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A Repeatable, Visual Survey of Three Rare *Percina* (Osteichthyes: Percidae) Fish in Little River, Blount County, Tennessee

Charles H. Heacock
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Charles H. Heacock entitled "A Repeatable, Visual Survey of Three Rare *Percina* (Osteichthyes: Percidae) Fish in Little River, Blount County, Tennessee." I have examined the final electronic 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 Animal Science.

David A. Etnier, Major Professor

We have read this thesis and recommend its acceptance:

Dewey Bunting, J. Larry Wilson

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Dr. Dewey L. Bunting II

Dr. J. Larry Wilson

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

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Date 21 July 1995

A REPEATABLE, VISUAL SURVEY OF THREE RARE *PERCINA* (OSTEICHTHYES: PERCIDAE) FISH IN LITTLE RIVER, BLOUNT COUNTY, TENNESSEE

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

Charles H. Heacock
August 1995

DEDICATION

To my parents, William Bell (deceased) and Mary Elizabeth, for their unanimous support, encouragement, and love.

ACKNOWLEDGEMENTS

A sincere thank you to Dr. David A. Etnier, who exemplified the meaning of teacher. As my major professor and committee chairman, Ets shared his knowledge and always had the time to answer a question. Special recognition and appreciation is directed to my other committee members, Dr. Dewey L. Bunting II and Dr. J. Larry Wilson. Dr. Wilson was my undergraduate advisor and I made Dr. Bunting's acquaintance during the same time period. Both gentlemen are excellent teachers.

I would like to thank my fellow graduate students, David J. Eisenhour, Stan Z. Guffey, and Dr. Mark H. Hughes, for their interest in fish and assistance with my research. I would also like to thank my peers, John T. "Bo" Baxter and Chris E. Skelton for their assistance with high tech computer programs and problems. In addition, I extend my gratitude to the numerous individuals who provided information from their collection records in order to complete Appendix F.

Finally, I would like to express my appreciation to the following people, who live along Little River, for their generosity in granting permission to access the river. Hopefully, their interest and appreciation for the aquatic environment will become contagious. It is recommended that any visitors make a courtesy call (phone number indicated) to announce your presence before snorkeling.

Site 2: Jerry and Pat Ringler, Mountaineer Campground, 615) 448-6421

Site 3: Michele Messinger, Strawberry Patch Inn, (615) 448-6306

Site 12: Earl Ailor, Sr., (615) Home 984-9080 Cabin 977-9596

Site 18: "River John" Molish, (615) 982-0793

Site 19: Mr. C. L. Trundle, (615) 983-7711 (son-Dale)

ABSTRACT

A recent apparent decline of darter species in Little River, Blount County, Tennessee, suggested a deterioration in habitat quality was taking place. The objective of this study was to establish a baseline of the abundance and distribution of three large and easily recognized darter species (Percina aurantiaca, P. burtoni, and P. macrocephala) believed to be very pollution intolerant.

The study area included 27 river miles with 20 accessible sites which were determined by an area reconnaissance. Each site has been described, including diagrams and photographs, and was surveyed six times between July and October 1993. A review of published accounts of the darters' habitats are presented along with observations of the unique type of stream habitat utilized by each darter.

This visual study was set up to be repeatable, using site and habitat descriptions, for future monitoring of the fish populations. The baseline of abundance included adults and young-of-the-year of the three species. The number of fish sightings was compiled from the 120 observations conducted during the 6 surveys at each site. Additional information included sightings of fish observed in areas adjacent to the survey sites. Finally, a comparison was made between the 1993 study and a survey following a historical flood in 1994.

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CHAPTER 1

INTRODUCTION

A visual survey of three rare Percina (Osteichthyes: Percidae) species was completed from June to October 1993. The fish in the study included the tangerine darter, Percina aurantiaca (Cope), the blotchside logperch, P. burtoni Fowler, and the longhead darter, P. macrocephala (Cope). The purpose of this study was to establish a baseline of abundance for the fish and to adequately describe methodology to make the survey repeatable in the future.

The study area comprised 20 sites distributed along 26.7 miles of Little River in Blount County, Tennessee. The river, from the headwaters to the mouth, has supported a rich diversity of aquatic organisms, including approximately 90 fish taxa. In recent years, an apparent decrease in the numbers of some of the fish suggested a decline in the water quality of this river.

A drastic decrease in several darter species in the much-studied area at the U.S. 411 bridge has been commented on (D. A. Etnier, pers. comm.). He noted that P. aurantiaca and P. macrocephala were not seen in this area in four seining collections in 1992. He also stated that P. burtoni has not been collected from there for many years. Other

researchers (Charles Saylor, Tennessee Valley Authority; Steve Moore, Great Smoky Mountains National Park) agreed with Etnier in suspecting that the three darters may be declining.

Underwater observation, while snorkeling, was chosen as the method for this study, since it required a minimum expense in equipment, and it was felt that a non-lethal method of collecting information was necessary because of the rarity of the three species.

A snorkeling reconnaissance was conducted to find where each darter occurred in Little River and to locate appropriate study sites. Preliminary information on the habitat of the three darters was based on published accounts.

The habitat for P. aurantiaca was described by Etnier and Starnes (1993) as being in pools (below riffles) with a 2-3 foot depth and a substrate of boulders and bedrock. They noted that the fish inhabited riffles and chutes with swift to torrential currents at 2.5-4.5 feet depths. They also included flat gravel areas below riffles, near water willow beds, and near bridges. Page (1983) agreed with Etnier and Starnes, adding that males can be found in swift, deep, rocky riffles and that females can be found in pools below riffles. Kuehne and Barbour (1983) defined the river habitat as having moderate to steep gradients. They noted that the fish were located in deep currents with

torrential flows, and in spring, adult fish were observed at intermediate depths downstream from chutes and rapids. They found juveniles in shallow, comparatively quiet areas marginal to the main channel, and stated that the fish preferred sites without siltation and forms of domestic or industrial pollution.

The habitat for P. burtoni was described by Etnier and Starnes (1993) as being over fine to medium gravel substrates with depths averaging 2 feet. They noted the fish preferred swift but not torrential currents. The authors stated that the fish can also be located near islands, bridges, and mouths of small creeks. Page (1983) added that the fish are found in swift streams, usually over gravel in water of 1.6-3.3 foot depth. He stated they were also in riffles and in transition zones (Howell, 1971) between riffles and pools. Kuehne and Barbour (1983) mentioned large creeks and upland rivers with strong currents. They noted the fish inhabited clean gravel in the lower portion of strong riffles at a 1.6 foot depth.

The habitat for P. macrocephala, as described by Etnier and Starnes (1993), was in substrates with silt-covered coarse gravel or boulders. The authors noted the fish were found in gentle currents with a 3 foot average depth. Page (1983) added that the habitat consisted of clear, moderate sized rivers with steep gradients. He stated the fish are found in pools with a current, above

and below riffles. Kuehne and Barbour (1983) described the habitat as a variety of clean substrates varying from weed beds to exposed bedrock. They noted the fish inhabited depths from 1.6-3.3 feet in steady currents above and below riffles. In addition, the authors mentioned the fish were found in pools or chutes of moderate sized streams with moderate gradients.

CHAPTER 2

METHODS AND MATERIALS

METHODS

A 10-day reconnaissance was conducted between 8 June and 20 July 1993 (Table 1). A 26.7 river mile area was surveyed to select 20 riffle/pool sites (Figure 1) for the later visual surveys. Six sites were located at bridges, nine were at recreational roadside pull-offs (two were at a post office and a dam), and five were located behind private property. During the reconnaissance, a total of 39 hours and 45 minutes was spent searching for the three Percina species (Figures 2, 3, and 4). The amount of effort at a single site ranged from 30 minutes to 4 hours.

Data was collected at each of the 20 sites during the 6 surveys for a total of 120 observations. The time of day for each of the individual observations varied (Appendix A). The information recorded at each site included the following:

1. date
2. Secchi disk reading
3. observation start and stop time
4. number of survey species observed
5. age group--adult or young-of-the-year

Table 1. Survey completion dates for three *Percina* species in Little River, Blount County, Tennessee, 1993. Data include the dates and flow rates (cubic feet per second). Surveys 1-6 and the reconnaissance (R) are blocked and numbered.

Date Month	Day	Flow rate	Date Month	Day	Flow rate	Date Month	Day	Flow rate
June	8	275	July	14	84	Aug.	18	112
	9	275		15	67		19	77
R	10	243		16	243		20	126
	11	222		17	118		21	154
	12	208		18	95		22	92
	13	212	1	19	80		23	72
	14	212		20	71		24	68
	15	431	R	20	71		25	60
	16	232	2	21	69		26	77
	17	178		22	63		27	323
	18	170		23	56	4	28	99
R	19	166		24	50		29	72
	20	162		25	54		30	87
	21	151	3	26	63		31	60
	22	162		27	52	4	1	60
	23	147		28	46	Sept.	2	60
R	24	136		29	45		3	84
	25	125		30	39		4	102
	26	123		31	36		5	196
	27	118	Aug.	1	33		6	112
	28	108		2	34		7	77
	29	113		3	39		8	65
	30	118		4	123		9	147
July	1	147		5	108		10	82
	2	186		6	133		11	63
	3	108		7	337		12	48
	4	108		8	170	5	13	48
	5	88		9	113		14	48
R	6	91		10	93		15	42
	7	84		11	84		16	48
	8	73		12	77		17	126
	9	73		13	217		18	96
	10	147		14	170		19	63
	11	82		15	108		20	48
	12	75		16	92		21	52
1	13	67		17	80		22	60

Table 1. (continued)

Date Month	Day	Flow rate	Date Month	Day	Flow rate	Date Month	Day	Flow rate
Sept.	23	48	Sept.	29	87	6	5	38
	24	68		30	63	Oct.	6	38
	25	58	Oct.	1	56		7	34
6	26	65		2	48		8	36
	27	105		3	44	6	9	29
6	28	147		4	38			

Figure 1. Map of the study sites in Little River, Blount County, Tennessee. The river's location in Tennessee is in the inset.

Source: Adapted from Stiles, R. A. 1972. The comparative ecology of three species of Nothonotus (Percidae: Etheostoma) in Tennessee's Little River. Ph.D. Dissert., Univ. Tenn., 97 p.

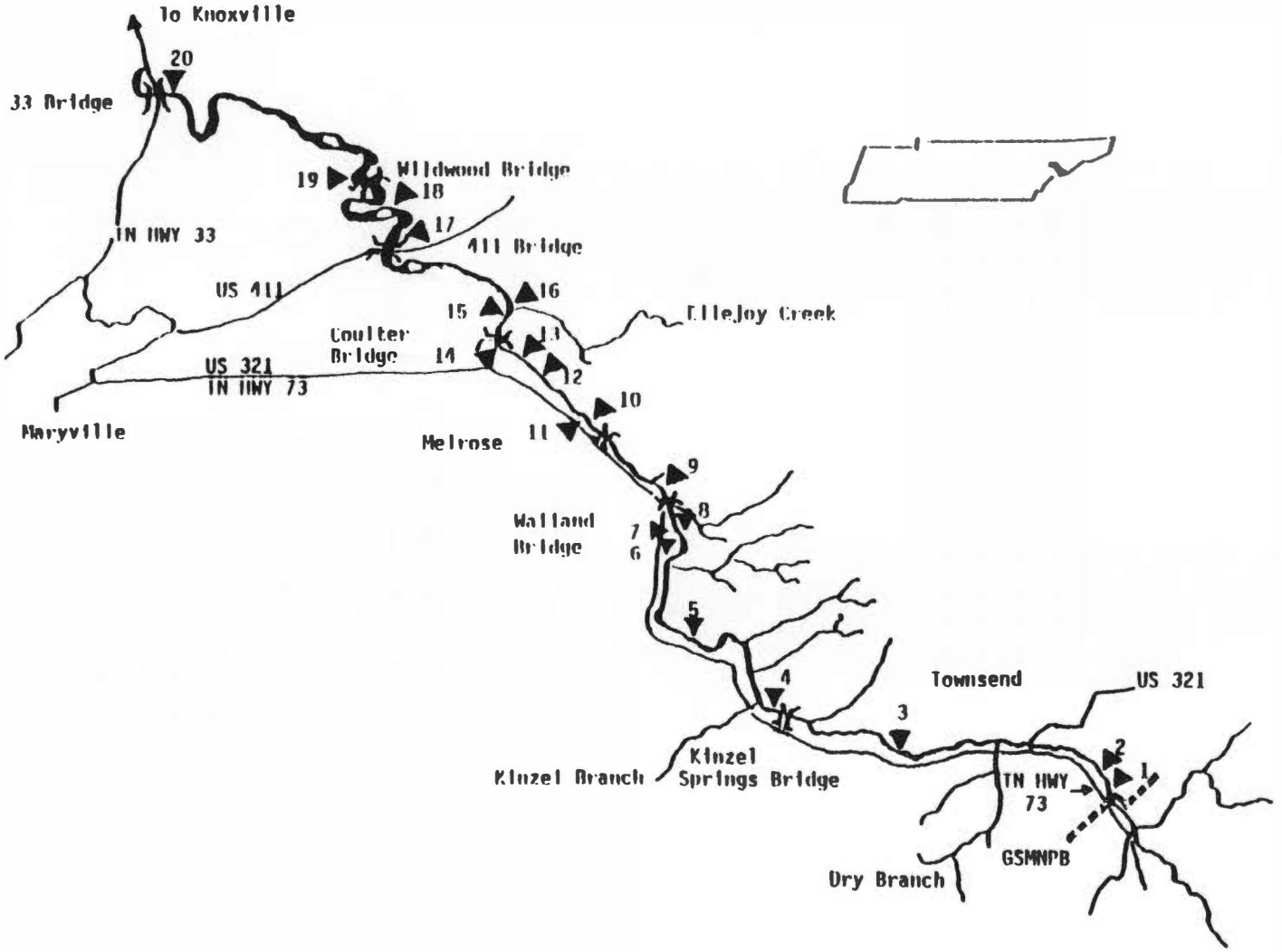

To Knoxville
20
33 Bridge
19
Wildwood Bridge
18
17
IN HWY 33
411 Bridge
US 411
16
15
Coulter
Bridge
14
13
12
10
US 321
IN HWY 73
Maryville
Melrose
11
9
8
Walland
Bridge
7
6
5
4
3
Townsend
US 321
2
1
Kinzel
Springs Bridge
Kinzel Branch
TN HWY
73
GSMNPB
Dry Branch

Figure 2. The tangerine darter, Percina aurantiaca.

Source: Richard T. Bryant

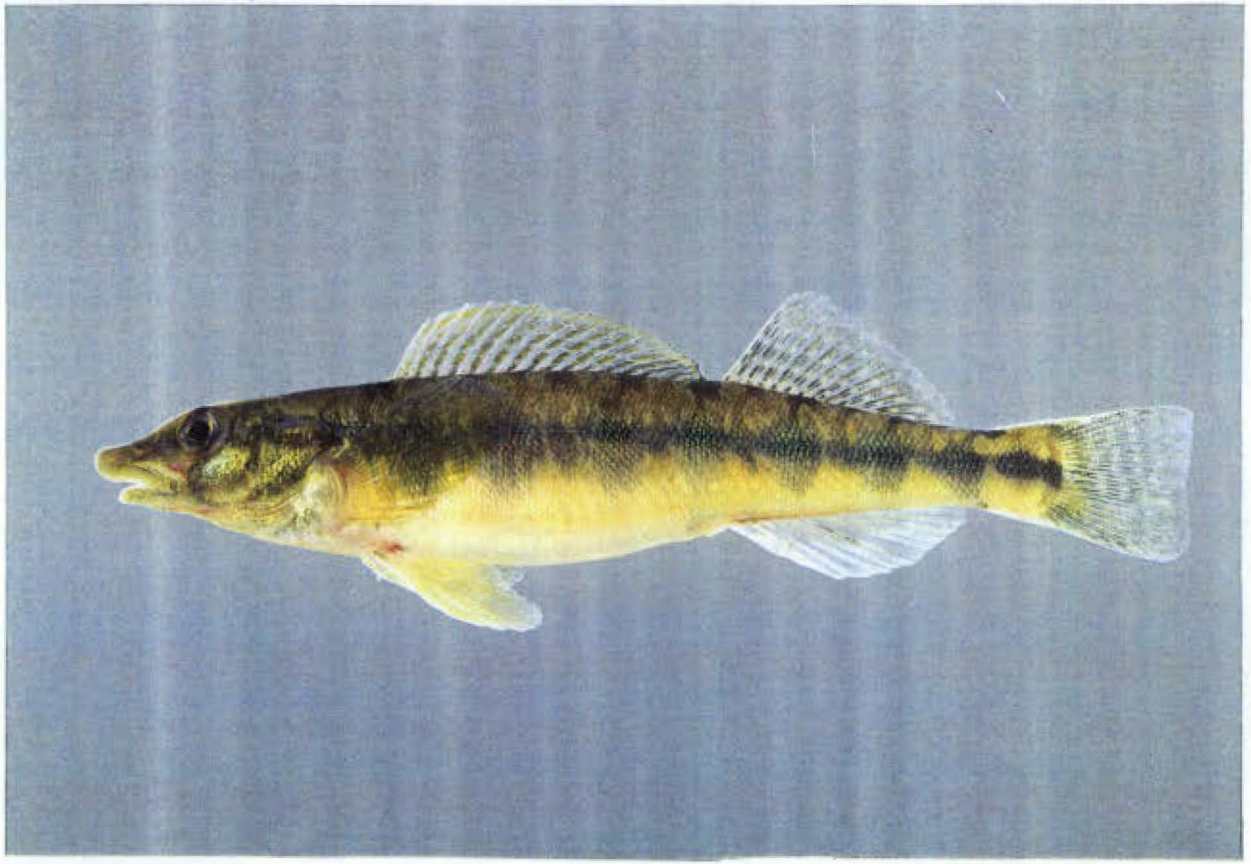


Figure 3. The blotchside logperch, Percina burtoni.

Source: Richard T. Bryant

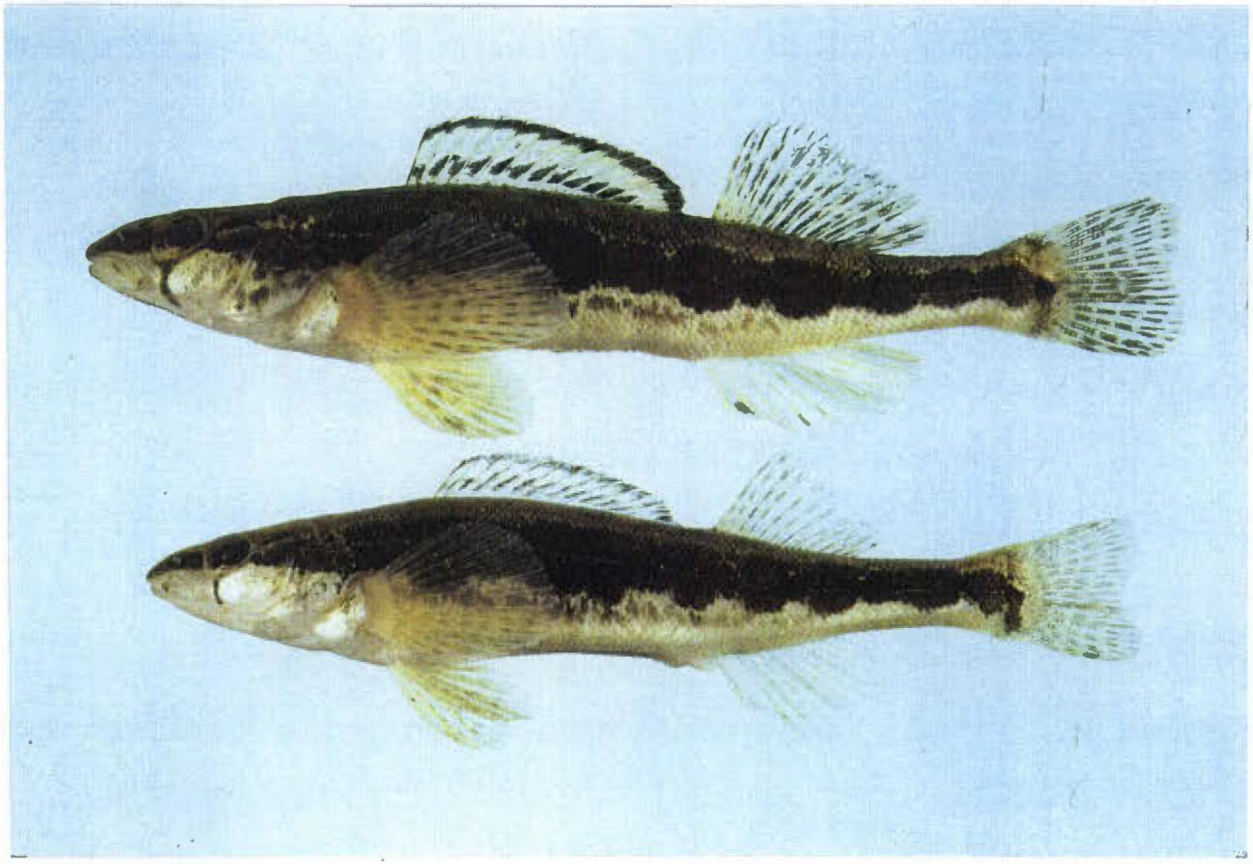


Figure 4. The longhead darter, Percina macrocephala.

Source: Richard T. Bryant

6. activity

7. habitat

8. substrate

A standard observation procedure was set up for snorkeling at each of the 20 sites. A Secchi disk reading was taken to measure underwater visibility. The measurement was obtained by placing the disk 1 foot off the bottom (on a stand), perpendicular to the current, and then drifting downstream until the disk's pattern was barely visible. The distance (recorded in feet) to the disk represented the Secchi disk reading, and its value reflected the range of underwater visibility. A reading of less than 5 feet limited the range of observation, and readings above 12 feet resulted in excellent viewing conditions.

The Secchi disk reading (Table 2) and the pool area (Table 3) of each site were used to determine the number of transects per pool. A transect was the single upstream or downstream observational pass between the riffle and the pool area. For example, with a Secchi disk number of 10 a fish could be recognized at 5 feet. Therefore, the observation area of one transect line included five feet on either side of this line. A total of five transects would be required with a Secchi disk reading of 10 and a pool area width of 50 feet.

The extension of the transect into the pool area was determined by the substrate and the sighting of the study

Table 2. Secchi disk readings. Readings were recorded in feet for each site during the 6 surveys in Little River, Blount County, Tennessee.

Survey Site	1	2	3	4	5	6	Mean
1	12.0	12.0	12.0	12.0	14.0	12.0	12.3
2	11.0	11.0	13.0	14.0	15.0	20.0	14.0
3	11.0	10.0	12.0	8.0	15.0	14.0	11.7
4	11.0	9.0	7.0	12.0	18.0	9.0	11.0
5	9.0	9.0	8.0	10.0	18.0	12.0	11.0
6	10.0	11.5	8.0	7.5	12.0	9.0	9.7
7	11.0	12.8	7.5	7.0	11.0	7.5	9.5
8	11.0	12.0	8.0	9.0	13.0	7.5	10.1
9	8.0	12.0	7.8	9.0	12.0	7.5	9.4
10	9.0	9.0	7.5	7.5	12.0	7.5	8.8
11	6.0	7.5	10.0	7.5	10.5	7.5	8.2
12	8.0	8.8	8.3	9.0	11.0	9.0	9.0
13	5.0	9.0	9.0	7.5	10.0	10.0	8.4
14	7.0	10.0	7.0	6.0	9.0	10.0	8.2
15	6.0	6.8	6.5	6.0	7.5	10.0	7.1
16	6.0	7.5	6.0	6.0	7.5	10.0	7.2
17	4.0	4.8	3.8	2.5	4.0	6.0	4.2
18	4.0	5.5	4.5	2.5	4.0	3.0	3.9
19	3.0	3.0	3.0	2.5	4.0	7.0	3.8
20	3.0	3.0	3.0	2.5	4.0	3.0	3.1

Table 3. Area of individual sites in Little River, Blount County, Tennessee. Data include the areas, in square feet, for upper and lower pools, single pools, and the total area.

