

## Fishes of the Main Channel New River, West Virginia.

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### ABSTRACT

Fishes were collected at five sites within a 92-km section of the New River in southern West Virginia in 1988, 1989, and 1990, and compared to previous surveys from 1979 and 1984. A total of 42 species were collected, representing five orders and eight families. Twenty of the 42 species (48 percent) are considered introduced to the drainage. A low number of native species (22 native species) was collected since 1979 and indicates a relatively depauperate fish fauna. Of the six endemic species in the New River drainage, only the bigmouth chub *Nocomis platyrhynchus* was common; the others were rare or not collected. Species richness was higher at the site immediately below Bluestone Dam compared to sites further downstream. New main channel distributional records were documented for gizzard shad and mountain redbelly dace.

### INTRODUCTION

The New River drainage harbors few indigenous fishes but a relative wealth of endemics (Ross and Perkins, 1959; Jenkins et al., 1972; Hocutt et al., 1986; Jenkins and Burkhead, 1994). Several authors have attributed the uniqueness of New River fish fauna to factors such as high gradient, hard bottom, poorly developed flood plain, (Addair, 1944; Ross and Perkins, 1959), high dissolved sulfates (Ross and Perkins, 1959), and isolation caused by several major falls (Jenkins et al., 1972; Hocutt et al., 1986). Previous counts have reported a total of 88 fish species in the New drainage with 46 native species including six endemics (Jenkins and Burkhead, 1994).

The scenic beauty and unique features of the New River inspired the creation of the New River Gorge National River (NRGMR) in 1978. The NRGMR is a 90-km corridor located in West Virginia and administered by the U.S. Department of the Interior, National Park Service. There are few published accounts of the fish fauna in this reach of the New River from which to develop a baseline for future monitoring (Stauffer et al., 1980; Hess 1983; Lobb, 1986). In this paper we summarize the fish species collected during 1988, 1989, and 1990 and past fish surveys for a current checklist of the fish fauna in the main channel New River.

### METHODS

Five study sites (Bluestone Dam, Sandstone Falls, Prince, Thurmond, and Fayette Station) were sampled in the New River (Figure 1). The Bluestone Dam site (latitude 37° 38' 37", longitude 80° 53' 5") is located immediately downstream

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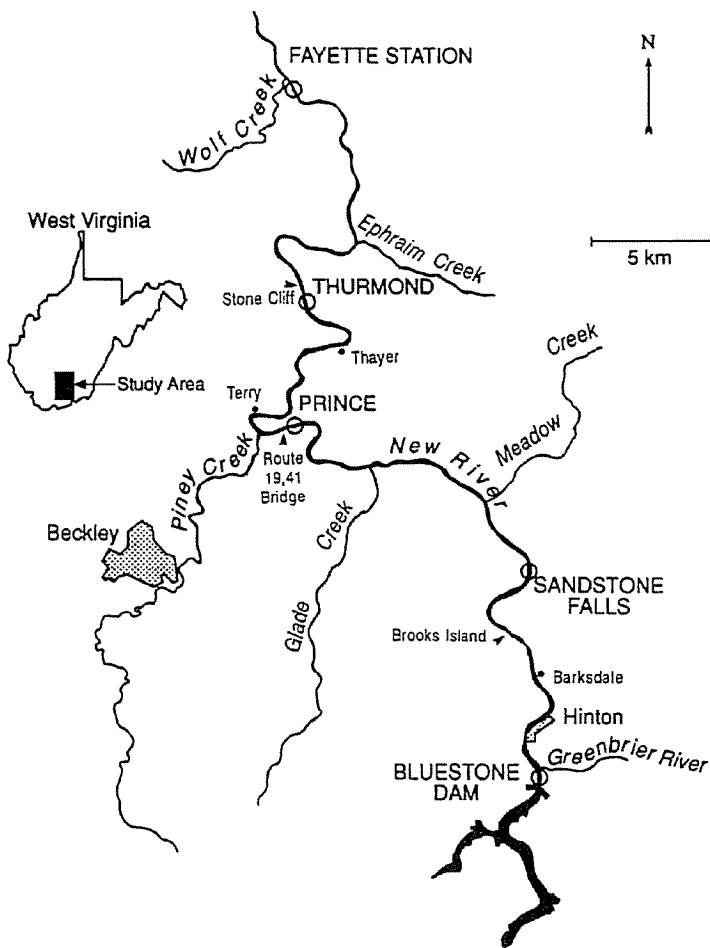


