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ABSTRACTS



Design and Preliminary Results of a Study of the Ecological Effects of Nutrients on Small Streams in the Ozark Plateaus

By

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As part of the U.S. Geological Survey National Water-Quality Assessment Program approximately 30 stream sites were sampled in June-August of 2006. Sites were selected to represent a range of nutrient conditions and agricultural land use in small streams of the Springfield Plateau and Salem Plateau sections of the Ozark Plateaus of Arkansas, Missouri, and Oklahoma. Water samples were collected and analyzed for nutrients and suspended sediment at 30 sites in June. Additional samples were collected from these sites (or replacement sites added because of inadequate streamflow) in July or August and analyzed for nutrients, suspended sediment, organic carbon, and phytoplankton. Biological communities (periphyton, benthic macroinvertebrate, and fish) were sampled and habitat was measured at each site in July or August. Metabolism data (48-hour temperature/dissolved-oxygen curves) were collected at a subset of the sites in July.

Water-quality results from the July/August time period indicate that total phosphorus, orthophosphorus, and nitrate concentrations are positively correlated with agricultural land use upstream from a sample site. Nutrient increases appear to be most consistent when agricultural land use exceeded 60 percent of the basin upstream from the site. Measures of phytoplankton and periphyton biomass do not appear to be strongly related to land use percentages or nutrient concentrations. Shading and grazing by fish and invertebrates are two other factors that may have affected algal biomass.

Additional seasonal water-quality, metabolism, habitat, periphyton, and benthic macroinvertebrate data will be collected at 7 of the 30 sites in the winter through summer of 2007. Water-quality, habitat, and metabolism data will be compared to biological community data after the 2007 sampling period is completed.

USGS Sampling Plans for a Nutrient-Reference Lakes Study and the Ecological Monitoring and Assessment Program for Great River Ecosystems in Arkansas

By

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The U.S. Geological Survey (USGS) will participate in two new studies in Arkansas in 2007 that have implications to fishery resources. The Arkansas Reference Lakes Study is a cooperative project with both the Arkansas Department of Environmental Quality (ADEQ) and U.S. Environmental Protection Agency (USEPA) Region VI. The purpose of this study will be to identify nutrient-reference lakes (generally the lakes with the lowest concentrations of nutrient and nutrient-related constituents) in two ecoregions and for four lake classifications--oxbow lakes in the Mississippi Alluvial Plain that are disconnected from the main stem of large rivers, lowland reservoirs in the Mississippi Alluvial Plain, upland reservoirs constructed in the Southern Coastal Plain, and upland reservoirs constructed on Crowley's Ridge. The Ecological Monitoring and Assessment Program for Great River Ecosystems (EMAP-GRE) is being conducted in cooperation with the USEPA Office of Research and Development (ORD). The purpose of the EMAP-GRE is to develop methods for assessing large rivers in the Central Basin of the United States. EMAP-GRE protocols are currently being applied on the Missouri, Ohio, and Upper Mississippi Rivers.

The Arkansas Reference Lakes Study has been underway since late summer. In early September 2006, ADEQ and USGS personnel used USGS topographic maps, aerial photography, and Geographic Information System coverages to select lakes to be screened as candidates for reconnaissance sampling. In mid-September, USGS screened 66 lakes within the four lake classifications. The intent of this screening was to record observations related to water quality such as potential agriculture runoff, presence of point sources, and physical features of the lakes. To better determine suitability of each lake for reconnaissance sampling, area water-resource managers and private land owners also were consulted, when available. Following the screening effort, ADEQ and USGS reviewed the resulting data and observations and selected 24 lakes representing the four-lake classifications for reconnaissance. In late September 2006, USGS and ADEQ collaborated to conduct reconnaissance sampling. In early December, personnel of the three cooperating agencies reviewed all data and observations from the reconnaissance and compared these data, as well as historic data. Two lakes having the best water quality were selected from each of the four lake classifications and USGS sampled the following 8 lakes in mid-December: Rodgers Reservoir and Hamptons Reservoir near Bayou Meto, Lake Grampus near Grampus, Noble Lake at Noble Lake, Cox Creek Lake near Leola, Lower White Oak Lake east of Bluff City, Lake Austell at Village Creek State Park, and Bear Creek Lake near Marianna. Samples are being analyzed by the ADEQ laboratory.

For EMAP-GRE, USGS is scheduled to monitor water, habitat, fish tissue, and sediment; and also phytoplankton, zooplankton, benthic invertebrate, periphyton, and fish communities along the Arkansas segment of the Mississippi River. Approximately 29 sites—about 3 sites in the Tennessee-Arkansas section and 26 sites in the Mississippi-Arkansas section—will be sampled for each of the next three years. Some sites will be sampled multiple times for quality assurance but all other sites will change from year to year. Sampling will begin in July and will extend through September. All samples will be collected from within two 500-m transects that will be selected by USEPA ORD using a probabilistic design. Fish will be sampled by electrofishing one bank of both 500-m transects.

An Assessment and Analysis of Benthic Macroinvertebrate Communities Associated with the Appearance of *Didymosphenia geminata* in the White River Below Bull Shoals Dam

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The White River below Bull Shoals dam is located in the Ozark Mountains in north-central Arkansas and is considered to be one of the most famous trout fisheries in the world. In late spring to early summer of 2005, several area residents and business owners along the White River, directly below the Bull Shoals dam, notified ADEQ with concerns of a whitish-brown paper-like substance hanging from trees and docks after a typical surge or release of reservoir water. Samples of this material were collected by ADEQ biologists and determined to be *Didymosphenia geminata*. This particular algae is known to be an invasive and nuisance species in many regions across the world including, most notably, New Zealand and the western U.S. *D. geminata* is thought to be the cause of a decline in western U.S. Trout fisheries, therefore it is important for us to understand and determine the effects of *D. geminata* on Arkansas trout-supporting streams. A 13+ mile reach of the White River below Bull Shoals dam has been affected by *D. geminata*. A macroinvertebrate analysis was performed at four locations downstream of Bull Shoals Dam to determine any current or future impacts to the biological communities. Two samples were taken at each site; submerged aquatic vegetation and *D. geminata* affected vegetation. Macroinvertebrate indices were calculated for each site. HBI scores ranged from 6.60 to 7.71. Dominant taxa were highly variable, ranging from 24.5% to 76.05%, and dependent upon substrate and percent coverage of *D. geminata*. Total organisms within each sub-sample ranged from 544 to 14,640. Percent tolerant taxa ranged from 26% to 77%. This characterizes the unsuitable habitat conditions created by an over abundance of *D. geminata*; as the density of *D. geminata* increases, the number of taxa and total organisms decreases.