Site	Upper pool	Lower pool	Single pool	Total area
1			2912	2912
2	4248	5130		9378
3			2980	2980
4			5470	5470
5			1827	1827
6	2726	3864		6590
7	3570	2520		6090
8			2900	2900
9	3360	960		4320
10			3200	3200
11			1600	1600
12	6000	2961		8961
13			3105	3105
14			3120	3120
15	4356	1968		6324
16	1140	3658		
16		2655		7453
17	2925	200		
17		2848		
17		300		6273
18			4012	4012
19	2400	1860		4260
20			1991	1991

species. The pool area, above and below the riffle, is defined as the tail and head of adjoining upstream and downstream pools (Ensign et al., 1993). The transect ended when the substrate contained round, flat rocks embedded in silt, and a pool depth of 3 to 4 feet. Darters were usually observed within 100 feet above and below the riffle. The entire pool area was not surveyed to observe a few additional fish.

Heavy rains, potentially affecting viewing conditions in the river, could be determined by telephoning the TVA Lake Information line in Knoxville (632-2264). Daily flow rates (cubic feet per second) were given for the river (Table 1). An increase in the rate indicated rain with a decrease in visibility due to siltation. After two days, the settling of the silt typically allowed the surveys to be completed.

MATERIALS

The equipment used included the following: the Secchi disk, a wet suit, the writing cuff, and a mask and snorkel. The University of Tennessee Zoology Department donated the Secchi disk and the wet suit. The writing cuff was built by the U.T. Biology Services Facility. The author provided the remainder of equipment.

Data was recorded on a writing cuff made of white

polyvinylchloride (PVC) pipe. The dimensions of the PVC pipe were 6 inches in length and 4 inches in diameter. The pipe was cut forming two equal halves (sleeves). Slots were cut in the four corners of the pipe where two velcro straps formed wrist bands. Small holes were placed in two corners, and two pencils were fastened with wire and tape. While snorkeling, data were recorded on the writing cuff at five or six sites and then permanently transferred into a field notebook. The data were washed off the PVC pipe with a sponge and cleanser.

A coat hanger was arranged into a L-shaped stand to support the Secchi disk 1 foot above the river bottom. The top of the hanger was used to secure the disk, and the angled bottom portion of the hanger was supported with a large rock.

CHAPTER 3

STUDY AREA AND SURVEY SITES

STUDY AREA

Little River extends 58 miles, northwestwardly, through the Blue Ridge and Ridge and Valley physiographic provinces. The headwaters are near Clingman's Dome (elevation 5,600 feet) in Sevier County, Tennessee (Table 4). The mouth (elevation 810 feet) empties into the Tennessee River (presently Ft. Loudon Reservoir) in Knox County, Tennessee. The watershed is 379 square miles (C. Rogers, TVA River System Operations, pers. comm.). The 20 sites, all located in Blount County, Tennessee, were chosen with a priority for easy access and equal spacing along the river. The study area started at the Great Smoky Mountains National Park Boundary (GSMNPB) on Tennessee Highway (TN Hwy.) 73, River Mile (RM) 35 (Table 4). The most downstream site was located at the TN Hwy. 33 bridge, RM 8.3.

The sites were selected from six 1953 topographic quadrangle maps (7.5 minute series, U.S. Geological Survey). The six maps (Fullerton, 1974) included the following: Thunderhead Mountain, 157 SW; Wear Cove, 157 NW; Kinzel Springs, 148 NE; Wildwood, 147 SE; Maryville, 147 SE; and Knoxville, 147 NW.

Table 4. River mile and elevation data for the 20 survey sites on Little River, Blount County, Tennessee. Site data include the river mile, the distance between sites (in river miles), and the (approximate) elevation in feet.

Site	River mile	Distance between sites	From to	Elevation (feet)
head-waters	58.0			5600
1	35.0			1150
2	34.4	0.6	1-2	1150
3	31.0	3.4	2-3	1025
4	29.0	2.0	3-4	1011
5	26.5	2.5	4-5	969
6	24.4	2.1	5-6	928
7	23.9	0.5	6-7	927
8	23.8	0.1	7-8	927
9	23.5	0.3	8-9	925
10	21.8	1.7	9-10	902
11	21.8	0.0	10-11	902
12	20.8	1.0	11-12	887
13	20.7	0.1	12-13	886
14	20.3	0.4	13-14	885
15	19.7	0.6	14-15	875
16	19.6	0.1	15-16	874
17	17.3	2.3	16-17	850
18	14.5	2.8	17-18	830
19	14.2	0.3	18-19	829
20	8.3	5.9	19-20	820
mouth	0.0			810

SURVEY SITES

The general area of a site consisted of an upper pool, a riffle, and a lower pool. Descriptions of the individual sites included the number of pools, substrate composition, and other descriptive features. The individual site area, in square feet, for the upper and lower pool or the single pool, and the total area, is shown in Table 3. There were nine sites that had an upper and lower pool, one site contained four pools, and the remaining 10 sites contained a single pool. Individual site diagrams are shown in Appendix B, the individual site photographs are provided in Appendix C, and the River Mile (RM) for each site is listed in Table 4. References to the left and right side of the river were determined by facing upstream.

Site 1, located at the GSMNPB, consisted of a single pool between two riffles, with a substrate of small to medium boulders and additional rocks. A run (chute) originated from the left side of the upper riffle to halfway into the pool. The lower riffle was built up with rocks, apparently set there by people in order to form the pool.

Site 2 was accessible from the Mountaineer Campground with the stipulation that a notification of presence is given. The survey area consisted of a diagonal riffle with upper and lower pools. The substrate of the pools included

silt, large boulders, and various size rocks. A deep run on the left side of the riffle extended through the lower pool area, which gradually exceeded 10 feet in depth.

Site 3 was accessible by walking through (permission required) the Strawberry Patch Inn property to the river. The upper pool was shallow and was not included in the survey. The lower pool gradually extended to a depth of 18 feet and had a run on the right side. Several large boulders and a transition zone of cobble were in the pool. Beds of water willow (Justicia) were located on the left side.

Site 4 was located at the Kinzel Springs Bridge and the access point, a concrete platform, is part of the Fair residence. The site area included a large pool extending from the bridge downstream to the water willow beds on the right side, just above the riffle. Bedrock dominated the substrate under and downstream from the bridge.

Site 5 was at a roadside picnic area and selected to fill in a gap between sites 4 and 6. This area of Little River is surrounded by steep, inaccessible banks and has few parking areas. Due to the constant use by swimmers during the summer, upper pool sightings in surveys 5 and 6 were not included in the survey data (Appendix D). The lower pool had a run through most of the area. The substrate consisted of numerous small to medium boulders and various size rocks.

Site 6 was the second downstream riffle/pool area below the swimming hole where Manning Road enters U.S. 321/TN Hwy. 73. No study species were observed in the pools at the first riffle. The upper pool substrate contained one large boulder, bedrock, and silt. The lower pool had a run on the right side, which flowed through the site area, and water willow beds on the left side. A transition zone, with cobble, occurred below the riffle.

Site 7 was located behind the Post Office in Walland, Tennessee. The upper pool consisted of water willow beds and cobble on the left, bedrock in the upper middle and right side, and large rocks covered with riverweed (Podostemum) throughout the pool. The lower pool had runs, with small boulders and other rocks, on the far left and right sides. Water willow beds were located in the middle and a transition zone was below the riffle.

Site 8, a single pool, was located downstream from the lower pool of site 7. The site area was under the center section of the old Walland Bridge. The bottom consisted of numerous cobbles, various other rocks, and silt.

Site 9 was below the new Walland Bridge and had a long riffle with small to large boulders and a definite gradient. The narrow upper pool site was on the right side and was separated from the main pool by a small island with water willow beds. The substrate contained various size rocks. The lower pool was in excess of 12 feet deep, and

the survey concentrated on the area with large boulders.

Site 10, a single narrow pool, was at the second riffle/pool area located below Peery's Mill dam. The pool area extended from the mouth to the small riffle at the upper end. It is surrounded by water willow beds on both sides and a stone wall on the right side. The substrate consisted mainly of silt and a few rocks, with gravel in and just below the riffle.

Site 11, a single pool, was 100 feet below site 10 and included the left half of the river. The left side had water willow beds, the upper end contained two small boulders, and the lower end had one large boulder. The substrate was mainly silt and various size rocks.

Site 12 is located behind a private residence. The upper pool had water willow beds on the left side, and the substrate consisted of bedrock and cobble. The lower pool had a run, flowing over bedrock on the right side. Water willow beds and a transition zone of cobble were on the left side.

Site 13 is 0.7 miles east of the Coulter Bridge (site 14) on the Old Walland Highway. A major landmark was a concrete water gauge tower between the road and the left bank. It was positioned at the lower end of this single pool. The area was below a riffle and covered the left side of the river. The substrate was mostly bedrock with varied depressions.

Site 14 is located at the Coulter Bridge and consisted of a single pool below the riffle. The pool area extended from the lower end of the riffle to the water willow beds on the right side. Most of the substrate on the right side was bedrock, and silt covered the left side. The pool continued under the bridge, exceeding 10 feet in depth.

Site 15 was above Ellejoy Creek and the recently completed bridge. The upper pool substrate consisted mainly of silt, with some rock. Water willow beds were on the left side of the upper and lower pools. The lower pool had a run on the right side with a bedrock substrate. The substrate in the middle of the lower pool was mixed with silt, cobble (transition zone), and various size rocks.

Site 16 was accessible by walking or snorkeling downstream towards Ellejoy Creek, which is heavily silted. The upper pool had a 37-foot-long submerged tree in the middle of the river, 100 feet above the riffle. The substrate consisted of silt and rock. The first area of the lower pool contained cobble (transition zone) below the left side of the riffle, which was next to the mouth of Ellejoy Creek. The second area's substrate consisted of silt and rocks, and the lower end had small to large boulders. The area between the two lower pool areas was heavily silted, and no study species were seen.

Site 17 is located at the U.S. 411 bridge and comprised four pool areas. The upper pool is located under

the right half of the bridge. The substrate contained small boulders, various size rocks, and silt. The first lower pool was below a large section of concrete pipe in the riffle. The substrate consisted of different size rocks and small boulders. The second lower pool, added during the third survey, was a pool area below the pipe and on the right side. Snorkeling efforts in the swift current below the pipe were directed to this pool area. The substrate consisted of silt, small boulders, and small areas with cobble. The third lower pool was downstream on the left side of the river near a section of wire fence and large boulders. The substrate included boulders and bedrock.

Site 18, behind a private residence and 0.3 RM above the Wildwood Bridge, was selected in order to survey the area between sites 17 and 19. The single pool area consisted of the right half of the river above the riffle, and the substrate consisted of bedrock. The lower right area had water willow beds.

Site 19, next to a private residence, was located at the Wildwood Bridge. Parking was permitted near the brick utility building. The upper pool was under the bridge. It had a substrate of small to large boulders and silt. The lower pool (above the riffle) was on the right side next to the water willow beds. It had a substrate of silt, cobble, and a few small boulders. There was a new subdivision nearby, and with any appreciable rainfall, heavy siltation

reduced water clarity to unworkable levels.

Site 20 was located above the TN Hwy. 33 bridge. The single pool area was across the river from the access area near Martin Mill Pike. Water willow beds were on the right side, and the substrate consisted of silt, cobble, and various size boulders. Visibility was constantly poor, making observations difficult.

CHAPTER 4

RESULTS

During the reconnaissance a total of 109 sightings was recorded (Appendix E). The sightings were all of adults and represented 83 tangerine darters, 21 blotchside logperch, and 5 longhead darters. The 120 observations for the 6 surveys resulted in a total of 816 sightings of the Percina species. The total included 709 adults (Table 5) and 107 young-of-the-year (Y.O.Y.) fish (Table 6). The total of adults is represented by 571 P. aurantiaca, 103 P. burtoni, and 35 P. macrocephala. The total of Y.O.Y. is represented by 67 P. aurantiaca, 34 P. burtoni, and 6 P. macrocephala. Individual site observations of adults of the three species during each survey are presented in Table 7; Y.O.Y. are recorded in Table 8.

ADULTS

A summary of the individual surveys showed an overall decrease in the number of adult sightings (Figure 5). The number of all adult fish sighted per survey ranged from 161 in survey 1 to 94 in survey 6 (Table 5). This decrease is especially noted for two of the three species. For P. aurantiaca there were 132 adults in survey 1 and only 76

Table 5. Total adult sightings for individual surveys. Data include the number of individual and all adult fish observed for each survey for 20 sites in Little River, Blount County, Tennessee. Data were compiled from Table 7. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Survey	Individual adult fish observed for 20 sites			All adult fish observed for 20 sites
	Pa	Pb	Pm	
1	132	24	5	161
2	107	22	6	135
3	97	15	6	118
4	78	18	7	103
5	81	12	5	98
6	76	12	6	94
Total	571	103	35	709

Table 6. Total Y.O.Y. sightings for individual surveys. Data include the number of individual and all Y.O.Y. (young-of-the-year) fish observed for each survey for 20 sites in Litte River, Blount County, Tennessee. Data were compiled from Table 8. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Survey	Individual Y.O.Y. fish observed for 20 sites			All Y.O.Y. fish observed for 20 sites
	Pa	Pb	Pm	
1	0	0	0	0
2	1	2	3	6
3	4	1	3	8
4	20	10	0	30
5	31	13	0	44
6	11	8	0	19
Total	67	34	6	107

Table 7. Sightings of three adult *Percina* species. Data include observations from the 20 sites during the 6 surveys in Little River, Blount County, Tennessee. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Survey	1			2			3			4			5			6		
Individual fish Site	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm
1	6	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
2	5	0	0	2	0	0	2	0	0	4	0	0	1	0	0	5	0	0
3	11	9	0	7	3	0	7	4	0	3	4	0	7	1	0	1	5	0
4	8	0	0	2	0	0	4	0	0	2	0	0	3	0	0	3	0	0
5	4	0	0	2	0	0	2	0	0	3	0	0	4	0	0	2	0	0
6	10	2	0	9	5	0	5	1	0	9	3	0	7	4	0	6	0	0
7	8	2	0	5	4	0	6	2	0	8	4	0	5	4	0	6	2	0
8	12	3	0	7	2	0	6	2	0	5	3	0	3	1	0	4	0	0
9	2	5	0	3	5	0	0	1	0	3	0	0	3	0	0	3	0	0
10	0	1	2	0	1	1	0	0	2	0	1	0	0	1	1	0	1	0
11	6	0	2	2	0	2	7	0	2	2	0	0	6	1	0	2	1	0
12	17	2	0	20	2	0	13	2	0	15	2	3	5	0	0	4	0	0
13	14	0	0	15	0	0	5	1	0	11	0	0	8	0	0	14	0	0
14	8	0	0	10	0	0	14	0	0	8	0	0	9	0	0	10	0	0
15	1	0	1	1	0	2	2	1	1	3	1	2	6	0	2	0	0	1
16	12	0	0	8	0	0	6	0	0	1	0	2	5	0	2	4	2	4
17	2	0	0	7	0	0	10	1	0	0	0	0	4	0	0	7	1	0
18	4	0	0	5	0	0	4	0	0	0	0	0	2	0	0	3	0	0
19	2	0	0	1	0	1	3	0	1	0	0	0	3	0	0	2	0	1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8. Sightings of three young-of-the-year *Percina* species. Data include observations from the 20 sites during the 6 surveys in Little River, Blount County, Tennessee. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Survey	1			2			3			4			5			6		
Individual fish Site	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm	Pa	Pb	Pm
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1	1	0	0	5	0	0	2	0
4	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	1	0
5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0
6	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	1	0
7	0	0	0	0	0	0	0	0	0	5	3	0	4	1	0	0	2	0
8	0	0	0	0	0	0	0	0	0	3	1	0	2	1	0	0	0	0
9	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
11	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0
12	0	0	0	0	0	0	1	0	0	2	1	0	2	1	0	0	0	0
13	0	0	0	0	0	0	0	0	0	3	1	0	4	1	0	4	0	0
14	0	0	0	0	0	0	0	0	0	2	0	0	5	0	0	2	0	0
15	0	0	0	0	0	0	0	0	1	1	0	0	3	0	0	0	1	0
16	0	0	0	0	2	0	1	1	1	0	0	0	3	0	0	1	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
18	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
19	0	0	0	0	0	1	0	0	1	0	0	0	2	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

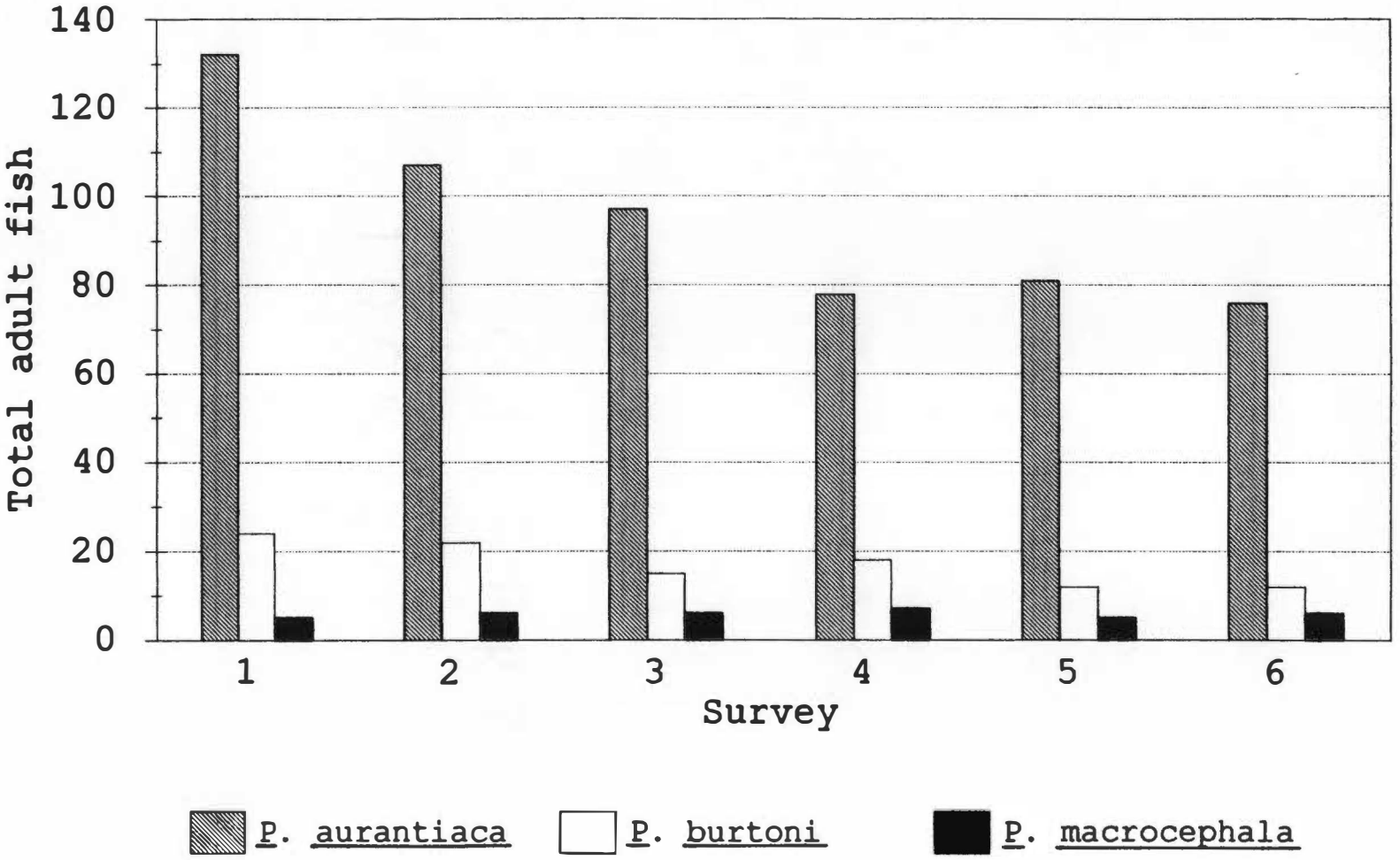


Figure 5. Total sightings of adult fish during the 6 surveys in Little River, Blount County, Tennessee.

adults seen in survey 6. For P. burtoni there was a similar decline with 24 adults in survey 1 and 12 adults in survey 6. Percina macrocephala had the fewest adults recorded, but numbers were consistent throughout the study with five to seven adults per survey.

A summary of the individual sites for all 6 surveys indicated that adults of the three species were not observed at all sites (Figure 6). None of the three species was seen at site 20 during any of the 6 surveys (Table 9). Abundance was greatest at site 12 with 85 adults; at site 13, 0.1 river miles downstream (Table 4), 68 adults were observed. Additional sites with large numbers of adults (in parentheses) were 3(62), 6(61), and 14(59). Of the 709 adults sighted, 212 were at sites 12-14 located in a 0.5 river mile area, RM 20.8-20.3 (Table 4).

Of adults of the three species, P. aurantiaca was the most abundant, and they were observed at all sites except 10 and 20 (Table 9). Sites with the largest concentration were 12(74), 13(67), and 14(59), and covered RM 20.8-20.3 (Table 4).

Percina burtoni was found at sites 3, 6-13, and 15-17 (Table 9). Sites with the largest concentration were 3(26), 7(18), 6(15), 8(11), and 9(11), and covered RM 31.0-23.5 (Table 4).