FIGURE 1. Map of study sites (open circle), cities (shaded area), towns (filled circles), and landmarks (arrow) on the New River, WV.

of Bluestone Dam. At this site the New River is approximately 300 m wide with an average depth of 1 m at low summer flow. Samples were collected in a section extending from 100 to 300 m downstream of Bluestone Dam. Samples were collected along the right descending river margin and in the main channel around rock outcrops and *Justicia americana* (water willow) islands.

The Sandstone Falls site (latitude 37° 46' 15", longitude 80° 53' 37") is located approximately 16 river km downstream of Bluestone Dam. At this site the river is approximately 300 m wide with an average depth of 1 m at low summer flow. Samples were collected in a section extending from 100 to 500 m upstream of Sandstone Falls. Samples were collected along the left descending river margin and in the main channel around water willow islands.

The Prince site (latitude 37° 51' 13", longitude 81° 4' 28") is located approximately 41.5 river km downstream of Bluestone Dam. At this site the river is approximate-

ly 150 m wide with wadable depths (less than 1 m) only along the margins. Samples were collected from a section extending from 100 to 500 m upstream of the route 19 and 41 bridge. All samples were collected along the left descending river margin.

The Thurmond site (latitude 37° 55' 53", longitude 81° 3' 52") is located approximately 61.5 river km downstream of Bluestone Dam. At this site the river is approximately 150 m wide with wadable depths (less than 1 m) only along the margins. Samples were collected from a section extending from 100 to 500 m upstream of Stone Cliff. All samples were collected along the left descending river margin.

The Fayette Station site (latitude 38° 3' 57", longitude 81° 4' 45") is located approximately 91.5 river km downstream of Bluestone Dam. At this site the river is approximately 50 m wide with wadable depths (less than 1 m) only along the margins. Samples were collected from a section extending from 100 to 500 m upstream of the confluence of the New River and Wolf Creek. All samples were collected along the left descending river margin.

Samples were collected in 1988, 1989, and 1990 from all five sites in mid to late summer (August and September). Additional samples were collected each year from Bluestone Dam and Sandstone Falls in early summer (June and July) and mid-fall (October and November). A total of 27 collections were made.

Twenty six of the 27 collections were made by electrofishing with a canoe-mounted generator, Coffelt (VVP-2C) control box and two hand-held electrodes. Each collection consisted of thirteen 10-minute electrofishing periods using pulsed DC electricity. In 1988, at Fayette Station, fish were collected during ten 10-minute sampling periods using a Coffelt electrofishing boat. During a 10-minute sample period all stunned fish were netted and placed in either a live well or bucket. After each 10-minute sample period, all large and familiar species were recorded and released. All other specimens were either stored on ice or preserved with 5-10% formalin. In the laboratory all specimens were identified using Jenkins and Burkhead (1994).

Sampling by Stauffer et al. (1980) was conducted in June and August of 1979. Collections were made by electrofishing into a 1.5 m X 3.0 m seine. For each collection, sampling was conducted until additional effort produced no additional species. For consistency, collections from several locations were pooled to represent collections at Bluestone Dam, Sandstone Falls, Prince, and Thurmond (Figure 1). Bluestone Dam was represented by six collections made between Bluestone Dam and the city of Hinton. Sandstone Falls was represented by four collections made between Brooks Island and the mouth of Meadow Creek. Prince was represented by one collection at the mouth of Piney Creek. Thurmond was represented by one collection immediately upstream of Stone Cliff.

