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Abstracts are listed alphabetically by presenter.

RECOVERY OF ENDANGERED FOUNTAIN DARTER HABITAT FOLLOWING A PERIOD OF EXCEPTIONAL DROUGHT

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Recovery of spring ecosystems following periods of extreme drought is critical for maintaining biodiversity. The fountain darter *Etheostoma fonticola*, is a federally endangered percid endemic to the headwaters of the San Marcos and Comal springs of central Texas. Following a year of exceptional drought conditions, we examined fountain darter habitat in the Comal Springs ecosystem (considered the most at-risk population) for signs of recovery. Localized recovery was observed including the return of higher quality habitat as indicated by vegetation type, number of darters sustained per square meter, and community structure (macroinvertebrates and fishes). Future work will also characterize changes in fountain darter diet as it relates to microhabitat changes, and describe trends in exotic gill parasite numbers, a possible threat to extirpation during periods of low flow. Insight from this study will guide recovery actions in times of extreme disturbance.

Keywords: drought, recovery, springs, ecology

GENETIC STRUCTURE AND DIVERSITY OF VARIEGATE DARTERS (*ETHEOSTOMA VARIATUM*) IN THE BIG SANDY RIVER DRAINAGE

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Variagate darters (*Etheostoma variatum*) are widespread throughout the upper Ohio River drainage, but the effects of landscape features on the population genetic structure of this species are unstudied. We used microsatellite DNA markers to investigate the population genetic structure and diversity of variegate darters in the Big Sandy River drainage in southwestern Virginia and southern West Virginia. Results of both STRUCTURE and F_{ST} analyses indicated the existence of at least two populations (Tug Fork and Levisa Fork), and possibly three populations (Tug Fork, Levisa Fork upstream and downstream of Fishtrap Lake). A flood control dam was constructed on the Levisa Fork to create Fishtrap Lake in 1968, and genetic analyses indicated genetic differentiation via random genetic drift occurring upstream

and downstream of the dam. Levels of genetic diversity within all three populations were consistent with large contemporary effective population sizes, and no population exhibited evidence of a recent bottleneck. Most genetic variance (95%) was found to be between individuals within populations, while 4% of the variance was among drainages. Genetic variance was not large between populations (<1%), and pairwise F_{ST} values indicated greater genetic differentiation between Tug Fork and Levisa Fork drainages than between populations upstream and downstream of the reservoir on the Levisa Fork. Despite large numbers of breeders, Fishtrap Lake dam has affected the population structure of variegated darters, and it is likely that populations in the Levisa Fork will continue to differentiate without either the removal of the dam or translocation of breeding individuals between populations.

Keywords: *Etheostoma variatum*, variegated darter, barriers, genetic structure, microsatellite

INFLUENCES OF SEASONAL RIVER FLOW ON RECRUITMENT OF SHORTNOSE STURGEON, *ACIPENSER BREVIROSTRUM*, IN THE ALTAMAHA RIVER, GEORGIA

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The shortnose sturgeon is a small, long-lived, late-maturing amphidromous sturgeon species inhabiting large tidal rivers on the Atlantic coast of North America. In response to range-wide declines caused by overfishing and habitat degradation, shortnose sturgeon were listed as endangered in 1967. Like other Acipenserids, shortnose sturgeon require specific habitats in freshwater rivers areas for successful reproduction. Presently, long-term studies assessing the influence of in-river conditions on shortnose sturgeon recruitment are lacking. The objective of this study was to quantify the effects of river flow on shortnose sturgeon recruitment in the Altamaha River, Georgia. From 2004-2010, we used entanglement gear to conduct mark-recapture estimation of the population of age-1 shortnose sturgeon within the Altamaha River. Data were analyzed using the Huggins closed-capture model in Program Mark. Over the seven years of the study, age-1 population estimates varied from 31 to 3860 individuals. Age-1 population estimates were then used as an index of recruitment and compared to seasonal high and low river flows. Our results showed that recruitment of shortnose sturgeon in the Altamaha River was positively linked to the duration of high flow (>75th percentile) during the spring spawning season. We suggest that future studies determine how natural and anthropogenic changes in freshwater inputs may affect long-term viability of the Altamaha River shortnose sturgeon.

