Use of Shadow Bass Stock Characteristics to Evaluate Natural and Scenic Waterways in Mississippi

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Abstract: Shadow bass *(Ambloplites ariommus)* stocks were characterized in the Yockanookany and upper Pearl Rivers (1994–1996) to determine if this relatively uncommon fish could be used to evaluate streams for inclusion in the Mississippi Natural and Scenic Waterways System. Habitat influences (e.g., negative effects of channelization) on shadow bass were best reflected in stock characteristics that need considerable data and laboratory work (i.e., age and growth studies, condition factor analysis). Such studies focusing on shadow bass are incompatible with programs requiring rapid assessments of stream characteristics. Therefore, and unless the legislative initiative recommends slow, thorough processes for evaluating streams for the Mississippi Natural and Scenic Waterways System, shadow bass should not be selected as an indicator species, even though shadow bass can reflect the general well-being and relative status of the stream as a naturally functioning system.

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During the 1999 General Session of the Mississippi Legislature, a bill was passed to initiate a natural and scenic waterways system for the state (Reid and Ammerman 1999). Streams considered most likely to be included in the system will be small- to medium-size systems supporting stocks of centrarchid fishes that can provide angling opportunities for persons visiting the resources. Additionally, there is interest in showcasing aspects of these streams that are specifically representative of the state and region.

In anticipation of development of Mississippi's Natural and Scenic Waterway System, 2 small lowland streams and a centrarchid fish were identified that together

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fulfill the objective of representing Mississippi streams in the east-central portion of the state: the Yockanookany and the upper Pearl rivers and the shadow bass *(Ambloplites ariommus)*. The shadow bass is a relatively uncommon fish in Mississippi streams, but one indigenous to the southeastern United States that can be a special prize for anglers on these systems.

The 1999 legislative bill establishing the natural and scenic waterways system specifically designated the upper reaches of the Pearl River as one of 6 candidate streams for initial inclusion into the scenic waterways system. The Yockanookany River joins the Pearl River downstream from the designated scenic river section and has been subject to a variety of anthropogenic influences, particularly flood control activities, in its upper reaches.

In Mississippi, streams have been subject to a variety of modifications, primarily as a result of flood control programs. In addition to altering the interaction between a stream and its floodplain (Junk et al. 1989), flood control programs that incorporate clearing, dredging, and snagging along the stream channel can be detrimental to within-channel dynamics of the stream's fisheries by removing riparian vegetation (a principal source of allochthonous organic material including large woody debris: *sensu* Vannote et al. 1980), altering and homogenizing stream channel habitat (Hubbard et al. 1993), and removing large woody debris from the channel (fish habitat as well as attachment sites for invertebrates; Cobb and Kaufman 1993).

Modified streams are part of the Mississippi landscape. Showcasing the human interface with streams in Mississippi was recognized as an important aspect of the natural and scenic waterways system as set forth by the Mississippi legislature. However, criteria established by the legislature for inclusion of streams or sections of streams into the natural and scenic waterways system stipulated that channel modification could not have occurred within 5 years of nomination for candidacy. This was designed to afford streams opportunity to reestablish aspects of natural instream and riparian characteristics while maintaining evidence of humankind's evolving relationships with these aquatic resources. In this sense the Mississippi legislature recognized humans as components of ecosystem dynamics rather than advancing a human exemptionalist perspective (*sensu* Catton and Dunlap 1980).

With this as our guiding precept, our objectives were to characterize shadow bass stocks in the 2 streams and to determine the extent to which channel modification influences these stock characteristics. The overriding goal was to ascertain if shadow bass populations can be used as components of the assessment criteria when evaluating streams for inclusion in the natural and scenic waterways system.

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Methods

The Yockanookany River is a principal tributary of the Pearl River and empties into the Pearl River below study sections of the upper Pearl River. Study sections of the upper Pearl River in Neshoba County, Mississippi, receive drainage from approximately 2,350 km^2. The Yockanookany River study sections in Attala and Leake counties, Mississippi, receive drainage from approximately 1,219 km^2. The upper Pearl River had 5 1.5-km unchannelized sampling sections. The Yockanookany River had 9 1.5-km unchannelized sampling sections: 4 upstream sections subject to channelization several decades ago and decoupled from their respective floodplains during elevated flow periods; 5 downstream sections that are unchannelized, sinuous, and connected with the floodplain during elevated flow periods (Flotermersch et al. 1999).

