Longitudinal Variation in the Fish Community of Brumley Creek, Virginia, and Implications for Sampling

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Abstract: The fish fauna of Brumley Creek, Virginia, a third-order cold water stream in southwest Virginia, was sampled by electrofishing at 9 sites from headwaters to mouth. A total of 19 species were collected. Upstream sites had few species because of previous management activities. Downstream sites varied in species richness and composition as a function of several watershed characteristics. The differences in species composition among samples illustrates the problem that can occur if the fish fauna is described based on limited sampling, especially if the watershed is small and the management history is complex.

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Physical and chemical variables of flowing waters change predictably from headwaters to mouth (Vannote et al. 1980). Because animal distributions depend on these variables, stream biota also change predictably. As a result of this predictability, stream classification systems have been created to define the relationship between abiotic and biotic components of a stream ecosystem, and the desire for an easily measured descriptor has led to emphasis on stream order as a principal index of the stream habitat (Barila et al. 1981). Abiotic classification schemes attempt to characterize macrohabitats, and presumably are accurate for average conditions over a long stream stretch. Studies of large watersheds, such as Little River, Texas (Rose

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and Echelle 1981) and Thompson Creek, Louisiana (Guillory 1982), illustrate this approach.

Most watersheds, however, do not change uniformly from top to bottom and most have been altered by man. This disrupts the consistency of longitudinal changes in abiotic conditions and alters the fauna, reducing the predictive value of stream classification models. Recognition of this fact has led to the use of biological data to indicate the quality of the abiotic environment, as in Karr's (1981) biotic index based on sampling the fish community of streams. Biotic indices characterize shorter stream segments than abiotic indices, so that deviations from the expected biotic community can be identified.

The biotic index is useful to the fishery manager, but the data may be misleading. A common reason for sampling streams is to assess the impact of alterations to the stream; the biotic index is well-suited for this task. The harried manager, however, watches many streams and may get only 1 chance to sample each. Our concern is how accurately a restricted sample can represent the larger stream section. For example, is a single sample adequate for a 20-km stream, or do samples need to be taken at intervals throughout the stream? We illustrate the need for consideration of this point by describing variable results obtained by sampling Brumley Creek, a short stream, at several locations.

Brumley Creek is a third-order stream in Washington County, Virginia. In 1957 the headwaters were impounded to form Hidden Valley Lake, a shallow, 24.4-ha impoundment (Wollitz and Jesse 1969). The stream is 20 km long and has a 55.3-km^2 drainage basin. The basin consists of forested land in upper and lower sections and pasture in between. Brumley Creek ends at the confluence with the North Fork Holston River. Water quality of Brumley Creek is suitable for trout throughout its length and is typical of similar local drainages (Ruska 1980). The data for this paper were collected under a grant from Appalachian Power Company. In addition to the authors, William T. Kendall and Robert T. Lackey participated in the project. R. E. Jenkins, Roanoke College, verified identifications of fish, and Richard Neves contributed to the analysis.

Methods

We determined relative abundance and species composition of fish in Brumley Creek by electrofishing at 9 stations during June-August in 1978 and 1979 (Fig. 1). We chose sites that represented a variety of physical characteristics. At each site, we sampled a section of stream that included pools, riffles, and runs, as appropriate for the gradient at the sampling site. Ruska (1980) gave detailed description of study sites, including water

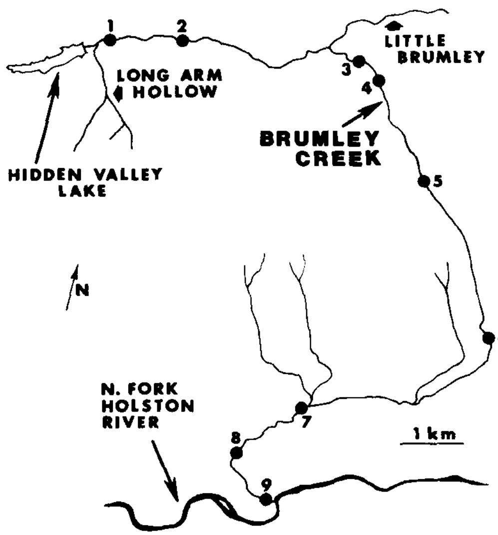

Figure 1. Map of the Brumley Creek watershed, Washington County, Virginia, showing locations of sampling sites.

quality data. We sampled each site using either a back-pack or shore-operated electroshocker with a gasoline generator producing 240-volt direct current. One person carried the electric probes and 2 others netted all shocked fish as they walked upstream through the sampling site. We sampled each site for approximately 40 minutes. All fish were identified to species using Eddy (1969), Scott and Crossman (1973), and Pflieger (1975). Common names in the text follow Robins (1980).

