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Abstract

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Keywords

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BIOLOGY AND CONSERVATION OF THE SLACKWATER DARTER, ETHEOSTOMA BOSCHUNGI (PISCES:PERCIDAE)

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Abstract

The slackwater darter, Etheostoma boschungi, has a disjunct distribution in tributaries to the south bend of the Tennessee River in Alabama and Tennessee. The species requires two distinctly different, but necessarily adjacent, habitats in order to complete its life cycle. The non-breeding habitat is typically a slow-flowing stream with silt and gravel substrate and accumulations of organic detritus. The breeding habitat is winter seepage water in open pastures or wooded areas. The larvae, after reaching about 12 mm standard length (SL), return to adjacent streams. Lowering of the groundwater table and urbanization are threats to the survival of this species.

Introduction

The slackwater darter, Etheostoma boschungi, was described by Wall and Williams (1974) from specimens collected in Cypress Creek, Lauderdale County, Alabama; Flint River, Madison County, Alabama; and Buffalo River, Lawrence County, Tennessee. Although this species was originally placed in the subgenus Oligocephalus, Williams and Robison (1980) later erected a new subgenus (Ozarka) to contain E. boschungi, E. punctulatum, E. cragini, E. pallididorsum, and E. trisella. The species of Ozarka are medium-sized darters, ranging from 40-70 mm SL, that typically inhabit gentle riffles and slackwater areas of small to medium-size, shallow, upland tributary streams (Williams and Robison 1980).

Etheostoma boschungi differs from all other forms of Ozarka in having the following combination of characters: two anal spines; lateral line with 45-58 scales, 34-38 of which are pored; soft dorsal fin usually with 11-12 rays; a bold blue-black subocular bar; three prominent dorsal saddles; and 35-37 total vertebrae (Wall and Williams 1974; Williams and Robison 1980). In the field, specimens in the water can readily be identified by the three prominent saddles and wide subocular bar. Wall and Williams (1974) presented no evidence of significant variation in this species.

The following publications complete the bibliography on the slackwater darter: metabolism, critical oxygen tension, and habitat selection (Ultsch et al. 1978); an account of the species in the Atlas of North American Freshwater Fishes (Boschung 1980); an abstract on life history notes (Boschung 1979a); and papers proposing to recognize the species as threatened or endangered in Alabama (Ramsey 1976), in Tennessee (Starnes and Etnier 1980), and nationally (Deacon et al. 1979). Page (1983), Kuehne and Barbour (1983), and Boschung et al. (1983) each included an account and color photograph of E. boschungi in their books. Data presented in the present paper are mostly from reports by Boschung (1976, 1979b) to the U.S. Department of Agriculture (USDA) and the Soil Conservation Service (SCS), and the Slackwater Darter Recovery Plan (Boschung 1984) for the U.S. Fish and Wildlife Service. Since these reports have limited distributions in the scientific community, a compendium of our knowledge of the biology and conservation of the slackwater darter is presented here.

Distribution and Habitat

Distribution. The slackwater darter is only known from five streams, all tributary to the south bend of the Tennessee River: (a) Buffalo R. system, Lawrence Co., TN: South Fork, 15.8 km N of Lawrenceburg, at U.S. hwy 43 and upstream; Chief Cr., at TN hwy. 20, about midway between Henryville and Center; (b) Cypress Cr. watershed (exclusive of Little Cypress Cr.), Wayne Co., TN, and Lauderdale Co., AL; (c) Shoal Cr., Lawrence Co., TN, near Lawrenceburg (one collection; Page 1983); (d) Swan Cr., Limestone Co., AL, near Athens, and (e) Flint R. system, Madison Co., AL: Copeland Branch on West Limestone Rd; West Fork at U.S. hwy. 431; Briar Fk. at U.S. hwy. 431 (Fig. 1).

The physiographic area occupied by Etheostoma boschungi is the Highland Rim of the Nashville Basin. Congeners more or less limited to this area include E. blennius, E. duryi, and E. tuscumbia. With the exceptions of Flint River and Swan Creek, current distribution of the slackwater darter is restricted to those headwater streams rising from the highlands of Lawrence and Wayne counties, TN. The darter is not known from Elk River, the largest tributary in the south bend of

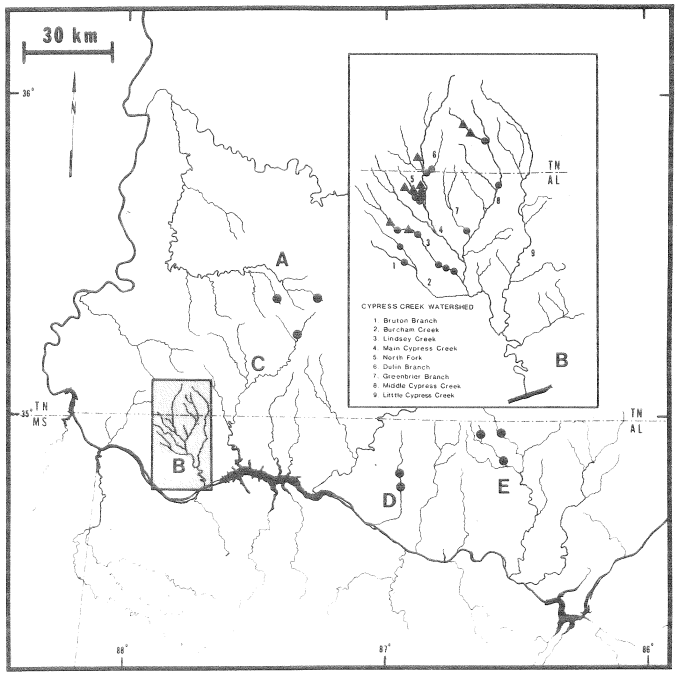

Figure 1. South bend of Tennessee River, Alabama and Tennessee. A - Buffalo River, B. Cypress Creek (and inset), C - Shoal Creek, D - Swan Creek, E - Flint River. Dots indicate localities for Etheostoma boschungi. Triangles on Cypress Creek inset indicate known breeding habitats.

the Tennessee River, even though the Elk is situated between the Buffalo and Flint rivers, streams in which the darter does occur. It also is not known from southern tributaries to the south bend of the Tennessee River.

Origin. Etheostoma boschungi may be derived from parental Ozarkian stock from Arkansas and Missouri, and probably evolved following isolation resulting from some vicariant event, such as formation of the Mississippi embayment. The five disjunct populations are probably remnants of a past continuous and more ubiquitous distribution. Possible reasons for reduction in geographic distribution of the species are discussed later in this paper.

Non-breeding habitat. The slackwater darter's non-breeding habitat comprises small (60 cm wide and 15 cm deep) to moderately large (12 m wide and up to 2 m deep) streams. Current is usually slow, ranging from still to 0.34 m/sec. under normal conditions. In small streams, individuals show no position preference; however, in larger streams, such as Lindsey Creek, they seem to be situated near banks or in bank undercuts. They also occur over gravel infiltrated by silt, over silt and mud, or over a combination of these, but have not been observed over clean gravel in swift streams, or in swift areas. The species shows a preference for accumulations of detritus, such as small twigs and rotting leaves, but not for large masses of newly-fallen, compacted leaves. Apparently their migrations are not impeded by moderate riffles or shallow water. Oxygen does not seem to be a habitat-limiting factor, inasmuch as individuals are tolerant of rather low oxygen levels; they inhabit water during the summer that would not be habitable without a downward shift in critical oxygen tension (Ultsch et al. 1978). Physical nature of the stream probably is the main factor limiting the distribution of this species.

Breeding habitat. The breeding habitat of the slackwater darter invariably is seepage water in open fields and woods. Water in these places is usually about 4 to 8 cm deep, and flows slowly into an adjacent stream. Since the breeding site typically is 30-45 cm above the adjacent stream, the stream must periodically rise to provide ripe darters access to their breeding grounds.

Locations and characteristics of the known breeding sites, all in the Cypress Creek watershed, are as follows: (1) AL, Lauderdale Co., Elijah Branch, trib. to North Fork of Cypress Cr.; Threet, AL quadrangle, T1S, R12W,S12; elev. 680 ft.; soil type, Lee cherty silt loam; water source, wet weather seepage; vegetation, open pasture, with Juncus and Eleocharis; (2) AL, Lauderdale Co., off North Fk. of Cypress Cr.; Threet, AL quadrangle, T1S,R12W,S8; elev. 655 ft.; soil type, Lee and Lobelville cherty loam; water source, wet weather seepage; vegetation, semi-wooded, partly open, sparse sweetgum and beech, Panicum and Festuca; (3) AL, Lauderdale Co., trib. to main Cypress Cr.; Threet, AL quadrangle, T1S,R12W,S8; elevation 640 ft.; soil type, Staffell and Bodine, Etowah silt loam, Lee cherty silt loam; water source, wet weather seepage and spring; vegetation, wooded, partly open, mixed hardwoods, Festuca; (4) AL, Lauderdale Co., off Lindsey Cr.; Threet, AL quadrangle, T1S, R13W,S24; elev. 695 ft.; soil type, Lobelville cherty silt loam; water source, wet weather seepage; vegetation, wooded, sweetgum and red maple; (5) AL, Lauderdale Co., off Lindsey Cr.; Threet, AL quadrangle, T1S,R12W,S29; elev. 620 ft.; soil type, Lee cherty silt loam; water source, wet weather seepage; vegetation, wooded, river birch, alder, sweetgum, willow, Eleocharis, Fontinalis; (6) TN, Wayne Co., trib. to main Cypress Cr., ca. 0.5 mi. NW of Cypress Inn, Cypress Inn; TN-AL quadrangle; elev. 690 ft.; water source, wet weather seepage; vegetation, open pasture, Juncus, Eleocharis, Festuca; (7) TN, Wayne Co., Middle Cypress Cr., ca. 4 mi. NE of Cypress Inn, Cypress Inn; TN-AL quadrangle; elev. 830 ft.; water source, spring and seepage; vegetation, open pasture, Juncus, Eleocharis, Ranunculus; (8) TN, Wayne Co., Middle Cypress Cr., ca. 4 mi. NE of Cypress Inn, Cypress Inn; TN-AL quadrangle; elev. 840 ft; water source, wet weather seepage and spring; vegetation, open pasture, Juncus and Callitriche.

Essential habitat. Both the non-breeding and breeding habitats described above are necessary for sustaining populations of Etheostoma boschungi. Obviously these two distinctly different habitats must be adjacent. It appears that the limiting factor relative to reproductive success is the breeding habitat. The declining groundwater table probably has adversely affected the number of breeding sites, and thus has limited the geographical distribution of the species.

Figure 2. Eggs of Etheostoma boschungi on submersed leaves of rush (Juncus sp.).

Life History Aspects

Reproduction. The sequence of events in the reproductive chronology of the slackwater darter was observed in the Cypress Creek watershed during 1978-1979 as follows:

10 November-31 January - adults aggregate for spawning migration, nuptial colors developing, gametes developing; 10 January-10 February - spawning migration; 20 January-28 February - nuptial colors reach maximum development, gametes fully developed; 31 January-10 March - adults reach breeding habitat; 20 February- 20 March - territoriality and courtship; 28 February- 31 March - spawning activity; 20 March-30 April - larvae develop in breeding habitat; 20 April-31 May - larvae leave breeding habitat.

Exact timing of the above undoubtedly varies from year to year, depending upon temperature and rainfall. There is no evidence of spawning when water temperatures are less than 14°C. Observations on North Fork of Cypress Creek suggest strongly that slackwater darters assemble in certain places downstream of the breeding site, and then make a unified final surge to the spawning area. This behavior permits the entire breeding deme to take advantage of a single high-water event that will "lift" the darters into the spawning area.

The spawning act has not yet been observed; however, a male was observed "guarding" a clump of rush (Juncus sp.). His behavior was aggressive, as he attacked a straw probe placed nearby. Several days after this observation, eggs were found on the Juncus that had been guarded by the male. These were arranged either singu-

larly or in two's or three's (Fig. 2).

Fecundity. Estimates were made of the number of eggs produced per female. Three specimens averaged 320 ripe eggs; however, another had approximately 1000 eggs in some stage of development. Based on a cursory inspection of swimming larvae, the annual replacement potential is impressive.

Growth. The initial growth period is rather rapid. Specimens in early April are about 10-12 mm SL, but by early June have doubled in length. By the end of the first year, most are 28-32 mm SL. Year-round length-frequency data are not available, but it appears that most specimens collected at any given time are either in the 1- or 2-year class. We believe that few, if any, live more than three years. The largest known specimen is 65 mm SL. Growth-rate data appear in Figure 3.