Both rivers had limited public access (1 functional public boat ramp per river). There were 5 private boat ramps on the Pearl River but no private boat ramps on the Yockanookany River. The Yockanookany River was subject to polychlorinated biphenyl (PCB) and mercury human health fish consumption advisories. The Pearl River did not have human health fish consumption advisories. Anglers were observed fishing in sections of the Yockanookany River not under the PCB advisory but that were under the mercury advisory (sections 1, 2, 8, and 9). In the Pearl River, anglers were observed fishing in 2 of the sections. Based on interviews with these local anglers, shadow bass were not targeted by anglers in either river.

Hoop nets were used to collect shadow bass from the Pearl and Yockanookany rivers during January 1994–December 1996. There were 3 net configurations: (1) 4.3-m long with 7 1.07-m diameter hoops and 3.81-cm bar mesh netting; (2) 1.3-m long with 4 0.51-m diameter hoops and 3.81-cm bar mesh netting; (3) 1.3-m long with 4 0.51-m diameter hoops and 2.54-cm bar mesh netting. Nets were set at approximately 100-m intervals along the stream section on alternating banks in a systematic order by net configuration randomly determined prior to setting the nets.

Relative abundance of shadow bass was expressed in terms of catch per unit of effort (CPUE: fish/net). The total daily ratio estimator for CPUE (total *N* fish/total *N* nets) was determined for each sample date for each net configuration. These 3 CPUE values then were used to generate an overall mean CPUE value for the sample dates. Analyses of variance were used to discern differences in CPUE, if any, among the 4 treatments: (1) Yockanookany River channelized area (2) Yockanookany River unchannelized area (3) Yockanookany River areas combined (4) Pearl River. A Kolmogorov-Smirnov 2-sample test was used to test hypotheses of homogeneous distributions of CPUE standard errors.

Total lengths of shadow bass were used to generate length-frequency distributions with respect to each of the 4 treatments. For these purposes, fish from all years of the study were combined by treatment, and fish total lengths were placed in 2-cm groups. A Kolmogorov-Smirnov 2-sample test was used to test hypotheses of homogeneous length-frequency distributions.

Shadow bass scales were mounted between 2 glass slides and magnified (40×) on an Eberbach scale projector. For each scale, total scale radius (mm) and annuli distances (mm) from the scale focus were measured. Scale measurements and total lengths were used to establish age-specific lengths from the Fraser-Lee equation (Carlander 1981, Schramm et al. 1992) and for use in development of von Bertalanffy growth equations (Bertalanffy 1938).

Growth coefficients (*k*-values) from the von Bertalanffy equations for ages 1–5 were compared among treatments using analyses of covariance (ANCOVA; SAS Inst.

1988). LeCren's (1951) relative condition factor (K_n) was calculated to compare condition by length groups with a paired *t*-test (SAS Inst. 1988). The sign test was used to test for differences in standard errors of condition factors. Because standard weights for shadow bass did not exist, a population-specific (upper Pearl River basin) length-weight relationship was established. Length and weight were $\log_{10}$-transformed to product a linear regression for assigning a standard weight (W') for a given length (Wege and Anderson 1978). Standard weights then were calculated from the equation: $\log_{10}\text{weight} = -5.1461 + 3.2110 \log_{10}\text{length}$. Slopes of the length-weight relationship were compared between and among treatments using analysis of covariance.

During base flow conditions in spring and summer 1996, means for stream depth and width were determined for 4 randomly selected 50-m subsections in each of the 14 stream sections. One cross-sectional measurement at the mid-point of the subsection, perpendicular to the main axis of the stream, was used to estimate stream width for the subsection. For depth, measurements were taken at 1-m intervals along the cross-sectional transect.

Within each 50-m subsection, the diameter (cm) of all woody structure (i.e., snags) at the water surface was measured in conjunction with site-specific water depth (m) at the respective structure. The diameter of each snag was multiplied by 3.14 and the water depth at the snag to estimate the amount of subsurface area that would exist with a hypothetical vertical pole. For each subsection, a cumulative snag subsurface area then was calculated and divided by the estimate of the subsection's water surface area. This yielded a value for relative cover density (RCD) for the subsection. Values from these 50-m subsections then were utilized to calculate a mean RCD for each of the sections within a treatment area. Depth, width, and RCD then were compared between and among treatments.

