer in fingerling and yearling rainbow trout. *North American Journal of Fisheries Management* 22:961-964.
- Cooper, R.T. 2001. Effective clove oil concentrations for anesthetizing selected hatchery reared species. Masters thesis, University of Tennessee. 67 pp.

- Cushing, C.E. and J.D. Allan. 2001. Streams Their Ecology and Life, Academic Press, San Diego.
- Davis, C.S. 1955. The injection of latex solution as a fish marking technique. *Investigations of Indiana Lakes and Streams* 4(4):111-116.
- Dewey, M.R., and S.J. Zigler. 1996. An evaluation of fluorescent elastomer for marking bluegills in experimental studies. *Progressive Fish-Culturist* 58:219-220.
- Dinkins, G.R., and P.W. Shute. 1996. Life histories of *Noturus baileyi* and *N. flavipinnis* (Pisces:Ictaluridea), two rare madtom catfishes in Citico Creek, Monroe County, Tennessee. *Bulletin Alabama Museum of Natural History* 18:43-69.
- Ensign, W.E., P.L. Angermeier, and C.A. Dolloff. 1995. Use of line transect methods to estimate abundance of benthic stream fishes. *Canadian Journal of Fisheries and Aquatic Sciences* 52:213-222.
- Etnier, D.A., and C.F. Saylor. 2001. Annotated list of the fishes of the Pigeon River System, North Carolina and Tennessee. Unpublished manuscript. 8 pp.
- Etnier, D.A., and W.C. Starnes. 1993. The fishes of Tennessee. University of Tennessee Press, Knoxville. 695 pp.
- Frederick, J.L. 1997. Evaluation of fluorescent elastomer injection as a method for marking small fish. *Bulletin of Marine Science* 61(2):399-408.
- Freeman, M.C. 1995. Movements by two small fishes in a large stream. *Copeia* 1995(2):361-367.
- Funk, J.L. 1955. Movement of stream fishes in Missouri. *Transactions of the American Fisheries Society* 85:39-57.
- Gerking, S.D. 1950. Stability of a stream fish population. *Journal of Wildlife Management* 14(2):193-202.
- Godin, D.M., W.H. Carr, G. Hagino, F. Segura, J.N. Sweeney, and L. Blankenship. 1996. Evaluation of a fluorescent elastomer internal tag in juvenile and adult shrimp *Penaeus vannamei*. *Aquaculture* 139:243-248.
- Goldstein, R.M. 1978. Quantitative comparison of seining and underwater observation for stream fishery surveys. *Progressive Fish-Culturist* 40(3):108-111.
- Haines, G.B., and T. Modde. 1996. Evaluation of marking techniques to estimate population size and first year survival of Colorado squawfish. *North American Journal of Fisheries Management* 16:905-912.

- Hall, C.A.S. 1972. Migration and metabolism in a temperate stream ecosystem. *Ecology* 53:585-604.
- Hankin, D.G., and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. *Canadian Journal of Fisheries and Aquatic Sciences* 45:834-844.
- Hanski, I., A. Moilanen, and M. Gyllenberg. 1996. Minimum viable metapopulation size. *The American Naturalist* 147:527-541.
- Hill, J., and G.D. Grossman. 1987. Effects of subcutaneous marking on stream fishes. *Copeia* 1987(2):492-495.
- Hill, T.K., G.B. Pardue, and W. Smith. 1970. An evaluation for several marks on channel catfish, *Ictalurus punctatus* (Rafinesque). *Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners* 24(1970):304-307.
- Holland-Bartels, L.E., M.R. Dewey, and S.J. Zigler. 1989. Effects of water temperature on the mortality of field-collected fish marked with fluorescent pigment. *North American Journal of Fisheries Management* 9:341-344.
- Johnston, C.E. 2000. Movement patterns of imperiled blue shiners (Pisces: Cyprinidae) among habitat patches. *Ecology of Freshwater Fish* 9:170-176.
- Johnston, C.E. 2001. Nest site selection and aspects of the reproductive biology of the pygmy sculpin (*Cottus paulus*) in Coldwater Spring, Calhoun County, Alabama. *Ecology of Freshwater Fish* 10(2):118-121.
- Jung, R., E.S. Droege, J.R. Saur, and R.B. Landy. 2000. Evaluation of terrestrial and streamside salamander monitoring techniques at Shenandoah National Park. *Environmental Monitoring and Assessment* 63:65-79.
- Karr, J.R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6:21-27.
- Kazyak, P.F., and J.M. Dietz. 1990. Characterization of dissolved oxygen, carbonaceous biochemical oxygen demand, and color in Walters Reservoir and the Pigeon River in Tennessee. Prepared for U.S. EPA Region IV, Atlanta, GA. March 1990. 45 pp.
- Keene, J.L., L.G. Noakes, R.D. Moccia, and C.G. Soto. 1998. The efficacy of clove oil as an anaesthetic for rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Aquaculture Research* 29:89-101.

- Kohler, C.C., and W.A. Hubert, editors. 1993. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, MD. 594 pp.
- Larson, G.L., R.L. Hoffman, and S.E. Moore. 2002. Observations of the distributions of five fish species in a small Appalachian stream. Transactions of the American Fisheries Society 131:791-796.
- McKinney, A.D., D.L. Melgaard, and S.C. Bechwith. 1978. Biological assessment and inventory, chemical and bacteriological sampling. Pigeon River, Cocke County, TN. Tennessee Department of Public Health, Knoxville, TN. 14 pp.
- Melgaard, D.L., and A.D. McKinney. 1980. Biological and chemical investigation of the Pigeon River: intensive survey. Tennessee Department of Public Health, Control, Knoxville, TN. 36 pp.
- Messer, J.B. 1964. Survey and classification of the Pigeon River and tributaries, North Carolina. Final Report, Federal Aid in Fish Restoration Job I-N, Project F-14-R North Carolina Wildlife Resources Commission. 37 pp.
- Moyle, P.B., and J.J. Cech, Jr. 2000. Fishes. Prentice Hall, Upper Saddle River, NJ. 612 pp.
- Murphy, B.R., and D.W. Willis, editors. 1996. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, MD. 732 pp.
- Mundahl, N.D., and C.G. Ingersoll. 1983. Early autumn movements and densities of johnny (*Etheostoma nigrum*) and fantail (*E. flabellare*) darters in a southwestern Ohio stream. Ohio Journal of Science 83:103-108.
- Munday, P.I., and S.K. Wilson. 1997. Comparative efficacy of clove oil and other chemicals in anesthetization of *Pomacentrus amboinensis*, a coral reef fish. Journal of Fish Biology 51:931-938.
- Nielsen, J.L. 1998. Scientific sampling effects: electrofishing California's endangered fish populations. Fisheries Management 23(12):6-12.
- Nielsen, L.A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23. 88 pp.
- Olsen, E.B., and L.A. Vollestad. 2001. An evaluation of visible implant elastomer for marking age-0 brown trout. North American Journal of Fisheries Management 21:967-970.
- Peake, S. 1998. Sodium bicarbonate and clove oil as potential anesthetics for nonsalmonid fishes. North American Journal of Fisheries Management 18:919-924.

- Plumb, J.A., T.E. Schwedler, and C. Limsuan. 1983. Experimental anesthesia of three species of freshwater fish with etomidate. *Progressive Fish-Culturist* 45:30-33.
- Prince, A., and C. Powell. 2002. Clove oil as an anesthetic for invasive field procedures on adult rainbow trout. *North American Journal of Fisheries Management* 20:1029-1032.
- Rakes, P.L., and J.R. Shute. 2002a. Development of tagging protocols and monitoring of the endangered boulder darter, *Etheostoma wapiti*, in the Elk River system in Tennessee. Final Report to U.S. Fish and Wildlife Service, Cookeville, Tennessee Field Office (Contract No. 1448-40181-00-G-166) January 15, 2002. 16 pp.
- Rakes, P.L., and J.R. Shute. 2002b. Captive propagation and population monitoring of rare southeastern fishes: 2001. Unpublished final report for 2001 field season and second quarter report for fiscal year 2002 to the Tennessee Wildlife Resources Agency (Contract No. FA-99-13085-00) March 1, 2002. 42 pp.
- Reed, R.J. 1968. Mark and recapture studies of eight species of darters (Pisces:Percidae) in three streams of Northwestern Pennsylvania. *Copeia* 1968:172-175.
- Saylor, C.F., A.D. McKinney, and W.H. Schacher. 1993. Case study of the Pigeon River in the Tennessee River drainage. Pages 241-254 in *Proceedings of the symposium on restoration planning for the rivers of the Mississippi River ecosystem*. Larry W. Hessee, editor. Biological Report 19. U.S. Department of the Interior, National Biological Survey Washington, D.C.
- Scalet, C.G. 1973. Stream movements and population density of the orangebelly darter, *Etheostoma radiosum cyanorum* (Osteichthyes:Percidae). *Southwestern Naturalist* 17:381-387.
- Schram, S.T., J. Lindgren, and L.M. Evrard. 1999. Re-introduction of lake sturgeon in the St. Louis River, western Lake Superior. *North American Journal of Fisheries Management* 19:815-823.
- Schreck, C.B. 1981. Stress and compensation in teleostean fishes: response to social and physical factors. Pages 295-321 in A.D. Pickering, editor. *Stress and fish*. Academic Press, New York, NY.
- Smithson, E.B., and C.E. Johnston. 1999. Movement patterns of stream fishes in a Ouachita Highlands stream: an examination of the restricted movement paradigm. *Transactions of the American Fisheries Society* 128:847-853.
- Soto, C.G., and C.G. Burhanuddin. 1995. Clove oil as a fish anesthetic for measuring length and weight of rabbitfish (*Siganus lineatus*). *Aquaculture* 136:149-152.

- Stauffer, J.R., J.M. Boltz, K.A. Kellogg, and E.S. van Snik. 1996. Microhabitat partitioning in a diverse assemblage of darters in the Allegheny River System. *Environmental Biology of Fishes* 46:37-44.
- Taylor, P.W., and S.D. Roberts. 1999. Clove oil: an alternative anaesthetic for aquaculture. *North American Journal of Aquaculture* 61:150-155.
- Waterstrat, P.R. 1999. Induction and recovery from anesthesia in channel catfish *Ictalurus punctatus* fingerlings exposed to clove oil. *Journal of the World Aquaculture Society* 30(2):250-255.
- Watson, R.A., G.M. Carlos, and M.A. Samoilys. 1995. Bias introduced by the non-random movement of fish in visual transect surveys. *Ecological Modelling* 77:205-214.
- Whaley, R.A., O.E. Maughan, and P.H. Wiley. 1978. Lethality of electroshock to two freshwater fishes. *Progressive Fish-Culturist* 40:161-163.
- Whitworth, W.R., and R.E. Schmidt. 1980. Snorkeling as a means of evaluating fish populations in streams. *New York Fish and Game Journal* 27(1):91-95.

Appendices

Appendix A
IBI Sample Data 1988-2002

Table A1. A summary by TVA of fish data collected in IBI samples from Pigeon River at Tannery Island PRKM 13.2 (PRM 8.2), Cocke County, Tennessee, during summers 1988-2002.

Common Name	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ohio lamprey											X		X		
Chestnut lamprey			X				X		X					X	X
Spotted gar	X														
Gizzard shad	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Central stoneroller	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Goldfish	X														
Whitetail shiner		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Spotfin shiner	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
River chub										X	X		X		X
Bigeye chub						X		X	X	X	X	X	X	X	X
Silver shiner							X	X	X	X	X	X	X	X	X
Rosyface shiner						X			X	X	X	X	X	X	X
Telescope shiner							X		X	X		X	X	X	X
Blacknose dace									X						
Longnose dace									X	X	X	X	X		X
River carpsucker						X	X	X	X	X	X	X	X	X	X
Quillback carpsucker		X			X		X	X	X	X	X				
Northern hogsucker	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Smallmouth buffalo	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Black buffalo					X	X		X	X	X	X	X	X	X	X
Silver redhorse					X	X	X	X	X	X	X	X	X	X	X
River redhorse			X			X	X	X	X	X	X	X	X	X	X
Black redhorse	X		X			X	X		X	X	X	X	X	X	X
Golden redhorse		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Shorthead redhorse						X					X	X	X	X	X
Channel catfish	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Fathead catfish						X	X	X		X			X		
Banded sculpin	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White bass					X	X	X	X	X	X			X	X	
Rock bass		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Redbreast sunfish	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table A1. (Continued).

Common Name	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Warmouth											X				
Bluegill	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Smallmouth bass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Spotted bass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Largemouth bass	X			X					X	X	X	X	X	X	X
White crappie									X						
Black Crappie											X		X		
Greenside darter					X			X	X	X	X	X	X	X	X
Redline darter	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Snubnose darter	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Banded darter										X		X	X	X	X
Logperch	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
hybrid Percina sp	X														
Sauger									X	X	X			X	
Walleye						X		X	X	X	X	X	X	X	X
hybrid Stizostedion sp			X												
Freshwater drum	X		X		X	X	X	X	X	X	X	X	X	X	X
Golden shiner												X	X		
Threadfin shad												X		X	
Yellow bullhead												X	X		
Hybrid shad													X		
Redear sunfish													X	X	X
Gilt darter															X
Green sunfish															
Total # of Species	21	19	22	18	22	30	29	32	38	34	37	37	42	36	37

Table A2. A summary by TVA of fish data collected in IBI samples from Pigeon River at Denton PRKM 26.6 (PRM 16.5), Cocke County, Tennessee, during summers 1988-2002.