Percina macrocephala, the least abundant species, was found at sites 10-12, 15, 16, and 19 (Table 9). This area

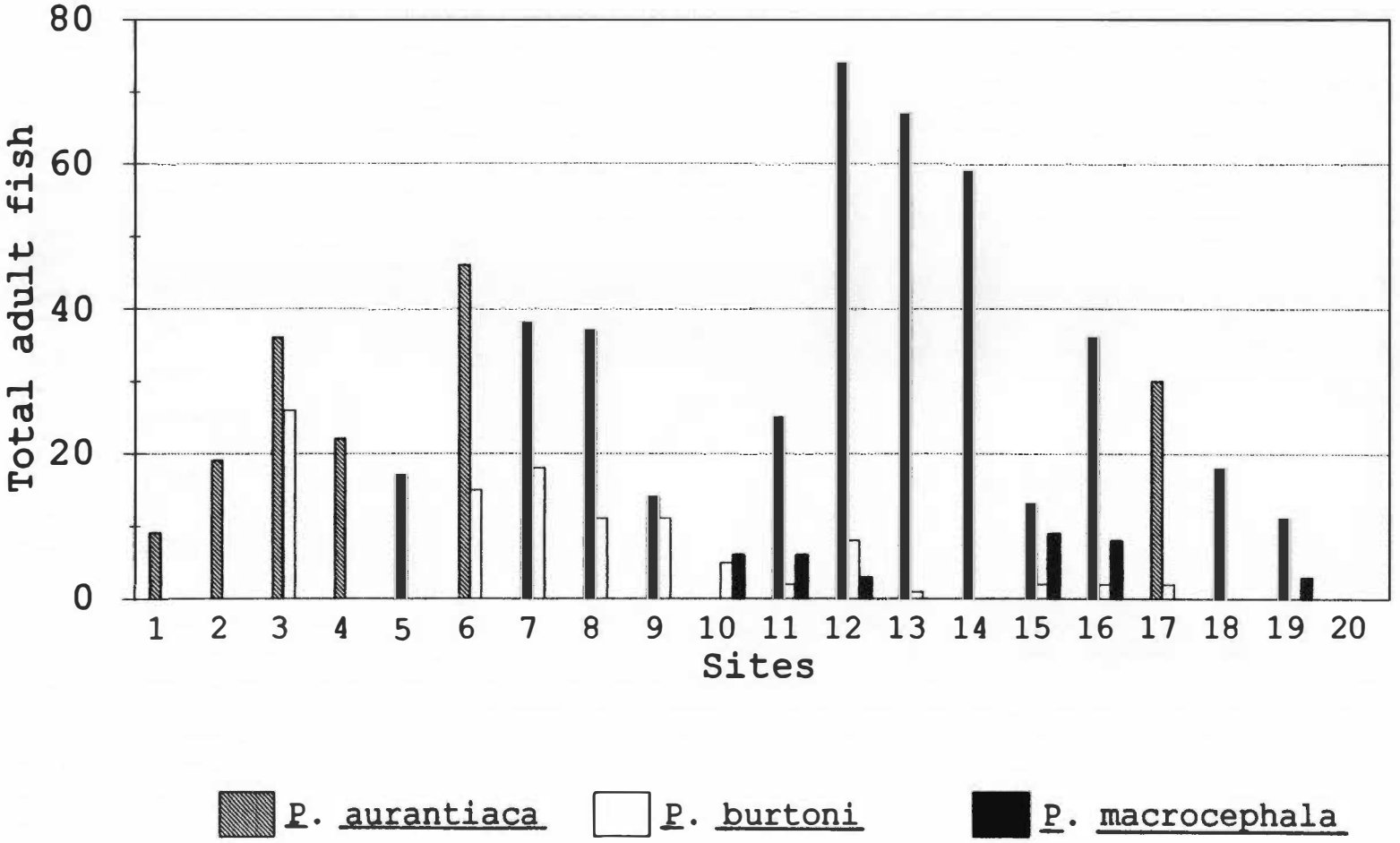


Figure 6. Total sightings of adult fish for each site during the 6 surveys in Little River, Blount County, Tennessee.

Table 9. Total adult sightings for individual sites. Data include the number of individual and all adult fish observed for each site in the 6 surveys in Little River, Blount County, Tennessee. Data were compiled from Table 7. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Site	Individual adult fish observed for 6 surveys			All adult fish observed for 6 surveys
	Pa	Pb	Pm	
1	9	0	0	9
2	19	0	0	19
3	36	26	0	62
4	22	0	0	22
5	17	0	0	17
6	46	15	0	61
7	38	18	0	56
8	37	11	0	48
9	14	11	0	25
10	0	5	6	11
11	25	2	6	33
12	74	8	3	85
13	67	1	0	68
14	59	0	0	59
15	13	2	9	24
16	36	2	8	46
17	30	2	0	32
18	18	0	0	18
19	11	0	3	14
20	0	0	0	0
Total	571	103	35	709

included RM 21.8-14.2 (Table 4). The number of fish sighted ranged from nine at site 15 to three at sites 12 and 19.

YOUNG-OF-THE-YEAR

Young-of-the-year (Y.O.Y.) of the three Percina species were observed only during surveys 2-6 (Figure 7). The largest concentration was recorded during survey 5, occurring in September (Table 1), with 44 fish (Table 6), followed by 30 fish in survey 4, in August.

Individually, P. aurantiaca was the most numerous during the surveys, with 31 seen in survey 5 and 20 during survey 4 (Table 6). For P. burtoni results were similar, with 13 seen in survey 5 and 10 in survey 4. Percina macrocephala had the fewest Y.O.Y., with six fish seen, three each in surveys 2 and 3. Both surveys occurred in July (Table 1).

A summary of the individual sites revealed that zero Y.O.Y. were observed at sites 1 and 20 (Figure 8). Sites with the highest concentration were 7(15), 13(13), 3(9), and 16(9) (Table 10). Percina aurantiaca was the most numerous, and was observed at all sites except 1, 10, 11, and 20. Sites with the highest concentration of P. aurantiaca were 13(11), 7(9), and 14(9). Percina burtoni Y.O.Y. were observed at sites 3-13, 15, and 16, and the highest numbers were recorded at sites 3(8) and 7(6).

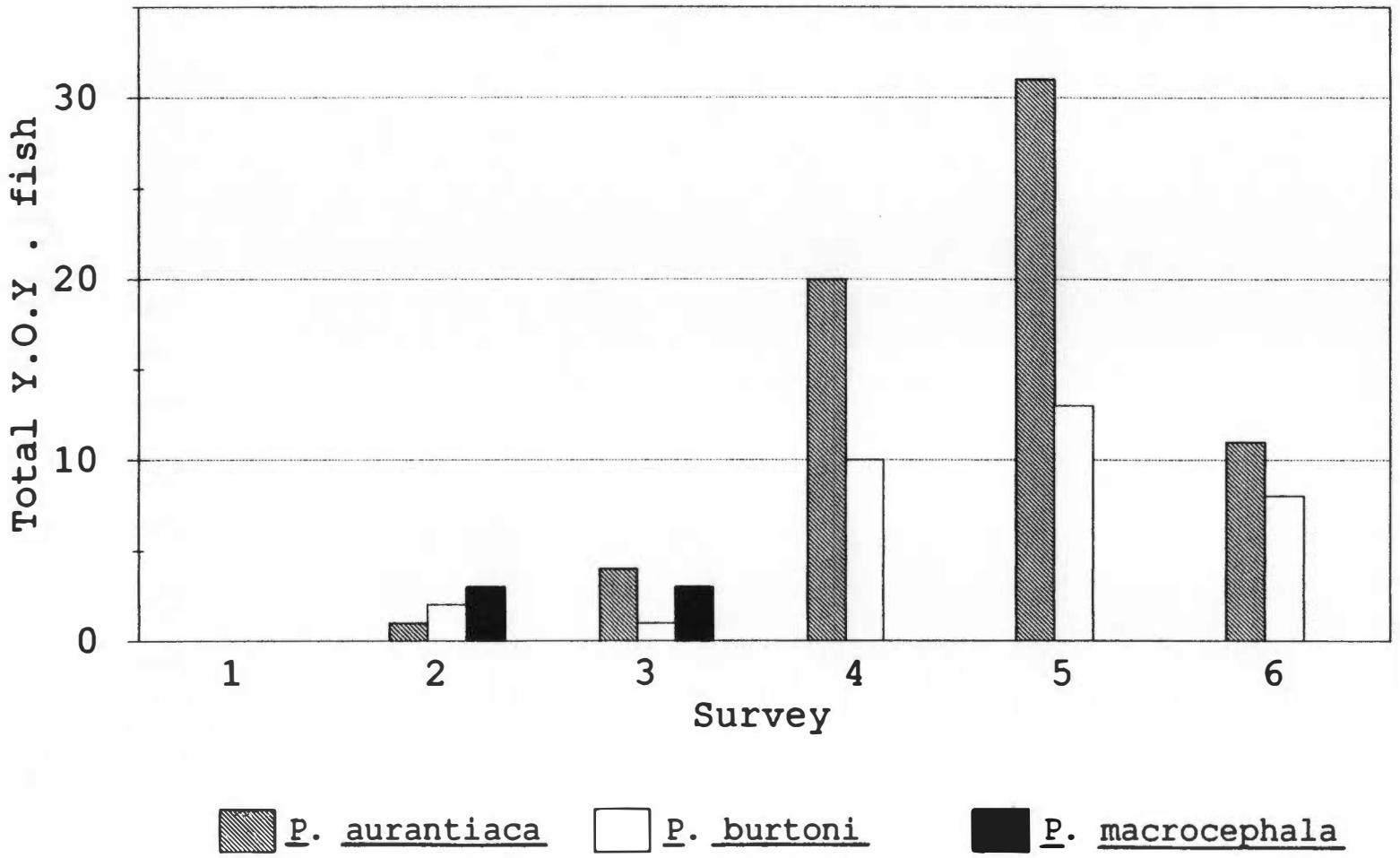


Figure 7. Total sightings of Y.O.Y. fish during the 6 surveys in Little River, Blount County, Tennessee.

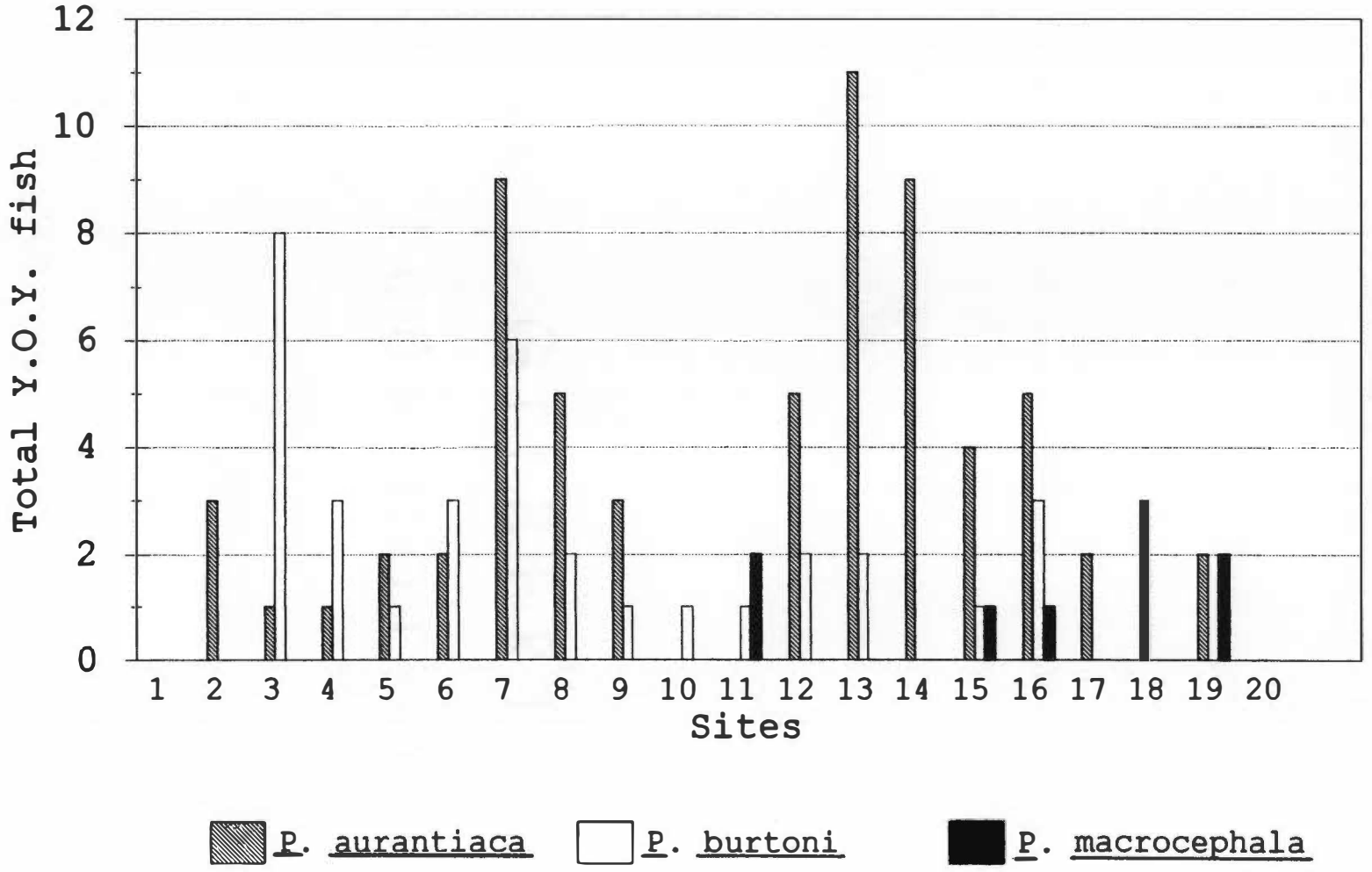


Figure 8. Total sightings of Y.O.Y fish at each site during the 6 surveys in Little River, Blount County, Tennessee.

Table 10. Total Y.O.Y. sightings for individual sites. Data include the number of individual and all Y.O.Y. (young-of-the-year) fish observed for each site in the 6 surveys in Little River, Blount County, Tennessee. Data were compiled from Table 8. Pa= P. aurantiaca, Pb=P. burtoni, and Pm=P. macrocephala.

Site	Individual Y.O.Y. fish observed for 6 surveys			All Y.O.Y. fish observed for 6 surveys
	Pa	Pb	Pm	
1	0	0	0	0
2	3	0	0	3
3	1	8	0	9
4	1	3	0	4
5	2	1	0	3
6	2	3	0	5
7	9	6	0	15
8	5	2	0	7
9	3	1	0	4
10	0	1	0	1
11	0	1	2	3
12	5	2	0	7
13	11	2	0	13
14	9	0	0	9
15	4	1	1	6
16	5	3	1	9
17	2	0	0	2
18	3	0	0	3
19	2	0	2	4
20	0	0	0	0
Total	67	34	6	107

Percina macrocephala occurred at the fewest sites; two specimens were seen at sites 11 and 19, while sites 15 and 16 had one fish each.

ADULTS AND Y.O.Y.

Sighting results of adult and Y.O.Y. fish at individual sites can be compared in Figures 6 and 8. For P. aurantiaca both groups were recorded at sites 2-9 and 12-19. For P. burtoni both age classes occurred at sites 3, 6-13, and 15-16. Percina macrocephala adults and Y.O.Y. were seen at sites 11, 15, 16, and 19.

DENSITY

The density of specimens (adults and Y.O.Y.) per unit area is shown in Table 11. Variation was noticed for each darter and site square area. The tangerine darter had the highest density. Highest numbers of fish per unit area (1000 square feet) and sites (in parentheses) were 2-5(13) and 1-4(3, 5-8, 11, 12, 14, 16, and 18). The highest density for the blotchside logperch occurred at site 3 with 1-3 fish/area and sites 7-9 had 1 fish/area but not in all surveys. The longhead darter had the lowest density with 1-2 fish at site 11 during three surveys. The remaining five sites had a density of 0.1-0.6/area.

Table 11. Density per unit area of three *Percina* species in Little River, Blount County, Tennessee. Data include the site number, the site area in square feet, surveys 1-6, and the individual fish densities (specimens per 1000 square feet) for adults and young-of-the-year, for each site during the 6 surveys.

Site	Site area	*Percina aurantiaca* Survey						*Percina burtoni* Survey						*Percina macrocephala* Survey					
		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	2912	2.1	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	9378	0.5	0.3	0.3	0.4	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2980	3.7	2.4	2.4	1.3	2.4	0.3	3.0	1.0	1.3	1.7	2.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0
4	5470	1.5	0.4	0.9	0.4	0.6	0.6	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
5	1827	2.2	1.1	1.1	1.6	2.7	1.6	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
6	6590	1.5	1.4	0.8	1.5	1.2	0.9	0.3	0.8	0.2	0.5	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0
7	6090	1.3	0.8	1.0	2.1	1.5	1.0	0.3	0.7	0.3	1.1	0.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0
8	2900	4.1	2.4	2.1	2.8	1.7	1.4	1.0	0.7	0.7	1.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	4320	0.5	0.7	0.0	0.9	1.1	0.7	1.2	1.2	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3200	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.6	0.3	0.6	0.3	0.6	0.0	0.3	0.0
11	1600	3.8	1.3	4.4	1.3	3.8	1.3	0.0	0.0	0.0	0.6	0.6	0.6	1.3	2.5	1.3	0.0	0.0	0.0
12	8961	1.9	2.2	1.6	1.9	0.8	0.5	0.2	0.2	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.0
13	3105	4.5	4.8	1.6	4.5	3.9	5.8	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	3120	2.6	3.2	4.5	3.2	4.5	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	6324	0.2	0.2	0.3	0.6	1.4	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.2	0.3	0.3	0.3	0.3	0.2
16	7453	1.6	1.1	0.9	0.1	1.1	0.7	0.0	0.3	0.1	0.0	0.0	0.3	0.0	0.0	0.1	0.3	0.3	0.5
17	6273	0.3	1.1	1.6	0.0	0.6	1.4	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
18	4012	1.0	1.3	1.0	0.3	0.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	4260	0.5	0.2	0.7	0.0	1.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.2
20	1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CHAPTER 5

DISCUSSION

POPULATION DECLINE

Etnier and Starnes (1991) noted that the three species, Percina aurantiaca, P. burtoni, and P. macrocephala, occupied wide ranges in rivers in the eastern United States. The three darters are found in the following major drainages: the tangerine darter in the upper Tennessee river (Figure 9); the blotchside logperch in the Cumberland and Tennessee rivers (Figure 10); and the longhead darter in the Ohio, Cumberland, and Tennessee rivers (Figure 11). A review of recent literature and personal contacts has generated a list of the most recent occurrence for each species, by state and river drainage, and is presented in Appendix F.

Currently, Little River, Blount County, Tennessee, is one of three rivers containing all three darters (Appendix F). Clinch River, in Virginia, and two tributaries, Copper Creek and Little River (P. macrocephala was last collected in Little River in 1967), also has the darters. All three fish exist in Virginia in North Fork Holston River. Prior to 1950, the three darters were probably found in the French Broad system in North Carolina; P. macrocephala was

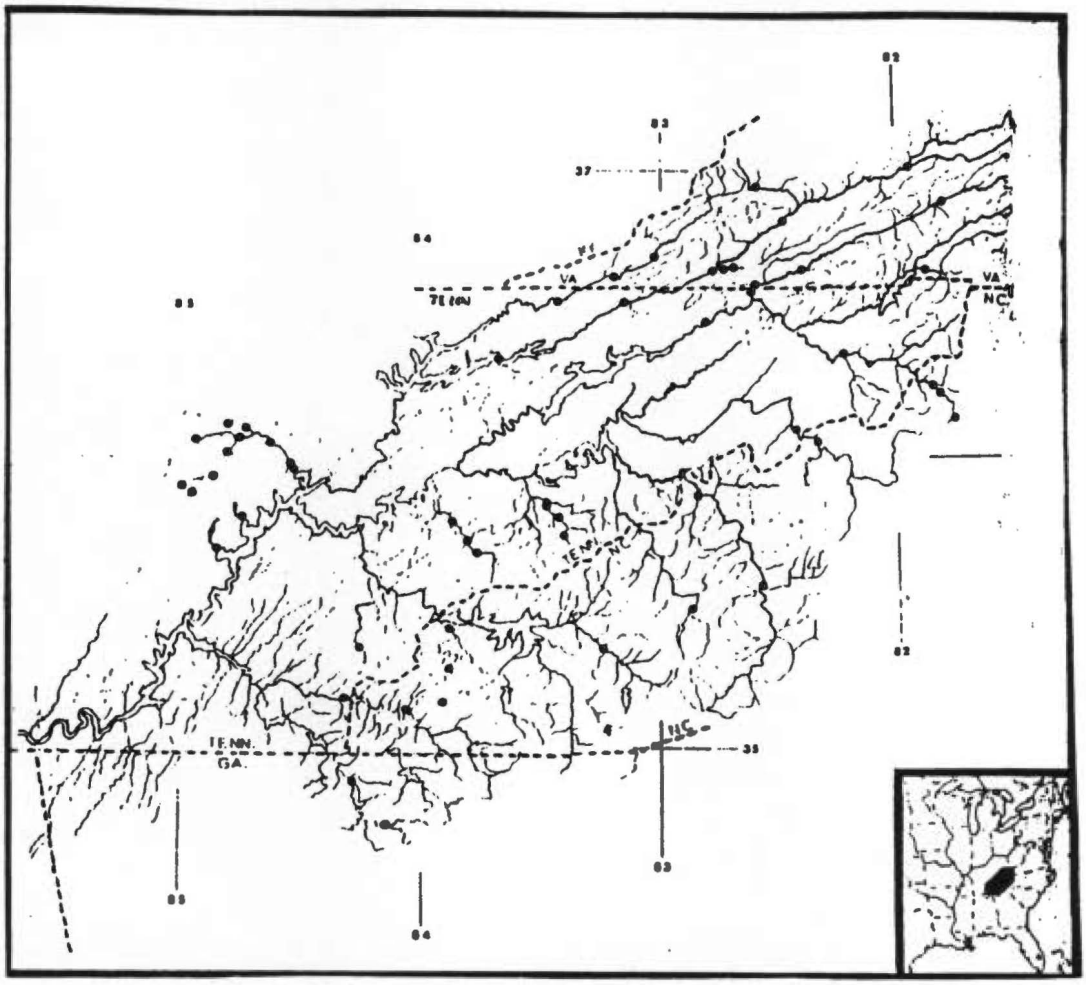


Figure 9. Distribution map of the tangerine darter.
Source: Adapted from Lee, et al., 1980.
Additional sources: Beane, J. N.C. State Mus. Nat. Hist. research collection records of fishes (pers. comm.); Hughes, M. H. 1994.; and Univ. Tenn. research collection records of fishes.

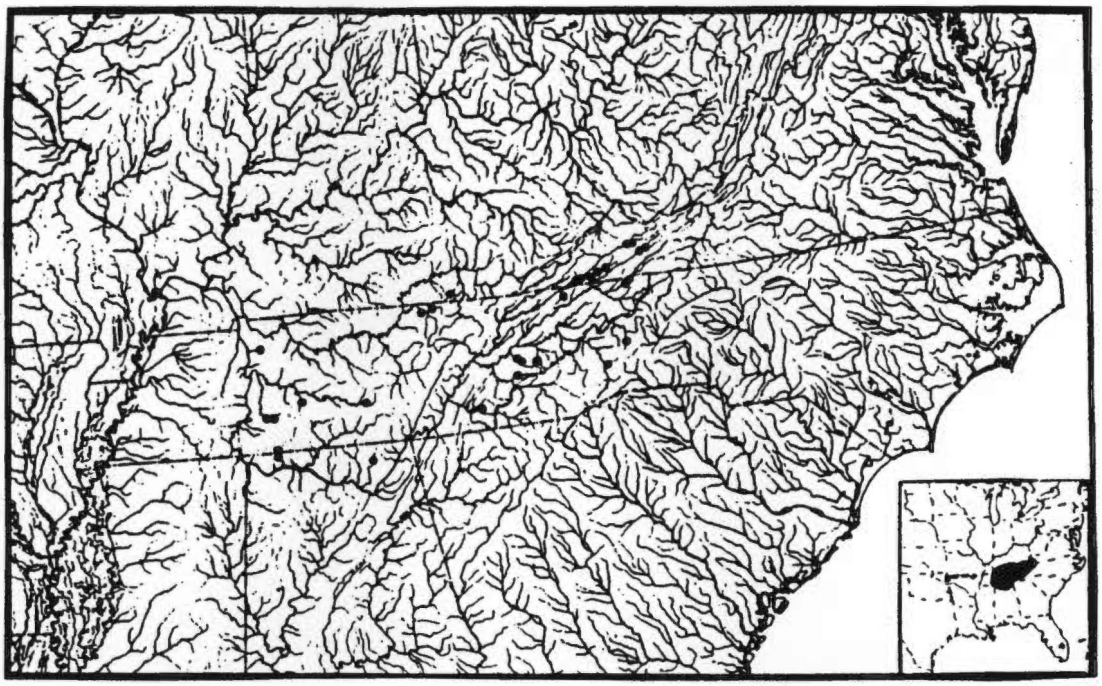


Figure 10. Distribution map of the blotchside logperch.
Source: Adapted from Lee, et al., 1980.
Additional sources: Boschung, H. T. Univ. Ala. research collection records of fishes (pers. comm.); and Univ. Tenn. research collection records of fishes.