Patterns in Largemouth Bass (*Micropterus salmoides*) Population Dynamics in the Lower Arkansas River.

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Largemouth bass is one of the most popular sport fishes in Arkansas, especially in the impounded lower Arkansas River. However, little information exists upon which to conduct science-based management of this fishery. This is especially important given the perceived decline in the fishery over the past decade and the popularity of largemouth bass tournaments in the river. The primary objective of this study was to conduct an intensive stock assessment of the lower 11 pools (500 km) of the Arkansas River over 2 years to support future management of this fishery. Population age structures were skewed towards younger fish, with a low numbers of individuals older than age 3. Largemouth bass size structure varied by pool and year. Proportional stock density (PSD) values throughout all pools averaged 51 ($\pm 3 = SE$) in 2004 (range 33-67) and 55 (± 3) in 2005 (range 27-61). Average annual mortality values computed from catch curves were 49% (range 28-65%) and 47% (range 28-64%) for 2004 and 2005, respectively. Mean total lengths (mm) at age for largemouth bass for ages 1-6 were 205, 289, 345, 392, 427, and 418 for 2004 and 167, 264, 345, 388, 419, 434 for 2005. These length at age estimates were comparable to similar impounded river systems in the region. Results of the study suggest a quality largemouth bass fishery in the lower Arkansas River, though we recommend continued monitoring of populations in light of continuing environmental changes in the river.

Egg and Larval Characteristics and Culture Techniques for Rearing Yellow Cheek Darters, *Etheostoma moorei*.

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The yellowcheek darter *Etheostoma moorei* is endemic to four headwater tributaries of the Little Red River, Arkansas. Creation of Greers Ferry Reservoir in 1962 inundated much of the historical habitat, and the yellowcheek darter experienced a decline in population abundance. The U.S. Fish and Wildlife Service elevated yellowcheek darter to candidate status in 2001, and efforts to determine propagation methods were begun. We reared yellowcheek darters in recirculation systems with a partial water exchange at 21° C. Larvae and eggs were collected and photographed to determine morphometric characteristics. Egg diameters ranged in size from 1.73 to 2.73 mm with an average (SD) diameter of 2.34 (0.15; N=103). Larvae were fed copepods, saltwater rotifers *Brachionus plicatilis*, and artificial plankton. Post yolk sac larvae ranged from 4.46 to 5.69 mm TL, with an average (SD) total length of 5.29 (0.31) mm.. The larvae survived for approximately 10 d and grew an average of 0.14 mm/d. The cause of egg and larvae mortality is not clear, although poor water quality may have been a contributing factor.

Effects of Temperature on the Growth of Golden Shiners

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Temperature-dependent growth models were developed for juvenile golden shiners (*Notemigonus crysoleucas*). A 10-wk trial was conducted in a flow-through aquaria system to determine the growth response of juvenile golden shiners to temperature. Four temperature treatments (15, 20, 25, and $30 \pm 1.5^\circ\text{C}$) were randomly assigned to 20, 110-L glass aquaria. Each tank contained 20 fish; the average weight per fish was 0.54 ± 0.02 g (4.01 ± 0.03 mm total length), with 5 replicate tanks per temperature. Each tank received a constant inflow of water at a rate of approximately 200 mL/min, equivalent to one exchange per 9 hr. Water temperature was maintained with heaters or chillers, and a water pump within each tank provided circulation. Fish were handfed twice daily to satiation with a 32% crude protein commercial minnow feed in the form of extruded pellets that had been crumbled and sieved (particle size < 0.85 mm). Fish in each tank were batch-weighed and counted every 2 wk to document growth and survival. Water quality was measured weekly. Fish were harvested after 10 wk (66 d). Average survival across the treatments ranged from 93% to 96% and was not significantly different ($P > 0.05$). Mean weight gains were 0.43, 0.91, 0.97, and 0.92 g for the 15, 20, 25, and 30°C treatments, respectively. Quadratic equations were derived to predict maximum growth rates for total weight (ΔW g/day) and length (ΔL mm/day) from temperature. These analyses indicated that maximum growth under those conditions was obtained at $(25 \pm 1.5^\circ\text{C})$.

Evaluation of Aquatic Mitigation on the McClellan-Kerr Arkansas River Navigation System in Arkansas and Oklahoma

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The McClellan-Kerr Arkansas River Navigation System provides 455 miles of channel modifications for flood control, barge traffic, and hydropower on the White, Arkansas, and Verdigris rivers from the confluence of the Mississippi River to Catoosa, Oklahoma. It includes a series of 18 locks and dams with a minimum 9-foot deep navigation channel and widths ranging from 150 to 300 feet maintained through dredging and training structures. Navigation improvements are underway that will expand the channel depth to 12 feet by modifying or adding training structures and by dredging. Achieving a 12-foot depth will result in the removal of over 10 million cubic yards of dredge material at 140 locations along the MKARNS, with 68 new disposal sites. Mitigation activities of aquatic and terrestrial impacts have been developed in coordination with the United States Fish and Wildlife Service, the Arkansas Game and Fish Commission, and the Oklahoma Department of Wildlife Conservation. Evaluation of aquatic mitigation is being conducted by researchers from Arkansas Tech University, University of Arkansas at Pine Bluff, University of Central Arkansas, Mississippi State University, Oklahoma State University, and the United States Geological Survey – Water Resources Division. Three primary categories of mitigation being evaluated are 1) deepening and/or reconnecting backwater entrances to the main stem river for fish access to spawning and rearing locations, 2) notching dikes to reduce sedimentation, increase habitat diversity, and provide fish access to dike pools, 3) relocation of dredged gravel to minimize loss of coarse substrates used by a variety of mussels and fish, and 4) measurement of bathymetric changes in dike fields, gravel bars and backwater lakes in the Arkansas River. Long-term sampling protocols and baseline data are the first priority for the project followed by monitoring population and community changes.

Growth and Condition Indices for a Native Puerto Rico Fish, Bigmouth Sleeper *Gobiomorus dormitor*

Nathan J. Harris, J. Wesley Neal, and Peter Perschbacher

Bigmouth sleepers *Gobiomorus dormitor* are an amphidromous riverine species native to Puerto Rico. This species has been extirpated from many upper river reaches due to river impoundment, but may grow well in reservoir environments when introduced. Bigmouth sleepers are a locally popular sport fish on the island, and are of primary interest for future sport fish restoration and management. In this study, we assessed bigmouth sleeper growth potential under high prey availability, and suggest standard weight parameters and length categories for relative stock density (*RSD*) analyses. Growth (mm) per day decreased with the initial size of fish: 100-199 mm bigmouth sleepers averaged 0.46 mm/day (SE \pm 0.02); 200-299 mm fish averaged 0.21 mm/day (SE \pm 0.04); and fish greater than 300 mm averaged 0.05 mm/day (SE \pm 0.02). The regression-line-percentile technique was used on data from eight Puerto Rico river populations to determine the standard weight equation for bigmouth sleepers. The standard weight equation was: $\text{Log}_{10}(Ws) = -5.131 + 3.018 * \text{Log}_{10}(TL)$ ($r^2=0.99$; SE \pm 0.004) with minimum size of 100 mm. Suggested length categories for this species were determined using published methods based on the world record catch of 610 mm. Minimum lengths for each category were: stock = 150 mm, quality = 230 mm, preferred = 300 mm, memorable = 380 mm, and trophy = 480 mm. This information will be useful for future management of this species.