Common Name	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Chestnut lamprey						X		X				X		X	
Longnose gar			X												
Gizzard shad	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Central stoneroller	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Whitetail shiner	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	X	X	X	X	X	X	X	X	X				X	X	X
Warpaint shiner					X										
Bigeye chub						X	X		X	X	X	X	X	X	X
Tennessee shiner			X				X		X		X	X	X	X	X
Silver shiner									X		X	X	X	X	X
Rosyface shiner				X											
Telescope shiner										X	X	X	X	X	X
Fatlips minnow											X				
Longnose dace								X	X	X	X				
River carpsucker					X	X	X	X	X	X	X	X	X	X	X
Northern hogsucker	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Smallmouth buffalo	X	X	X	X	X	X			X	X	X	X	X	X	X
Black buffalo						X							X		
Silver redbhorse							X	X	X	X	X	X	X	X	X
Black redbhorse			X				X								
Golden redbhorse							X								
Brown bullhead		X													
Channel catfish	X	X	X	X	X	X	X	X	X	X					
Rainbow trout						X	X			X	X		X	X	X
Banded sculpin							X	X	X	X	X	X	X	X	X
White bass					X	X	X	X		X					
Rock bass			X	X	X	X	X	X	X	X	X	X	X	X	X
Redbreast sunfish	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Warmouth					X										
Green sunfish									X		X	X	X	X	X
Bluegill	X	X	X				X	X	X	X	X	X	X		
hybrid sunfish sp.									X						

Table A2. (Continued).

Common Name	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Smallmouth bass	X			X	X	X	X	X	X	X	X	X	X	X	X
Spotted bass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Largemouth bass	X	X	X	X									X	X	
White crappie					X		X		X	X	X				
Black crappie		X		X							X	X			
Greenside darter						X	X	X	X	X	X	X	X	X	X
Redline darter	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Snubnose darter				X	X	X	X	X	X	X	X	X	X	X	X
Swannanoa darter											X				
Logperch	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Sauger			X	X	X	X	X	X	X	X	X		X		
Walleye	X							X	X	X					X
hybrid Stizostedion sp									X						
Freshwater drum	X		X	X	X	X	X	X	X	X	X	X	X	X	X
hybrid shad													X		
Ohio lamprey													X		
Redear sunfish													X		X
Snhothead redborse													X	X	X
Yellow bullhead													X		
White sucker														X	
Largescale stoneroller															X
Gilt darter															X
Total # of Species	17	14	19	18	21	24	26	22	30	26	30	23	29	28	30

Appendix B
Modified IBI Metrics

Table B1. List of metrics used in calculating Index of Biotic Integrity*

-
1. Number of native species
 2. Number of darter species
 3. Number of sunfish species (excluding Micropterus sp.)
 4. Number of sucker species
 5. Number of intolerant species
 6. Proportion of individuals as tolerant species
 7. Proportion of individuals as omnivores
 8. Proportion of individuals as specialized insectivorous minnows and darters
 9. Proportion of individuals as piscivores
 10. Catch rate (average number/unit sampling effort)
 11. Proportion of individuals as hybrids
 12. Proportion of individuals with disease, tumors, fin damage, and other anomalies

*Each is assigned a value as follows: 1-poor, 3-intermediate, 5-the best to be expected. The IBI for a given site is the sum of those values.

Table B2. Biotic integrity classes used in assessing fish communities along with general descriptions of their attributes (Karr et al. 1986).

<u>Class</u>	<u>Attributes</u>	<u>IBI Range</u>
Excellent	Comparable to the best situations without influence of man; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with full array of age and sex classes; balanced trophic structure.	58-60
Good	Species richness somewhat below expectation, especially due to loss of most intolerant forms; some species with less than optimal abundances or size distribution; trophic structure shows some signs of stress.	48-52
Fair	Signs of additional deterioration include fewer intolerant forms, more skewed trophic structure (e.g., increasing frequency of omnivores); older age classes of top predators may be rare.	40-44
Poor	Dominated by omnivores, pollution-tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.	28-34
Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.	12-22
No fish	Repetitive sampling fails to turn up any fish.	

Table B3. Native fish species expected to occur under optimum environmental conditions at IBI stations on the Pigeon, and Little Rivers (letters¹ indicate nature of occurrence). The following information is used to set scoring criteria for metrics 1-5.

Scientific and Common name	Pigeon R. RM 8.0	Pigeon R. RM 16.5	Little R. RM 20.0
<u>Ichthyomyzon</u> sp.			
Lamprey sp. ²	O	E	O
<u>Lepisosteus oculatus</u>			
Spotted gar	R		
<u>Lepisosteus oseus</u>			
Longnose gar	O	O	O
<u>Dorosoma cepedianum</u>			
Gizzard shad	O	O	O
<u>Campostoma anomalum</u>			
Central stoneroller	O	O	O
<u>Cyprinella galactura</u>			
Whitetail shiner	O	O	O
<u>Cyprinella spiloterus</u>			
Spotfin shiner	O	E	O
<u>Erimystax insignis</u>			
Blotched chub	E		O
<u>Hybopsis amblops</u>			
Bigeye chub	E	E	O
<u>Luxilus chrysocephalus</u>			
Striped shiner	E	E	O
<u>Luxilus coccogenis</u>			
Warpaint shiner	E	E	O
<u>Lythrurus lirus</u>			
Mountain shiner			O
<u>Nocomis micropogon</u>			
River chub	E	E	O
<u>Notropis leuciodus</u>			
Tennessee shiner	E	O	O
<u>Notropis photogenis</u>			
Silver shiner	E	E	O
<u>Notropis rubellus</u>			
Rosyface shiner	E	E	O
<u>Notropis spectrunculus</u>			
Mirror shiner		E	
<u>Notropis stramineus</u>			
Sand shiner	E		O
<u>Notropis telescopus</u>			
Telescope shiner	E	E	O

Table B3. (Continued).

Scientific and Common name	Pigeon R. RM 8.0	Pigeon R. RM 16.5	Little R. RM 20.0
<u>Notropis volucellus</u>			
Mimic shiner	E	E	O
<u>Phenacobius crassilabrum</u>			
Fatlip minnow		E	
<u>Phenacobius uranops</u>			
Stargazing minnow	E		O
<u>Pimaphales vigilax</u>			
Bullhead minnow	E		
<u>Carpiodes cyprinus</u>			
Quillback	O	E	O
<u>Hypentelium nigricans</u>			
Northern hog sucker	O	O	O
<u>Ictiobus bubalus</u>			
Smallmouth buffalo	O	O	
<u>Ictiobus niger</u>			
Black buffalo	O	R	
<u>Moxostoma anisurum</u>			
Silver redhorse	E	E	O
<u>Moxostoma carinatum</u>			
River redhorse	O	E	O
<u>Moxostoma duquesnei</u>			
Black redhorse	O	O	O
<u>Moxostoma erythrurum</u>			
Golden redhorse	O	O	O
<u>Moxostoma macrolepidotum</u>			
Shorthead redhorse	E	E	E
<u>Ictalurus natalis</u>			
Yellow bullhead	O	E	O
<u>Ictalurus nebulosus</u>			
Brown bullhead		R	
<u>Ictalurus punctatus</u>			
Channel catfish	O	O	O
<u>Noturus eleutherus</u>			
Mountain madtom	E		O
<u>Pylodictis olivaris</u>			
Flathead catfish	E	E	O
<u>Fundulus catenatus</u>			
Northern studfish	E		O
<u>Ambloplites rupestris</u>			
Rock bass	O	O	O

Table B3. (Continued).

Scientific and Common name	Pigeon R. RM 8.0	Pigeon R. RM 16.5	Little R. RM 20.0
<u>Lepomis</u> sp.			
Sunfish sp. ³	E	E	O
<u>Lepomis macrochirus</u>			
Bluegill	O	O	O
<u>Micropterus dolomieu</u>			
Smallmouth bass	O	O	O
<u>Micropterus punctulatus</u>			
Spotted bass	O	O	O
<u>Micropterus salmoides</u>			
Largemouth bass	O	O	O
<u>Pomoxis annularis</u>			
White crappie			R
<u>Pomoxis nigromaculatus</u>			
Black crappie	E	O	O
<u>Etheostoma blennioides</u>			
Greenside darter	E	E	O
<u>Etheostoma camurum</u>			
Bluebreast darter	E		O
<u>Etheostoma chlorobranchium</u>			
Greenfin darter		E	
<u>Etheostoma cinereum</u>			
Ashy darter			R
<u>Etheostoma s. jessiae</u>			
Blueside darter			O
<u>Etheostoma</u> sp.			
Darter sp. ⁴			E
<u>Etheostoma maculatum</u>			
Spotted darter	E	E	O
<u>Etheostoma rufilineatum</u>			
Redline darter	O	O	O
<u>Etheostoma simoterum</u>			
Tennessee snubnose darter	O	E	O
<u>Etheostoma zonale</u>			
Banded darter	E	E	O
<u>Percina aurantiaca</u>			
Tangerine darter	E	E	O
<u>Percina burtoni</u>			
Blotchside logperch			R
<u>Percina caprodes</u>			
Logperch	O	O	O

Table B3. (Continued).

Scientific and Common name	Pigeon R. RM 8.0	Pigeon R. RM 16.5	Little R. RM 20.0
<u>Percina evides</u>			
Gilt darter	E		O
<u>Percina macrocephala</u>			
Longhead darter			O
<u>Percina sciera</u>			
Dusky darter			R
<u>Percina squamata</u>			
Olive darter	E	E	
<u>Stizostedion canadense</u>			
Sauger		R	
<u>Stizostedion vitreum</u>			
Walleye	E	O	E
<u>Aplydinotus grunniens</u>			
Freshwater drum	O	O	O
<u>Cottus carolinae</u>			
Banded sculpin	O	O	O
<u>Labidesthes sicculus</u>			
Brook silverside			R
Species richness (number of E and O species)	53	47	53

¹O-species known to occur at site (used to set scoring criteria)

E-species expected to occur but absent from sample (used to set scoring criteria)

R-species occurs rarely due to factors other than environmental degradation (not used in setting scoring criteria)

²American brook, Ohio, Chestnut, or Alleghany brook lamprey

³Green sunfish, Warmouth, or Longear sunfish

⁴Fantail, Stripetail, or Duskytail darter

Appendix C

Annotated list of the fishes of the Pigeon River System, North Carolina and Tennessee

Annotated list of the fishes of the Pigeon River System, North Carolina and Tennessee

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16 June 1997 (updated 13 Feb.
2001, DAE)

Following is a list of fish species known from or expected to occur in the Tennessee portion of the Pigeon River plus those known from the North Carolina portion of the system. Pigeon River has its headwaters in North Carolina, flows into Tennessee in Cocke County, and enters Douglas Reservoir (French Broad River Mile 73.8) in summer pool) and 17 river miles above Douglas Reservoir (Fr. Brd. R.M. 57) at lowest winter pool. Major tributaries (order three or larger) in Tennessee include Cosby, English, and Sinking creeks. All of these enter Pigeon River from the west. Additional first and second order tributaries enter the system from both the east and west.

In the list, species collected from the river in Tennessee within the past decade are listed without comment. Species known to persist in Cosby, English, or Sinking creeks, portions of the French Broad River system above Douglas Dam (not including Nolichucky River), or Pigeon River above the Champion International paper mill effluent near Canton, North Carolina, are preceded with a single asterisk, and their status is briefly discussed. All of these have access to the Tennessee portion of Pigeon River and can be expected to reinvade if water quality continues to improve. Reinvasion from above Canton may be very difficult, especially for benthic species, because of intervening impounded water and associated flow design. Efforts to reintroduce these from brood stock in Pigeon River above Canton should be considered. Species preceded with two asterisks are those which were likely part of the historical fish fauna of Pigeon River, but for which there are no known populations which could easily serve as sources to naturally recolonize Pigeon River. These species are also discussed. The list includes 56 native species and 7 introduced species known from Pigeon River in the last decade; 30 species (6 non-native) likely to appear in the system if water quality continues to improve; and 15 species that were probably former inhabitants of Pigeon River, but no longer have access to Pigeon River. The total fauna in historical times is estimated to be 95 species of native fishes plus 13 introduced species.

Species

Ichthyomyzon bdellium • *Ichthyomyzon castaneus*

(need vouchers)

**Ichthyomyzon greeleyi*--Known from Cosby Creek and the upper French Broad system of Tennessee and North Carolina.

**Lampetra appendix*--Known from Cosby Creek, and probably present in other Pigeon River tributaries.

***Acipenser fulvescens*--There is an accepted record from the French Broad River in North Carolina, and hearsay records from the Tennessee portion of the French Broad. The species is believed extirpated from the entire Tennessee River drainage, and unable to naturally colonize the Pigeon River. It is unlikely that the Pigeon River is large enough to ever have supported more than an occasional stray individual.