Keywords: Shortnose sturgeon, recruitment, flow, endangered

PRELIMINARY ANALYSIS OF FISH COMMUNITY COMPOSITION AND HABITAT IN THE FLINT RIVER WATERSHED OF NORTH ALABAMA

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A study of fish community composition and response to changes in the land use/land cover (LULC), specifically urbanization effects, was initiated in 2009 in the Flint River watershed of North Alabama. Land use/land cover changes in the Flint River watershed have included increases in suburban and urban development, impervious surfaces, and a decrease in rural agricultural and pasture lands. The Flint River contains a highly diverse assemblage of fish species including several rare species of darters. Electrofishing surveys and habitat data were collected yearly at 10 locations within the Flint River watershed including headwater tributaries and main stem sites. Land use/land cover data was obtained

for 2005 using object-based classification in ERDAS. Principle Components Analysis was used to determine those habitat variables most important to fish assemblages in the Flint River. Land use/Land cover and habitat variables derived from PCA were used in conjunction with fish data in a Canonical Correspondence Analysis to examine the relationship between habitat variables, LULC, and fish distributions in the Flint River. Additional data will be collected through 2011.

Keywords: Flint River Alabama, land use/land cover, habitat, urbanization, fish communities

ENTRAINMENT AND RECOVERY OF STURGEON THROUGH THE BONNET CARRÉ SPILLWAY DURING FLOODING OF THE MISSISSIPPI RIVER

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We present a case study in which sturgeon were entrained during operation of a water diversion structure, and subsequently rescued and returned to the river. Data obtained in this effort were used to estimate total numbers of sturgeon lost and impacts to the population. Construction of the Bonnet Carré Spillway near Norco, LA diverts water from the Mississippi River into a floodway that empties into Lake Pontchartrain, which reduces flooding in New Orleans, LA. Opened only nine times since its construction, the U.S. Army Corps of Engineers opened the spillway 11 Apr 2008 (first time since 1997), diverting 4500 cms (max=7079 cms) from the Mississippi River, and closed it 8 May 2008. A major concern was that endangered pallid sturgeon (*Scaphirhynchus albus*) and common shovelnose sturgeon (*S. platyrhynchus*) were entrained. Sturgeon were captured quickly and easily using a variety of gears: electricity, gill nets, hoop nets, trotlines, trawling, and seining until the canal became dewatered and sampling discontinued. A total of 14 pallid sturgeon and 41 shovelnose sturgeon were obtained over a five week period. All sturgeon were measured, tagged, and released back into the Mississippi River. Under Section 9 of the U.S. Endangered Species Act, the presence of pallid sturgeon below Bonnet Carré Spillway, constitutes loss (or “take”) requiring consultation with the US Fish and Wildlife Service. We developed four approaches of estimating the total number of pallid sturgeon loss: historical precedent, hydrology of the floodway, biology of the fish, and statistical models. We estimated 0 to 123 pallid sturgeon were potentially entrained. Captures of endangered species below river structures are troubling for conservationists, but our experiences at Bonnet Carré Spillway indicate that sturgeon can be rescued, relocated, and used to evaluate losses and impacts to the population.

Keywords: water diversion, entrainment, sturgeon, *Scaphirhynchus*

ANALYSIS OF THE FISH ASSEMBLAGES IN THE COOSAWATTEE RIVER DOWNSTREAM OF CARTERS LAKE: DOES THIS HIGHLY ALTERED REACH PROVIDE HABITAT FOR IMPERILED FISHES?