Sampling by Lobb (1986) was conducted at each site from July to October of 1984. Collections were made using a raft-mounted generator, Coffelt (VVP-2C) control box, and two hand-held electrodes, a Coffelt electrofishing boat, a Coffelt backpack electrofisher, and by electrofishing into a seine. Each collection consisted of a 15-minute electrofishing period. For consistency, collections from several locations were pooled to represent collections at Bluestone Dam, Sandstone Falls, Prince, and Thurmond (Figure 1). Bluestone Dam was represented by five collections made between Bluestone Dam and the town of Barksdale.

Sandstone Falls was represented by 33 collections made between Brooks Island and 0.5 km downstream of the mouth of Meadow Creek. Prince was represented by 36 collections made between the mouth of Glade Creek and 3.3 km downstream of the town of Terry. Thurmond was represented by 26 collections made between Thayer and the mouth of Ephraim Creek. No collections were made by Lobb (1986) near the Fayette Station site.

For the purposes of this paper and as was done by Lobb (1986) no distinction was made between *Luxilus albeolus* white shiner and *L. chrysocephalus* striped shiner. The authors believe that both species inhabit this section of the New River; however, distinction of the two species proved to be problematic. Stauffer et al. (1980) reported only white shiners from this section of the New River. *Luxilus* spp. were not included in species counts. In order to discuss commonness and rarity of species we defined common as a species which occurred in more than 10 of the 13 site surveys and rare as a species which occurred in fewer than three of the 13 site surveys.

To allow for discussion of sampling efficiency, an estimate for species richness (Krebs, 1989) was used to calculate absolute species richness and a 95 percent confidence interval at each of the five sites for the 1988 to 1990 mid-summer collections only.

For discussion of longitudinal variation in species richness, total species richness was tabulated for the 1988-1990 survey and for all three surveys combined. Total species richness was not calculated separately for Stauffer et al. (1980) and Lobb (1986) because of unequal sampling effort among sites.

## RESULTS AND DISCUSSION

A total of 42 fish species (not including both *Luxilus* spp.) and one recognized hybrid, from eight families and five orders were collected in the New River between Bluestone Dam and Fayette Station from 1979 to 1990 (Table 1). Jenkins and Burkhead (1994) reported 88 fish taxa known from the New drainage and 42 (48 percent) of these they considered introduced. Twenty (48 percent) of the 42 fish species listed in Table 1 are considered introduced (Jenkins and Burkhead, 1994). Addair (1944) reported 25 fish species from the main channel of the New River between Bluestone Dam and Fayette Station with nine (36 percent) introduced species (Jenkins and Burkhead, 1994). Orth and Leonard (1985) reported 28 fish species from the main channel of the New River near Prince and Thurmond with ten (36 percent) introduced species (Jenkins and Burkhead, 1994). The low number of native fish species (22 native species) collected between Bluestone Dam and Fayette Station since 1979 further supports previous discussions of the depauperate fish fauna of the New drainage (Ross and Perkins, 1959; Jenkins et al., 1972; Hocutt et al., 1986; Jenkins and Burkhead, 1994).

Main channel distribution records for the 1988-1990 survey include *Dorosoma cepedianum* gizzard shad and *Phoxinus phoxinus* mountain redbelly dace. To our knowledge this is the first published account of gizzard shad within the New drainage. One individual was collected on October 31, 1989, from the Bluestone Dam site and 13 specimens were collected from the Bluestone Dam (12 fish) and Thurmond (1 fish) sites in 1990. Two individuals collected on November 1, 1990, at Bluestone Dam exceeded 400 mm TL and one specimen was 480 mm TL.

TABLE 1. List of species collected in the New River between Bluestone Dam and Fayette Station in 1979, 1984, 1988, 1989, and 1990 (X denotes species was collected).