Lepisosteus oculatus

Lepisosteus osseus

**Hiodon tergisus*--known from the upper French Broad River in

Tennessee and North Carolina. *Dorosoma cepedianum* *Campostoma anomalum*--Specimens from the North Carolina portion of

the system represent this species. *Campostoma oligolepis*--Host specimens from the Tennessee portion

of the system are this species or hybrids with *C. anomalum*. *Carassius auratus*--an introduced species *Cyprinella galactura*

***Cyprinella monacha*--formerly occurred in Swannanoa River and Spring Creek of the upper French Broad system of North Carolina, but likely extirpated. A healthy Pigeon River would provide a potential transplant site for this Threatened species.

Cyprinella spiloptera

Cyprinus carpio--an introduced species

**Erimystax insignis*--Carl Hubbs made two collections in Cosby Creek in June of 1940, and both samples included this species. We have not seen it since, but it may persist in Cosby Creek. It also occurs in the upper French Broad system of North Carolina, and single specimens were taken from 1996 and 1997 collections from French Broad River Mile 78, Boyer Island, about 1 mile above the mouth of Pigeon River.

Hybopsis amblops

**Luxilus chrysocephalus*--Known from the French Broad River in

Tennessee (one record in Harned, 1979), from one of the two Hubbs collections in Cosby Creek in June, 1940, and from 1 specimen from Sinking Creek in 1997. This species may persist in lower Cosby Creek, but has not been seen there

since 1940. It is a common species in small streams in the Ridge and Valley Ecoregion, and other sources for recruitment may exist.

**Luxilus coccogenis*—Known from Pigeon River above Canton, the

French Broad system above Douglas Reservoir, and from three localities in the Cosby Creek system of Pigeon River in 1940 (but not seen there since). Jordan and Brayton (1878) listed it as "abundant in every stream examined" [in the Tennessee Basin], and two of the sites they reported on in that paper were Pigeon River at Clifton and French Broad River at Newport.

**Macrhybopsis hyostoma*—This species has appeared in TVA IBI

collections from French Broad River Mile 78, Boyer Island, about 1 mile above mouth of Pigeon River, in 1993, 1996, and 1997. It seems likely that the lower Pigeon River at one time contained a population of this species, and if so it should reinvade.

Nocomis micropogon—Occurs in adjacent upper French Broad River in Tennessee and North Carolina. A single specimen was recently released from a Cosby Creek collection. This species reappeared in lower Pigeon River, Mile 8.2, in TVA's 1997 and 1998 IBI samples, and in the Pigeon River, North Carolina, below Canton, in 1980 (EA Sci. & Tech.).

**Notemigonus crysoleucas*—This lentic species is established in Douglas Reservoir and has been taken in the French Broad River about 1 mile above the mouth of Pigeon River. It is known from River Miles 42.6 and 52.3 in North Carolina, 1987 (EA). Although there is little in the way of preferred habitat for this species in Pigeon River in Tennessee, it should eventually be taken there in deeper pools in small numbers. It is likely an introduced species in this area.

Notropis leuciodus—taken in TN portion of river at Denton in 1996, 1997, and 1998. (and 2000, Greg Seegert, EA, RM?).

Notropis photogrenis—reestablished in TN portion of river in 1994, and consistently present since then.

Notropis rubellus

**Notropis rubricroceus*—Known from Cosby Creek and the Pigeon

River above Canton, North Carolina. Pigeon River is rather large for this tributary Blue Ridge species, but strays should have occurred there occasionally, especially in winter.

**Notropis spectrunculus*—Although this species is known from the upper Pigeon and French Broad rivers of North Carolina, there are no Tennessee records from either system, and it probably was not a resident of the Tennessee Pigeon River fauna in historical times. This is typically a Blue Ridge species, and, as with *Notropis rubricroceus*, winter strays are expected to have occurred historically in the Tennessee portion of the system.

*****Notropis stramineus***—Both Hubbs collections from Cosby Creek in June 1940 contained this species. It has not been seen since, and is likely extirpated from Cosby Creek, it's only possible source for reinvasion of Pigeon River, where it surely occurred.

Notropis telescopus

****Notropis volucellus***—This species formerly occurred in lower Cosby Creek, and persists in the main channel of the French Broad River about 1 mile above mouth of Pigeon River. There appears to be suitable habitat for this species in Pigeon River, and it should reinvade.

Phenacobius erassilabrum—Known from lower Cosby Creek, and probably persistent there. Found at Pigeon River Mile 16.5, Denton, in 1998.

*****Phenacobius uranops***—Known from the Nolichucky River and the French Broad River system below Douglas Dam. This species and *P. crassilabrum* co-occur in portions of the Nolichucky and Holston river systems, with *P. uranops* in the Ridge and Valley areas and *P. crassilabrum* more of a Blue Ridge species. Pigeon River appears to offer suitable habitat for both, and we feel that both species probably occurred there.

*****Phoxinus tennesseensis***—There is an earlier record from the Cosby Creek system, and a possibility that it occurs in other Pigeon River tributaries. It is a species that would rarely be found in a river the size of the Pigeon, even if it continues to occur in the Tennessee portion of the Pigeon River system.

****Pimephales notatus***—A single specimen was taken recently from the TVA IBI site at French Broad River Mile 78, Boyer Island, about 1 mile above mouth of Pigeon River. This species is fairly widespread in the Nolichucky portion of the French Broad system, but is otherwise unknown from above Douglas Reservoir.

****Pimephales promelas***—Fathead minnows occur in Douglas Reservoir and may be established there, presumably due to repeated releases by crappie fishermen. It is unlikely that this species is native to the French Broad River system above Douglas Reservoir, but strays from the reservoir will probably eventually turn up in pool areas in the lower Pigeon River.

****Pimephales vigilax***—Known from Douglas Reservoir and the French Broad River above the reservoir. It is likely that it will show up occasionally in the lower Pigeon River, but its preference is for larger, lower gradient habitats.

Rhinichthys atratulus

Rhinichthys cataractae

****Semotilus atromaculatus***—Known from Cosby and Sinking creeks, presumably present in other tributaries to Pigeon River, and certain to eventually be found in Pigeon River, even though

its preferred habitats are first and second order creeks. *Carpiodes carpio* *Carpiodes cyprinus*

**Carpiodes velifer*—Although rare, this species persists in the French Broad and Nolichucky rivers above Douglas Reservoir, and was presumably a former resident of the Pigeon River.

Catostomus commersoni

**Cycleptus elongatus*—This rare sucker persists in the French Broad River system above Douglas Reservoir, and the Pigeon River was presumably included in its former range.

Hypentelium nigricans

Ictiobus bubalus

Ictiobus niger

Moxostoma anisurum

Moxostoma breviceps

Moxostoma carinatum

Moxostoma duquesnii

Moxostoma erythrurum

Moxostoma macrolepidotum

Ameiurus catus—introduced into the French Broad River in North

Carolina. Although not yet recorded from the Tennessee portion of the French Broad, it is likely there. It showed up at Pigeon River Mile 20.3, Hartford, Cocke Co., TN, on 21 June 2000 (UT 48.1014), provided by TWRA. Collected by EA at River Mile 42.6, North Carolina, in 1987.

**Ameiurus melas*—Known from the French Broad River in North

Carolina, and likely to eventually be taken in the Pigeon River, (need voucher specimens)

**Ameiurus natalis*—Surprisingly, this widespread, common, and

tolerant bullhead has not been taken in the Pigeon River. We have a single specimen from French Broad River Mile 78, about 1 mile above mouth of Pigeon River, 1994. It is likely already present in Pigeon River in Tennessee, and if not, it will likely invade in the near future.

Ameiurus nebulosus—Well established in Douglas Reservoir, this species was present at River Mile 7.8 and 24.9 during 1987 (EA), and at R.M. 8.2 (1988) and R.M. 16.5 (1989) in TVA samples. The reservoir population is probably introduced, and these specimens may be strays from Douglas Reservoir, or may have originated there, (need voucher specimens)

**Ameiurus platycephalus*—introduced into the French Broad River in North Carolina, and, like the white catfish, eventually may make it into Tennessee and into the Pigeon River. Found in NC portion of Pigeon R. in 1997 and persistent (Greg Seegert, EA).

Ictalurus punctatus

***Noturus* sp. cf. *elegrans*—This extremely rare species was taken

in the French Broad system in Dunn Creek (Little Pigeon River tributary), where it is presumably extirpated, and in Chucky Creek in the Nolichucky River portion of the French Broad system. It may have occurred in the Pigeon River system at one time, but could not reinvade from any known population. Additionally, Pigeon River may be too large to serve as anything but a dispersal route for the species.

**Noturus eleutherus*—Known from the adjacent French Broad River, and likely to reinvade Pigeon River.

***Noturus flavus*—Known from the North Carolina portions of the Nolichucky and Little Tennessee river systems, and formerly in the Tennessee portion of the latter. Also present in the Holston and Clinch river systems. It is extremely rare in the upper Tennessee River drainage portion of its range. Since it persists in adjacent river systems on both sides of the French Broad, and since habitat in Pigeon River seems suitable, we consider it a likely former inhabitant of the Pigeon River. Systematics of this species, currently under study by Ted Cavender at Ohio State University, may result in the Tennessee drainage populations being recognized as a distinct taxon. If so, it would certainly qualify for protected status.

Pylodictis olivaris

***Esox masquinongy*—The native population that formerly occurred in the French Broad River from Tennessee into North Carolina is presumably extirpated. Hamed (1979) reported capturing one specimen from the French Broad River in Madison County, North Carolina, where it has been introduced. The introduced population is not believed to represent the native stock. Continued stocking of these in North Carolina is likely to result in occasional strays in the French Broad River and Pigeon River in Tennessee.

Oncorhynchus mykiss—*ari* introduced species

**Salmo trutta*—an introduced species

**Salvelinus fontinalis*—Pigeon River in Tennessee is probably at too low an elevation to have had a resident population of brook trout. The species persists in GSMNP tributaries to Pigeon River, and would be expected to show up occasionally in Pigeon River during cooler months.

**Fundulus catenatus*—Collected from lower Cosby Creek on 30 June 1940 by Carl Hubbs, and by TWRA on 25 April 1998. It should be able to reinvade Pigeon River.

**Gambusia affinis*—Present in Douglas Reservoir, where presumably introduced. It may eventually appear in Pigeon River.

**Cottus bairdii*—Known from Cosby Creek and from the upper Pigeon River in North Carolina. Pigeon River may be cool enough to sustain a population or to at least serve as a dispersal route during cooler months.

Cottus carolinae

Morone chrysops

Ambloplites rupestris

Lepomis auritus

Lepomis cyanellus

Lepomis gulosus--Known from Douglas Reservoir and from the French

Broad River in North Carolina, and from from Pigeon River
Mile 11.5 (1991), Mile 16.5 (1993), and Mile 8.2 (1998).

This appears to be a vagile species that can persist in low
population densities, (need vouchers) *Lepomis*

macrochirus

**Lepomis microlophus*--Present in Douglas Reservoir and widely

stocked in farm ponds, this species is likely to be taken in Pigeon River. It was
probably not a native species there.

Micropterus dolomieu

Micropterus punctulatus

Micropterus salmoides

Pomoxis annularis

Pomoxis nigromaculatus

Etheostoma blennioides

***Etheostoma camurum*--Formerly present in the French Broad River above Douglas
Reservoir but apparently extirpated. It persists in the Nolichucky portion of the system,
where it has a very narrow zone of overlap with the closely related and more upland
E. chlorobranchium. Since *E. camurum* has been found in Fort Loudon Reservoir near
George's Creek in winter pool conditions, they might be able to reinvade the French
Broad and Pigeon River portions of the system via upper Douglas Reservoir. It was
likely a former inhabitant of the lower Pigeon River.

**Etheostoma chlorobranchium*-- known from the Pigeon River above Canton, North
Carolina, and likely to reinvade the Pigeon River in Tennessee. Pigeon below
Champion outfall, 2000, Greg Seegert

^*Etheostoma flabellare*--Known from Cosby Creek and the upper Pigeon River in North
Carolina, it is likely to reinvade Pigeon River.

Etheostoma gutselli--Although formerly considered a subspecies of

Etheostoma blennioides, the recent occurrence of both *blennioides* and
gutselli in the Pigeon River firmly establishes *gutselli* as a valid species.

***Etheostoma jessiae*--There are no records from the Pigeon River. It is known from two
records from the French Broad River system in North Carolina. It also persists below
Douglas Dam and in the Nolichucky River, and was likely a member of the Pigeon
River fauna.

***Etheostoma kennicotti*--The scenario for this species is exactly the same as described for *E.*
jessiae above.

Etheostoma rufilineatum *Etheostoma simoterum* *Etheostoma swannanoa*--Known from Cosby Creek and Sweetwater

Branch. At Pigeon River Mile 16.5, Denton, in 1998 (TVA).

*****Etheostoma vulneratum***--Harned (1979) reported collecting one specimen of this species in the French Broad River about half way between the mouth of Pigeon River and the North Carolina border. It may persist in the French Broad, but there is some question concerning the identification of the specimen (which has not been located). UT 91.5539 is a female from E. Fk. Pigeon R. in eastern Haywood Co., 1997. The species persists in the Nolichucky River.

Etheostoma zonale--A single specimen taken at River Mile 24.9 in 1987 by EA. Present at Pigeon River Mile 8.2 in 1997 (TVA). Abundant in adjacent French Broad River.

