HABITAT USE BY FISHES OF THE NEW RIVER, WEST VIRGINIA

by

M. Delbert Lobb, III

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APPROVED:

Donald J. Orth, Chair

Richard J. Neves

Dean F. Stauffer

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(ABSTRACT)

Density estimates of the species and lifestages in different habitat types were made from electrofishing collections and underwater fish counts. During midday, fish densities in edge pool and riffle habitats were comparable, but densities in edge pool habitat were significantly higher than densities in middle pool and run habitats. Snag and edge riffle habitats supported the highest densities of fish. Habitat use and activity shifts between daytime and nighttime were found for many species. Fish species and lifestage composition and densities differed among the habitat types, and five habitat-use guilds (edge-pool, middle-pool, edge-channel, riffle, and generalists) were described. Larger centrarchids preferred deep habitats with slow velocities (deep edge and middle pool, and snags), while young centrarchids preferred shallower habitat. However, all sizes of smallmouth bass were nearly ubiquitous in the habitats of the study area. The cyprinids and percids preferred shallow areas, but preferences for velocity differed among the species and lifestages.

Spawning and habitat preferences of the endemic bigmouth chub, *Nocomis platyrhynchus*, were described. Bigmouth chubs used areas with plenty of small to large gravel (3-64 mm diameter), shallow depths, and moderate velocities for constructing spawning mounds. Bigmouth chubs were seen only using riffle and adjacent run habitat during late summer. Within these areas, depth, velocity, substrate, and cover were used in accordance with their availability, except for an avoidance of the shallowest available depths. Bigmouth chubs occupied positions near the substrate, where velocities were slower than the mean water column velocity.

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INTRODUCTION

Altered ecosystems below dams are the most prevalent lotic ecosystems on Earth (Stanford and Ward 1979). Many researchers feel that stream regulation has exerted more profound effects on the world's rivers than have pollutants (Ward and Stanford 1979). Presently, Bluestone Dam, which impounds the New River in West Virginia, is being considered for conversion to a hydroelectric power generation facility. Five kilometers downstream from the dam is the New River Gorge National River (NRGNR). The National Park Service is concerned that fluctuating flows associated with the proposed hydroelectric operation of Bluestone Dam will adversely affect the indigenous fish fauna and the fishery in the NRGNR.

To assess the impacts of such flow fluctuations, on the fish fauna, it is necessary to have information on each species spawning requirements, habitat-type use, and tolerances and requirements for depth, velocity, substrate, and cover. Previous efforts to inventory the fish fauna of the New River, WV (Addair 1944; Hocutt et al. 1978; Hocutt et al. 1979; Stauffer 1980) have been concentrated on tributary streams, but provide an adequate inventory of the species in the mainstem. The effects of temperature and streamflow on spawning by smallmouth bass (*Micropterus dolomieui*) were studied by Graham and Orth (in press), and the microhabitat requirements of several fish species have been partially identified (Joy et al. 1981). However the relative abundance of fish in different habitat types and the requirements for depth, velocity, substrate, cover, and spawning in the New

River, are unknown for most of the species. Therefore, this study was designed to 1) determine the fish species-habitat associations in the major habitat types in the New River, WV, and 2) to describe the microhabitat and spawning habitat requirements of one of the endemic fish species, the bigmouth chub, *Nocomis platyrhynchus*.

FLOW FLUCTUATIONS

Hydropower dams can be operated as run-of-river or storage facilities. A run-of-river operation generally uses normal river flow for power generation and usually does not change the normal water level fluctuations already present in the drainage basin (Baxter 1977; Hildebrand 1980), unless diversions are constructed to route the water to a powerhouse. A storage hydroelectric facility is associated with a reservoir that is large enough to allow water storage from the wet season to the dry season (Hildebrand 1980; Walburg et al. 1981). The capacity for such storage can provide more consistent flows for hydroelectric power generation. Such facilities are generally operated in a peaking mode, in which discharge is varied in accordance with the demand for electricity. This generally results in high flows during weekdays and low flows at night and on weekends (Hildebrand 1980; Walburg et al. 1981).

The amplitude of fluctuations below hydropower dams and in unimpounded streams are essentially equivalent. However, flow fluctuations below hydroelectric facilities are more frequent and rapid (Hildebrand 1980; Walburg et al. 1981). In some hydropower tailwaters, daily fluctuations in water level can be as great as two meters (Holden 1979). Large daily fluctuations below hydropower dams usually have a destructive influence on tailwater biota by creating an unstable, highly variable downstream habitat (Walburg et al. 1981). Because of the recreational and economic importance of many fish populations, the effects on the fishery below hydropower dams are usually of great concern.

Large diel fluctuations in the tailwaters of hydropower dams can have several effects on the tailwater fishery. Rapid flow reductions can disrupt spawning, strand fish and expose nests. Abrupt flow increases can sweep away eggs and fry as well as disrupt spawning. Kroger (1973) found that rapid reduction in flow below Jackson Lake, Wyoming, stranded sculpins (*Cottus sp.*) in the Snake River. Trout and salmon have also been found stranded below hydropower and diversion dams (Anderson 1972; Fowler 1978). Corning (1969) found high stream flows, resulting from sudden water releases from a Colorado reservoir, disinterred 75% of artificially buried rainbow trout (*Salmo gairdneri*) eggs, and the viability of the remaining eggs was apparently lowered. Also, because fish have preferred depths and velocities for spawning, spawning conditions may be met only for a short time each day below a hydropower dam (Bauersfield 1978). Few studies have documented the effects of fluctuating flows on fish in warmwater streams below impoundments. However, the effects on warmwater fish are probably similar to described impacts. For example, flooding, which is similar to the rapid releases during power generation, terminated nesting behavior, apparently destroyed nests and displaced fry of smallmouth bass (*Micropterus dolomieui*) in a small Ohio stream (Winemiller and Taylor 1982).

Diel fluctuations in flow alter fish habitat. Changes in flow cause changes in velocity, depth and wetted area of a river, which may consequently influence the survival and distribution of fish (Brooker 1981). Different life stages of fish have distinct preferences for various combinations of depth, velocity and other physical characterisics of a stream (Stalnaker 1981). Due to these preferences, each life stage may find a specific stream reach suitable or unsuitable at a given discharge and time (Stalnaker 1979, 1981). Low flows decrease habitat quality and quantity, and fish become concentrated and redistribute to less suitable habitat (Walburg et al. 1981). Reduced habitat increases competition for food and space among and within species and can lead to increased susceptibility to predation (Corning 1969; Walburg et al. 1981; Stevens and Miller 1983). During maximum releases the tailwater may change from a typical pool-riffle association to a deep, swift river (Walburg et al. 1981), and fish may be displaced downstream. Hubert (1981) found that high flows, resulting from opening flood gates of a hydroelectric dam, displaced smallmouth bass downstream. When displaced, the fish generally moved into areas near the shoreline where eddies and rock cover created protection from the current. MacPhee and Brusven (1976) found that any alteration in flow displaced juvenile salmon downstream in a diversion channel used to simulate fluctuating flows below a power dam. Only fish adapted to high velocities are able to sustain their populations below hydroelectric dams (Walburg et al. 1981). High flows are less detrimental to fish populations if the tailwater has deep pools, sufficient cover and backwater areas (Walburg et al. 1981, 1983). Since streamflow changes alter fish habitat, the abundance, diversity, and productivity of fish species may also be affected (Neel 1963; Stalnaker 1981; Brocksen et al. 1982; Cushman 1985). Bain and Finn (unpublished manuscript) found that fish that preferred shallow habitats with slow velocities were reduced in abundance in a river with dramatic daily flow fluctuations, compared to the fish community structure in a river with a natural daily flow regime. The species and lifestages that were habitat generalists, or those that specialized on other habitat types, either increased in abundance or were unaffected. The shallow, slow habitat guild constituted the majority of species and individuals in the unregulated river.

High flows following periods of low discharge result in increased streambed and bank instability and scouring of the substrate (Ward 1976). This may decrease streambank vegetation, streambed algae and higher plants and detritus which may alter the trophic structure of the tailwater biota (Walburg et al. 1981). Scouring, erosion and sedimentation change the substrate and channel morphology (Buma and Day 1977), which may change the complexity of fish habitat. Stream habitat complexity has been positively correlated with fish species diversity (Gorman and Karr 1978; Schlosser 1982). Thus, any change in channel morphology and substrate below impoundments is likely to influence the tailwater fish fauna (Hildebrand 1980; Brooker 1981).

The downstream effects of fluctuating flows decrease as the distance from the reservoir increases. Tributary and groundwater inflow, meteorological conditions, pools, substrate and other factors moderate the effects of the discharge (MacPhee and Brusven 1976; Walburg et al. 1981, 1983). Walburg et al. (1983) found that warmwater fish species generally were more abundant downstream than immediately below the dam in three hydropower dam tailwaters.

Presently, discharge variations from Bluestone Dam are primarily a result of water releases for power generation from Claytor Dam in Virginia; however, fluctuations are less frequent and less rapid below Bluestone Dam (Graham and Orth in press). If Bluestone Dam is converted to produce hydroelectric power, discharge fluctuations will become more severe. In order to be able to predict and mitigate the impacts of flow alteration on the fish fauna, specific habitat requirements of fishes need to be identified.

STUDY AREA

The New River is a sixth-order stream which originates in the Blue Ridge Mountains near Blowing Rock, North Carolina and flows northward through Virginia into West Virginia, and eventually merges with the Gauley to form the Kanawha River. The New-Kanawha River system is considered to be the oldest river system in North America, occupying the same river channel established by the ancient Teays River that flowed across the eastern half of the continent during the Tertiary period (Addair 1944). The extreme age of the New River basin makes this river unique among major rivers of the eastern United States. The New River fish fauna is also considered unique in being depauperate and yet having a high degree of endemism (Jenkins et al. 1971). Five fish species, the bigmouth chub (*Nocomis platyrhynchus*), Kanawha darter (*Etheostoma kanawhae*), finescale saddled darter (*Etheostoma osburni*), New River shiner (*Notropis scabriceps*), and Kanawha minnow (*Phenacobius teretulus*), are found in no other river system. The river is characteristically montane with much of the relatively narrow channel consisting of bedrock, boulders, and large cobbles (Hocutt et al. 1978). Three dams are situated on the river: Claytor Dam near Newbern, Virginia, operated by Appalachian Power Company for the production of hydroelectric power; Bluestone Dam, an epiliminial-release U.S. Army Corps of Engineers flood-control dam located at Hinton, West Virginia, 1.3 km upstream of the confluence of the New and its largest tributary, the Greenbrier River; and Hawks Nest Dam, downstream of the study area, near Ansted, WV, which diverts river water into a 6.5 km tunnel for hydroelectric power generation and returns the water 8.1 km downstream.

The average gradient of the New River, along its 516 km course, is 1.86 m/km. The river originates at an elevation of 1158 m, and falls 960 m to an elevation of 198 m at the mouth. Total area of the drainage basin is 18,085 km^2. The mean discharge (1949 to 1983) is 163 m^2/s and 230m^2/s at Bluestone Dam and Hinton, WV, respectively (Flug 1985). March has the highest mean discharge (340 m^2/s at Bluestone Dam), while August and September have the lowest (85 m*sup2./s and 77.5 m*sup2./s, respectively; Flug 1985). River width ranges from 400 m at Hinton, WV, to between 60 and 150 m within the main gorge below Thurmond, WV. In West Virginia, water temperatures in the river range from 0.0° C in winter to 30° C during the summer. Alkalinity ranges from 30 to 80 mg/l (West Virginia Department of Natural Resources unpublished data).

The NRGNR was established in 1978 to conserve the values and resources in the New River Gorge, a 84-km corridor of the New River from Hinton to the U.S. 19 bridge near Fayetteville, West Virginia. Legislation which established the NRGNR stated that "the Secretary of the Army shall provide for release of water from the Bluestone Lake Project in such a manner to facilitate protection of biological resources and recreational use of the national river". The NRGNR receives considerable fishing pressure. The 24 km of the New River from Hinton to Meadow Creek, WV, supported an estimated 99,444 hours of fishing from April to November, 1980 (Pierce et al. 1981). In that fishery survey, the angler catch was dominated by (in decreasing order of abundance) smallmouth bass (*Micropterus dolomieui*), channel catfish (*Ictalurus punctatus*), crappie (*Pomoxis sp.*), rock bass (*Ambloplites rupestris*), sunfish (*Lepomis sp.*), and flathead catfish (*Pylodictis olivaris*). In the same section of the river, Austen (1984) found that smallmouth bass, rock bass, redbreast sunfish (*Lepomis auritus*), channel catfish, and flathead catfish were the fish most commonly harvested.

The electrofishing survey for this study was conducted at sites between Hinton and Ephraim Creek, WV (Figure 1), which are 5 km and 70 km downstream of Bluestone dam, respectively. Under-

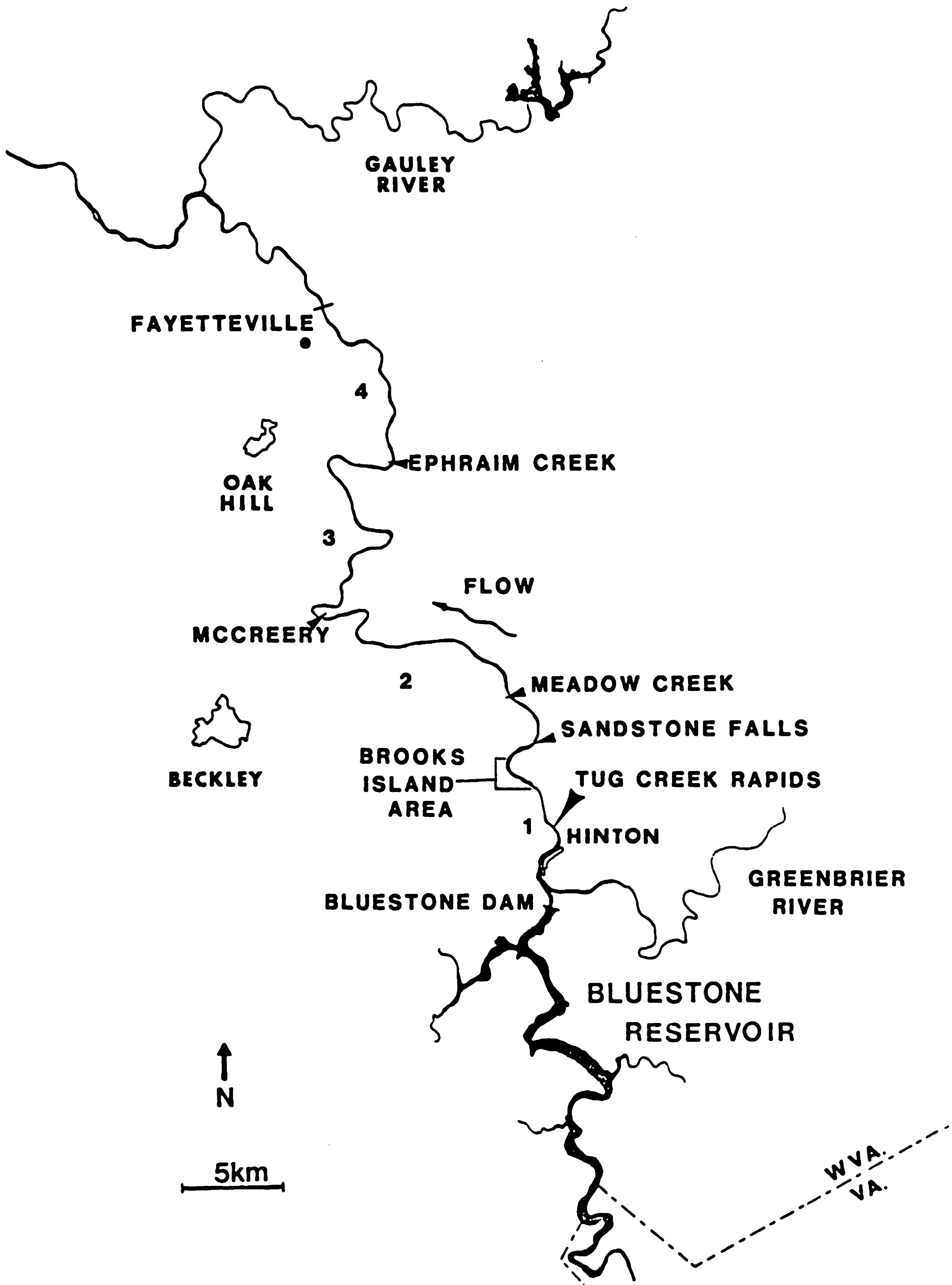

Figure 1. Map of New River, WV, study area.

water transects were conducted at the Brooks Island and Tug Creek rapid areas (Figure 1). Bigmouth chub habitat requirements were investigated in the 18 km section between Bluestone Dam and Sandstone Falls.

FISH ASSEMBLAGES

INTRODUCTION

Stream fish tend to select particular habitat types (Zaret and Rand 1971; Gorman and Karr 1978; Moyle and Li 1979), and therefore, specific assemblages of fishes are expected to be associated with each habitat type available within a stream. To evaluate the effects of flow alteration on the fish fauna in the New River, WV, or any warmwater stream, it is necessary to determine which fish species comprise the assemblages associated with each major habitat type. For example, Bain and Finn (unpublished manuscript) found that the species and life stages specializing on shallow habitat with slow velocities were reduced in abundance in a regulated stream with dramatic daily flow fluctuations. The selection of appropriate species and life stages on which to base instream flow assesments is a critical step in warmwater streams which have diverse fish and invertebrate faunas (Orth 1986). Currently, however, selection of target species is arbitrary. There is presently insufficient information to suggest how many habitat-use guilds of fishes exist in warmwater streams or which habitats support the highest densities of fish. Therefore, this study was designed to compare fish densities and fish assemblages associated with major habitat types in the New River, West Virginia. During the first phase of this study, data on fish species-habitat associations were collected using electrofishing gear. Electrofishing is often selective for larger fish (Catchings et al. 1984) and is less effective as stream width, depth and velocity increase (Peterman 1978; Catchings et al. 1984). Consequently electrofishing may not adequately represent the fish-habitat associations. Therefore direct underwater counts of fish were conducted during 1985 to further explore habitat utilization by the fish fauna in the New River, WV. The specific questions that I asked were:

1. Are certain assemblages of fish species and lifestages associated with the major habitat types?
2. Are there differences in fish densities (total and by species) among the major habitat types?
3. Are there shifts in habitat use and activity of species from day to night?

METHODS

Phase 1 - Electrofishing

Field

The New River from Hinton, WV, to near the mouth of Ephraim Creek, was sampled with back-pack, generator, and boat electrofishing equipment in 1984. The river within the boundaries of the New River Gorge National River (NRGNR) was divided into four sections to determine any longitudinal changes in species composition (Figure 1). Section 1, Hinton, WV (southern boundary of NRGNR) to the town of Meadow Creek, had a a gradient of 1.8 m/km; however, approximately 6 m of the 36.6 m drop in elevation occurred at Sandstone Falls. Section 1 had the largest average width (221m) and greatest fishing pressure (Pierce et al. 1981). Section 2, from Meadow Creek to McCreery, had a slightly lower gradient (1.7m/km) and smaller average width (126m) than section 1. Section 3, from McCreery downstream to Ephraim Creek was intermediate in gradient (1.6m/km) compared to Sections 1 and 2, and had an average width (125m) similar to Section 2, but the river became more sinuous. Section 4, which extends from Ephraim Creek to the northern (downstream) boundary of the NRGNR, had the steepest gradient (3.2m/km) and narrowest average width (90m) of all the sections. Section 4 had many rapids and was not sampled for fish because of the difficulty and danger of getting equipment into this stretch of the river.

Four types of electrofishing methods were used to collect fish. The most frequently used method was a generator-powered system set up in a 4.3-m raft. The system included a Coffelt variable voltage pulsator (model VVP-2C) with two 1.5-m hand-held probes with 25 cm long diamond-shaped anodes and a cathode which consisted of three 3-m long pieces of aluminum conduit (5 mm diameter) hung at even intervals along a 3-m long float. The system was powered by a 120-volt, 1500-watt Homelite generator. The generator was placed in the rear of the raft on a platform support with brackets to prevent the generator from sliding. The cathode was attached to one side of the raft. A four-person crew was used when electrofishing with the generator and raft. Each of two persons held a probe, and also netted the stunned fish, another worker netted and transferred fish to a live-well (water-filled bucket), and the fourth person pulled the raft. Sampling was accomplished by wading in an upstream direction, parallel with the current, for 15 minutes. The VVP was set on pulsed DC current at voltages ranging from 250 to 450 and wattages ranging from 750 to 1000. The anodes were turned on and off to avoid herding fish but not capturing them. The generator system was used in areas less than approximately 1.1m deep.

In shallow (average depth < 0.55 m deep) habitats where manuevering the raft was difficult, backpack electrofishing was conducted by a 3 or 4 person crew with a Coffelt gasoline-powered backpack unit (Model BP-1C). Backpack electrofishing also proceeded in an upstream direction for 15 minutes. The unit was operated between 200 and 450 volts and 100 to 250 watts. Electrical current was not on continuously. Boat electrofishing was used to sample areas deeper than 1.1 m. A Smith-Root 5.5-m (SR-18) boat with Wisconsin hoop anodes was used. Sampling generally proceeded in an upstream direction with a zig-zag pattern. Voltage ranged from 800 to 1000, and wattage ranged from 6.5 to 8.5 amperes. Sampling time for each run was approximately 15 minutes of electrical current.

The fourth technique was the use of a 6 meter (8 mm mesh) seine in combination with the generator and raft. With two persons each holding one of the brails of the seine, two other workers would operate an anode and kick-up the substrate approximately two meters upstream from the siene, gradually working downstream toward the seine.

All fish captured and identified in the field were measured to the nearest mm and returned to the river (except voucher specimens). Selected individuals also were weighed. Fish that could not be identified were preserved in 10% buffered formalin and later identified and measured in the laboratory. In all, 100 stations were sampled between July 3 and October 10, 1984.

Habitat type was classified using the following definitions (adapted from Bisson et al. 1982):

Riffle	- shallow, fast water with some surface turbulence
Rapid	- very fast current with considerable turbulence
Run	- moderately shallow to deep with moderately fast, laminar flow (usually the transistion area between a pool and a riffle)
Lateral pool	- large area of slack water along channel margins, with slower flow than adjacent riffle, rapid or run.
Pool	- generally, deeper habitat with slower current velocity
Edge of pool	- slow habitat along stream margins and adjacent to a pool
Backwater	- area along channel margins with little or no current, usually behind a point of land or vegetation.
Emergent vegetation	- dense bed of emergent vegetation. Primarily *Justicia americana*
Submersed vegetation	- dense bed of submersed vegetation. Includes *Elodea canadensis*, *Heteranthera dubia*, *Potomageton* spp., and *Vallisneria* sp.
Snag	- large tree which has fallen in the river.
Side channel	- secondary channel along an island.