Species	Bluestone Dam			Sandstone Falls			Prince			Thurmond			Fayette Station		
	Origin <sup>a</sup>	79	84	88-90	79	84	88-90	79	84	88-90	79	84	88-90	79	88-90
Clupeidae															
<i>Dorosoma cepedianum</i> (Lesueur) gizzard shad	I			X										X	
Cyprinidae															
<i>Camposoma anomalum</i> (Rafinesque) <sup>c</sup> central stoneroller	N	X	X	X	X	X	X	X	X	X		X	X		
<i>Cyprinella galactura</i> (Cope) whitetail shiner	IP			X			X							X	
<i>Cyprinella spiloptera</i> (Cope) <sup>bc</sup> spottfin shiner	N	X		X	X	X			X	X		X	X		X
<i>Cyprinus carpio</i> Linnaeus <sup>bc</sup> common carp	I			X	X	X									
<i>Luxilus</i> spp. (Rafinesque) <sup>c</sup> white and/or striped bass	NI	X	X	X	X	X	X	X	X	X		X	X		
<i>Noconis platyhynchus</i> Lachner & Jenkins <sup>c</sup> bigmouth chub	E	X	X	X	X	X	X	X	X	X		X	X		X
<i>Notemigonus crysoleucas</i> (Mitchill) golden shiner	I	X		X											
<i>Notropis hudsonius</i> (Clinton) <sup>c</sup> spottail shiner	IP	X	X	X	X	X	X	X	X	X			X	X	
<i>Notropis photogenis</i> (Cope) <sup>c</sup> silver shiner	N	X	X	X	X	X	X		X					X	
<i>Notropis rubellus</i> (Agassiz) <sup>bc</sup> rosyface shiner	N			X	X	X	X	X	X	X		X	X		
<i>Notropis telescopus</i> (Cope) <sup>c</sup> telescope shiner	IP	X	X	X	X	X	X	X	X	X		X	X		X
<i>Notropis volucellus</i> (Cope) <sup>bc</sup> imic shiner	N	X		X	X	X	X	X	X	X		X	X		X



TABLE 1. continued

Species	Origin <sup>a</sup>	Bluestone Dam			Sandstone Falls			Prince			Thurmond			Fayette Station 88-90
		79	84	88-90	79	84	88-90	79	84	88-90	79	84	88-90	
Percichthyidae														
<i>Morone chrysops</i> (Rafinesque) x	I			X										
<i>Morone saxatilis</i> (Walbaum) sunshine bass											X			
Centrarchidae														
<i>Ambloplites rupestris</i> (Rafinesque) <sup>bc</sup> rock bass	I	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Lepomis auritus</i> (Linnaeus) redbreast sunfish	I		X	X		X	X	X	X	X	X	X	X	X
<i>Lepomis cyanellus</i> Rafinesque <sup>b</sup> green sunfish	N	X		X			X			X	X	X		X
<i>Lepomis gibbosus</i> (Linnaeus) <sup>c</sup> pumpkinseed	I	X	X	X		X				X	X	X		
<i>Lepomis macrochirus</i> Rafinesque <sup>bc</sup> bluegill	I	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Lepomis megalotis</i> (Rafinesque) longear sunfish	I								X	X				X
<i>Micropterus dolomieu</i> Lacepède <sup>bc</sup> smallmouth bass	I	X	X	X		X	X	X	X	X	X	X	X	X
<i>Micropterus punctulatus</i> (Rafinesque) <sup>bc</sup> spotted bass	I	X	X	X		X	X	X	X	X	X	X	X	X
<i>Micropterus salmoides</i> (Lacepède) <sup>b</sup> largemouth bass	I			X		X	X					X		
<i>Pomoxis annularis</i> Rafinesque <sup>b</sup> white crappie	I	X	X	X	X	X			X					X
<i>Pomoxis nigromaculatus</i> (Lesueur) <sup>b</sup> black crappie	I	X	X	X	X	X					X			