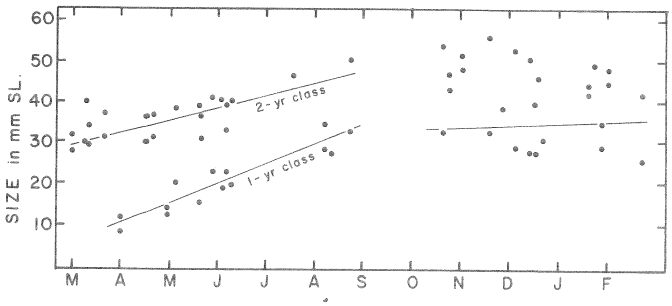

Figure 3. Distribution of minimum and maximum sizes of Etheostoma boschungi, 1 March to 20 February. N = 339.

Food. Stomachs of 80 specimens of E. boschungi, 25 mm SL or greater, were examined (Table 2). Thirty were from breeding habitats from the Cypress Creek watershed, whereas the remainder were from various non-breeding habitats throughout the same area. The overlap between diets of slackwater darters occupying the two habitats was quantified, using Pianka's (1973) equation in which zero indicates no overlap and one indicates complete overlap. The value obtained was 0.135, which indicates little similarity between diets. It is obvious that this darter is capable of shifting its diet concomitant with a shift in habitat.

Species Associates. The following forty fish species in 12 families are known to occur with E. boschungi: Ichthyomyzon gagei, Lampetra aepyptera (Petromyzontidae), Esox americanus, E. niger (Esocidae), Campostoma anomalum, Clinostomus funduloides, Hemitremia flammea, Nocomis micropogon, Notropis ardens, N. c. chrysocephalus, N. coccogenis, N. fumeus, N. telescopus, Phoxinus erythrogaster, Pimephales notatus, Rhinichthys atratulus, Semotilus atromaculatus (Cyprinidae), Catostomus commersoni, Erimyzon oblongus, Hypentelium nigricans, Moxostoma duquesnei, M. erythrurum (Catostomidae), Ictalurus natalis (Ictaluridae), Aphredoderus sayanus gibbosus (Aphredoderidae), Fundulus catenatus, F. olivaceus (Cyprinodontidae), Gambusia a. affinis (Poeciliidae), Ambloplites rupestris, Lepomis cyanellus, L. macrochirus, L. megalotis, Micropterus dolomieui, M. punctulatus, M. s. salmoides (Centrarchidae), Etheostoma caeruleum, E. duryi, E. flabellare, E. simoterum, E. cf. squamiceps (Percidae), Cottus carolinae (Cottidae). The most common associates of the slackwater darter are (in order of percent occurrence): Clinostomus funduloides, Etheostoma cf. squamiceps, Campostoma anomalum, E. flabellare, E. duryi, Hypentelium nigricans, and Fundulus olivaceus. As expected, the least frequent associates are large-stream inhabitants, such as species of the genera Moxostoma and Micropterus.

Predators. Although many fish species may possibly prey on slackwater darters should the occasion arise, green sunfish (Lepomis cyanellus) and pirate perch (Aphredoderus sayanus) were the only fishes actually found to have slackwater darter remains in their stomachs.

Conservation

Population size. Those populations of slackwater darters outside the Cypress Creek watershed appear to be small in terms of numbers of individuals, probably because of a paucity of essential habitat. A total of only 89 specimens are known from 8 localities in 4 stream systems outside Cypress Creek. Of these, 41 were collected (20 subsequently released) from Copeland Branch (Flint River system) on 24 October 1970; however, subsequent attempts to find specimens at this site and elsewhere in Flint River have failed.

TABLE 1

Stomach contents of Etheostoma boschungi from Cypress Creek watershed, Alabama and Tennessee

	Percent of Stomachs in which Food Organisms occurred			Mean Number of Food Organisms per Stomach		
	Non-breeding Habitat	Breeding Habitat	Total	Non-breeding Habitat	Breeding Habitat	Total
	N=50	N=30	N=80	N=50	N=30	N=80
Crustacea						
Ostracoda	....	6.67	2.50	....	0.07	0.03
Copepoda	....	3.33	1.25	....	3.40	1.28
Isopoda	....	23.33	8.75	....	0.30	0.11
Amphipoda	....	36.67	13.75	....	1.50	0.56
Decapoda	....	.....	3.75	0.06	....	0.04
Insecta						
Ephemeroptera	46.0	30.00	40.00	0.62	0.43	0.55
Trichoptera	4.0	.....	2.50	0.08	....	0.05
Coleoptera	2.0	6.67	3.75	0.02	0.07	0.04
Diptera	6.0	20.00	11.25	0.12	0.47	0.25

Cypress Creek, exclusive of Little Cypress Creek, is the stronghold of the slackwater darter, and we had earlier estimated its numbers there to be around 3,600 (Boschung 1976). In December 1978, we attempted to estimate the population size in Cemetery Branch, a tributary to North Fork of Cypress Creek. Cemetery Branch is near three known breeding sites. Mark-and-recapture studies in a 27 m long section of stream resulted in a population estimate between 103 and 195. It must be pointed out, however, that estimating numbers of slackwater darters is difficult because of the tendency of this species to congregate. In this instance, the group was assembled in a relatively small area, unable to proceed with its upstream migration to the spawning grounds until rains came that would enable flood waters to lift individuals over barriers. Thus, the above population estimate for this small section of stream certainly should not be regarded as representative of population size of the species throughout its range, or even within the Cypress Creek watershed itself. Overall, we think that its numbers in places other than Cypress Creek are dangerously low.

Threats to survival. The factor that appears to limit the abundance and distribution of the slackwater darter is suitable habitat. Habitat has undoubtedly decreased in both quality and quantity during the past 200 years because of man's activities. The remaining refuges are subject to a number of threats:

1. Spreading urbanization is a potential threat to the physical integrity of habitats. Homes, shopping centers, and industrial parks must be built away from essential habitats. The building of ditches designed to drain areas with shallow ground water is also a threat. Farming and cattle raising are the principal industries surrounding the darter's habitat. Since the breeding habitats are so limited, even a small chemical spill or biological pollutant could exterminate a breeding population.

2. Degradation of surface and ground water caused by toxins, pesticides, fertilizers, industrial and domestic wastes from sewage lines and septic tank seepage, and stockyard runoff are very real threats to E. boschungi.

3. Slackwater darter breeding habitats are "logical" sites for farm fish ponds. Much of the year the sites are too wet to plow, and since they abound in rush and spike-rush (Eleocharis sp.), they are undesirable areas for pasture. Probably a number of breeding sites for E. boschungi are now inundated by farm ponds.

4. On occasion, breeding sites may be destroyed by beaver ponds, as happened in the case of the first slackwater darter breeding site discovered, on Bruton Branch of Burcham Creek. Although farmers usually will destroy beaver dams, in the above instance this was left intact.

5. The U.S.Department of Agriculture, Soil Conservation Service has been studying the Cypress Creek water-

shed for a number of years relative to flood control. Studies by Boschung (1976, 1979b) were utilized in the decision to revise the SCS's original plan. The final watershed plan was developed in concert with other federal agencies, including various offices of the U.S. Fish and Wildlife Service, to ensure that the results of SCS's flood-control plan will not adversely affect the slackwater darter.

Conservation measures. Habitat preservation obviously is of prime importance in conservation of the slackwater darter. The fact that it inhabits relatively small to moderate-sized streams may be regarded as an advantage; such streams are easily monitored, and the disjunct occurrence of populations makes the species less subject subject to widespread eradication resulting from a major ecological disaster (e.g., a massive chemical or oil spill) than would be true for a big-river species. On the other hand, reproductive success of this fish is dependent more than for most species upon maintenance of proper groundwater levels, which are not easily controlled. Intelligent water conservation methods are required, which should not involve widespread dam building. Finally, this species probably could be cultured successfully in a hatchery, providing care is taken to regulate water levels on a seasonal basis.

Acknowledgments

Most of our knowledge of the distribution and biology of the slackwater darter resulted from studies sponsored by the U. S. Department of Agriculture, Soil Conservation Service, Auburn, AL. Thomas S. Jandebeur, who made numerous collections in the south bend of the Tennessee River in search of the darter, is responsible for its discovery in Swan Creek. Also, Tom was the senior author's able companion in the field on numerous occasions, as were Mason Dollar, John Hall, Leroy Koch, Patrick O'Neil, Benjamin Wall, James D. Williams, and John S. Williams. Additional collectors were J. A. Collins, Larry Davenport, Christopher Dyer, Mike Carroll, Thomas Gritzmacher, Benjamin Richey, George Smith, Fred Tatum, and John Weaver. Lawrence Page shared his knowledge of the slackwater darter in Shoal Creek. We thank these friends and colleagues for their valuable contributions to this study.

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FISHES OF THE NORTH FORK HOLSTON RIVER SYSTEM, VIRGINIA AND TENNESSEE

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Abstract

Recent surveys by the Tennessee Valley Authority (over 100 collections from 1971-1983), along with extensive historical collections, have shown the North Fork of the Holston River system to have a diverse fish fauna. Annotated accounts of 73 species, representing 11 families, are presented along with comments on distribution, habitat preference, and protective status. A discussion of past disturbances and their effects on the fish fauna are also presented.

Introduction

Since 1971 personnel of the Tennessee Valley Authority (TVA) have taken over 100 fish samples in the North Fork of the Holston River system. Samples were taken from 1971-1977 in order to monitor faunal recovery from pollution and to determine mercury levels assimilated by the fishes. From 1977-1983 collections were taken in conjunction with various other projects, including a search for suitable transplant sites for Conradilla caelata (Conrad), an endangered mussel species, and collections of selected fish species for research in mussel life history studies.

Numerous other collectors have sampled the North Fork system, beginning with Cope's collections in October 1867 (Cope 1868). Other publications dealing with fish collections in this system include Jordan (1889), Patrick (1961), Ross and Carico (1963), Hill et al. (1975), and Feeman (1980). Collection records that have not been reported in the literature were obtained from R. E. Jenkins. Also included are early TVA collections taken in the 1930's by A. R. Cahn, C. C. Davis, and E.R. Cady. The purpose of this paper is to present a compre-

hensive, annotated account of the fish fauna known from the North Fork of the Holston River system, including relative abundance, distribution, habitat preference, and protected status.

Description of Study Area

Located in the Ridge and Valley physiographic region of southwestern Virginia and northeastern Tennessee, the North Fork of the Holston River system is bounded on the northwest by the Clinch and Powell river systems, on the southeast by the Middle Fork of the Holston River system (all in the Tennessee River drainage), and on the east by the New River system (Ohio River drainage). It arises in Bland County, Virginia, and flows 193 kilometers to Sullivan County, Tennessee, where it joins the South Fork to form the Holston River proper, a large headwater tributary of the Tennessee River.

The system drains 1,888 km^2 and is dominated by hardwood forests on steep slopes, with narrow strips of farmland along most of the river. The North Fork is characterized by long sluggish pools and swift riffles, and has an average gradient of 1.9 m/km. It is a typical Appalachian stream, with tributaries of varying size and gradient. Aquatic vegetation is common in the lower portions of the main river and in lowland tributaries, with vegetation in some pool areas becoming so concentrated by the end of the summer that they appear to be islands. Average flow for the North Fork is 25.1 m/sec. Average rainfall is 103.6 cm, with October the driest month (5.6 cm) and July the wettest (10.9 cm).

Table 1 gives specific locality information for the TVA sampling sites (1971-1984), and includes river mile (RM) measured upstream from junction with the South Fork (Stas. 1-25) or North Fork (Stas. 26-34) of the Holston River.

Materials and Methods

A variety of collection methods was used to sample a total of 25 main river sites and 8 tributary sites (Figure 1, Table 1). From 1971-1977, a total of 80 rotenone samples were taken at 24 sites, including 9 samples on 8 tributaries. All of these samples were taken quantitatively by blocking the upstream and downstream limits with 5 mm square mesh block nets and treating with 5 percent emulsifiable rotenone at a rate not less than 0.5 mg/l at the upper net. Rotenone was neutralized at the lower net with an equal volume of potassium permanganate. Fish were then picked up, sorted to species, enumerated and weighed. Minnows and other small fish were preserved in 10% formalin, and returned to the laboratory for identification. Specimens of unknown or uncertain identity were examined by Dr. Robert E. Jenkins, of Roanoke College.

Since 1977, approximately 20 samples have been taken by various other collection methods at 10 additional sites (Figure 1, Table 1). Methods of collection include: day and night backpack electrofishing, both in swift current into a 20 ft. seine and along bank areas and pools; seine-snorkel method (Hickman and Saylor 1984) for quantitative sampling' qualitative snorkeling; and seine hauling. After capture, fishes were identified and counted. Fishes of uncertain or difficult identification and voucher specimens of most species were preserved in 10% formalin and returned to the laboratory for identification and curation.