Habitats, in the three sections that were sampled by electrofishing, were identified by floating through the sections with a raft in June 1984. An attempt was made to electrofish the habitats in accordance with their relative abundance in each section. Eight stations that were sampled in the side channel along an island near Lick Creek in Section 1 were combined and considered to be 1 station because fish were preserved together.

Data Analysis

Mean catch per unit effort (CPUE) by gear and habitat was calculated as catch per 15 minutes. Means were not weighted by station effort. The eight stations which were combined were not included in the determination of CPUE. For the stations sampled with boat electrofishing, CPUE was calculated as catch per 15 minutes of electrical current. Raft-based generator (37 stations) and backpack electrofishing (13 stations) were considered as one sampling gear type (GBP) because of the similarity in technique and in the habitats sampled. The increased power of the generator was assumed to be offset by the the greater manueverability in the shallow habitats provided by the backpack shocker. Within a habitat type, the CPUE's with the backpack shocker were generally within the range of CPUE with the raft-based generator system. Three length classes were used to define lifestages:

Length class 1 -	< 100 mm
Length class 2 -	100 mm to 199 mm
Length class 3 -	> 199 mm

For most species these length classes adequately represent their lifestages. However, for most of the *Notropis* spp. and the darters, this classification groups all lifestages into length class 1. Also, for bigmouth chub and rock bass, length classes 2 and 3 were combined because size class 3 fish were not abundant.

Phase 2 - Underwater Observations

Field

The Brooks Island study area extended from 11.5 to 15.5 km downstream of Bluestone Dam. Brooks Island is located in the upstream section of this study area. The main and secondary channels along the island were dominated by riffle and run habitats. The middle portion of the Brooks Island area contained shallow to deep pool habitat, while the downstream section is typical riffle habitat. The Brooks Island area ranged from 150 to 300 m wide and was fairly representative of the section of the New River between Bluestone Dam and Sandstone Falls (Figure 2). The Tug Creek rapids area (7 km downstream of Bluestone Dam) was sampled in order to adequately represent riffle habitat.

Depth contours of the Brooks Island area were mapped during July 1985. Eighty-eight depth transects were placed perpendicular to the bank (across the current) approximately 50m apart (range 35-70m). A 4-m long boat, with a trolling motor (to provide relatively constant speed) and an Eagle Mach 1 chart recorder and transducer, was used to obtain depths in the pool areas. In riffles and other areas too shallow for the boat, depths along the transect were measured by wading. Starting and ending points of each depth transect were located on an outline map of the study site developed from aerial photographs. Discharge on sampling days ranged from 36 m^3/s to 85 m^3/s (0.3m difference in water level).

In addition to the perpendicular depth transects, depths were measured parallel to the current with the boat and chart recorder, resulting in three lengthwise depth transects of a majority of the pool area. After completion of the field portion of mapping, the depth measurements were transferred to the outline map of the Brooks Island study section and depth intervals of 0-1m, 1-2m, 2-3m, and

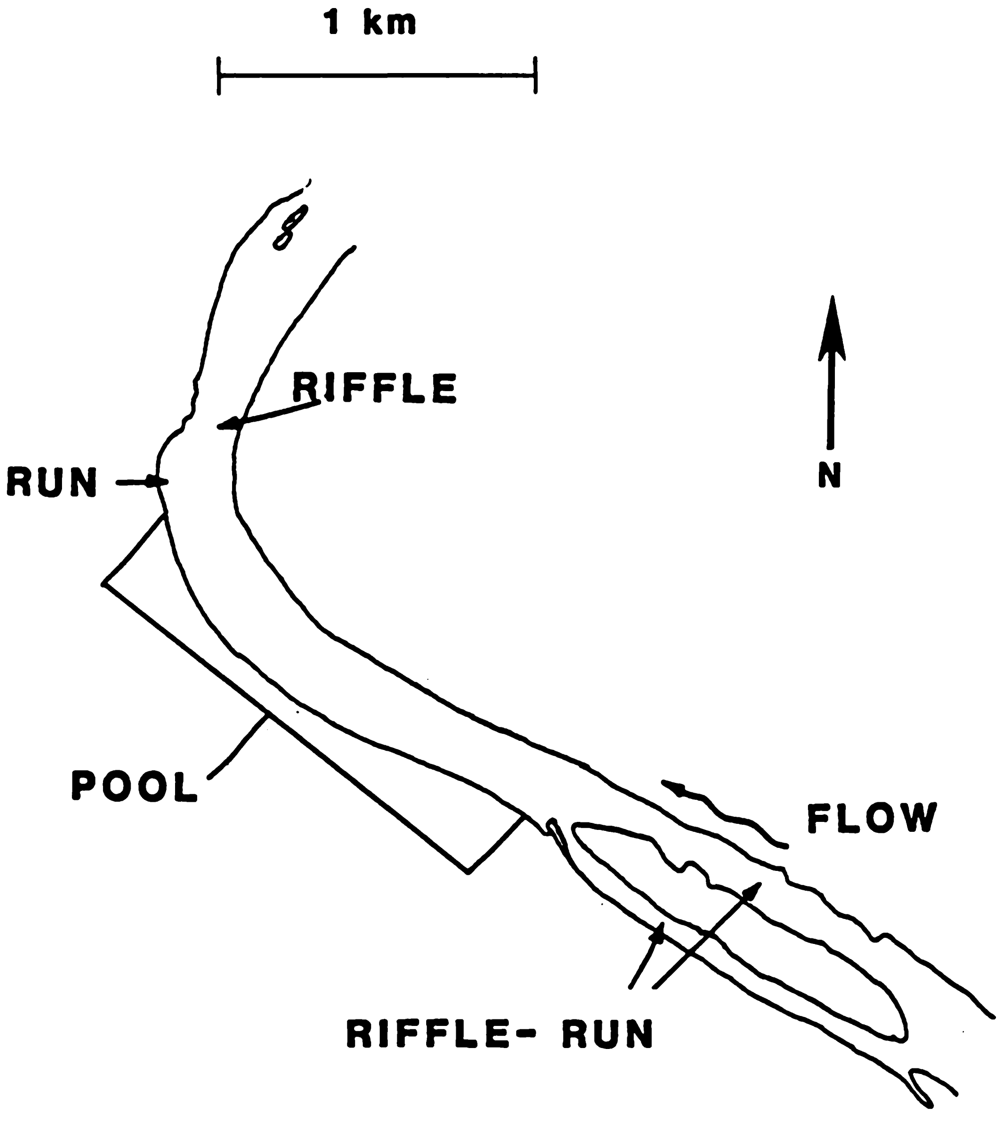

Figure 2. Map of Brooks Island area.

3-4m were plotted. After the depth intervals were mapped, depth contours were drawn and the total area of each depth interval was determined with a planimeter.

Underwater counts of fish were made along randomly selected transects (different than the depth transects). The contour intervals and the depth transect lines were used to randomly choose the placement of the underwater transects. Depending upon personnel and equipment availability, only certain depths could be sampled on any particular day (SCUBA for deep areas and snorkeling for shallow areas).

Underwater transects were selected to provide a stratified (by habitat and depth) random sample of the Brooks Island area. A few of the underwater transect locations were not randomly chosen, but were purposely located in the rare habitats such as backwater and snag areas. Two transects which were conducted in the Tug Creek riffle area were also not selected randomly. They were purposely located in the middle portion of the riffle to avoid the influence of the fish fauna in the pool and run areas upstream and downstream of the riffle on the fish found along the riffle transects. One transect was located in the middle and one at the edge of the channel.

Once the position of a transect was chosen, a 100-m tag line with a marker every 25 m was placed at the location. The line was laid out parallel to the current, either by wading or by boat, in a manner to insure placement of the transect in only one habitat type and to avoid areas too shallow to swim. A line and float were attached to the downstream anchor to facilitate finding the beginning of the transect.

Transect lines were left undisturbed for a minimum of two hours before divers entered the water to conduct the counts. Upon returning, divers entered the water and swam upstream to the beginning of the transect. When the divers reached the beginning of the transect, the starting time was recorded and the divers immediately began the count. Fish that were chased into the strip by the divers' initial swim to the transect were not counted. The width of the transect was dictated by underwater visibility. Underwater lights were used during nighttime dives. The majority of the transects were sampled by two divers. Each diver swam in an upstream direction on one side of the transect line. A distance of approximately 0.5-1.0m from the substrate was maintained by the divers. However, vegetation and large cobble and boulders were inspected in an attempt to observe any fish using these as cover. The distance the divers maintained from the tag line was dictated by the width of the transect. This technique allowed for comparable swimming speed and hand communication between divers. It also helped to avoid counting the same fish more than once. With three divers, the third diver maintained a constant distance from the middle diver and counted only those fish that he saw on the side that was opposite the transect line. When only one diver swam a transect, he swam over the transect line and counted fish on either side of it.

Several counts were conducted without a tag line. For these counts, the distance of the transect was either measured after the transect was completed, or only the time spent on the transect was used to quantify effort. During random swim transects, divers did not swim a predetermined transect and did not count fish but noted rarely seen species.

All fish seen were identified to species when possible and their length was recorded as one of six length classes. The length classes were:

1 mm to 49 mm
50 mm to 99 mm
100 mm to 199 mm
200 mm to 299 mm
300 mm to 399 mm
>400 mm

Each diver utilized a clipboard with Nalgene polypaper and a pencil to record the species, length class, and the count. The back of each clipboard was marked in increments corresponding to the first three length classes to facilitate length estimation. Most fish moved out of the transect or hid under cover when the diver approached and were probably not counted more than once. Other fish, particularly young-of-year smallmouth bass, would swim upstream of the diver. In such cases, the fish would be "herded" until a sufficient number were present to be counted then the diver would swim around the "herd" and position himself upstream of it.

After the transect was completed, the time and the area sampled were recorded. Then the divers would swim downstream along the transect and estimate depth, rate velocity, and record substrate type and the amount of vegetation and woody debris in 25 m sections of the transect. Subsequently, ratings for depth, velocity, amount of vegetation, amount of woody debris, and abundance of large cobble and boulder substrate were assigned to each transect (Table 1). The abundance of large cobble and boulder substrate was used to simplify substrate type description and as an indicator of the amount of cover provided by the substrate.

Fifty-seven SCUBA and snorkeling transects (daytime and nighttime) were sampled between 13 August and 19 September 1985. Discharges on sampling dates ranged from 32.6 m^3 to 147 m^3 (0.6m difference in water level at Brooks Island). Forty-two daytime transects were sampled at the Brooks Island area between 1055 and 1725 hours. However, two transects were timed but area sampled was not measured because of the random path divers swam. Subsequently, because of large differences in habitat characteristics and fish species and lifestage (species-lifestage) composition, three of the daytime transects were divided in two and considered to be six separate transects. In addition, two transects were completed between 1330 and 1550 hours at the Tug Creek riffle area. This provides a total of 45 daytime transects for which densities could be calculated. Nine additional transects were swam at night between 2200 and 0100 hours. Subsequently, one nighttime transect was divided, because of large differences in habitat characteristics, and considered to be two transects, providing a total of 10 nighttime transects.

Data Analysis

Mean densities for all fish and each species-lifestage were calculated for the the 45 daytime and the 10 nighttime transects for which area was determined. Means in each habitat type were not weighted by the area sampled. A chi-square goodness-of-fit test was used to compare actual number of fish seen with the expected (based on percent of total area sampled) number of fish in a habitat type. In addition, 95% simultaneous Bonferoni confidence intervals (Byers and Steinhorst

Table 1. Codes for depth, velocity, vegetation, woody debris, and large cobble and boulder substrate used to describe the habitat characteristics of 45 daytime underwater transects sampled in the New River, West Virginia, August and September, 1985.

DEPTH

Code	Meters
1	0-1
2	1-2
3	2-3
4	3-4

VELOCITY

Code	Current
0	Little or none
1	Slow
2	Slow to moderate
3	Moderate
4	Moderate to fast
5	Fast

VEGETATION

Code	Amount
0	None
1	Sparse
2	Moderate
3	Abundant

WOODY DEBRIS

Code	Amount
0	None/little
1	Abundant

COBBLE-BOULDER SUBSTRATE

Code	Amount
0	None
1	Sparse
2	Moderate
3	Abundant

1984) for the actual number of fish in each habitat were calculated. A Kruskal-Wallis test (Hollander and Wolfe 1973) was used to compare the mean densities of all fish in the four dominant habitat types: edge pool, middle pool, riffle, and run. Because there were significant differences, a Wilcoxon Rank Sum test was used to make pairwise comparisons among the four habitats.

Kruskal-Wallis tests and the associated Wilcoxon Rank Sum tests were performed to compare densities of young-of-year and juvenile smallmouth bass among edge pool, middle pool, riffle, and run habitats. Comparisons for other species-lifestages were not made because there were too many (44.7 to 92.0% of transects) zero densities.

Canonical correlation analysis (SAS Institute 1985) was used to determine if there was any association between densities of 20 species-lifestages and the habitat variable ratings for 43 of the 45 midday transects. The two snag transects (50 and 51) were not included because of their rarity and extremely high fish densities. Species that occurred on fewer than three of the transects were not included in this analysis. *Notropis* spp. and unidentified darters were not included because they were not identified to species and differences in habitat use among the species within these groups is potentially great. Young-of-year bigmouth chubs (< 50mm) were not included because of their potential to be confused with young-of-year bluntnose minnows in underwater identification. Use of canonical correlation analysis for descriptive purposes does not require any distributional assumptions (Dillon and Goldstein 1984). For descriptive purposes, such as in this study, predictor and criterion variables can be measured on a nominal or ordinal level (Dillon and Goldstein 1984). In this case, the habitat parameters are the predictor variables, measured on ordinal scales, and the densities are the criterion variables.

Principal component analysis (SAS Institute 1985) of the habitat variables was used to ordinate the transects. As with the canonical correlation analysis, the snag transects were not utilized in this analysis. A correlation rather than a covariance matrix was used in the analysis because the habitat variable rating scheme inherently produced different variances for the variables (eg. 6 velocity ratings vs. 4 for depth) and therefore, the first principal components would strongly load on the variables with the largest variances (Dillon and Goldstein 1984). Only those principal components with eigenvalues greater than one were used in further analyses (Dillon and Goldstein 1984).

To determine which species utilize similar habitats, mean principal component scores were calculated for each of the 20 species-lifestages. I calculated weighted (by density of the particular species-lifestage) means and standard errors of the first two principal component scores of the transects at which a particular species-lifestage occurred.

RESULTS

Phase 1 - Electrofishing

A total of 4,939 fish was collected with electrofishing gear during 1984 (Table 2). Thirty-two species, including two species in the subgenus *Notropis* (*Luxilus*), were identified. A hybrid *Morone chrysops X M. saxatilis* and a possible hybrid (not in Table 2) between *Nocomis platyrhynchus* and *Notropis albeolus* (R.E. Jenkins, Roanoke College, personal communication) also were collected. The species compositions were similar in the three sections although some of the rare species were not found in all sections (Table 2). The major differences in the fish fauna of the three sections were the relatively large numbers of rock bass (341) in Section 1 and mimic shiners (915) in Section 2.

A total of 4318 fish was collected during daylight hours. Mimic shiner was the most abundant species (24.6% of sample). However, 873 of the 1064 mimic shiners were collected at one edge pool station (station 55) in Section 2. Smallmouth bass, telescope shiner, rock bass, *Notropis* (*Luxilus*) spp., bluntnose minnow, bigmouth chub, and *Notropis* spp., were the next most abundant species groups.

Catch per unit effort (CPUE) with generator-backpack equipment was greatest in edge pool habitat (Table 3). However, the standard error was large because of the large number of mimic shiners at station 55. CPUE was also relatively high in *Justicia* and submersed aquatic vegetation and declined in lateral pool, riffle, backwater, side channel, edge riffle, and run habitat (Table 3).

Catch per 15 minutes of electrical current with boat electrofishing was highest in submersed aquatic vegetation and rapid habitat, and lowest in run and middle pool habitats (Table 4). CPUE was

Table 2. Number and percent of total of each species collected with electrofishing equipment at 100 stations (daytime and nighttime) in the New River, West Virginia, between Hinton and Ephraim Creek, July to October, 1984.

SPECIES	COMMON NAME	SECTION 1 NUMBER	SECTION 1 PERCENT	SECTION 2 NUMBER	SECTION 2 PERCENT	SECTION 3 NUMBER	SECTION 3 PERCENT	ALL SECTIONS NUMBER	ALL SECTIONS PERCENT
Notropis volucellus	mimic shiner	33	2.0	915	46.6	117	8.9	1065	21.6
Micropterus dolomieui	smallmouth bass	322	19.4	231	11.8	304	23.1	857	17.4
Ambloplites rupestris	rock bass	341	20.6	110	5.6	68	5.2	519	10.5
Notropis telescopus	telescope shiner	140	8.4	177	9.0	195	14.8	512	10.4
Notropis (*Luxilus*) spp.[1]	striped and white shiner	193	11.6	128	6.5	110	8.4	431	8.7
Pimephales notatus	bluntnose minnow	104	6.3	108	5.5	102	7.8	314	6.4
Nocomis platyrhynchus	bigmouth chub	97	5.8	38	1.9	92	7.0	227	4.6
Unidentified *Notropis* spp.	shiners	181	10.9	6	0.3	1	0.1	188	3.8
Hypentelium nigricans	northern hog sucker	35	2.1	44	2.2	75	5.7	154	3.1
Notropis spilopterus	spotfin shiner	32	1.9	42	2.1	33	2.5	107	2.2
Campostoma anomalum	stoneroller	46	2.8	12	0.6	40	3.0	98	2.0
Micropterus punctulatus	spotted bass	12	0.7	29	1.5	23	1.7	64	1.3
Notropis rubellus	rosyface shiner	1	0.1	27	1.4	30	2.3	58	1.2
Lepomis macrochirus	bluegill sunfish	25	1.5	9	0.5	12	0.9	46	0.9
Percina roanoka	Roanoke darter	18	1.1	10	0.5	18	1.4	46	0.9
Pylodictis olivaris	flathead catfish	16	1.0	10	0.5	17	1.3	43	0.9
Etheostoma blennioides	greenside darter	6	0.4	9	0.5	20	1.5	35	0.7
Percina caprodes	logperch	13	0.8	6	0.3	8	0.6	27	0.5
Percina oxyrhyncha	sharpnose darter	3	0.2	7	0.4	17	1.3	27	0.5
Notropis hudsonius	spottail shiner	5	0.3	20	1.0			25	0.5
Etheostoma caeruleum	rainbow darter	9	0.5	6	0.3	3	0.2	18	0.4
Lepomis auritus	redbreast sunfish	8	0.5	4	0.2	1	0.1	13	0.3
Labidesthes sicculus	brook silverside	1	0.1	7	0.4	3	0.2	11	0.2
Lepomis gibbosus	pumpkinseed sunfish	3	0.2			8	0.6	11	0.2
Notropis photogenis	silver shiner	5	0.3	2	0.1	3	0.2	10	0.2
Rhinichthys cataractae	longnose dace	3	0.2			6	0.5	9	0.2
Unidentified darter	darter			3	0.2	2	0.2	5	0.1
Ictalurus punctatus	channel catfish					4	0.3	4	0.1
Pomoxis annularis	white crappie	3	0.2	1	0.1			4	0.1
Cyprinus carpio	common carp	3	0.2					3	0.1
Lepomis megalotis	longear sunfish			3	0.2			3	0.1
Lepomis cyanellus	green sunfish					2	0.2	2	0.0
*Morone chrysops*X*saxatilis*	hybrid whiteXstriped bass					1	0.1	1	0.0
Micropterus salmoides	largemouth bass	1	0.1					1	0.0
Unidentified *Lepomis* spp.	sunfish					1	0.1	1	0.0
Totals		1659	100	1964	100	1316	100	4939	100

1 This subgenus includes striped shiner (*Notropis chrysocephalus*) and white shiner (*Notropis albeolus*).

Table 3. Effort and mean catch per 15 minutes of effort with generator and backpack electrofishing in nine habitat types in the New River, WV, July to October, 1984.

Habitat	Catch per 15 min	SE	Range	Effort - minutes	Number of fish	Number of stations
Edge pool	244.6	200.1	3.8 - 1042.0	72	1222	5
Submersed vegetation	98.2	36.3	11.0 - 258.0	70	367	6
Justicia	51.5	9.6	28.0 - 116.0	150	515	10
Lateral pool	42.7	14.6	14.0 - 61.0	45	61	3
Riffle	29.1	10.6	7.0 - 102.0	125	320	9
Backwater	25.0	11.4	9.0 - 47.0	45	75	3
Side channel	24.0	18.0	6.0 - 420.0	30	48	2
Edge riffle	20.6	4.0	10.0 - 35.0	88	122	6
Run	8.5	1.8	0.0 - 12.0	90	51	6

Table 4. Effort and mean catch per 15 minutes of effort with boat electrofishing (daytime) in seven habitats sampled in the New River, WV, September, 1984.

Habitat	Catch per 15 min	SE	Range	Effort - minutes	Number of fish	Number of stations
Submersed vegetation	168.2	-	-	9	97	1
Rapid	109.8	29.1	80.7 - 139.0	31	224	2
Backwater	69.5	-	-	15	70	1
Riffle	64.0	-	-	15	64	1
Edge pool	54.1	7.9	28.0 - 86.5	115	415	8
Run	29.8	25.4	2.0 - 80.6	45	90	3
Middle pool	14.7	6.1	0.0 - 40.3	83	89	6

much greater in the backwater habitat than in riffle habitats with generator-seine gear (Table 5). Mean CPUE for each species-lifestage with each gear type are presented in Appendices 1-3.

Boat electrofishing at night resulted in the collection of an additional 621 fish. Twenty-two species were collected, two of which (channel catfish and hybrid white/striped bass) were not collected during daytime electrofishing. Smallmouth bass, rock bass, and telescope shiner, were the most abundant species. Edge pool habitat had the greatest catch per unit effort (Table 6). Mean CPUE at night for each species-lifestage in each habitat type are presented in Appendix 4.