Factors Influencing Post-Stocking Survival of Hybrid Striped Bass

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Survival of hybrid striped bass following stocking into small impoundments can be low and is often attributed to changes in water chemistry and/or temperature. We examined the effects of hardness, temperature, and acclimation rate on post-stocking survival of hybrid striped bass under controlled laboratory conditions. In the first study, hybrid striped bass (mean TL = 86.9 mm, SE = 1.4) were stocked from high hardness (350 mg/L CaCO₃) water into three experimental conditions: 1) low hardness with 30 minutes acclimation, 2) low hardness with 60 minutes acclimation, and 3) no change in hardness and no acclimation. In the second study, hybrid striped bass (mean TL = 139.2 mm, SE = 0.8) were stocked without acclimation from high hardness (365 mg/L CaCO₃) water into four experimental conditions: 1) low hardness only, 2) low hardness with 5 C temperature increase, 3) 5 C temperature increase only, and 4) no change in hardness or temperature. For both studies, low hardness water had a mean hardness of 52 mg/L CaCO₃ (SE = 2.5 mg/L CaCO₃), and fish were observed for 1 week after stocking. Acclimation time to low hardness did not influence mortality. Likewise, changes in temperature, hardness, or both without acclimation did not increase mortality of hybrid striped bass. These results suggest that acclimation, hardness, and temperature are not the primary factors leading to poor survival of hybrid striped bass. We suggest additional research on handling stress as the primary factor in hybrid striped bass stocking mortality.

Does Stocking Frequency Matter in the Arkansas Family and Community Fishing Program?

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Arkansas Game and Fish Commission (AGFC) currently stocks channel catfish biweekly as part of their Family and Community Fishing Program (FCFP), and the transportation costs can be prohibitive because frequent stockings at many locations are required. Therefore, we evaluated monthly stocking as an alternative to biweekly stocking in the FCFP, while holding the amount of catfish each location received on monthly basis constant. In 2005 and 2006, we conducted creel studies from April to August on six ponds stocked with channel catfish. Bus-route type roving creel surveys were used to collect data on angler demographics, effort, catch, and attitudes. We approached 1,533 angler parties, of which 1,474 angler parties representing 3,066 individual anglers agreed to be interviewed. African-Americans made up 82% of urban pond anglers both years. Effort, catch, and harvest of catfish varied greatly between the six ponds over the two years with average catch rate ranging from 0.21 to 0.61 per pond. The majority (63% yr 1, 68% yr 2) of anglers had not caught any catfish when interviewed, but most (56% yr 1, 58% yr 2) anglers still rated their overall trip as good or excellent. The mean catch rates for the three ponds stocked monthly (0.45 catfish/h yr 1, 0.36 catfish/h yr 2) were not significantly different than ponds stocked biweekly (0.36 catfish/h yr 1, 0.36 catfish/h yr 2), nor did angler ratings of fishing success differ significantly between the two stocking frequencies. In conclusion, AGFC can stock their FCFP locations less frequently without causing detrimental effects on the levels of effort, harvest, or satisfaction.

If You Stock It Will They Come: Effects of Fishing Derbies on Effort and Harvest at Derby Locations

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Recruiting new anglers is a chief concern of fish and game agencies because of declining license sales. The American Fishing Tackle Manufacturers Association (1990) reported that 88% of freshwater anglers began fishing before the age of 20; so successful recruitment depends on reaching potential anglers at a young age. Fishing derbies are widely considered to be an effective means of recruitment. Arkansas Game and Fish Commission (AGFC) currently supports fishing derbies in the state of Arkansas by stocking channel catfish into derby ponds prior to derby events. In this study, we evaluated the derby program to determine if angling increased following derby events, if the derby events are attracting and potentially recruiting non-anglers, and if derby type influences these effects. We sampled 29 derby events divided between rural and urban locations, and derby events that were open or closed to the public. Preliminary findings suggest that fishing effort on derby ponds increases after a derby event, particularly those open to the public and in urban areas. Derby participants reported fishing much less in the past 12 months than the anglers fishing outside of the derby event. It appears that the Fishing Derby program may have a greater effect on retaining anglers than recruiting new anglers.

Improvements in New Hatchery Methods for Fathead Minnows

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According to the Census of Aquaculture, in 2005, 160 fish farms sold \$9.85 million worth of fathead minnows. This is an increase of \$2.42 million from the farm-gate value in 1998. Recent discoveries of exotic fish viruses, as well as aquatic nuisance species concerns, have stimulated interests in culturing additional fathead minnows to replace wild harvest. However, reported yields from traditional spawning-rearing pond methods are relatively low (150 to 300 lb/acre). Researchers at the UAPB Aquaculture/Fisheries Center have been developing new hatchery methods for fathead minnows, including removing eggs from substrates with sodium sulfite and subsequent jar incubation. Prior to evaluating the feasibility of such a system, several key elements remain to be resolved. Current research efforts are focused on these problem areas, including 1) efficient methods to collect and harvest fathead minnow eggs, and the costs involved; 2) controlling fungus during egg incubation; and 3) appropriate stocking densities for fathead minnow fry. Two spawning substrates designed for rapid egg removal are being developed for testing. Egg numbers per unit of substrate and broodfish will be determined and labor requirements documented. Three fungus control treatments (formalin, hydrogen peroxide, and water flow) will be tested at several levels and frequencies. Newly hatched fry will be stocked into pools at a range of stocking rates to evaluate the effects of density on fish production parameters. Results of these studies will assist in the development of a comprehensive hatchery system for fathead minnows.