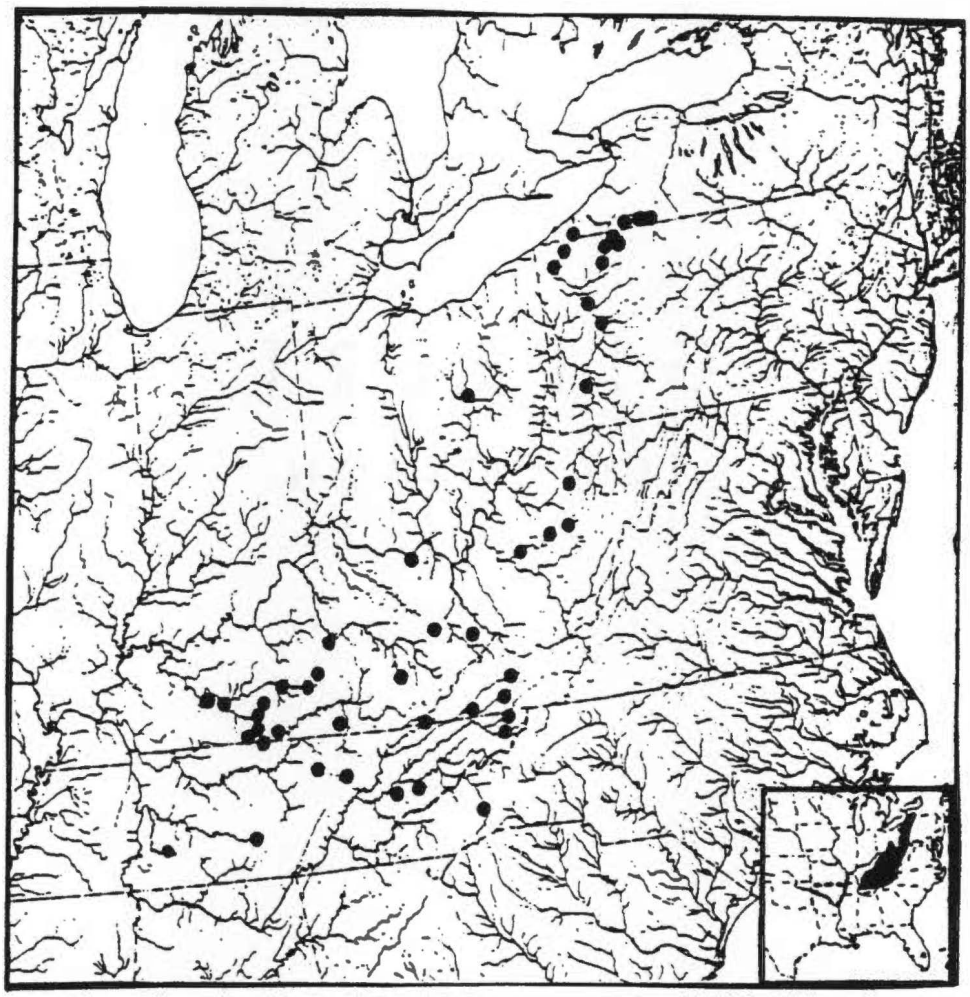


Figure 11. Distribution map of the longhead darter.

Source: Adapted from Lee, et al., 1980.

Additional sources: Shute, P. W. TVA Regional Natural Heritage Program records of fishes (pers. comm.).

last collected about 1940. The fish were possibly in the Pigeon and Little Pigeon River systems in Tennessee (D. A. Etnier, pers. comm.).

Etnier (1994) reflected on the decline of the populations and possible extirpation (elimination of a species from an individual river) of two of these species. Percina burtoni was extirpated from 7 of 15 rivers with known historical populations, and from all three Cumberland River drainage locales, where the last collection was in the late 1800s. Four populations from four rivers in the Tennessee River drainage were likely extirpated. The rivers and the last collection dates include the following: South Fork of the Holston River (1947), French Broad River (1934), Nolichucky River (1980), and Little Tennessee River in Abrams Creek (1957) and in the Tellico Reservoir area (1975, Tennessee River Mile 6.8 collected by Rick Eager). The remaining populations are isolated by reservoirs with additional extirpations probable. The long-term outlook for P. burtoni is not good.

Etnier (1994) added that about half of the 20 known populations of P. macrocephala appear to be extirpated. The last collection date in the Cumberland River drainage was 1891, according to Page (1978). Other extant populations are vulnerable to extirpation because of their small size or recent declines in populations.

Records representing 35 years of collecting P.

macrocephala in the Allegheny River system showed an overall decline in specimens taken (J. R. Stauffer, Pennsylvania State Univ. research collection records of fishes, pers. comm.). The collection effort, by several different groups, has probably varied over time. The time period, divided into year groups and the number of fish collected (in parentheses), included 1958-1966(55), 1971-1979(25), 1985-1989(18), and 1991-1993(35). The number of longhead darters collected in the future could indicate a cyclic population trend or a gradual decline with possible extirpation due to environmental pressures (Etnier, 1994).

DISTRIBUTION, DECLINE, AND MORTALITY

Percina aurantiaca was found throughout Little River (Figures 6 and 8). It was not seen at site 20, which contained boulders and bedrock in the middle of the river. Siltation probably affects this species; this site had a mean Secchi disk reading of 3.1 feet (Table 2).

Simbeck (1990) stated that the tangerine darter was uncommon to rare in Little River above the GSMNPB. He noted that three collections were made between 1980 and 1988, two at the GSMNPB and one upstream above the "Y".

The sightings of adult tangerine darters declined from 132 in survey 1 to 76 in survey 6 (Table 5 and Figure 5). Several possibilities may have contributed to the decline.

Spawning occurred from May to July (Howell, 1971) or mid-May to mid-June (Kuehne and Barbour, 1983) and may account for the darters being more abundant in the shallower pool areas surveyed. As fall approached, the fish possibly retreated to deeper pool areas.

Another factor could be mortality; this darter lives up to 4+ years (Howell, 1971). On two separate occasions, a single adult was observed being chased, in rapid pursuit, by a large smallmouth bass. Water snakes were another possible form of predation for the three darters.

The majority of stomach contents of the northern water snake (Nerodia sipedon) were minnows, sculpins, and darters (P. T. Andreadis, in Litt., Determinants of food intake in the northern water snake, Nerodia sipedon, Ph.D. Dissert. draft, Univ. Tenn.). He stated that darters were especially found in smaller water snakes. He noted that the snakes feed, by crawling on the bottom two to three hours after sunset, on fish resting on the substrate, especially in riffles. After four summers of observations, he also noted that water snakes feed on fish in water willow beds, which may cause predation on P. macrocephala, particularly Y.O.Y.

Percina burtoni was noted at sites 3-17, except for site 14, (Figures 6 and 8) but appeared less abundant in the lower part of the river. The mean disk readings for each site have been compared. Sites with a mean reading of 9.0 feet or greater contained a higher number of adult P.

burtoni than sites with less water clarity (Figure 12).

Sites 3 and 6-9 contained 79% of the adult P. burtoni sighted during the surveys (Table 9 and Figure 6). This area covered 7.5 river miles, RM 31.0-23.5 (Table 4). The mean disk reading in this area ranged from 9.4 to 11.7 feet (Table 2). In the lower part of the river, sites 10, 11, 13, and 15-17 averaged one to five fish and had a mean reading below 9.0 feet (4.2-8.8 ft.). The exception was at site 12, RM 20.8, where eight fish were recorded with a mean reading of 9.0 feet. Low disk readings resulted from increased siltation which may have covered the preferred feeding area of this fish and possibly caused a population reduction in the area. A drastic decrease of darters at the U.S. 411 bridge (site 17) has been noticed. A minimal amount of suitable feeding area (cobble) was noted during the reconnaissance of site 17 and this darter was not observed at that time (Appendix E).

Percina macrocephala was observed in the lower reaches of Little River from Peery's Mill dam (site 10) to the TN Hwy. 33 bridge (site 20) (Figures 6 and 8). This lower area, RM 21.8-8.3 (Table 4), had a mean disk reading of 3.1-9.0 feet (Table 2).

Upstream movement for the longhead darter has been restricted by the present Peery's Mill dam, built in 1906 (other dams at this site date back to the mid-1800s) (L. Smith, Blount County Library, pers. comm.). Two other dams

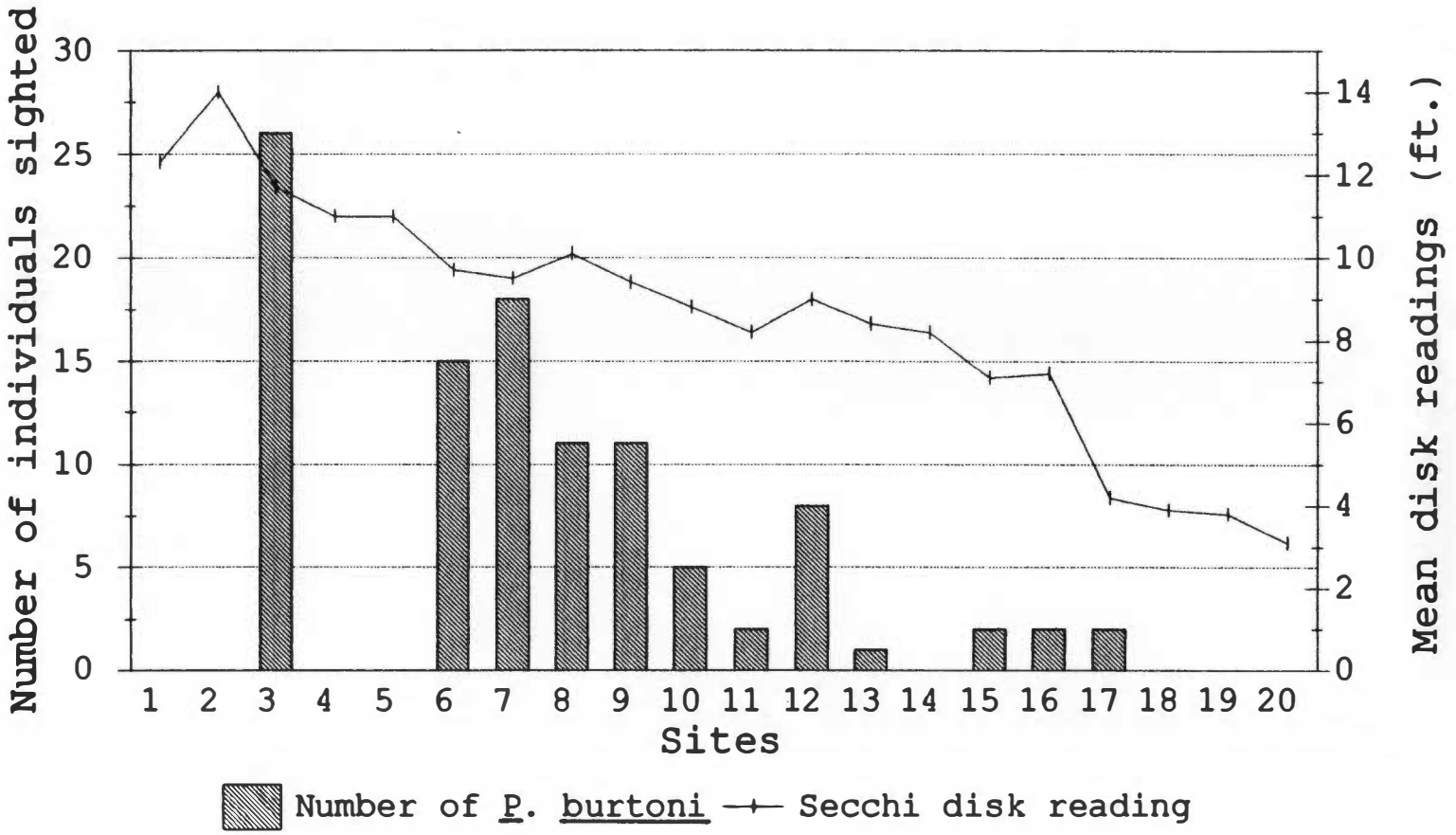


Figure 12. A comparison of adult Percina burtoni sightings and mean Secchi disk readings from Little River, Blount County, Tennessee. The site totals for fish are from Table 9 and mean disk readingss (in feet) are from Table 2.

occur in the river; one is in Townsend between sites 2 and 3. Percina burtoni was probably at site 2, which has a transition zone and a deep pool below the riffle, before this dam was built in the early 1900s (L. Smith, pers. comm.). The other dam is in Rockford below site 20. Sightings of P. tanasi suggest that this dam does not restrict upstream movement (D. A. Etnier, pers. comm.). Several other dams were built during the river's history, but no longer exist.

HABITAT AND ACTIVITY

Population declines of the three study species (Percina aurantiaca, P. burtoni, and P. macrocephala) may be related to their preference for specific river habitats. Descriptions of substrates and associated activities are presented for the individual species.

Tangerine Darter

The tangerine darter can be found in several types of substrate habitats throughout the pool area. The substrate area had a slower current, compared with the faster surface current, which enabled the fish to rest and feed on the bottom.

A substrate of a few to many boulders provided shelter

(rest) and a feeding area comprised of periphyton (aufwuchs), a "carpet" of algae, diatoms, and small dipterans that covered boulders and bedrock. The darters, often in groups of four to ten, appeared to graze on the periphyton in search of aquatic insect larvae. Solid bedrock, with deep recesses, was another substrate that offered shelter and a feeding area. Pool depths in these areas averaged 2-5 feet, and occasionally over 6 feet deep. The scarcity of this species in collection records is in part related to the difficulty of seining in this type of habitat.

Other areas where tangerine darters were seen included pools with various size boulders, or bedrock under bridges. This species was discovered under bridges at five sites (4, 8, 14, 17, and 19). Resting and feeding occurred in moderate currents and depths averaged 3-5 feet. Tangerine darters were occasionally found near the substrate in riffles and runs, averaging 1-3 feet deep, and occasionally deeper. Activities there included swimming and feeding in a fast current.

Y.O.Y. were observed in close proximity to the adults near boulders and on bedrock. They appeared to be about half the size of the adults. Etnier and Starnes (1993) stated that first year fish are 2-2.5 inches total length (TL) while fourth year fish are 5 inches TL or more (maximum TL 6.75 inches).

Displaying friendly behavior on numerous occasions, these fish swam within one foot of the snorkeler or followed at a short distance. After completing survey 1 at site 14 and taking a flow meter reading, 10 of these fish were observed, directly behind, two feet away; 8 adults and zero Y.O.Y. were counted during the survey (Tables 7 and 8). The fish would often remain stationary, observing the snorkeler's activity. During survey 4 at site 12, 12 tangerine darters and two longhead darters watched, from 2-3 feet away, as a temperature reading was being taken. One tangerine darter approached and nibbled on the end of the thermometer. Site 12 contained 15 adult and two Y.O.Y. tangerine darters and three adult longhead darters.

Other observations included mating during the 12 June reconnaissance (site 12). With the male directly on top, both sexes quivered briefly. Then the male swam away, the female shortly thereafter. The substrate was comprised of boulders and flat rocks surrounded by silt. At site 5, solitary male adults retained their nuptial color (slightly faded) until late September.

Blotchside Logperch

The preferred feeding substrate of the blotchside logperch was small stones (cobble) in areas adjacent to riffles, referred to as the transition zone by Howell

(1971). Of the 54 observations of this fish, 33 (61%) where in this habitat, mostly in the pool below the riffle, with an average depth of about 2 feet. The zone is located between rocks covered with riverweed in the riffle and smooth rocks surrounded by silty areas in the deeper pool (three to four feet deep). Feeding was observed three times in the upper pool, but was not observed in other areas.

Observed activities of this fish were stone flipping, feeding, reactions to the diver, and resting. The fish has a bulbous snout and uses it to flip stones. After the flip, the fish moved in to look for food, turning its head (and body) at a sharp angle from one side to the other (similar to a robin looking for worms).

Usually active, the fish would rapidly escape the survey area when approached. This fish could be difficult to collect because of this movement into deep pools. One blotchside logperch was observed resting on the bottom, side by side with a logperch (P. caprodes) at site 11, during surveys 5 and 6. Occasionally this species was as friendly as P. aurantiaca.

Y.O.Y. fish measured 2.4-2.8 inches TL (Etnier and Starnes, 1993) the first year, and were not observed with the adults. Adults are 4+ inches TL the second year and a maximum TL of 6.4 inches (UT 91.4423). Y.O.Y. were observed in water willow beds in shallow water near the bank; in gravel at the lower end of the riffle where Ellejoy Creek

entered Little River, Site 16; and near the large submerged tree in the upper pool at the same site. Depths averaged 1-2 feet.

Young adult fish were observed in the lower end of shallow riffles (sites 3 and 10) and in a creek mouth (below site 8). Large adult fish were observed in riffles (1-3 foot average depth) and also in pools in excess of 6 feet deep.

Feeding Technique

The feeding behavior of four P. burtoni, two adults and two Y.O.Y., was noted on three occasions. The observations lasted approximately one minute for each fish. Jenkins and Burkhead (1993) noted that three juveniles averaged 9.3 flips per minute per fish. Stone flipping and searching was a continuous activity until terminated. The four fish, the number of stones flipped, and the collected stone data are shown in Table 12. The site and survey number (in parentheses) and the collection dates are: adult #1 at 8(2) on 7/22, adult #2 at 8(5) on 9/14, Y.O.Y. #1 at 4(4) on 8/28, and Y.O.Y. #2 at 8(5) on 9/14. Separate means were calculated for adults and Y.O.Y. A comparison showed a similar number of stones flipped (in parentheses) for each individual observed; #1(8) and #2(5) for the adults, and #1(7) and #2(4) for the Y.O.Y. A difference is noted in the

Table 12. Description of stones flipped by Percina burtoni in Little River, Blount County, Tennessee. Data include the number of stones flipped by two adults and two Y.O.Y. (young-of-the-year). Measurements include length in inches (in.), width (in.), height (in.), weight in ounces, and volume in cubic inches. Separate means were calculated for the adults and the Y.O.Y. Observation time for each fish averaged one minute.

Adult # 1						Y.O.Y. # 1					
Number of stones	Length	Width	Height	Weight	Volume	Number of stones	Length	Width	Height	Weight	Volume
1	1.02	0.59	0.16	0.08	0.07	1	0.55	0.43	0.24	0.04	0.03
2	1.57	0.98	0.51	0.57	0.55	2	0.55	0.51	0.35	0.05	0.04
3	2.52	1.10	0.39	0.92	0.73	3	0.63	0.55	0.12	0.03	0.02
4	1.42	0.98	0.71	1.09	0.85	4	0.98	0.67	0.28	0.14	0.10
5	1.26	0.83	0.31	0.28	0.24	5	0.94	0.35	0.20	0.06	0.05
6	1.22	0.94	0.31	0.33	0.31	6	0.71	0.59	0.24	0.07	0.06
7	1.42	1.14	0.16	0.29	0.27	7	1.46	0.98	0.31	0.38	0.48
8	2.60	1.42	0.79	2.49	1.71						

Adult # 2						Y.O.Y. # 2					
Number of stones	Length	Width	Height	Weight	Volume	Number of stones	Length	Width	Height	Weight	Volume
1	0.59	0.55	0.51	0.13	0.09	1	1.22	0.87	0.51	0.38	0.48
2	1.10	0.83	0.35	0.22	0.18	2	1.50	1.02	0.43	0.44	0.49
3	1.97	1.85	0.20	0.59	0.55	3	1.22	1.10	0.39	0.28	0.24
4	2.24	1.38	0.24	1.09	0.85	4	0.91	0.75	0.24	0.13	0.09
5	2.52	1.89	0.24	2.16	1.52						
Mean	1.53	1.04	0.35	0.73	0.57		0.89	0.65	0.28	0.17	0.18

size, weight, and volume of the stones. Adults flipped larger and heavier stones, although Y.O.Y. chose a few stones comparable in size to those selected by the adults. Y.O.Y. #2 flipped a stone weighing 0.44 ounces. Adults also chose small stones; adult #1 flipped a 0.08-ounce stone. Both groups of fish attempted to flip a few larger stones (not collected) during the one-minute period but were unsuccessful in turning them over. A separate observation noted an adult flipping the same stone six times.

Longhead Darter

Longhead darter adults were observed along the protected edge of the water willow beds in the pool area (1-2 foot depth). Observations were difficult in the water willow beds because the fish were stationary and have a camouflaged pattern. The fish were also seen in open pool areas (2-4 foot depths) and appeared to be extremely wary, usually escaping rapidly into deeper water. Not all adult longhead darters swam away; some remained stationary in the middle of the water column. This may be a unique swimming trait. Percina evides, P. sciera, and the two other study species usually were found closer to the substrate.

Activities such as feeding and associating with other species of fish were not observed. Adult longhead darters appeared to be solitary and did not congregate like the

other two species; if there was more than one fish, they divided the territory. This solitary behavior was observed at site 10 during survey 1, with one adult adjacent to the upper water willow bed and one adult adjacent to the lower water willow bed. In survey 2, one adult was observed at site 10; two isolated adults were observed at site 11. Survey 3 revealed two separate adults at site 10 and two separate adults at site 11. A question as to why only one of the two darters was observed during survey 2 at site 10 was partially clarified in survey 5, when one adult was observed on the bottom hiding under a large blade of water willow next to a small rock.

The largest longhead darter was observed during survey 2 at site 15. Page (1978) noted that the maximum SL is 4.7 inches. This darter was observed 6 feet from the water willow beds in the lower pool, at a depth of 2.5 feet. An attempt to follow this fish elicited an immediate escape into deep water. In survey 3, it was found in the substrate in the upper part of the riffle next to the run (1 foot depth). The darter, because of its size, easily maintained a position in the faster current. A smaller longhead darter may have had difficulty remaining stationary on the bottom in the swift current. Mathews (1985) studied critical current speed (CCS) and microhabitats of two benthic fish, including P. roanoka. He noted that larger fish with a higher CCS could maintain a benthic position without

swimming, and the occupation of swifter current offered the advantage of escaping predators. He stated that smaller fish were found at the edge in calmer water. No other longhead darters were observed in riffles during the surveys.

Longhead darters reach 2-2.5 inches SL in their first year (Page 1978). Several observations noted them in the vicinity of the adults, which exceeded 3.5 inches SL in their third and fourth year (Page, 1978), but not as closely associated as P. aurantiaca adults and Y.O.Y. Solitary Y.O.Y. were observed within 6 feet of, were at the edge of, or in water willow beds, and were usually stationary. The water willow beds offered protection and food.

SNORKELING EFFORT AND BIAS

A total of 120 observations was made during the six surveys. The total observation effort was 2688 minutes (44.8 hours) (Table 13). The 816 sightings (Tables 5 and 6) resulted in 0.3 fish observed per minute. Survey 1 had the highest total minutes per survey with 644, perhaps due to my lack of familiarization with the sites. The reconnaissance had occurred several weeks prior to this survey. Survey 5 had the lowest observation time, 345 minutes, and disk readings for each site (except 17) were

Table 13. Duration of snorkeling observations. Observations were made at 20 sites for 6 surveys in Little River, Blount County, Tennessee. Time was measured in minutes.