Results

Forty-six shadow bass were caught in the Pearl River. In the Yockanookany River, 85 shadow bass were captured in the channelized area and 85 were caught in the unchannelized area. Mean CPUE values (fish/net) and associated standard errors for the Yockanookany River were 0.10 ± 0.03 for the channelized area, and 0.08 ± 0.03 for the unchannelized areas. There was no significant difference in CPUE between channelized and unchannelized areas of the Yockanookany River ($P=0.43$). For the Yockanookany River (areas combined), overall CPUE was 0.08 ± 0.02, whereas for the Pearl River CPUE was 0.04 ± 0.02. CPUE values for the Yockanookany and Pearl rivers differed significantly ($P=0.01$). In each season, mean CPUE was greater in the Yockanookany River than in the Pearl River.

Length-frequency distributions of shadow bass in the Yockanookany River (Fig. 1) did not differ significantly between channelized and unchannelized areas ($P=0.37$) Likewise, length-frequency distributions for the Yockanookany River (areas combined) and the Pearl River (Fig. 2) did not differ significantly ($P=0.99$).

Length-specific comparisons did not reveal significant differences in condition factor (K_n) and associated standard errors between channelized and unchannelized

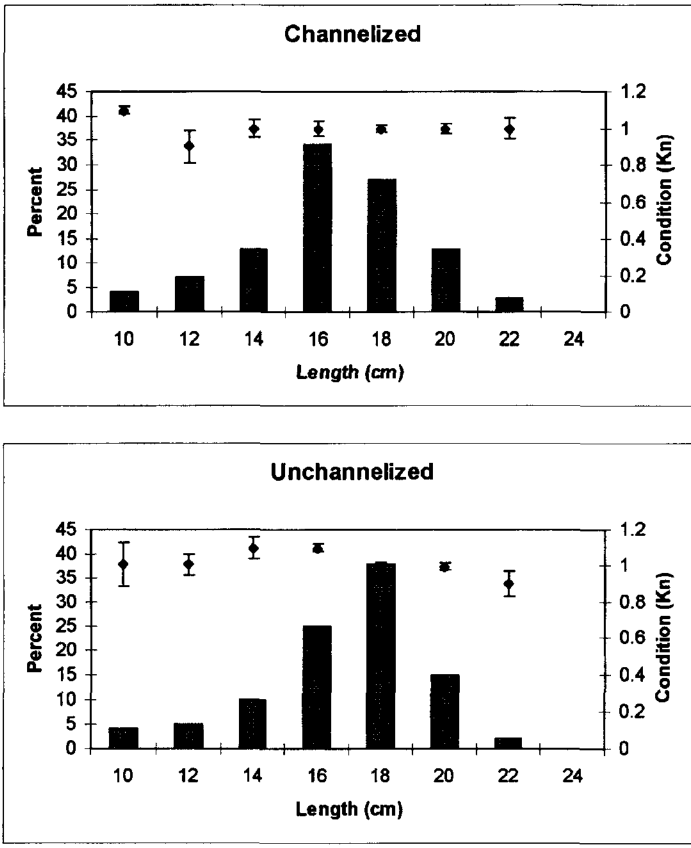

Figure 1. Length-frequency distributions (cm group) and condition factors of shadow bass in channelized and unchannelized sections of the Yockanookany River, Mississippi (1994–1996).

areas of the Yockanookany River (Fig. 1). Although K_n of fish in the Yockanookany River (treatments combined) and the Pearl River did not differ significantly, standard errors of K_n were more variable in the Pearl River than in the Yockanookany River (Fig. 2). Slopes for length-weight regressions did not differ significantly between channelized and unchannelized areas of the Yockanookany River ($P=0.96$) nor were they significantly different between the Yockanookany River (treatments combined) and the Pearl River ($P=0.54$) (Table 1).

The von Bertalanffy growth coefficient (k) for age groups 1–5 years in the unchannelized area of the Yockanookany River (Table 1) was significantly greater than the one calculated for these ages in the channelized area of the river ($P<0.001$). The von Bertalanffy k-value for age groups 1–5 years in the unchannelized area of the Yockanookany River was significantly less than the k-value calculated for these age groups in the Pearl River ($P=0.041$).