TABLE 1. continued

Species	Origin <sup>a</sup>	Bluestone Dam			Sandstone Falls			Prince			Thurmond			Fayette Station		
		79	84	88-90	79	84	88-90	79	84	88-90	79	84	88-90	88-90	88-90	
Percidae																
<i>Etheostoma blennioides</i> Rafinesque <sup>bc</sup>	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
greenside darter																
<i>Etheostoma caeruleum</i> Storer <sup>c</sup>	NI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
rainbow darter																
<i>Etheostoma flabellare</i> Rafinesque	N	X														
fantail darter																
<i>Perca flavescens</i> (Mitchill)	I				X											
yellow perch																
<i>Percina caprodes</i> (Rafinesque) <sup>c</sup>	N	X		X		X			X	X		X	X		X	
logperch																
<i>Percina gymnocephala</i> Beckham <sup>d</sup>	E							X								
Appalachia darter																
<i>Percina oxyrhynchus</i> (Hubbs & Raney) Sharpnose darter <sup>bc</sup>	N	X		X	X	X		X	X	X		X	X	X	X	
<i>Percina roanoka</i> (Jordan & Jenkins) <sup>c</sup>	IP	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Roanoke darter																

<sup>a</sup>N = native; E = endemic; NI = regarded as native, but possibly introduced; IP = regarded as introduced, but possibly native; I = introduced; taken from Jenkins and Burkhead (1994).

<sup>b</sup>reported from the mainstem New River between Bluestone Dam and Fayette Station by Addair (1944); also reported *Anguilla rostrata* (Lesueur) American eel, *Erinostax dissimilis* (Kirtland) streamline chub, *Notropis scabriceps* (Cope) New River shiner, and *Sizostedion vireum* (Mitchill) walleye.

<sup>c</sup>reported from the mainstem New River near Prince and Thurmond by Orth and Leonard (1985); also reported *Lythrurus ardens* (Cope) rosefin shiner and *Notropis scabriceps* (Cope) New River shiner.

<sup>d</sup>reported as *Percina maculata* blackside darter.



Carlander (1969) reports sizes for gizzard shad greater than 480 mm TL only after age-5. If the 480 mm TL individual collected in 1990 was a lifelong resident of the New River, then gizzard shad entered the New drainage prior to 1986. Gizzard shad were also collected in Bluestone Lake by West Virginia Department of Natural Resources (WVDNR) personnel in 1989 (Mark Scott, pers. comm.) and Claytor Lake by Virginia Department of Game and Inland Fisheries (VDGIF) personnel in 1988 (Joe Williams, pers. comm.). An article in the September 10, 1992 edition of the Roanoke Times and World-News (page C3) referred to an anonymous phone-caller who claimed to have stocked thousands of gizzard shad from Smith Mountain Lake of the Roanoke drainage into Claytor Lake of the New drainage over a five-year period in the mid-to-late 1980's.

Whitetail shiners, which were introduced from Tennessee River drainage, have previously been recorded from main channel and tributary sections of the New River in Virginia and upper regions in West Virginia (Jenkins et al., 1972; Lee et al., 1980; Stauffer et al. 1980; Hess 1983); however, this is the first account from the lower New River in West Virginia (Prince and Thurmond). Previous authors have suggested that the fauna of New River is unsaturated, at least in parts of the drainage, possibly because of barriers such as reservoirs (Jenkins et al., 1972; Hocutt et al., 1986). During the spring of 1989, frequent high flows may have carried larval whitetail shiners downstream to the lower New River.

The appearance of mountain redbelly dace in the main channel of the New River in West Virginia is probably not evidence for established populations in the main river; however, it may be a result of a few transient individuals being washed into the river from tributaries during flooding. Jenkins and Burkhead (1994) indicate that the mountain redbelly dace is more common in upland, mountain streams and creeks than large rivers such as the New River. Mountain redbelly dace have previously been collected in tributaries of the New River in West Virginia (Leonard and Orth, 1986; Hocutt et al., 1978).