****Percina aurantiaca***--Present in Pigeon River above Canton, this species should find adequate habitat in Pigeon River, and is likely to reinvade. Taken below Champion outfall in NC in 2000, Greg Seegert, EA.

*****Percina burtoni***--This rare inhabitant of large creeks and small rivers of the highest quality formerly occurred in the upper French Broad River system in North Carolina, and likely is a former member of the Pigeon River fauna

Percina caprodes

****Percina evides***--Present in French Broad River in North Carolina. Pigeon River appears to offer suitable habitat, and this sensitive darter could reinvade provided it can utilize the French Broad River as a dispersal route.

*****Percina macrocephala***--Like *P. burtoni*, this is an extremely rare species of high quality streams. It is known from the French Broad system from only two localities--one in North Carolina and one in the Little Pigeon system in Tennessee. It is probably extirpated from the system, but is a probable former member of the Pigeon River fish fauna

*****Percina sciera***--Formerly occurred in French Broad River in North Carolina, but believed to be extirpated.

****Percina shumardi***--Known from the adjacent French Broad River, and very likely to be found in lower Pigeon River, especially during late winter and early spring spawning movements.

****Percina squamata***--Rare in the adjacent French Broad River and in Pigeon River above Canton, North Carolina, this species should eventually reinvade Pigeon River in Tennessee. Taken in 2000 in NC below Champion outfall, Greg Seegert.

Sander canadense

Sander vitreus

Aplodinotus grunniens

Appendix D

Laboratory Tag Retention Data

Redline Darter

Tagging Date: 10/30/01

Location: Conservation Fisheries, Inc

VIE Color: Green

Length Sex			Length Sex			Length Sex		
1	51	F	26	49	M			
2	56	F	27	41	M			
3	57	M	28	52	F			
4	55	F	29	44	F			
5	58	F	30	57	M			
6	58	F						
7	39	F						
8	47	F						
9	58	M						
10	60	M						
11	50	M						
12	47	F						
13	54	F						
14	53	F						
15	50	F						
16	55	M						
17	52	M						
18	56	M						
19	49	F						
20	49	F						
21	43	F						
22	48	M						
23	50	M						
24	48	M						
25	62	M						

MS-222 Knockdown Time Trials

<u>Trial</u>	<u>Time</u>	<u>Temp</u>
1	3 5	55°F/12 7°C
2	3 0	56°F/13 3°C
3	3.0	56°F/13 3°C
4	3 5	56°F/13 3°C

Redline Darter

Tagging Date: 10/30/01

Location: Conservation Fisheries, Inc

VIE Color: Red

Length Sex			Length Sex			Length Sex		
1	52	F	26	50	F			
2	46	F	27	50	F			
3	52	M	28	48	M			
4	45	F	29	50	M			
5	60	M	30	46	M			
6	45	F						
7	51	M						
8	55	F						
9	45	F						
10	46	M						
11	46	F						
12	53	F						
13	42	M						
14	44	F						
15	41	F						
16	38	F						
17	40	F						
18	39	F						
19	48	F						
20	60	M						
21	48	F						
22	45	M						
23	47	F						
24	47	F						
25	62	F						

MS-222 Knockdown Time Trials

<u>Trial</u>	<u>Time</u>	<u>Temp</u>
1	3 3	56°F/13 3°C
2	3.2	56°F/13 3°C
3	3 0	56°F/13 3°C

Redline Darter

Tagging Date: 10/30/01

Location: Conservation Fisheries, Inc

VIE Color: Yellow

Length Sex			Length Sex			Length Sex		
1	47	F	26	47	F			
2	83	M	27	45	M			
3	48	M	28	41	M			
4	54	F	29	46	F			
5	60	F	30	52	M			
6	57	M						
7	45	F						
8	38	F						
9	36	F						
10	40	F						
11	38	F						
12	49	M						
13	55	F						
14	58	F						
15	65	M						
16	46	F						
17	46	F						
18	53	F						
19	50	F						
20	42	F						
21	40	F						
22	53	M						
23	39	F						
24	49	F						
25	45	M						

MS-222 Knockdown Time Trials

<u>Trial</u>	<u>Time</u>	<u>Temp</u>
1	3 0	54°F/12 2°C
2	3 5	54°F/12 2°C
3	3 2	55°F/12 7°C

30 - DAY OBSERVATION

Date: 11/30/01

Time: 1310

Tank #1

	Red				Green				Yellow			
	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2	2		S	2	1	1	P/S	2	1	1	S
2	2	2		B	2	2		S	2	1	1	S
3	2	2		B	2	2		S	2	2		B/P
4	2	1	1	B/P	2	2		B/P	2	2		S
5	2	2		S	2	2		B/P	2	2		S
6	2	2		S	2	2		S	2	2		S
7	2	2		S	2	2		S/P	2	2		S
8	2	2		S	2	2		B	2	2		S
9	2	2		B	2	2		S	2	1	1	S/B
10	2	2		S	2	2		S				
11					2	2		S				

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

Note Untagged (1) fish removed to another tank

NOTE One yellow tagged fish misidentified as a green tag

30 - DAY OBSERVATION

Date: 11/30/01

Time: 1350

Tank #2

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2		S	2	2		S	2	2		S
2	2		S	2	2		S	2	2		S
3	2		S	2	2		S	2	2		S
4	2		S	2	2		S	2	2		S
5	2		S	2	2		S	2	2		B/P
6	2		S	2	2		S	2	2		S
7	2		S	2	2		S	2	2		B+
8	2		S	2	2		S	2	2		B+
9	2		S	2	2		S	2	2		S
10	2		S	2	2		S	2	2		S

Shape of Tag: (S)stripe, (B)lotch, (P)inpoint

+ Tag showed thru light pigmented skin only
and appeared as 3 blotches -
Blue light showed stripe

30 - DAY OBSERVATION

Date: 11/30/01

Time: 1425

Tank #3

Red						Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye
1	2		S	2	2		S	2	2		S	2	2
2	2		S	2	2		S/P	2	2		S	2	2
3	2		S	2	2		S	2	2		P/S	2	1
4	2		S	2	2		S	2	2		S	2	2
5	2		S	2	2		P*	2	2		S	2	2
6	2		S	2	2		Faint S *	2	2		S	2	2
7	2		S	2	2		S	2	2		S	2	2
8	2		S	2	1	1	P	2	2		S	2	2
9	2		S	2	2		S	2	2		S/B	2	2
10	2		S	2	2		S	2	2		S	2	2

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

* Darkly pigmented fish

60 - DAY OBSERVATION

Date: 12/31/01

Time: 1045

Tank #1

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2	1	S/B	2	2		S	2	2		S
2	2		S	2	2		S	2		2	B*
3	2		S	2	2		S	2		2	S
4	2		B	2	2		S	2		2	B*
5	2		S	2	2		S	2		2	S
6	2		S	2	2		S	2	2		S
7	2		S	2	2		S	2	2		S
8	2		S	2	2		S	2	1	1	S/B
9	2		S	2	2		S/B	2	2		S
10	2		S					2	2		S
11								2	2		S

Shape of Tag' (S)stripe, (B)lotch, (P)inpoint

NOTE Yellow and green tags
not visible to eye
are very difficult to differentiate w/the blue light

* Darkly pigmented fish

NOTE One green tagged fish misidentified as a yellow tag

60 - DAY OBSERVATION

Date: 12/31/01

Time: 1135

Tank #2

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2		S	2	2		S	2	2		Faint S
2	2		S	2	2		S	2	2		S
3	2		S	2	2		S	2	2		S
4	2		S	2	2		S	2	2		S
5	2		B/S*	2	2		S	2	1	1	S*
6	2		S	2	2		S*	2	2		S
7	2		S	2	2		S	2	2		B+
8	2		S	2	2		B/S	2	2		B+
9	2		S	2	2		S	2	2		S
10	2		B/S	2		2	P/B*	2	2		S

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

+ stripe appears as
blotches between darkly
pigmented bands

* Darkly pigmented fish

60 - DAY OBSERVATION

Date: 12/31/01

Time: 1215

Tank #3

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2		S*	2	2		B/P*	2	2		Faint S/B
2	2		S	2	2		B+	2		2	S/B
3	2		S/P	2			B*	2	1	1	P/S*
4	2		B*	2	2		S*	2	2		S
5	2	1	S*	2	2		Faint S*	2		2	S*
6	2		S*	2			S	2		2	S
7	2		S	2			S/P	2		2	B*
8	2		S	1			P	2		2	S*
9	2	1	S/B*	2			S*	2		2	S*
10	2		S					2		2	S/B*
11								2		2	S*

Shape of Tag: (S)stripe, (B)lotch, (P)inpoint

+ stripe appears as
blotches between darkly
pigmented bands

* Darkly pigmented fish

NOTE One green tagged fish misidentified as a yellow tag

90 - DAY OBSERVATION

Date: 1/31/02

Time: 1315

Tank #1

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2		S	2	2		S	2	2		S
2	2		*S	2	2		S	2	2		S/B
3	2		S	2	2		S	2	2		S
4	2		*S	2	2		S	2	2		S
5	2		S	2	2		S	2	2		S
6	2		S	2	2		S	2	2		S
7	2		S	2	2		S	2	2		S/B
8	2		S	2	2		S	2	2		S
9	2		S	2	2		S	2	2	2	S
10	2		S	2	2		S	2	2	2	B

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

Water Temp: 17.7°C (64°F)

* Darkly pigmented fish

90 - DAY OBSERVATION

Date: 1/31/02

Time: 1350

Tank #2

Red						Green						Yellow					
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye
1	2		S	2	2		*S/B	2	2			2	2		Faint S/P		
2	2		S	2	2		S	2	2			2	2		S		
3	2		S	2	2		S	2	2			2	2		S		
4	2		S	2	2		S	2	2			2	2		S		
5	2	1	* Faint S/B	2	2		S	2	2			2	2		S		
6	2		S	2	2		S	2	2			2	2		S		
7	2		S	2	2		S	2	2			2	2		S		
8	2		S	2	2		S/B	2	2			2	2		S		
9	2		S	2	2		S	2	2			2	2		S		
10	2		S	2	2		S	2	2			2	2		+ B		

Shape of Tag: (S)stripe, (B)lotch, (P)inpoint

Water Temp: 17.7°C (64°F) - 18.8°C (66°F)

+ stripe appears as
blotches between darkly
pigmented bands

* Darkly pigmented fish

NOTE Only 2 dark fish before observation
and 5 dark fish after observation

90 - DAY OBSERVATION

Date: 01/31/02

Time: 1435

Tank #3

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2		S/B	2	2		*S/P	2		2	*S
2	2		S	2	2		*S	2		2	*B
3	2		S	2	2		S	2	2		S
4	2		S	2	1	1	*P/S	2	2		S
5	2		S	2	2		S	2	1	1	P/S
6	2		*B+	2	2		S	2	2		S
7	2		S	2	2		S	2		2	S
8	2	2	*B+	2	2		S	2	2		S
9	2		*B+	2	2		*B+	2	2		S
10	2		*B+	2	2		S	2	2		S

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

Water Temp: 18.8°C (66°F)

+ stripe appears as
blotches between darkly
pigmented bands

* Darkly pigmented fish

FINAL OBSERVATION

Date: 03/08/02

Time: 1045

Tank #1

Red				Green				Yellow			
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag
1	2		* faint S +	2	2		S	2	2		S
2	2		S	2	2		S	2	2		S
3	2		S	2	2		S	2	2		S
4	2		S	2	2		S	2	2		S
5	2		S	2	2		S	2	1	1	S
6	2		* faint S	2	2		S	2	2		S
7	2		S	2	2		S	2	2		S
8	2		S	2	2		S	2		2	* B +
9	2		S	2	2		S	2		2	* S
10	2		S	2	2		S	2		2	B +

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

* Darkly pigmented fish

+ stripe appears as
blotches between darkly
pigmented bands

Water Temp. 11.1°C (52°F)

FINAL OBSERVATION

Date: 03/08/02

Time: 1145

Tank #2

Red				Green				Yellow			
# Of Tags	Visible To Eve	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eve	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eve	Blue Light Only	Shape Of Tag
1	2	2			2	2	S	2	2		S
2	2	2			2	2	S	2		2	* B
3	2			2	2		S	2	2		S/B
4	2	2		2	2		S	2	2		S
5	2	2		2	2		S	2	2		S
6	2	2		2	2		S	2	2		S
7	2	2		2	2		* faint S	2	2		S
8	2	2		2	2		S	2	2		S
9	2	2		2	2		S	2	2		S
10	2	2		2	2		S	2	2		S

Shape of Tag: (S)tripe, (B)lotch, (P)inpoint

Water Temp: 11.6°C (53°F)

+ stripe appears as blotches between darkly pigmented bands

* Darkly pigmented fish

FINAL OBSERVATION

Date: 03/08/02

Time: 1305

Tank #3

Red						Green						Yellow					
# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye	Blue Light Only	Shape Of Tag	# Of Tags	Visible To Eye
1	2	2	S	2	2		S	2	2		S	2	2		S	2	2
2	2	2	S	2	2		S	2	2		S	2	2		S	2	2
3	2	2	S	2	2		*B+	2	2		*B	2	2		*B	2	2
4	2	2	S	2	2		S	2	2		S	2	2	1	P/S	2	1
5	2	2	S	2	2		*S	2	2		*S	2	2	2	S	2	2
6	2	2	S	2	2		*S/P	2	2		*S/P	2	2	2	S	2	2
7	2	2	S	2	2		*S	2	2		*S	2	2	2	*S	2	2
8	2	2	S	2	2		S	2	2		S	2	2	2	*S	2	2
9	2	2	S	2	2		S	2	2		S	2	2	2	S	2	2
10	2	2	S	2	2		S	2	2		S	2	2	2	S	2	2