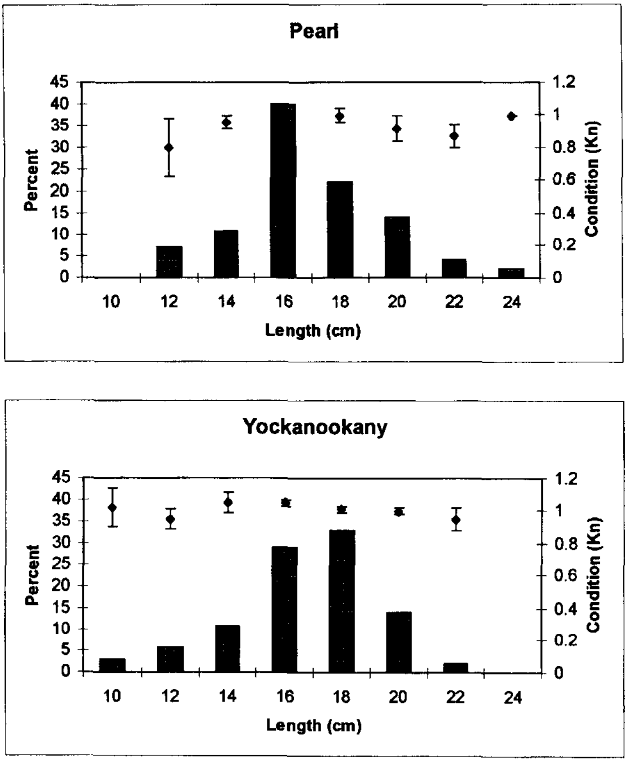

Figure 2. Length-frequency distributions (cm group) and condition factors of shadow bass in the Yockanookany and Pearl rivers, Mississippi (1994–1996).

Relative cover density (RCD) was greater in the channelized sections (0.04) of the Yockanookany River than in the unchannelized sections (0.02)(P=0.01), but was not significantly different (P=0.81) between the Pearl River (0.02) and the unchannelized sections of the Yockanookany River. This pattern reflected the greater number of snags in the channelized sections of the Yockanookany River (mean: 135 snags/section) than in the unchannelized sections (mean: 70 snags/section). However, the number of snags was not significantly different between the Pearl River (mean: 68 snags/section) and the unchannelized sections of the Yockanookany River. Additionally, the mean diameter of snags in the channelized sections of the Yockanookany River (6.7 cm) and the unchannelized sections (9.6 cm) differed significantly (P=0.03). The mean diameter of snags in the Pearl River (13.9 cm) significantly exceeded that of the unchannelized sections of the Yockanookany River.

Mean widths of channelized sections of the Yockanookany River (13.1 m) did not differ from mean widths of unchannelized sections of the river (14.5 m) (P=0.16). The Pearl River was significantly wider (mean: 16.5 m) than the unchannelized Yockanookany River (P=0.002). Mean depths for the channelized sections of the Yockanookany River (0.53 m) and unchannelized sections (0.96 m) differed

Table 1. Parameters for von Bertalanffy equations and length-weight regressions for shadow bass in the Yockanookany and Pearl rivers, Mississippi (1994–1996).

		von Bertalanffy parameters			Length-weight regression	
Treatment	Fish ages	L_∞[a]	K[b]	to[c]	Intercept	Slope
Yockanookany River (channelized)	1–7	233	–0.2307	0.2968	–5.086	3.183
	1–5	297	–0.1546	0.4363		
Yockanookany River (unchannelized)	1–6	242	–0.2532	0.2546	–5.086	3.189
	1–5	239	–0.2656	0.1844		
Yockanookany River (all sections)	1–7	233	–0.2437	0.0473	–5.111	3.197
Pearl River	1–5	245	–0.3259	0.0472	–5.375	3.305
Overall[d]	1–7	241	–0.2306	0.6255	–5.146	3.211

a. Asymptotic length (mm).
b. Growth coefficient.
c. Age of fish when length=0.
d. Combined data from all treatments.

significantly (P=0.01). However, the mean depth of the unchannelized sections of the Yockanookany River did not differ significantly from mean depth of the Pearl River (1.18 m)(P=0.12).