*Morone chrysops* x *M. saxatilis* sunshine bass, the one recognized hybrid collected by both Lobb (1986) and the authors, have been stocked intermittently in Bluestone Reservoir between 1976 and the present (Mark Scott, pers. comm.) and probably entered the New River through the dam. *Morone chrysops* white bass and *Morone saxatilis* striped bass were stocked by the WVDNR in Bluestone Reservoir in 1955 and 1975, respectively (Mark Scott, pers. comm.). Moreover, the latter species has been stocked in Virginia portions of the New River by VDGIF from 1969 to the present (Joe Williams, pers. comm.). Another species known to be stocked in the New River drainage and not collected in any of the three surveys is *Esox masquinongy* muskellunge, which were observed in underwater surveys in 1984 (Lobb and Orth, 1991). WVDNR has stocked muskellunge in Bluestone Reservoir intermittently from 1958 to the present (Mark Scott, pers. comm.) and VDGIF has stocked muskellunge in Virginia portions of the New River since 1963 (Joe Williams, pers. comm.). *Esox lucius* x *E. masquinongy* tiger muskellunge were stocked by VDGIF in Virginia portions of the New River in the late 1970's and early 1980's (Joe Williams, pers. comm.). Several trout species (*Oncorhynchus mykiss* rainbow trout, *Salmo trutta* brown trout, and *Salvelinus fontinalis* brook trout) are stocked annually by the WVDNR in the tributaries of the New River between Bluestone Dam and Fayette Station (Mark Scott, pers. comm.); however, none of

these species were collected in the three surveys listed herein. Other species stocked historically in Bluestone Reservoir by WVDNR include: *Dorosoma petenense* threadfin shad in 1965, 1966, and 1971; *Notropis atherinoides* emerald shiner in 1962, and *Stizostedion vitreum* walleye intermittently between 1976 and 1983 (Mark Scott, pers. comm.).

Three New River drainage fish species (New River shiner, *Phenacobius teretulus* Kanawha minnow, and candy darter) have previously been mentioned as species of special concern due to low numbers, limited distributions, or recent declines (Johnson, 1987; Burkhead and Jenkins, 1991). None of these species occurred in the surveys listed in Table 1 and only the New River shiner has ever been reported from the main channel of the New River between Bluestone Dam and Fayette Station (Addair, 1944; Orth and Leonard, 1985).

Fifteen of the 42 species collected are considered common and nine other species are considered rare. Common species include *Campostoma anomalum* central stoneroller, bigmouth chub, *Notropis rubellus* rosyface shiner, *N. telescopus* telescope shiner, *N. volucellus* mimic shiner, *Hypentelium nigricans* northern hog sucker, *Pylodictis olivaris* flathead catfish, *Ambloplites rupestris* rock bass, *Lepomis macrochirus* bluegill, *Micropterus dolomieu* smallmouth bass, *M. punctulatus* spotted bass, *Etheostoma blennioides* greenside darter, *E. caeruleum* rainbow darter, *Percina oxyrhynchus* sharpnose darter, and *P. roanoka* Roanoke darter. Rare species include gizzard shad, *Notemigonus crysoleucas* golden shiner, mountain redbelly dace, *Rhinichthys atratulus* blacknose dace, creek chub, *Catostomus commersoni* white sucker, *Etheostoma flabellare* fantail darter, *Perca flavescens* yellow perch, and Appalachia darter.

Absolute species richness estimates varied both spatially and temporally (Figure 2). The absolute species richness was greatest at Prince in 1990 and lowest at Fayette Station in 1990. The 95 percent confidence interval for absolute species richness estimates indicate that sampling efficiency of species numbers was generally good during 1988-1990 mid-summer collections. Ten of the actual species richness values fell inside the 95% confidence interval for absolute species richness, while the remaining five collections were just outside the lower range of this confidence interval.

The greatest number of fish species was collected from Bluestone Dam (38 species) with decreasing numbers of species occurring with distance from Bluestone Dam (Figure 3). However, sampling effort was greatest near Bluestone Dam. The same trend was less distinct for collections made 1988-1990, when sampling effort remained equal among all five sites. Species numbers may be greatest immediately downstream of Bluestone Dam due to emigration of game and forage species from Bluestone Lake. Introduced species collected only at Bluestone Dam or Sandstone Falls include common carp, golden shiner, and yellow perch. Species numbers may decrease with distance from Bluestone Dam due to reduced habitat diversity; for example, Lobb (1986) found that in general, channel width decreased and gradient increased with distance from Bluestone Dam.