Survey Site	1	2	3	4	5	6	Individual site Total	Mean
1	20	10	11	14	9	12	76	12.7
2	49	18	29	37	12	22	118	27.8
3	28	14	22	19	14	15	112	18.7
4	18	8	10	27	14	11	88	14.7
5	25	18	18	19	10	12	102	17.0
6	44	23	29	33	16	18	163	27.2
7	66	32	43	51	23	27	242	40.3
8	23	12	11	10	10	12	78	13.0
9	41	30	24	26	17	19	157	26.2
10	20	14	12	18	13	16	93	15.5
11	20	9	23	13	21	21	107	17.8
12	58	36	37	32	23	31	217	36.2
13	19	12	10	8	8	11	68	11.3
14	19	14	14	11	10	9	77	12.8
15	27	24	35	20	27	31	164	27.3
16	27	24	45	27	28	22	173	28.8
17	31	43	45	17	27	34	197	32.8
18	38	17	14	15	14	17	115	19.2
19	43	50	21	24	30	48	216	36.0
20	28	28	8	16	19	26	125	20.8
Total	644	436	461	437	345	414	2688	
Mean								22.8

above their mean readings (Table 2), resulting in good viewing conditions.

The mean time for a single site survey observation (of the 120) was 22.8 minutes (Table 13), with a range of 11.3 minutes at site 13 (area 3105 square feet, mean disk reading 8.4 feet, Tables 3 and 2) to 40.3 minutes at site 7 (area 6090 square feet, mean disk reading 9.5 feet).

An important aspect of this study was the easy recognition of the study species (Shute et al., 1992). Adults of the three darter species are large and easily recognized after studying photographs and museum specimens. Young-of-the-year have similar identifiable markings.

Platts et al. (1983) stated that snorkeling offered the best perspective in sampling because of the observation of the fish's habitat, behavior, and distribution. He recommended that the survey area should be defined, photographed, and snorkeled upstream for the most effective results.

Ensign et al.(1993) commented on the scarcity of information available from visual observations of Threatened, Endangered, and Special Concern (TES) species. They stated that methods for estimating distribution and abundance of TES species should be encouraged, especially SCUBA and snorkeling observations. They noted that TES species are smaller and live in diverse habitats, unlike game fish, for which most population surveys are designed.

Finally, they emphasized that mortality during the collection of TES species is unacceptable, and may be considered illegal under the Endangered Species Act.

Platts et al. (1983) recognized two types of bias while collecting data using the snorkeling method. First, they noted the number of sightings at each site could be affected by fish reactions to the snorkeler in the pool area. Types of reactions in this study included escape from the area, escape and return, and individuals or groups following the snorkeler. They stated that a second bias was the variability of technique for each observer.

A species/habitat bias was encountered while observing the three darters, and variations of site area (and Secchi disk readings) were important. The estimation of relative density, an index of population density, assumes that catch (sightings) per unit effort (CPUE) is proportional to stock density (Hubert, 1985). It was assumed that all darters were counted during observations at each site per survey. Hubert (1985) stated that a variability in fish behavior can cause fluctuations in CPUE and affect relative density data. In this study, behavior was associated with the individual habitat preference by each darter. Hubert (1985) added that variability in methods should be reduced, and that the data be applied to changes in populations over time.

Another bias was counting the fish twice (Platts et

al. 1983). Percina aurantiaca was the most susceptible because they formed groups during site observations. Observing the fishes' movement during the surveys usually eliminated this problem. Additional factors were encountered during the surveys. The river level was lower, due to less rainfall during the summer of 1993. Because of this, several sites with an upper and lower pool were changed, after the reconnaissance, to sites with a single pool. Lower water depths may have affected the number of sightings by restricting the fish to the immediate pool area. Rain increased current, making snorkeling difficult in the runs and riffles. The amount and angle of the sunlight affected visibility, which improved with more light and having the source behind the observer. Observation times were lengthened by watching the activity of the fish or following the fish in the pool area.

WATER QUALITY

Siltation from runoff was the primary source of poor water quality and visibility. Ensign et al. (1993) noted that after two years of sampling experience, sightings were greatly affected by turbidity (siltation). Other sources were from recreational activities (swimming, canoeing, tubing, and fishing) which agitated the bottom silt. Water quality was assessed with a Secchi disk reading. The

variation in readings, 2.5-20.0 feet (Table 2), resulted in different observation durations per site per survey (Table 13). Site 2 had the optimal mean reading with 14.0 feet and the highest individual site reading of 20.0 feet. Readings continued to decline from this site downstream to site 20 which had a mean of 3.1 feet.

Significant declines in water quality were apparent. An analysis of the mean disk readings separated the river into three areas. Sites 1-5 had a mean reading of 11.0-14.0 feet (Table 2) and covered 8.5 river miles (Table 4). Sites 6-16 had a mean reading of 7.1-10.1 feet and covered 4.8 river miles. Sites 17-20 had a mean reading of 3.1-4.2 feet and covered 9.0 river miles. The two areas between the groups had a noticeable change. The 2.1 river miles between sites 5 and 6 had a mean reduction of 1.3 feet. The 2.3 river mile agricultural area from site 16 to 17 reduced the mean disk reading by 3 feet. A significant source of siltation was visible at the mouth of Ellejoy Creek (site 16). There was a distinct separation of muddy and clear water in the lower pool at site 16.

The largest area omitted from the survey was a 5.9 river mile section between sites 19 and 20. Two reconnaissances were attempted in this area on 2 July 1993. The first was at the Alcoa water filtration plant, RM 9.6. The second was downstream at the Hitch farm, RM 8.9. Both sites had a disk reading of less than 1 foot and were not

included in the survey. The water appeared semitransparent, having a "light milk" coloration. Very few fish were observed.

ADDITIONAL SIGHTINGS

Opportunistic observations were made in areas adjacent to study site pools. This information is shown in Appendix D but not included in the survey data. A total of 121 additional sightings was recorded and represented 102 adults and 19 Y.O.Y.

Tangerine darters were represented by 97 sightings (84 adults and 13 Y.O.Y.). Eight sightings were blotchside logperch (6 adults and 2 Y.O.Y.) and the longhead darter was represented by 16 sightings (12 adults and 4 Y.O.Y). These 4 Y.O.Y. and those in survey 7 (Table 14) (all in 1994) brought the total longhead darter Y.O.Y. sightings to 9. This was an increase from the 1993 survey total of 6 Y.O.Y. longhead darters (Table 6), and may suggest that flooding improved this fish's habitat.

Other notable sightings of longhead darters included a single adult that occupied a new pool at site 19 during surveys 5 and 6; the new pool formed after a heavy rain before survey 5. During survey 6, between sites 13 and 14, four young adults were observed swimming in a pool area, 10 feet from water willow beds (C. F. Saylor, TVA, pers.

Table 14. Results of survey 7, 8-10 August 1994. Data include the site number, Secchi disk readings (feet), observation (obs.) times (minutes), and the number of individual and all adult fish sighted in Little River, Blount County, Tennessee. A total of five Pm young-of-the-year (Y.O.Y.) was observed and noted by {}. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Site	Secchi disk readings	Obs. time	Individual adult fish observed			Y.O.Y. Pm	All adult fish observed
			Pa	Pb	Pm		
1	12.5	15	0	0	0		0
2	18.0	39	3	0	0		3
3	14.0	6	3	6	0		9
4	12.0	11	7	0	0		7
5	14.0	4	3	0	0		3
6	11.0	16	8	1	0		9
7	11.0	26	7	2	0		9
8	11.0	9	6	0	0		6
9	11.0	20	3	0	0		3
10	10.0	22	1	1	5		7
11	10.0	5	5	0	0		5
12	9.0	37	22	2	0		24
13	9.0	5	16	0	0		16
14	9.0	8	1	0	0		1
15	9.0	23	0	0	0		0
16	9.0	15	0	0	0		0
17	5.5	38	2	0	0	{2}	2
18	6.0	8	3	0	0		3
19	5.5	27	7	0	0		7
20	5.0	15	0	0	1	{3}	1
Total		349	97	12	6	{5}	115
Mean		17.5					

comm.). In October, 1993, The U.T. Ichthyology class collected two adults (UT 91.3069) in the pool (5.5 foot depth) below the riffle at site 17.

SURVEY 7

This survey was initiated due to a historical flood that occurred on 27 March 1994. Rainfall totaled 5.75 inches in a 24 hour period (J. Davis, National Weather Service, pers. comm.). The 24 hour record was 6.2 inches in July 1917, and older river residents stated the 1994 flood was the worst flood since the late 1800s (Knoxville News Sentinel, 29 March 1994). The U.S. Geological Survey has kept records since 1963 (Knoxville News Sentinel, 30 March 1994); Little River crested at 15.75 feet the evening of the 28th, 3.5 feet higher than the previous record in March 1973. At the Maryville water gauge station (site 17), on 28 March 1994 the river was flowing at 52,462 cubic feet per second (C. Rogers, TVA River System Operations, pers. comm.).

The survey dates occurred on 8-10 August 1994. The flow rates were 568, 453, and 374 cubic feet per second, respectively. The mean observation time for the survey was 17.5 minutes (Table 14), lower than the six survey mean (22.8 minutes) (Table 13). The total observation time was 349 minutes, comparable with survey 5 (Table 13). The

survey's individual site mean disk readings (Table 14) were similar to those of survey 5 (Table 2), resulting in good water clarity and lower observation time.

A total of 120 sightings was recorded; 115 were adults (Table 14). This survey was similar to survey 3 (118 adults) (Table 5). The highest concentration of fish in surveys 1-6 was at sites 12-14 and represented 30% of the total fish. In this survey, these sites represented 36% of the total. Total individual fish sightings, per site, were also similar to survey 3 (Table 9). Zero fish were recorded at site 1 and notably at sites 15 and 16. Percina aurantiaca was observed throughout its range, sites 2-19, except site 14 had a decline in numbers. Percina burtoni was seen at sites 3, 6, 7, 10, and 12; a decline of seven sites (Tables 9 and 14). Percina macrocephala was observed at six sites in surveys 1-6 and at two sites (10 and 20) in this survey. This species was finally recorded at site 20; it was last seen there during the reconnaissance on 8 June 1993 (Appendix E).

An interesting observation occurred at site 10. Five large adult longhead darters were in a silty depression (3.5 foot depth) with brush below the mouth of the pool. After the survey, they were observed for 10 minutes during which time they associated with one adult tangerine darter, one adult blotchside logperch, and four adult logperch. Mathew Teffeteller, a local resident, also observed the 11

fish.

Pimm et al. (1988) noted that as the environment fluctuates, additional (extinction) pressure is placed on populations through demographic accidents. Mathews (1986) stated that floods and droughts may not cause permanent damage to a stream's fish population. He raised a question as to whether a flood could change the fish fauna--the entire river and its ecosystem should be analyzed over a period of time. He noted that recovery depended on adult survival and redispersal, and an increase in reproduction. After a study of north Georgia streams, Freeman et al. (1988) stated that annual fish population fluctuations could be due to environmental variability and density dependent variables. They recommended multiple sites when studying a stream's fish population. They noted that some fish species had an increase in Y.O.Y. after a drought while a decrease of Y.O.Y. was noticed after a flood.

The 1994 flood resulted in a significant decline in Y.O.Y. sightings. Only two separate observations of Y.O.Y. were noted during the 1994 survey (Table 14). Five sightings of P. macrocephala were recorded, two at site 17 and three at site 20. During the 1993 survey, 107 Y.O.Y. were recorded, six were longhead darters. An increase of smallmouth bass Y.O.Y. was noticed throughout Little River. An increase of the silty area along the bank, after flood waters receded, possibly created an expanded nesting area

for increased spawning activity.

Steve Moore, a GSMNP biologist, also noted a decline of Y.O.Y. fish in the Park section of upper Little River. The Park study, dating back to 1986, concentrated on a trout management/ecology program. In the 1993 study it was noted that Y.O.Y. had increased for brown and rainbow trout but brook trout had decreased (Carter, 1993). The 1994 spring flood definitely affected all three trout species; Y.O.Y. were drastically reduced (S. Moore, pers. comm.).

Physical differences in the river area were apparent in this survey. Peripheral damage included bank erosion, large tree removal, and river road damage. Significant changes occurred were the river had changed course, altering sites 17 and 19. Due to scouring, most of the riffles had changed in length and width, the riverweed and aquatic mosses had been removed, and some pools were deeper. Water willow beds had disappeared or were slow to grow back, and may explain why very few Y.O.Y. were observed (for any fish species). Very few fish were observed at site 8. An environmental cleanup was in progress during the survey, due to an underground fuel storage tank leak.

Mathews (1986) stated that the recolonization of fish into a disturbed stream relates to habitat recovery to pre-flood conditions. Peterson and Bayley (1991) emphasized that colonization, the return of fish to a disturbed area,

is based on habitat preference. Substrate scouring of bedrock and boulders removed periphyton, and large areas of silt deposits in the transition zones were noticeable. These disturbances were probably responsible for the absence of the tangerine darter and the blotchside logperch in their preferred feeding area. Both types of habitat destruction may have altered the aquatic insect larval composition.

CHAPTER 6

CONCLUSIONS

This visual, repeatable study was designed to establish a baseline of abundance for three rare darters. These fish have been hard to catch and the fluctuation in darter collectability was due to seasonal change in habitat preference (D. A. Etnier, pers. comm.). By utilizing site and habitat descriptions, researchers could compare their results with these data to assess fish population trends. All three fish are sensitive to pollution, especially siltation, which has affected the river water quality. The following information has been presented as recommendations to study and improve the conditions of the river and its watershed.

Little River has been an important ecological area for graduate and doctoral studies at the University of Tennessee. The close proximity and abundant fauna has furnished excellent research material for at least a dozen students and numerous university class field trips. In addition, TVA has collected river data since 1950 and the area has provided extensive recreational activities.

A set of geochronographic data (Jenkins and Burkhead, 1984) should be compiled from Little River. This would provide a comparison of population fluctuations of the

three darters. Data from U.T. and other collections could be used to review historical surveys. Current information can be obtained from annual surveys and Steve Moore's (GSMNP) long term study from upper Little River. In addition, the effects of the drought of 1993 and the flood of 1994 have presented interesting recovery data, especially for young-of-the-year.

The Tennessee status for the tangerine darter and the blotchside logperch is listed as Special Concern, and the longhead darter is listed as Threatened (Etnier and Starnes, 1993). Due to the decline of the blotchside logperch and its preferred habitat (this may be occurring in other rivers), a change is recommended to that of threatened.

The longhead darter should be introduced above Peery's Mill dam to sites 6-8. This area has similar river morphometry as downstream sites that contained this fish. This darter could exist here along with the other two species, which are adequately represented in this area. All three darters were found at four downstream sites and two other sites contained all three fish with the inclusion of additional sightings. Longhead darters likely occurred in this area previously, were extirpated, and were unable to recolonize subsequent to the building of the dam.

Etheostoma cinereum, a Tennessee Threatened species (Etnier and Starnes, 1993), was observed at sites 15 and

16. The observed areas were noted in Appendix B, diagrams 15 and 16, with a "C" designating the fish. The pool area between the two sites contained large, flat rocks which are the preferred nesting sites of madtoms (Noturus species). Further observations for these fish are encouraged.

The 1994 flood removed large trees, exposing the bank. Continued removal of bank flora would result in excess siltation and diminished water quality. The tree line width along the bank should be increased. The planting of trees and conscientious riparian management could secure the river bank's future.

A river watch program that would monitor pollution and other negative impacts in Little River (and its watershed) could be developed by concerned citizens (J. D. Williams, National Biological Service, pers. comm.). The enforcement of water quality laws is definitely needed to retain the current ecological status of the river.

Recently, the Little River area has been at a decisive crossroad. Residents are divided between retaining the quiet, historical value of the region and an upscale economic program of development. Any increased anthropogenic impacts would adversely affect the river. One impact has been the runoff from agriculture areas and housing developments, which has caused significant siltation problems. Another impact, sewage waste, has escalated because the sewer line only extends to Heritage

High School (east Maryville) near the Coulter Bridge (site 14, RM 20.3). Little Pigeon River, which has experienced a decline in aquatic fauna, had a similar scenario occur in the Gatlinburg area. In May 1993, the state health department declared this river unsafe for humans due to pollution.

Percina macrocephala has been extirpated from Little Pigeon River (last collected in 1967). Percina aurantiaca has been extirpated from the entire West Prong, the portion flowing through Gatlinburg and Pigeon Forge, but persists in the less impacted Middle Prong. Percina burtoni has never been recorded from Little Pigeon River, but almost certainly occurred there (D. A. Etnier, pers comm.). Without positive action it seems likely that this Little Pigeon scenario will be repeated in Little River.

The uniqueness of Little River is that it has been one of the cleanest rivers in the Southeast and could continue to beckon local residents and future tourists. The future of the quality of the Little River will be determined by the residents that live in the watershed.

LIST OF REFERENCES

Braswell, A. L. 1991. Scientific Council Report on the conservation status of North Carolina freshwater fishes. Submitted to: Nongame Advisory Committee of the North Carolina Wildlife Resources Commission, 128 p.

Burr, B. M., and M. L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Kentucky Nature Preserves Commission Scientific and Technical Series No. 4, 398 p.

Carter, B. D. 1993. Annual aquatic resources summary report Great Smoky Mountains National Park. Report No. GRSM-INTFM-02, 120 P.

Clay, W. M. 1975. The fishes of Kentucky. Kentucky Dept. of Fish and Wildlife Resources, Frankfort, 416 p.

Ensign, W. E., P. L. Angermeier, and C. A. Dolloff. 1993. Use of underwater observation to estimate abundance of three benthic stream fish. Manuscript submitted to Can. J. Fish. Aquat. Sci., 32 p.

Etnier, D. A. 1994. Our Southeastern fishes--what have we lost and what are we likely to lose. Southeastern Fishes Council Proceedings No. 29:5-9.

Etnier, D. A., and W. C. Starnes. 1991. An analysis of Tennessee's jeopardized fish taxa. J. Tenn. Acad. Sci. 66:129-133.

Etnier, D. A., and W. C. Starnes. 1993. The fishes of Tennessee. The Univ. of Tenn. Press, Knoxville, 681 p.

Freeman, M. C., M. K. Crawford, J. C. Barrett, D. E. Facey, M. G. Flood, J. Hill, D. J. Strouder, and G. D. Grossman. 1988. Fish assemblage stability in a southern Appalachian stream. Can. J. Fish. Aquat. Sci. 45:1949-1958.

Fullerton, R. O. 1974. Place names of Tennessee. State of Tenn. Dept. of Conservation Bull.73:1-25.

Howell, J. F. 1971. The life history, behavior, and ecology of Percina aurantiaca (Cope). Ph.D. Dissert., Univ. Tenn., 76 p.

Hughes, M. H. 1994. The spatial and temporal distribution of fishes in the Holston River system of North Carolina, Tennessee, and Virginia. Ph.D. Dissert., Univ. Tenn., 538 p.

Hubert, W. A. 1985. Passive capture techniques, p 106-108 In: Fisheries techniques. L. A. Nielsen and D. L. Johnson (eds.). American Fisheries Society, Bethesda, Maryland.

Jenkins, R. E., and N. M. Burkhead. 1984. Description, biology, and distribution of the spotfin chub, Hybopsis monacha, a threatened cyprinid fish of the Tennessee River drainage. Bull. Ala. Mus. Nat. Hist. 8:1-30.

Jenkins, R. E., and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland, 1079 p.

Kuehne, R. A., and R. W. Barbour. 1983. The American darters. Univ. Ky. Press, Lexington, 201 p.

Leftwich, K. N., P. L. Angermeier, and C. A. Doloff. 1994. Potential use of a closely related surrogate in assessing impacts of stream degradation on endangered fish species. Report to: Virginia Dept. of Game and Inland Fisheries, 38 p.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980 et seq. Atlas of North American freshwater fishes. N.C. State Mus. Nat. Hist., Raleigh, 854 p.

Mathews, W. J. 1985. Critical current speeds and microhabitats of the benthic fishes Percina roanoka and Etheostoma flabellare. Environmental Biology of Fishes 12:303-308.

Mathews, W. J. 1986. Fish faunal structure in an Ozark stream: stability, persistence and a catastrophic flood. Copeia 1986:388-397.

Menhinick, E. F. 1991. The freshwater fishes of North Carolina. N.C. Wildlife Resources Comm., Raleigh, 227 p.

Page, L. M. 1978. Redescription, distribution, variation, and life history notes on Percina macrocephala (Percidae). Copeia 1978:655-664.

Page, L. M. 1983. Handbook of darters. T.F.H. Pub., Inc., Neptune City, NJ, 271 p.

Peterson, J., and P. Bayley. 1991. Fish recovery in depopulated streams. Illinois Nat. Hist. Survey Reports No. 307, 3 p.

Pimm, S. L., H. L. Jones, and J. Diamond. 1988. On the risk of extinction. The American Naturalist 132:757-785.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. Gen. Tech. Rep. INT-138. Ogden, UT: Dept. of Agriculture, U.S. Forest Service, Intermountain Forest and Range Experiment Station, 70 p.

Simbeck, D. J. 1990. Distribution of the fishes of the Great Smoky Mountains National Park. M.S. Thesis, Univ. Tenn., Knoxville, 128 p.

Shute, P. W., P. L. Rakes, and J. R. Shute. 1992. Status report and historical review of reintroduction efforts for the endangered smoky madtom (Noturus baileyi) and threatened yellowfin madtom (Noturus flavipinnis). Report to: U.S. Forest Service, U.S. Fish and Wildlife Service, Tennessee Wildlife Resources Agency, and Great Smoky National Park Service, 51 p.

Stiles, R. A. 1972. The comparative ecology of three species of Nothonotus (Percidae-Etheostoma) in Tennessee's Little River. Ph.D. Dissert., Univ. Tenn., 97 p.

Trautman, M. B. 1981. The fishes of Ohio. Ohio State Univ. Press, Columbus, 782 p.

APPENDICES

APPENDIX A

Time of Day for Individual Observations

Data include the time of day (military 24 hour period) for individual observations at each site per suvey in Little River, Blount County, Tennessee.

Survey Site	1	2	3	4	5	6
1	1135-1155	1827-1837	1002-1013	1129-1143	1837-1846	1852-1904
2	1310-1359	1855-1922	1045-1125	1229-1308	1800-1813	1410-1446
3	1529-1557	1749-1803	1145-1207	1429-1448	1639-1653	1547-1602
4	1716-1734	1721-1729	1230-1240	1549-1616	1601-1615	1615-1626
5	1821-1846	1642-1700	1259-1317	1703-1722	1513-1541	1720-1750
6	1014-1100	1544-1609	1407-1444	1415-1451	1429-1454	1625-1649
7	1152-1330	1410-1454	1507-1600	1535-1640	1254-1337	1503-1539
8	1338-1401	1504-1516	1608-1619	1705-1715	1340-1350	1543-1555
9	1507-1626	1304-1343	1642-1715	1816-1857	1151-1217	1415-1445
10	1712-1732	1159-1213	1737-1749	1939-1957	1033-1126	1309-1325
11	1740-1800	1133-1142	1755-1818	1920-1933	1002-1023	1243-1304
12	1101-1236	1926-2012	1838-1924	0900-0937	1857-1933	1140-1157
13	1238-1257	1847-1859	1943-1953	1010-1018	1828-1836	1605-1616
14	1317-1421	1810-1824	0957-1011	1041-1052	1756-1806	1518-1527
15	1517-1558	1639-1706	1027-1108	1115-1135	1614-1646	1747-1820
16	1637-1737	1720-1751	1123-1224	1156-1228	1704-1733	1830-1902
17	1805-1908	1515-1605	1314-1449	1751-1832	1419-1509	1612-1709
18	1622-1650	1432-1449	1512-1526	1632-1647	1131-1145	1254-1311
19	1349-1450	1255-1312	1542-1604	1702-1727	1218-1315	1434-1543
20	0919-0947	1145-1213	1653-1701	1510-1526	0952-1104	1155-1221

Appendix B

Diagram of Sites 1-20

The following are individual diagrams for the 20 sites along Little River, Blount County, Tennessee. Each diagram shows the survey area, comprised of a single pool or upper and lower pools, and the area dimensions. In addition, the diagram illustrates the main road, parking area, the path to the site, natural structures (trees, boulders, riffles, and water willow beds), man-made structures (buildings, signs, and bridges), and other useful information. The three Percina species are represented as: A=P. aurantiaca, B=P. burtoni, M=P. macrocephala, and a special reference to C= Etheostoma cinereum (at sites 15 and 16).