Discussion

Passage of the bill establishing the Mississippi Natural and Scenic Waterways System by the 1999 General Session of the Mississippi Legislature is considered by most conservation-minded persons, groups, and institutions in the state as the state's most significant natural resources stewardship legislation in over a decade. The success of the initiative will hinge to a large degree on development and application of assessment criteria utilized by the state to evaluate streams for inclusion in the system. There are 4 major components addressed by the assessment criteria document: (1) biological criteria (2) physical criteria (3) human interaction criteria, and (4) historical criteria.

Identifying measurable elements within each criteria group is a major challenge. Because a fishery by definition incorporates fish populations, environmental support systems, and human interactions with both the fish and the environment (Nielsen 1993), it is appropriate to consider fisheries or components of fisheries in the assessment of these streams. However, one must bear in mind that fisheries *per se* are not the driving force behind the legislative initiative, and it is not the purpose of the Mississippi Natural and Scenic Waterways System to advance, enhance, or promote fisheries. Rather, the desire is to identify aspects of fisheries that provide insight into the overall status and functioning of the stream.

The shadow bass seems to be a good candidate fish to address in this regard. It is a small centrarchid fish inhabiting Mississippi streams and typically is not targeted by anglers. While not restricted to Mississippi streams, it is a fish that is a regional specialty. Its distinctive patterns and cryptic coloration make it an attractive fish. Its propensity to live in association with instream woody structure (e.g., snags, cypress knees) and in the scour holes downstream from root wads and embedded logs, appropriately advances the notion that Mississippi streams are inextricably linked to riparian and watershed components of the ecosystem (Jackson 2000).

The body depth of shadow bass is approximately 46% of the total length (Cashner 1974). This body shape restricted our hoopnet catches to shadow bass having total lengths ≥120 mm. Beyond this minimal size, our catches were dominated by larger fish. This suggests minimally exploited fish stocks (Goedde and Cobble 1981, Reed and Rabeni 1989). We believe that minimal exploitation of shadow bass in these systems is in fact true because (1) human health advisories are in effect on the Yockanookany River (2) the remoteness of the sampling areas discourages angling on both the Yockanookany and upper Pearl rivers (3) once in the vicinity of the rivers, access is very difficult (4) encounters with anglers during our study were rare events, even near access points such as bridges, and (5) the few anglers we encountered did not target shadow bass. If angling were a significant factor in shadow bass stock characteristics in these rivers, we would expect to see fewer larger fish in samples of shadow bass ≥120 mm, more smaller to intermediate-size fish in this segment of the stock, and perhaps faster growth rates than we observed. We therefore proceeded to address shadow bass stocks from the perspective that stock characteristics reflected biological and physical processes in the rivers (and sections therein).

Stock structure of shadow bass, as addressed by length-frequency distributions, was similar in all of the study areas. This was surprising because channelization of a stream typically has long lasting negative influences on centrarchid fish populations (Schlosser 1987, Filipek et al. 1991). However, Filipek et al. (1991) noted that shadow bass populations were not affected by a hundred-year flood event in Arkansas. From our study it seems that (1) channelization does not impact shadow bass to the same degree as it does other fishes (2) the impacts of former channelization in the Yockanookany River are fading with the passing of years, or (3) impacts of channelization are not reflected in length-frequency distributions of shadow bass. Additional analyses we conducted indicated that length-frequency distributions for shadow bass may not be the appropriate approach for making such determinations.

The relative abundance of shadow bass was similar between channelized and unchannelized sections of the Yockanookany River but greater in the Yockanookany River (sections combined) than in the upper Pearl River. The lower relative abundance of shadow bass in the upper Pearl River suggests that shadow bass habitat declines as size of stream increases, and/or that predation on shadow bass may increase as the size of the stream increases. Boschung (1987) also noted that shadow bass abundance declined as stream size increased.

Determination of von Bertalanffy equations revealed that the maximum obtainable length for shadow bass increased as one proceeded from the channelized sections of the Yockanookany River to the unchannelized sections of the river, and on to the Pearl River. The effects of channelization are further reflected in aspects of condition factors (K_n) for shadow bass in these rivers. Condition factor, as a measure of the general well-being of fish (Ney 1993), is subject to seasonal, environmental, and reproductive influences. Although no significant differences were found overall for the standard errors of condition factor among treatments, standard errors of condition factor for length groups 16–20 cm from the channelized sections of the Yockanookany River had greater variability than was exhibited for fish in these length groups collected from the unchannelized sections of the river. The greater variability can be attributed to channelization influences on habitat that results in patchy distribution of forage items (*sensu* Springer et al. 1990).