#### ADDENDUM

In subsequent routine surveys of the New River the European cyprinid, rudd

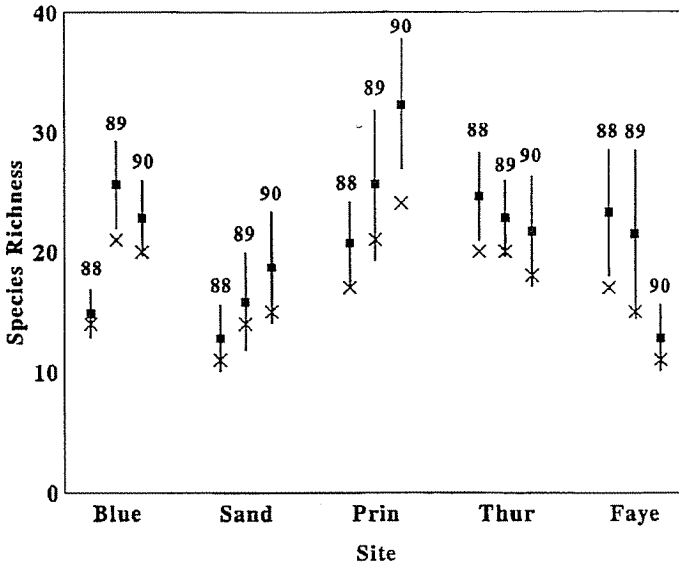


Figure 2. Absolute species richness estimates (square), 95 percent confidence interval for the absolute species richness estimates (vertical bar), and actual species richness values (X) for mid-summer collections at Bluestone Dam, Sandstone Falls, Prince, Thurmond, and Fayette Station in 1988, 1989, and 1990 (88 = 1988, 89 = 1989, 90 = 1990, Blue = Bluestone Dam, Sand = Sandstone Falls, Prin = Prince, Thur = Thurmond, Faye = Fayette Station).

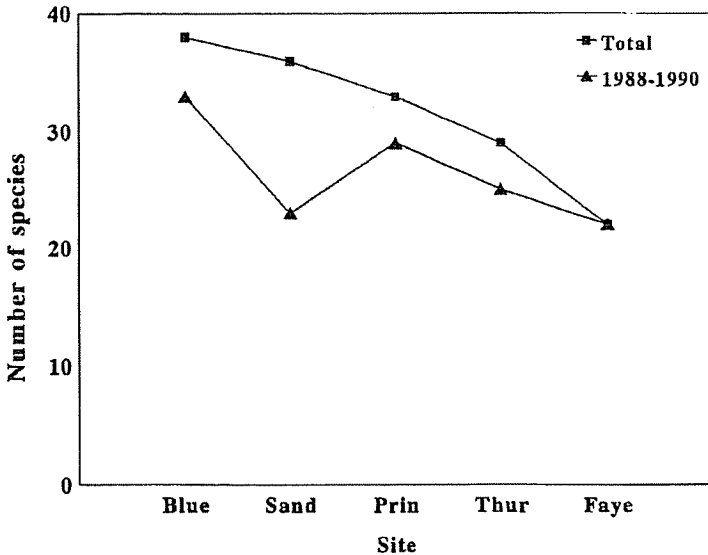


Figure 3. A site comparison of the total number of species collected in all three New River, WV studies with the total number of species from the 1988-1990 surveys (Blue = Bluestone Dam, Sand = Sandstone Falls, Prin = Prince, Thur = Thurmond, Faye = Fayette Station).

*Scardinius erythrophthalmus* was collected in the main channel New River near Stone Cliff in Fayette County, West Virginia (Easton et al. 1993).