Phase 2 - Daytime transects

Transects were classified as being in one of eight habitat types. Habitat classification was similar to that used in Phase 1; however, submersed vegetation, *Justicia*, and side channels were not considered separate habitats. Habitat type, area sampled, and the habitat variable rankings for the 45 daytime transects are presented in Appendix 5. The different sections and depth areas of the Brooks Island area were sampled approximately in accordance with the available proportions (Table 7). A total of 4560 fish, in 26 species-lifestage groups (19 species groups) was counted during the 45 daytime transects (Table 8). Young-of-year smallmouth bass was the most abundant species-lifestage (n = 1448) and composed 31.8% of the total sample. *Notropis* spp. (n = 1089) and young-of-year sunfish (n = 629) were the next most abundant species-lifestages, comprising 23.9% and 13.8%, respectively, of the total sample. These three species-lifestage groups together made up 69.5% of the sample. The most abundant species was smallmouth bass (n = 1867), which constituted 40.9% of the sample.

Edge pool, backwater, snag, edge riffle, and riffle transects each contained more fish than would be expected if fish were randomly distributed (chi-square $P < 0.0001$; Table 9); number of fish in each of these habitats was greater than the expected number of fish (based on percentage of total area

Table 5. Mean catch per station with generator-scine electrofishing in two habitats sampled in the New River, WV, July to October, 1984.

Habitat	Catch per station	SE	Range	Number of fish	Number of stations
Backwater	162.0	-	-	162	1
Riffle	9.4	4.4	0 - 39	94	10

Table 6. Effort and mean catch per 15 minutes of effort with boat electrofishing at night in four habitats in the New River, WV, September, 1984.

Habitat	Catch per 15 min	SE	Range	Effort - minutes	Number of fish	Number of stations
Edge Pool	92.8	9.3	57 - 111	75	465	5
Rapid	52.0	-	-	15	52	1
Middle Pool	38.5	30.6	8 - 69	30	78	2
Run	25.9	-	-	15	26	1

Table 7. Comparison of available depths (based upon mapping) at the Brooks Island area with depths sampled by 45 daytime underwater transects in the New River, WV, August and September, 1985.

Depth/ location	Percent available	Percent of total transect area sampled	Number of transects
0-1m	29.9	33.1	17
1-2m	28.2	21.6	8
2-3m	12.0	14.0	5
3-4m	0.5	5.2	2
Varied depth[1]	5.7	5.7	1
Main channel[2]	10.9	10.9	5
Side channel[3]	12.7	9.5	5

[1] Depths varied drastically between intervals.
[2] Main channel along Brooks Island.
[3] Side channel along Brooks Island.

Table 8. Numbers and percentages of species-lifestages found in 45 daytime underwater transects sampled in the New River, WV, August and September, 1985. A t indicates a percentage less than 0.1.

Species-lifestage	Length class (mm)	Number	Percent
Smallmouth bass - YOY	< 100	1448	31.8
Notropis spp.	< 200	1089	23.9
Sunfish - YOY & juvenile	< 100	629	13.8
Smallmouth bass - juvenile	100-199	319	7.0
Rock bass - adult	≥ 100	176	3.9
Stoneroller	50-200	146	3.2
Bigmouth chub - YOY	< 100	144	3.2
Smallmouth bass - adult	≥ 200	100	2.2
Spotted bass - YOY	< 100	89	2.0
Logperch	< 200	76	1.7
Sunfish - adult	≥ 100	63	1.4
Bluntnose minnow	< 100	60	1.3
Greenside darter	< 125	38	0.8
Bigmouth chub - adult	≥ 100	31	0.7
Rock bass - YOY	< 100	28	0.6
Northern hogsucker - YOY	< 100	18	0.4
Rainbow darter	< 100	17	0.4
Spotted bass - juvenile	100-199	17	0.4
Spotted bass - adult	≥ 200	14	0.3
White crappie	≥ 50	14	0.3
Unidentified darter		12	0.3
Flathead catfish - adult	≥ 100	8	0.2
Common carp	> 400	6	0.1
Flathead catfish - YOY	< 100	5	0.1
Sharpnose darter	50-125	3	t
Muskellunge	> 400	1	t
Channel catfish - YOY	< 100	1	t
Unidentified spp.		8	0.2
Totals		4560	100

YOY - young-of-year

Table 9. Comparison of actual with expected number of fish (based on proportion of total area sampled) in eight habitats, in the New River, WV, (chi-square goodness-of-fit $P < 0.0001$) with 95% simultaneous Bonferroni confidence intervals for the actual number of fish. The habitat types were sampled with 45 daytime underwater transects in August and September, 1985.

Habitat	Area (m^2) Sampled	Number of fish	Expected number of fish	95% C.I. for number of fish
Snag	114	530	24.2	470.7 - 589.3
Edge riffle	435	628	92.5	564.2 - 691.8
Backwater	200	181	42.5	144.9 - 217.1
Edge pool	3925	1503	834.4	1416.0 - 1590.0
Riffle	3825	920	813.2	845.8 - 994.3
Lateral pool	800	60	170.1	38.9 - 81.2
Run	3150	206	669.7	167.6 - 244.4
Middle pool	9000	532	1913.4	472.6 - 591.3
Totals	21449	4560		

sampled in all habitats). Middle pool, lateral pool, and run areas were used less than would be expected with a if fish were randomly distributed.

Densities of fish were highest in and adjacent to the snag habitats and in the edge riffle habitats (Table 10). Fish densities among the dominant habitats (edge pool, middle pool, riffle, and run), were significantly different (Kruskal - Wallis $P < 0.001$; Table 11). Fish densities in edge pool and riffle habitats were comparable (WRS $P = 0.110$; Table 11), but densities in edge pool habitat were significantly higher than densities in middle pool and run habitats (Table 11). Fish densities in riffles were significantly higher than those in middle pool habitat ($P = 0.0042$), but were comparable to those in run habitat ($P=0.0493$; Table 11). The lateral pool habitat fish densities were comparable to those in middle pool and run habitats (Table 10).

Fish species-lifestage composition and densities also differed among the habitat types (Table 12). To facilitate comparison, the species-lifestages in Table 12 are ordered such that those species-lifestages with similar habitat use patterns are grouped together (edge pool, riffle, etc).

The edge pool and backwater transects were predominantly occupied by young-of-year and juvenile smallmouth bass, young-of-year and juvenile sunfish, logperch, *Notropis* spp., young-of-year spotted bass, bluntnose minnows, stonerollers, and young-of-year bigmouth chub (Table 12). Bluntnose minnows, stonerollers, and northern hog suckers were not frequently found in edge pool transects but were abundant when present. The snags in the deeper edge pool areas were occupied by all sizes of centrarchids (Table 12). Snag habitats were the only transects in which white crappie were seen during day transects. Densities for centrarchids were higher in snag habitat than in any other habitat (Table 12).

Smallmouth bass was the dominant species in middle pool habitat with young-of-year, juvenile, and adult smallmouth bass comprising 55.1%, 25.6% and 9.6%, respectively, of the sample. Adult rock bass were also common in middle pool habitat, occurring at 8 of 13 transects (Table 12).

Table 10. Mean (95% confidence interval), minimum, and maximum total fish densities (number/100 m^2) in eight habitat types sampled with 45 daytime underwater transects in the New River, WV, August and September, 1985. The number of transects in a habitat is represented by n.

Habitat type	n	Mean ±95% CI	Minimum	Maximum
Snag	2	436.5 ± 211.6	328.6	544.4
Edge riffle	2	135.2 ± 47.3	111.1	159.3
Backwater	1	90.5	90.5	90.5
Edge pool	10	42.9 ± 27.9	9.3	146.7
Riffle	9	22.2 ± 13.2	4.5	59.9
Lateral pool	2	7.5 ± 1.5	6.8	8.3
Run	6	6.3 ± 2.2	3.0	9.5
Middle pool	13	5.2 ± 2.0	2.2	13.7

Table 11. Significance levels from Wilcoxon Rank Sum tests (Kruskal-Wallis $P < 0.001$) for differences in total fish densities (See Table 10) among four habitat types in the New River, WV. Fish densities were estimated with daytime underwater transects sampled in August and September, 1985.

	Mid pool	Run	Riffle
Run	0.0941		
Riffle	0.0042	0.0493	
Edge pool	<0.0001	0.0008	0.1102

Table 12. Means and ranges of species-lifestage densities (number/100m^2) in 45 daytime underwater transects in eight habitat types in the New River, WV, August and September, 1985. The number of transects in a habitat is given by n, t is the number of transects in a habitat where a particular species-lifestage occurred, and * represents a mean density less than 0.05/100m^2. Young-of-year are represented by YOY.

Table 12 begins on next page.

Table 12. Means and ranges of species-lifestage densities (number/100m²)

Transects No. fish =	BKWATER n=1 181	EDGE POOL n=10 1503	SNAG n=2 530	MID POOL n=13 532	RUN n=6 206	RIFFLE n=9 920	E RIFFLE n=2 628	LAT POOL n=2 60
Species-lifestage	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t
Bluntnose minnow	5.0 - 1	1.0 0.0-10.0 1	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.0 - -
Logperch	0.0 - -	2.2 0.0-11.3 4	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.1 0.0-0.3 1
Northern hogsucker - YOY & juv	4.5 - 1	0.2 0.0-1.7 2	0.0 - -	0.0 - -	0.0 - -	* 0.0-0.4 1	0.0 - -	0.0 - -
White crappie	0.0 - -	0.0 - -	11.2 7.1-15.3 2	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.0 - -
Spotted bass - YOY	0.0 - -	1.7 0.0-6.7 6	23.7 23.6-23.8 2	0.0 - -	0.0 - -	* 0.0-0.3 1	0.0 - -	0.0 - -
Spotted bass - juv	0.5 - 1	0.3 0.0-1.1 5	6.6 1.4-11.9 2	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.0 - -
Spotted bass - adult adult	0.0 - -	0.2 0.0-1.0 3	4.0 2.4-5.6 2	* 0.0-0.2 1	0.0 - -	* 0.0-0.3 1	0.0 - -	0.0 - -

Table 12 continued on next page.

Table 12 Continued - Means and ranges of species-lifestage densities (number/100 m²).

Transects	BKWATER n=1	EDGE POOL n=10	SNAG n=2	MID POOL n=13	RUN n=6	RIFFLE n=9	E RIFFLE n=2	LAT POOL n=2
No. fish =	181	1503	530	532	206	920	628	60
Species-lifestage	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t
Sunfish YOY & juv	8.0 - 1	12.0 0.0-68.0 5	166.4 61.9-270.8 2	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.1 0.0-0.3 1
Sunfish - adult	0.5 - 1	0.1 0.0-0.9 2	42.5 40.5-44.4 2	* 0.0-0.5 2	0.1 0.0-0.3 1	0.0 - -	0.0 - -	0.0 - -
Rock bass - YOY & juv	0.0 - -	0.1 0.0-0.3 3	12.9 11.9-13.9 2	0.1 0.0-0.3 3	0.1 0.0-0.2 2	0.1 0.0-0.9 1	0.2 0.0-0.3 1	0.0 - -
Rock bass - adult	0.0 - -	0.4 0.0-2.9 3	101.6 64.3-138.9 2	0.2 0.0-0.8 8	0.1 0.0-0.5 2	0.4 0.0-1.0 6	0.0 - -	0.0 - -
Smallmouth bass - YOY	29.0 - 1	19.2 7.0-42.3 10	44.7 18.1-71.4 2	2.9 0.6-7.3 13	3.6 1.5-8.8 6	3.6 0.8-9.8 9	19.1 10.0-28.1 2	5.5 4.5-6.5 2
Smallmouth bass - juv	1.0 - 1	1.1 0.0-2.2 9	9.6 9.5-9.7 2	1.3 0.0-3.8 12	1.9 0.3-6.0 6	1.5 0.0-3.3 8	0.0 - -	1.0 0.8-1.3 2
Smallmouth bass - adult	0.0 - -	0.1 0.0-0.4 4	12.1 2.8-21.4 2	0.4 0.0-2.3 9	0.1 0.0-0.4 3	0.5 0.0-3.0 5	0.0 - -	0.3 0.0-0.5 1

Table 12 continued on next page.

Table 12 Continued - Means and ranges of species/lifestage densities (number/100 m²).

Transects No. fish =	BKWATER n = 1 181	EDGE POOL n = 10 1503	SNAG n = 2 530	MID POOL n = 13 532	RUN n = 6 206	RIFFLE n = 9 920	E RIFFLE n = 2 628	LAT POOL n = 2 60
Species-lifestage	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t
Stoneroller	25.0	0.3	0.0	0.0	0.0	1.4	9.6	0.0
	-	0.0-3.0	-	-	-	0.0-5.3	4.3-14.8	-
	1	1	-	-	-	3	2	-
Notropis spp.	13.5	1.9	0.0	0.0	0.0	12.9	80.5	0.1
	-	0.0-15.0	-	-	-	0.0-42.9	30.4-130.7	0.0-0.3
	1	4	-	-	-	5	2	1
Greenside darter	3.5	0.3	0.0	0.1	0.2	•	2.0	0.1
	-	0.0-2.0	-	0.0-0.3	0.0-0.5	0.0-0.3	0.3-3.7	0.0-0.3
	1	3	-	4	2	1	2	1
Rainbow darter	0.0	0.0	0.0	0.0	•	0.2	1.7	0.1
	-	-	-	-	0.0-0.1	0.0-1.0	0.7-2.7	0.0-0.3
	-	-	-	-	1	3	2	1
Sharpnose darter	0.0	0.0	0.0	0.0	0.1	•	0.0	0.0
	-	-	-	-	0.0-0.2	0.0-0.3	-	-
	-	-	-	-	2	1	-	-
Unidentified darter	0.0	0.1	0.0	•	0.0	•	1.2	0.0
	-	0.0-0.5	-	0.0-0.1	-	0.0-0.3	0.0-2.3	-
	-	2	-	1	-	1	1	-
Channel catfish - YOY	0.0	0.0	0.0	0.0	•	0.0	0.0	0.0
	-	-	-	-	0.0-0.1	-	-	-
	-	-	-	-	1	-	-	-

Table 12 continued on next page.

Table 12 Continued - Means and ranges of species/lifestage densities (number/100 m²).

Transects No. fish =	BKWATER n=1 181	EDGE POOL n=10 1503	SNAG n=2 530	MID POOL n=13 532	RUN n=6 206	RIFFLE n=9 920	E RIFFLE n=2 628	LAT POOL n=2 60
Species-lifestage	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t	Mean Range t
Bigmouth chub-YOY	0.0 - -	1.6 0.0-10.5 3	0.0 - -	0.0 - -	0.0 - -	0.5 0.0-2.4 4	19.6 8.0-31.1 2	0.1 0.0-0.3 1
Bigmouth chub - adult	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.8 0.0-2.2 8	0.7 0.0-1.5 1	0.0 - -
Flathead catfish - YOY	0.0 - -	0.0 - -	0.0 - -	0.0 - -	0.1 0.0-0.4 2	0.0 - -	0.2 0.0-0.3 1	0.0 - -
Flathead catfish - adult	0.0 - -	0.0 - -	0.0 - -	♦ 0.0-0.2 3	♦ 0.0-0.3 1	0.1 0.0-0.7 2	0.0 - -	0.0 - -
Carp	0.0 - -	0.0 - -	0.0 - -	0.1 0.0-1.0 1	0.0 - -	0.0 - -	0.0 - -	0.0 - -
Muskellunge	0.0 - -	0.0 - -	0.0 - -	♦ 0.0-0.8 1	0.0 - -	0.0 - -	0.0 - -	0.0 - -
Unidentified spp.	0.0 - -	♦ 0.0-0.4 1	1.2 0.0-2.4 1	♦ 0.0-0.5 1	0.1 0.0-0.5 1	0.0 - -	0.5 0.3-0.7 2	0.0 - -

Carp and muskellunge were each only found on one (but two separate) middle pool transect. However, during a random swim transect, an adult muskellunge was seen in a vegetated edge pool habitat. Additional carp and an adult channel catfish were seen in middle pool habitat during random swim transects.

Compared to the above habitat types, species composition was different in the swifter riffle, edge riffle, run, and lateral pool habitats. In the riffle areas, *Notropis* spp. (60.8%), all sizes of smallmouth bass, stonerollers, and both sizes of bigmouth chubs were dominant (Table 12). *Notropis* spp., young-of-year smallmouth bass, young-of-year bigmouth chub, and stonerollers were dominant in edge riffle areas. Young-of-year and juvenile smallmouth bass were dominant in run and lateral pool habitats (Table 12).

The above general descriptions only give the most common species-lifestages in each habitat type. Other species-lifestages, because of their general low abundance in the river, are rare in all habitat types. However, the rarer species may prefer a particular habitat. Generally it can be discerned (from Table 12) which habitat types are used most often by a particular species-lifestage by comparing its mean densities among the different habitat types. Using this approach, groups of fishes with similar habitat use patterns can be determined. Table 12 shows that bluntnose minnow, logperch, young-of-year and juvenile northern hog sucker, white crappie, all three sizes of spotted bass, and both size groups of sunfish were most abundant in edge pool habitat. Although other habitat types were occupied by these species, their occurrence in them was rare and densities were low.

It is more difficult to determine the habitat preferences of rock bass, smallmouth bass, stonerollers, *Notropis* spp. and greenside darters (Table 12). Young-of-year and juvenile rock bass were present in all habitat types except backwater and lateral pool, but were most abundant at the snag transects ($12.9/100m^2$). Likewise adult rock bass were found in 5 of 8 habitat types but were most abundant (mean = $101.6/100m^2$) in the snag transects. Although the mean densities were much lower in middle pool and riffle habitats, adult rock bass were found at more than half of the transects in these two habitats (8/13 and 6/9, respectively). Mean adult rock bass densities at edge pool and run transects were similar to middle pool and riffle densities, but the frequency of occurrence was lower.

Young-of-year smallmouth bass were observed on all 45 day transects; however, they were most abundant in the snag (44.7/100m^2), backwater (29/100m^2), edge pool (19.2/100m^2), and edge riffle (19.1/100m^2) habitats. A comparison of the densities of young-of-year smallmouth bass in edge pool, middle pool, riffle, and run transects (Kruskal-Wallis $P < 0.001$, Table 13) shows that densities were indeed highest in edge pool habitats, and similar at middle pool (2.9/100m^2), riffle (3.6/100m^2), and run (2.9/100m^2) transects. Juvenile and adult smallmouth bass also were most abundant in the snag transects. Juvenile smallmouth bass had similar densities in all the remaining habitat types (except for edge riffle, which was 0 fish/100m^2), and densities were not significantly different among edge pool, middle pool, riffle and run habitats (Kruskal-Wallis $P > 0.10$). Adult smallmouth bass were not found at the backwater or edge riffle transects, but were similar in densities among the other habitats (except snags). Greenside darters were found in all habitat types except for the snag transects. Highest mean densities of greenside darter were in backwater and edge riffle habitats. Stonerollers also had highest mean densities in backwater and edge riffle habitats.

To summarize, young-of-year, juvenile and adult rock bass, and juvenile and adult smallmouth bass exhibit a strong preference for snag transects and an avoidance of shallow edge channel areas, while young-of-year smallmouth bass prefer shallower areas as well as the snag areas. Stonerollers and greenside darters use a wide range of velocities but predominantly use the shallower depth edge channel (backwater, edge pool, edge riffle) and riffle areas.

Several species were grouped together to form *Notropis* spp. complex. Therefore, this group was expected to be found in several habitats, and such was the case. *Notropis* spp. were abundant in backwater, edge pool, riffle, and edge riffle habitat (Table 12). However, based on the electrofishing data (Appendices 1-3), one can assume that mimic shiners, spottail shiners, and small white and striped shiners, and spotfin shiners were the *Notropis* spp. which dominated the backwater and edge

Table 13. Significance levels from Wilcoxon Rank Sum tests (Kruskal-Wallis $P < 0.001$) for differences in young-of-year smallmouth bass densities among four habitat types in the New River, WV. Densities were estimated with daytime underwater transects sampled in August and September, 1985.

	Mid pool	Run	Riffle
Run	0.315		
Riffle	0.5000	0.3400	
Edge pool	<0.0001	0.001	0.0003

pool habitat. Telescope shiners, rosyface shiners, silver shiners, and large white and striped shiners were probably the dominant *Notropis* spp. in riffle and edge riffle areas.

Rainbow darters and adult bigmouth chub were most abundant in riffle and edge riffle habitat. Bigmouth chub young-of-year were most abundant in edge riffle and edge pool areas. Sharpnose darter (riffle and run), young-of-year flathead catfish (run and edge riffle), and young-of-year channel catfish (run), common carp (middle pool), and flathead catfish (middle pool) were rarely found (Table 12).

Canonical Correlation

Because woody debris was correlated with velocity ($r = 0.604$; $P = 0.0001$) and because it was abundant at only 7 of 43 transects, the woody debris variable was dropped from use in canonical correlation and principal component analyses. The other habitat variables, (depth, velocity, vegetation, and cobble-boulder substrate) were not strongly correlated ($r < 0.40$). The strongest correlations between the fish densities and the habitat variables involved velocity and/or vegetation variables (Table 14). Densities of young-of-year smallmouth bass and juvenile spotted bass were negatively correlated with velocity ($P < 0.002$) and positively correlated with vegetation ($P = 0.0001$). Densities of logperch, young-of-year and adult spotted bass, young-of-year and juvenile sunfish, and young-of-year and juvenile northern hog sucker were positively correlated with vegetation ($P < 0.006$; Table 14). Adult bigmouth chub and young-of-year smallmouth bass were slightly negatively correlated with depth ($P < 0.06$). Young-of-year flathead catfish, rainbow darter, and sharpnose darter were positively correlated with cobble-boulder substrate ($P < 0.04$), while logperch, young-of-year smallmouth bass, young-of-year and juvenile spotted bass, and young-of-year and juvenile sunfish were negatively correlated with cobble-boulder substrate ($P < 0.04$).

Only the first canonical correlation was significant ($r = 0.95$; $P = 0.0001$). Logperch, young-of-year smallmouth bass, young-of-year spotted bass, juvenile spotted bass, and young-of-year and juvenile

Table 14. Correlations (with significance levels) between fish densities and habitat variables from 43 daytime underwater transects sampled in the New River, WV, August and September, 1985. Two transects in snag habitat were not included.