KEY:

Path: XXXXXXX

Water willow beds: WW

Boulders: BLD

Tree used as a site boundary: T

Bridge foundations:

Picnic table:

Diagram of site 1.

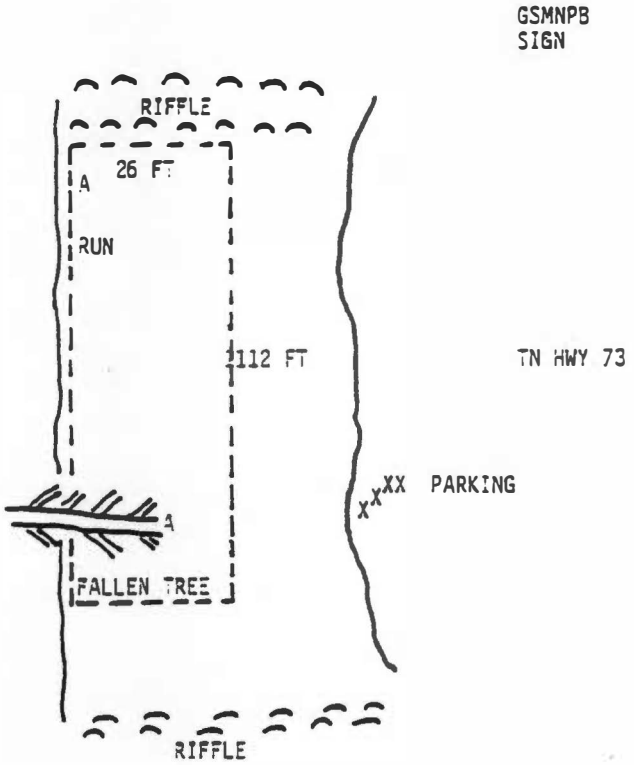


Diagram of site 2.

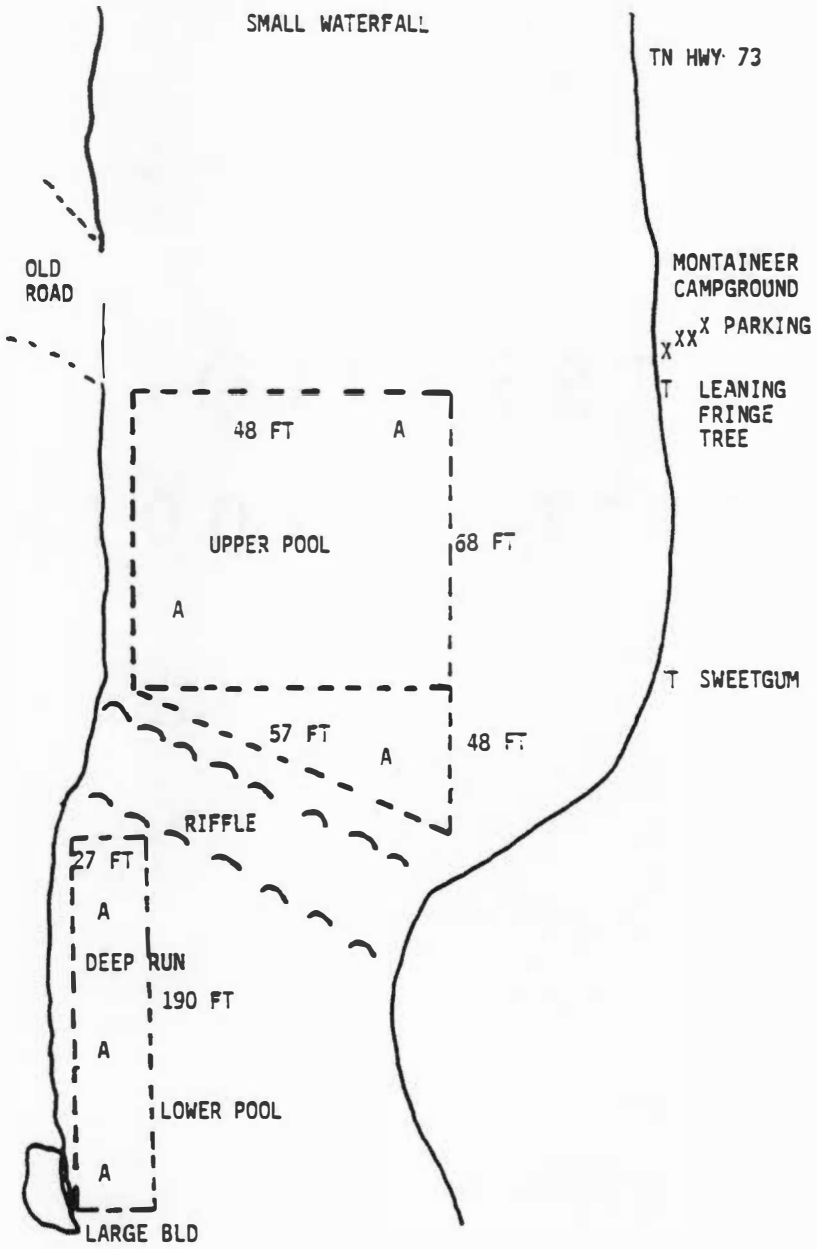


Diagram of site 3.

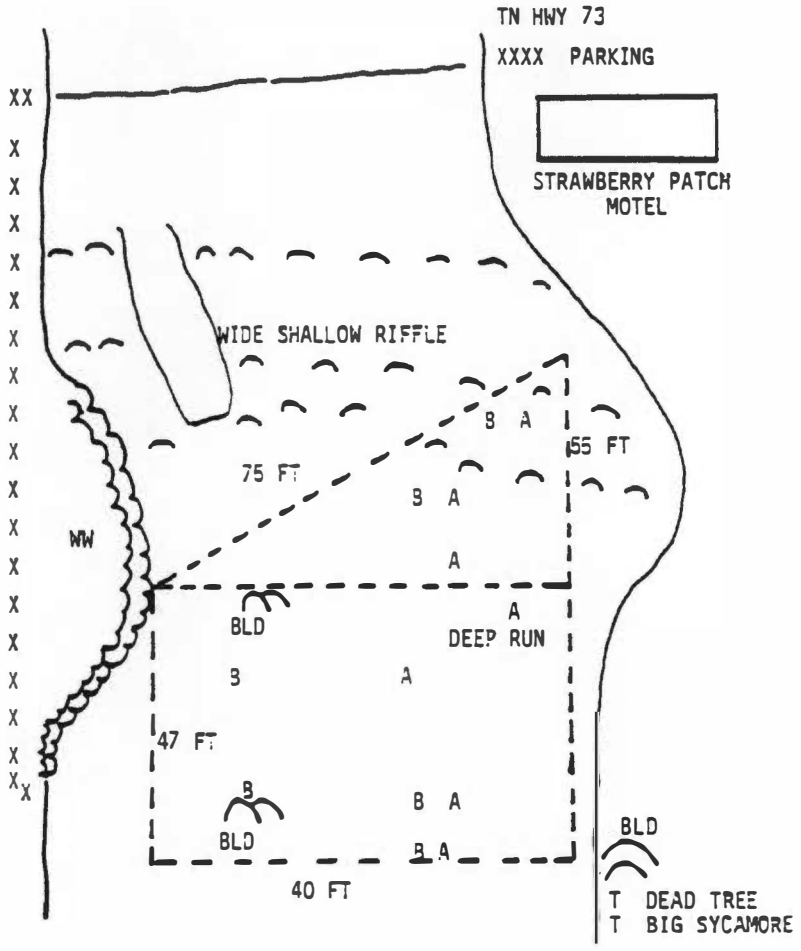


Diagram of site 4.

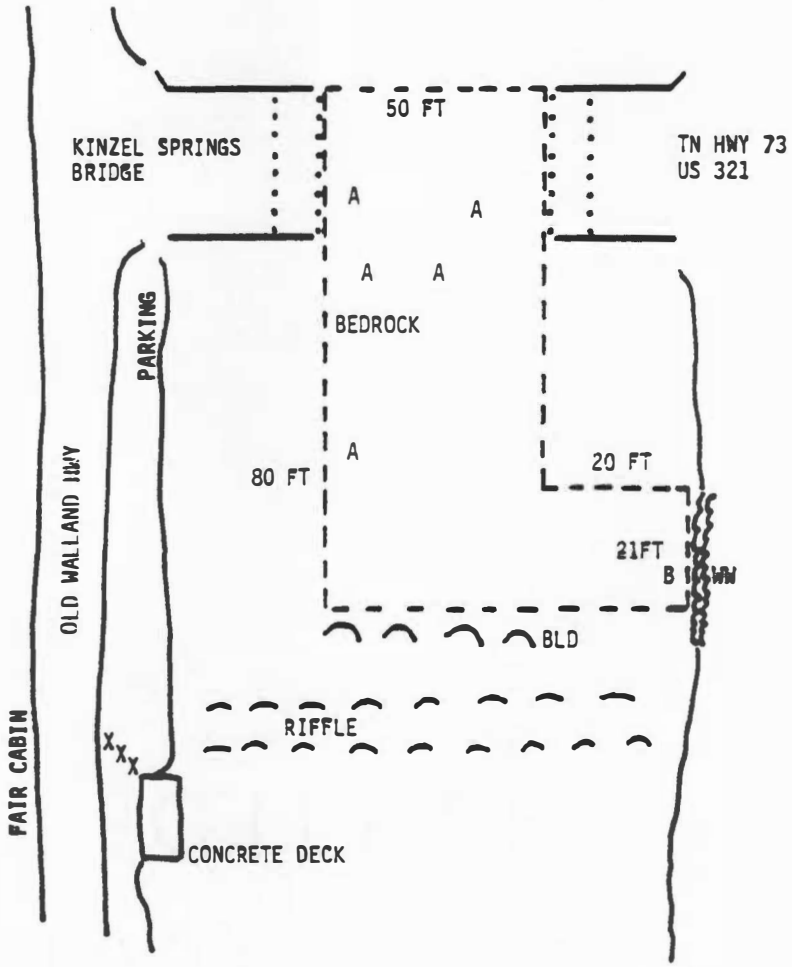


Diagram of site 5.

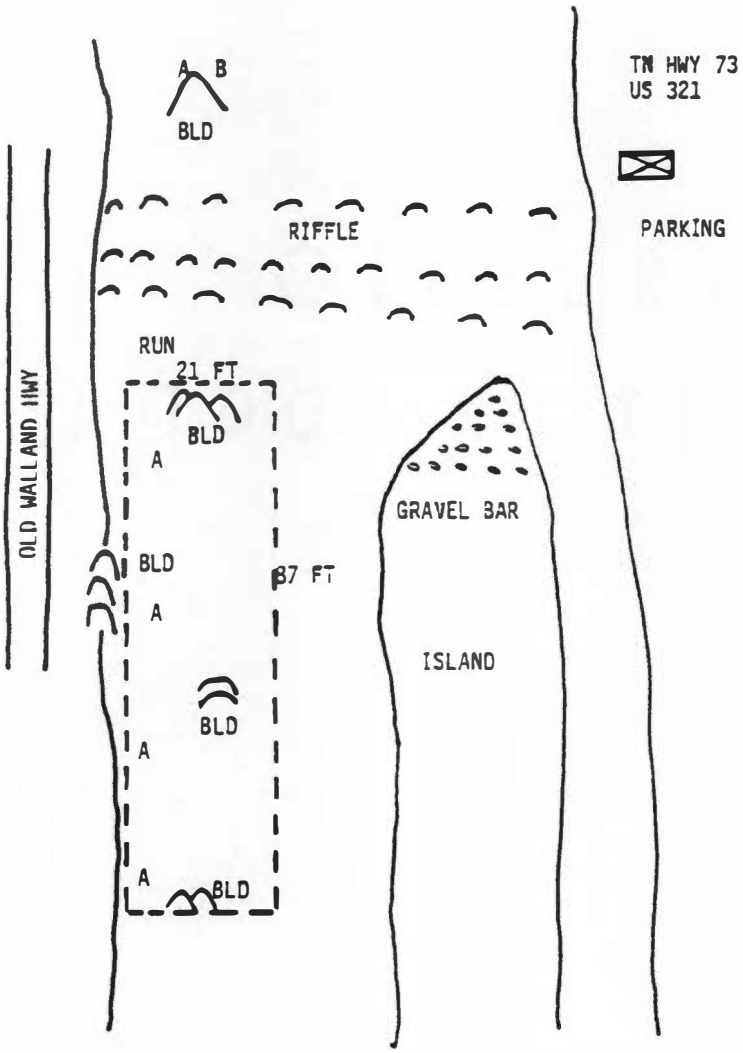


Diagram of site 6.

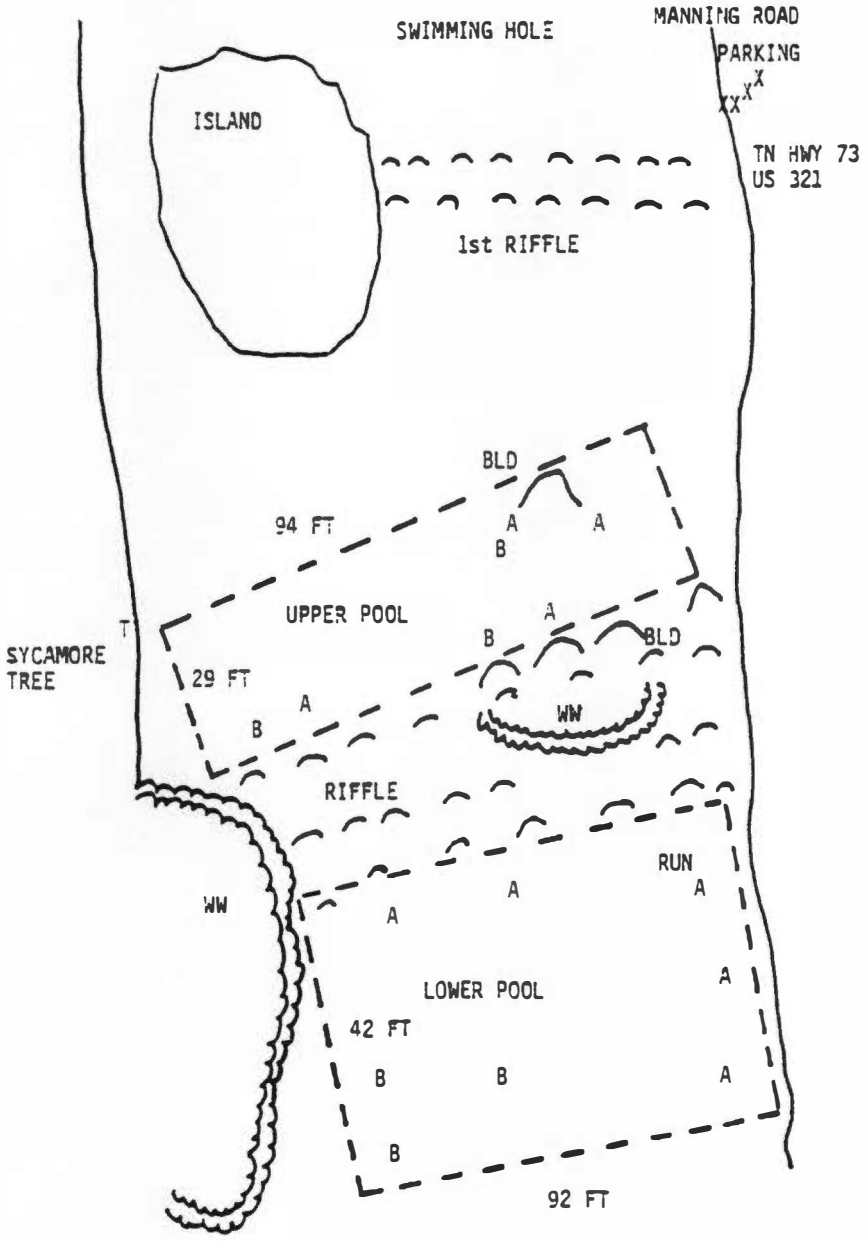


Diagram of site 7.

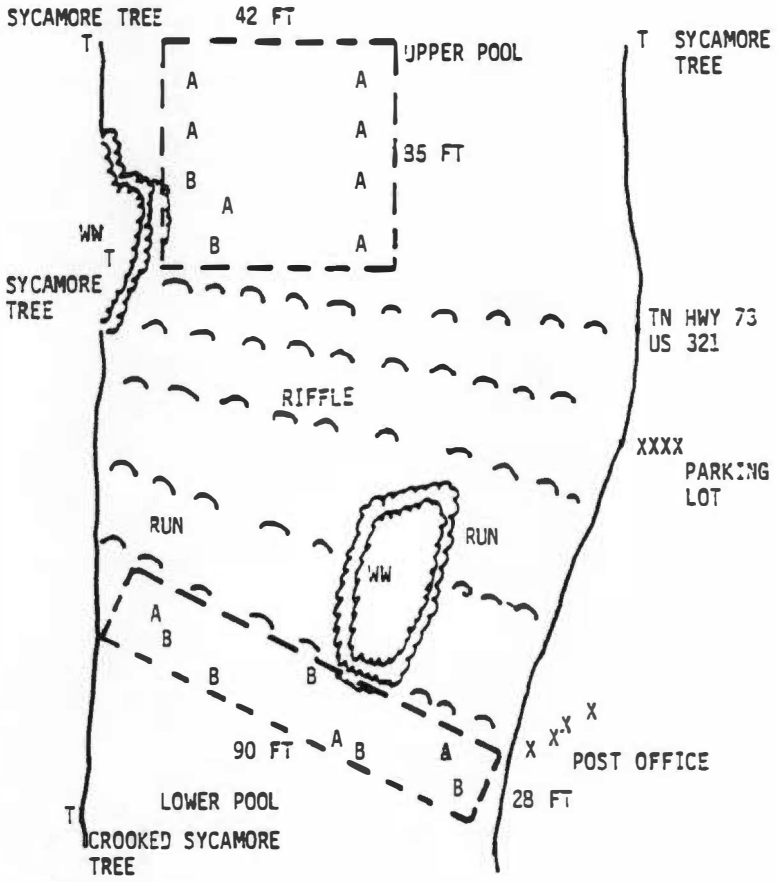


Diagram of site 8.

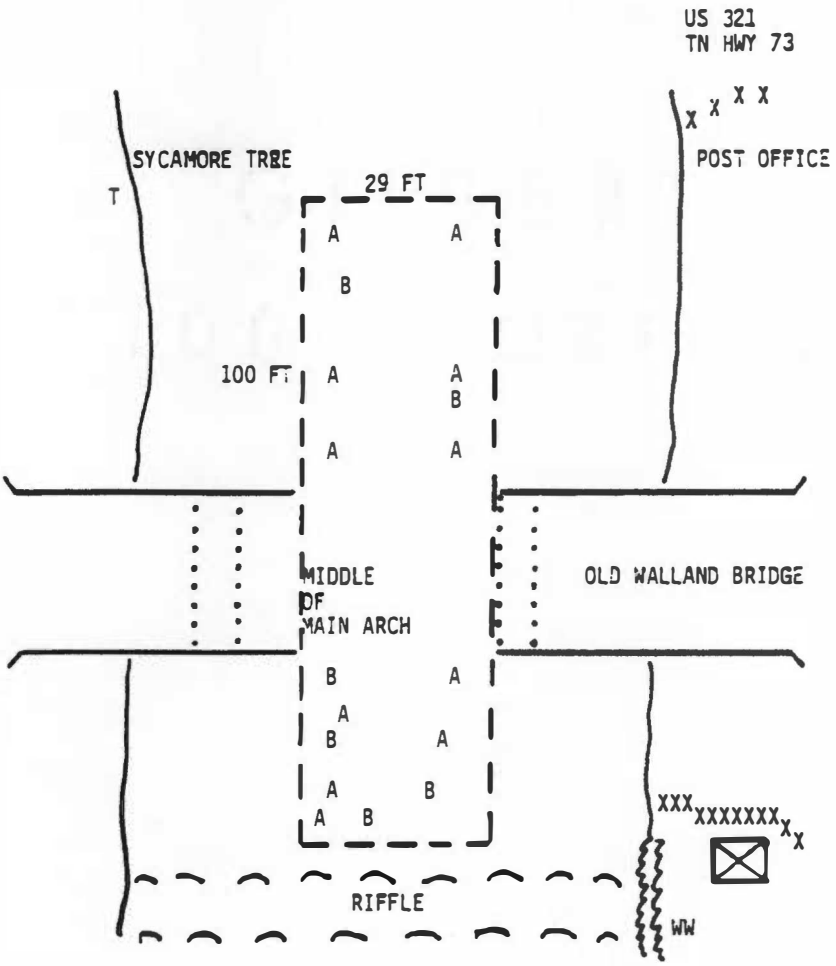


Diagram of site 9.

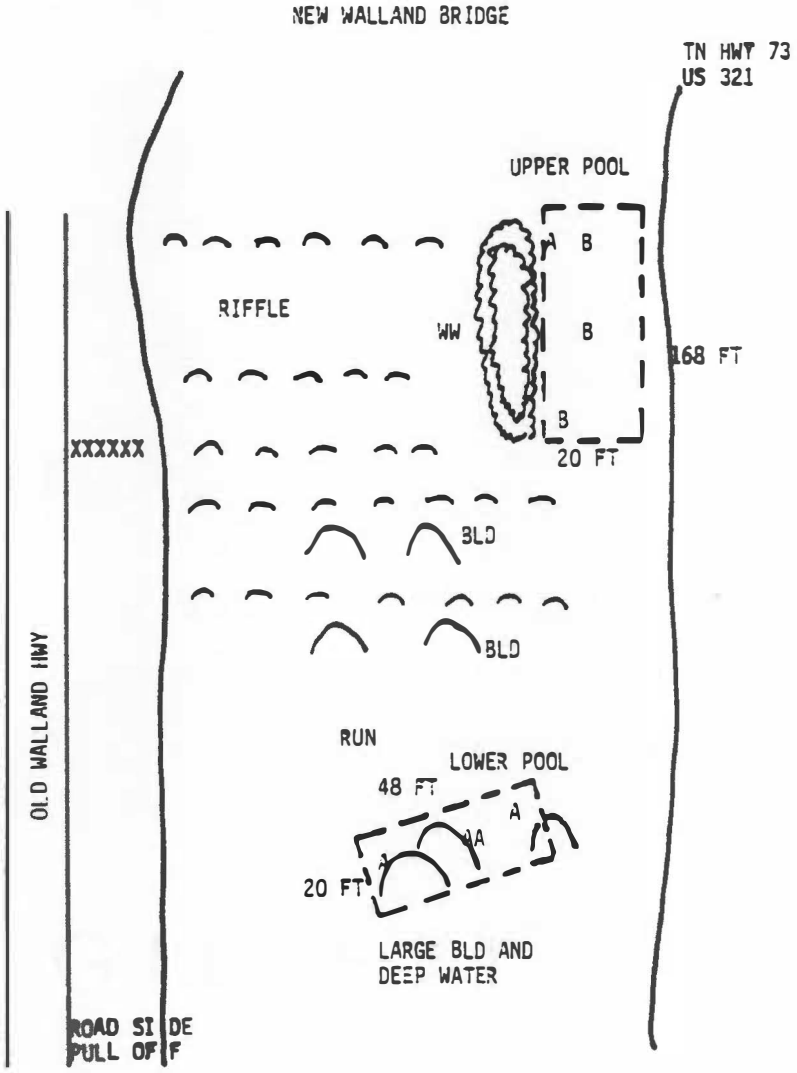


Diagram of site 10.