Shape of Tag: (S)stripe, (B)lotch, (P)inpoint

* Darkly pigmented fish

+ stripe appears as
blotches between darkly
pigmented bands

Water Temp: 12.2°C (54°F)

Appendix E
Anesthesia Study Data

Date: 2/07/02

End Time: 1150

CLOVE OIL PRELIMINARY TRIALS

	Gm		Ylw		None		Red	
	40mg/L		60mg/L		80mg/L		100mg/L	
	Ind	Rec	Ind	Rec	Ind	Rec	Ind	Rec
1	3 33	2 01	2 49	3 48	1 53	4 53	1 41	6 55
2	3 33	2 01	2 10	2 59	1 21	2 49	1 07	6 34
3	3 12	1 22	2 36	4 02	1 53	7 37	1 24	3 31

Mean: 3 26 1 74 2 32 3 36 1 42 5 20 1 24 5 40

Water Temp: 10°C 10°C 10°C 10°C

Date: 2/07/02

Start Time: 1315

End Time: 1900

CLOVE OIL TRIALS

	Red		Grn		Ylw	
	30 mg		40 mg		50 mg	
	Ind	Rec	Ind	Rec	Ind	Rec
1	2 49	4 03	2 19	8 36	1 35	6 55
2	4 39	5.42	2 25	6 20	2 00	5 46
3	2 41	4 29	3 00	4 42	2 15	7 51
4	3 06	3 23	3 20	4 02	2 51	7 11
5	2 28	2 15	2 57	5 23	2 09	4 00
6	4 02	6 12	2 57	5 23	2 27	5 52
7	3 33	7 07	2 09	3 50	2 28	4 49
8	2 58	3 15	2 28	4 39	2 36	6 30
9	4 05	5 10	* 2 10	2 58	1 49	7 00
10	2 55	2 03	* 2 45	7 30	2 09	4 12
11	5 13	4 55	1 53	3 53	2 16	6 25
12	3 45	6 30	2 40	3 11	1 57	4 11
13	3 00	4 09	2 55	4 01	2 46	6 37
14	2 31	2.25	3 07	4 11	2 58	7 25
15	2 36	2 08	3 23	3 33	1 46	4 47
16	3 06	3 26	3 51	4 53	2 44	6 02
17	1.58	2 04	3 23	4 30	2 37	7 42
18	3 01	4 10	4 12	6 26	2 34	6 27
19	3 35	1 55	3 09	4 55	2 34	6 46
20	4 00	3 29	3 25	4 50	2 34	6 53

Water Temp: 10 5°C

11 1°C

11 1°C

NOTE gasping behavior

* Timer malfunction One minute added to time to account for estimated time loss

Appendix F
Snorkel Survey Data

Pigeon River Snorkel Survey: Tannery Island

Darter Count

Date: 7/26/02

Replicate:		#1			#2			#3		
		Darter			Darter			Darter		
Transect	Tag	G	BB	BS	G	BB	BS	G	BB	BS
1	R	0			0			1		
	G	0			0			0		
	Y	0			1	1		0		
	O	0			7			5		
	NV	1			0			2		
	NT	0			0			0		
2	R	2			6			2		
	G	2			4			0		
	Y	0			0			1		
	O	4			10			11		
	NV	2			5			1		
	NT	0			0			0		
3	R	0			2			1		
	G	0			3			2		
	Y	2			0			1		
	O	2			9			7		
	NV	3			3			4		
	NT	0			0			0		
4	R	0			0			0		
	G	0			2			1		
	Y	0	1		0	1		1		
	O	7			3			2		
	NV	11			2			1		
	NT	0			0			0		
5	R	0			3			2		
	G	2			1			5		
	Y	0			1			1		
	O	3			1			7		
	NV	0			4			5		
	NT	0			0			1		
Total		41	1	0	67	2	0	64	0	0

NOTE: Phenacobius - 1

R = Red

G = Green

Y = Yellow

O = Orange

NV = Tag not visible

NT = No tag

Pigeon River Snorkel Survey: Tannery Island

Flow Data

Date: 7/26/02

Sightings	Rep 1		Rep 2		Rep 3	
	Flow (m/s)	Depth (cm)	Flow (m/s)	Depth (cm)	Flow (m/s)	Depth (cm)
1	0.72	51	0.36	33	0.66	42
2	0.69	39	0.59	44	0.84	31
3	1.06	36	0.51	44	1.10	36
4	0.65	45	0.52	41	0.81	38
5	1.12	39	0.54	45	0.61	42
6	1.07	37	0.65	43	0.47	43
7	0.76	41	0.46	46	0.70	36
8	1.03	37	0.49	41	0.76	40
9	0.79	43	0.53	42	0.77	37
10	0.69	37	0.58	42	0.74	39
11	0.83	39	0.60	46	0.88	38
12	0.77	41	0.57	44	0.64	42
13	0.64	43	0.68	44	0.67	43
14	0.52	44	0.42	43	0.67	42
15	0.75	49	0.66	42	0.64	44
16	0.79	42	0.53	42	0.74	42
17	0.78	42	0.65	44	0.64	44
18	0.60	43	0.43	38	0.50	46
19	0.77	43	0.85	30	0.71	42
20	0.58	43	0.57	34	0.60	41
21	0.48	43	0.80	40	0.55	42
22	0.38	37	0.97	30	0.62	37
23			1.01	36	0.43	40
24			0.78	39		
25			0.68	42		
26			0.94	38		
27			0.52	35		

* = Bluebreast darter

Pigeon River Survey #2

Date: 8/13/02

GPS Location: N35°56'41.1", W83°10'71.1" (riffle upstream of release site)

Sightings	Velocity (m/s)	Depth (cm)		Tag	Gilts	Bluebreast
1	0.49	35		Red	5	
2	0.49	40		Green	1	
3	0.58	35		Yellow	0	1
4	0.46	35		Orange	* 16	
5	0.37	33		NV	3	
6	0.54	36		NT	2	
7	0.70	38				
8	0.51	38				
9	0.50	48				
10	0.62	49				
11	0.62	48				
12	0.50	62				
13	0.69	55				
14	0.68	70				
15	0.70	58				
16	* 0.96	50				

* = Bluebreast darter

P

Appendix G
Field Collection Data

Blueside Darter

Collection Date. 03/14/01
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 3/14/01
Release Site: Pigeon River, Tannery Island
Release Date. 3/14/01
VIE. Red

Length Sex			Length Sex			Length Sex			Length Sex		
1	58	F	26	55	F	51	64	F	76	49	F
2	61	M	27	68	F	52	57	M	77	56	F
3	52	F	28	55	M	53	55	M	78	50	F
4	58	F	29	61	M	54	50	F	79	54	F
5	52	F	30	75	M	55	77	M	80	53	F
6	49	F	31	61	M	56	73	M	81	47	F
7	63	M	32	64	F	57	64	F	82	52	F
8	51	F	33	75	M	58	59	F	83	53	F
9	64	F	34	56	F	59	58	M	84	51	F
10	53	M	35	53	F	60	51	F	85	61	M
11	70	M	36	58	M	61	73	M	86	51	F
12	74	F	37	58	F	62	61	M	87	54	F
13	75	M	38	65	M	63	59	M	88	51	F
14	64	F	39	49	F	64	52	M	89	54	F
15	58	M	40	58	M	65	45	F	90	64	M
16	55	M	41	73	F	66	55	M	91	54	F
17	61	F	42	51	F	67	54	M	92	52	F
18	61	M	43	52	F	68	56	M	93	46	F
19	71	M	44	59	M	69	56	M	94	50	F
20	76	M	45	51	M	70	71	M	95	59	M
21	63	F	46	50	F	71	57	M	96	49	F
22	55	F	47	54	M	72	70	F	97	52	F
23	59	M	48	52	F	73	52	F	98	69	F
24	58	M	49	66	F	74	61	M	99	51	F
25	76	M	50	52	F	75	52	F	100	52	F

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	0945	10 0°C	5 7		2 (before tagging)
	0950	9 9°C	5 8		
Confluence	1025	10 1°C	7 6		
Tannery Island	1715	9 9°C	7 8		

Blueside Darter

Collection Date 03/14/01
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date: 3/14/01
Release Site: Pigeon River, Tannery Island
Release Date: 3/14/01
VIE. Red

Length Sex			Length Sex			Length Sex			Length Sex		
101	47	F									
102	61	F									
103	57	F									
104	58	M									
105	52	F									
106	68	M									
107	48	M									
108	50	F									
109	40	F									
110	50	F									
111	52	F									
112	54	F									
113	57	M									
114	51	F									
115	56	M									
116	55	F									
117	61	M									
118	49	F									
119	52	F									
120	51	F									
121	54	F									
122	52	F									
123	63	F									
124	45	F									
125	52	F									
126	50	F									
127	55	F									
128	71	M									

Gilt Darter

Collection Date 05/23/01
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 05/23/01
Release Site. Pigeon River, Tannery Island
Release Date 05/23/01
VIE. Red

Length Sex			Length Sex			Length Sex			Length Sex		
1	56	F	26	58	F	51	53	F	76	55	F
2	53	F	27	58	F	52	58	M	77	64	F
3	55	M	28	58	M	53	49	F	78	49	F
4	55	F	29	57	F	54	55	F	79	63	M
5	60	M	30	68	M	55	51	F	80	68	M
6	68	M	31	52	F	56	56	F	81	67	F
7	54	F	32	65	M	57	56	F	82	66	F
8	52	F	33	54	F	58	52	F	83	58	M
9	71	M	34	59	M	59	57	F	84	63	M
10	63	F	35	52	F	60	55	F	85	60	M
11	60	M	36	52	F	61	50	F	86	62	M
12	62	M	37	57	M	62	67	M	87	62	F
13	52	F	38	54	F	63	55	F	88	52	F
14	53	F	39	56	M	64	59	M	89	55	F
15	54	F	40	69	M	65	55	M	90	56	F
16	59	M	41	52	F	66	65	M	91	40	F
17	45	F	42	57	M	67	66	F	92	44	F
18	62	F	43	44	F	68	58	F	93	46	F
19	64	M	44	52	F	69	46	F	94	68	F
20	61	F	45	50	F	70	47	F	95	58	F
21	58	F	46	67	M	71	45	F	96	64	F
22	61	M	47	52	F	72	57	F	97	60	M
23	60	M	48	60	M	73	47	F	98	54	F
24	42	F	49	46	F	74	70	M	99	59	F
25	67	F	50	48	F	75	59	M	100	66	M

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1435	18.4°C	—	--	0
Bag	1435	20.0°C			
Pigeon River	1630	19.0°C			

Gilt Darter

Collection Date	05/23/01
Collection Site	Confluence of West Prong and Little Pigeon River
Tagging Date.	05/23/01
Release Site	Pigeon River, Tannery Island
Release Date:	05/23/01
VIE:	Red

[illegible]

Blueside Darter

Collection Date: 05/23/01
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 05/23/01
Release Site: Pigeon River, Tannery Island
Release Date: 05/23/01
VIE: Red

[illegible]

Gilt Darter

Collection Date 10/02/01
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 10/02/01
Release Site Pigeon River, Tannery Island
Release Date 10/02/01
VIE. Green

Length			Sex	Length			Sex	Length			Sex	Length			Sex
1	68	M		26	64	F		51	50	F		76	55	F	
2	72	M		27	55	F		52	54	F		77	58	M	
3	54	F		28	63	M		53	55	F		78	65	M	
4	49	F		29	63	M		54	57	F		79	55	M	
5	61	F		30	54	F		55	53	F		80	63	M	
6	73	M		31	64	M		56	54	F		81	46	F	
7	62	F		32	68	M		57	60	M		82	54	M	
8	55	F		33	57	M		58	52	F		83	68	M	
9	62	F		34	52	F		59	52	F		84	53	F	
10	52	F		35	45	M		60	63	M		85	70	M	
11	53	F		36	54	F		61	72	M		86	60	M	
12	51	F		37	53	F		62	55	F		87	66	M	
13	59	F		38	54	F		63	55	F		88	61	M	
14	73	M		39	58	M		64	61	M		89	58	M	
15	62	M		40	65	M		65	71	M		90	60	M	
16	56	F		41	52	F		66	60	M		91	55	F	
17	59	M		42	55	M		67	52	F		92	51	F	
18	42	F		43	54	F		68	54	M		93	64	F	
19	54	M		44	71	M		69	51	F		94	73	M	
20	54	F		45	55	F		70	63	M		95	71	M	
21	79	M		46	63	M		71	60	M		96	60	F	
22	50	F		47	58	M		72	63	M		97	75	M	
23	60	M		48	49	F		73	64	M		98	60	F	
24	54	F		49	65	F		74	57	M		99	62	F	
25	52	F		50	73	M		75	64	M		100	55	F	