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Although extensive surveys have been conducted on neighboring Etowah and Conasauga Rivers, little is known of the fishes in the Coosawattee River downstream of Carter’s Lake. Boat electrofishing surveys for sportfishes were conducted in 1968, 1983, and 2003, but few surveys have targeted small-bodied nongame fishes. The paucity of sampling can be attributed to high water levels and limited access points on the lower portion of the river. As part of a project to aid commercial navigation, the US Army Corps

of Engineers removed gravel bars and dynamited bedrock in the lower Coosawattee River in the late 1800s. In 1974, Carter's hydroelectric dam and re-regulation dam were completed, fragmenting the Coosawattee at river kilometer 42. Collectively, these impacts have resulted in an altered flow and temperature regime, fragmentation of fish populations, and extremely limited shoal habitat. Renewed interest in the lower Coosawattee was sparked by an effort to revise the water management plan for Carter's Lake, which could improve habitat quality downstream. Recent surveys for this project, which consisted of backpack electrofishing and kick seining at ten shallow water habitat sites, have led to the discovery of the federally endangered amber darter (*Percina antesella*) and the state endangered freckled darter (*Percina lenticula*) in the Coosawattee River system. These surveys have also documented persistence of the state endangered trispot darter (*Etheostoma trisella*), which is poorly represented in historic collections. However, the federally threatened goldline darter (*Percina aurolinata*) has not been observed in this reach of the Coosawattee since 1998 despite its prevalence upstream of Carter's Lake. Currently, there are 60 native species and eight introduced species known from the Coosawattee River below Carter's Lake. We recommend additional sampling to better assess the status and habitat requirements of rare fishes in the lower Coosawattee.

ONE FISH, TWO FISH, RED FISH, WHO FISH: PRELIMINARY ATTEMPT TO CLARIFY PHYLOGENETIC RELATIONSHIPS AMONG *NOTROPIS LUTIPINNIS*, *N. CHLOROCEPHALUS*, AND *N. SP. CF.*

CHLOROCEPHALUS

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Notropis chlorocephalus and *Notropis lutipinnis* are sister taxa within the subgenus *Hydrophlox*; however, Broad/Santee and Lynches/Pee Dee populations, previously designated as *N. lutipinnis*, may be more closely related to *N. chlorocephalus*. Historically *N. chlorocephalus* was considered endemic to the Catawba River system in North Carolina and very northern South Carolina, but recently the range has been extended to include the Broad/Santee and Lynches River systems in North Carolina and South Carolina. There is no consensus in the literature as to the number of species, phylogenetic relationships, and distributions of this complex. We are beginning to investigate the relationships among these taxa using molecular markers (ND2 mtDNA and ITS1 nucDNA) and including multiple individuals from at least five populations within each river system. Preliminary results support a sister relationship between Catawba River *N. chlorocephalus* and Broad/Santee populations of *N. lutipinnis*/*N. sp. cf. chlorocephalus*. Placement of Lynches/Pee Dee populations are being investigated. We hope to create a framework to clarify number of species present, distributions, and evolutionary relationships for these closely related taxa.

Keywords: *N. chlorocephalus*, *N. lutipinnis*, phylogenetics, distribution

DIET AND FEEDING-RELATED MORPHOMETRICS OF THE BLACKSTRIPE TOPMINNOW, *FUNDULUS NOTATUS*

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The *Fundulus notatus* species complex consists of three described species: *F. notatus*, *F. olivaceus* and *F. euryzonus*. *F. notatus* and *F. olivaceus* have broad overlapping ranges with many populations being found both in and out of contact zones. Contact zones are generally found in mid reaches with *F. olivaceus* dominating headwaters and *F. notatus* larger rivers downstream. Both species share similar ecological niches so the mechanism allowing for stable coexistence in contact zones is unknown. The