Species	Depth	Velocity	Amount vegetation	Cobble-boulder
Bigmouth chub - YOY	-0.1561 (0.3174)	-0.0630 (0.6881)	-0.0486 (0.7569)	0.2193 (0.1578)
Bigmouth chub - adult	-0.2899 (0.0594)	0.3252 (0.0333)	-0.1618 (0.3000)	0.1794 (0.2496)
Flathead catfish - YOY	-0.1049 (0.5033)	0.3058 (0.0461)	-0.0487 (0.7565)	0.3302 (0.0306)
Flathead catfish - adult	0.0982 (0.5309)	0.2278 (0.1418)	-0.1531 (0.3269)	0.1190 (0.4473)
Greenside darter	-0.2264 (0.1443)	-0.2659 (0.0848)	0.2699 (0.0801)	0.0224 (0.8865)
Logperch	-0.1369 (0.3815)	-0.3871 (0.0103)	0.5472 (0.0001)	-0.3541 (0.0198)
Northern hog sucker - YOY and juvenile	-0.1690 (0.2785)	-0.3031 (0.0482)	0.4157 (0.0056)	-0.2474 (0.1097)
Rainbow darter	-0.1222 (0.4349)	0.2302 (0.1376)	0.1794 (0.2496)	0.3768 (0.0127)
Rock bass - YOY and juvenile	-0.0564 (0.7194)	0.0900 (0.5658)	-0.0815 (0.6032)	0.2276 (0.1422)
Rock bass - adult	-0.0738 (0.6381)	-0.0616 (0.6946)	0.2014 (0.1953)	0.0673 (0.6679)
Smallmouth bass - YOY	-0.3106 (0.0426)	-0.6198 (0.0001)	0.6703 (0.0001)	-0.3238 (0.0342)
Smallmouth bass - juvenile	0.0204 (0.8968)	0.2493 (0.1069)	-0.3259 (0.0329)	0.2783 (0.0707)
Smallmouth bass - adult	0.0795 (0.6125)	0.0979 (0.5321)	-0.0023 (0.9885)	0.1494 (0.3391)
Sharpnose darter	0.0136 (0.9309)	0.3366 (0.0273)	0.0122 (0.9382)	0.3368 (0.0272)
Spotted bass - YOY	-0.1427 (0.3615)	-0.3900 (0.0097)	0.5368 (0.0002)	-0.3437 (0.0240)
Spotted bass - juvenile	-0.1639 (0.2936)	-0.4680 (0.0016)	0.5929 (0.0001)	-0.4066 (0.0068)
Spotted bass - adult	-0.1014 (0.5178)	-0.3199 (0.0365)	0.4498 (0.0025)	-0.2507 (0.1050)
Stoneroller	-0.2277 (0.1420)	-0.1499 (0.3373)	0.2141 (0.1681)	0.0079 (0.9597)
Sunfish - YOY and juvenile	-0.1684 (0.2803)	-0.3470 (0.0226)	0.4848 (0.0010)	-0.3165 (0.0387)
Sunfish - adult	0.0687 (0.6615)	-0.3053 (0.0465)	0.3712 (0.0142)	-0.2119 (0.1726)

YOY - young-of-year

Table 15. Standardized canonical coefficients and correlations with the canonical variables for species-lifestage densities and habitat variables from 43 daytime underwater transects sampled in the New River, WV, August and September, 1985. Two transects in snag habitat were not included in analysis.

CANONICAL DENSITY VARIABLE

Species	Canonical coefficient	Correlation with canonical density variable
Bigmouth chub - YOY	0.72	0.02
Bigmouth chub - adult	0.34	0.32
Flathead catfish - YOY	0.18	0.24
Flathead catfish - adult	0.12	0.24
Greenside darter	-1.07	-0.34
Logperch	0.46	-0.59
Northern hog sucker - YOY and juvenile	0.10	-0.45
Rainbow darter	0.05	0.05
Rock bass - YOY and juvenile	-0.28	0.12
Rock bass - adult	0.02	-0.16
Smallmouth bass - YOY	-0.45	-0.80
Smallmouth bass - juvenile	0.36	0.37
Smallmouth bass - adult	-0.38	0.06
Sharpnose darter	0.08	0.21
Spotted bass - YOY	-1.63	-0.59
Spotted bass - juvenile	0.03	-0.67
Spotted bass - adult	-0.23	-0.49
Stoneroller	0.16	-0.21
Sunfish - YOY and juvenile	1.06	-0.53
Sunfish - adult	0.28	-0.43

CANONICAL HABITAT VARIABLE

Habitat variable	Canonical Coefficient	Correlation with canonical habitat variable
Depth	-0.05	0.13
Velocity	0.55	0.82
Amount vegetation	-0.62	-0.84
Cobble - boulder	0.06	0.49

YOY - young-of-year

sunfish were the species-lifestages most negatively correlated with the first fish density canonical variable (Table 15). The canonical habitat variable is strongly correlated with velocity (0.8230) and negatively correlated with vegetation (-0.8438). Species-lifestages that were negatively correlated with the first fish density canonical variable were also negatively correlated with the first canonical habitat variable (Table 15). Accordingly, logperch, young-of-year smallmouth bass, young-of-year spotted bass, juvenile spotted bass, and young-of-year and juvenile sunfish were most abundant in habitats with low velocity and high vegetation. None of the species were strongly positively correlated with the canonical habitat variable, although adult bigmouth chub, flathead catfish, and juvenile smallmouth bass exhibited weak positive correlation with the canonical habitat variable.

Principal Component Analysis

The first two principal components accounted for 71.6% of the variation in the habitat variables among the transects (Table 16). The first principal component (PC1) had positive loadings on velocity (0.549) and cobble-boulder substrate (0.539) and was negatively loaded on vegetation (-0.587). Therefore, a large negative value for PC1 indicates a habitat with low velocity, little cobble and boulder substrate, and abundant vegetation. A large positive value represents an area with low vegetation, high velocity, and high amounts of cobble and boulder substrate. The second principal component (PC2) had a strong positive loading for depth (0.864); large positive values of PC2 correspond to deeper areas. Figure 3 shows generalized habitat characteristics of each quadrant for the graph of PC2 against PC1 with reference lines drawn at the zero marks. The upper left corner of Figure 3, in general, represents deep, slow, vegetated habitat with little cobble-boulder substrate. The upper right corner of the graph represents deeper, swifter areas with no vegetation and high amounts of cobble-boulder substrate. This corner would correspond to a deep, swift run or relatively swift pool habitat. The lower right corner would represent shallow swift areas without vegetation. The lower left corner represents shallow, vegetated habitat with slow current and no cobble-boulder substrate.

Table 16. Factor loadings, eigenvalues, and proportion of variance accounted for from principal components analysis on the habitat parameters of 43 underwater transects. Only the first two principal components are presented. Transects were sampled in the New River, WV, August and September, 1985.

Factor loadings	Prin1	Prin2
Depth	0.252	0.864
Velocity	0.549	-0.373
Vegetation	-0.587	-0.217
Cobble-boulder	0.539	-0.261
Eigenvalue	1.812	1.053
Proportion variance explained	0.453	0.263
Cumulative variance explained	0.453	0.716

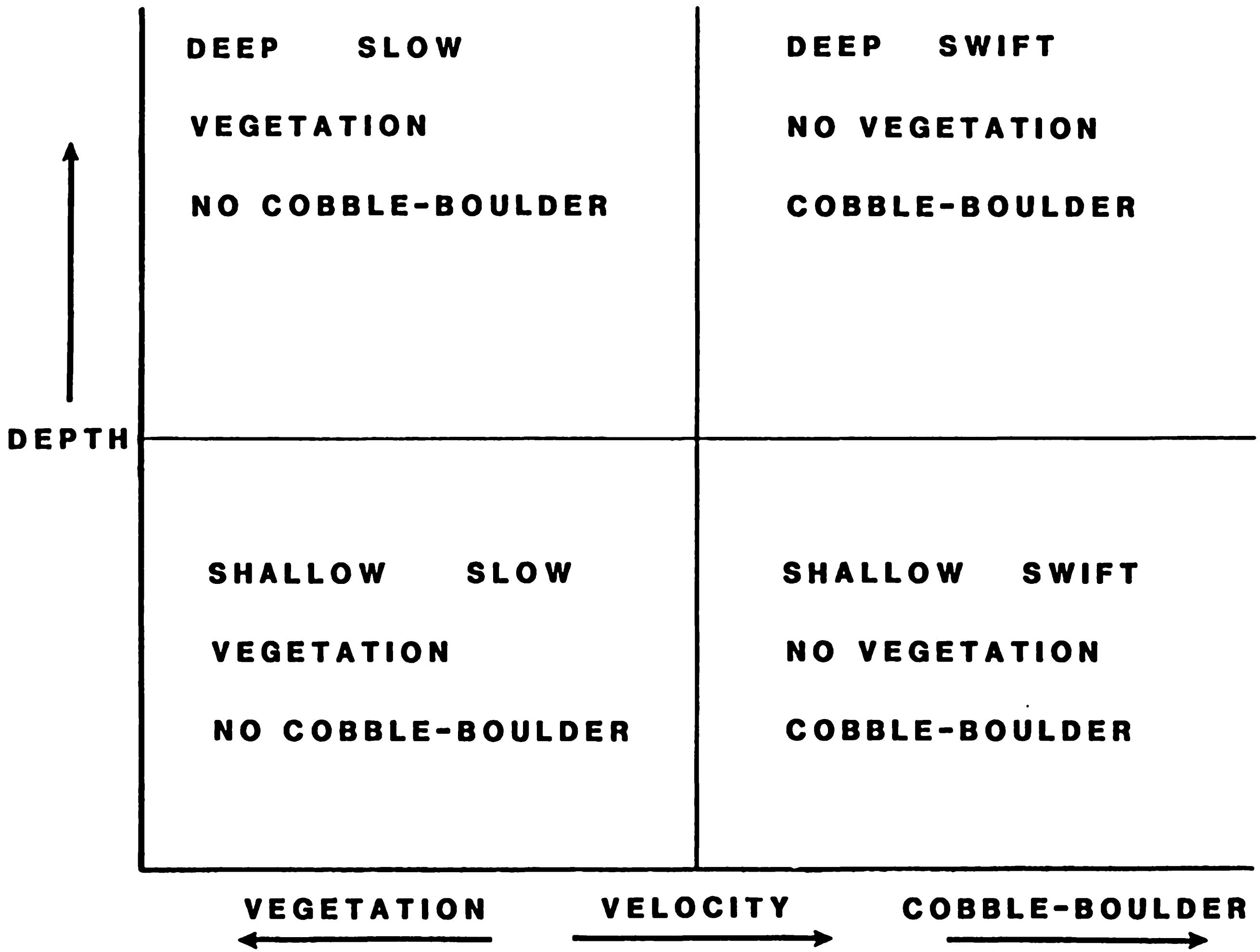

Figure 3. Quadrant characteristics of the graph of the first two principal components. Principal components analysis was performed on the habitat variables of 43 underwater transects sampled in the New River, WV, August and September, 1985.

In general, based upon the locations of the different habitat types on the graph of the first two principal components, the quadrants corresponded to the habitat descriptions given above. Nine of ten edge pool transects and the backwater and the lateral pool transects had negative values of PC1 (Figure 4). In addition, all 13 of these transects had moderate (weak positive and negative) values for PC2. This gives a general description of edge pool transects as being shallow to moderately deep with abundant vegetation and/or little cobble-boulder substrate, and slow velocities. Transects in other habitat types also formed relatively tight clusters. Five of six run transects had positive values for PC1 (Figure 4). However, there was fairly large variation in depth (PC2). As expected, run areas can generally be described as shallow to deep with swift current and cobble-boulder substrate, with little or no vegetation. Riffle and edge riffle form an even tighter cluster of transects, with 10 of 11 transects located in the lower right corner of the graph of the first two principal components (Figure 4). This corner of the graph represents shallow, swift areas with large amounts of cobble-boulder substrate and little vegetation. Riffle transects were expected to be located in this quadrant.

Middle pool transects were not as tightly clustered as the transects in the other habitat types (Figure 4). However, in general, middle pool transects (10 of 13) had moderate to large values for PC2 (ie moderate to large depths). The middle pool transects had moderate values for PC1, indicating that many different combinations of velocity, vegetation, and cobble-boulder substrate were found among the middle pool transects.

The mean principal component scores (Figure 5; Appendix 6) can be used to place the species-lifestages into groups similar to those developed from the mean densities (Table 12) in each habitat type. Logperch, young-of-year and juvenile sunfish, northern hogsucker, and all sizes of spotted bass form a fairly tight cluster in the middle left portion of the graph of the first two principal components (Figure 5, A-F). This area of the graph corresponds to edge pool habitat. Adult sunfish (Figure 5, G) are also found in the edge pool area of the graph, but appear to use the deeper edge pool habitat (upper left portion of graph).

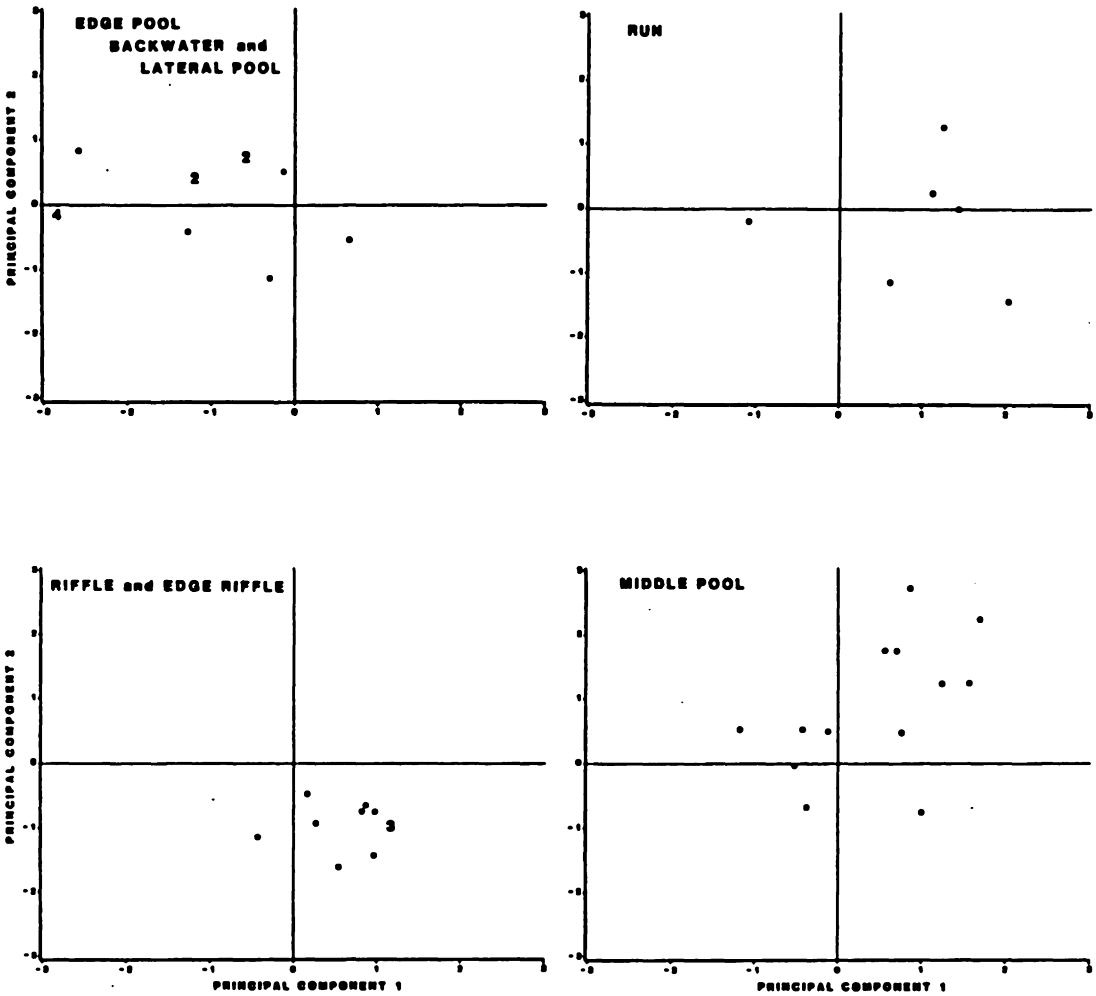

Figure 4. The locations of transects, which were in various habitat types, on graphs of the first two principal components. Principal component analysis was performed on the habitat variables of 43 underwater transects sampled in the New River, WV, August and September, 1985. Numbers represent the number of transects at that point (a closed circle represents one transect).

Figure 5. Weighted mean principal component scores, with weighted standard errors for 20 species-lifestages. Mean scores were calculated with principal component scores (based on habitat variables) from transects at which a particular species-lifestage occurred. Means were weighted by species-lifestage density. Alphabetic codes for each species-lifestage are given.

A	Sunfish - YOY and juvenile
B	Logperch
C	Spotted bass - YOY
D	Northern hog sucker - YOY and juvenile
E	Spotted bass - juvenile
F	Spotted Bass - adult
G	Sunfish - adult
H	Smallmouth bass - YOY
I	Greenside darter
J	Stoneroller
K	Rock bass - adult
L	Smallmouth bass - adult
M	Smallmouth bass - juvenile
N	Rock bass - YOY and juvenile
O	Flathead catfish - adult
P	Bigmouth chub - YOY
Q	Bigmouth chub - adult
R	Rainbow darter
S	Flathead catfish - YOY
T	Sharpnose darter

Figure 5 is on next page.

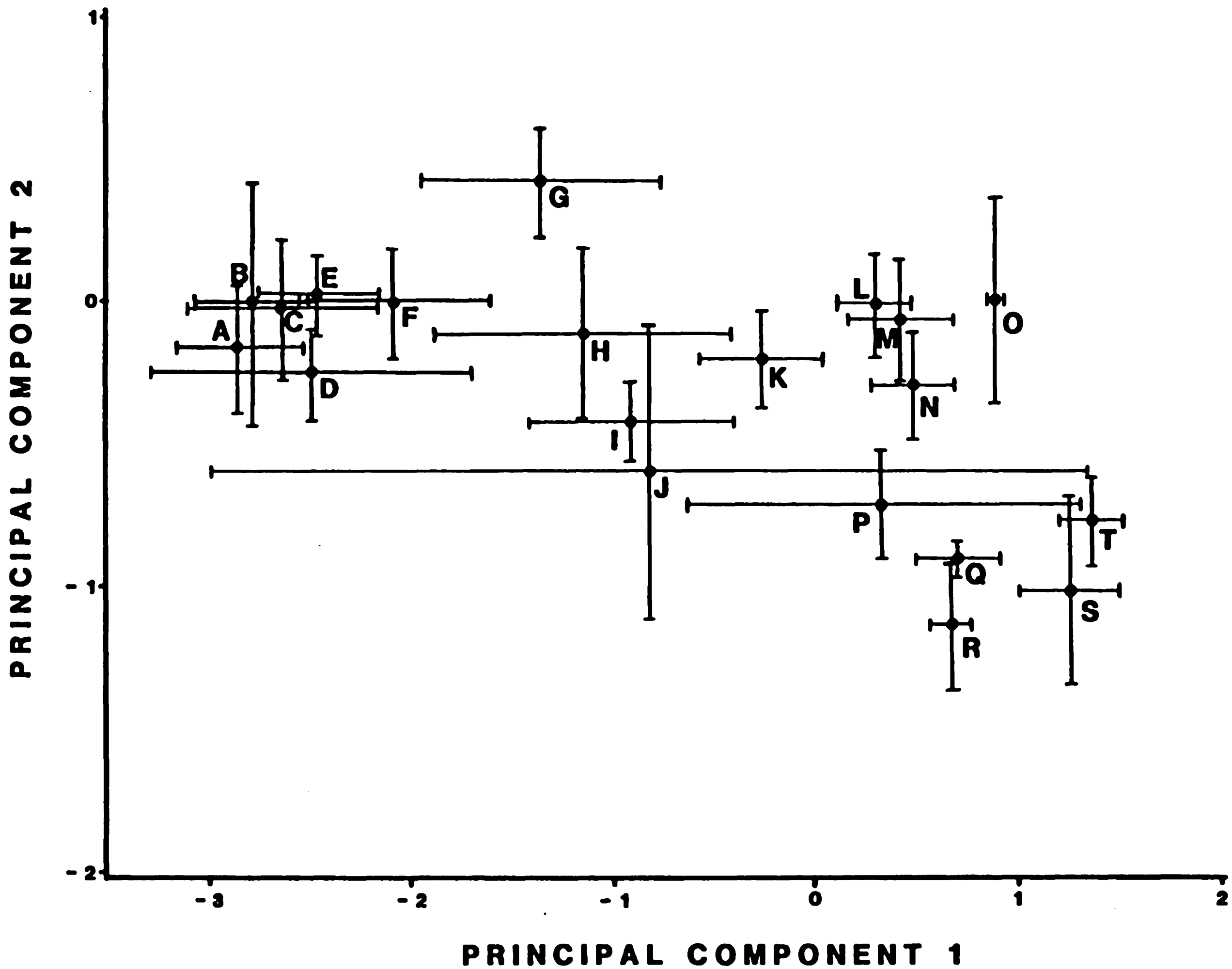

Figure 5. Mean principal component scores ± standard errors

Mean scores for small and large bigmouth chubs, rainbow darters, sharpnose darters are located in the lower right section of Figure 5 (P-T). This section represents the riffle, edge riffle, and shallow run habitat. Therefore, these species prefer shallow, swift velocity habitats. However, young-of-year bigmouth chub use of a wider range of velocities, substrate, and vegetation, as indicated by the larger PC1 standard error.

The mean PC score locations and standard errors are similar for young-of-year smallmouth bass and greenside darter (Figure 5, H-I). Figure 5 indicates that these two species prefer habitat that is shallow, with slow to moderate velocities, but they use fairly wide ranges of velocity and amounts of vegetation and cobble-boulder substrate. Young-of-year smallmouth bass also use a wide range of depths. The large standard errors are not surprising, because young-of-year smallmouth bass were found in every habitat type and greenside darters were found in all habitats except for the snag type. The mean PC score for stonerollers (Figure 5, J) is similar to those of young-of-year smallmouth bass and greenside darters. However, the variability for PC1 is extremely high because mean stoneroller densities were high in both edge riffle and backwater habitat. This, along with the fairly low score for PC2, indicates that stonerollers prefer shallow depths and use a wide range of velocities and amounts of vegetation and cobble-boulder substrate. Adult rock bass are also located in this area of the Figure 5 (K), but they prefer moderate depths and velocities and moderate amounts of vegetation and cobble-boulder substrate. However, a moderate value for PC1 can represent several different combinations of velocity, vegetation, and cobble-boulder substrate.

Young-of-year rock bass, juvenile and adult smallmouth bass, and flathead catfish form another group in the right middle portion of the principal component graph (Figure 5, L-O). The standard errors are smaller for PC1 than for PC2, indicating that they tolerate a fairly wide range of depth and a narrow range of cobble-boulder substrate, velocity, and vegetation. Adult flathead catfish have an especially small PC1 standard error. These fish occur in a wide range of habitats with an apparent selection for moderate depths and velocities and moderate amounts of cobble and boulder substrate, and against slow, vegetated areas. However, as stated previously, a moderate PC1 value can represent several combinations of velocity, vegetation amount, and cobble-boulder substrate.