The riparian forests in conjunction with relatively stable stream banks along the channelized sections of the Yockanookany River apparently introduced more but smaller woody debris to the stream channel than was found in the unchannelized sections of the river and in the upper Pearl River. Small diameter woody debris is less permanent and subsequently temporally more variable in stream channels, and provides aquatic invertebrates with less stable environments than does larger diameter woody debris (Benke et al. 1985, Brown and Matthews 1995). Under elevated flow conditions, there is little in the way of channel diversity (e.g., meandering) to disrupt the scouring force of laminar currents in the channelized sections of the Yockanookany River. This scouring can remove woody debris (Bilby 1984) and subsequently can reduce macroinvertebrate production and associated drift in the stream (Etnier 1972, Borcharadt 1993). The result can be reduced and variable abundance on invertebrate forage available for shadow bass. These conditions, in conjunction with generally lower water temperatures recorded for the stream during the warm season growing periods, can result in more variable condition, slower, more variable growth, and smaller length at age for shadow bass in these channelized stream sections.

It is also possible that sight-feeding fish such as shadow bass are less efficient foragers under low light conditions (*sensu* Gardner 1981, Lloyd et al. 1987). In this regard, we measured illumination in all treatment areas and recorded less light incident on stream channels of the channelized sections of the Yockanookany River than in the river's unchannelized sections and in the upper Pearl River, This can be attributed to dense canopy from riparian forest overhanging the relatively stable channel of the channelized areas. In contrast, the unchannelized sections of the Yockanookany River and the upper Pearl River had more light incident on the stream channel, apparently the result of channel meandering processes that can cause riparian zone trees to fall into the water thereby opening the canopy (and also introducing large woody debris to the channel).

Conclusion

Our study indicates that stock structure of shadow bass, as reflected by length-frequency distributions, does not clearly reveal habitat-induced differences in population characteristics for these fish in small Mississippi streams. Relative abundance of shadow bass also does not reflect influences of channelization in these streams, but does reflect the propensity of these fish to prefer smaller, shallower streams over larger, deeper streams. Growth rate and condition factor provided the best insight into population dynamics of shadow bass in the streams we studied and in this regard, our study indicated that channelization negatively affects shadow bass.

Assessments of shadow bass stocks in small east-central Mississippi streams can be helpful in evaluating these streams as possible candidates for inclusion in the Mississippi Natural and Scenic Waterways System. Shadow bass stocks tend to reflect aspects of stream habitats in these streams that are of interest and utility to persons conducting stream evaluations for the program. However, shadow bass generally are not abundant fish, even in streams where stocks apparently are dynamic and healthy. Furthermore, habitat influences on shadow bass tend to be reflected in stock characteristics that need considerable data and laboratory work (i.e., age and growth studies, condition factor analysis). Such studies may not be compatible with programs requiring rapid assessments of stream characteristics.

Therefore, and unless the legislative initiative recommends slow, thorough processes for evaluating streams for the Mississippi Natural and Scenic Waterways System, shadow bass should not be selected as an indicator species, even though shadow bass stocks can reflect the general well-being and relative status of the stream as a naturally functioning system.

Alternative fishes such as catfishes may be more appropriate alternatives as indicators of stream quality in Mississippi streams. For example, Insaurralde (1992) and Skains and Jackson (1995) reported how riparian zone and stream channel characteristics influence population structure, relative abundance, and movements of flathead catfish *(Pylodictis olivaris)*. Jackson (2000) reported that channel catfish *(Ictalurus punctatus)* populations were negatively influenced by channelization. Jackson and Ye (2000) found that channel catfish populations were positively influenced by elevated hydrological regimes in floodplain river ecosystems. Jackson and Jackson (1999) found that the integrity of stream channels was important to channel catfish but that yellow bullhead *(Ameiurus natalis)* depended on the availability of seasonally connected backwater areas. Additionally, and because of the popularity of catfishes among Mississippi fishers (Brown et al. 1996, Cloutman 1997), catfishes may better reflect prevailing cultural connections between humans and streams in this state (Jackson 1999, Jackson 1991).

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