Location	Time	Temp	pH	DO	Mortality
West Prong	1000	14.9°C	7.2	9.55	3
Little Pigeon	1020	14.0°C	7.3	10.20	
Holding Tank	1330	12.7°C			

Gilt Darter

Collection Date: 10/02/01
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 10/02/01
Release Site: Pigeon River, Tannery Island
Release Date: 10/02/01
VIE: Green

Length Sex			Length Sex			Length Sex			Length Sex		
101	71	M	126	53	F						
102	50	F	127	53	F						
103	47	F	128	64	M						
104	54	F	129	48	F						
105	64	M	130	67	M						
106	51	F	131	42	F						
107	55	F	132	73	M						
108	71	M	133	51	F						
109	49	F	134	65	M						
110	51	F	135	56	F						
111	73	M									
112	50	F									
113	66	M									
114	58	M									
115	67	F									
116	51	F									
117	70	M									
118	48	F									
119	59	M									
120	66	M									
121	55	F									
122	55	M									
123	55	F									
124	61	M									
125	65	F									

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ert

Bluebreast Darter

Collection Date 10/09/01
Collection Site: Bewley's Island RM-28 Nolichucky
Tagging Date 10/09/01
Release Site: Pigeon River, Tannery Island
Release Date. 10/09/01
VIE Yellow

Length Sex			Length Sex			Length Sex			Length Sex		
1	56	M	26	65	M	51	65	M	76	62	M
2	49	M	27	51	F	52	63	M	77	49	M
3	48	M	28	53	F	53	65	M	78	48	M
4	51	M	29	52	M	54	50	F	79	42	F
5	61	M	30	46	M	55	64	M	80	72	M
6	58	F	31	70	M	56	69	M	81	61	F
7	74	M	32	65	M	57	69	F	82	62	M
8	62	F	33	53	F	58	67	M	83	62	M
9	64	M	34	63	F	59	55	M	84	55	F
10	50	F	35	69	M	60	51	F	85	71	M
11	54	F	36	53	F	61	62	F	86	60	M
12	74	M	37	55	F	62	74	M	87	61	M
13	51	M	38	54	F	63	56	M	88	67	M
14	64	M	39	47	F	64	59	F	89	70	M
15	71	M	40	52	M	65	63	F	90	53	M
16	48	F	41	49	M	66	53	F	91	59	M
17	69	M	42	61	F	67	47	M	92	54	M
18	61	F	43	51	F	68	56	M	93	74	M
19	60	F	44	46	M	69	68	M	94	65	M
20	60	F	45	60	M	70	53	M	95	62	F
21	58	F	46	58	F	71	62	M	96	71	M
22	60	F	47	55	M	72	62	M	97	66	M
23	64	M	48	53	M	73	45	F	98	56	M
24	70	M	49	66	M	74	70	M	99	38	F
25	64	M	50	61	M	75	67	M	100	47	M

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Nolichucky	1020	14.9°C	7	10.30	1 (before tagging)

NOTE First 51 were collected by electroshocking, remainder were seined

Bluebreast Darter

Collection Date: 10/09/01
Collection Site: Bewley's Island RM-28 Nolichucky
Tagging Date: 10/09/01
Release Site: Pigeon River, Tannery Island
Release Date: 10/09/01
VIE: Yellow

Length Sex			Length Sex			Length Sex			Length Sex		
101	62	F									
102	66	M									
103	68	M									
104	59	M									
105	50	F									
106	71	M									
107	54	F									
108	65	M									
109	54	F									
110	66	M									
111	61	M									
112	59	F									
113	71	M									
114	67	M									
115	61	F									
116	53	F									
117	63	M									
118	65	M									
119	70	M									
120	61	F									
121	60	F									

Gilt Darter

Collection Date. 10/09/01
 Collection Site. Bewley's Island RM-28 Nolichucky
 Tagging Date 10/09/01
 Release Site. Pigeon River, Tannery Island
 Release Date. 10/09/01
 VIE Yellow

Length	Sex	Length	Sex	Length	Sex	Length	Sex
1	73	F	26	79	M	51	
2	77	M	27	62	M	52	
3	82	M	28	81	M	53	
4	81	M	29	78	M	54	
5	65	M	30	77	M	55	
6	65	F	31	71	F	56	
7	70	M	32	83	M	57	
8	70	M	33	82	M	58	
9	76	M	34	76	M	59	
10	67	M	35	61	F	60	
11	70	M	36	72	F	61	
12	65	M	37	65	F	62	
13	66	F	38	69	F	63	
14	52	F	39	61	F	64	
15	71	M	40	73	F	65	
16	82	M	41	70	F	66	
17	80	M	42			67	
18	59	M	43			68	
19	83	M	44			69	
20	78	M	45			70	
21	75	F	46			71	
22	72	F	47			72	
23	72	F	48			73	
24	66	F	49			74	
25	64	M	50			75	
						76	
						77	
						78	
						79	
						80	
						81	
						82	
						83	
						84	
						85	
						86	
						87	
						88	
						89	
						90	
						91	
						92	
						93	
						94	
						95	
						96	
						97	
						98	
						99	
						100	

Location Time Temp pH DO Mortality
 Nolichucky 1020 14 9°C 7.4 10.30 1 (jumped out of cooler before tagging)

NOTE First five were seined, remainder were collected by electroshocking

Bluebreast Darter

Collection Date: 11/06/01
Collection Site: Bewley's Island RM-28 Nolichucky
Tagging Date: 11/06/01 and 11/07/01
Release Site: Pigeon River, Tannery Island
Release Date: 11/06/01 and 11/08/01
VIE: Yellow

Length			Sex	Length			Sex	Length			Sex	Length			Sex
1	66	M		26	81	M		51	46	F		76	55	F	
2	71	M		27	49	M		52	64	M		77	78	M	
3	61	M		28	51	F		53	50	M		78	79	M	
4	54	F		29	60	F		54	53	M		79	48	F	
5	64	M		30	54	F		55	47	F		80	45	F	
6	59	M		31	55	F		56	50	F		81	58	F	
7	50	F		32	56	M		57	51	M		82	53	F	
8	54	F		33	56	M		58	49	M		83	49	F	
9	56	F		34	52	M		59	45	M		84	56	M	
10	62	M		35	48	F		60	65	M		85	67	M	
11	51	M		36	65	M		61	53	F		86	72	M	
12	68	F		37	61	M		62	51	F		87	50	M	
13	54	M		38	49	M		63	49	F		88	71	M	
14	60	F		39	47	M		64	52	F		89	71	M	
15	56	F		40	63	M		65	65	F		90	67	M	
16	51	F		41	61	F		66	62	M		91	55	M	
17	59	F		42	65	F		67	58	M		92	56	F	
18	54	F		43	53	F		68	48	F		93	49	F	
19	62	M		44	47	F		69	53	F		94	59	F	
20	49	M		45	48	F		70	65	M		95	61	M	
21	61	M		46	60	M		71	64	M		96	63	M	
22	72	M		47	58	M		72	66	M		97	57	M	
23	71	M		48	53	F		73	58	M		98	56	M	
24	55	F		49	52	F		74	68	M		99	62	M	
25	60	F		50	57	M		75	49	F		100	70	M	

Location	Time	Temp	pH	DO	Mortality
Nolichucky	1020	11 6°C	8	13 90	2 (seining injunes)
	1530	13 7°C		10 50	
JARTU	1800	11 0°C			
11/7/2001	1600	12 0°C	NOTE	Used 125mb/L due to colder temperatures in the field on 11/06	
11/8/2001	1130	13 5°C			
	1530	13 5°C			
Pigeon River	1730	11 0°C	NOTE	Approximately half of the fish were tagged in the field and released 11/06	

Bluebreast Darter

Collection Date 11/06/01
Collection Site. Bewley's Island RM-28 Nollchucky
Tagging Date 11/06/01 and 11/07/01
Release Site. Pigeon River, Tannery Island
Release Date 11/06/01 and 11/08/01
VIE- Yellow

Length Sex			Length Sex			Length Sex			Length Sex		
101	59	F									
102	60	F									
103	54	F									
104	55	F									
105	75	M									
106	57	M									
107	57	F									
108	55	F									
109	51	M									
110	75	M									
111	54	M									
112	65	M									
113	59	F									
114	65	F									
115	67	F									
116	47	F									
117	57	F									
118	52	F									
119	61	M									
120	53	F									
121	58	M									
122	60	F									

Gilt Darter

Collection Date 11/06/01
Collection Site Bewley's Island RM-28 Nolichucky
Tagging Date 11/06/01 and 11/07/01
Release Site Pigeon River, Tannery Island
Release Date: 11/08/01
VIE Yellow

Length		Sex	Length		Sex	Length		Sex	Length		Sex
1	68	F	26	82	M	51	79	M	76		
2	67	F	27	65	M	52	50	F	77		
3	60	F	28	82	M	53			78		
4	72	M	29	68	F	54			79		
5	55	F	30	62	F	55			80		
6	66	M	31	78	M	56			81		
7	75	M	32	83	M	57			82		
8	75	M	33	64	M	58			83		
9	85	M	34	74	M	59			84		
10	67	M	35	57	F	60			85		
11	70	M	36	69	M	61			86		
12	75	M	37	80	M	62			87		
13	73	M	38	71	M	63			88		
14	78	M	39	79	M	64			89		
15	54	F	40	66	F	65			90		
16	68	F	41	64	F	66			91		
17	84	M	42	70	F	67			92		
18	80	M	43	71	F	68			93		
19	68	M	44	80	M	69			94		
20	56	F	45	70	F	70			95		
21	67	M	46	68	M	71			96		
22	70	M	47	63	M	72			97		
23	80	M	48	72	F	73			98		
24	55	F	49	75	M	74			99		
25	67	M	50	63	M	75			100		

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Nolichucky	1020	11 6°C	8	13 90	0
	1530	13 7°C		10 50	
JARTU	1800	11 0°C			
11/07/01	1600	12 0°C			
11/08/01	1130	13 5°C			
	1530	13 5°C			
Pigeon River	1730	11 0°C			

Blueside Darter

Collection Date	11/06/01
Collection Site	Bewley's Island RM-28 Nollchucky
Tagging Date:	11/06/01 and 11/07/01
Release Site	Pigeon River, Tannery Island
Release Date	11/08/01
VIE	Yellow

[illegible]

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Nolichucky	1020	11 6°C	8	13 90	0
	1530	13 7°C		10 50	
JARTU	1800	11 0°C			
11/07/01	1600	12 0°C			
11/08/01	1130	13 5°C			
	1530	13 5°C			
Pigeon River	1730	11 0°C			

Blueside Darter

Collection Date: 2/08/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 2/11/02
Release Site: Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date: 2/14/02
VIE: Orange

Length			Sex	Length			Sex	Length			Sex	Length			Sex
1	45	M		26	53	F		51	54	M		76	58	M	
2	52	F		27	79	M		52	60	F		77	50	M	
3	50	F		28	66	F		53	58	M		78	53	F	
4	52	M		29	61	M		54	60	M		79	50	F	
5	59	M		30	68	F		55	59	M		80	62	M	
6	67	M		31	54	M		56	55	M		81	64	M	
7	69	F		32	61	M		57	54	F		82	52	M	
8	49	F		33	73	M		58	54	M		83	50	F	
9	51	F		34	56	M		59	46	F		84	70	F	
10	49	F		35	60	M		60	58	M		85	50	F	
11	50	F		36	53	F		61	63	M		86	63	M	
12	51	F		37	63	M		62	57	F		87	62	M	
13	46	F		38	53	F		63	63	F		88	48	F	
14	59	M		39	69	M		64	56	M		89	73	F	
15	60	M		40	51	F		65	55	M		90	77	M	
16	51	F		41	57	M		66	44	F		91	65	M	
17	45	F		42	59	M		67	53	M		92	60	M	
18	58	M		43	60	M		68	59	M		93	53	M	
19	54	M		44	69	F		69	62	M		94	55	M	
20	57	M		45	60	M		70	59	F		95	60	M	
21	60	M		46	60	M		71	55	M		96	61	M	
22	47	F		47	59	M		72	51	F		97	61	F	
23	53	F		48	53	F		73	53	M		98	61	M	
24	57	M		49	72	M		74	63	M		99	59	M	
25	56	M		50	48	F		75	63	M		100	49	F	

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1000	7 0°C	--	--	
JARTU (2/11)	1320	15 0°C			1 (M)
Pigeon River	1130	6 8°C			

Blueside Darter

Collection Date: 2/08/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 2/11/02
Release Site: Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date: 2/14/02
VIE: Orange

[illegible]

Gilt Darter

Collection Date 2/08/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date. 2/12/02
Release Site: Pigeon River, Tannery Island
Release Date 2/14/02
VIE: Orange

Length Sex			Length Sex			Length Sex			Length Sex		
1	60	F	26	78	M	51	47	F			
2	67	F	27	48	F	52	46	F			
3	74	M	28	46	M						
4	57	F	29	60	M						
5	68	M	30	50	F						
6	51	F	31	61	M						
7	45	F	32	47	F						
8	51	F	33	63	F						
9	50	F	34	52	M						
10	56	F	35	53	F						
11	63	M	36	66	F						
12	69	M	37	51	F						
13	48	F	38	47	F						
14	56	M	39	61	M						
15	55	F	40	55	M						
16	71	F	41	53	M						
17	66	M	42	53	F						
18	53	M	43	53	F						
19	46	F	44	57	M						
20	68	F	45	51	M						
21	47	F	46	63	F						
22	52	M	47	55	M						
23	54	M	48	67	M						
24	46	M	49	44	M						
25	48	M	50	55	M						