Guilds

Using the information from the electrofishing data, the daytime underwater transects, and the principal components analysis, I described 5 habitat-use guilds for fishes of the New River, WV (Table 17). Bluntnose minnow, logperch, young-of-year and juvenile northern hog sucker, white crappie, all sizes of spotted bass and sunfish, mimic shiner, spottail shiner, small white and striped shiners, and spotfin shiners are considered to be edge-pool guild members. These species-lifestages were consistently abundant in edge pool habitat, especially in vegetation. White crappie and large spotted bass and sunfish prefer deeper edge pool habitat than the other members of this guild. Spotfin shiners were frequently found in shallow, swift habitat, however, based on the electrofishing data (Appendices 1-3) they appear to prefer habitat with slow velocities. The middle-pool guild includes common carp, adult flathead catfish, channel catfish, and muskellunge.

Adult bigmouth chub, rainbow darter, sharpnose darter, young-of-year flathead catfish, telescope shiner, rosyface shiner, and large white and striped shiners are most common in shallow habitat with swifter velocities. This group of species-lifestages is considered the riffle guild.

The edge-channel guild includes young-of-year smallmouth bass, greenside and Roanoke darters, stonerollers, and young-of-year bigmouth chubs. These species-lifestages prefer shallow water (either slow or moderate current) along the shoreline. Young-of-year smallmouth bass were most abundant in edge pool habitat and young-of-year bigmouth chub were most abundant in edge riffle habitat.

The fifth group of fish that uses habitat in a similar manner is the generalist guild. This guild includes juvenile and adult smallmouth bass, and all sizes of rock bass. These species-lifestages were relatively abundant in all the dominant habitats. However, they do prefer snag habitat and avoid the shallowest areas.

Table 17. Habitat guilds and associated fishes proposed for the New River, WV. Guilds were described from data collected with electrofishing and underwater transects.

Edge-pool	Edge-channel	Riffle
-shallow	Smallmouth bass - YOY	Bigmouth chub - adult
Bluntnose minnow	Greenside darter	Rainbow darter
Logperch	Roanoke darter	Sharpnose darter
Northern hogsucker - YOY and juvenile	Stoneroller	Flathead catfish - YOY
	Bigmouth chub - YOY	Telescope shiner
Spotted bass - YOY		Rosyface shiner
Sunfish - YOY and juvenile		Silver shiner
Mimic shiner		Striped shiner - large
Spottail shiner	**Middle-pool**	White shiner - large
Striped shiner - small		
White shiner - small	Common carp	**Generalists**
Spotfin shiner	Flathead catfish - adult	
	Channel catfish	Rock bass
-deep	Muskellunge	Smallmouth bass - juvenile and adult
White crappie		
Spotted bass - juvenile and adult		
Sunfish - adult		

Nighttime Transects

A total of 895 fish (23 species-lifestages, 13 species groups; Table 18) was counted in three habitat types; middle pool, edge pool, and riffle (Appendix 7). The middle pool transects made up the majority (48.9%) of the total area sampled at night, although the edge pool transects contained the greatest number (51.8%) of fish counted (Table 19). *Notropis* spp. was the most abundant species group (481 fish, 53.7% of sample). Young-of-year sunfish (12%), young-of-year smallmouth bass (8.4%), young-of-year and juvenile rock bass (6.2%) and adult rock bass (4.6%) were the next most abundant species-lifestage groups. Appendix 8 gives the mean density of each species-lifestage in each of the habitats.

At nighttime, edge pool habitat had the highest mean total density of fish ($55.0/100m^2$), and middle pool and riffle areas had similar densities ($12.8/100m^2$ and $9.0/100m^2$, respectively) (Table 20). Edge pool habitat was dominated by *Notropis* spp. (53.9%) and young-of-year sunfish (22.8%). However, during the day, young-of-year smallmouth bass (41.8%) and young-of-year sunfish (32.7%) were the most abundant species-lifestage groups in edge pool habitat (Table 21). Fewer young-of-year smallmouth bass, young-of-year spotted bass, and logperch, and more young-of-year, juvenile, and adult rock bass were seen at night in edge pool habitat. In addition, adult flathead catfish, brook silverside and white crappie were seen at night but not during the day. Juvenile and adult smallmouth bass, young-of-year, juvenile and adult sunfish, young-of-year and juvenile northern hogsucker, and juvenile and adult spotted bass were each similar in abundance between day and night transects.

Habitat use and activity shifts were also found in middle pool habitat. During the day, no *Notropis* spp. were seen in the four middle pool transects. However, at night *Notropis* spp. was the most abundant species group (62.1% of sample, Table 22). In addition, more young-of-year, juvenile and adult rock bass, and adult flathead catfish were seen at night than during the daytime transects.

Table 18. Frequencies and percentages of each species-lifestage in ten nighttime transects. Transects were sampled in the New River, WV, August and September, 1985.

Species	Number	Percent
Notropis spp.	481	53.7
Sunfish - YOY & juvenile	107	12.0
Smallmouth bass - YOY	75	8.4
Rock bass - YOY	55	6.2
Rock bass - adult	41	4.6
Bigmouth chub - YOY	26	2.9
Smallmouth bass - juvenile	22	2.5
Smallmouth bass - adult	17	1.9
Flathead catfish - adult	11	1.2
Northern hogsucker - adult	6	0.7
Logperch	5	0.6
Spotted bass - YOY	4	0.5
Sunfish - adult	4	0.5
Brook silverside	4	0.5
Channel catfish - YOY	3	0.3
Northern hogsucker - YOY	3	0.3
Channel catfish - juvenile	2	0.2
Greenside darter	1	0.1
Largemouth bass	1	0.1
Spotted bass - juvenile	1	0.1
Spotted bass - adult	1	0.1
White crappie	1	0.1
Unidentified spp.	2	0.2
Totals	895	100

YOY - young-of-year

Table 19. Comparison of actual with expected number of fish (based on proportion of total area sampled) in three habitats, in the New River, WV, (chi-square goodness-of-fit $P < 0.0001$) with 95% simultaneous Bonferroni confidence intervals for the actual number of fish. The habitats were sampled with ten nighttime underwater transects in August and September, 1985.

Habitat	Area (m^2) Sampled	Number of fish	Expected number of fish	95% C.I for number of fish
Edge pool	800	464	162.7	428.1 - 499.9
Middle pool	2150	298	437.3	264.2 - 331.8
Riffle	1450	133	294.9	107.5 - 158.5
Totals	4400	895		

Table 20. Mean (95% confidence interval), minimum, and maximum total fish densities (number/100 m^2) in three habitat types sampled with ten nighttime underwater transects in the New River, WV, August and September, 1985. The number of transects in a habitat is represented by n.

Habitat type	n	Mean ± 95% CI	Minimum	Maximum
Edge pool	3	55.0 ± 20.6	35.3	71.2
Middle pool	4	12.8 ± 13.0	3.0	31.7
Riffle	3	9.0 ± 2.1	7.1	10.8

Table 21. Species-lifestage frequencies and percentages in three edge pool transects. Transects were sampled in the New River, WV, August and September, 1985.

	Nighttime (800 m^2)		Daytime (1200 m^2)	
Species	Number	Percent	Number	Percent
Notropis spp.	250	53.9	50	7.6
Sunfish - YOY & juvenile	106	22.8	216	32.7
Smallmouth bass - YOY	44	9.5	276	41.8
Rock bass - YOY	15	3.2	2	0.3
Smallmouth bass - juvenile	11	2.4	7	1.1
Rock bass - adult	7	1.5	1	0.2
Logperch	5	1.1	59	8.9
Smallmouth bass - adult	4	0.9	1	0.2
Sunfish - adult	4	0.9	2	0.3
Flathead catfish - adult	4	0.9	0	0.0
Brook Silverside	4	0.9	0	0.0
Spotted bass - YOY	3	0.6	33	5.0
Northern hogsucker - YOY	2	0.4	5	0.8
Spotted bass - juvenile	1	0.2	4	0.6
Spotted bass - adult	1	0.2	5	0.8
White crappie	1	0.2	0	0.0
Unidentified spp.	2	0.4	0	0.0
Totals	463	100	652	100

YOY - young-of-year

Table 22. Species-lifestage frequencies and percentages in four middle pool transects. Transects were sampled in the New River, WV, August and September, 1985.

	Nighttime (2150 m²)		Daytime (2350 m²)	
Species	Number	Percent	Number	Percent
Notropis spp.	185	62.1	0	0.0
Rock bass - YOY	40	13.4	1	0.9
Smallmouth bass - YOY	27	9.1	65	60.8
Rock bass - adult	16	5.4	3	2.8
Smallmouth bass - juvenile	8	2.7	26	24.3
Smallmouth bass - adult	4	1.3	6	5.6
Flathead catfish - adult	3	1.0	1	0.9
Channel catfish - YOY	3	1.0	0	0.0
Bigmouth chub - adult	2	0.7	0	0.0
Channel catfish - juvenile	2	0.7	0	0.0
Northern hogsucker - adult	2	0.7	0	0.0
Spotted bass - YOY	2	0.7	0	0.0
Greenside darter	1	0.3	2	1.9
Largemouth bass - juvenile	1	0.3	0	0.0
Northern hogsucker - YOY	1	0.3	0	0.0
Sunfish - YOY & juvenile	1	0.3	0	0.0
Unidentified spp.	1	0.0	3	2.8
Totals	299	100	107	100

YOY - young-of-year

Conversely, substantially fewer young-of-year and juvenile smallmouth bass were seen at night. Adult smallmouth bass were as abundant in middle pool habitat during the day as at night.

On the riffle transects (Table 23), *Notropis* spp. was the dominant group (64% of sample) during the day as well as at night (34.6%). However, they were much more abundant during the day ($3.2/100m^2$ vs $17.6/100m^2$). *Notropis* spp. appear to move from riffles during the day to the edge and middle pool areas at night, where they rest on the bottom. Stonerollers and all cohorts of smallmouth bass were also more abundant during the day. Adult flathead catfish and adult northern hog suckers were found in the riffles at night but not during the day. Adult rock bass were found during the day, but were five times more abundant at night. Young-of-year and adult bigmouth chubs were similar in abundance along daytime and nighttime transects.

Table 23. Species-lifestage frequencies and percentages in three riffle transects. Transects were sampled in the New River, WV, August and September, 1985.

	Nighttime (1450 m^2)		Daytime (1700 m^2)	
Species	Number	Percent	Number	Percent
Notropis spp.	46	34.6	300	64.0
Bigmouth chub - adult	24	18.1	16	3.4
Bigmouth chub - YOY	21	15.8	24	5.1
Rock bass - adult	18	13.5	4	0.9
Smallmouth bass - adult	9	6.8	26	5.5
Flathead catfish - adult	4	3.0	0	0.0
Smallmouth bass - YOY	4	3.0	48	10.2
Northern hogsucker - adult	4	3.0	0	0.0
Smallmouth bass - juvenile	3	2.3	35	7.5
Stoneroller	0	0.0	16	3.4
Totals	133	100	469	100

YOY - young-of-year

DISCUSSION

Results of this study indicate that five assemblages of fish (segregated by habitat) are present in the New River in late summer. Habitat guilds of fish have also have been proposed by previous investigators (Finger 1982; Schlosser 1982; Leonard et al. 1986; Bain and Finn unpublished manuscript). Schlosser (1982) used cluster analysis and an ecological overlap index to identify five habitat guilds (pool, raceway-pool, raceway, raceway-riffle and riffle) in a second-order warmwater stream. Finger (1982) identified three (pool, riffle, and transistion) midsummer habitat assemblages in a small warmwater stream using polar ordination of fish capture data. Although habitat use has been shown to vary among lifestages of species (Gosse 1981; Moyle and Baltz 1985; Sechnick et al. 1986), neither Finger (1982) nor Schlosser (1982) attempted to describe habitat guilds based upon different sizes of fish species. However, they did note that shallower areas were used more often by young fish than were deeper areas. Leonard et al. (1986) used spawning and microhabitat utilization and preference curves to propose five habitat guilds (riffle, run, run-pool, pool and shoreline) for the James River drainage in Virginia.

Bain and Finn (unpublished manuscript) used multivariate analyses to evaluate the relationships between 15 size classes of species and stream habitat and to propose habitat guilds for two (a natural and a regulated) medium sized fifth order coolwater rivers. They classified the 15 species-size classes into two groups. One was the shallow-slow guild (9 species-size classes) which included mainly the smaller size classes and species. The other group was composed of two habitat generalists (smallmouth bass > 100 mm and American eel, *Anguilla rostrata*) and four habitat specialists (largemouth bass, *Micropterus salmoides*, rock bass > 100 mm, longnose dace, and white sucker, *Catostomus commersoni*) using habitats other than shallow, slow areas. The habitat guilds which I have proposed (riffle, edge-pool, middle-pool edge-channel, and generalists) are in general agreement with those guilds proposed by previous investigators working with smaller streams. Variations can be attributed to the differences in the fish fauna, habitat available, and habitat classifications, as well as the differences in sizes of the streams.

The edge-pool guild (bluntnose minnow, logperch, young-of-year and juvenile northern hogsucker, white crappie, spotted bass, sunfish, mimic shiner, spottail shiner, small white and striped shiner, and spotfin shiner) developed in this study is in agreement with other studies describing habitat use by these species in other stream systems (Clay 1975; Lee et al. 1980; Finger 1982; Schlosser 1982; Joy et al. 1981; Rose and Echelle 1981; Yant 1982; Leonard et al. 1986; Bain and Finn unpublished manuscript). However, Finger (1982) found that northern hog suckers (mean total length 101mm) were widely distributed among habitats, being most abundant in the head of the pool, although larger hog suckers were in raceways. Schlosser (1982) considered northern hog suckers (not separated by size) to be raceway-pool guild members. Finger (1982) and Schlosser (1982) studied smaller streams with different fish faunas and habitats. It is likely that differences in stream width and depth were important factors contributing to the discrepancies between guilds. In streams studied by Finger (1982) and Schlosser (1982) width was less and depths were shallower than those of the New River. Consequently, the pools in those streams were probably not suitable for classification into edge vs. middle pool. Pool habitat in Finger's and Schlosser's streams may have been similar to what I classified as edge pool habitat.

The habitat generalist guild (juvenile and adult smallmouth bass, and rock bass) in the New River is in agreement with the habitat use patterns previously described for members of this guild (Munther 1970; Joy et al. 1981; Schlosser 1982; Probst et al. 1984; Leonard et al. 1986; Rankin 1986; Sechnick et al. 1986; Bain and Finn unpublished manuscript). Larger smallmouth bass were described as being a run-pool inhabitant by Leonard et al. (1986), a pool guild member by Schlosser (1982), and a habitat generalist by Bain and Finn (unpublished manuscript). Munther (1970) found that smallmouth bass (> 122 mm) used a wide variety of habitats during the summer. However, they are often associated with some type of cover (Sechnick et al. 1986; Probst et al. 1984), as evidenced in this study by the high densities in snag habitats. In contrast, Rankin (1986) found smallmouth bass were usually not near cover (however, he did not sample run and riffle habitat).

Rock bass were considered to be a pool guild member by Schlosser (1982). Bain and Finn (unpublished manuscript) considered rock bass to be a habitat specialist which used an intermediate set of depths, velocities, and substrates. Leonard et al. (1986) considered rock bass as a pool inhabitant, preferring areas greater than 0.6 m deep with little or no current. Pajak (1985) found that in two fourth-order tributaries of the New River in Virginia, rock bass occupied pools and runs during the summer. He determined that the summer habitat supporting the highest rock bass densities was characterized by mean depths of 20 to 39 cm, mean current velocities of 10 to 19 cm/s, and silt as the dominant substrate. He also found that rock bass densities tended to increase with increasing amounts of cover.

The classification of young-of-year smallmouth bass in the edge-channel guild agrees well with the results of other studies (Coble 1975; Bain and Finn unpublished manuscript). However, greenside darter, roanoke darters, and stonerollers are generally considered riffle species (Smith 1979, Trautman 1981; Orth and Maughan 1982; Schlosser 1982; Matthews 1985; and Leonard et al. 1986). The disparities in habitat-use descriptions of these species between this and the other studies can probably be attributed to differences in stream size. In the smaller streams, because of the narrower widths and shallower depths, there may not have been enough areas to recognize as edge-channel habitat or to support a separate habitat guild of fishes. No reports of young-of-year bigmouth chub habitat were found. The riffle guild (adult bigmouth chub, rainbow darter, sharpnose darter, young-of-year flathead catfish, telescope shiner, rosyface shiner, silver shiner, large white and striped shiners) agrees well with reports on their habitat use (Lachner and Jenkins 1971; Denoncourt 1977; Smith 1979; Trautman 1981; Schlosser 1982) as does the middle pool guild (common carp, adult flathead catfish, channel catfish and muskellunge) (Smith 1979; Trautman 1981).

Finger (1982), Schlosser (1982), and Leonard et al. (1986) recognized species that specialized on run (raceway or transition) habitat. However, run habitat was often grouped with riffle or pool habitat to form a combined habitat guild (eg. raceway-pool, run-pool, raceway-riffle). I believe that the absence of a run guild in the New River, WV is due to the relatively small amount of clearly defined run habitat resulting from the low flow of late summer. At higher flows the run areas are larger and more clearly defined. There were a few transects on which the tail and head of the riffle would have been run habitat at a higher flow. Juvenile and adult smallmouth bass were the dominant species-lifestages in the run habitat of the New River. Rock bass and members of the riffle guild were also common in run areas.

To summarize habitat segregation in the New River, West Virginia, the larger centrarchids prefer the slower velocity, deep habitats (deep edge and middle pool, and snags), while the young centrarchids prefer shallower habitat. However, young-of-year smallmouth bass were found in all habitats, and juvenile and adult smallmouth bass were nearly ubiquitous in the habitats of the study area. The cyprinids and percids prefer shallow areas, with certain species preferring slow current habitat, others preferring habitats with swifter velocities, and still others that used both slow and swift velocity habitats (specifically stonerollers, young-of-year bigmouth chubs, and greenside darters). In a more general sense, forage species and young of the predator species prefer shallow areas, while large predators prefer deeper habitats.

Competion, predation risk, and food availability are three factors which may be contributing to the spatial segregation of fishes in the New River. Overlap in use of food and space by fish species can lead to competition for these resources when demand exceeds supply (Zaret and Rand 1971). As a result, fish species often change their feeding habits and habitat use when resources are limited. Such competition can lead to evolutionary divergence in food and habitat use and morphology of species, thus producing nonrandom assemblages of species (Gatz 1979).

It has been hypothesized by many workers, that fish species balance the risk of predation with food availability (Sih 1980; Dill 1983). The basic assumption of this theory is that prey species will be most abundant in areas with high amounts of preferred foods and low predation risk, and they will use areas with high risk and low food less than areas with high risk and high food.

The presence of predators has been shown to affect the distribution of other stream fishes: stonerollers (Power and Matthews 1983), blacknose dace *Rhinichthys atratulus* (Fraser and Cerri

1982; Cerri and Fraser 1983; Fraser and Emmons 1984), and armored catfish (Loricaridae) (Power 1984). Power and Matthews (1983) demonstrated that stonerollers avoided pool areas with predators, even though an abundant food source, attached algae, was available on cobbles in the pools. Susceptibility to avian predators was presumed to be the reason armored catfish avoided shallow areas of a stream even though their food, attached algae, was abundant there (Power 1984). In the above two cases (Power and Matthews 1983; Power 1984), the benefits of increased food were not balanced against the risk of predation. The use of structure, such as vegetation, woody debris and boulders, is an adaptive strategy (Cerri and Fraser 1983) to avoid predators (Fraser and Cerri 1982; Savino and Stein 1982;) and may be used to mediate the risk of predation in areas of abundant food (Fraser and Cerri 1982).

Predation risk and food availability may be influencing the habitat segregation of the fishes of the New River, WV. The abundance of benthic invertebrates, the primary food source for New River fishes (Hess 1983) including smallmouth bass (Austen 1984), varies among habitats. The riffle areas are characterized by gravel, cobble, boulder, and bedrock substrate, often with the macrophyte *Podostemum ceratophyllum* and the filamentous algae *Cladophora* covering the bedrock. Benthic invertebrate production on bedrock outcrops immediately below Bluestone dam exceeds all invertebrate production values previously reported in the literature (Voshell 1985a). The high level of production was attributed to the microenvironment provided by the *Podostemum* and the high food quality of seston released from Bluestone Lake (Voshell 1985a). Edge pool habitat is characterized by silt and mud covering various larger substrates, often with emergent and/or submersed vegetation. Also, swifter flowing habitats along the river margins often have vegetation (*Justicia*) Macrophytes in streams are known to offer more substrate surface area for aquatic insects and to retain more detritus (invertebrate food source) than unvegetated substrate (Gregg and Rose 1982). In the New River, WV, Voshell (1985b) found that standing stocks of macroinvertebrates were highest in *Podostemum* in August; when *Justicia* was growing vigorously, the second highest standing stocks were found in *Justicia* (Voshell 1985b). In addition, the slow velocity areas are more apt to contain small and large pieces of woody debris (7 of 10 edge pool transects had woody debris; Appendix 5). Woody debris provides stable substrates for aquatic organisms such as bacteria, fungi, and invertebrates that decompose wood and can represent maior components of trophic webs in stream ecosystems (Angermeier and Karr 1984).

The deeper pool habitats of the New River have predominantly bedrock and boulder substrate devoid of vegetation. Benthic invertebrate production is less in middle pool areas because bedrock provides few interstices (Minshall 1984). The greater amount of food availability and/or the predator-avoidance advantages (shallow and often more structure) of the edge pool and edge riffle areas make them most suitable for smaller fish. In contrast, middle pool habitats with fewer macroinvertebrates and greater predation risk, are less suitable for smaller fish, at least according to the food benefit-predation risk balance theory.

The influence of food availability and habitat structure are certainly contributing factors to the disparities in total densities among the different habitat types. Snag habitat, which was occupied exclusively by centrarchids and had the highest mean total fish densities of all the habitats (Table 10), can serve as a source of food as well as provide structure. Probst et al. (1984) also found that rock bass and smallmouth bass were concentrated near woody structure in a Missouri stream. Angermeier and Karr (1984) found that when a small Illinois stream (Jordan Creek) was divided along midchannel and woody debris was manipulated, more species and individuals and more large fish were captured on the side with artificial woody debris than on the cleared side. In addition, they found that benthic invertebrates were more abundant on the side with artificial debris. Benke et al. (1985) also found that invertebrate diversity, biomass and production were considerably higher on snags than in either sandy or muddy substrates in a Georgia stream; although snags represented only 4% of all habitat surfaces, they supported 60% of the invertebrate biomass and 16% of the production. The snag habitat provided food for fishes because the snag invertebrate fauna, primarily midges (Chironomidae) and caddisflies (Trichoptera) comprised at least 60% of the diet for redbreast sunfish, bluegill, and spotted sunfish (*Lepomis punctatus*), 46% of the warmouth (*Lepomis gulosus*) diet and approximately 19% of the largemouth bass diet (Benke et al. 1985).