Movement of Rainbow Trout in the Catch and Release Areas of Arkansas Tailwaters

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Catch-and-release (CR) areas were developed in the mid 1990's on the tailwater systems of the White and Norfork Rivers, Arkansas, with the goal of improving survival and residence time of rainbow trout *Oncorhynchus mykiss* in areas normally under put-and-take management. In a paired study design, rainbow trout were implanted with radio-transmitters from within and below four CR areas to investigate the assumptions that, 1) trout stay within CR areas and 2) trout maintain home-ranges within CR areas. 124 fish with 15+ weekly locations were tracked from July 2005 to October 2006. Home-ranges were determined based on total linear distance and kernel density estimates. Most fish did not move outside of the area where they were tagged (70% in CR areas, 54% in non-CR areas). The most downstream area, with higher water temperatures, had the greatest proportion of fish moving outside the CR area. There were no significant differences in movement patterns between fish tagged in and out of CR areas. Summer movements in all but the farthest downstream area were limited (0-10 meters). In fall and spring several fish made upstream migrations covering distances ranging from 6-40 kilometers. The length of most CR areas in the White River and Norfork River appears to be sufficient to encompass movement and home ranges of most rainbow trout. However, downstream CR areas with high water temperatures may not provide suitable habitat for rainbow trout to remain resident. Knowledge of movement patterns and home ranges will allow managers to more effectively establish the size and location of special regulation areas.

Cumulative Watershed Effects of the South fork Spring River: Habitat, Mussels, Macroinvertebrates, and Fish response Variables.

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One of the most difficult tasks in characterizing a watershed is to quantify the stream habitat and determine the cumulative impacts on streams and their biota. The South Fork Spring River (SFSR) originates in southeastern Missouri and flows through the Ozark and Salem Plateaus of Arkansas. The objectives of this study are: 1) to qualitatively sample the entire SFSR for mussels; 2) to quantitatively sample mussels at 9 sites; 3) to determine water quality by sampling fish and macroinvertebrate communities at the 9 sites; 4) to characterize and assess habitat at the 9 sites; 5) to determine cumulative watershed effects; 6) to relate the biological and habitat data to the cumulative watershed effects; and 7) to propose alternative solutions in the watershed to improve suspected effects. The entire SFSR was qualitatively surveyed for mussels. Based on the qualitative survey, 3 sites each, for a total of 9 sites, were selected from the upper, middle, and lower portions of the SFSR. Aggregates were delineated and sampled to determine mussel population densities, species richness, and size structure. Habitat characterization and assessment, fish community assessment and macroinvertebrate community assessments also were conducted at each of the 9 sites. A total of 22 species of mussels were recorded from the SFSR with richness ranging from 2 to 12 species per site. Of the 22 species, 16 were ranked S1, S2, or S3. The remainder of the objectives for this project will provide a complete picture of stream health for the SFSR.

Assessment of a Potential *Potamilus capax* (Green 1832) Refuge: The Use of Biotic and Habitat Indices as Indicators of Freshwater Mussel Habitat in the Tyronza River, Arkansas.

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The Tyronza River, Arkansas has been designated by the Arkansas Department of Environmental Quality as a channel altered stream for the Mississippi Alluvial Valley - Delta Ecoregion. The Federal Highway Administration (FHWA) and the Arkansas Highway and Transportation Department (AHTD) have suggested the Tyronza River, Arkansas as a candidate for habitat restoration and a potential refuge for the fat pocketbook, *Potamilus capax*. The objectives of this study are to: 1) complete a qualitative mussel survey of the river to obtain species distribution, relative abundance, and catch per unit of effort (CPUE) data; 2) quantitatively sample nine mussel beds spatially distributed throughout the river; 3) assess habitat and water quality using USEPA protocols for habitat and fish and aquatic macroinvertebrates; 4) characterize stream habitat using the Basin Area Stream Survey; and 5) analyze cumulative watershed effects using GIS. The qualitative mussel survey was initiated in summer 2006 and will continue through spring 2007. To date, 247 sites have been sampled and 24 mussel species encountered. The mean CPUE per site was 0.8 mussels min⁻¹, ranging from 0 to 7 mussels min⁻¹. Quantitative samples of selected mussel beds, collection of fish and macroinvertebrates, habitat assessment and characterization, and cumulative watershed assessment will occur in 2007. The results of this study will aid in the development of a FHWA and AHTD agency habitat restoration plan for *Potamilus capax*.

Fourier Analyses of Otolith Shape to Discriminate Spotted and Largemouth Bass in the Arkansas River

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Shape analysis of otoliths can be used for a variety of purposes, including discrimination of fish stocks or identification of stomach contents in fish-eating birds. Fourier shape analysis allows an accurate and repeatable measure of the shape of an otolith. Otoliths from largemouth bass and spotted bass from pools 2 and 10 in the Arkansas River, collected during two springs, were analyzed using Fourier analysis. The objectives of the study were to use Fourier analysis and discriminant function analysis to differentiate between largemouth bass and spotted bass otoliths, and to determine whether this type of analysis would allow differentiation of largemouth bass from different pools. Differentiation of largemouth from spotted bass was successful for 97%-99% of 386 otoliths, with only eight otoliths being incorrectly categorized. Sixty-six to sixty-nine percent of the 255 largemouth bass otoliths were correctly categorized for pool location. Training a discriminant function, using Fourier analysis output, to differentiate between otoliths from a variety of fish eaten by birds would allow a more accurate identification of stomach contents during diet studies. For largemouth bass in the Arkansas River, the results suggest similar largemouth bass growth rates for the two pools and/or that largemouth bass in the Arkansas River are a single stock. These conclusions support largemouth bass management strategies that consider all pools as a single unit.

A Comprehensive Nongame Fish and Wildlife Strategy for Arkansas

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State and federal natural resource conservation agencies have been successful in bringing back or maintaining viable populations of many game fish and wildlife in the United States. However, the same cannot be said for many nongame species, both aquatic and terrestrial, which have been overlooked as they become less common across our nation due to both natural and anthropogenic impacts. Several years ago, the US Fish and Wildlife Service (FWS) and Congress partnered together to develop a vehicle that would begin to do for nongame animals what the Sport Fish Restoration and Pittman-Robertson Acts did for sport fish and wildlife, provide additional stable federal funding for nongame species conservation programs. Over the last 3 years, several state and federal natural resource agencies have worked together to develop a Comprehensive Wildlife Conservation Strategy (CWCS) to do a better job of managing the numerous important, but less visible, nongame animals in Arkansas. The objective of the strategy was to: 1) determine which species in the state were Species of Greatest Conservation Need (SGCN), 2) what habitats needed to be conserved or improved to ensure the health of these SGCN, 3) what conservation practices could be encouraged to private land owners, and 4) how could the conservation community best communicate and motivate the public to implement conservation practices. In exchange for an 8-element CWCS from each state, the FWS would continue its funding of nongame projects using State Wildlife Grants (SWG) that would be managed through the state fish and wildlife agency with assistance from their natural resource partners, both state and federal. Overseen by the Arkansas Game and Fish Commission (AGFC), several committees were formed to provide oversight for the plan development, to work with the ecoregion concept most appropriate to Arkansas, to draft habitat classifications appropriate to the animals that need conservation, and to decide which animals needed the most help (separate teams for fish, mussels, crayfish, reptiles and amphibians, birds, mammals, and invertebrates), prioritize their needs, determine limiting factors or threats to these species and their habitats, and strategize on what would be the best conservation actions to keep these species viable. Examples are given in this presentation on how this management system is working with some aquatic species.