Nomenclature used in this paper follows Robins et al. (1980).

Table 1. TVA Sampling Stations,
North Fork Holston River, 1971-1984.

1. RM 0.2, left side of small island, 200 yds upstream from U.S. hwy. 11 bridge, Sullivan Co., TN. 3 samples (1975-1977). Species: 9,13-16,19-24,27,29-30,38,42,44-45,48-51,55,59-60,64-67,70,73.
2. RM 4.8, 0.2 river mi. upstream from co. rd. 2462 bridge, at Cloud Ford, 0.1 mi. downstream from st. line, Sullivan Co., TN. 11 May 1983. Species: 9,13,15-16,19-22,24,27,29-30,38-40,42,44-45,50-51,55,59-60,63-67,70,73.
3. RM 6.2, right side of and below island at end of co. rd. 821, 0.4 mi. upstream from st. line, Scott Co., VA. May,June,July 1981. Species: 9,13-16,19-24,26-27,29-30,33,38,42,44-45,50-51,53-56,59-60,64-67,70,73.
4. RM 6.3, left side of island at end of co. rd. 821, 0.4 mi. upstream from st. line, Scott Co., VA. 14 samples (1971-1976). Species: 4,9-10,12-16,18-24,26-30,32,34-36,38,41-42,44-45,48-51,53-55,57,59-60,64-67,70-71,73.
5. RM 7.7, off co. rd. 614, 0.7 rd. mi. from jct. with U.S. hwy. 23 at Weber City, Scott Co., VA. 17 Aug. 1981. Species: 9,13,16,19-24,27,29-30,38,50-51,55,59,64-65,73.
6. RM 13.4, right side of island off co. rd. 778, 0.3 rd. mi. E of jct. with co. rd. 614, Scott Co., VA. 5 samples (1973-1977). Species: 9,13-14,16,18-24,26-27,29-30,34-35,38,42,44-45,48-51,53-55,59,64-67,70,73.
7. RM 18.1, right side of island off co. rd. 614, 1.0 rd. mi. S of jct. with U.S. hwy. 421, Scott Co., VA. 3 Aug. 1976. Species: 9-10,13-14,16,19-24,27,29-30,38,42,44-45,48,50-51,55-59,64-66,70,73.
8. RM 21.9, just above and below U.S. hwy. 421 bridge at Hilton, Scott Co., VA. 17 Aug. 1981. Species: 9,13,16,19-22,24,27,29-30,38-40,50-51,55,59,64-65,67,73.
9. RM 25.7, left side of island 0.75 rd. mi. N of U.S. hwy. 421, at island across from Blue Springs Branch at Old Ford, Scott Co., VA. 4 Aug. 1976. Species: 9,13-14,16,19-24,27,29-30,38,42,44,48,50,55,59,64-66,73.
10. RM 36.7, both sides of island and ca. 0.25 mi. downstream, 0.3 river mi. upstream from Martin Ford, 1.0 air mi. SW of Mendota, Washington Co., VA. Aug. 1981. Species: 9,13-14,16,19-24,27,29-30,38,42,50-51,55,59,64-65,67,70,73.
11. RM 36.8, right side of island, 0.5 rd. mi. S of co. rds. 614 & 615, on co. rd. 615, 1.0 air mi. SW of Mendota, Washington Co., VA. Species: 9,13-14,16,18-24,27,29-30,38,42,44,48,50,55,59,64-66,70,73.
12. RM 48.6, left side of island, off co. rd. 614, 100 yds. SW of co. rds. 614 & 623, Washington Co., VA. 4 samples (1973-1975). Species: 9,13-14,16,18-24,27-30,34-35,38,42,44,48-51,53,55,59,64-66,70,73.
13. RM 56.3, left side of island off co. rd. 802, 2.5 rd. mi. S of jct. with U.S. hwy. 19, Washington Co., VA. Species: 9,13-14,16,18-24,27,29-30,34-35,38,42,44,49-51,53,55,59,64-66,70,73.
14. RM 59.3, ca. 0.5 river mi. downstream from U.S. hwy. 19 bridge at Holston, Washington Co., VA. Species: 9,13,16,19-22,24,27,38-40,50-51,53,55,59,64-65,67,73.
15. RM 69.7, 200 yds. upstream from hwy. 80 bridge at Hayters Gap, Washington Co., VA. 6 samples (1971-1975). Species: 5,9,13,16,18-22,24,26-30,34-35,38,42,44,48,50-51,53-57,59,64-67,70,73.
16. RM 72.0, left side of island off co. rd. 611, 4.0 mi. NE of jct. with hwy. 80, Washington Co., VA. 10 samples (1973-1977). Species: 9,13,16,18-22,24-27,29-30,34-35,38,42,44,47,49-51,53-55,59,63-66,69-70,73.
17. RM 74.4, 0.6 river mi. upstream from mouth of Big Cr., off co. rd. 611, Washington Co., VA. 18 Aug. 1981. Species: 9,12-13,16,19-22,24,27,29,38,44,47,50-51,53,55,59,64-65,67,73.
18. RM 76.5, both sides of island off co. rd. 611, 1.6 river mi. below mouth of Tumbling Cr., Washington Co., VA. 5 samples (1973-1977). Species: 9,13,16,19-22,24,26-27,29-30,34-35,37-38,42,44,47-51,53,55-56,59,61,64-66,68,70,72-73.
19. RM 76.9, 1.3 river mi. below mouth of Tumbling Cr., off co. rd. 611, Washington Co., VA. 18 Aug. 1981. Species: 9,13,16,19-22,24,27,29,38-40,47,50,55,59,64-65,67,73.
20. RM 80.1, just below sludge ponds on co. rd. 611 near Saltville, Washington Co., VA. 1 sample (1975). Species: 9,13,16,19-24,27,29-30,38,42,47-48,53,55,59,73.
21. RM 85.2, both sides of island, 0.6 river mi. up-

stream from st. rt. 91 bridge at Saltville, Smyth Co., VA. May,June,July 1981. Species: 1,9,13,16, 19-24,27,29,38,47,50,53,55,59,64-65,67,69,73.

22. RM 88.6, just below Neil Bridge on co. rd. 633, 0.5 rd. mi. S of jct. with st. rt. 91, Smyth Co., VA. 3 samples (1971-1975). Species: 8-9,13,16,18-24, 26-30,34-35,38,47-51,53-59,63-65,69,71,73.
23. RM 91.4, off st. rt. 91 at Old Broad Ford, 4.5 rd. mi. NE of McCready, Smyth Co., VA. 8 samples (1974-1977). Species: 7,9,13,16,19-24,27,29-30,34-35,38, 47-50,53-55,59,63-67,68-69,71,73.
24. RM 97.9, at horse show arena just below co. rd. bridge at Riverside, Smyth Co., VA. 18 Aug. 1981. Species: 9,13,16,19-22,24-25,27,38,47,50,55,59, 64-66,73.
25. RM 107.4, just above co. rd. 687 bridge at Chatham Hill, Smyth Co., VA. 3 samples (1975-1977). Species: 9,13,16-19,22,24-25,27,30,32,34-35,37-38, 49-50,54-56,59,64-66,73.

Tributary Stations

26. Possum Cr., RM 2.4, off co. rd. 639, 1.0 rd. mi. S of jct. with co. rd. 614, Scott Co., VA. 2 Aug. 1976. Species: 9,13,16,19-22,27,38,50-51,55,59, 64-66,73.
27. Big Moccasin Cr., RM 9.0, 0.4 rd. mi. W of st. rt. 71, on co. rd. 669 near Antioch Church, Scott Co., VA. 13 Sept. 1973. Species: 9,13,16,19-22,27,34, 38,46,50-51,53,55,59,64-65,73.
28. Big Moccasin Cr., RM 44.8, off co. rd. 679, 2.0 rd. mi. NE of jct. with co. rd. 613, Russell Co., VA. 14 Sept. 1973. Species: 9,13,16,19-22,27,34,38,42, 50,53,55,59,61,64-65,73.
29. Cove Cr., RM 0.2, 1.0 rd. mi. W of Beech Grove School, off U.S., hwy. 421, Scott Co., VA. 4 Aug. 1976. Species: 9,13,16,19-22,27,38,42,50-51,55,59, 64-66,73.
30. Abrams Cr., RM 1.0, at mouth of Little Wolf Run Cr., just below railroad trestle on co. rd. 6290, 0.1 rd. mi. NE of jct. with co. rd. 616, Washington Co., VA. 6 Aug. 1976. Species: 9,13,16,19-22,25,27,34-35, 37-38,50,53,55,59,64-66,73.
31. Brumley Cr., RM 0.2, 0.1 rd. mi. S of jct. of co. rds. 687 & 611, at co. rd. 611 bridge, Washington Co., VA. 5 Sept. 1976. Species: 5-6,9,13,16,19-22, 25,27,34,38,42,50-51,55,59,64-65,73.
32. Beaver Cr., RM 0.1, just above mouth, Smyth Co., VA. 10 Aug. 1976. Species: 9,13,16,19-22,25,27,34-35, 38,47,50,55,59,64-65,73.
33. Laurel Cr., RM 5.5, 4.5 rd. mi. N of st. rt. 42, on st. rt. 91, Tazewell Co., VA. 5 Sept. 1973. Species: 9,13,16,19-22,27,35,38,46,50,55,59,61,64-65, 68,73.
34. Lick Cr., RM 1.0, off co. rd. 620, 1.0 rd. mi. N of jct. with st. rt. 42, Smyth Co., VA. 11 Aug. 1976. Species: 9,13,16,19-22,25,27,32,35,37-38,47,50-51, 54-55,59,61,64-65,72-73.

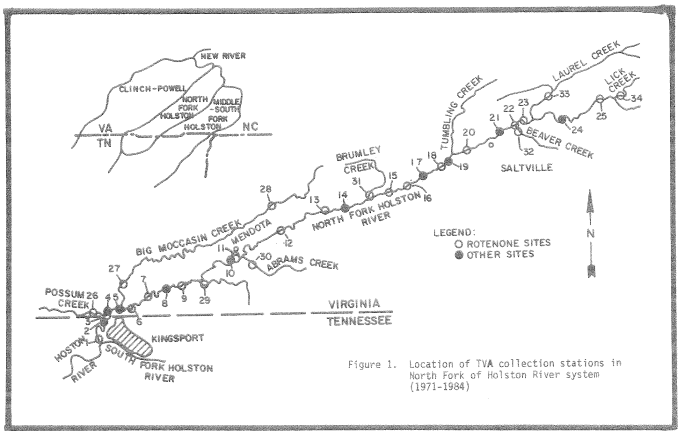

Figure 1. Location of TVA collection stations in North Fork of Holston River system (1971-1984)

Annotated Species List

Species included in this list represent the following families: Petromyzontidae (lampreys) (1-3), Clupeidae (herrings) (4), Salmonidae (trouts) (5-7), Esocidae (pikes) (8), Cyprinidae (carps and minnows) (9-35), Catostomidae (suckers) (36-41), Ictaluridae (catfishes) (42-48), Cyprinodontidae (killifishes) (49), Centrarchidae (sunfishes and black basses) (50-58), Percidae (perches) (59-71), Cottidae (sculpins) (72-73).

1. Ichthyomyzon bdellium (Jordan) - Ohio lamprey. Four specimens were collected at RM 85.2 in 1981. These were identified by the author, but were lost in shipment to Dr. R. E. Jenkins. One specimen was collected by H. R. Becker et al in 1928 above Saltville (Hubbs and Trautman (1937), and more recently (1981) by Jim Wadlak at RM 86.9 (R. E. Jenkins, pers. comm.). Station: 21.

2. Ichthyomyzon greeleyi Hubbs and Trautman - mountain brook lamprey. A single specimen of this nonparasitic lamprey was taken by R. E. Jenkins just above Saltville (RM 82) in 1972.

3. Lampetra appendix (DeKay) - American brook lamprey. The specimen reported by Ross and Carico (1963) from Riverside, 6 mi. from Chatham Hills, was subsequently reexamined by R. E. Jenkins and found to be an Ichthyomyzon ammocoete, either I. bdellium or I. greeleyi. One adult L. appendix, taken in 1972 from Sprout Creek, just above its mouth, Washington Co., Va., was identified by R. E. Jenkins (pers. comm.).