Results and Discussion

Of the 19 fish species collected in Brumley Creek (Table 1) all are typical of watersheds in the Tennessee River drainage except for brown and rainbow trout. Species richness and total relative abundance increase from headwaters to mouth, but the pattern is not continuous. The number and kinds of species captured and their relative abundance varied widely among sampling sites in response to particular local features of Brumley Creek and to a complex management history.

At Stations 1-5, we collected only 3 species, all of which occurred because of stocking (rainbow and brown trout) or passage through the lake dam (rock bass). Other species expected in first- and second-order streams,

Table 1. Catch of Fish Species at 9 Sites on Brumley Creek, Virginia, during June–August, 1978 and 1979

	Catch/Effort[b] at Station								
Species[a]	1	2	3	4	5	6	7	8	9
Rainbow trout (*Salmo gairdneri*)					13	4		4	
Brown trout (*Salmo trutta*)	1								
Warpaint shiner (*Notropis coccogenis*)							1		2
Whitetail shiner (*Notropis galacturus*)						11	2	1	4
Saffron shiner (*Notropis rubricroceus*)						36	7		
Telescope shiner (*Notropis telescopus*)							3		
Blacknose dace (*Rhinichthys atratulus*)						36			
Creek chub (*Semotilus atromaculatus*)						1			
Stoneroller (*Campostoma anomalum*)						36	66	16	42
Northern hog sucker (*Hypentelium nigricans*)							3		4
Rock bass (*Ambloplites rupestris*)	1		2	1			1		18
Smallmouth bass (*Micropterus dolomieui*)							2		
Greenside darter (*Etheostoma blennioides*)						4	3	11	18
Fantail darter (*Etheostoma flabellare*)						24	52	1	
Redline darter (*Etheostoma rufilineatum*)									16
Tennessee snubnose darter (*Etheostoma simoterum*)						1	32	1	8
Logperch (*Percina caprodes*)									1
Black sculpin (*Cottus baileyi*)						39	20	6	23
Banded sculpin (*Cottus carolinae*)								1	
Total number of species	2	0	1	1	1	10	12	8	10
Total catch	2	0	2	1	13	192	192	41	137

[a] Common names of fishes follow Robins (1980).
[b] Data represent numbers of fish sampled from each 50-m station during a 40-minute period.

such as blacknose dace, creek chub, black sculpin, and greenside darter (Barila et al. 1981), were absent for at least 2 reasons. First, Brumley Creek was treated with rotenone for the first 1.6 km below Hidden Valley Lake in 1977 to kill rock bass and other species which anglers regularly stock into the lake. Second, a series of steep ledges below station 5 acts as a natural barrier to upstream movement of native fishes. This influence was verified in Little Brumley Creek and Long Arm Hollow, tributaries upstream of the ledges, but not treated with rotenone. We collected no fish in Little Brumley Creek and only stocked brown trout in Long Arm Hollow.

Species richness and abundance increased at station 6, just downstream of a 6-km long privately owned fishing camp. The stream has not been altered within recent memory, and the watershed is completely forested. We collected rainbow trout at this site because they are stocked within the fishing camp. Six of the 9 other species collected are common in small to moderate streams throughout the eastern U.S. and 3 species (saffron shiner, Tennessee snubnose darter, and black sculpin) are common in small to moderate streams in the Tennessee-Cumberland drainage (Lee et al. 1980).

Sampling at station 7 revealed similar numbers of species and individuals as at station 6, but the species composition differed. Blacknose dace and creek chubs, more typical of smaller streams, and rainbow trout, not stocked in this part of the stream, were absent. Species such as smallmouth bass, rock bass, warpaint shiner, and telescope shiner, typical of larger, slower waters (Lee et al. 1980), were present. Among species present at both stations 6 and 7, those typical of larger streams (fantail darter, Tennessee snubnose darter) increased in abundance and those typical of smaller streams (saffron shiner, black sculpin) decreased in abundance.