The Ecological in Stormwater Infrastructure

Huber, Jeffrey, Project Designer, Luoni, Stephen & Gabriel, Aaron.
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“Research indicates that when impervious area in a watershed reaches 10 percent, stream ecosystems begin to show evidence of degradation, and coverage more than 30 percent is associated with severe, practically irreversible degradation.”

Green Streets: Innovative Solutions for Stormwater and Stream Crossings

Watershed Urbanism

Contemporary planners have never known what to do with water. Seen as an obstacle to development it is drained away or appropriated as a transport mechanism for goods and wastes. UACDC projects counter with a model for integrating riparian systems with urban systems. It is watershed-based land-use proposals that incorporate ecological services into urban systems. “Pipe and Pond” solutions, common in civil engineering practices, transport runoff problems elsewhere and are prone to systematic failures, whereas ecologically based solutions, like “green streets” can treat runoff *in-situ* and improve regional groundwater quality. The integration of an ecological fabric in urban infrastructure offers solutions to achieve sustainability in the built environment and bypass the costly infrastructure associated with civil engineering solutions. Contrary to civil “pipe and pond” solutions, the “green street” becomes an integral landscape component in a larger watershed solution.

Developing Greenways in an Urban Environment

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The City of Rogers, Arkansas is part of the rapidly growing Fayetteville-Springdale-Rogers metropolitan area of Northwest Arkansas. The natural resources of the area, particularly water resources, have been stressed as the cities struggle to develop infrastructure needed for the rapid growth. Increased wastewater effluent, nonpoint source pollution and loss of riparian vegetation have degraded the water resources. In 2002, the US EPA and the Arkansas Natural Resources Commission awarded a grant to the city to demonstrate protection of ecological services through the use of greenways in their stormwater system. The demonstration stream is a second order urban stream draining roughly 16 km². The watershed is rapidly developing as commercial, industrial, multi and single-family residential property. In the initial phase of the demonstration, an evaluation of the stream was made including evaluation of habitat, biodiversity, trees, land use and land use change, and hydrologic/geomorphologic conditions in the stream to analyze the ecological services being provided by the stream. The project is unique in its combination of environmental sciences and engineering in the initial planning stages. A local stakeholders committee consisting of landowners, local educators, and interested citizens was created to direct the project. As a result of this project, a local Greenways and Trails Committee was established to extend the greenway concept to the rest of the city. The city changed its development approval process to require dedication of riparian areas for greenway trails development.

In addition to recreation and conservation, this urban greenway project delivered many other tangible and intangible benefits to the citizens of Rogers, and the entire region through its ability to connect communities. Those benefits included:

- Increased health and welfare for trail users
- Created alternative and safe transportation options – corridors for students traveling to school
- Opportunity to incorporate exercise into daily transportation routines
- Local and regional connectivity – neighborhoods, parks, school and businesses not only in Rogers but also with the larger Northwest Arkansas trail system.
- Increased property values associated with trail development
- Increased community pride and sense of improved “Quality of Life”
- Equal access for the entire community regardless of location, socioeconomic issues, cultural issues, age, or physical ability.
- Opportunity for community volunteerism and participation in enhancement
- Expansion of existing parks, facilities and programs.
- Enjoyment of the community’s natural beauty in a safe environment.
- Alternative natural classroom and environmental learning center
- Opportunity to include greenways in transportation planning and development efforts.
- Opportunity to promote trails and greenways as a resources for the future – an investment in more livable communities

Arkansas Watershed Groups: Partnerships for Protection

Robert Beadel, Ecologist II, Water Division, Arkansas Department of Environmental Quality

Watershed organizations have been around in Arkansas since 1995 with the formation of the Bayou Bartholomew Alliance; Arkansas' first watershed group. Since then a slow but steady effort has been made to establish more watershed groups throughout the state to help protect Arkansas' precious aquatic resources.

By adopting the watershed approach to address environmental issues; citizens have become more understanding of the local natural resources, economics, and ecology of their waterbodies and have taken a sense of ownership in their aquatic resources. The watershed approach is valuable because it brings together different entities: loggers, farmers, ranchers, business owners, organizations, students, elected officials, corporations, and local, state and federal governments. These stakeholders have the task of finding common ground in their beliefs and practices and focusing on the issue of protecting the aquatic resource. This partnership of stakeholders combines knowledge, technical resources, manpower, financial assistance, and responsibility – a more cooperative effort when compared to traditional forms of environmental issues resolution.

In 2000, the Arkansas Watershed Advisory Group (AWAG) was formed to assist interested citizens and organizations by promoting local voluntary approaches to watershed management and conservation. Today 12 state agencies, 6 federal agencies, 7 organizations, 3 universities, 3 water utilities, and 5 citizen representatives come together to lend technical and organizational assistance to community-led watershed groups across the state. By combining efforts, AWAG provides valuable resources and expertise to 20+ watershed coalitions that function at varying levels of organization. This partnership between citizens and professionals provides an opportunity for success and ultimately benefits our aquatic resources.

Fluctuations in Zebra Mussel Densities and Associated Limnological Conditions in Lake Dardanelle, Arkansas

Brandon K. Peoples and Joseph N. Stoeckel

Zebra mussels (*Dreissena polymorpha*) were discovered in Lake Dardanelle, Arkansas in 1992. This study characterizes long-term trends in their density along with corresponding trends in water quality. Adult zebra mussels were collected annually at 16 sites by snorkeling at a depth of 1 m. Veligers, juvenile settlers, and water quality data were collected at four sites. Vegetation coverage was visually estimated at three sites.

Changes in zebra mussel density were correlated with summer water temperatures. In years following summers with temperatures $\geq 29^\circ\text{C}$ for over 10 weeks, mean adult densities decreased 99.9%, whereas density increased 13-fold in years in years when summers temperatures were $< 29^\circ\text{C}$ for less than two weeks. No veligers were collected at temperatures below 2.9°C or above 31.9°C . Adult zebra mussel densities were positively correlated with secchi disk depth ($r = 0.37$), and negatively correlated with turbidity ($r=0.26$). From 1997 to 2001, mean percent macrophyte coverage was positively correlated with mean zebra mussel density ($r = 0.90$). However, from 2002 onward, vegetation was not correlated with mean zebra mussel population density and it steadily increased. In conclusion, zebra mussels have the potential to greatly alter water clarity in southern reservoirs, and their densities are strongly and negatively affected by prolonged periods of high temperature.