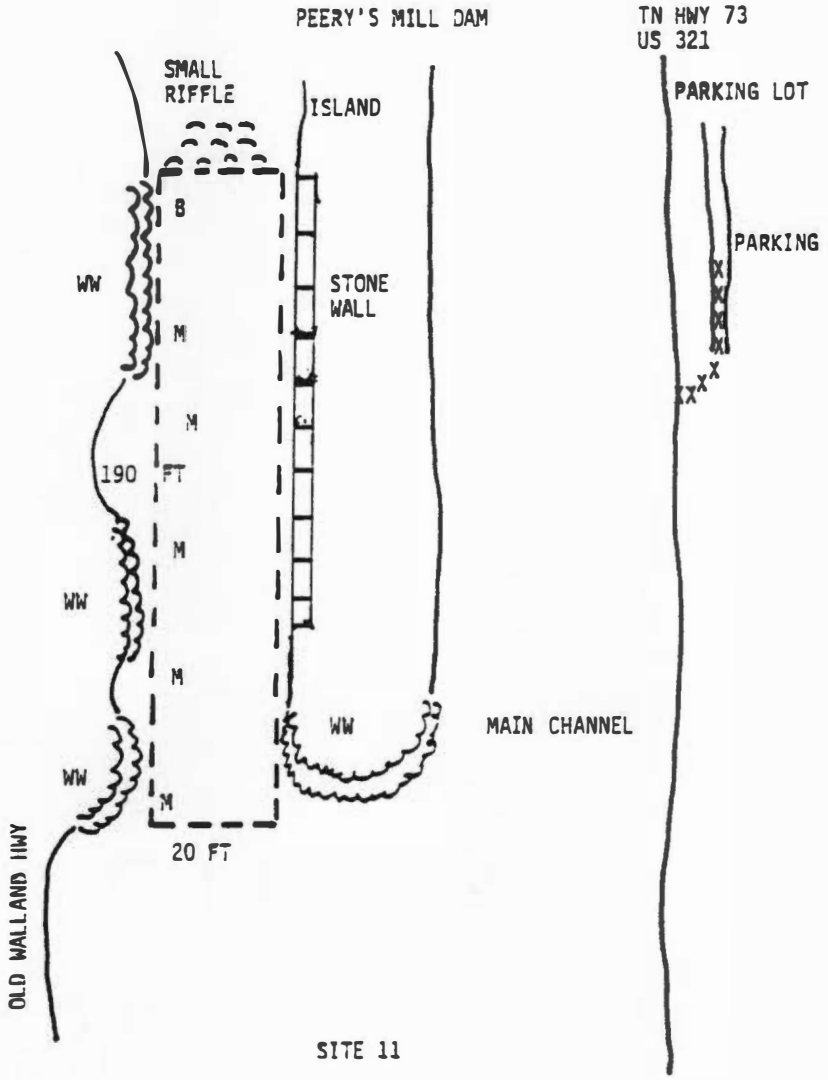


Diagram of site 11.

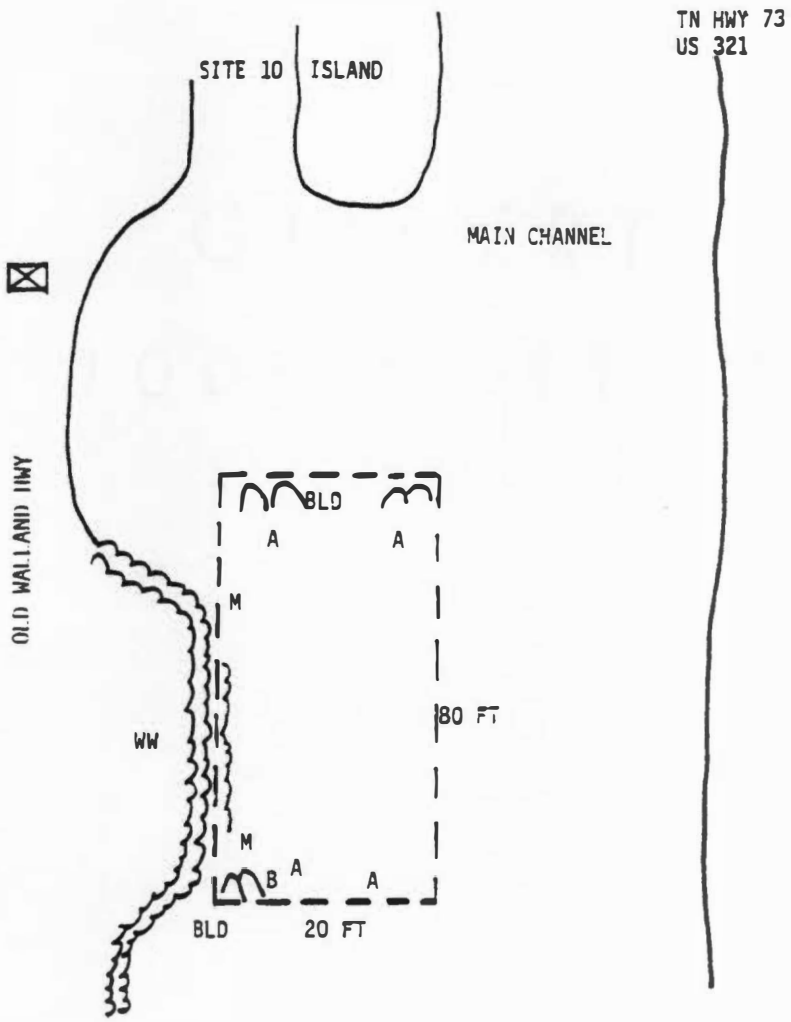


Diagram of site 12.

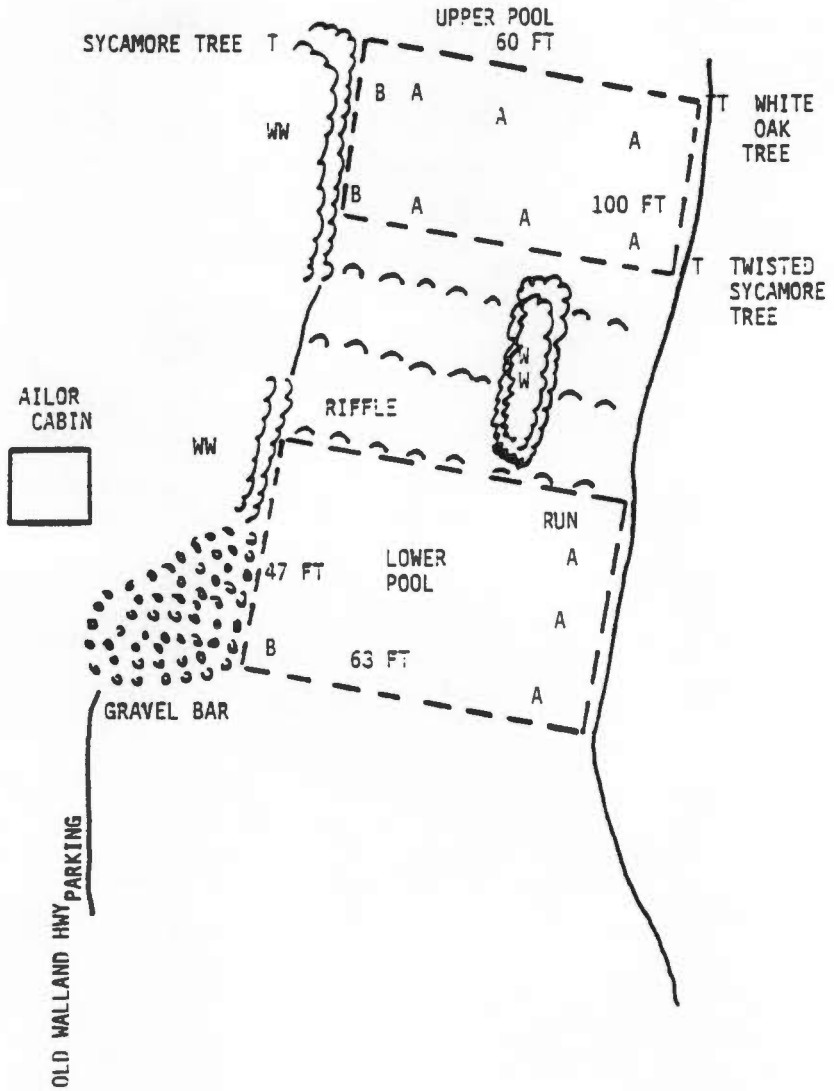


Diagram of site 13.

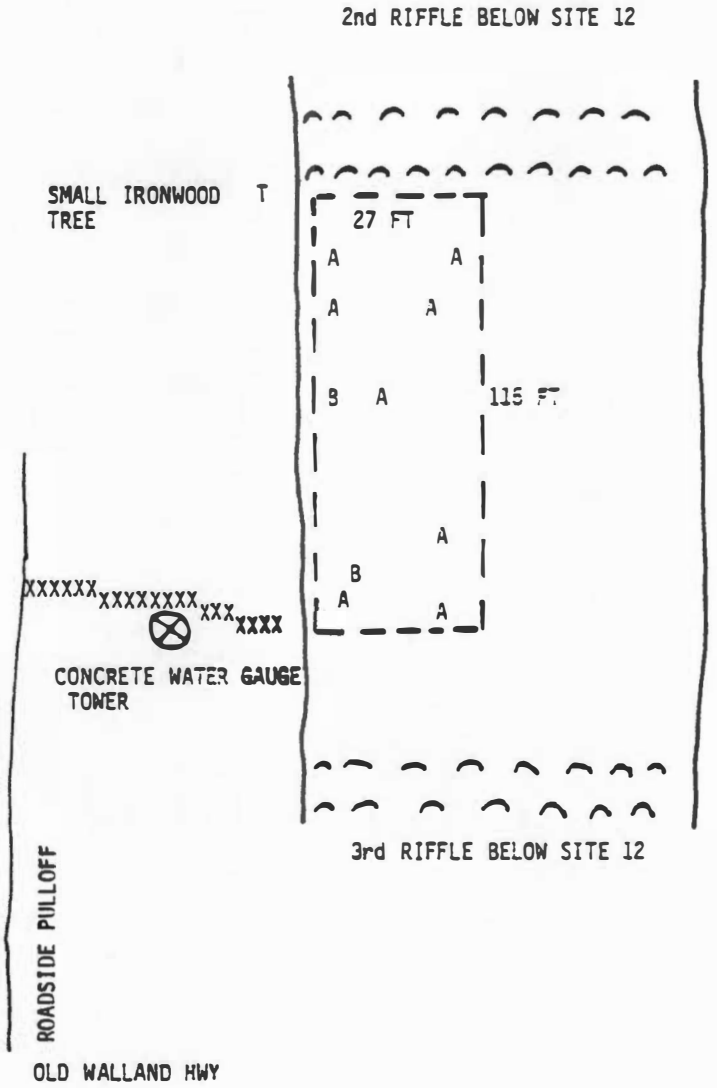


Diagram of site 14.

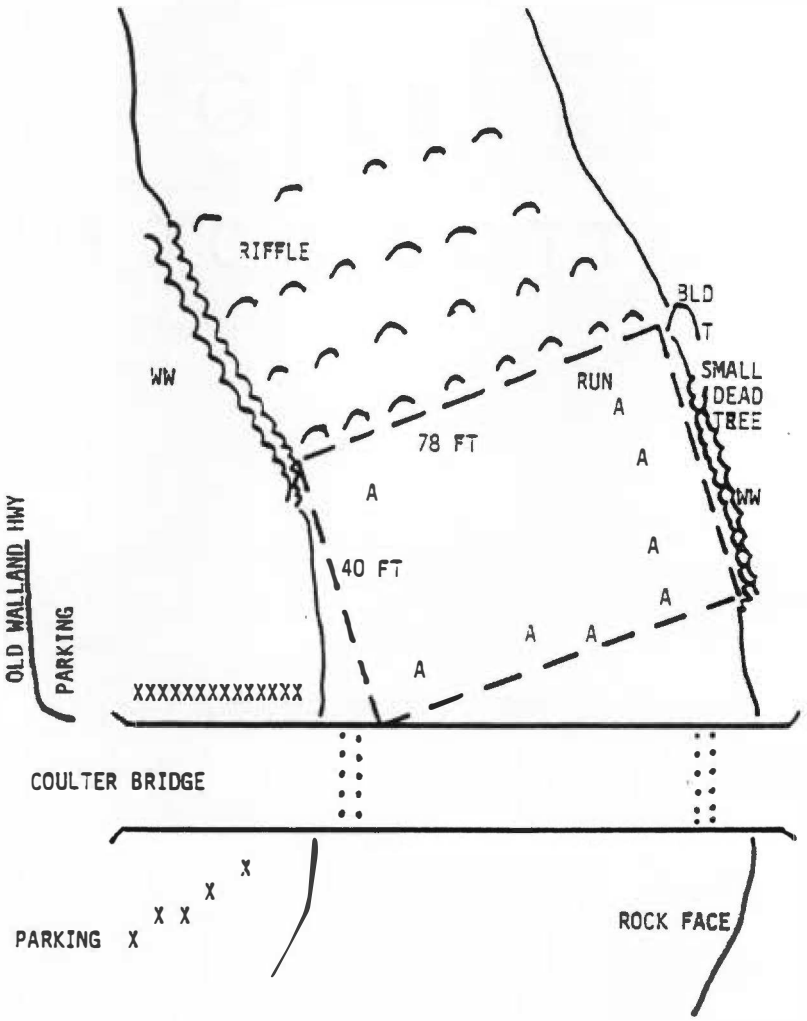


Diagram of site 15.

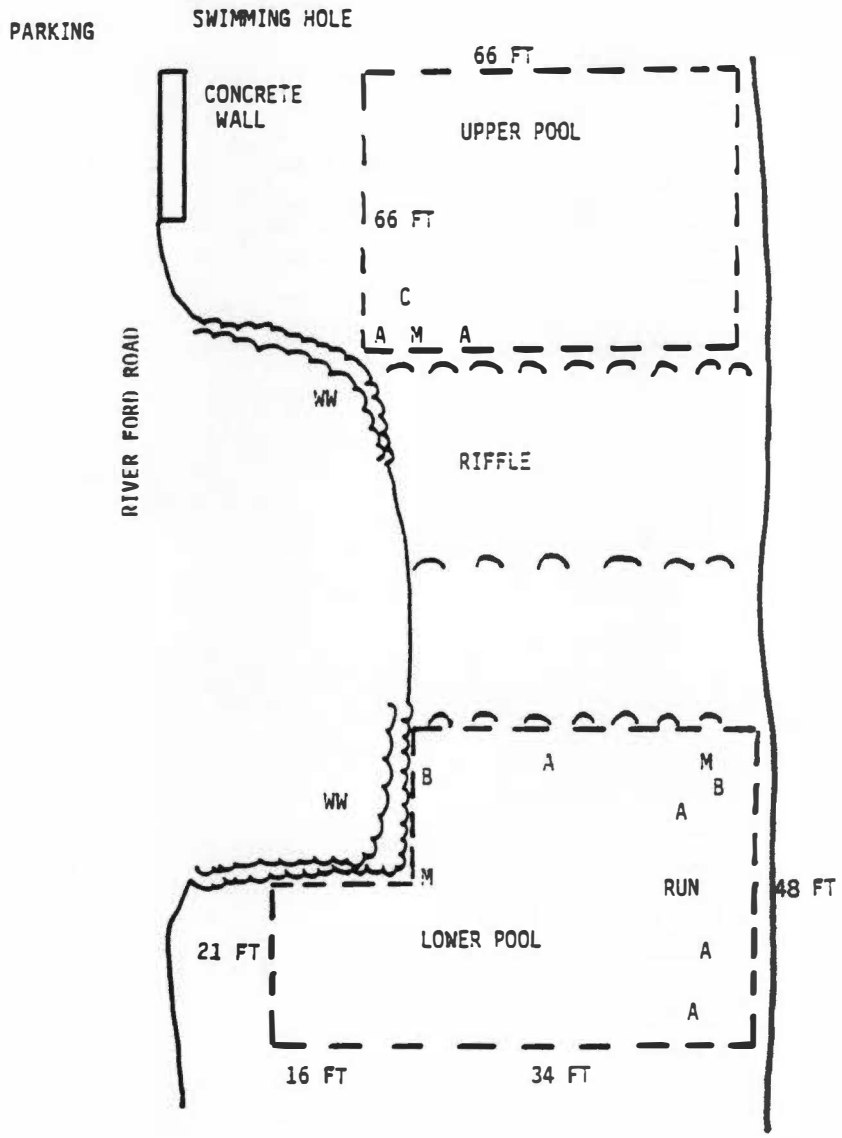


Diagram of site 16.

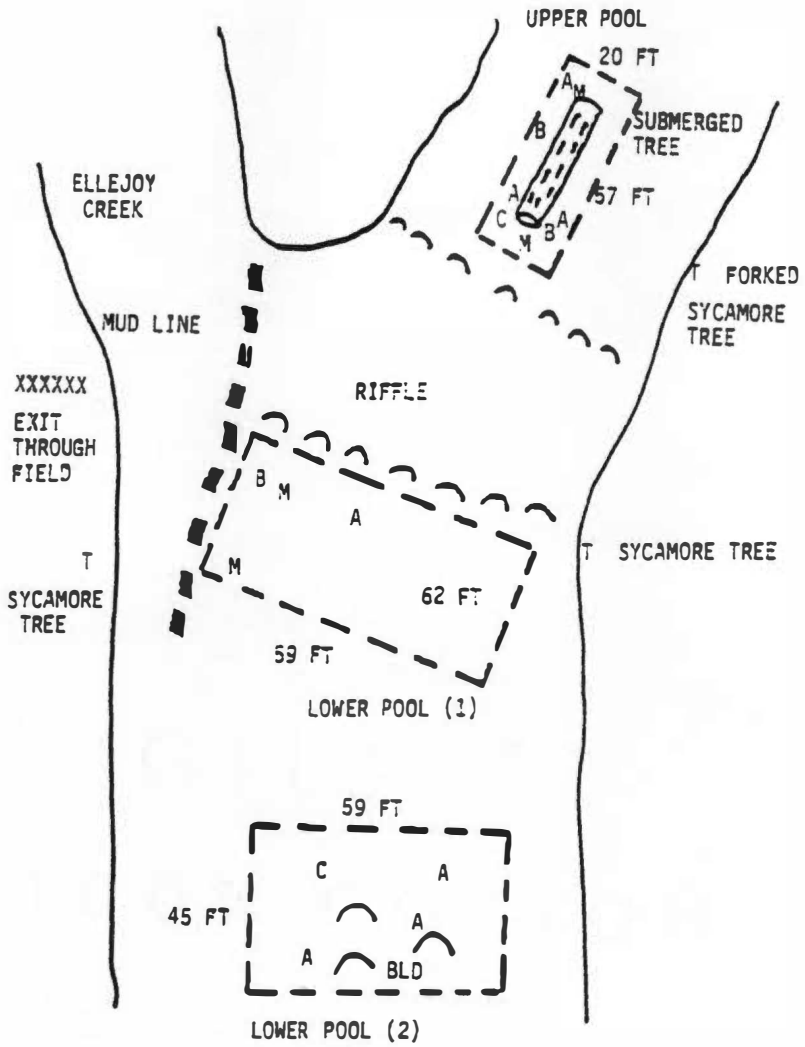


Diagram of site 17.

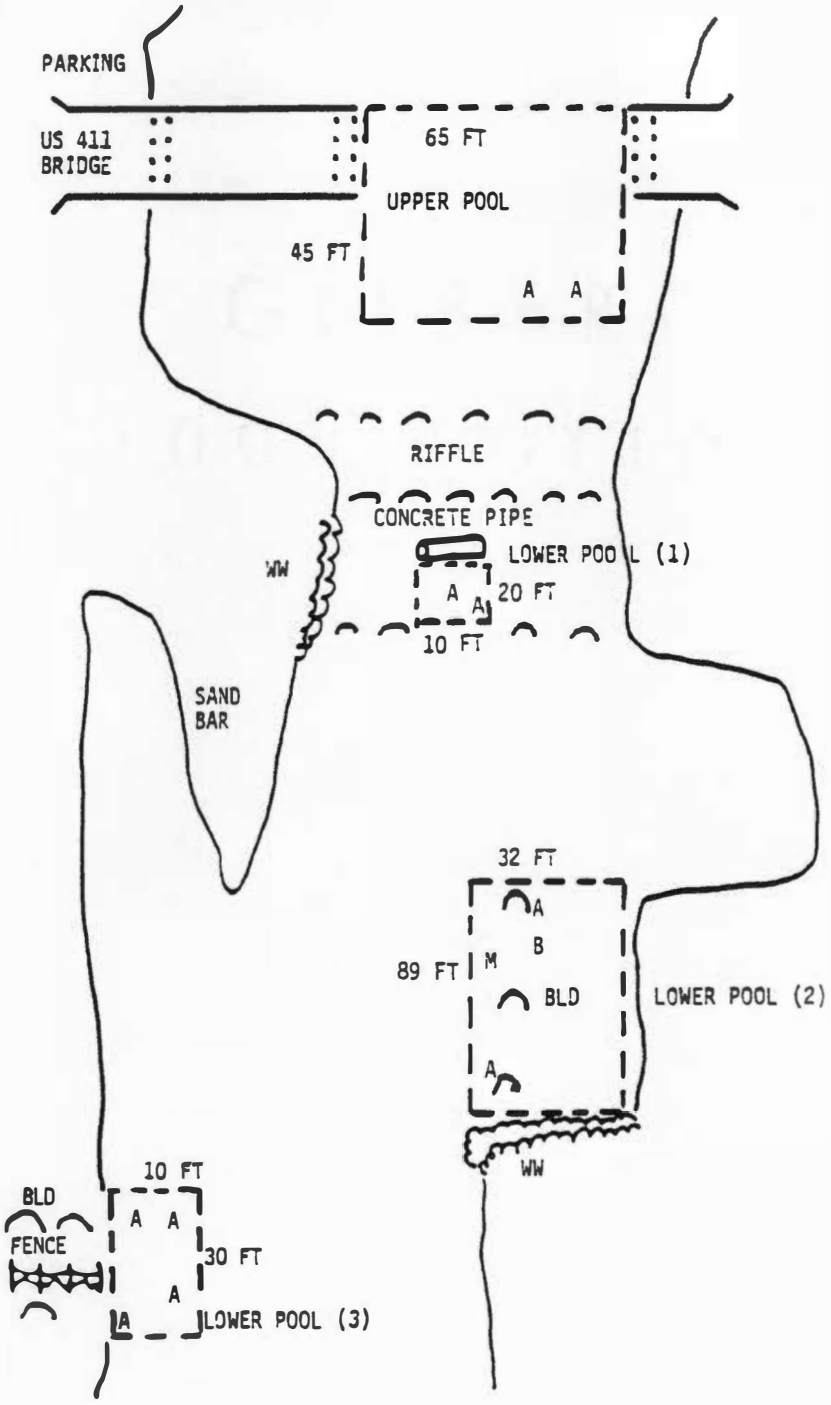


Diagram of site 18.