4. Dorosoma cepedianum (Lesueur) - gizzard shad. Several individuals were taken at RM 6.3. Station: 4.

5. Salmo gairdneri Richardson - rainbow trout. Rainbow trout have been introduced into several tributaries of the North Fork, and are being managed by the Virginia Game and Inland Fisheries Commission. Stations: 15,31.

6. Salmo trutta Linnaeus - brown trout. Introduced. Several individuals were taken in Brumley Creek, which is managed for trout by the State. Station: 31.

7. Salvelinus fontinalis (Mitchill) - brook trout. According to Cope (1868), brook trout were not native to the North Fork system. The species has been introduced into several tributaries by the state of Virginia. Station: 23.

8. Esox masquinongy Mitchill - muskellunge. Introduced by the state of Virginia, one small individual was taken at RM 88.6 in 1973. Station: 22.

9. Campostoma anomalum (Rafinesque) - central stoneroller. The stoneroller was the most abundant and widespread fish taken, occurring in all TVA samples. It was most abundant over a small to medium-sized rubble substrate in riffles with moderate current. Stations: all.

10. Carassius auratus (Linnaeus) - goldfish. Introduced; taken at two sites. Stations: 4,7.

11. Clinostomus funduloides Girard - rosyside dace. The only known population of this cyprinid in the North Fork system is in Lick Creek, a large, cool headwater stream. Two collections have been made, the most recent in 1976 by R. E. Jenkins off rt. 625, 1.8 air miles NNW of Ceres, Bland Co., Va.

12. Cyprinus carpio Linnaeus - carp. Introduced. This large cyprinid was collected in the main river. Stations: 4,17.

13. Hybopsis amblops (Rafinesque) - bigeye chub. Abundant throughout the system in pools over small rock or rubble substrate and in silty backwater areas. Stations: all.

14. Hybopsis dissimilis (Kirtland) - streamline chub. This chub is common in runs with moderate to swift current over small rock or rubble substrate in the main river. Its preference for moderate to large rivers is illustrated in the North Fork system, where it is absent above RM 91.4. Stations: 1,3-4,6-7,9-13.

15. Hybopsis monacha (Cope) - spotfin chub. The North Fork apparently has one of the strongest extant populations of this chub, which is listed as threatened by the U.S. Fish and Wildlife Service. It has been collected over pea-sized gravel substrate on shoals from the mouth to RM 88.6 (historically). Stations: 1-4.

16. Nocomis micropogon (Cope) - river chub. Abundant thoughout the system, usually in riffles and runs over boulder and rubble substrate. Stations: all.

17. Notropis ardens (Cope) - rosefin shiner. The only record for this species in the North Fork system is a collection of 16 juveniles in Possum Creek, about 0.25 miles above the mouth, Scott County, Virginia, 13 May 1967, by R. E. Jenkins.

18. Notropis ariommus (Cope) - popeye shiner. This species, which Gilbert (1969) did not record from Virginia, is common in the lower North Fork. It becomes increasingly less common upstream as the river becomes smaller, with no specimens being collected above RM 91.4. Most often found in pools and runs with slight current. Gilbert (1969) indicated this to be one of a small number of eastern North American fishes characteristically found over a gravel substrate. Listed as of special concern in Virginia (Jenkins and Musick 1980). Stations: 4,6,11-13,15-16,22.

19. Notropis chrysocephalus chrysocephalus (Rafinesque) - northern striped shiner. Common throughout the North Fork system in a variety of pool habitats. Stations: all.

20. Notropis coccogenis (Cope) - warpaint shiner. Common throughout the main river and its tributaries, usually in or near swift riffles with large rubble or rock substrate. Stations: all.

21. Notropis galacturus (Cope) - whitetail shiner. Found in moderate numbers throughout the North Fork system in swift riffles over a variety of substrates, including bedrock. Stations: all.

22. Notropis leuciodus (Cope) - Tennessee shiner. Common throughout the North Fork system in a variety of riffle habitats. Stations: all.

23. Notropis photogenis (Cope) - silver shiner. Taken in the main river, usually in low numbers, in deep pools with moderate current over gravel or rubble substrate. Stations: 1-25.

24. Notropis rubellus (Agassiz) - rosyface shiner. The most abundant shiner in the main river, but absent from tributaries. This species prefers riffles and runs with gravel or rubble substrate. Stations: 1-25.

25. Notropis rubricroceus (Cope) - saffron shiner. This montane species was common in the upstream tributaries, but was only taken occasionally in the main river. It was collected in a variety of habitats. Stations: 16,24-25,30-32,34.

26. Notropis spilopterus (Cope) - spotfin shiner. Taken at several localities in low numbers, usually in pool habitats. Stations: 3-4,6,15-16,18,22.

27. Notropis telescopus (Cope) - telescope shiner. Abundant and widespread in pools and runs of the North Fork system. Stations: all.

28. Notropis volucellus (Cope) - mimic shiner. Rare in the North Fork system, where it was only taken at four localities. Generally prefers pools with moderate current over a gravel/rubble substrate. Stations: 4,12, 15,22.

29. Notropis new species - sawfin shiner. This undescribed species prefers larger sections of the main river, where it was found to be abundant in variety of habitats (pools, backwaters, and riffles). Ross and Carico's (1963) record of the similar Notropis spectrunculus (Cope) from Big Moccasin Creek has since been found by Michael Masnik to have been based on N. leuciodus. The sawfin shiner occurs in both the Cumberland and Tennessee river drainages. Stations: 1-13,15-23.

30. Phenacobius uranops Cope - stargazing minnow. Found commonly in runs and riffles with moderate current over a gravel substrate throughout the main river. Stations: 1-13,15-16,18,20,22-23,25.

31. Phoxinus oreas (Cope) - mountain redbelly dace. Ross and Carico (1963) reported this species (based on a 1955 collection) from a small tributary, 1 mi. N of Pine Grove, but specimens were unavailable for examination. This species was also collected in Lick Creek by Monte Seehorn in 1973 (two collections) and by R. E. Jenkins in 1976 (one collection). These specimens represent an undescribed subspecies that is native to the upper Tennessee River drainage (R. E. Jenkins, pers. comm.).

32. Pimephales notatus (Rafinesque) - bluntnose minnow. Found in large numbers at RM 107.4 and in Lick Creek, but only collected at one other site (RM 6.3). Taken in both backwater areas over silty substrate and in riffles with sand and gravel substrate. Stations: 4,25,34.

33. Pimephales vigilax (Baird and Girard) - bullhead minnow. Although this species is to be expected in the area, this nevertheless represents the first collection from the North Fork system, and only the fourth collection of P. vigilax from Virginia. A total of five specimens were taken at RM 6.2 in a pool over sand and gravel substrate. Station: 3.

34. Rhinichthys atratulus (Hermann) - blacknose dace. A common inhabitant of headwater streams and small tributaries, but uncommon in the main river and in larger tributaries. It was collected from a variety of habitats. Stations: 4,6,12-13,15-16,18,22-23,25, 27-28,30-32.

35. Semotilus atromaculatus (Mitchill) - creek chub. The creek chub shows a preference for small streams, where it is common, but it was only rarely collected in the main river and large tributaries. Stations: 4,6, 12-13,15-16,18,22-23,25,30,32-34.

36. Carpiodes cyprinus (Lesueur) - quillback. Several individuals were taken at RM 6.3 in spring samples, probably during the spawning run. Station: 4.

37. Catostomus commersoni (Lacepede) - white sucker. Found in moderate numbers in tributaries and headwater sections of the main river, where it usually occurred in runs with a rubble/rocky substrate. Stations: 18,25,30, 34.

38. Hypentelium nigricans (Lesueur) - northern hog sucker. Abundant throughout the North Fork system in riffles of varying current over a gravel and rubble substrate. Stations: all.

39. Moxostoma duquesnei (Lesueur) - black redhorse. Stations: 1,3-7,9-13,15-18,20-34.

40. Moxostoma erythrurum (Rafinesque) - golden redhorse. Both M. erythrurum and M. duquesnei were collected in moderate numbers throughout most of the North Fork system. They were taken in a variety of habitats. Stations: 1,3-7,9-13,15-18,20-34.

41. Moxostoma macrolepidotum (Lesueur) - shorthead redhorse. Although present in adjacent areas of Virginia, there is only one apparent record from the North Fork system. One specimen (no longer extant), taken from RM 6.3, is regarded by R. E. Jenkins (pers. comm.) as probably representing a valid record, based on other confirmed records of the species from closely adjacent localities outside the system. Station: 4.

42. Ictalurus natalis (Lesueur) - yellow bullhead. Common in a variety of pool habitats throughout most of the North Fork system, where probably native (R. E. Jenkins, pers. comm.). Stations: 1-4,6-7,9-13,15-16, 18,20,28-29,31.

43. Ictalurus nebulosus (Lesueur) - brown bullhead. The only collection of this species, which is rare in the upper Tennessee River drainage, was made in 1981 by Jim Wadlak (unpublished M.Sc. thesis, VPI) at North Holston Ford (RM 86.9) (R. E. Jenkins, pers. comm.). Originally identified as I. melas, it was later reidentified as I. nebulosus by Jenkins, who considers it to be introduced.

44. Ictalurus punctatus (Rafinesque) - channel catfish. Taken only in small numbers in the main river. Most were juveniles, collected in pools with vegetation. Stations: 1-4,6-7,9,11-13,15-18.

45. Noturus eleutherus Jordan - mountain madtom. This species was common in riffles over gravel substrate, often associated with aquatic vegetation. Populations virtually disappear upstream above RM 18.1. Stations: 1-4,6-7.

46. Noturus flavus Rafinesque - stonecat. Ten specimens of N. flavus were taken from pools with bedrock and boulder substrate. LeGrande and Cavender (1980) have shown that specimens from the Tennessee River drainage usually have two more chromosomes (50 vs. 48) than those from elsewhere. Stations: 27,33.

47. Noturus insignis (Richardson) - margined madtom. This large madtom occurs in moderate numbers in both pools and riffles above RM 69.7. It is native to Atlan-

tic slope drainages (Taylor 1969), and its presence in the North Fork appears to be a result of bait bucket introduction. Stations: 16-24,32,34.

48. Pylodictis olivaris (Rafinesque) - flathead catfish. Common in deep sluggish pools throughout the main river. Stations: 1,4,6-7,9,11-12,15,18,20,22-23.

49. Fundulus catenatus (Storer) - northern studfish. The northern studfish was taken in backwaters and sluggish pools adjacent to the main river. One specimen was also collected in Laurel Creek. Stations: 1,4-6,12-13, 16,18,22-23,25.

50. Ambloplites rupestris (Rafinesque) - rock bass. Common throughout the North Fork system in pools and runs. Stations: 1-19,21-34.

51. Lepomis auritus (Linnaeus) - redbreast sunfish. Native to the Atlantic slope. Introduced into this area and now common throughout most of the North Fork system. Stations: 1-8,10,12-18,22,26-27,29,31,34.

52. Lepomis cyanellus Rafinesque - green sunfish. One specimen collected by William S. Woolcott in Logan Creek, ca. 1.0 mi. E of Hayters Gap, Washington Co., Virginia, 9 July 1963. This is a puzzling record, since there have been no other collections of this often abundant species in the North Fork system. Most likely this represents an introduction.

53. Lepomis macrochirus Rafinesque - bluegill. Common throughout the North Fork system, usually in pools. Stations: 3-4,6,12-18,20-23,27-28,30.

54. Lepomis megalotis (Rafinesque) - longear sunfish. Taken throughout the North Fork system in small numbers. Stations: 3-4,6,15-16,22-23,25,34.

55. Micropterus dolomieui Lacepede - smallmouth bass. This popular gamefish was found throughout the system in a variety of habitats, although characteristically it occurs in open, flowing water over a rock/rubble bottom. The population appears to have increased greatly since closure of an Olin Corporation plant at Saltville. Stations: all.

56. Micropterus punctulatus (Rafinesque) - spotted bass. Only a few individuals were taken at scattered localities in the main river. Stations: 3,15,18,22,25.

57. Micropterus salmoides salmoides (Lacepede) - northern largemouth bass. Taken only at three localities (RM 6.3, 69.7, 88.6). Stations: 4,15,22.

58. Pomoxis nigromaculatus (Lesueur) - black crappie. A single specimen was taken at RM 88.6. Station: 22.

59. Etheostoma blennioides Rafinesque - greenside darter. This darter was common at all sites sampled, where it usually was found in riffles over a variety of substrates. Stations: all.

60. Etheostoma camurum (Cope) - bluebreast darter. The bluebreast darter was collected in a variety of habitats. They were taken in low numbers in riffles with gravel substrate, but in swift riffles with rubble substrate (RM 0.2, 6.2, 85.2) they were abundant. Listed as of special concern in Virginia (Jenkins and Musick 1980). Stations: 1-4.