Edge riffle habitat also had relatively high mean total fish densities, consisting primarily of smaller individuals (Table 12). Large fish may avoid shallower areas because of the risk of predation from avian predators (Power 1984), such as green and blue herons, kingfishers, and ospreys that are present along the New River. In turn the small fish, as discussed earlier, may be "restricted" to shallower areas by piscine predators. The high densities in edge riffle habitats may be influenced by food availability and energetic cost of foraging. Riffle areas in the New River, WV generally have high invertebrate production (Voshell 1985b); however, the energetic costs of maintaining a position in the current may also be high. Fausch (1985) demonstrated that juvenile salmonids selected positions which maximized the potential for net energy gained (available prey energy minus energy costs for swimming). Probst et al. (1984) often observed smaller smallmouth bass holding positions adjacent to moderate current velocity as if feeding on drifting invertebrates. The use of edge riffle vs. riffle may be a means of maximizing food availability while minimizing energy expended for foraging.

I am confident that the habitat guilds I have proposed accurately represent the true late summer habitat use patterns of the fishes in the New River, WV. First, the guilds were developed using data collected during two years; thereby decreasing the influence of an atypical year. Secondly, the two different sampling methods used (direct observation and electrofishing) provide a means to compensate for any influences of sampling method bias on the development of guild hypotheses. In addition, the data from the two sampling methods are similar. However, there are definite sampling biases with both sampling methods.

Electrofishing is often selective for larger fish (Catchings et al. 1984) and is less effective as stream width, depth and velocity increase (Peterman 1978, Catchings et al. 1984). At current velocities greater than 1m/sec netting fish becomes difficult (Peterman 1978). Even if fish are affected by the electrical current in deeper areas, they may not be visible to the netter because fish break the water surface less often than in shallow water (Peterman 1978). While electrofishing is limited in deep areas, underwater observation is less effective in shallow areas. Areas less than 0.5m deep are difficult for a snorkeler to negotiate. Depths less than 0.3m are nearly impossible to sample unless the diver observes fish from deeper water adjacent to the area. Areas with abundant submersed and emergent vegetation were also more efficiently sampled with electrofishing equipment because vegetation obstructs diver vision. Large cobbles and boulders also limit observation of fish.

In regard to the accuracy of the fish density estimates in this study, I feel that avoidance of divers by fish is more of a concern than attraction to divers. Although, many fish, most noticeably young-of-year smallmouth bass, would move from their original positions toward a diver, I do not believe that they were attracted from outside the transect area. Larger fish were often seen just before they moved out of the transect. There were certainly some fish that moved out of the strip before they were noticed by the divers. Therefore, since some fish were not counted, either because they used cover or avoided the divers, density estimates are lower than the actual densities.

Active fish are more easily observed by divers. Diel activity patterns make certain fish species more suitable for underwater observations during the day, and can explain the differences that I found in the densities of certain species. Helfman (1981) found that mimic shiner, bluntnose minnow, pumpkinseed and bluegill sunfish, and smallmouth bass were diurnally active, whereas rock bass were nocturnally active in a New York lake. I found similar activity patterns for New River fishes. Most shiners (*Notropis* spp.) were active during the day in edge pool and riffle habitat. However at night, the majority of the shiners were found resting on the substrate in edge and middle pool habitat. More young-of-year sunfish, young-of-year spotted bass, and logperch were counted during the day than at night in three of the edge pool transects, presumably because they are active during the day and occupy locations at night where observation is more difficult, such as on the substrate in vegetation. Young-of-year sunfish were not found to shift to either middle pool or riffle habitat. Young-of-year smallmouth bass were less abundant at night than during the day in edge pool, middle pool and riffle habitat. Because they were not found to be moving between habitat types, they were probably resting in cover where they could not be observed by the divers. Because juvenile smallmouth bass were less abundant at night in middle pool and riffle habitat, and adult smallmouth bass were less abundant in riffle habitat at night, they were presumably less active at night also. Conversely, rock bass were more active and seen more often at night. During the day rock bass were generally seen using boulders as cover. At night, they were more active and were found in open areas, not using cover. Activity differences between day and night for a species can generally explain the different density estimates for that species between day and night. Sampling efficiency was not as great at night because of low visibility. However, I do not believe that this can account for the large day/night differences in densities found for many of the species.

The highest midday densities of fish were found along the shoreline in snag, vegetation, and edge riffle habitat and the highest macroinvertebrate densities and production are in riffle and vegetation areas (Voshell 1985a). Therefore, any adverse impacts on these areas can be expected to be detrimental to the fish populations of the New River, WV. The high and low flows below peaking power facilities alternately inundate and expose portions of the streambed. Shoreline and riffle habitat, and other shallow areas are the habitats most affected by flow fluctuations (Pfitzer 1967; Walburg et al. 1981). Daily flow fluctuations result in increased streambed and bank instability, streambed scouring, erosion and turbidity, which discourage riparian vegetation and streambed vegetation and algal growth (Fisher and LaVoy 1972; Kroger 1973; Ward 1976; Ward and Short 1978; Walburg et al. 1981). Voshell (1985b) believed that the proposed peaking power operations at Bluestone dam from November to February would have a significant detrimental impact on the standing stock of benthic macroinvertebrates in the New River, WV. The reduction in standing stock would be brought on by the erosion of macrophytes, particularily *Podostemum* and the dislodging of clinging macroinvertebrates (Voshell 1985b). The productivity of the summer macroinvertebrate community depends in part, on the success of *Podostemum* (Voshell 1985a); consequently, the loss of *Podostemum* would reduce the summer standing stock of macroinvertebrates in one of the major habitats in the New River, WV (Voshell 1985b). The productivity of many fish would be adversely affected because of the reduction of macroinvertebrate prey in the food chain (Voshell 1985b). The loss of emergent and submersed vegetation would also be detrimental to the aquatic biota. Voshell (1985b) found that macroinvertebrate densities in *Justicia* in late summer were second only to *Podostemum*. In this study I found that vegetation also serves as nursery areas for young fish. The majority of young-of-year fish were found in emergent and submerged vegetation during electrofishing collections in 1984. Vegetation is used extensively by young crayfish (Michael Roell, VPI&SU personal communication), which are an important food source for New River smallmouth bass (Austen 1984) and rock bass (Michael Roell, personal communication). I noted that forage fish species appeared to be more abundant in the summer of 1985, when vegetation was more abundant, than in 1984 when high spring flows appeared to discourage establishment and growth of emergent and especially submersed vegetation. However, the high flows in 1984 may have disrupted spawning or increased forage fish mortality.

Although they are rare, snags provide important habitat to New River centrarchids. Consequently, the loss of snag habitat could be detrimental to these fishes. The majority of snags are located along the shoreline, and are in the zone of fluctuation (Walburg et al.1981). Thus, they would be subjected to recurring flow fluctuation associated with a peaking power facility. Therefore, it is expected that snags would be dislodged from the bank and displaced downstream due to increased bank instability associated with daily flow fluctuations.

Peaking power operation produces low flows at night and high flows during the day. Low nighttime flows can be expected to be most detrimental to those species-lifestages that use the shoreline and shallow habitats at night. Since the highest mean total densities of fish at night were found in edge pool habitat, the impacts of low night time flows on the fish fauna in the New River, WV may be significant.

To more precisely predict the effects of peaking power flow fluctuations on the fish fauna in the New River, more specific habitat requirements of the fish need to be known. It would be labor intensive and time consuming to evaluate the specific habitat requirements of all the species in the river. Therefore, it would be prudent to select a few target species. A reasonable approach would be to select representative species-lifestage(s) from each guild, and assume that the members of a guild will be impacted by flow fluctuations in the same manner as the representative species for that guild.

SUMMARY

1. Analysis of counts of fish, conducted with the use of SCUBA and snorkeling equipment, indicated that fish densities among the dominant habitats (edge pool, middle pool, riffle, and run), were significantly different. Fish densities in edge pool and riffle habitats were comparable, but densities in edge pool habitat were significantly higher than densities in middle pool and run habitats. Densities of fish in riffles were significantly higher than those in middle pool habitat, but were similar to those in run habitat. Snag and edge riffle habitats supported the highest densities of fish. All sizes of centrarchids found in the New River were seen using snag habitat.

2. Canonical correlation of the fish densities and four habitat variables (depth, velocity, amount of vegetation, and amount of cobble-boulder substrate), showed that velocity and vegetation amount were most strongly correlated with fish densities.

3. Fish species-lifestage composition and densities differed among the habitat types. Five habitat-use guilds (edge-pool, middle-pool, edge-channel, riffle, and generalists) were described for fishes of the New River and compared to guilds proposed by other researchers.. Larger centrarchids preferred slower velocity, deep habitats (deep edge and middle pool, and snags) while the young centrarchids preferred shallower habitat. However, all ages of smallmouth bass were nearly ubiquitous in the habitats of the study area. The cyprinids and percids preferred shallow areas, but preferences for velocity differed among the species-lifestages. Forage species and young of the predator species preferred shallow areas, while large predators preferred deeper habitats. Predation risk and food availability are discussed as contributing to the spatial segregation among New River fishes.

4. At nighttime, edge pool habitat had the highest fish densities, and middle pool and riffle areas had similar densities. Habitat-use and activity shifts between daytime and nighttime were found for many species-lifestages.

5. The habitats with the greatest number of fish are also the areas most susceptible to the dramatic, daily flow fluctuations associated with hydropower generation. The potential effects of flow fluctuation associated with the proposed conversion of Bluestone Dam to hydroelectric operation are discussed.

BIGMOUTH CHUB HABITAT REQUIREMENTS

INTRODUCTION

The bigmouth chub is one of the five species endemic to the New River drainage. It is the most abundant of the endemic species in the mainstem New River within the NRGNR. It inhabits medium-sized tributary streams to the main channel, and is widespread in North Carolina, Virginia, and West Virginia (Lachner and Jenkins 1971).

The bigmouth chub, like all other *Nocomis* spp., builds a mound nest out of gravel. Lachner and Jenkins (1971) observed large nests of the bigmouth chub in the Greenbrier River system during May, but they did not measure any spawning habitat attributes of the nests or nesting areas. However, they described the nests as often being over 1 m in diameter, located in the deeper, swifter channels of the stream.

More detailed information on spawning habits and requirements have been reported for other species of *Nocomis*. Reighard (1943) found that in Michigan, *Nocomis micropogon* built nests from mid-April through May at water temperatures of 15 to 20.5^0 C. Nests were built of gravel and located in pools 45 cm to 61 cm deep. In New York, *Nocomis micropogon* nests were built at water temperatures from 15.5 to 20.5^0 C in June (Miller 1964). Most of the nests were located in runs with moderate current and typically were near the bank. Only a few nests were found in riffles or very swift water. *Nocomis leptocephalus* spawned from April through June (Lachner 1952). Nests of *Nocomis leptocephalus* were 0.3 m to 0.6 m in diameter, 15 cm to 30 cm high, and usually were located just above or at the head of riffles in moderately swift water 45 cm deep (Raney 1947). Leonard et al. (1986) measured habitat attributes of 19 nests of *Nocomis leptocephalus* and/or *Nocomis raneyi*, in June, in the Maury River, Virginia. Most of the mounds were located at depths between 0.2 and 0.8 m, with current velocities between 0.15 and 0.5 m/s. The mounds were constructed of small and large gravel (2-64 mm) and were located at the head or margins of riffles. The substrate surrounding the nests consisted of small and large cobble (64 to 256 mm). *Nocomis biguttatus* spawning occurs at water temperatures of 18.3^0 C or warmer (Hankinson 1932).

The bigmouth chub is considered a riffle species, but no previous work has been done to describe its habitat preferences. Because it inhabits riffles, which can undergo dramatic changes in depth and velocity due to flow fluctuation, the bigmouth chub may be adversely affected by the proposed peaking power operation of Bluestone Dam. In addition, daily flow fluctuations have the potential to seriously disrupt bigmouth chub spawning as well as egg and fry survival, because large nests in shallow water are susceptible to dewatering and to being swept away. For example, Miller (1964) found *Nocomis micropogon* nests were obliterated by high flows.

To determine the microhabitat and spawning requirements of the bigmouth chub, the specific questions I asked were:

1. Are bigmouth chubs randomly distributed among the major habitat types?
2. Do bigmouth chubs prefer specific locations based on certain habitat gradients, or are they randomly distributed within utilized macrohabitat areas?
3. Do different size bigmouth chubs have different microhabitat preferences?
4. What are the characteristics of bigmouth chub spawning areas and mounds?

METHODS

Field

Spawning habitat

Four river reaches (Figure 6) were periodically searched for bigmouth chub spawning mounds between April 28 and June 5, 1985. Searches were conducted by wading and snorkeling. At each mound, mean current velocity on top of the mound, and water depth and mean current velocity at a position upstream or adjacent to the mound, were measured. Depths and velocities were not measured if it was determined, based upon the amount of discharge fluctuation prior to the sampling date, that conditions were not representative of those present at the time of mound construction. Velocity upstream or adjacent to the mound was assumed to be an indication of the velocity at the mound location prior to mound construction. In addition, the height, size, and substrate (Table 24) of the mound, substrate around the mound, cover, and distance of mound from the bank were recorded. Mound size was measured as the width along the longest axis and

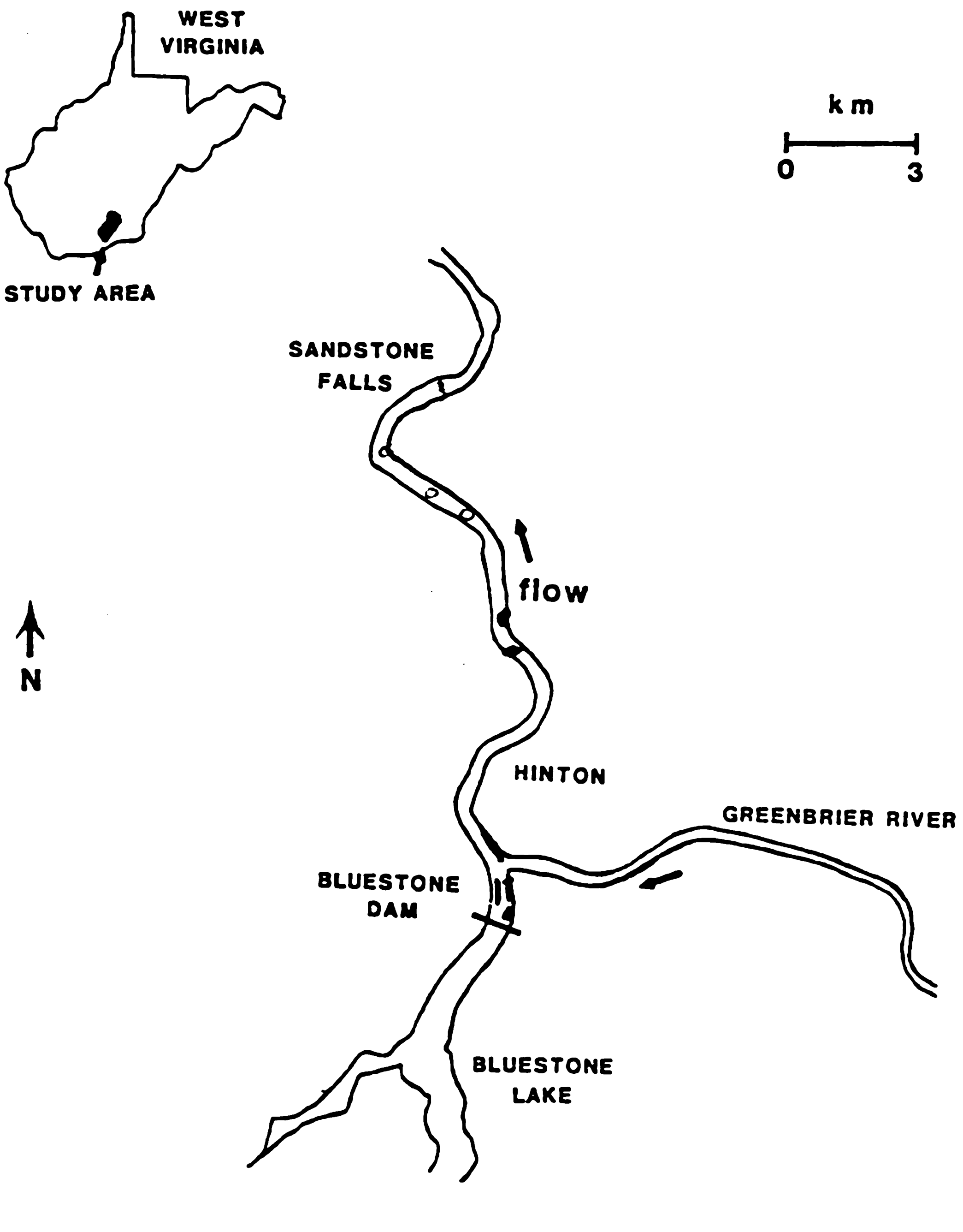

Figure 6. Locations of known bigmouth chub spawning areas in the New River, WV, mid-April to mid-June, 1985. Solid areas represent locations where measurements of nests and nest areas were taken. Open circles represent areas where nests were seen, but no measurements were taken.

Table 24. Substrate codes used for bigmouth chub microhabitat use description. Format was dominant-subdominant.

Substrate type	Diameter
0. Bedrock	
1. Organic[1]	
2. Fines	< 1 mm
3. Sand	1 - 2 mm
4. Small gravel	3 - 16 mm
5. Large gravel	17 - 64 mm
6. Small cobble	65 - 128 mm
7. Large cobble	129 - 256 mm
8. Small boulder	257 - 512 mm
9. Large boulder	> 513 mm

[1] Includes *Podostemum* and *Cladophora*.

the width along the axis perpendicular to the longest axis. The age (old vs. new) of each mound was estimated, based on the mound's structural integrity and the amount of silt on the mound. At areas to be searched again at a later date, each mound was marked with a piece of cobble with a numbered flag tied to it.

Microhabitat Utilization

Eighteen underwater transects in five reaches of the river were sampled between September 6 and 26, 1985 (Figure 7). Discharges on sampling dates ranged from 31.9 m^3/s to 70.6 m^3/s (0.15 m difference in water level at Hinton). Transects were sampled between 1100 and 1700 hours. Transect width was dependent upon underwater visibility and the number of divers (1-2). Transect widths ranged from 3-7 m, and lengths ranged from 25-160 m. Divers swam in an upstream direction. When a bigmouth chub was located, it was observed until a mean location could be determined. Total length of fish, activity (stationary, active or feeding), and position in the water column (focal point depth) were determined. Position in the water column (focal point depth) was recorded as distance from substrate (1-5, 5-10, 10-20, 20-30, 30-40, or > 40 cm). Young-of-year bigmouth chubs (< 100mm) were not included in this portion of the study because they use a wide range of macrohabitats.

The type of cover (no cover, instream object, vegetation, bedrock ledge, or turbulence) being used and the species of fish within 1m of the bigmouth chub(s) were recorded. Finally, a weighted marker was placed at the mean location of the bigmouth chub, and the diver continued along the transect. When more than one bigmouth chub was found at a specific location, several markers were placed in a manner to represent the area used by the school. One marker represented approximately five bigmouth chubs. After a transect was completed, the diver returned to each marker and measured water depth, mean water column velocity, focal point velocity, maximum mean water column velocity within 1 m of each marker, and substrate type (Table 24). Current

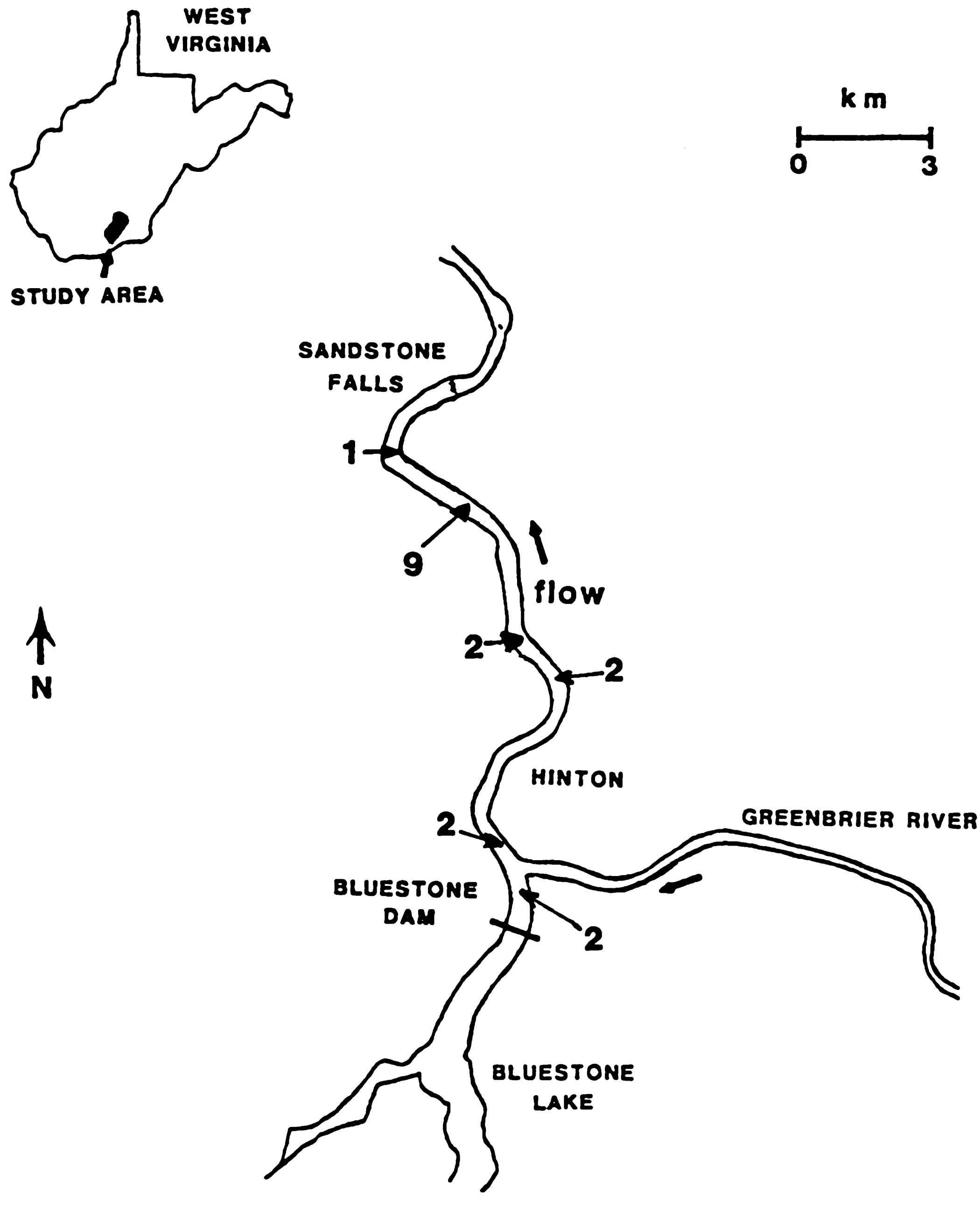

Figure 7. Locations and numbers of underwater transects sampled to study microhabitat use by the bigmouth chub in the New River, WV. Sampling was conducted during midday in September, 1985.

velocity was measured with a pygmy current meter. Mean velocity was measured at 0.6 depth from the water surface. In water greater than 1 m deep the mean velocity was recorded as the average of the velocities at 0.2 and 0.8 of the depth. Focal point velocity was measured at the approximate midpoint of the focal point depth interval.