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1000	7 0°C	-	-	
JARTU (2/12)	1215	15 0°C			1 (F)
Pigeon River	1100	6 0°C			

Stargazing Minnow

Collection Date	2/08/02
Collection Site	Confluence of West Prong and Little Pigeon River
Tagging Date.	2/12/02
Release Site	Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date	2/14/02
VIE	Orange

[illegible]

Blueside Darter

Collection Date 2/15/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date: 2/18/02
Release Site Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date 2/19/02
VIE: Orange

Length		Sex	Length		Sex	Length		Sex	Length		Sex
1	60	M	26	55	M	51	70	F	76	53	M
2	49	F	27	56	M	52	50	F	77	51	F
3	52	F	28	53	F	53	67	F	78	64	F
4	56	F	29	53	F	54	48	F	79	60	M
5	76	M	30	56	M	55	50	F	80	68	F
6	52	M	31	49	F	56	71	M	81	52	F
7	46	F	32	64	M	57	53	F	82	76	M
8	55	M	33	70	M	58	60	M	83	52	M
9	63	F	34	60	F	59	49	F	84	58	M
10	57	M	35	56	M	60	52	F	85	56	M
11	50	F	36	55	M	61	56	M	86	50	F
12	63	M	37	60	M	62	58	M	87	64	M
13	54	F	38	69	F	63	71	F	88	51	F
14	67	F	39	63	M	64	59	M	89	52	F
15	56	F	40	60	M	65	69	M	90	53	M
16	58	M	41	56	M	66	55	F	91	55	F
17	61	M	42	50	F	67	64	F	92	55	M
18	59	M	43	55	M	68	62	M	93	63	M
19	78	M	44	57	F	69	57	M	94	51	F
20	50	F	45	60	M	70	58	M	95	50	M
21	52	F	46	75	F	71	70	F	96	54	M
22	62	M	47	60	M	72	51	F	97	50	F
23	46	F	48	57	F	73	60	M	98	53	M
24	49	F	49	56	M	74	53	F	99	55	F
25	53	F	50	61	M	75	45	F	100	52	F

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1000	6.4°C	--	--	2 (M)
Little Pigeon	1230	7.2°C			
Transport Bag	1450	11.3°C			
JARTU (2/15)	1530	14.2°C			
JARTU (2/18)	1245	15.0°C			
JARTU (2/19)	0930	15.2°C			
Pigeon (2/19)	1235	7.2°C			

Blueside Darter

Collection Date	2/15/02
Collection Site	Confluence of West Prong and Little Pigeon River
Tagging Date	2/18/02
Release Site	Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date	2/19/02
VIE.	Orange

[illegible]

Gilt Darter

Collection Date 2/15/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 2/18/02
Release Site Pigeon River, Tannery Island
Release Date 2/19/02
VIE Orange

Length Sex			Length Sex			Length Sex			Length Sex		
1	74	M	26	55	F						
2	59	M	27	48	F						
3	63	F	28	50	F						
4	57	F	29	63	M						
5	46	F	30	51	M						
6	66	M	31	49	M						
7	51	F	32	62	F						
8	74	M	33	49	F						
9	47	F	34	52	M						
10	56	F	35	63	M						
11	63	F	36	55	F						
12	54	M	37	54	F						
13	49	F	38	46	F						
14	65	M	39	53	F						
15	62	M	40	45	F						
16	68	M	41	53	F						
17	66	F									
18	61	F									
19	63	M									
20	47	F									
21	63	M									
22	55	F									
23	72	M									
24	48	F									
25	64	M									

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1000	6.4°C	--	--	6 (F) 2/19
Little Pigeon	1230	7.2°C			
Transport Bag	1450	11.3°C			
JARTU (2/15)	1530	14.2°C			
JARTU (2/18)	1615	15.0°C			
JARTU (2/19)	0930	15.2°C			
Pigeon (2/19)	1100	7.0°C			

Blueside Darter

Collection Date 3/15/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 3/15/02
Release Site: Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date: 3/15/02
VIE. Orange

LengthSex			LengthSex			LengthSex			LengthSex		
1	55	F	26	57	M	51	53	F	76	62	M
2	55	F	27	58	F	52	56	M	77	60	M
3	52	F	28	53	M	53	58	M	78	61	M
4	57	M	29	58	M	54	54	F	79	60	M
5	50	M	30	53	F	55	47	M	80	54	F
6	72	F	31	59	M	56	52	M	81	55	F
7	49	F	32	57	M	57	52	F	82	51	F
8	59	F	33	56	M	58	50	F	83	62	M
9	60	F	34	50	F	59	58	M	84	55	M
10	59	M	35	59	F	60	64	M	85	59	M
11	53	M	36	60	M	61	49	F	86	51	F
12	53	F	37	58	M	62	59	M	87	56	M
13	54	F	38	56	F	63	51	F	88	58	M
14	65	F	39	61	M	64	58	M	89	52	F
15	49	F	40	53	F	65	60	M	90	53	M
16	61	M	41	57	M	66	52	F	91	56	M
17	55	F	42	56	F	67	57	M	92	60	M
18	61	M	43	57	M	68	62	F	93	54	M
19	59	M	44	55	M	69	55	F	94	49	F
20	67	F	45	63	M	70	55	F	95	54	F
21	54	F	46	56	M	71	60	M	96	54	M
22	53	F	47	59	M	72	55	M	97	55	M
23	59	M	48	51	F	73	58	M	98	54	M
24	50	F	49	74	M	74	60	M	99	48	F
25	53	F	50	56	M	75	58	M	100	56	M

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1100	13.5°C	-	12.30	3 (F) (1 Non-tagging) 4 (M)

Blueside Darter

Collection Date. 3/15/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 3/15/02
Release Site Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date. 3/15/02
VIE- Orange

Length Sex			Length Sex			Length Sex			Length Sex		
101	57	M	126	53	F	151	51	F			
102	61	M	127	66	M	152	53	F			
103	42	F	128	62	M						
104	50	F	129	60	M						
105	60	M	130	60	M						
106	55	M	131	58	M						
107	59	M	132	65	F						
108	62	M	133	59	M						
109	54	F	134	54	F						
110	57	M	135	53	M						
111	59	M	136	60	M						
112	47	F	137	60	M						
113	53	M	138	49	F						
114	55	F	139	52	F						
115	55	F	140	68	F						
116	68	F	141	68	F						
117	60	M	142	61	M						
118	60	M	143	51	F						
119	55	F	144	48	F						
120	54	F	145	65	M						
121	54	F	146	52	M						
122	48	F	147	49	F						
123	57	M	148	48	F						
124	56	M	149	51	M						
125	58	M	150	55	F						

NOTE In 16 unit efforts (300 sq ft /seine effort), collected 5 tagged (1 red, 1 ylw, 3 gm) redlines,
 all healthy, only 1/effort, all from just downstream of their release site

Gilt Darter

Collection Date: 05/21/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 05/21/02
Release Site: Pigeon River, Tannery Island
Release Date: 05/21/02
VIE: Orange

Length			Sex	Length			Sex	Length			Sex	Length			Sex
1	55		M	26	65		M	51	64		F	76	75		M
2	69		F	27	64		M	52	56		F	77	75		M
3	56		F	28	64		M	53	60		F	78	55		F
4	67		F	29	59		M	54	65		F	79	76		M
5	67		F	30	51		F	55	55		M	80	54		M
6	65		F	31	52		M	56	58		M	81	69		M
7	64		M	32	64		M	57	64		M	82	58		M
8	57		M	33	57		M	58	55		M	83	61		M
9	55		M	34	52		M	59	61		M	84	60		M
10	43		F	35	65		F	60	52		F	85	56		M
11	54		F	36	58		M	61	64		M	86	68		F
12	52		F	37	61		F	62	60		F	87	49		M
13	56		M	38	54		F	63	51		M	88	58		F
14	55		F	39	55		F	64	49		M	89	64		M
15	57		M	40	61		M	65	59		F	90	66		M
16	54		F	41	81		M	66	50		M	91	62		M
17	65		M	42	56		M	67	56		M	92	52		F
18	53		M	43	70		M	68	59		F	93	69		M
19	63		M	44	54		F	69	54		M	94	64		M
20	53		M	45	57		F	70	54		F	95	54		F
21	60		M	46	55		M	71	51		F	96	56		F
22	41		M	47	55		F	72	58		M	97	56		F
23	55		M	48	66		F	73	55		M	98	64		F
24	50		M	49	68		M	74	53		F	99	57		M
25	65		M	50	62		M	75	58		M	100	59		M

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1030	12.9°C	--	11.30	0

NOTE: Collected one tagged redline

Gilt Darter

Collection Date: 05/21/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 05/21/02
Release Site: Pigeon River, Tannery Island
Release Date: 05/21/02
VIE: Orange

Length Sex			Length Sex			Length Sex			Length Sex		
101	58	F	126	58	F	151	58	F			
102	57	M	127	61	F	152	56	F			
103	59	M	128	60	F	153	50	F			
104	52	F	129	53	F	154	66	F			
105	57	M	130	62	F	155	63	F			
106	63	F	131	60	M	156	55	F			
107	65	M	132	61	F	157	53	F			
108	57	F	133	58	M						
109	55	F	134	83	M						
110	70	F	135	52	F						
111	52	F	136	63	F						
112	62	F	137	55	F						
113	51	F	138	65	F						
114	51	F	139	56	F						
115	64	M	140	55	F						
116	47	F	141	63	F						
117	55	M	142	66	F						
118	65	F	143	65	F						
119	54	F	144	56	F						
120	64	F	145	52	F						
121	55	M	146	58	F						
122	59	F	147	70	M						
123	57	F	148	65	F						
124	54	F	149	51	F						
125	54	M	150	56	F						

Gilt Darter

Collection Date 05/21/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date: 05/21/02
Release Site Pigeon River, Tannery Island
Release Date: 05/21/02
VIE- Orange

Length Sex			Length Sex			Length Sex			Length Sex		
1	55	M	26	65	M	51	64	F	76	75	M
2	69	F	27	64	M	52	56	F	77	75	M
3	56	F	28	64	M	53	60	F	78	55	F
4	67	F	29	59	M	54	65	F	79	76	M
5	67	F	30	51	F	55	55	M	80	54	M
6	65	F	31	52	M	56	58	M	81	69	M
7	64	M	32	64	M	57	64	M	82	58	M
8	57	M	33	57	M	58	55	M	83	61	M
9	55	M	34	52	M	59	61	M	84	60	M
10	43	F	35	65	F	60	52	F	85	56	M
11	54	F	36	58	M	61	64	M	86	68	F
12	52	F	37	61	F	62	60	F	87	49	M
13	56	M	38	54	F	63	51	M	88	58	F
14	55	F	39	55	F	64	49	M	89	64	M
15	57	M	40	61	M	65	59	F	90	66	M
16	54	F	41	81	M	66	50	M	91	62	M
17	65	M	42	56	M	67	56	M	92	52	F
18	53	M	43	70	M	68	59	F	93	69	M
19	63	M	44	54	F	69	54	M	94	64	M
20	53	M	45	57	F	70	54	F	95	54	F
21	60	M	46	55	M	71	51	F	96	56	F
22	41	M	47	55	F	72	58	M	97	56	F
23	55	M	48	66	F	73	55	M	98	64	F
24	50	M	49	68	M	74	53	F	99	57	M
25	65	M	50	62	M	75	58	M	100	59	M

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1030	12.9°C	--	11.30	0

NOTE Collected one tagged redline

Gilt Darter

Collection Date 05/28/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 05/28/02
Release Site Pigeon River, Tannery Island
Release Date 05/28/02
VIE: Orange

Length			Sex	Length			Sex	Length			Sex	Length			Sex
1	71	M		26	65	F		51	57	F		76	61	F	
2	62	M		27	66	M		52	55	F		77	58	M	
3	56	F		28	74	M		53	64	M		78	67	M	
4	61	F		29	56	F		54	55	F		79	52	F	
5	74	M		30	72	M		55	55	F		80	64	M	
6	60	F		31	61	F		56	56	M		81	57	F	
7	75	F		32	61	M		57	59	M		82	53	F	
8	73	M		33	50	F		58	55	F		83	57	M	
9	65	F		34	59	F		59	67	M		84	68	F	
10	49	F		35	55	F		60	62	F		85	55	F	
11	55	F		36	64	F		61	59	M		86	67	M	
12	62	M		37	55	F		62	61	M		87	64	F	
13	62	M		38	64	F		63	56	F		88	54	F	
14	54	F		39	66	M		64	64	M		89	52	F	
15	51	F		40	52	F		65	55	F		90	57	F	
16	55	F		41	55	F		66	55	F		91	66	M	
17	59	M		42	58	M		67	56	M		92	69	M	
18	65	M		43	55	F		68	55	F		93	56	M	
19	53	F		44	52	F		69	53	F		94	71	M	
20	63	F		45	46	F		70	60	F		95	60	F	
21	59	M		46	65	M		71	64	F		96	62	F	
22	66	M		47	57	F		72	63	M		97	52	F	
23	62	F		48	60	M		73	65	F		98	63	F	
24	56	F		49	63	F		74	59	F		99	50	F	
25	63	M		50	52	M		75	52	M		100	59	M	