61. Etheostoma flabellare Rafinesque - fantail darter. Collected from tributaries, where it inhabits both pools and riffles, usually over bedrock and/or boulder substrates. Stations: 18,28,33-34.

62. Etheostoma meadiae (Jordan and Evermann) - no common name. Cahn and Davis collected this darter from Cove Creek in 1937. The only other collection was made by R. D. Ross, who collected one large specimen in Possum Creek. Our samples from these two tributaries failed to produce this species. Listed as either Etheostoma jessiae or E. stigmaeum in the past, recognition of E. meadiae as a distinct species is based on unpublished studies by Dr. W. M. Howell. According to R. E. Jenkins (pers. comm.), it will continue to be listed as E. stigmaeum in Jenkins and N. H. Burkhead's upcoming book on Virginia fishes. Listed as of special concern in Virginia (as Etheostoma jessiae) (Jenkins and Musick 1980).

63. Etheostoma maculatum vulneratum (Cope) - spotted darter. Taken only in the upper portion of the main river, this darter prefers riffles with swift current, usually over a gravel or cobble substrate. Specimens were also collected in vegetation along the shoreline. Although presently recognized as a subspecies of E. maculatum, the status of this and other populations of the spotted darter are under study by Dr. D. A. Etnier, who indicates that full species recognition for each of the three recognized subspecies may be in order. Stations: 2,16,21-23.

64. Etheostoma rufilineatum (Cope) - redline darter. Abundant throughout the North Fork system, in riffles with moderate to fast current over a variety of substrates. Stations: 1-19,21-34.

65. Etheostoma simoterum (Cope) - Tennessee snubnose darter. Found throughout the North Fork system, usually in sluggish pools. Stations: 1-19,21-34.

66. Etheostoma zonale (Cope) - banded darter. Common throughout the main river, but rare in tributaries. Banded darters were usually associated with riffles of moderate current over sand and/or gravel substrate, especially in areas with emergent vegetation. Stations: 1-4,6-7,9,11-13,15-16,18,23-26,29-30.

67. Percina aurantiaca (Cope) - tangerine darter. This large darter is common to abundant in the main river, where it inhabits a variety of habitats from pools with boulder, large rubble, and/or bedrock substrate to riffles of moderate current with sand and gravel substrate. It is listed as of special concern in Virginia (Jenkins and Musick 1980) and in need of management in Tennessee (Starnes and Etnier 1980). Stations: 1-4,6,8,10,14-15,17,19,21,23.

68. Percina burtoni Fowler - blotchside logperch. There appears to be a good population of this scarce darter at RM 91.4, where it is usually found at the head of a pool over bedrock, boulder, and rubble substrate. A single specimen was also collected at RM 76.6, and five were collected from Laurel Creek in similar habitats. Listed as of special concern in Virginia (Jenkins and Musick 1980). Stations: 18,23,33.

69. Percina caprodes caprodes (Rafinesque) - logperch. The logperch is not common in the North Fork system, being taken only in small numbers at a few localities above RM 72.0. They are usually found in riffles over a gravel substrate. Stations: 16,21-23.

70. Percina evides (Jordan and Copeland) - gilt darter. Preference for a specific stream size is illustrated by this darter, which occurs in high numbers in the main river up to RM 76.5, but does not occur upstream or in any tributaries. It is usually found in riffles over a sand and gravel substrate. Stations: 1-4,6-7,10-13,15-16,18.

71. Percina macrocephala (Cope) - longhead darter. This rare percid was collected at three localities in the main river, from RM 6.3 to RM 91.4. It was usually associated with deep pools over varying substrate of boulders, bedrock, sand and gravel. It is listed as of special concern in Virginia (Jenkins and Musick 1980). Stations: 4,22-23.

72. Cottus baileyi Robins - black sculpin. This species, which is restricted to several upper Tennessee River tributaries, was taken at two sites: RM 76.6 and Lick Creek. These specimens were recently reidentified by R. E. Jenkins as this species. Other collections of C. baileyi have been taken, all well above Saltville (R. E. Jenkins, pers. comm.). Reports of Cottus bairdi Girard from the North Fork are probably based on this species, since C. bairdi does not occur in the system (R. E. Jenkins, pers. comm.). Stations: 18,34.

73. Cottus carolinae (Gill) - banded sculpin. The banded sculpin was taken throughout the drainage in small numbers, usually in association with a rubble or gravel substrate. Stations: all.

Discussion

The North Fork of the Holston River has a history of pollution from a large Olin Corporation chlor-alkali plant located in Saltville, VA (RM 82.0), which began operation in 1894. Fish samples taken in 1971 indicated generally small population sizes, although diversity was comparable to adjacent streams of similar size. It appears that heavy releases of dissolved solids (sodium and chloride wastes) were primarily responsible for these low fish populations (Hill et al. 1975, Neves

1983). The plant was closed in 1972, and since then there has been a steady recovery of the fish fauna, with 1983 samples showing the greatest numbers of individuals since sampling was initiated. One species that has shown exceptional recovery is the smallmouth bass, with individuals of all size classes being well represented in the samples.

Despite this significant recovery, it was found that fishes still retained excessively high concentrations of mercury in their bodies, which exceeded FDA limits for safe human consumption (Bailey 1974, Toole and Ruane 1976, Milligan and Ruane 1978). This led to a ban, by both Tennessee and Virginia, on consumption of fish taken from the North Fork. The source of this contamination was a disposal site remaining from the old Olin plant, from which there was a continual flow of mercury into the river and accumulation of mercury along the river bottom. Reclamation efforts were begun in August 1982. The stream was first diverted around the affected site. The substrate of the now-dry streambed was removed, the bottom scraped, and the site was cleaned via high-pressure applications of water. Following this the stream bottom was sealed with concrete and covered with fresh substrate, after which the stream was redirected back into the old channel. Samples taken by Olin biologists shortly after renovation indicated numbers of fishes to be nearly comparable to those prior to renovation (M. Smithson, pers. comm.). The biologists also found evidence of insect colonization. However, it is still too soon to judge how effective this action has been in eliminating mercury seepage and the resultant uptake by fishes.

Our collections, along with others (totaling over 200), show the North Fork Holston River system to have a fish faunal diversity typical of most upper Tennessee River tributaries. A total of 73 species, representing 11 families, is known from the system, of which all but eight species were taken in our samples. Based on the large number of collections and intensity of sampling efforts, I feel this is an accurate indication of the system's present faunal composition.

Additional species not included in the above annotated list have been reported from the North Fork system by earlier workers. Masnik (1974) summarized these from the literature. Of these, the harelip sucker (Lagochila lacera Jordan and Brayton), which was reported by Jordan (1889), is now extinct throughout its entire range (Jenkins 1980). The yellowfin madtom (Noturus flavipinnis Taylor) was collected just above Saltville, Virginia, by Jordan in 1888 (RM 82.0), who indicated it to be "not rare" (Jordan 1889). It still occurs in the neighboring Clinch River system (Taylor et al 1971), but no additional individuals have been taken in the North Fork. Cope (1868) reported a gar (Lepisosteus huronensis Richardson), which was based on a head found along the river near Saltville. The species in question almost certainly was the longnose gar (Lepisosteus osseus (Linnaeus)), which may still occur in the main river in small numbers; however, since no specimens have been collected from this area in over 100 years, I have not included it in my list. Records for the blackside darter (Percina maculata (Girard)) and orangethroat darter (Etheostoma spectabile (Agassiz)), which emanate from an early collection by H. R. Becker, almost certainly are the result of transposition of locality data (R. E. Jenkins, pers. comm.). Reported occurrence of the mirror shiner (Notropis spectrunculus (Cope)) is plausible (this species is known from the Middle and South Fork systems), but more likely is based on the closely related sawfin shiner (Notropis new species). Records of Cottus bairdi from the North Fork system were earlier discussed in the account of C. baileyi.

The above discussion serves to introduce the point that certain species present (and sometimes common) in the adjacent Middle and/or South forks of the Holston are apparently absent from the North Fork. These include (together with the systems in which they are present) the river redhorse (Moxostoma carinatum (Cope)) (Middle and South forks), blotched chub (Hybopsis insignis Hubbs and Crowe) (South Fork), mirror shiner (Notropis spectrunculus) (Middle and South forks), fatlips minnow (Phenacobius crassilabrum Minckley and Craddock) (South Fork), longnose dace (Rhinichthys cataractae (Valenciennes)) (South Fork), Swannanoa darter (Etheostoma swannanoa Jordan and Evermann) (Middle and South forks), and broadband sculpin (Cottus sp. cf. carolinae) (Middle and South forks). According to R. E. Jenkins (pers. comm.), waters of the North Fork system tend to be slightly warmer, on the average, than those of either the Middle or South fork systems. This factor may be involved in the absence of some of the above species from the North Fork area, since ranges of the last five species in the Tennessee River drainage are largely confined to the cooler upland streams of North Carolina.

The occurrence and/or abundance in the North Fork system of several species of Notropis (N. spilopterus, N. volucellus, N. ardens) are puzzling. Notropis spilopterus, which is common to abundant in downstream sections of the main Holston River and in the adjacent Clinch and Powell rivers, is rarely taken in the North Fork. Although found at scattered localities from RM 4.8 to RM 53.6, collections usually consisted of one or a few specimens. Since stream size does not appear to be the primary factor affecting distribution of this species, its reduced abundance in the North Fork may result from competition with other species of Notropis. Notropis volucellus, which is common in the Clinch and Powell rivers, is scarce in the North Fork, and it appears that only a small relict population still exists in this system. It is tempting to speculate that this may somehow be related to presence of a large population of the morphologically similar sawfin shiner (Notropis sp.), although it should be noted that these species occur sympatrically in moderate numbers in the Clinch and Powell rivers. The occurrence of Notropis ardens in the North Fork is also peculiar. This species has a spotty distribution in the main Holston River system, and is only known from the North Fork from a single sample from Possum Creek. A 1976 rotenone collection by us from the same area did not include this species.

For some unknown reason the population of Hybopsis monacha in the Nork Fork system appeared to be declining during the mid-1970's. However, recent underwater observations by R. E. Jenkins, N. M. Burkhead, and TVA personnel have shown an increase in numbers, and in addition the species has recently been discovered at several new localities (Jenkins and Burkhead 1984). These fluctuations may be attributable to several factors: (a) H. monacha may always have normally had large population fluctuations in this area, (b) some environmentally limiting factor(s) has (have) been eliminated; and/or (c) the species has experienced exceptional reproductive success in recent years. The most upstream occurrence of H. monacha is above Saltville, at RM 88.6 (specimens taken in 1954 by a crew from the Academy of Natural Sciences of Philadelphia), but this upstream population appears to have been extirpated. It was earlier reported as "rare" or "scarce" by Cope (1868) and Jordan (1889), respectively, in the vicinity of Saltville (RM 81). However, it was not taken above RM 23.4 between 1954 and 1981, after which Burkhead and Jenkins began to find new localities upstream to ca. RM 54. At present, this species apparently is doing well in parts of the lower half of the North Fork system.

A unique relationship exists between the three species of Noturus found in the North Fork system. Noturus eleutherus was taken in large numbers in lower sections of the main river upstream to RM 18.1, whereas N. insignis was only taken above RM 72.0. These two species were not collected at any locality in the North Fork system, but the downstream range limit of N. insignis (now at RM 72.0) has increased since sampling was begun in 1971. The two species may eventually become syntopic in the system. Noturus flavus is restricted to tributaries and does not occur with either of the other two species.

Ross and Carico (1963) considered the occurrence of N. insignis in the North Fork to result from stream piracy of the New River around Burke's Garden, Virginia. Both Taylor (1969) and I are inclined to attribute the occurrence of the species in this area to bait-fish in-

troduction, for the following reasons: (a) madtoms are popular bait fish, and N. insignis is readily available in the adjacent New River drainage; (b) N. insignis was absent from early collections from the area (the earliest were made in 1951 by E. C. Raney); and (c) this species appears to be expanding its range in the North Fork system (our collections over the past 15 years clearly indicate dispersal downstream).

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FISHES OF THE BUTTAHATCHEE RIVER SYSTEM OF ALABAMA AND MISSISSIPPI

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Abstract

The Buttahatchee River serves as a potential refugium for riverine fishes and invertebrates once found in the Tombigbee River of western Alabama and eastern Mississippi. Changes in physical characteristics of the Tombigbee, resulting from recent completion of the Tennessee-Tombigbee waterway, means that many species either will be eliminated or will survive in reduced numbers only in a few large tributaries, such as Bull Mountain Creek (Pierson and Schultz 1984) and the Sipsey and Buttahatchee rivers. The present survey was conducted for the purpose of obtaining baseline data on the fish fauna for the last of those potential refugia listed above.