The Effects of Increased Minimum Base Flow on Centrarchid Annual Growth in the Ouachita River, Arkansas

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The goal of our research was to determine if increased minimum flow downstream from Rempel Dam in the Ouachita River improved annual growth of bluegill (*Lepomis macrochirus*), longear sunfish (*L. megalotis*), shadow bass (*Ambloplites ariommus*), largemouth bass (*Micropterus salmoides*), and spotted bass (*M. punctulatus*). Fish were collected in 2000, 2001, and 2005 downstream from Rempel Dam to the confluence of the Caddo River using boat electrofishing. An attempt was made to collect 10 fish/25-mm length group/species for sagittal otolith removal and age/growth analysis. Fish length at age was back-calculated using the direct-proportion method. Average annual incremental growth was determined by age for each growth year before and after increased minimum flows were implemented in 2001. Student's *t* tests indicated first year growth was significantly greater for all species after 2001. Bluegill grew an average (\pm SE) of 64 ± 1.3 mm ($n = 5$ years) before and 91 ± 2.3 mm ($n = 4$ years) after the flow change. Longear sunfish, shadow bass, largemouth bass, and spotted bass were an average of 58 ± 0.5 mm ($n = 5$ years), 76 ± 1.6 mm ($n = 7$ years), 120 ± 4.2 mm ($n = 8$ years), and 118 ± 4.4 mm ($n = 6$ years) before flow change and 81 ± 3.2 mm ($n = 4$ years), 96 ± 6.0 mm ($n = 4$ years), 167 ± 27.8 mm ($n = 4$ years), and 152 ± 13.5 mm ($n = 4$ years) after flow change, respectively. However, by age 3 average total lengths were similar between pre- and post-flow change growth years for all species.

Smallmouth Bass Mortality, Movement, and Habitat Use in Response to Seasonally Discontinuous Surface Flow

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Toward the southwestern edge of the smallmouth bass (*Micropterus dolomieu*) range, the Boston Mountains Ecoregion of Arkansas contains streams which are prone to drying during the summer when rainfall is limited and evapotranspiration is high. Associated changes in habitat throughout the summer have the potential to negatively impact smallmouth. The objectives of this study were (1) characterize changes in the extent of available habitat (velocity, depth, temperature, and substrate) throughout the summer, (2) characterize smallmouth bass summer habitat use, and (3) estimate smallmouth mortality during this potentially critical time. Study streams included the East, Middle, and North Forks of the Illinois Bayou in the Ozark National Forest. Sixty radio-transmitters (20 per stream) were surgically implanted into smallmouth during May and fish were tracked until October. Habitat was measured three times from June-September. As summer progressed, most riffle and run habitat dried completely resulting in a series of disconnected, remnant pools. Generally, cumulative movements were limited (<300 m) yet mortality as a response appeared high (at least 20% of the transmitter-fish in one stream). Smallmouth, in all streams and months, were consistently found in an average depth of 0.85 m. In June, smallmouth were found in velocities near 0.01 m/s; however, by July they were confined to remnant pools where velocity was negligible and water temperature occasionally exceeded 30°C. Thus, seasonally discontinuous surface flow appears to have substantial negative impacts on smallmouth habitat which likely constitutes a major limiting factor in the Boston Mountain Ecoregion of the Interior Highlands.

**Habitat Use of the Grotto Sculpin (*Cottus carolinae*)
A Troglotic Fish Species in Perry County, Missouri**

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Habitat studies in caves have been limited to qualitative studies providing general descriptions of the habitat utilized by fish populations. The lack of quantitative habitat use data for troglotic species makes it hard to examine important ecological traits such as the effects of habitat change or evidence of habitat specialization. This study quantitatively examined the habitat use of two Grotto Sculpin (*Cottus carolinae*) populations and corresponding populations in the primary resurgence stream in Perry County, Missouri. We specifically examined differences between the habitat use of epigeal and hypogean populations and the effects of siltation in hypogean streams. Perry County, Missouri has a high abundance of sinkholes which allow a large amount of agricultural runoff to directly enter the cave. Silt from this runoff can drastically alter the habitat available for the Grotto Sculpin to use by replacing cobble substrate with silt. The loss or reduction in cobble substrate availability can affect Grotto Sculpin populations both directly and indirectly. The increase of silt may have a direct impact on Grotto Sculpin reproduction. When spawning, Grotto Sculpin utilize cobble substrate by attaching their eggs to the undersides of available rocks. Additionally, the loss of cobble substrate may reduce the availability of isopods and amphipods, the primary food source for Grotto Sculpin. We will present a quantitative evaluation of habitat use and the possible effects of altering this delicate habitat. Benefits from this study will reach beyond Grotto Sculpin populations and help us to better understand the habitat use of other benthic fish in hypogean ecosystems.

**Population Dynamics, Movement and Growth of the Grotto Sculpin (*Cottus carolinae*)
in Perry County, Missouri**

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The Grotto Sculpin, endemic to caves in Perry County, was listed as a federal candidate species in 2002 and assigned a priority number of 2, indicating an imminent threat to the species exists. Due to the unstable nature of the cave environment in Perry County, Missouri, it was imperative to obtain baseline data on the population ecology of Grotto Sculpin and factors influencing their ability to repopulate caves in response to a catastrophic event (e.g., a contaminant spill). As with most cave species, few quantitative data are available on general life history characteristics. The objective of this study was to examine population dynamics, movement and growth of the Grotto Sculpin in two cave populations and their primary resurgence stream. Cave sites were divided into 10 m increments and individual fish were uniquely marked with visual tags at four to six week intervals between August 2005 and September 2006. A total of 811 fish were tagged during the study. A fish kill was observed in the upstream portion of one of the cave sites in August 2005. Throughout the course of the study, few individuals were observed in this section while only one tagged individual migrated into this affected region of the cave. Approximately 70% of individuals in cave populations moved less than 20 meters between sampling intervals. Maximum movement of an individual was 270 meters. Based on our data, the relatively sedentary nature of the Grotto Sculpin may limit their ability to recolonize habitats. Population estimates and growth rates for each sampling site will also be discussed.

Is Gear Selection Bias Correctable With Increase in Sample Size for the Estimation of Fish Size Distribution?