purpose of this study was to examine variability in diet and feeding morphology of *F. notatus* in sympatry and allopatry across three drainages. Both *Fundulus* were sampled in Pascagoula River, Pearl River and Neches River contact zones in the summer of 2008. As a control for plastic effects, both *Fundulus* were reared in syntopic and allotopic common garden mesocosms. Fish were genotyped and feeding-related morphometrics were taken (standard length, body width, body depth, head length, head width, head depth, interorbital distance, preorbital length, orbit length, postorbital length, gape width, gape height, maxillary length and dentary length). Analyses were conducted to determine if there were ontogenetic shifts or sexual dimorphisms in allotopic and syntopic populations. Analyses were also conducted to determine if there were differences among species and syntopic-allotopic populations.

Keywords: *Fundulus notatus*, contact zone, feeding, diet, syntopic and allotopic

A CHECKLIST OF THE FRESHWATER FISHES OF THE PATAPSCO RIVER BASIN IN MARYLAND

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Maryland has a relatively diverse freshwater ichthyofauna with 91 species in its non-tidal rivers and streams. River basin specific fish lists and distributions are generally lacking in the state however. Sampling by the Maryland Department of Natural Resources (MDDNR) Maryland Biological Stream Survey (MBSS) has provided a thorough statewide database of the contemporary distributions of freshwater fishes across the state, as well as information on associated physical habitat, water chemistry, and landscape data from 1995 to the present. The focus of this study is the Patapsco River basin, located in central Maryland. Data from the MBSS is supplemented with fish records from an extensive literature review and university and museum collections to produce a comprehensive checklist of the freshwater fishes of this river basin. Additional emphasis is placed on the compositions of the fish and benthic macroinvertebrate assemblages in proximity to three dams on the lower portion of the Patapsco River mainstem.

Keywords: fishes, Patapsco River, Maryland, dams

FISH ASSEMBLAGE PATTERNS FOLLOWING AN ACUTE DISTURBANCE CAUSED BY COAL MINING WITHIN THE CONTEXT OF THE REGIONAL CONDITION

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Coal mining within the Appalachian Mountains is pervasive and the impacts of the practice on water quality and aquatic life have been well documented within the region. However, the recovery of fishes following a coal mining environmental disaster is not well documented. In October 2000 an estimated 1.14 billion liters (300,000,000 US gallons) of coal slurry were released into two adjacent watersheds, Coldwater Fork and Wolf Creek, in Martin County, Kentucky. Approximately 32 river kilometers within the two watersheds were considered void of life. Monitoring stations (3 control and 5 disturbed sites) were sampled annually within the two watersheds for fishes in October from 2000 – 2008. To measure ecological function following the spill the Kentucky Biotic Index of Integrity (KIBI) was used. Richness metrics and the overall KIBI score indicated the impacted sites achieved levels similar to the control sites within a few years. However in the context of the regional benchmark, both the control and impacted sites were lower than the regional reference condition in a variety of water quality parameters and fish metrics. A non-metric multidimensional scaling ordination showed the species composition for several

impacted sites and control sites were still dissimilar to each other, and distinctly unique from the regional reference condition. Overall, the two impacted streams have recovered to a certain level of ecological function prior to the acute disturbance but the chronic disturbance legacy within the watersheds is the limiting factor for these systems, because of increased sedimentation and elevated conductivity levels.

Keywords: environmental disaster, fish recovery, reference condition

REGIONAL WATER PLANNING IN GEORGIA

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Georgia adopted its first statewide water plan in February 2008 as authorized by the 2004 Comprehensive State-wide Water Management Planning Act. The 2008 State Water Plan defined a framework for development of regional water plans that will span the entire state. The Plan established 10 water planning regions and 10 regional water planning councils, whose charge is to develop and submit recommend regional water plans to the Director of the Environmental Protection Division. Councils began work on regional plans in 2009 and are on track to complete recommended regional water plans for public comment and adoption by July 2011. Once adopted by the GAEPD Director, regional plans will guide EPD permitting and state grant and loan programs. This poster session will provide an overview of regional planning and the status of each of the regional Councils.