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#### LITERATURE CITED

- Addair, J. 1944. The fishes of the Kanawha River system in West Virginia and factors which influence their distribution. PhD dissertation. Ohio St. Univ., Columbus, OH. 225 pp.
- Burkhead, N.M. and R.E. Jenkins. 1991. Fishes. Pp. 321-409. In K. Terwilliger (ed.), *Virginia's Endangered Species: Proceedings of a Symposium*. McDonald and Woodward Publishing Co., Blacksburg, VA.
- Carlander, K.D. 1969. *Handbook of Freshwater Fishery Biology*. Iowa St. Univ. Press, Ames, IA. 752 pp.
- Easton, R.S., D.J. Orth, and N. M. Burkhead. 1993. The first collection of rudd, *Scardinius erythrophthalmus* (Cyprinidae), in the New River, West Virginia. *J. Freshwat. Ecol.* 8:263-264.
- Hess, L. 1983. Preliminary analysis of the food habits of some New River fishes with emphasis on black fly utilization Pp 15-21 *In* W. E. Cox and M. Kegley (eds.), *New River Symposium*. Glen Jean, WV.
- Hocutt, C.H., R.F. Denoncourt, and J.R. Stauffer, Jr. 1978. Fishes of the Greenbrier River, West Virginia, with drainage history of the Central Appalachians. *J. Biogeogr.* 5:59-80.
- Hocutt, C.H., R.E. Jenkins, and J.R. Stauffer, Jr. 1986. Zoogeography of fishes of the central Appalachians and in central Atlantic coastal plain. Pp. 161-211. In C.H. Hocutt and E.O. Wiley (eds.), *The Zoogeography of North American Freshwater Fishes*. John Wiley and Sons, New York.
- Johnson, J.E. 1987. Protected fishes of the United States and Canada. *Am. Fish. Soc.*, Bethesda, MD. 42 pp.
- Jenkins, R.E., E.A. Lachner, and F.J. Schwartz. 1972. Fishes of the central Appalachians drainage: Their distribution and dispersal. Pp. 43-117. In P.C. Holt (ed.), *The Distributional History of the Biota of the Southern Appalachians. Part III: The Vertebrates*. Va. Poly. Inst. St. Univ., Res. Div. Monogr. 4, Blacksburg, VA.
- Jenkins, R.E. and N.M. Burkhead. 1994. *Freshwater Fishes of Virginia*. *Am. Fish. Soc.*, Bethesda, MD. 1079 pp.
- Krebs, C.J. 1989. *Ecological Methodology*. HarperCollins, New York, NY. 654 pp.
- Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R.

- Stauffer, Jr. 1980 et seq. Atlas of North American Freshwater Fishes. N.C. St. Mus. Nat. Hist., Raleigh, NC. 854 pp.
- Leonard, P.M. and D.J. Orth. 1986. Application and testing of an index of biotic integrity in small, coolwater streams. *Trans. Am. Fish. Soc.* 115:401-414.
- Lobb, M.D., III. 1986. Habitat use by fishes of the New River, West Virginia. M.S. thesis. Va. Poly. Inst. St. Univ., Blacksburg, VA. 119 pp.
- Lobb, M.D., III, and D.J. Orth. 1991. Habitat use by an assemblage of fish in a large warmwater stream. *Trans. Am. Fish. Soc.* 120:65-78.
- Orth, D.J. and P.L. Leonard. 1985. Comparisons of fish assemblages in the New River, West Virginia, above and below polluted tributaries. Pp 95-106. In USDI, National Park Service (eds.), *Proceedings of the New River Symposium*. Glen Jean, WV.
- Ross, R.D. and B.D. Perkins. 1959. Drainage evolution and distribution problems of the fishes of the New (upper Kanawha) River system in Virginia. Part III. Records of fishes of the New River. *Va. Agri. Exp. Stat. Tech. Bull.* 145:1-35.
- Stauffer, J.R., Jr., C.H. Hocutt, and S.L. Markham. 1980. Aquatic biological survey of the New River, Virginia and West Virginia. Final report to the U.S. Fish Wildl. Serv., Appalachian Environmental Laboratory, Univ. Md., Frostburg, MD. 36 pp.