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Unbiased estimation of fish size distributions from samples is an important component in fishery science, as these distributions are used to determine age and growth, mortality, and stock structure of the population. However, a certain portion of a population may not be sampled effectively due to sampling gear selectivity and insufficient sample size. In this study, the effects of gear selectivity and sample size on the distribution estimations were examined using computer simulation experiments. For simulations, a finite population of individual fish weights ($n = 50,000$) was generated based on the distributional characteristics of channel catfish samples collected from a commercial aquaculture pond in Arkansas, US. Four different scenarios of gear selectivity were examined; equal catch probability, reduced probability for either-end and for both-ends of the size distribution. Each end of the size distribution comprised of about 3% of total population. The effect of six different sample sizes were also examined, ranging from 0.1% to 5% of population size. Nonparametric Kolmogorov-Smirnov tests were used statistically to compare the distributions of samples-to-population and samples-to-samples. The results indicated that uneven selectivity for only a small fraction of the size classes could bias the distribution estimates. Small sample size could lead to false positive conclusions. Interestingly, increase in sample size did not reduce the discrepancy in distributions between samples and population, when sampled under uneven selectivity. Careful examinations on the characteristics of gear selectivity appear to be more critical than increase in sample size for unbiased estimate of size distribution.

Lake Hogue 2005 Creel Survey: Results and Management Implications

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We conducted a 10-month, roving creel survey on 101-hectare Lake Hogue from March 1 through December 31, 2005. Information about angler use and fish harvest as well as species directed pressure was gathered during the survey. Total fishing effort was estimated to be 37,844 angler hours for the survey period with anglers harvesting an estimated 31,261 fish weighing 6,617 kg. (14,557 lbs.). Catch-and-release was practiced on another 22,656 fish with 84% of them being classified as small-sized fish. Catch-per-unit effort for all harvested species combined was 0.826 fish/ang. hr. and 0.175 kg./ang. hr. (0.385 lb./ang. hr.). Creel data indicated that almost 56% of the angling pressure took place from March through May while over 31% of fishing effort took place from June through August. Directed pressure by panfish anglers accounted for almost 70% of the total fishing pressure calculated for Lake Hogue. They were also responsible for 87% of the total fish biomass taken during the survey. Largemouth bass anglers accounted for 28% of the total number of angler hours spent at Lake Hogue.

Renovation of Parker Bend Angler Access Facility Beaver Tailwater, Carroll County, Arkansas

Rider, Larry and Burnley, Tim
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During the summer of 2006, Arkansas Game and Fish Commission personnel renovated the Parker Bend Angler Access Facility on the Beaver Tailwater. The original facility was constructed in 1999 and sustained significant damage when flood waters had to be evacuated from Beaver Reservoir in 2004. This major renovation project included the construction of two “J-Vanes”, each 200 feet long which were constructed with large boulders. All the large boulders used for this renovation were obtained as a donation from a commercial construction site in NW Arkansas. The unique design and construction technique of these “Vanes” helps protect the streambank from future erosion, helps improve channel morphology/fish habitat and provides angler access. Each “Vane” has a 160 foot sidewalk to help enhance fishing opportunities, especially for handicap anglers. These were all key issues brought out in a public workshop that was held to help formulate future trout management activities for the Beaver tailwater during 2005. Because of hydropower operations extreme water level fluctuations often hamper fishing opportunities. As a direct result of directing increased water flows toward mid-channel and at the same time, slowing flows along the bank, these “Vanes” also improve fishing opportunities during normal periods of hydropower generation.

This renovation was supported in part by Sportfish Restoration Funding, a donation from the Arkansas Chapter of Trout Unlimited and FEMA Disaster Relief Funds and was completed for a total cost of \$113,000. The donated boulders for the project had an estimated value of over \$100,000.

Arkansas River Sauger Population Evaluation

Leone, Frank, J.

Arkansas Game and Fish Commission

Saugers were sampled with gill nets and electrofishing gear below two dams on the Arkansas River, Arkansas to determine population characteristics and to determine if sampling for this species on the Arkansas River was practical. Two hundred seventeen saugers were captured during the 2006 sampling season. Gill net catch per unit effort (CPUE) was 0.93 saugers per 56m² of gill net per 1 hour of set time, and was highest in Lake Dardanelle. Catchability varied by gill net mesh size, and significantly fewer fish were captured in 51-mm bar mesh gill nets compared to 25-mm, 32-mm, and 38-mm bar-mesh nets. CPUE was not dependent on flow rate. Mean length of saugers varied by mesh size in which they were captured. Fifty-one millimeter and 38-mm nets captured the longest saugers (mean = 414 mm and 394 mm, respectively), followed by 32-mm (mean = 332 mm) and 25-mm (mean = 296 mm) nets. No saugers were collected with electrofishing gear in 99 minutes of sampling time. Saugers ranged from 265- to 464-mm (mean = 357-mm) in total length (TL), and from 151 to 1045 grams (mean = 488 grams) in weight. Saugers captured from both pools were in good condition (mean relative weight = 97), and condition did not vary by pool of capture. Fecundity was estimated from 18 gravid females collected from Lake Dardanelle. Fecundity ranged from 28,700 to 95,499 eggs/gravid female (mean = 56,002). Otoliths were extracted from 158 fish to determine length at age. Five year-classes were represented in each tailwater (ages-1 through 5). Growth slowed considerably after age-2 and appeared to be slightly slower for fish captured from Lake Dardanelle. Annual mortality was estimated to be 66% for Lake Dardanelle, and 40% for Pool 9. The Lake Dardanelle population was modeled using FAST software. Two models were developed and ran at varying rates of conditional natural mortality (30 and 50%) to predict yield (kg/1000 fish) and spawning potential ratio (SPR) at varying rates of conditional fishing mortality (10 to 90%). Models indicate that “growth over fishing” is likely to occur between 17 and 26% exploitation and that “recruitment over fishing” would likely occur between 21 and 25% exploitation. The modeling results indicate that a minimum length limit should be considered for saugers harvested from the Arkansas River. In addition to saugers, 22 other species of fish (998 fish) were captured in gill nets. Historical reservoir data indicates that sampling should be possible approximately 61 days per sampling season (between December 1st and March 20th), and a full-scale project should be feasible in approximately 76% of sample seasons. Expenditures for this year’s sampling project were \$4,442.00 dollars.