INTERSPECIFIC INDUCED SHIFTS OF HABITAT USAGE AMONG A BENTHIC COMMUNITY OF FISHES

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To better understand assemblages of sympatric populations of *Etheostoma* darters, we examined the distribution of eight darter and one madtom species (*Noturus flavus*) based in 14 riffles in the Ohio River basin. Our hypothesis was more specialized species would cause shifts in habitat usage of more broadly distributed species. We expected this pattern to be most evident in riffles of high species richness. Over 700 samples were taken by seine at 14 riffles in ten streams in the Ohio River drainage to test our hypothesis. First, we used CCA to visualize the relationships between species and flow, depth, and substrate composition. Common species such as *E. blennioides* and *E. zonale* were associated with sand and gravel while rarer species such as *E. camurum* and *E. maculatum* were associated with cobble, higher flow and deeper segments. The strength of these relationships was more apparent for subgenus *Nothonotus* males when sex and ontogeny were examined. Second, using a univariate density estimator, we were able to produce distribution curves of habitat use with and without the presence of an associated species, and detect significant shifts in habitat use. We found significant shifts in habitat usage for most species where we were able to make comparisons and supported our hypothesis that specialized species would cause shifts in habitat usage of more common species. For example, the greatest number of significant shifts occurred in the presence of *E. flabellare*, *E. maculatum* and *E. variatum*, while these species exhibited the least number of shifts in the presence of their associates. Perhaps more revealing is that *Noturus flavus* produced shifts for all species with the exception of *E. flabellare*, while only shifting its habitat use in the presence of *E. maculatum* and *E. variatum*.

Keywords: *Etheostoma*, darter, niche, habitat usage, shift

POPULATION RECOVERY OF AMERICAN SHAD IN THE EDISTO RIVER, SC: USING GENETICS TO CHARACTERIZE POPULATION DYNAMICS AND STOCKING CONTRIBUTION

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American shad is a diadromous species of fish that supports an important commercial and recreational fishery within river systems along the eastern coast of the United States. The 2007 Atlantic States Marine Fisheries Council stock assessment of American shad indicated declines in both commercial landings and catch per unit effort over the last fifteen years within the Edisto River population and recovery efforts are being planned. The goal of our project is to determine if larval stocking will be a viable management tool for enhancing the Edisto River American shad population. Nearly five hundred genetic samples have been collected during the 2008-2010 sampling seasons. All samples have been genotyped at thirteen *Alosa*-specific microsatellite loci. Initial evaluation has indicated high confidence in the utilization of our suite of markers for parentage analysis and identifying individual fish. Additionally, an initial evaluation of our stocking program detected no difference in genetic composition among the broodstock and field collections in either 2009 or 2010. We have determined that no temporal genetic differentiation exists between sampling periods, and effective population size estimates for the Edisto River are low. Our first evaluation of stocking contribution will occur this fall, with estimates of contribution to the 2010 year class prior to their out migration. We will continue monitoring the population genetics of American shad in the Edisto River over the next several years as well as determine stocking contributions for both the 2009 and 2010 year-classes during their return spawning migrations. The project results will be critical in designing effective long-term management efforts through our increased understanding of American shad spawning and juvenile survival in the Edisto River.

SHIFTS IN FISH ASSEMBLAGE STRUCTURE AS A RESULT OF WATER AVAILABILITY AND AGRICULTURAL LAND USE IN A PORTION OF THE MIDDLE CHATTAHOOCHEE RIVER DRAINAGE