Habitat availability at the time of observation was determined by measuring mean velocity, depth, substrate, and cover at sampling points randomly selected throughout the transect strip. To be able to combine availabilities from all transects, the areas represented by the sampling points must be equal. Each transect was divided into 25 m^2 transverse sections, with the number of sections being dependent upon transect length and width. Sampling point location within a 25-m^2 section, was determined by selecting five random digits, with the first two digits indicating the linear distance (in 0.1m) along the center line of the transect. The third digit designated which side of the imaginary center line was sampled (eg. odd = left). The perpendicular distance (in 0.1 m) from the center line was determined by the last two digits.

Data analysis

Microhabitat Utilization

For comparisons of habitat use by small (100 - 150mm) and large (> 150 mm) bigmouth chubs, I used nonparametric statistical procedures to test for location (Wilcoxon Rank Sum;WRS), dispersion (Moses Rank-like; MRL), and general distribution (Kolmogorov-Smirnov two sample) differences in depth, velocity, and focal point velocity. Chi-square tests for independence (Conover 1971) were used to compare substrate and cover use, and focal point depth of both sizes of bigmouth chubs. To have enough observations in each class, small and large gravel and small cobble were combined, and large cobble and small and large boulders were combined. In addition, all cover types (except for no cover) were combined, resulting in classes of cover and no cover.

Chi-square goodness-of-fit tests (Conover 1971) were used to compare habitat measurements at bigmouth chub locations (use) with the habitat parameters that were measured randomly along the transects (availability). Expected use values were determined by multiplying the proportion of availability in a class by the total number of utilization observations. To determine if bigmouth chubs were selecting their positions at the microhabitat level, only those transects at which bigmouth chubs were present were used in the following analyses. Furthermore, any availability observations with depth or velocity measurements outside of the utilized ranges were considered to be unavailable to the chubs and were not included in the analyses.

To determine which habitat classes were preferred by bigmouth chubs, simultaneous Bonferroni confidence intervals (Bern and Steinhorst 1984) were calculated for the proportions of use and were compared with availability proportions for each class of a habitat variable. Comparisons between use and availability measurements of the different habitat variables were conducted with both unweighted (N = 75) and weighted (by number of fish; N = 199)) utilization data. Only the results from the unweighted data are reported, unless the use of the weighted data produced significantly different results.

Using the unweighted utilization data for both size classes of bigmouth chub, I tested the hypothesis that focal point velocity was less than the average water column current velocity. Randles test for symmetry (Hollander and Wolfe 1973) showed that the distribution of the differences (velocity-focal point velocity) was not symmetrical (2-sided P = 0.0035). Therefore, the sign test (Hollander and Wolfe 1973) was used to test for a difference in location (median) between velocity and focal point velocity. I also used the sign test to compare mean average velocities with maximum velocities.

RESULTS AND DISCUSSION

Spawning Habitat

Spawning activity probably began in mid-April and ended in mid-June, because few new mounds were seen on April 28 and on June 5. Mid-May was the apparent peak in spawning activity. Active mounds were observed at water temperatures between 15° C and 25° C. Mounds were located only in riffle, run, and tail of pool habitats, with the majority being at the head or just upstream of riffles, in laminar flow. Most (70.4%) of the mounds were located within 10m of the bank. The following descriptions are based upon the 90 new mounds which were measured. Mound size ranged from 0.2x0.2m to 1.8x0.7m, with most (74.4%; N=90) mounds being between 0.5x0.4m and 0.9x0.7m. Most (72.2%; N=75) mounds were between 0.10 and 0.25m in height. Mounds were exclusively constructed of small and large gravel, with large gravel being dominant in 65.6% (N=90) of the mounds. Mounds were located over several substrate types, ranging from bedrock to nestled among boulders. However, the majority (56%; N=89) of mounds were located where small gravel and small cobble were abundant. It is likely that prior to mound construction, the areas around the mounds had an abundance of large gravel. Current velocity at mounds ranged from 0.07 to 0.69 m/s (N=55; mean=0.38m/s), and mean velocity representative of conditions prior to mound construction ranged from 0.05 to 0.69 m/s (N=53; mean=0.33). Water depth at mound locations ranged from 0.15 to 0.75 m (N=72; mean=0.38 m).

Bigmouth chub mounds are similar to those described for other *Nocomis* (Reighard 1943; Raney 1947; Lachner 1952; Miller 1964; Leonard et al. 1985). However, most bigmouth chub mounds had a smaller diameter than the typical nest (average diameter of one nest of "typical size and shape" was 1.1m) of *Nocomis micropogon* found by Reighard (1943). The use of shallow riffle and run areas by bigmouth chubs for spawning, is in agreement with the findings of Raney (1947), Miller

(1964), and Leonard et al. (1985) concerning the spawning habitat of other *Nocomis*. However, Reighard (1943) found that *Nocomis micropogon* mainly used shallow pool areas for nest construction. Also in contrast to this studies findings, Lachner and Jenkins (1971) reported that bigmouth chubs built nests in the deeper, swifter channels of the Greenbrier River. It is likely that the location of the nest site is largely determined by the character of the substrate (Reighard 1943). Therefore, between stream differences in nest placement by *Nocomis* can be attributed to the availability and location of suitable substrate for nest construction.

Bigmouth chubs have narrow habitat requirements for spawning. Areas with plenty of small to large gravel for mound construction, shallow depths, and moderate velocities are needed. The location of spawning mounds in shallow riffle and run areas near the bank makes these nests especially vulnerable to dewatering and destruction caused by flow fluctuations. Such impacts could disrupt bigmouth chub spawning and also affect egg and larval survival. Also, nest construction may be inhibited by siltation or armouring of the substrate which can result from peaking power flow fluctuations.

Nocomis nests are often used by other cyprinids for spawning. Fish species found in the New River that commonly use *Nocomis* nests are crescent shiner (*Notropis cerasinus*), striped shiner, rosyface shiner, rosefin shiner (*Notropis ardens*), stoneroller, mountain redbelly dace (*Phoxinus oreas*), and blackside darter (*Percina maculata*) (Reighard 1943; Raney 1947; Lachner 1952). On several occasions during the spring of 1985, I witnessed stonerollers and striped shiners spawning (and/or feeding) in bigmouth chub nests. Because they are similar (subgenus *Luxilus*) to striped and crescent shiners, it is likely that white shiners also use bigmouth chub nests for spawning. The collection (during Phase 1 of this study) of the probable hybrid between bigmouth chub and white shiner supports this contention. Lachner (1952) suggested that the use of *Nocomis* nests by other cyprinids for breeding purposes may be important in the maintenance of a large supply of forage minnows. Any adverse impacts, resulting from fluctuations in discharge, on bigmouth chub mounds may also be detrimental to other cyprinid species which use their nests to spawn. It is doubtful that the supply of other forage minnows in the New River is significantly affected by the presence of bigmouth chub nests. However, events associated with flow fluctuations that impact bigmouth chub spawning may also be deleterious to other fish species which spawn in similar areas.

Microhabitat Utilization

Bigmouth chubs were seen on 10 of 18 microhabitat transects. A total of 199 bigmouth chubs was counted and 75 utilization measurements were made. Bigmouth chubs were only seen using riffle and (adjacent) run habitat, where their densities ranged from 0.002 to 0.559/100 m^2 (mean = 0.09/100 m^2). Bigmouth chubs were frequently found in multi-species schools with *Notropis* spp. and stonerollers. They were often near smallmouth bass, particularly young-of-year smallmouth bass, and were occasionally found near darters and young-of-year northern hog suckers.

Along the transects with bigmouth chubs, depth ranged from 0.12 - 1.40 m (mean = 0.48 m) and velocity ranged from 0.01 - 1.5 m/s (mean = 0.45 m/s; Table 25). Depths were deeper (0.4 - 3.5 m) and velocities were slower (0.04 - 1.07 m/s) on transects without bigmouth chubs ($P < 0.0001$; WRS; Table 25). Bedrock was the most common dominant substrate at transects with (65.9% of availability measurements) and without (67.7%) bigmouth chubs. However, fines were less common (1.1% of subdominant substrates) at transects with bigmouth chubs than at those without bigmouth chubs (19.5%). The small amount of fines along transects with bigmouth chubs is probably due to the greater velocities.

Small and large bigmouth chubs used locations with similar depths and mean and maximum water column velocities (Table 26). Focal point velocities were also similar. There was a tendency for the larger bigmouth chubs to occupy slightly deeper locations (median difference = 0.08 m; $P = 0.0548$; WRS). Using the weighted data, the difference was more significant (median difference = 0.15 m; $P = 0.001$; WRS). In addition, dominant substrate ($P = 0.3838$; chi-square),

Table 25. Means (± standard error), medians (and sample size), and ranges of measurements at locations used by and available to bigmouth chubs in the New River, WV. Eighteen underwater transects were sampled in September, 1985. See text for descriptions of unweighted and weighted data.

UTILIZATION

	All bigmouth chubs ≥ 100mm		Small bigmouth chubs (100-149mm)		Large bigmouth chubs (≥ 150mm)	
	unweighted	weighted	unweighted	weighted	unweighted	weighted
Depth(m)	0.52(±0.022) 0.48 (75) 0.16-0.98	0.56(±0.014) 0.52 (199)	0.49(±0.024) 0.46 (53) 0.16-0.90	0.51(±0.018) 0.47 (116)	0.57(±0.032) 0.52 (37) 0.27-0.98	0.63(±0.019) 0.66 (83)
Velocity(m/s)	0.41(±0.025) 0.38 (75) 0.01-0.92	0.42(±0.014) 0.38 (199)	0.44(±0.030) 0.45 (53) 0.07-0.92	0.43(±0.021) 0.45 (116)	0.39(±0.032) 0.35 (37) 0.01-0.91	0.41(±0.019) 0.35 (83)
Focal Point Velocity(m/s)	0.28(±0.018) 0.26 (74) 0.02-0.70	0.31(±0.013) 0.25 (196)	0.30(±0.024) 0.27 (52) 0.02-0.65	0.31(±0.017) 0.26 (113)	0.30(±0.028) 0.25 (37) 0.08-0.70	0.31(±0.019) 0.25 (83)
Maximum Velocity(m/s)	0.55(±0.025) 0.56 (73) 0.19-1.27	0.54(±0.015) 0.62 (197)	0.56(±0.027) 0.59 (52) 0.19-1.08	0.54(±0.021) 0.59 (115)	0.52(±0.038) 0.48 (36) 0.22-1.27	0.55(±0.021) 0.67 (82)

AVAILABILITY

	Transects with bigmouth chubs	Transects without bigmouth chubs
Depth(m)	0.48(±0.064) 0.44 (129) 0.12-1.40	1.50(±0.059) 1.40 (130) 0.40-3.50
Velocity(m/s)	0.45(±0.023) 0.41 (129) 0.01-1.50	0.30(±0.017) 0.31 (130) 0.04-1.07

Table 26. P-values for Wilcoxon Rank Sum (WRS), Moses Rank-like (MRL), and Kolomogorov-Smirnov Two Sample (K-S) tests for differences in microhabitat utilization between small (100-149mm) and large (≥ 150mm) bigmouth chubs.

	WRS	MRL	K-S
Depth(m)	0.0548	0.0510	0.2202
Velocity(m/s)	0.3090	0.4945	0.6777
Focal Point Velocity(m/s)	0.9402	0.9226	0.7728
Max. Velocity(m/s)	0.2870	0.9226	0.3036

subdominant substrate (P = 0.3003), and cover (P = 0.5204) use were similar for small and large bigmouth chubs. Lachner and Jenkins (1971) report that female bigmouth chubs rarely exceed 125 mm; therefore, it can be assumed that all the large bigmouth chubs were males.

In most stream fish species, the smaller sizes are associated with habitat that is shallow with slow current velocities. The size classes of bigmouth chub which were studied did not have distinct differences in microhabitat use. However, it was determined in the macrohabitat portion of this research that young-of-year bigmouth chubs (< 100 mm) used edge pool as well as riffle habitat, particularly the edges of riffles.

Depths used by bigmouth chubs ranged from 0.16 - 0.98 m and were significantly smaller (P = 0.008; chi-square) than the available depths (Table 27). Within the utilized range, most bigmouth chubs used depths of 0.34 - 0.52 m and avoided depths of 0.16 - 0.33 m. No depth interval within the utilized range was preferred. With the weighted data, the 0.72 - 0.98 m depth class was preferred.

Bigmouth chubs used a narrower range of velocities (0.07 - 0.92 m/s) than was available (0.01 - 1.5 m/s) and they were most commonly found (64%) in 0.18 - 0.62 m/s. However, utilized velocities were not significantly different from available velocities (P = 0.3502; chi-square) and no single velocity interval in the range used was preferred (Table 27). Most (55.8%) of the bigmouth chubs maintained positions (focal point depth) within 10 cm of the substrate. Focal point velocity was significantly lower than mean velocity (P < 0.0001; Sign test). The estimated median difference was 0.11 m/s with a 95% confidence interval of 0.08 to 0.16 m/s. In addition, maximum velocity was significantly greater than mean velocity (P < 0.0001; Sign test). The estimated median difference is 0.08 m/s with a 95% confidence interval of 0.00 to 0.16 m/s. These results indicate that bigmouth chubs select positions near the substrate that provide velocities that are slower and less variable than the average water column velocity.

Table 27. Depth, velocity, substrate, and cover use by and availability to bigmouth chubs. Includes 95% simultaneous Bonferroni confidence intervals for the proportion of use (U). An A indicates an avoided class at the 0.05 significance level.

Categories	Utilized N	Utilized proportion	Available proportion	Bonferroni interval
Depth(m)				
0.16 - 0.33	10	0.133	0.236	0.035 < U < 0.231 A
0.34 - 0.52	39	0.520	0.473	0.376 < U < 0.664
0.53 - 0.71	14	0.187	0.218	0.074 < U < 0.300
0.72 - 0.98	12	0.160	0.073	0.054 < U < 0.266
	75		(N = 110)	
Velocity (m/s)				
0.07 - 0.17	13	0.173	0.100	0.058 < U < 0.289
0.18 - 0.32	15	0.200	0.255	0.078 < U < 0.322
0.33 - 0.47	16	0.213	0.245	0.088 < U < 0.338
0.48 - 0.62	17	0.227	0.200	0.099 < U < 0.354
0.63 - 0.77	10	0.133	0.145	0.030 < U < 0.237
0.78 - 0.92	4	0.053	0.055	0 < U < 0.122
	75		(N = 110)	
Dominant substrate				
Bedrock	42	0.575	0.679	0.431 < U < 0.720
Gravel	6	0.082	0.064	0.002 < U < 0.163
Cobble	12	0.164	0.128	0.056 < U < 0.273
Boulder	13	0.178	0.128	0.066 < U < 0.290
	73		(N = 109)	
Subdominant substrate				
Bedrock	3	0.055	0.049	0 < U < 0.135
Organic[1]	15	0.273	0.123	0.114 < U < 0.431
Fines	1	0.018	0.037	0 < U < 0.066
Gravel	15	0.273	0.432	0.114 < U < 0.431
Cobble	10	0.182	0.148	0.445 < U < 0.319
Boulder	11	0.200	0.210	0.058 < U < 0.343
	55		(N = 80)	
Cover type				
No Cover	33	0.440	0.358	0.311 < U < 0.569
Cover	42	0.560	0.642	0.431 < U < 0.689
	75		(N = 109)	

[1] Includes *Podostemum* and *Cladophora*

Bigmouth chubs were primarily (57.5%) found over bedrock substrate. However, use of dominant substrate was not different from availability (P = 0.2936; chi-square) and no utilized class was preferred over the others (Table 27). When weighted utilization data were used, boulder substrate was apparently avoided. Use and availability of subdominant substrate were significantly different (P = 0.0140; chi-square), but based on the confidence intervals no class was preferred or avoided (Table 27). When the weighted utilization data were used, bigmouth chubs selected for organic (*Podostemum* and *Cladophora*) and against gravel subdominant substrate. Cover was also used in accordance with its availability (P = 0.13; Table 27). However, the weighted utilization data indicate that they prefer positions with cover not present within 1m.

Bigmouth chubs prefer a narrow range of habitat types; they were only found in riffle and adjacent run areas. Within the riffle and run areas, the classes of habitat parameters - depth, mean current velocity, substrate, and cover - are used in accordance with their availability. However, bigmouth chubs did appear to avoid the shallowest depths within the utilized range. They also occupied positions near the substrate, where velocities are slower than the average water column velocity. Water column position (focal point depth) has been determined to be an important spatial resource gradient for several cyprinid species (Mendelsen 1975; Baker and Ross 1981; Yant 1985). Yant (1985) found that *Nocomis biguttatus* also maintained positions close to the substrate.

Bigmouth chubs often occupy positions where mean current velocity is slower than that in adjacent areas. The maximum mean velocity within 1 m of the fish location is considered to be important in feeding. Cleary (1956) and Munther (1970) observed smallmouth bass near the edge of the current. When location of the current changed due to water level fluctuation, the smallmouth bass shifted to the new position of the current edge (Munther 1970). Maintaining a position with low velocity but near areas of high velocity would minimize energy expenditure and maximize the quantity of drifting food available to a fish (Fausch 1984; Rimmer et al. 1984). However, based on qualitative observations of the feeding activity of bigmouth chubs, I do not believe that they have completely adopted this strategy.

I observed bigmouth chubs (> 100 mm) feeding on food items on the substrate and upon drifting food. While feeding upon drifting food, bigmouth chubs generally moved laterally throughout a relatively small area where mean current velocity was relatively constant. They appear to minimize energy expenditure and maximize the amount of drifting food available to themselves by maintaining positions near the substrate, and only moving up into the swifter velocities of the water column to capture drifting items.

Although the food habits of the bigmouth chub have not been studied, data on the summertime food habits of *Nocomis biguttatus* and *Nocomis micropogon* indicate that only minor differences existed in food taken by each species, and *Simulium*, *Chironomus*, Helicopsyche, various Ephemeroptera, and *Cambarus* (occasionally found in adults) were the organisms most frequently encountered in the stomachs (Lachner 1950). Filamentous algae and vascular plants were also common, but it is probable the much of the plant material was taken along with animal food. The dentition, the short intestines of both species, and the apparent difficulty in digestion do not suggest that the chubs are adapted to a vegetable diet (Lachner 1950). Except for Ostracada and Cladocera eaten by the younger chubs, and a few terrestrial insects, nearly all the food was benthic in origin.

The New River has an abundant supply of aquatic invertebrates (Voshell 1985b) similar to those found by Lachner (1950) to be eaten by *Nocomis biguttatus* and *Nocomis micropogon*. It is likely that the bigmouth chub has feeding habits similar to those of *Nocomis biguttatus* and *Nocomis micropogon*.

Habitat selection by juvenile and adult bigmouth chubs was fairly similar to that of other *Nocomis*, which are all generally considered riffle species. However, the other *Nocomis* have been reported to use habitat other than riffles and runs (Lachner 1952, Lachner and Jenkins 1971). *Nocomis leptocephalus* were found to be equally abundant in riffle, run, and pool areas in two small Virginia streams (Christopher J. Goudreau, VPI&SU, personal communication). The difference in pool size is one possible explanation for the rarity of bigmouth chubs(> 100mm) in pool areas of the New River. The shorter length of pools in smaller streams allows *Nocomis* to occupy pool areas and still be near the riffle and run areas. However, a bigmouth chub in the New River that occupied pool habitat would, in most cases, be farther from the preferred riffle areas. In tributary streams and in the main channel headwaters, bigmouth chubs may use habitats other than riffles and runs. Lachner and Jenkins (1971) report that bigmouth chubs are found in both riffle and pool habitat.

Food availability is probably an important resource dictating habitat selection by the bigmouth chub. As discussed in the previous chapter, aquatic insects are more abundant in the riffles, where *Podostemum* and *Cladophora* are most abundant, than in pool habitat (Voshell 1985b). The highest densities of bigmouth chubs were found in riffles with large amounts of aquatic vegetation and algae. Lachner (1950) found that *Nocomis micropogon* populations were greatest in streams with an abundance of algae and plants.

In addition to the potential disruption of spawning, there are other possible effects of flow alteration on the bigmouth chub. If flow fluctuations become more frequent and rapid, bigmouth chub populations may become limited by turbidity and siltation which will probably increase due to increased erosion. *Nocomis micropogon* populations have apparently declined or disappeared due to increased turbidity and siltation (Trautman 1981). *Nocomis raneyi* populations have declined in the most silted sections of the Roanoke River drainage (Lachner and Jenkins 1971).

As discussed in the previous chapter, flow fluctuations in the New River may decrease the abundance of aquatic macrophytes and attached algae, and thereby decrease the densities of associated aquatic insects. Also, flow fluctuations may force bigmouth chubs to temporarily redistribute to less suitable habitat (eg. pools) where aquatic insects are generally least abundant. If aquatic insects become less available to bigmouth chubs, growth and survival of bigmouth chubs could be affected.

Impacts of flow fluctuations on bigmouth chub populations may indirectly affect other fish species of the New River. For example, as suggested earlier, fish species that use bigmouth chub nest for spawning will be impacted. Also, declines in bigmouth chub populations will make them less available to piscivorous species. Species which compete with the bigmouth chub for food and space may increase. However, riffle species that compete with bigmouth chub will probably also be adversely affected by the events impacting bigmouth chubs.

SUMMARY

1. Measurements of spawning areas and mound nests of the endemic bigmouth chub (*Nocomis platyrhynchus*) indicate that bigmouth chubs have narrow habitat requirements for spawning. Areas with plenty of small to large gravel (3-64 mm diameter), for mound construction, shallow depths, and moderate velocity are needed. The location of spawning mounds in shallow riffle and run areas near the bank makes these nests especially vulnerable to flow fluctuations.