Evaluation of Biweekly versus Monthly Stocking of Rainbow Trout in the Arkansas Urban Fishing Program

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Declines in recreational fishing participation, under-representation of women and minorities among the angling population, and increasing urban flight have prompted many state management agencies to start urban fishing programs. Arkansas Game and Fish Commission (AGFC) currently stocks rainbow trout biweekly during the winter months as part of their Urban Fishing Program (UFP), and the transportation costs can be prohibitive because frequent stockings at many locations are required. We evaluated monthly stocking as an alternative to biweekly stocking in the UFP. We conducted a creel study from December 10, 2005 to March 31, 2006 on four ponds stocked with rainbow trout by AGFC. Two ponds received the AGFC standard biweekly stocking, and two ponds received monthly stocking at double the biweekly density. Bus-route type roving creel surveys at the study ponds were used to collect data on angler demographics, effort, catch, and attitudes. Urban pond anglers were predominantly African-American (68%). Effort, catch, and harvest of trout varied greatly between the four ponds with average catch rate (CPUE) ranging from 1.12 to 2.66 per pond. The majority (55%) of anglers had caught a trout when interviewed, and most (68%) anglers rated their overall trips as good or excellent. The mean CPUE for the two ponds stocked monthly was 1.89 trout/h, and was only 1.44 trout/h for the ponds stocked biweekly. These findings suggest that monthly stockings are capable of maintaining high angler satisfaction ratings.

Long Term Population Dynamics of the Yellowcheek Darter *Etheostoma moorei*

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The Yellowcheek darter *Etheostoma moorei*, a candidate species for federal listing, is endemic and obligate to headwater riffles of the upper Little Red River drainage in north central Arkansas. We compared community assemblages for present and historic data (1979-1980). We also compared riffle densities during drought (1999-2001), water recovery periods (2003-2004) and historic data. *Etheostoma moorei* distributions were compared within riffles as functions of size, gender and season. Last, we compared physicochemical variables within riffles to determine which factors were important for presence/absence. Community assemblages were similar between present and historic samples, although proportions and densities of *E. moorei* and another obligate riffle species, *Noturus albater*, declined greatly. Conversely, *E. caeruleum* and *Campostoma anomalum* occupied pools during riffle drying; their proportions increased greatly during the present study. The obligation of a species to riffle habitats may hamper recolonization of re-wetted sites compared to habitat-generalist species. Populations of upstream sites were extirpated during 1999-2001, and densities at other sites were significantly lower than the historic study. *Etheostoma moorei* densities increased during 2003-2004, yet several upstream sites remain extirpated. Instability of upstream habitat due to anthropogenic effects and loss of downstream refugia as a result of filling of Greers Ferry Reservoir in 1964 continue to exacerbate natural climatic cycles which include drought.

Variability in Size at Hatch and Percent Hatch of Sunshine Bass Larvae due to Different Male Striped Bass

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Maternal influences account for a significant portion of the variability in size at hatch and percent hatch. We wanted to examine the amount of variability in size at hatch and percent hatch of sunshine bass due to paternal influence. Eggs from a female white bass were separated into four equal aliquots. Each aliquot was fertilized by sperm from a different male striped bass. We examined eggs from each aliquot for indications of fertilization. Fertilized eggs were placed individually in 10-ml vials and incubated at 18 °C. Half the water was exchanged daily. Ammonia, pH, and dissolved oxygen were monitored daily. Temperature was monitored every 6 h. Eggs were examined every 6 h until the first eggs hatched, and every 3 h thereafter. Approximately 50 yolk-sac larvae were removed from the vials at hatching and photographed. At 4 d post hatch, the remaining yolk-sac larvae were photographed and enumerated. Standard lengths of larvae were estimated from the photographs. This experiment was repeated in two subsequent weeks. Different white bass and striped bass were used each week. We analyzed each week separately and conducted an analysis of covariance using standard length at hatch as the response variable, male as the treatment, and egg stage duration as the covariate. There were significant differences in size at hatch among males during the first and third weeks ($P=0.014$ and $P=0.020$, respectively, Figure 1). Choice of male only explained 2%-4% of the variability in size at hatch, while egg stage duration explained 29%-63% of the variability in size at hatch. There were also significant differences in size at 4 d post hatch among males during the first and third weeks ($P=0.034$ and $P=0.002$, respectively). During the first week, the male with the shortest larvae at hatch was also the male with the shortest larvae at 4 d post hatch. During the third week, the male with the longest larvae at hatch was also the male with the longest larvae at 4 d post hatch. This suggests that the advantage of larger size at hatch continues at least until yolk sac absorption.

Estimating production relationships to improve hatchery production of channel catfish

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Recent catfish, *Ictalurus punctatus*, production studies at the University of Arkansas at Pine Bluff have tested effects of various combinations of stocking density, stocking size, culture days, and the type of batch system used on resulting fish production parameters, such as size at harvest, yield, growth and survival. Ten independent channel catfish studies conducted at the University of Arkansas at Pine Bluff between 2001 and 2006 were used to examine relationships among variables most likely to affect the final size of catfish produced. Fish in all studies were fed to satiation with a 32% protein floating feed and ponds were aerated nightly. Major differences in these studies included a combination of different stocking densities, sizes of fish stocked, duration of culture and stocking strategy (single or multiple-batch). In the ten studies examined, stocking density ranged from 8,600/ha to 1,400,000/ha; size of fish stocked ranged from fry to 31-cm; and duration of culture ranged from 112 to 210 days. Tables were created from study data to display culture options. For example, to produce a 0.27-kg stocker, farmers could use two different options: (1) stock 10-cm fingerlings in single-batch at 100,000/ha for 210 days or (2) stock 7.6-cm fingerlings in multiple-batch at 15,000/ha for 201 days. Multiple regressions were done to obtain equations for estimation of these parameters over a broader range. Multiple regressions were run with size of fish at harvest (SH), the dependent variable, as a function of stocking density (SD), size of fish at stocking (SS), days of culture (D), and type of batch system (B) for the production of fingerlings (8-23 cm) and stockers (0.10-0.53 kg). Coefficients from multiple regressions were used to develop equations to identify combinations of options to produce various sizes of fish. For production of fingerlings in single-batch, the equation was estimated to be: $SH = 59.346 - 4.999 \times 10^{-6}(SD) + 1.116(SS) - 0.420(D)$. ($R^2 = 0.93$). For production of stockers in single or multiple-batch, the equation was estimated to be: $SH = -0.174 - 1.365 \times 10^{-6}(SD) + 0.017(SS) + 0.002(D) - 0.062(B)$. ($R^2 = 0.94$). Regression results indicated that stocking density and size at stocking both significantly ($P < 0.05$) influence the size of fish at harvest when producing fingerlings in single-batch. The days of culture variable was weakly significant ($P = 0.06$). The stocker regression results indicated that stocking density, size at stocking, culture days, and batch system significantly ($P < 0.05$) influence the size of fish produced at harvest. It is apparent that there are many different ways to produce a given size of fish, but producers often do not have a good basis from which to make these decisions. The relationships estimated will be used to develop user-friendly means of assisting fish farmers or hatchery managers in the adjustment of culture practices to meet production goals.