The stream was third order at both stations 6 and 7, and only 3 small tributaries enter the stream between stations. The watershed, however, changes as the stream enters a narrow, flat valley. Gradient drops from approximately 20 m/km at station 6 to 10 m/km at station 7, and land use changes from forest to pasture.

At station 8, the stream passes through Brumley Gap, a narrow break in the ridge that separates Brumley Creek and North Fork Holston River watersheds. The gradient increases to 20 m/km and the riparian habitat is forested, resembling stations 1-6. Rainbow trout collected at this station were stocked by the Virginia Commission of Game and Inland Fisheries to maintain a put-and-take trout fishery. Five species first present at station 7 were absent from station 8. Three species (saffron shiner, blacknose dace and creek chub) typical of headwater streams (Lee et al. 1980) were present at station 6 but absent from station 8. Although habitat may be suitable at station 8, the isolation of this high gradient section between 2 low gradient sections (stations 7 and 9) presumably prohibits some species from utilizing the habitat. The result is a lower species richness and relative abundance compared to upstream and downstream stations.

Station 9 was located 200 m upstream of the confluence of Brumley Creek and North Fork Holston River, a stream with a much richer fish fauna. Sampling at station 9 revealed species present at both higher and lower gradient sites farther upstream and 2 species (redline darter and logperch) common to the North Fork Holston River but not found upstream in Brumley Creek. The species collected at this site presumably depend on conditions that favor either movement of Brumley Creek fishes downstream or North Fork Holston River species upstream. Thus as many as 41 species could be collected from this site if all species found in nearby collections on the North Fork Holston River were present (TVA, unpublished data).

The composition of the fish fauna differed substantially among sites within Brumley Creek. Detailed conclusions based on these samples are unwarranted, of course, because each site was sampled only once, and some species probably escaped capture. The appropriate conclusion is that the fish fauna of Brumley Creek is approximated by the sum of collections at the 9 sites. This conclusion brings up 3 problems that must be considered in the use of fish samples as indices of stream conditions.

First, the spatial distribution of samples must be considered. Single samples of a stream will under-estimate the species composition. Of the 19 species caught in total, only 63% were captured at the richest site. Expanding the sampling length at each site probably would not improve results because a range of local habitat differences were covered by the 40-min. sample. An appropriate method of sampling is to determine the range of major habitats from initial reconnaissance and to sample within each. This design would include more sites of shorter length instead of fewer sites of longer length.

Second, the fish fauna in streams is highly affected by management. Thus, the species composition will change unpredictably over time, and an assessment of stream conditions must document the local management history. For example, the fish fauna of the upper reaches of Brumley Creek has developed because anglers stock rock bass and bait fishes into Hidden Valley Lake, and management requires periodic rotenone treatment. Since 1979, however, the lake has been managed as a self-sustaining smallmouth bass fishery, and a major tributary has been managed for trophy brown trout. Future sampling in Brumley Creek below the lake will probably turn up smallmouth bass, fathead minnows *(Pimephales promelas),* golden shiners *(Notemigonus crysoleucas),* and brown trout instead of rainbow trout.

Third, the type of watershed presumably affects the degree to which the fish fauna conforms to expected patterns. Longitudinal zonation has been found in large watersheds where streams form a dendritic pattern and physical features such as gradient change regularly (Evans and Noble 1979, Barila et al. 1981, Guillory 1982). Brumley Creek does not fit this pattern. The stream is short, and consequently the fish fauna is influenced by the fauna of the larger river downstream. In this sense, the North Fork Holston River watershed has a pinnate form in which small streams enter the main stream directly throughout the drainage. Within the Brumley Creek watershed, gradient is initially steep, then flat, then steep, then flat. The stream and the fish fauna resemble that of Conowingo Creek (Hocutt and Stauffer 1975), where species richness declines and gradient increases near the mouth. Streams like these occur throughout the ridge and valley province of the Appalachian Mountains (Hunt 1974).

These data are presented to highlight the difficulty of characterizing a stream on the basis of limited sampling. Because we collected at 9 locations over 2 years and because we know the history of management in the watershed, we can describe the Brumley Creek fish community in great detail. If we only sampled the stream at 1 location, we might have concluded the stream was like the larger river, was a cold-water stream, was a cool-water stream, or was a degraded stream. None of these characterizations are accurate, and the potential inaccuracy emphasizes the caution needed when evaluating stream conditions from faunal surveys.

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