Introduction

Construction of the Tennessee-Tombigbee waterway (TTW) has resulted in change of the Tombigbee River proper from a lentic river with firm substrate to a lotic environment with a mud-silt bottom. Two predictable effects of this project will be (a) the complete elimination or severe reduction in numbers of many Tombigbee species and (b) mixing of the Tennessee and Tombigbee faunas in ways yet to be determined. If any riverine species native to the Tombigbee are to survive in this area, their only hope is several Tombigbee River tributaries still containing remnants of big-river habitat, such as the Buttahatchee River. It is important to document the fish fauna of the Buttahatchee at this time in order to provide baseline data that can be used to measure the impacts of future invasions of fishes from the Tennessee River and to monitor the survival of big-river species.

The Buttahatchee River, a major tributary of the Tombigbee River, drains an area of 870 sq. mi., and has an average discharge of 1265 cfs at Caledonia, Mississippi, a point 19 miles from its mouth. The system is situated almost entirely within the Fall Line Hills physiographic district; only a few miles of the lowermost part of the river is in the Black Belt physiographic district. The headwater streams in Marion County, Alabama, begin at approximately 900 feet elevation. As the river meanders southwestward, it enters the upper Tombigbee River (Columbus Reservoir) at the Monroe-Lowndes County line in Mississippi, where the elevation is about 230 feet above sea level. The tributaries typically consist of alternating riffles and pools; the river proper above the Fall Line usually flows over rock and rubble. Below the Fall Line the river deepens and begins to meander over a gravel and sand substrate.

Several studies have reported on the species occurring in the Buttahatchee (Caldwell 1969; Schultz 1971, 1981,1982; Boschung 1973); however, this is the first comprehensive list of species published.

The species list contained herein was compiled from 99 seine, hoop net, and rotenone collections at 34 stations during 1968-1973 and 1979-1981 (Fig. 1). Hoop nets, seldom used in ichthyological surveys in the southeastern U.S., were employed for 560 net days and

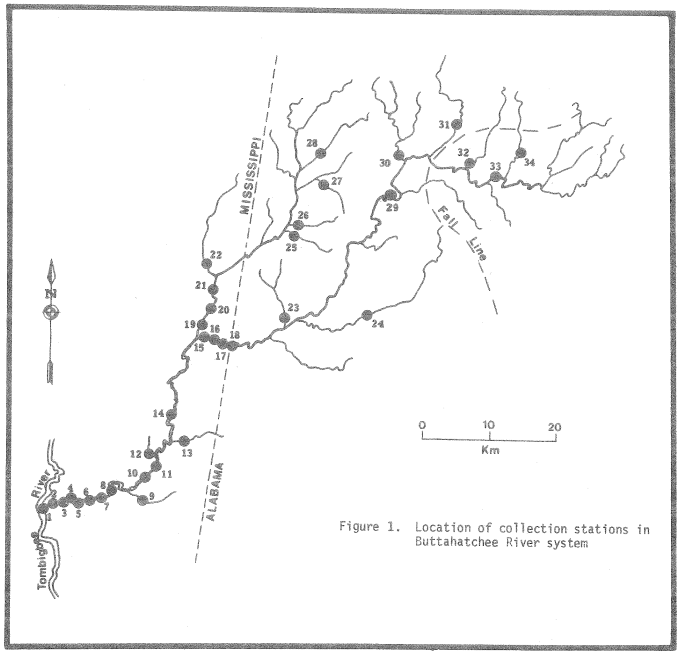

Figure 1. Location of collection stations in Buttahatchee River system

yielded 26 species, five of which were not collected by other methods. Rotenone collections accounted for 69 species, of which seven were not otherwise collected. Hoop nets are selective for larger, more mobile fishes such as catostomids, ictalurids and centrarchids. Conventional seine collecting accounted for 79 species, 16 of which were not collected by rotenone or hoop nets. Overall, 94 species can be documented from the Buttahatchee system. Most of the 11,550 specimens resulting from these collections are housed in the University of Alabama Ichthyological collection, the Mississippi Museum of Natural Science, Auburn University, and Mississippi State University fish collections.

Table 1 lists all collection localities by numbers corresponding to collecting stations in Figure 1. After the locality description, fishes collected at each station are listed numerically in phylogenetic sequence as they appear in Table 2. Table 2 lists all species collected during the study, as well as stations where each species was found.

Table 1

Collection localities in the
Buttahatchee River system of Alabama and Mississippi
(species listed by number as referenced in Table 2;
sampling method indicated by s (seine), h (hoop
net, and r (rotenone))

1. Buttahatchee R., 11.7 km SW of New Hamilton, at confluence with Tombigbee R., Monroe Co., MS. T16S,R19W,Sec.22. Sampling method: s. 24 July 1982, 11 Aug. 1980, 12 Aug. 1980. Species: 4,7-8, 12,15-19,21,23-34,36,40,44,48,50-52,56-59,64-66, 68-70,72-74,76-77,80-82,86,89-94.
2. Buttahatchee R., 11.5 km. SW of New Hamilton, Monroe Co., MS. T16S,R19W,Sec.22. Sampling method: s. 16 Oct. 1981. Species: 15,23,25-26,28-30,34, 64,82,89-90,92.
3. Buttahatchee R., 9.6 km SSW of New Hamilton, Monroe Co., MS. T16S,R19W,Sec.23. Sampling method: s. 16 Oct. 1979. Species: 12,15-16,19,23,28-30,32-33, 40,51-52,56,65,73-74,76,80-82,88-90,92.

4. Buttahatchee R., 8.5 km S of New Hamilton, Monroe Co., MS. T16S,R18W,Sec.17. Sampling methods: s,r. Dates: 14 July 1971, 19 June 1980. Species: 2,7-8, 12,24,28,30-32,34,36,40-41,44-45,48,51-52,56,62, 64-65,69-70,72-74,76-77,80-82,89-90,92.
5. Buttahatchee R., 9.8 km SSW of New Hamilton, Monroe Co., MS. T16S,R18W,Sec.19. Sampling method: r. 27 Aug. 1968. Species: 7,9,13,15,17-18,23,27-31, 34,36,40,45,48-49,54-56,59,62,64-65,69-70,82,86-88, 90,94.
6. Buttahatchee R., 7.7 km SSE of New Hamilton, Monroe Co., MS. T16S,R18W,Sec.19. Sampling methods: s,r. 5 Oct. 1970, 14 April 1981. Species: 7,9,12,22-25, 27-28,30-31,34,36,41,45,48,52,56,65,69-70,74,80-82, 90,92,94.
7. Buttahatchee R., 7.5 km SSE of New Hamilton, Monroe Co., MS. Sampling method: h. 21 collections between January and December 1981. Species: 3-5,7,9, 13,36,39-45,48,54,59,62,64-66,69-71,93-94.
8. Buttahatchee R., 6.9 km SE of New Hamilton, Monroe Co., MS. T16S,R18W,Sec.11. Sampling method: s. 18 June 1980, 21 Aug. 1980. Species: 12,15,18-19, 22-25,27-30,32-34,40,48,51-52,56,59,64-65,69,72,74, 76-77,80-82,86,90,92.
9. Unnamed tributary to Buttahatchee R., 3.7 km W of Caledonia, Lowndes Co., MS. T16S,R17W,Sec.18. Sampling method: r. 27 Sept. 1979. Species: 10, 12,19-20,22-23,25,29-30,32-33,35,37,47,49,51,55-56, 62-63,65,77,83,89.
10. Buttahatchee R., 3.8 km NNW of Caledonia, Lowndes Co., MS. T15S,R17W,Sec.32. Sampling method: s. 13 Jan. 1981. Species: 23-24,28-32,34,51-52,56-58, 65,74,77,80-82,90,92.
11. Buttahatchee R., 5.6 km N of Caledonia, Lowndes Co., MS. T15S,R17W,Sec.28. Sampling method: s. 8 May 1980. Species: 11-12,15,22-25,28,30-31, 51-52,56-58,65,69-70,74,80-81,89-90,92.
12. Grub Springs Branch, 8.6 km E of Hamilton, Monroe Co., MS. T15S,R9E,Sec.21. Sampling method: r. 13 March 1969. Species: 12,19-23,25,27-29,50,60-61, 77,79-80,82-83,88-90.
13. Rye Cr., 13.8 km SSW of Gattman, Monroe Co., MS. T15S,R17W,Sec.10. Sampling method: r. 24 Aug. 1979. Species: 1,10,19-20,22-23,25,29,33,35,37, 45-47,49,55-56,62-65,67,69,77-78,80,83,85,88-89.
14. Buttahatchee R., 10.7 km. S of Greenwood Springs, Monroe Co., MS. T15S,R17W,Sec.3. Sampling methods: s,r. 2 Oct. 1968, 29 July 1972, 14 Sept. 1981. Species: 7,9,11,14-15,17-18,23,28-30,32,34, 36,40-42,48,53-54,56-57,62,64-65,69,73,77,79-82,84, 86-88,90-92,94.
15. Buttahatchee R., 5.3 km W of Gattman, downstream from U.S. hwy. 278, Monroe Co., MS. T14S,R10E, Sec.2. Sampling method: s. 4 Nov. 1981. Species: 12,19,22-25,27-32,34,40,45,48,50-52,56-58,62,64-65, 68,74-77,79-82,85,88-90,92.
16. Buttahatchee R., 5.1 km W of Gattman, 0.3 km downstream from U.S. hwy. 278, Monroe Co., MS. T14S, R10E,Sec.2. Sampling method: r. 17 Sept. 1980. Species: 4,7,12,18,24,28-30,34,36,40,44-45,48-49, 52,54,59,62,64-65,68,70,76,80,82,87,89-90,92-94.
17. Buttahatchee R., 4.3 km WNW of Gattman, 1.6 km upstream from U.S. hwy. 278, Monroe Co., MS. T13S, R17W,Sec.36. Sampling method: r. 17 Aug 1971. Species: 4-7,9,15,17-18,23,28-31,34,36,41,43,45,48, 53-54,59,65,69,74,82,90,92,94.
18. Buttahatchee R., 1.6 km NE of Gattman and 0.8 km N of U.S. hwy. 278, Lamar Co., AL. T13S,R17W,Sec.33. Sampling method: s. 29 July 1972. Species: 12,18, 22-23,25,28-30,32,35,40,45,49,51,56,65,80-82,89-90.
19. Sipsey Cr., 5.8 km NE of Gattman, Monroe Co., MS. T13S,R10E,Sec.24. Sampling method: r. 27 Sept. 1971. Species: 10-11,40,42,45,47-48,55,59,62-65, 69-70,93-94.
20. Sipsey Cr., 7.2 km NNW of Gattman, Monroe Co., MS. T13S,R10E,Sec.7. Sampling methods: s,r. 16 Aug. 1979, 20 Aug. 1980. Species: 11-12,15,19,22-23,25, 28-30,35,40,45,49,51-52,55-56,59,61-63,65,69,80-83, 85-86,89,92.
21. Sipsey Cr., 7.4 km NNW of Gattman, Monroe Co., MS. T13S,R10E,Sec.6. Sampling method: r. 20 Aug. 1980. Species: 11-12,15,18-19,22-25,28-30,40,45, 48-49,51-52,55-56,59,62,65,80,82,85-86,88-89,92-93.
22. Splunge Cr., 3.0 km NNE of Splunge, Monroe Co., MS. T12S,R10E,Sec.30. Sampling method: r. 26 Aug. 1968. Species: 10-11,23,29,55-56,60-64,67,69,82.
23. Pine Cr., 2.4 km NNW of Sulligent, Lamar Co., AL. T13S,R15W,Sec.18. Sampling method: s. 9 Aug. 1971. Species: 12,20,22-25,29-31,35,38,40,47,57, 61,64-65,77,81,90.
24. Beaver Cr., 0.7 km NW of Beaverton, Lamar Co., AL. T13S,R14W,Sec.17. Sampling method: s. 9 Aug. 1971. Species: 12,19,23-25,27-30,42,56,62-63,65, 69,80-81,85.
25. Aston Branch, 5.1 km NE of Detroit, on st. hwy. 17, Marion Co., AL. T11S,R15W,Sec.33. Sampling method: s. 30 Sept. 1971. Species: 11-12,19,22-23, 25,29,37,40,49,51,56,64,69,78,80-82,85,89.
26. Factory Cr., 6.7 km NNE of Detroit, on st. hwy. 19, Marion Co., AL. T11S,R15W,Sec.29. Sampling method: s. 29 Sept. 1971. Species: 19,22-23,25,32, 37,40,50-51,53,56-57,63-64,77,80-81,83,85,89.
27. Barnesville Cr., 8.6 km W of Hamilton, Marion Co., AL. T11S,R15W,Sec.2. Sampling method: s. 29 Sept. 1971. Species: 19,22-23,25,29,40,51,56, 64-65,77,81,85,89.
28. Boardtree Cr., 10.5 km WNW of Hamilton, Marion Co., AL. T10S,R15W,Sec.27. Sampling method: s. 30 Sept. 1971. Species: 12,19,22-23,25,29,40,45,56, 65,69,77,80-81,85.
29. Buttahatchee R., 4.0 km S of Hamilton, on U.S. hwy. 78, Marion Co., AL. T11S,R14S,Sec.15. Sampling method: s. 9 Aug. 1971. Species: 15,20,23-25,28, 30-33,48,56,59,64-65,69,74,81,89.
30. Williams Cr., 1.7 km NNE of Hamilton, on U.S. hwy. 43, Marion Co., AL. Sampling method: s. 9 Aug. 1971. Species: 12,15,18-19,22-25,30,32-35,37,40, 44,46,51,56,65,68,77,80-81,90.
31. Slifty Cr., 10.4 km NE of Hamilton, Marion Co., AL. T10S,R13W,Sec.15. Sampling method: s. 10 Aug. 1971. Species: 12,15,22,24-25,30,32,35,37,40,44, 48,51,56,65,77,80,85,89-90.
32. Camp Cr., 10.7 km E of Hamilton, Marion Co., AL. T10S,R13W,Sec.35. Sampling method: s. 10 Aug. 1971. Species: 12,15,22,24-25,32-33,35,40,44,48, 68,77,80-81,89-90.
33. Buttahatchee R., 16 km E of Hamilton, on st. hwy. 253, Marion Co., AL. T11S,R12W,Sec.5. Sampling method: s. 30 Sept. 1971. Species: 12,23-25,28, 30-31,33,49,51,56,59,64-65,69,77,80-81,85,89.
34. Barn Cr., 13.3 km SW of Bear Cr., on co. rd. 48, Marion Co., AL. T10S,R12W,Sec.22. 10 Aug. 1971. Species: 12,19,22-25,35,37,40,56,62,65,69,77,80-81, 85,89.