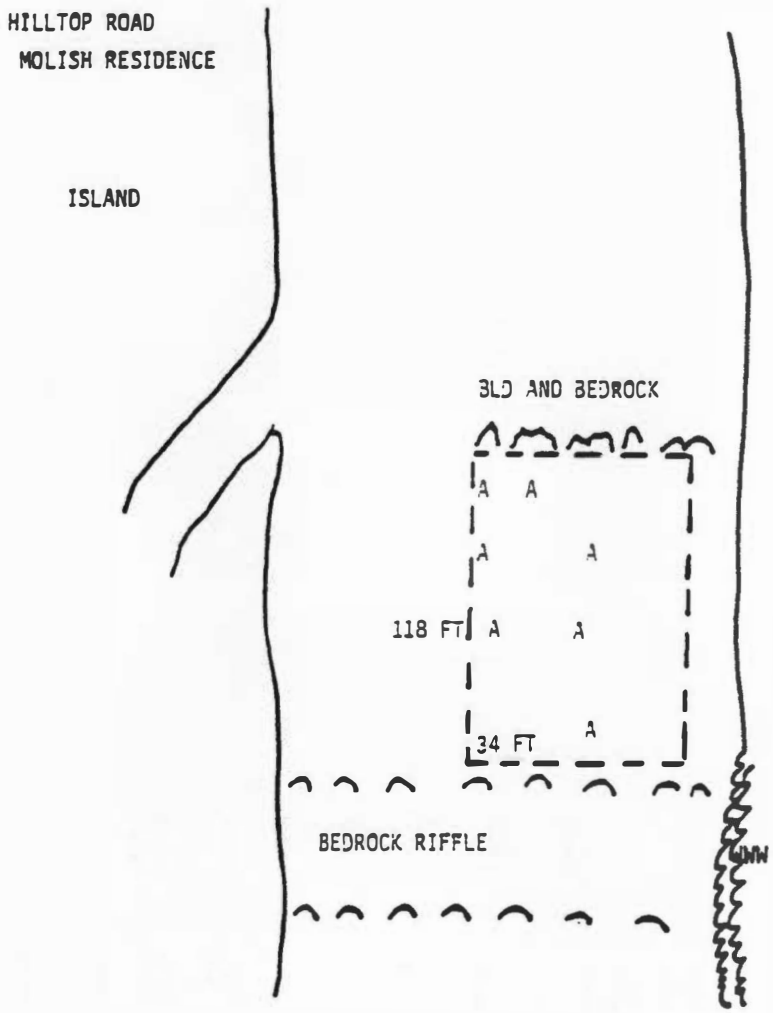


Diagram of site 19.

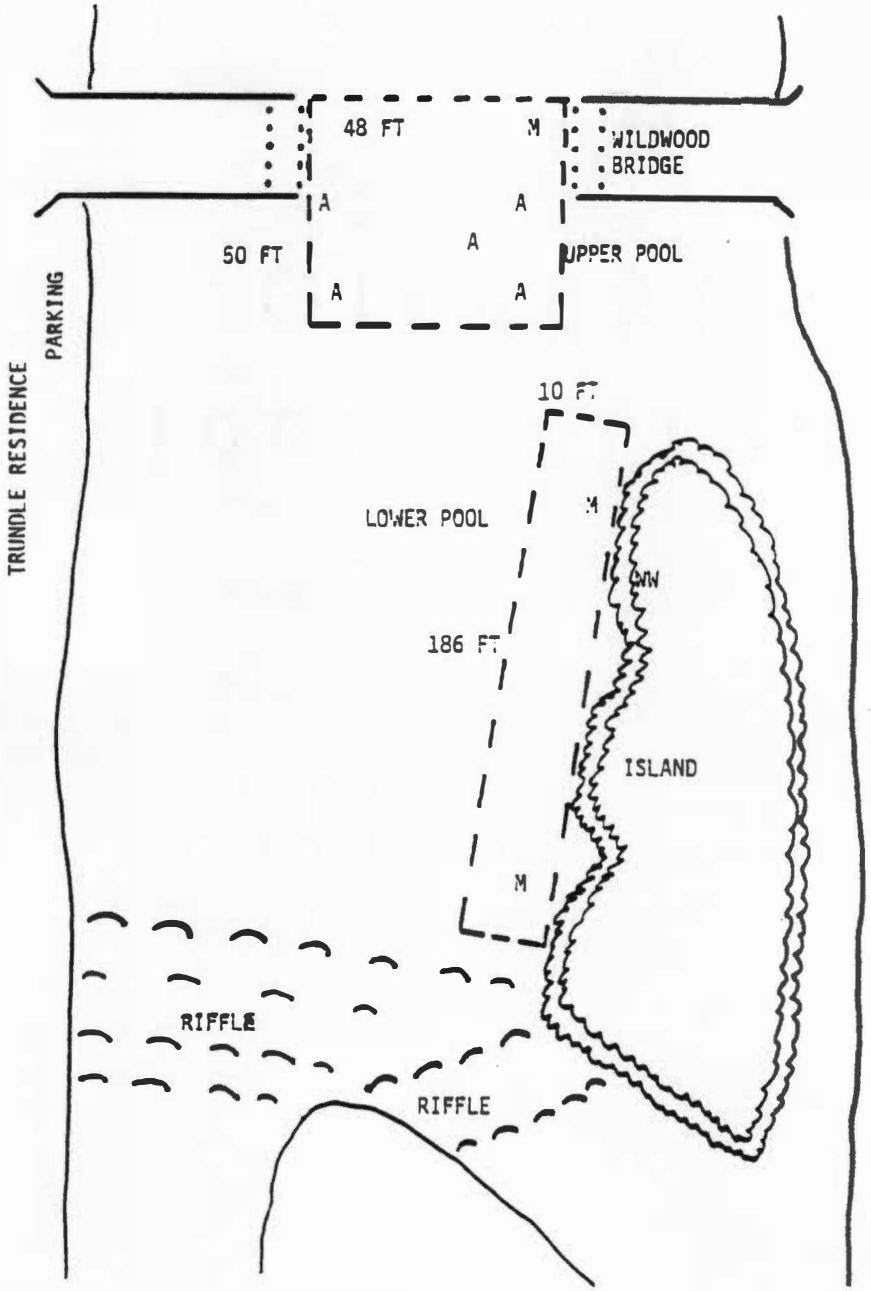
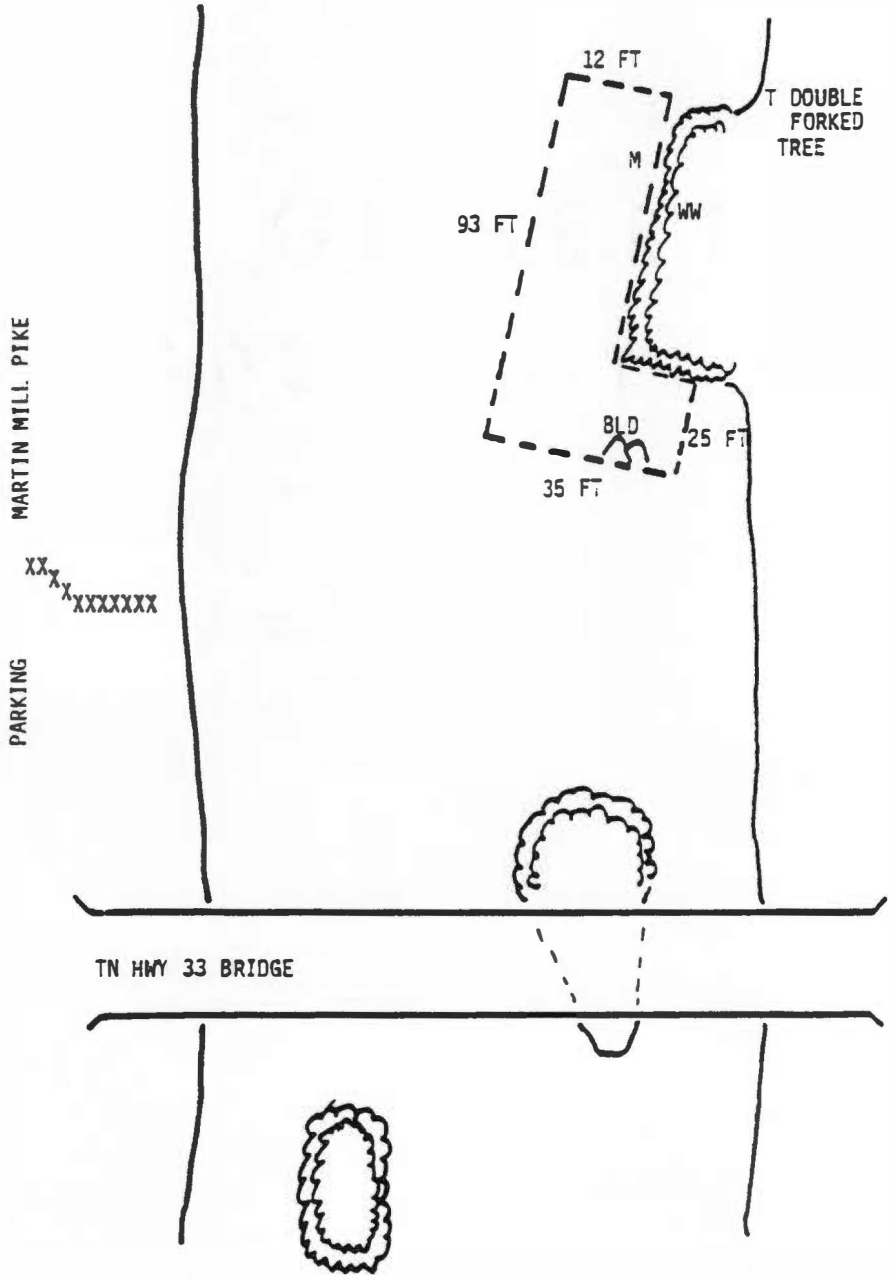


Diagram of site 20.



Appendix C

Photographs of sites 1-20.

The following are individual photographs of the 20 sites along Little River, Blount County, Tennessee. The photographs are of the single pool area or of the upper and lower pool areas. The upper pool is placed in the top position and the lower pool is placed in the bottom position. The viewing direction for each site is upstream; downstream views are indicated by a (D). Additional information is included for each site were applicable.

Photograph of the single pool at site 1.

Photographs of the upper (D) and lower pools at site 2.

Photograph of the single pool at site 3 (D).

Photograph of the single pool at site 4.

Photograph of the single pool at site 5 (D).

Photographs of the upper (D) and lower (D) pools at site 6.

Photographs of the upper and lower (D) pools at site 7.

Photograph of the single pool at site 8, site 7 lower pool (background).

Photographs of the upper (D) and lower pools at site 9.

Photographs of the single pool at site 10, upper end (top, D) and lower end (bottom).

Photograph of the single pool at site 11 (D).

Photographs of the upper and lower pools at site 12.

Photograph of the single pool at site 13.

Photograph of the single pool at site 14.

Photographs of the upper (D) and lower (D) pools at site 15, site 16 in background (bottom).

Photographs of the upper and lower (D) pools at site 16, site 15 in background (top).

Photographs of the upper and three lower pools at site 17. Note the center concrete pipe, the water willow beds on the left and the boulders in the background (bottom, D).

Photograph of the single pool at site 18 (D).

Photographs of the upper and lower (D) pools at site 19.

Photograph of the single pool at site 20 (D).

APPENDIX D

Additional Sightings of Three *Percina* Species

The fish were adjacent to the survey areas in Little River, Blount County, Tennessee, but omitted from the data. Data include the reconnaissance (R) and surveys 1-7, site number, number of specimens per species, and location remarks. Fish numbers are for adults and Y.O.Y. (young-of-the-year). Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Survey	Site	Individual fish			Remarks
		Pa	Pb	Pm	
R	8		1		small adult Reed Cr. mouth at new brg.
	12	3			pools at 2 riffles sites 12-13
	13	10	2		Pa in pools at 6 riffles sites 13-14 Pb in lwr pools 1st 2 riffs sites 13-14
	16	2			pools at 1st riffle below site 16
1	3	1			below pool in deeper water
	6	1	2		both below the lower pool
4	2	10			between the upper pool and waterfall
	9		1 Y.O.Y.		below the upper pool

Appendix D (continued)

Survey	Site	Individual fish Pa	Pb	Pm	Remarks
5	5	5 1 Y.O.Y.			both near boulders in upper pool
	10		1		pool enclosed in a wall, below the dam
	19			1	new formed pool after heavy rain
6	2	1			between upper pool and the waterfall
	5	1 1 Y.O.Y.	1 Y.O.Y.		all near boulders in upper pool
	13			4	between sites 13-14, Saylor, TVA
	14	11 8 Y.O.Y.			both in pool below brg. at rock face
	15	4			between site 15 and 16
	17	1 3 Y.O.Y.		2	Pa under left side of the bridge Pm in pool below riffle (UT 91.3069)
	19			1	new formed pool after heavy rain
7	12	28			in pools at 2 riffles btw. sites 12-13

Appendix D (continued)

Survey	Site	Individual fish			Remarks
		Pa	Pb	Pm	
7	15	5			pool between sites 15-16
	17	1			above the riffle
				4	area between sandbar & 3rd lower pool
				4 Y.O.Y.	

APPENDIX E

Total Adult Sightings During the Reconnaissance

Reconnaissance sightings of three adult *Percina* species in Little River, Blount County, Tennessee. Data include the site number, date completed in 1993, and individual and all adult fish sighted. Pa=*P. aurantiaca*, Pb=*P. burtoni*, and Pm=*P. macrocephala*.

Site	Date Month	Day	Individual adult fish			All adult fish observed
			Pa	Pb	Pm	
1	June	25	2	0	0	2
2	July	6	12	0	0	12
3	June	25	10	5	0	15
4	June	25	10	0	0	10
5	July	6	4	0	0	4
6	June	25	3	1	0	4
7	June	24	1	4	0	5
8	June	24	11	4	0	15
9	June	24	3	2	0	5
10	June	19	0	0	4	4
11	June	19	2	0	0	2
12	June	12	12	4	0	16
13	June	12	2	1	0	3
14	June	12	1	0	0	1
15	June	11	2	0	0	2
16	June	11	4	0	0	4
17	June	10	0	0	0	0
18	July	20	4	0	0	4
19	June	9	0	0	0	0
20	June	8	0	0	1	1
Total			83	21	5	109

Appendix F

A List of the Distribution of Three *Percina* Species and Their Most Recent Occurrence

Data include the major drainage systems and tributaries, by state, for *Percina aurantiaca*, *P. burtoni*, and *P. macrocephala*. The most recent collection date is listed for each river, and the sources (note) of information are listed as a number and found at the end. State abbreviations are AL=Alabama, GA=Georgia, KY=Kentucky, NY=New York, NC=North Carolina, OH=Ohio, PA=Pennsylvania, TN=Tennessee, VA=Virginia, and WV=West Virginia.

Species: *P. aurantiaca*

State	Major river drainage	Tributaries		Date	Note
GA	Tennessee	Hiwassee R.		1981	1
			Willscott Cr.	1981	1
			Little R.	1981	1
			Star Cr.	1975	2
			Toccoa R.	1992	1
NC	Tennessee	Holston R.	Watauga R.	1991	2
		French Broad R.			
			Big Laurel Cr.	1972	3
		Pigeon R.		1990	4
		Nolichucky R.		1991	3
			Cane R.	1991	2
			North Toe R.	1993	3
		Little Tenn. R.		1993	3
			Hazel Cr.	1989	2
			Nolan Cr.	1990	2
			Cheoah R.	1965	3
		Hiwassee R.	Valley R.	1968	3
			Hanging Dog Cr.	1964	3
TN	Tennessee	Holston R.		1992	5

Appendix F (continued)

State	Major river drainage	Tributaries		Date	Note
TN	Tennessee	Holston R.	Watauga R.	1988	6
			Doe Cr.	1977	2
			North Fork	1991	5
		French Broad R.		1877	6
			Nolichucky R.	1991	2
		Little Pigeon R.			
			Middle Prong	1994	2
		Little R.		1994	7
		Little Tenn. R.			
			Tellico R.	1978	6
		Clinch R.		1994	2
			Powell R.	1989	2
			Emory R.	1994	2
			Clear Cr.	1981	2
			Obed R.	1968	2
			Daddy's Cr.	1982	2
		Whites Cr.		1981	2
		Piney R.		1969	2
		Hiwassee R.		1981	6
VA	Tennessee	Holston R.	South Fork	1970	8
			Laurel Cr.	1992	9
			North Fork	1995	4
			Big Moccasin Cr.	1984	10
		Clinch R.		1993	9
			Little R.	1993	9
			Guest R.	1947	8
			Copper Cr.	1993	9
			Powell R.	1981	10

Species: *P. burtoni*

AL	Tennessee	Paintrock R /Larkin Fork		1994	11
KY	Cumberland	Big South Fork		1893	12
NC	Tennessee	French Broad R.		1974	13
			Swannanoa R.	1968	6
			Cane Cr.	----	14

Appendix F (continued)

State	Major river drainage	Tributaries		Date	Note
NC	Tennessee	Nolichucky R.		1980	15
			South Toe R.	1991	14
TN	Tennessee	Holston R.	North Fork	1994	4
			Big Cr.	1995	2
		French Broad R.		1934	2
		Little R.		1994	7
		Little Tn. R.			
			Abrams Cr.	1957	6
			Tellico Res.	1975	2
		Hiwassee R.		1975	6
			Spring Cr.	1994	11
		Estill Fork		1980	11
		Shoal Cr.		1981	2
			Little Butler Cr.	1972	11
		Duck R.		1977	2
			Big Swan Cr.	1976	6
			Buffalo R.	1990	6
			Upper 48 Cr.	1971	6
			Green R.	1971	6
		White Oak Cr.		1983	2
	Cumberland	Wolf R.		1947	6
		Obey R.	Eagle Cr.	1891	6
VA	Tennessee	Holston R.	South Fork	1947	6
			North Fork	1993	9
			Laurel Cr.	1973	6
			Big Moccasin Cr.	1993	9
		Clinch R.		1993	9
			Little R.	1993	9
			Copper Cr.	1993	9
			Obey's Cr.	1970	10

Species: *P. macrocephala*

KY	Ohio	Big Sandy R.		1975	16
			Johns Cr.	1975	16

Appendix F (continued)

State	Major river drainage	Tributaries		Date	Note
KY	Ohio	Kinniconick Cr.		1981	17
		Kentucky R.		1893	12
		Green R.		1961	17
			Upper Green R.	1978	12
			Russel Cr.	1982	17
			Big Muddy Cr.	1963	6
		Barren R.		1959	6
			Salt Lick Cr.	1955	6
			Trammel Fork	1982	17
			Drakes Cr.	1892	6
		Cumberland		1893	18
			Little South Fork	1975	16
OH	Ohio	Wallhounding R.		1939	19
PA	Ohio	Allegheny R.		1991	20
			Conewango Cr.	1992	20
			Brokenstraw C.	1967	21
			Thompson Run	1979	20
			Hickory Cr.	1963	20
			French Cr.	1993	20
		Youghiogheny R.		1869	18
NY	Ohio	Allegheny R.		1978	18
			French Cr.	1937	21
NC	Tennessee	French Broad R.		1940	3
		Holston R.	Watauga R.	1974	6
TN	Tennessee	Holston R.	Watauga R.	1947	6
			Doe R.	1984	2
			South Fork	1947	6
		French Broad R.			
		Little Pigeon R.			
			West Prong	1967	2
			Walden Cr.	1943	6
		Little R.		1994	7
		Clinch R.	Powell R.		
			Indian Cr.	1893	6
			Emory R.	1975	6

Appendix F (continued)

State	Major river drainage	Tributaries		Date	Note
TN		Clinch R.	Rock Cr.	1971	2
	Tennessee	Duck R.		1978	2
			Buffalo R.	1978	6
	Cumberland	Obey R.	Eagle Cr.	1891	6
VA	Tennessee	Holston R.	South Fork	1947	8
			Middle Fork	1937	8
			North Fork	1995	4
		Clinch R.		1992	9
			Little R.	1967	8
			Copper Cr.	1992	10
WV	Ohio	Kanawha R.	Elk R.	1994	22

Sources:

1 Hartle, L. Univ. Georgia research collection records of fishes (pers. comm.).

2 Univ. Tenn. research collection records of fishes.

3 Beane, J. N.C. State Museum of Natural History research collection records of fishes (pers. comm.).

4 Saylor, C. F. TVA Water Management Division collection records of fishes (pers. comm.).

5 Hughes, M. H. 1994. The spatial and temporal distribution of fishes in the Holston River system of North Carolina, Tennessee, and Virginia. Ph.D. Dissert., Univ. Tenn., 538 p.

6 Shute, P. W. TVA Regional Natural Heritage Program records of fishes (pers. comm.).

7 Heacock, C. H. 1995. unpub. Masters thesis, Univ. Tenn.

8 Jenkins, R. E., and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland, 1079 p.

Appendix F (continued)

Sources:

9 Leftwich, K. N., P. L. Angermeier, and C. A. Doloff. 1994. Potential use of a closely related surrogate in assessing impacts of stream degradation on endangered fish species. Report to: Virginia Dept. of Game and Inland Fisheries, 38 p.

10 Jenkins, R. E. Roanoke College research collection records of fishes (pers. comm.).

11 Boschung, H. T. Univ. Alabama research collection records of fishes (pers. comm.).

12 Burr, B. M., and M. L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Kentucky Nature Preserves Commission Scientific and Technical Series No. 4, 398 p.

13 Menhinick, E. F. 1991. The freshwater fishes of North Carolina. N.C. Wildlife Resources Commission, Raleigh, 227 p.

14 Braswell, A. L. 1991. Scientific Council on the conservation status of North Carolina freshwater fishes. Submitted to: Nongame Advisory Committee of the North Carolina Wildlife Resources Commission, 128 p.

15 Etnier, D. A. 1994. Our Southeastern fishes--what have we lost and what are we likely to lose. Southeastern Fishes Council Proceedings No. 29: 5-9.

16 Clay, W. M. 1975. The fishes of Kentucky. Kentucky Dept. of Fish and Wildlife Resources, Frankfort, 416 p.

17 Burr, B. M. Dept. of Zoology, Southern Illinois Univ. at Carbondale research collection records (pers. comm.).

18 Page, L. M. 1978. Redescription, distribution, variation, and life history notes on Percina macrocephala (Percidae). Copeia 1978:655-664.

Appendix F (continued)

Sources:

19 Trautman, M. B. 1981. The fishes of Ohio. Ohio State Univ. Press, Columbus, 782 p.

20 Stauffer, J. R. Pennsylvania State University research collection records of fishes (pers. comm.).

21 Dardia, C. M. Cornell Univ. Ichthyology Collection records of fishes (pers. comm.).

22 Cincotta, D. West Virginia Dept. of Natural Resources, Wildlife Resources Division research collection records of fishes (pers. comm.).

VITA

Charles H. Heacock was born in the coastal town of Somers Point, New Jersey, on May 20, 1950. After moving to South Carolina in 1963, he graduated from Greenville High School in May 1968.

Charles attended Wingate College (N.C.) and earned an A.A. in Business Administration in August 1970. He earned a B.S. in Wildlife and Fisheries Science in August 1977 at the Univ. of Tenn. His most influential course was Ichthyology with Dr. David Etnier. He was a member of the U.T. Wildlife Society and worked with the aquatic biology lab at TVA.

Between 1977 and 1991, he had contract positions with the U.S. Forest Service and the National Marine Fisheries Service. He served in the U.S. Army for four years.

He has thoroughly enjoyed the challenge of completing a Masters degree in Zoology (Ichthyology). His studies have included reports on Little River clams and freshwater invertebrates, and a scanning electron microscope report using lateral line scales.

He is a member of the Southeastern Fishes Council, the American Society of Ichthyologists and Herpetologists, and the Association of Southeastern Biologists. Present plans include working with an aquatic ecology program and pursuing a Ph.D.