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1000	18 7°C	--	10 14	3 (F/Juv)
Little Pigeon	1100	19 5°C			

NOTE Collected 3 tagged redlines

Gilt Darter

Collection Date: 05/28/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 05/28/02
Release Site: Pigeon River, Tannery Island
Release Date: 05/28/02
VIE: Orange

Length Sex			Length Sex			Length Sex			Length Sex		
101	52	M	126	55	F						
102	54	F	127	49	F						
103	63	F	128	59	M						
104	74	M	129	53	F						
105	53	F	130	70	M						
106	56	F	131	65	F						
107	61	M	132	56	F						
108	53	F	133	60	F						
109	56	M	134	53	F						
110	54	F	135	66	F						
111	68	F	136	55	M						
112	80	M	137	61	F						
113	61	F	138	67	M						
114	60	F	139	60	F						
115	52	F									
116	52	F									
117	71	M									
118	64	M									
119	58	F									
120	56	F									
121	52	F									
122	63	M									
123	61	M									
124	60	M									
125	57	M									

Bluebreast Darter

Collection Date: 8/28/02
Collection Site: Bewley's Island RM-28 Nolichucky
Tagging Date: 8/28/02
Release Site: Pigeon River, Tannery Island
Release Date: 8/28/02
VIE: Pink

Length			Sex	Length			Sex	Length			Sex	Length			Sex
1	72	M		26	70	M		51	65	M		76	58	M	
2	65	F		27	61	M		52	58	F		77	66	M	
3	71	M		28	60	M		53	53	F		78	59	M	
4	56	F		29	52	F		54	40	F		79	61	F	
5	57	M		30	63	M		55	67	M		80	41	F	
6	71	M		31	46	F		56	61	F		81	71	M	
7	61	M		32	45	F		57	57	M		82	67	M	
8	61	M		33	43	M		58	72	M		83	56	F	
9	55	M		34	73	M		59	53	M		84	40	F	
10	76	M		35	63	M		60	47	M		85	60	F	
11	65	M		36	57	F		61	66	M		86	39	F	
12	71	F		37	43	M		62	55	F		87	65	M	
13	73	M		38	59	M		63	47	M		88			
14	72	M		39	57	M		64	59	M		89			
15	46	F		40	59	F		65	54	M		90			
16	47	F		41	62	M		66	37	F		91			
17	55	M		42	39	M		67	31	F		92			
18	72	M		43	52	F		68	63	M		93			
19	60	M		44	56	F		69	59	M		94			
20	65	M		45	55	M		70	68	M		95			
21	71	M		46	63	M		71	75	M		96			
22	73	M		47	73	M		72	72	M		97			
23	67	M		48	54	M		73	56	M		98			
24	46	F		49	68	M		74	79	M		99			
25	70	M		50	79	M		75	65	M		100			

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Bewley's Island	1115	26.0°C	--	7.60	1 (M)

Gilt Darter

Collection Date: 8/28/02
Collection Site: Bewley's Island RM-28 Nolichucky
Tagging Date: 8/28/02
Release Site: Pigeon River, Tannery Island
Release Date: 8/28/02
VIE: Pink

Length Sex			Length Sex			Length Sex			Length Sex		
1	62	M	26	52	F	51			76		
2	60	M	27	51	M	52			77		
3	61	M	28	61	F	53			78		
4	56	F	29	65	M	54			79		
5	65	M	30			55			80		
6	59	F	31			56			81		
7	64	F	32			57			82		
8	77	M	33			58			83		
9	70	F	34			59			84		
10	60	F	35			60			85		
11	64	F	36			61			86		
12	66	M	37			62			87		
13	52	F	38			63			88		
14	60	F	39			64			89		
15	54	F	40			65			90		
16	62	M	41			66			91		
17	79	M	42			67			92		
18	60	F	43			68			93		
19	64	F	44			69			94		
20	54	F	45			70			95		
21	55	F	46			71			96		
22	52	F	47			72			97		
23	69	M	48			73			98		
24	51	F	49			74			99		
25	60	M	50			75			100		

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Bewley's Island	1115	26.0°C	--	7.60	1 (non-tagging) 1 (F/Juv)

Gilt Darter

Collection Date. 10/23/02
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 10/23/02
Release Site Pigeon River, Tannery Island
Release Date 10/23/02
VIE Pink

Length		Sex	Length		Sex	Length		Sex	Length		Sex
1	51	M	26	72	M	51	65	M	76	54	M
2	64	M	27	55	F	52	61	M	77	61	M
3	55	M	28	62	F	53	65	M	78	55	M
4	52	F	29	70	M	54	59	M	79	65	M
5	65	M	30	50	F	55	54	M	80	45	F
6	59	F	31	44	F	56	62	M	81	70	M
7	69	M	32	52	M	57	60	M	82	64	F
8	64	M	33	55	F	58	57	M	83	53	F
9	65	F	34	47	F	59	53	M	84	67	M
10	62	F	35	56	F	60	61	M	85	62	F
11	50	F	36	52	F	61	66	M	86	71	M
12	66	M	37	57	M	62	70	M	87	57	M
13	60	M	38	51	F	63	49	F	88	52	F
14	70	M	39	48	F	64	55	M	89	51	F
15	59	M	40	43	F	65	61	M	90	62	M
16	60	F	41	62	M	66	60	M	91	65	M
17	71	M	42	44	F	67	61	M	92	59	F
18	65	F	43	48	M	68	70	M	93	56	F
19	59	F	44	49	M	69	63	M	94	56	F
20	64	F	45	64	M	70	64	F	95	52	F
21	48	F	46	65	M	71	55	M	96	49	F
22	52	M	47	51	F	72	52	M	97	61	F
23	56	F	48	58	M	73	71	M	98	63	F
24	65	M	49	50	M	74	62	F	99	64	F
25	71	M	50	45	F	75	64	M	100	52	F

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	1130	15.4°C	--	11.30	0

NOTE Collected 3 tagged redlines, 2 grn and 1 ylw

Gilt Darter

Collection Date: 10/23/02
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 10/23/02
Release Site: Pigeon River, Tannery Island
Release Date: 10/23/02
VIE: Pink

Length	Sex	Length	Sex	Length	Sex	Length	Sex
101	66	F	126	62	M	151	
102	49	F	127			152	
103	66	M	128			153	
104	50	F	129			154	
105	57	F	130			155	
106	55	F	131			156	
107	50	F	132			157	
108	55	M	133			158	
109	58	M	134			159	
110	54	M	135			160	
111	63	F	136			161	
112	55	F	137			162	
113	70	M	138			163	
114	69	M	139			164	
115	53	F	140			165	
116	64	M	141			166	
117	49	F	142			167	
118	53	F	143			168	
119	74	M	144			169	
120	52	F	145			170	
121	76	M	146			171	
122	48	F	147			172	
123	69	M	148			173	
124	54	F	149			174	
125	53	F	150			175	
							176
							177
							178
							179
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							196
							197
							198
							199
							200

Blueside Darter

Collection Date 3/13/03
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 3/13/03
Release Site Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date 3/13/03
VIE Red

Length		Sex	Length		Sex	Length		Sex	Length		Sex
1	59	M	26	65	F	51	58	M	76	48	F
2	75	M	27	73	M	52	76	M	77	55	M
3	53	F	28	60	M	53	50	F	78	50	F
4	57	M	29	52	M	54	57	F	79	49	F
5	71	M	30	54	M	55	57	M	80	74	M
6	71	M	31	70	M	56	50	F	81	59	M
7	52	M	32	49	F	57	59	M	82	57	M
8	53	M	33	64	F	58	60	M	83	54	M
9	50	M	34	74	M	59	55	M	84	51	M
10	58	M	35	59	M	60	69	M	85	56	M
11	53	M	36	64	F	61	63	F	86	48	M
12	59	M	37	56	F	62	74	M	87	59	M
13	46	F	38	49	F	63	49	F	88	62	F
14	60	M	39	74	M	64	55	M	89	55	M
15	50	F	40	67	F	65	45	F	90	61	F
16	54	M	41	62	M	66	61	F	91	51	M
17	52	M	42	57	M	67	71	M	92	54	M
18	54	M	43	59	M	68	55	M	93	44	F
19	46	F	44	71	M	69	55	M	94	45	F
20	65	F	45	59	F	70	72	M	95	59	M
21	49	F	46	69	M	71	50	F	96	46	F
22	58	M	47	57	M	72	44	F	97	60	F
23	68	M	48	60	M	73	52	M	98	54	M
24	49	F	49	52	M	74	49	F	99	60	F
25	58	M	50	65	F	75	52	M	100	47	F

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	0930	11 1°C	-	13 30	0
Bag	1540	16 4°C			
Pigeon	1606	12 1°C			

Blueside Darter

Collection Date 3/13/03
Collection Site Confluence of West Prong and Little Pigeon River
Tagging Date 3/13/03
Release Site: Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date 3/13/03
VIE Red

Length Sex			Length Sex			Length Sex			Length Sex		
1	59	M	26	65	F	51	58	M	76	48	F
2	75	M	27	73	M	52	76	M	77	55	M
3	53	F	28	60	M	53	50	F	78	50	F
4	57	M	29	52	M	54	57	F	79	49	F
5	71	M	30	54	M	55	57	M	80	74	M
6	71	M	31	70	M	56	50	F	81	59	M
7	52	M	32	49	F	57	59	M	82	57	M
8	53	M	33	64	F	58	60	M	83	54	M
9	50	M	34	74	M	59	55	M	84	51	M
10	58	M	35	59	M	60	69	M	85	56	M
11	53	M	36	64	F	61	63	F	86	48	M
12	59	M	37	56	F	62	74	M	87	59	M
13	46	F	38	49	F	63	49	F	88	62	F
14	60	M	39	74	M	64	55	M	89	55	M
15	50	F	40	67	F	65	45	F	90	61	F
16	54	M	41	62	M	66	61	F	91	51	M
17	52	M	42	57	M	67	71	M	92	54	M
18	54	M	43	59	M	68	55	M	93	44	F
19	46	F	44	71	M	69	55	M	94	45	F
20	65	F	45	59	F	70	72	M	95	59	M
21	49	F	46	69	M	71	50	F	96	46	F
22	58	M	47	57	M	72	44	F	97	60	F
23	68	M	48	60	M	73	52	M	98	54	M
24	49	F	49	52	M	74	49	F	99	60	F
25	58	M	50	65	F	75	52	M	100	47	F

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	0930	11 1°C	-	13 30	0
Bag	1540	16 4°C			
Pigeon	1606	12 1°C			

Blueside Darter

Collection Date:	3/13/03
Collection Site:	Confluence of West Prong and Little Pigeon River
Tagging Date:	3/13/03
Release Site:	Pigeon River, Newport, 200m below Hwy 321 Bridge
Release Date:	3/13/03
VIE:	Red

[illegible]

Gilt Darter

Collection Date: 3/13/03
Collection Site: Confluence of West Prong and Little Pigeon River
Tagging Date: 3/13/03
Release Site: Pigeon River, Tannery Island
Release Date: 3/13/03
VIE. Red

Length Sex			Length Sex			Length Sex			Length Sex		
1	65	M	26	49	F	51	64	M			
2	64	M	27	62	M	52	62	M			
3	55	F	28	53	F	53	62	M			
4	64	F	29	54	F	54	52	F			
5	56	F	30	65	F	55	49	F			
6	57	M	31	71	M	56	52	F			
7	65	M	32	64	F	57	57	F			
8	65	M	33	58	F	58	58	F			
9	60	M	34	65	M	59	57	M			
10	57	M	35	56	F	60	55	F			
11	62	F	36	58	F	61	46	F			
12	55	F	37	62	F						
13	59	M	38	60	M						
14	61	F	39	58	M						
15	62	F	40	50	F						
16	50	F	41	54	F						
17	60	M	42	57	F						
18	54	F	43	65	M						
19	64	M	44	63	F						
20	55	F	45	56	F						
21	50	F	46	62	M						
22	65	M	47	55	F						
23	59	F	48	53	F						
24	59	M	49	60	M						
25	60	M	50	49	F						

<u>Location</u>	<u>Time</u>	<u>Temp</u>	<u>pH</u>	<u>DO</u>	<u>Mortality</u>
Little Pigeon	0930	11.1°C		13.30	0

Vita

Joyce A. Coombs was born in Washington, D.C. on February 6, 1951. Growing up as a member of a military family, she lived and traveled throughout the United States.

She began her college career at James Madison University, Harrisonburg, VA, receiving a Bachelor of Science in Biology with a minor in chemistry in 1974. After college, she served in the United States Coast Guard as a Pollution Prevention and Control Officer at the rank of Lieutenant. Later, as a Fisheries Biologist, she worked for the Washington State Department of Fisheries and Wildlife, conducting stream surveys and port samplings.

In 1996, she returned to school and received an Associate of Applied Science degree in Environmental Science Technology from Pamlico Community College, Grantsboro, NC.

In January 2001, she enrolled in the Department of Forestry, Wildlife, and Fisheries at the University of Tennessee. She was awarded a Master of Science degree in Wildlife and Fisheries Science in May 2003.