Ictalurus punctatus numerically was the dominant fish appearing in hoop-net samples, a total of 248 individuals (32.1% of total) having been collected. This was followed by Lepomis macrochirus (89;11.5%), Moxostoma poecilurum (84;10.9%), Pomoxis annularis (78; 10.1%), Lepomis megalotis (54;7.0%), Pylodictis olivaris (41;5.3%), and Lepisosteus osseus (39;5.1%). P. olivaris comprised by far the greatest percentage of total biomass (39.6%), followed by I. punctatus (20.9%) and M. carinatum (5.0%). No other species made up more than 3.3% of the total biomass.

Several of the Buttahatchee's riverine species are assigned conservation status in Alabama and Mississippi. Noturus munitus and Percina lenticula are currently under status review by the U.S. Fish and Wildlife Service. Ramsey (1976) listed Noturus munitus as "endangered" and Percina lenticula and Ammocrypta asprella as "threatened" in Alabama. Clemmer et al (1975) considered Noturus munitus and Ammocrypta asprella to be "endangered" and Percina lenticula "rare" in Mississippi.

It is encouraging to find that the Buttahatchee is serving as a refugium for these large-stream species. Percina lenticula was represented by a total of five specimens, and Noturus munitus and Ammocrypta asprella were present in larger numbers (111 and 53, respectively). We presume that the above species will be

Table 2

List of fishes collected at 34 localities in the Buttahatchee River system of Alabama and Mississippi[4]

Species and Methods of Collection	Collection Localities
1. Ichthyomyzon gagei (r)	13
2. Polyodon spathula (r)	4
3. Lepisosteus oculatus (h)	7
4. Lepisosteus osseus (s,h,r)	1,7,16-17
5. Anguilla rostrata (h,r)	7,17
6. Alosa chrysochloris (r)	17
7. Dorosoma cepedianum (s,h,r)	1,4-7,14,16-17
8. Dorosoma petenense (s)	1,4
9. Hiodon tergisus (h,r)	5-7,14,17
10. Esox americanus (r)	9,13,19,22
11. Esox niger (s,r)	11,14,19-22,25
12. Campostoma oligolepis (s,r)	1,3-4,6,8-9,11-12,15-16,18,20-21, 23-25,28,30-34
13. Cyprinus carpio (h)	5,7
14. Hybognathus hayi (s)	14
15. Hybognathus nuchalis (s,r)	1-3,5,8,11,14,17,20-21,29-32
16. Hybopsis sp. cf. aestivalis (s)	1,3
17. Hybopsis storeriana (s,r)	1,5,14,17
18. Hybopsis winchelli (s,r)	1,5,8,14,16-18,21,30
19. Nocomis leptocephalus (s,r)	1,3,8-9,12-13,15,20-21,24-28,30,34
20. Notemigonus crysoleucas (s,r)	9,13,23,29
21. Notropis atherinoides (s)	1
22. Notropis baileyi (s,r)	6,9,11,13,15,18,20-21,23-28,30-32,34
23. Notropis bellus (s,r)	1-3,5-6,8-9,10-15,17-18,20-30,33-34
24. Notropis callistius (s,r)	1,4,6,8,10-11,15-16,21,23-24,29-34
25. Notropis chrysocephalus (s,r)	1-2,6,8-9,11-13,15,18,20-21,23-34
26. Notropis edwardraneyi (s)	1-2
27. Notropis emiliae (s)	1,5-6,8,12,15,24
28. Notropis stilbius (s,r)	1-6,8,10-12,14-18,20-21,24,29,33
29. Notropis texanus (s,r)	1-5,8-10,12-18,20-25,27-28
30. Notropis venustus (s,r)	1-6,8-11,14-18,20-21,23-24,29-31,33
31. Notropis volucellus (s,r)	1,4-6,10-11,15,17,23,29,33
32. Notropis sp. cf. longirostris (s,r)	1,3-4,8-10,14-15,18,26,29-30,32
33. Pimephales notatus (s,r)	1,3,8-9,13,29-30,32-33
34. Pimephales vigilax (s,r)	1-2,4-6,8,10,14-17,30
35. Semotilus atromaculatus (s,r)	9,13,18,20,23,30-32,34
36. Carpiodes velifer (s,r)	1,4-7,14,16-17
37. Erimyzon oblongus (s)	9,13,25-26,30-31,34
38. Erimyzon sucetta (s)	23
39. Erimyzon tenuis (r)	7
40. Hypentelium etowanum (s,h,r)	1,3-5,7-8,14-16,18-21,23,25-28,30-32, 34
41. Ictiobus bubalus (h)	4,6-7,14,17
42. Minytrema melanops (s,r)	7,14,19,24
43. Moxostoma carinatum (h)	7,17
44. Moxostoma erythrurum (s,h,r)	1,4,7,16,30-32
45. Moxostoma poecilurum (s,h,r)	4-7,13,15-21,28
46. Ictalurus melas (s,r)	13,30
47. Ictalurus natalis (s,r)	9,13,19,23
48. Ictalurus punctatus (s,h,r)	1,5-8,14-17,19,21,9,31-32
49. Noturus funebris (s,r)	5,9,13,16,18,20-21,25,33
50. Noturus gyrinus (s)	1,12,15,26
51. Noturus leptacanthus (s,r)	1,3-4,8-11,15,18,20-21,25-27,30-31,33
52. Noturus munitus (s,r)	1,3-4,6,8,10-11,15-16,20-21
53. Noturus nocturnus (s,r)	14,17,26
54. Pylodictis olivaris (s,h,r)	5,7,14,16-17
55. Aphredoderus sayanus (s,r)	5,9,13,19-22
56. Fundulus olivaceus (s,r)	1,3-6,8-11,13-15,18,20-22,24-31,33-34
57. Gambusia affinis (s)	1,10-11,14-15,23,26
58. Labidesthes sicculus (s)	1,10-11,15
59. Ambloplites ariommus (s,h,r)	1,5,7-8,16-17,19-21,21,33
60. Centrarchus macropterus (r)	12,22
61. Elassoma zonatum (s)	12,20,22-23
62. Lepomis cyanellus (s,h,r)	4-5,7,9,13-16,19-22,24,34
63. Lepomis gulosus (s,r)	9,13,19-20,22,24,26
64. Lepomis macrochirus (s,h,r)	1-2,4-5,7-8,13-16,19,22-23,25-27,29,33
65. Lepomis megalotis (s,h,r)	1,3-11,13-21,23-24,27-31,33-34
66. Lepomis microlophus (s,h)	1,7
67. Lepomis punctatus (s,r)	13,22
68. Micropterus punctulatus (s,r)	1,15-16,30,32
69. Micropterus salmoides (s,h,r)	1,4-8,11,13-14,17,19-20,22,24-25, 28-29,33-34
70. Pomoxis annularis (s,h,r)	1,4-7,11,16,19
71. Pomoxis nigromaculatus (h)	7
72. Ammocrypta asprella (s)	1,4,8
73. Ammocrypta beani (s)	1,3-4,14
74. Ammocrypta meridiana (s,r)	1,3-4,6,8,10-11,15,17,29
75. Etheostoma chlorosomum (s)	15
76. Etheostoma histrio (s,r)	1,3-4,8,15-16
77. Etheostoma nigrum (s,r)	1,4,8-10,12-15,23,26-28,30-34
78. Etheostoma parvipinne (s,r)	13,25
79. Etheostoma proeliare (s)	12,14-15
80. Etheostoma rupestre (s,r)	1,3-4,6,8,10-16,18,20-21,24-26,28, 30-34
81. Etheostoma stigmaeum (s,r)	1,3-4,6,8,10-11,14-15,18,20,23-30, 32-34
82. Etheostoma swaini (s,r)	1-6,8,10,12,14-18,20-22,25
83. Etheostoma whipplei (s,r)	9,12-13,20,26
84. Etheostoma zoniferum (s)	14
85. Etheostoma (Ulocentra) sp. (s,r)	13,15,20-21,24-28,31,33
86. Percina sp. cf. caprodes (s,r)	1,5,8,14,20-21
87. Percina lenticula (r)	5,14,16
88. Percina maculata (s,r)	3,5,12-15,21
89. Percina nigrofasciata (s,r)	1-4,9,11-13,15-16,18,20-21,25-27,29, 31-34
90. Percina sciera (s,r)	1-6,8,10,12,14-18,23,30-32
91. Percina shumardi (s)	1,14
92. Percina vigil (s,r)	1-4,6,8,10-11,14-17,20-21
93. Stizostedion vitreum (s,h,r)	1,7,16,19,21
94. Aplodinotus grunniens (s,h,r)	1,5-7,14,16-17,19

[4]Cook (1959) reported taking Ichthyomyzon castaneus from the Buttahatchee River

eliminated from the main channel of the Tombigbee as a result of the TIW, and hope that the Buttahatchee will continue to remain undisturbed and sustain populations of these rare or endangered species.

There are other river-dependent species that will probably invade the main channel of the Buttahatchee as their habitats are inundated or covered by silt resulting from the TIW. Such species as Hiodon tergisus, Hybopsis sp. cf. aestivalis, Moxostoma carinatum, and Percina shumardi, known from 4th and 5th-order parts of the Buttahatchee and documented in the Tombigbee proper by preimpoundment studies (Caldwell 1969, Boschung 1973, Schultz 1981), may continue to persist in the Buttahatchee and other large tributaries. This further illustrates the potential importance of the Buttahatchee as a refugium for riverine fishes.

Acknowledgments

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REINTRODUCTION OF AN UNDESCRIBED SPECIES OF ELASSOMA INTO PRYOR BRANCH, LIMESTONE COUNTY, ALABAMA

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Specimens of an undescribed species of Elassoma were first collected in 1937 from Cave Spring (T3S,R13W,S15), in Lauderdale Co., AL; and in 1941 from Pryor Springs (T4S,R4W,S22), Limestone Co., AL. Both localities are in the Tennessee River drainage. The Cave Spring locality was later inundated by Pickwick Reservoir, which apparently destroyed the spring habitat. Repeated sampling of Pryor Springs and other likely habitats within and without the Tennessee drainage has revealed no additional specimens of Elassoma. As a result, this Alabama endemic species was believed to be extinct until 17 February 1973, when D. A. Etnier and students collected specimens from Beaverdam Spring (T4S,R3W,S10), in Limestone Co., AL. Subsequent sampling by other ichthyologists has revealed additional populations within the Beaverdam Creek watershed.