2. Midday underwater observations of 199 bigmouth chubs (> 100 mm) were made in September. 1985, and 75 microhabitat utilization measurements were taken. Small (100-150 mm) and large (> 150 mm) bigmouth chubs had similar microhabitat use patterns. Bigmouth chubs were only seen using riffle and adjacent run habitat. Within utilized areas, habitat variables (depth, velocity, substrate, and cover) were used in accordance with their availability except for an avoidance of the shallowest available depths.

3. Bigmouth chubs occupied positions near the substrate, where velocities were slower than the mean water column velocity. This is probably a feeding strategy that allows the bigmouth chub to minimize energy expenditure and maximize exposure to drifting food items.

4. Because of its narrow habitat preferences, the bigmouth chub is potentially susceptible to the impacts of frequent, rapid fluctuations in flow associated with hydroelectric facilities. The potential affects of flow fluctuations associated with the proposed conversion of Bluestone Dam are discussed.

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APPENDICES

APPENDIX 1. Mean catch of species (by size class) per 15 minutes of effort (total catch in parentheses) with generator and backpack electrofishing in nine habitat types in the New River, WV, July to October, 1984. SIDE CH = secondary channel along island; VEG = submersed vegetation; EDGE RIF = edge riffle; LAT POOL = lateral pool. Size class codes are: 1= 1 to 99mm; 2= 100 to 199mm; 3= > 200mm; ?= no measurement.

SPECIES	CODE	BACKWATER	EDGE POOL	SIDE CH	*Justicia*	VEG	RIFFLE	RUN	EDGE RIF	LAT POOL
Northern hog sucker	1	0.3(1)	7.1(35)		0.2(2)	5.5(17)	0.4(4)			
Northern hog sucker	2		0.2(1)		0.1(1)				0.2(1)	0.3(1)
Northern hog sucker	3			0.5(1)			0.1(1)		0.4(2)	
Rock bass	1	2.7(8)	1.4(7)	2.0(4)	2.4(24)	4.0(24)			0.2(1)	1.7(5)
Rock bass	2,3	0.3(1)		5.0(10)	1.0(10)	5.1(31)	0.1(1)	0.8(5)	2.9(17)	1.7(5)
Rock bass	?									0.3(1)
Redbreast sunfish	1		0.2(1)		0.3(3)					
Green sunfish	2				0.2(2)					
Bluegill sunfish	1			1.0(2)	0.6(6)					2.0(6)
Bluegill sunfish	2			1.5(3)						0.3(1)
Unidentified sunfish	1	0.3(1)								
Unidentified sunfish	?							0.2(1)		
Smallmouth bass	1	5.7(17)	2.9(14)	3.5(7)	5.2(52)	5.0(26)	4.0(32)	3.7(22)	5.3(31)	10.0(30)
Smallmouth bass	2	1.7(5)	0.4(2)	0.5(1)	0.5(5)		0.3(1)	0.3(2)	1.5(9)	3.3(10)
Smallmouth bass	3			0.5(1)	0.1(1)	0.2(1)		0.3(2)	0.5(3)	
Smallmouth bass	?							0.2(1)		
Spotted bass	1	1.6(8)		0.1(1)	0.2(1)					

APPENDIX 1 continued on next page.

APPENDIX 1 continued.

SPECIES	CODE	BACKWATER	EDGE POOL	SIDE CH	*Justicia*	VEG	RIFFLE	RUN	EDGE RIF	LAT POOL
Stoneroller	1	4.0(12)	0.8(4)		2.9(29)	1.5(7)	1.4(13)			0.3(1)
Stoneroller	2				0.1(1)		0.6(5)	0.2(1)	0.5(3)	0.3(1)
Stoneroller	?		0.2(1)							
Common Carp	3				0.1(1)					
Bigmouth chub	1		1.0(5)		2.1(21)	2.0(8)	4.3(39)	0.3(2)	2.4(14)	2.7(8)
Bigmouth chub	2,3		0.2(1)	0.5(1)	0.6(6)	0.5(3)	2.4(21)	0.7(4)	1.2(7)	0.3(1)
Bigmouth chub	?				0.1(1)					
Spottail shiner	1		2.6(13)		0.2(2)	1.0(6)				1.0(3)
Rosyface shiner	1					0.5(1)	0.3(3)			
Spotfin shiner	1	2.0(6)	1.8(9)	0.5(1)	2.3(23)	1.5(5)	0.3(3)			1.3(4)
Telescope shiner	1		2.2(11)	3.5(7)	4.2(42)	3.3(10)	8.4(73)		2.5(15)	2.0(6)
Mimic shiner	1	5.3(16)	185.4(927)		4.1(41)	11.8(49)	0.7(6)		0.2(1)	0.7(2)
Notropis (*Luxilus*) spp.	1	1.0(2)	13.8(69)	3.0(6)	11.3(113)	39.3(86)	1.3(12)		1.2(7)	10.3(31)
Notropis (*Luxilus*) spp.	2		0.2(1)	1.5(3)	0.2(2)	0.8(5)	0.1(1)			0.3(1)
Notropis (*Luxilus*) spp.	?				0.1(1)		0.7(6)	0.2(1)		
Bluntnose minnow	1		15.4(77)	0.5(1)	11.4(114)	12.5(67)			0.2(1)	1.7(5)
Longnose dace	1,2						0.4(4)		0.2(1)	
Flathead catfish	1						0.2(2)		0.2(1)	0.2(2)
Flathead catfish	2		0.4(2)							
Flathead catfish	3					0.5(3)		0.2(1)	0.2(1)	

APPENDIX 1 continued on next page.

APPENDIX 1 continued.

SPECIES	CODE	BACKWATER	EDGE POOL	SIDE CH	*Justicia*	VEG	RIFFLE	RUN	EDGE RIF	LAT POOL
Greenside darter	1	0.7(2)	2.45(12)		0.5(5)	0.3(2)	0.3(1)	0.2(1)	0.3(2)	0.7(2)
Rainbow darter	1	1.0(3)			0.1(1)	0.5(3)	0.4(4)		0.2(1)	0.7(2)
Logperch	1		1.2(6)		0.1(1)	0.2(1)				
Logperch	2		0.2(1)			0.2(1)	0.1(1)			
Sharpnose darter	1		0.6(3)				0.6 (5)	0.8(5)		
Sharpnose darter	2						0.3(3)	0.2(1)	0.3(2)	
Sharpnose darter	?						0.1(1)			
Roanoke darter	1		2.4(12)		0.4(4)	1.7(10)	1.0(9)		0.2(1)	
Unidentified darter	1							0.5(3)		0.7(2)

APPENDIX 2. Mean catch of species-size classes per 15 minutes of electrical current (total catch in parentheses) with daytime boat electrofishing in seven habitat types in the New River, WV, July to October 1984. VEG = submersed vegetation. Size class codes are: 1 = 1 to 99mm; 2 = 100 to 199mm; 3 = > 200mm; ? = not measured.

SPECIES	CODE	BACKWATER	EDGE POOL	VEG	MID POOL	RAPID	RIFFLE	RUN
Brook silverside	1		0.3 (2)					0.3(1)
Northern hog sucker	1	1.0(1)	0.1(1)	1.7(1)				
Northern hog sucker	2	1.0(1)	0.2(2)					
Northern hog sucker	3		3.2(26)		1.0(6)	2.9(6)	4.0(4)	1.0(3)
Rock bass	1	7.9(8)	2.7(20)	17.3(10)	0.5(3)			
Rock bass	2,3	7.0(7)	14.4(101)	52.1(30)	4.0(24)	2.4(5)	10.0(10)	
Redbreast sunfish	1			5.2(3)				
Redbreast sunfish	2	1.0(1)		1.7(1)	0.2(1)			
Pumpkinseed sunfish	1		0.1(1)					
Pumpkinseed sunfish	2		0.2(2)	3.5(2)				
Bluegill sunfish	1	1.0(1)	0.1(1)	1.7(1)				
Bluegill sunfish	2	2.0(2)	1.2(8)	3.5(2)				
Longear sunfish	2		0.4(3)					
Smallmouth bass	1	6.0(6)	9.7(76)	34.7(20)	2.1(13)	2.0(4)	3.0(3)	1.0(3)
Smallmouth bass	2	3.0(3)	8.1(66)	3.5(2)	3.6(22)	6.4(13)	16.0(16)	2.0(6)
Smallmouth bass	3	1.0(1)	1.6(13)	1.7(1)	1.7(10)	5.9(12)	4.0(4)	0.3(1)
Spotted bass	1	1.0(1)	0.7(6)	1.7(1)				
Spotted bass	2		1.0(8)	3.5(2)				
Spotted bass	3		1.5(11)	1.7(3)	0.2(1)			
Largemouth bass	3			1.7(1)				

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Appendix 2 continued

SPECIES	CODE	BACKWATER	EDGE POOL	VEG	MID POOL	RAPID	RIFFLE	RUN
White crappie	3	1.0(1)	0.2(2)					
Common carp	1				0.2(1)			
Bigmouth chub	1						1.0(1)	
Bigmouth chub	2,3		1.1(9)		0.2(1)	3.9(8)	24.0(24)	0.7(2)
Spottail shiner	1			1.7(1)				
Silver shiner	1							0.3(1)
Silver shiner	2					3.9(8)		0.3(1)
Rosyface shiner	1					7.4(15)		7.6(23)
Spotfin shiner	1		0.8(6)			0.9(2)		0.7(2)
Telescope shiner	1		1.4(11)			64.7(132)		15.2(46)
Mimic shiner	1	1.0(1)	2.2(18)					
Notropis (*Luxilus*) spp.	1	12.0(2)				1.0(2)		
Notropis (*Luxilus*) spp.	2					7.8(16)		
Notropis (*Luxilus*) spp.	?		0.1(1)					
Bluntnose minnow	1	13.9(14)	0.9(7)	29.5(17)				
Flathead catfish	1				0.2(1)		1.0(1)	
Flathead catfish	2		0.4(2)					0.3(1)
Flathead catfish	3		0.4(3)		1.0(6)	0.5(1)		
Greenside darter	1	1.0(1)	0.3(2)				1.0(1)	
Logperch	1	7.0(7)	0.1(1)	1.7(1)				
Logperch	2	2.0(2)	0.6(5)					
Roanoke darter	1		0.1(1)					

Appendix 3. Mean catch per effort (total catch in parentheses) with generator-seine electrofishing in two habitat types in the New River, WV, July to October, 1984. Size class codes are: 1 = 1 to 99mm; 2 = 100 to 199mm.

Species	Code	Backwater	Riffle
Smallmouth bass	1		0.9(9)
Smallmouth bass	2	1(1)	
Bigmouth chub	1		0.3(3)
Rosyface shiner	1		0.8(8)
Telescope shiner	1	11(11)	6.5(65)
Notropis (*Luxilus*) spp.	1		0.2(2)
Unidentified *Notropis* sp.	1	149(149)	
Bluntnose minnow	1	1(1)	
Longnose dace	1		0.1(1)
Flathead catfish	1		0.1(1)
Flathead catfish	3		0.1(1)
Greenside darter	1		0.1(1)
Sharpnose darter	1		0.1(1)
Roanoke darter	1		0.2(2)

Appendix 4. Mean catch of species-size classes per 15 minutes of electrical current (total catch in parentheses) with boat electrofishing at night in 7 habitat types in the New River, WV, July to October 1984. Size class codes are: 1 = 1 to 99mm; 2 = 100 to 199mm; 3 = > 200mm; ? = not measured.

Species	Code	Edge pool	Mid pool	Rapid	Run
Brook silverside	1	1.6(8)			
Northern hog sucker	2	0.4(2)			
Northern hog sucker	3	2.6(13)	3.0(6)	12.0(12)	2.0(2)
Rock bass	1	3.0(15)			1.0(1)
Rock bass	2,3	11.2(56)	9.4(19)	1.0(1)	5.0(5)
Redbreast sunfish	2	0.4(2)			
Pumpkinseed sunfish	1	0.4(2)			
Pumpkinseed sunfish	2	0.8(4)			
Bluegill sunfish	1	1.0(5)			
Bluegill sunfish	2	1.6(8)			
Smallmouth bass	1	15.6(78)	1.0(2)	4.0(4)	3.0(3)
Smallmouth bass	2	20.2(101)	5.4(11)	7.0(7)	7.0(7)
Smallmouth bass	3	4.2(2)	3.0(6)	2.0(2)	3.0(3)
Spotted bass	1	2.2(11)			
Spotted bass	2	1.0(5)			
Spotted bass	3	1.4(7)			
White crappie	3	0.2(1)			
Common carp	3		0.5(1)		
Bigmouth chub	2,3			4.0(4)	
Silver shiner	1				4.0(4)
Rosyface shiner	1	1.4(7)			

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Appendix 4 continued

Species	Code	Edge pool	Mid pool	Rapid	Run
Spotfin shiner	1	6.0(30)		1.0(1)	
Telescope shiner	1	10.6(53)	3.5(7)	14.0(14)	
Mimic shiner	1	0.2(1)			
Notropis (*Luxilus*) spp.	1	0.4(2))	1.0(2)	1.0(1)	
Notropis (*Luxilus* spp.	2	1.4(7)	11.4(23)	1.0(1)	
Bluntnose minnow	1	1.6(8)			
Channel catfish	1	0.2(1)			
Channel catfish	3	0.4(6)			1.0(1)
Flathead catfish	1	0.2(1)			
Flathead catfish	2	0.8(1)			
Flathead catfish	3	1.6(8)	0.5(1)	2.0(2)	
White/striped bass	3			1.0(1)	
Greenside darter	1				1.0(1)
Sharpnose darter	1	0.4(2)			
Sharpnose darter	2			1.0(1)	

Appendix 5. Habitat type, habitat variable ratings, time spent sampling, and area sampled for 45 daytime underwater transects sampled in the New River, WV, August and September, 1985. Vel = velocity, Woody = woody debris, Sub = large cobble and boulder substrate.

Transect	Habitat	Depth	Vel	Veg	Woody	Sub	Area m^2	Time - minutes
D1	Edge pool	1	0	0	1	0	225	10
D2	Middle pool	1	2	0	0	0	400	10
D3	Edge pool	1	0	3	0	0	200	15
D4	Middle pool	2	3	1	0	0	500	10
D5	Edge pool	1	0	0	1	0	500	15
D6	Middle pool	1	4	1	0	0	600	15
D7	Edge pool	1	0	2	1	2	500	20
D8	Middle pool	4	3	0	0	2	500	10
D9	Edge pool	2	0	3	1	0	600	16
D12	Run	1	4	1	0	2	400	14
D13	Riffle	1	3	0	0	2	400	23
D14	Lateral pool	1	3	2	0	2	400	14
D15	Lateral pool	2	1	1	0	2	400	-
D16	Riffle	1	5	1	0	2	300	-
D17	Riffle	1	3	1	0	2	400	9
D18	Riffle	2	4	2	0	3	400	29
D19	Edge riffle	1	4	2	0	3	300	29
D20	Edge pool	1	1	0	1	3	600	33
D21	Run	3	4	0	0	1	300	13
D22	Middle pool	4	2	0	0	1	550	19
D25	Middle pool	3	2	0	0	1	550	21
D26A	Edge pool	1	0	3	1	0	300	}31
D26B	Edge pool	2	1	1	0	1	300	
D27	Riffle	1	4	0	0	2	600	18
D28	Riffle	1	4	2	0	1	700	31
D29	Riffle	1	4	0	0	2	400	12
D30A	Run	1	2	1	0	0	400	}40
D30B	Riffle	1	4	0	0	0	400	
D34	Middle pool	2	1	1	0	2	1000	17
D35	Middle pool	2	1	2	0	1	1000	18
D36A	Edge pool	1	0	3	1	0	350	}20
D36B	Edge pool	2	1	1	0	1	350	
D37	Middle pool	3	4	0	0	1	800	15
D38	Run	2	4	0	0	2	800	11
D39	Middle pool	1	2	0	0	3	600	20
D42	Middle pool	2	2	0	0	2	700	14
D43	Middle pool	3	2	0	0	3	1200	30
D44	Middle pool	3	1	0	0	2	600	15
D45	Backwater	1	0	3	0	0	200	13
D46	Run	1	5	0	0	3	550	35
D47	Run	2	3	0	0	2	700	27
D48	Riffle	1	4	0	0	2	225	20
D49	Edge riffle	1	2	0	0	3	135	15
D50	Snag	2	0	0	1	0	72	10
D51	Snag	2	0	0	1	0	42	10

Appendix 6. Weighted (by density) means of the first two principal components (± standard errors) for each of twenty species-lifestages. Weighted means were calculated with the principal components scores of 43 underwater transects sampled in the New River, WV, August and September, 1985. The number of transects where a particular species occured is given by n. Only those transects where a species was present were used to calculate it's mean score. Transects in snag habitat were not included.

SPECIES	n	MEAN PC1 ± SE	MEAN PC2 ± SE
Sunfish - YOY & juvenile	7	-2.855 ± 0.313	-0.160 ± 0.221
Logperch	5	-2.786 ± 0.306	-0.001 ± 0.426
Spotted bass - YOY	7	-2.632 ± 0.465	-0.016 ± 0.243
Northern hog sucker YOY and juvenile	4	-2.494 ± 0.797	-0.249 ± 0.157
Spotted bass - juvenile	6	-2.462 ± 0.303	0.030 ± 0.138
Spotted bass - adult	5	-2.087 ± 0.469	-0.002 ± 0.190
Sunfish - adult	6	-1.364 ± 0.585	0.418 ± 0.189
Smallmouth bass - YOY	43	-1.153 ± 0.732	-0.115 ± 0.311
Greenside darter	14	-0.917 ± 0.492	-0.422 ± 0.139
Stoneroller	7	-0.825 ± 2.167	-0.596 ± 0.515
Rock bass - adult	19	-0.267 ± 0.296	-0.203 ± 0.159
Smallmouth bass - adult	22	0.298 ± 0.182	-0.123 ± 0.179
Bigmouth chub - YOY	9	0.328 ± 0.973	-0.715 ± 0.182
Smallmouth bass - juvenile	38	0.420 ± 0.269	-0.067 ± 0.212
Rock bass - YOY	10	0.484 ± 0.200	-0.291 ± 0.192
Rainbow darter	7	0.668 ± 0.096	-1.138 ± 0.217
Bigmouth chub - adult	9	0.702 ± 0.203	-0.906 ± 0.062
Flathead catfish - adult	6	0.890 ± 0.038	0.006 ± 0.357
Flathead catfish - YOY	3	1.261 ± 0.249	-1.016 ± 0.330
Sharpnose darter	3	1.366 ± 0.154	-0.770 ± 0.164

YOY - young-of-year

Appendix 7. Habitat type, area, and amount of time sampled for ten night underwater transects (with corresponding day transect number) sampled in the New River, WV, August and September, 1985.

Transect	Habitat	Area in m^2	Time in minutes	Day transect
10N	Middle pool	400	14	8
11N	Edge pool	400	30	9
23N	Middle pool	550	24	25
24AN	Edge pool	250	}40	26A
24BN	Edge pool	150		26B
31N	Riffle	600	41	28
32N	Riffle	450	26	27
33N	Riffle	400	-	29
40N	Middle pool	600	34	42
41N	Middle pool	600	-	39
		4400		

Appendix 8. Means and ranges of species-lifestage densities (number/100m²) in ten nighttime underwater transects in eight habitat types in the New River, WV, August and September, 1985. The number of transects in a habitat is given by n, t is the number of transects in a habitat where a particular species-lifestage occurred. A * represents a mean density less than 0.05/100m². YOY represents young-of-year.

Appendix 8. Means and ranges of species-lifestage densities (number/100m^2)

Species-lifestage	EDGE POOL n=3 Mean	EDGE POOL Range	EDGE POOL t	MID POOL n=4 Mean	MID POOL Range	MID POOL t	RIFFLE n=3 Mean	RIFFLE Range	RIFFLE t
Brook silverside	0.5	0.0-0.8	2	0.0	-	-	0.0	-	-
Logperch	0.5	0.0-1.0	2	0.0	-	-	0.0	-	-
Northern hogsucker - YOY & juv	0.3	0.0-0.8	1	*	0.0-0.2	1	0.0	-	-
Northern hogsucker - adult	0.0	-	-	0.1	0.0-0.3	1	0.2	0.0-0.5	2
Spotted bass - YOY	0.4	0.0-1.2	1	0.1	0.0-0.3	1	0.0	-	-
Spotted bass - juv	0.1	0.0-0.4	1	0.0	-	-	0.0	-	-
Spotted bass - adult	0.1	0.0-0.3	1	0.0	-	-	0.0	-	-
White crappie	0.1	0.0-0.3	1	0.0	-	-	0.0	-	-
Sunfish - YOY & juv	14.2	0.3-41.6	3	*	0.0-0.2	1	0.0	-	-
Sunfish - adult	0.3	0.0-1.0	1	0.0	-	-	0.0	-	-
Rock bass - YOY & juv	2.2	1.0-2.8	3	1.7	0.0-4.5	3	0.0	-	-

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Appendix 8 continued. Means and ranges of species-lifestage densities (number/100m²)

Species-lifestage	EDGE POOL n=3 Mean / Range / t			MID POOL n=4 Mean / Range / t			RIFFLE n=3 Mean / Range / t		
	Mean	Range	t	Mean	Range	t	Mean	Range	t
Rock bass - adult	0.9	0.4-1.3	3	0.7	0.3-1.6	4	1.4	0.2-3.0	3
Smallmouth bass - YOY	6.4	2.5-8.8	3	1.1	0.0-3.2	3	0.2	0.0-0.7	1
Smallmouth bass - juvenile	1.6	0.0-3.6	2	0.3	0.0-0.7	3	0.2	0.0-0.3	2
Smallmouth bass - adult	0.5	0.0-1.2	2	0.2	0.0-0.5	2	0.6	0.0-1.0	2
Notropis. spp.	26.1	8.8-49.5	3	7.9	0.4-22.0	4	2.9	1.8-5.2	3
Largemouth bass	0.0	-	-	*	0.0-0.2	1	0.0	-	-
Flathead catfish - adult	0.4	0.0-0.8	2	0.1	0.0-0.4	2	0.3	0.0-0.8	2
Channel catfish	0.0	-	-	0.3	0.0-0.8	2	0.0	-	-
Greenside darter	0.0	-	-	*	0.0-0.2	1	0.0	-	-
Bigmouth chub-YOY	0.0	-	-	0.1	0.0-0.2	2	1.4	0.3-2.2	3
Bigmouth chub - adult	0.0	-	-	0.0	-	-	1.7	1.3-2.0	3
Unidentified spp.	0.4	0.3-0.7	3	0.0	-	-	0.0	-	-

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