In 1982, the U.S. Fish and Wildlife Service, Alabama Department of Conservation and Natural Resources, and landowners in the Beaverdam Creek watershed signed a 3-year, renewable conservation agreement (CA) to manage and protect the Beaverdam Creek habitat. A secondary goal involved the possible reintroduction of the species back into the Pryor Spring area.

On 17 February 1984, the authors and several associates collected 36 adult specimens (11 males and 25 gravid females) of Elassoma from Moss Spring (T4S,R3W, S16), a tributary to Beaverdam Creek (Fig. 1). All individuals were immediately transported to an unnamed spring tributary (T4S,R4W,S21) to Pryor Branch, which is located approximately 300 yards west of U.S. hwy. 31. This spring, herein called Lower Pryor Spring, is located a short distance downstream of Pryor Spring, the original site from which the species was collected. After a brief acclimation period, the individuals were released into the spring.

Lower Pryor Spring was not surveyed again until 13 September 1985, when approximately 10 minutes of sampling yielded 4 juvenile specimens (1 male and 3 females) from different areas along the spring margin. Satisfied that the Elassoma was present and appeared to be surviving, we returned to Moss Spring and collected 120 juveniles (37 males and 83 females) in approximately 30 minutes. These were then transported to Lower Pryor Spring and released.

The collection of Elassoma in Lower Pryor Spring is noteworthy for two reasons. First, measurements made in situ at the time of the original introduction indicated the following slight differences in water quality between Moss and Pryor springs (values for Moss Spring indicated first): temperature 16°C vs. 14.5°C; specific conductivity (umhos/cm) 55 @ 16°C vs. 142 @ 16°C; pH (as units) 5.7 vs. 6.3; alkalinity (as HCO_3 mg/l) 20 vs. 66. These differences were apparently not sufficient to preclude spawning success and survival of the eggs and larvae. Second, based on studies of its reproductive behavior and development (Mettee 1974), supplemented by repeated sampling during various times of the year, the senior author feels that this Elassoma likely is an annual species. Assuming this hypothesis is correct, the specimens collected from Lower Pryor Spring represent the progeny of two successful spawnings in this new habitat.

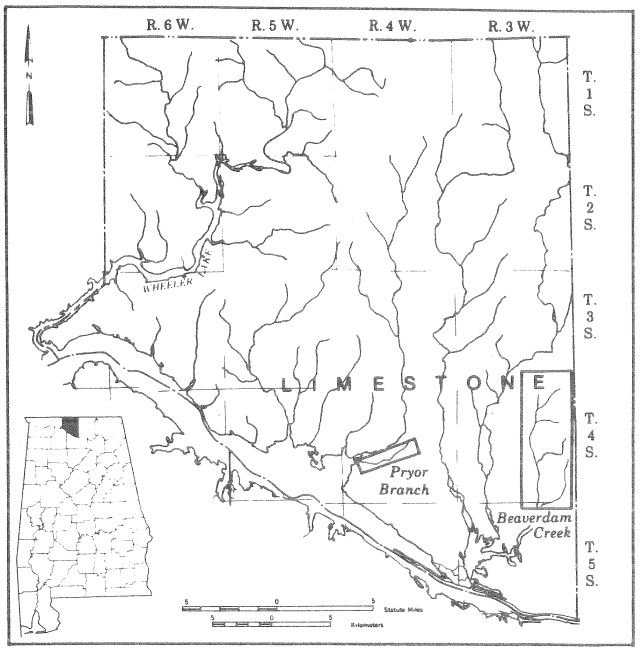

Figure 1.--Pryor Branch and Beaverdam Creek in Limestone County, Alabama.

Although the Elassoma collected in September 1985 were not individually measured, a distinct difference in size range was observed between populations. Specifically, all four individuals collected from Lower Pryor Spring were noticeably larger than most, if not all, of the 120 plus individuals collected at Moss Spring. Differences in water quality, the relative abundance of other fish species, and physical setting of the two springs could account for part or all of this variation in growth rate. Since Lower Pryor Spring contained no pygmy sunfishes prior to February 1984, increased growth could also reflect optimum utilization of a new environment and its previously untapped food supply by an introduced species. Lower Pryor Spring may contain fewer predator and competitor fish species. Esox americanus, Gambusia affinis, Lepomis cyanellus, L. macrochirus, L. microlophus, and Etheostoma tuscumbia were collected in both Moss Spring and Lower Pryor Spring, but fewer individuals of these 5 species were collected at the latter site. Differences in physical setting and use by man of the two springs may influence the abundance of pygmy sunfishes in ways not immediately obvious. Most of Moss Spring and its run is located in a pasture and is essentially unshaded, has a substrate comprised principally of silt and clay, and is regularly used as a livestock watering area. The spring and spring run nevertheless continue to support a thriving population of Elassoma. Lower Pryor Spring is located in a wooded area shaded by trees, has a substrate consisting principally of Tuscumbia Limestone with very little silt and sand, and is not utilized as a watering hole. Aquatic vegetation in both springs is comprised predominantly of Myriophyllum, an excellent spawning medium for Elassoma.

The CA for the Beaverdam Creek habitat is scheduled for renewal in 1986. Monitoring of both populations of Elassoma will continue on an annual basis. Consideration is also being given to the reintroduction of Elassoma into one additional spring in the Pryor Branch or Beaverdam Creek watershed, possibly within Wheeler National Wildlife Refuge.

Acknowledgments

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In answer to various inquiries received during the past year, this is the first issue of the Southeastern Fishes Council Proceedings to appear since August 1984. I apologize for the delay, which results from several factors, all related ultimately to economics. First, as can be seen from the contents, this issue contains four separate articles, which is much more economical than having these appear separately, and represents continuation of a policy begun with the preceding issue of the Proceedings. Thus, publication is delayed until a sufficient number of papers are available to fill out a 16-page issue. Second, I have personally taken on the tasks of entering all the edited manuscripts onto a word processor and then doing the layout. (Photographic reduction of the final typed manuscripts was done by the FSM photographer). This has resulted in substantial savings, which are crucial considering our limited budget. At the present time, one additional manuscript is on hand, which will appear in the next issue. Submission of additional manuscripts will ensure more rapid publication in the future. Beginning next year, the job of editor will be turned over to Dr. Michael M. Stevenson, Department of Biological Sciences, University of New Orleans, New Orleans, Louisiana 70148. All new manuscripts should be sent to that address.

The following news relating to southeastern fishes results from conversations with various colleagues, as well as information appearing in the Endangered Species Technical Bulletin. According to the June 1986 issue of that publication (vol. 11, no. 6), an individual of the Maryland darter (Etheostoma sellare) was seen in Deer Creek, Harford County, Maryland (its only known place of present occurrence) on 16 May, the first confirmed sighting of the species since September 1983.

Noel Burkhead and Bob Jenkins (Roanoke College) indicate that their Virginia fish book is almost ready to go to press. They also report that the Roanoke logperch (Percina rex), a Roanoke drainage endemic, will soon be listed as a nationally threatened species. However, the orangefin madtom (Noturus gilberti), another Roanoke endemic proposed for similar status, will not be listed because of the presence of a healthy introduced population in Craig Creek, in the upper James River drainage. The U.S. Army Corps of Engineers has denied permission to local interests to build a pump-storage reservoir on one of the tributaries of the upper Roanoke. Were this facility to be built, it would result in seriously reduced water levels in the main river at certain times, which in turn would impact the biota living there.

Nature Conservancy has purchased Pendleton Island (the site of a large mussel shoal), located in the Clinch River of western Virginia near the mouth of Copper Creek. The yellowfin madtom (Noturus flavipinnis) still occurs in Copper Creek. There had been some concerns expressed regarding its survival at this locality, inasmuch as efforts to locate it there in recent years had been unsuccessful. Recent monitoring work indicates that the rare pygmy madtom (Noturus stanauli) is still doing well at its type locality (Frost Ford, on the Clinch River). Dave Etnier (University of Tennessee) reports that his and Wayne Starnes' book on Tennessee fishes should go to press around the end of 1986. Dave has recently begun efforts to reestablish Noturus flavipinnis and the Smoky madtom (Noturus baileyi) in Abrams Creek (which flows out of Great Smoky Mountains National Park), from which stream the two species were eliminated via rough-fish removal operations in the mid-1950's. The first part of this operation (culturing in the lab) was intially successful, but the developing individuals of N. baileyi (though not N. flavipinnis) died as an apparent result of contamination of the air supply to the aquaria. Twenty-five N. flavipinnis were reared and introduced into Abrams Creek, and efforts will be repeated again next year for N. baileyi. Dave also reports the discovery of several additional populations of a rare, undescribed darter (genus Etheostoma, subgenus Nothonotus), which lives in fast-flowing water behind boulders in the main channel of the Elk River of south-central Tennessee and northern Alabama. His continuing work on Tennessee fishes has also revealed that the population of johnny darter (Etheostoma nigrum) inhabiting tributaries of the Mississippi River in western Tennessee and western Mississippi represents an undescribed species more similar superficially to the tesselated darter (Etheostoma olmstedi) of the Atlantic slope. Finally, he reports the apparent continuing recovery of fish populations in the lower Duck River, which had recently taken a "nosedive" for reasons not yet fully explained. Included in a recent collection of 45 species was the first specimen of the silvery minnow (Hybognathus nuchalis) recorded from the Tennessee River drainage in many years. Jim Grady (University of New Orleans), who has been studying systematic relationships among madtoms, tells us that the Duck River population previously called Noturus elegans is electrophoretically distinct, and externally may be distinguished from the true N. elegans by a more strongly mottled body pattern.

Thomas Spring (one of three known sites for the watercress darter (Etheostoma nuchale)) is now a national wildlife refuge under control of the U.S. Fish and Wildlife Service. There has recently been concern that the Roebuck Springs population of this species would suffer because of a new commercial development nearby. However, according to Fred Bagley (U.S. Fish and Wildlife Service), hydrological studies indicate that the danger is less than first thought, partly because there is a knoll between the spring and the area being developed (thus causing most of the drainage to be away from the spring), and also because the spring's recharge area is well below the surface of the ground and is not confined to the immediate area. This population of E. nuchale will of course continue to be closely monitored. Mike Howell (Samford University) is continuing efforts to locate and introduce the species into other suitable springs within the area. Bob Stiles (Samford University) and one of his students have recently completed a life history study of the undescribed Cahaba shiner. Bob indicates that the species may be found in concentrations close to shore following the first spring rains, but not at other times. Malcolm Pierson has been conducting a distributional survey of the species, and indicates that the present known range of the species encompasses about 35 miles of the Cahaba River (down from 60 miles historically). However, most of the population is concentrated in a 12-mile area between Centreville and Helena, Alabama, with only scattered

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individuals having been found in the lower 23 miles. Malcolm also has found the Alabama distribution of the formerly widespread blue shiner (Notropis caeruleus) to be limited to a few tributaries of the Coosa River in Cherokee, Calhoun, and Coosa counties. The last remaining "stronghold" for this species continues to be the upper Conasauga River of Georgia and Tennessee, where it is still common. He reports the following post-1975 sightings of the undescribed shovelnose sturgeon (genus Scaphirhynchus) from the lower Mobile Bay basin: Tensaw River in Monroe, Baldwin, and Wilson counties (5), Miller's Ferry Reservoir (1), and the lower Cahaba River, in Dallas County (1). The frecklebelly madtom (Noturus munitus), freckled darter (Percina lenticula), and crystal darter (Ammocrypta asprella), each of which has had a major portion of its preferred big-river habitat in the Mobile Bay basin eliminated as a result of the Tenn-Tom waterway, continue to exist in a few widely scattered places throughout the basin. One of the most interesting records involved the collection of a single P. lenticula from the channel of the Coosa River, below Jordan Dam, in the only remaining part of the original free-flowing river. The goldline darter (Percina aurolineata) continues to do well in the lower Cahaba River, particularly in its main tributary, the Little Cahaba River. It is otherwise known only from the upper Coosa River drainage, in Georgia. Finally, Bob Cashner (University of New Orleans), who has been working on systematics of the genus Fundulus, emphasizing electrophoretic techniques, says that the population of Fundulus stellifer occurring in the Tallapoosa River system of eastern Alabama and western Georgia differs from other populations in both color pattern and in six fixed alleles, and likely deserves species recognition.

It was recently learned that Jim Williams will be leaving the Office of Endangered Species office in Washington, and will be transferred to the new U.S. Fish and Wildlife Service laboratory in Gainesville, Florida, early next year. We want to take this opportunity to welcome Jim to his new home.