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Drought and water removal by humans threaten the existence of fishes all around the world. The shifting of fish assemblages over time due to habitat change is a growing concern as water availability becomes more limiting. Agricultural land use also negatively affects freshwater systems and has been shown to reduce habitat complexity, significantly impacting downstream fish community structure. The combination of water removal and nutrient loading from agriculture is jeopardizing the availability of a resource that is essential for fish community stability. The use of historic data is very beneficial for documenting these shifts and allowing for the evaluation and possible remediation of several habitat changes that cause these shifts. This study focuses on the effects water withdrawal and agricultural land use have on fish assemblages in a portion of the Middle Chattahoochee River Drainage. With the use of ESRI ArcMap, land use in the Uchee, Wacoochee, and Halawakee Creek watersheds was analyzed. Sites were selected based on historic data availability, stream order, surrounding land use, and physiographic region. Historic data from 2004-2006, and 2009 will be used in comparison with data from fishes collected at forty-nine sites in the summer of 2010. Jaccard and Morista similarity indices will be calculated to determine the change in fish assemblages relative to surrounding land use at each site and will be presented as preliminary data. Future work will include exploration of the role spawning mode plays in these assemblage shifts, and further analysis of additional complexities in the system. This type of study not only explores the mechanisms of fish assemblage shifts, it also provides implications for

freshwater conservation as a whole. Research in this area is needed to help stop further damage from occurring to freshwater systems, and to educate the public on steps they can take to protect stream ecosystems.

Keywords: drought, agriculture, fish, assemblage

GENETIC ISOLATION AS A RESULT OF DAM CONSTRUCTION: A LOOK AT THE EFFECTS ON TWO SPECIES OF DARTERS

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The addition of dams into a riverine system causes a wide range of changes to the river as well as to the fish assemblages of that river. Although there have been many studies documenting the changes that occur to the fish assemblages in the impounded river, there have been fewer studies examining the effects of the reservoir on the fish inhabiting the tributaries upstream of the impoundment. One possible impact of the reservoir downstream is that it might act as a barrier to fish migration from one stream to another. To determine the extent to which reservoirs restrict migration, we looked for genetic isolation in two species of darters, *Etheostoma caeruleum* and *Etheostoma kantuckeense*, from the Barren River Lake drainage basin. Twenty individuals of from each species were collected from a total of 6 sites (3 streams directly connected to Barren River Lake, 3 streams directly connected to Barren River upstream of the reservoir). Individuals have been genotyped at 5 microsatellite loci to determine the degree to which each population is isolated. If the reservoir is restricting gene flow between populations, we predict that the populations in streams directly connected to Barren River Lake will have lower allelic diversity, lower heterozygosity, and more population structure than the populations in streams directly connected to Barren River.

Keywords: habitat fragmentation, *Etheostoma caeruleum*, *Etheostoma kantuckeense*

REPRODUCTIVE BIOLOGY OF THE FRECKLEBELLY DARTER, *PERCINA STICTOGASTER* (TELEOSTEI: PERCIDAE)

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The reproductive biology of the frecklebelly darter, *Percina stictogaster*, was studied in the Red River, Menifee-Powell counties, Kentucky, from 2009-2010. Based on length-frequency data, this species is reproductively mature at about Age II. Spawning occurs from early March to early April in water temperatures of 7-16° C in areas with strong current and fine gravel. Aquarium observations confirm that this species buries its eggs in a manner similar to other *Percina* darters. Fertilized eggs are about 2.5 mm in diameter, clear, demersal and slightly adhesive. At 10° C eggs hatched in 18-25 days (100% survival) into larvae 7-8 mm TL. Larvae are initially benthic, but become pelagic a few days later. By about 11 mm TL, the yolk sac was absorbed, and the young return to the bottom. By early June, young (about 2 months old) are 16-25 mm SL and developing diagnostic pigmentation. They, along with the adults, occupy areas with *Justicia* or coarse woody debris in quiet water over sandy substrates. Compared to sympatric darters, early spawning results in relatively large young, which may reduce predation in this relatively pelagic species.

Keywords: *Percina*, *stictogaster*, reproduction, early development

LoCoH IN AN ARTIFICIAL STREAM: USING A GIS TO MAP THE EFFECTS OF RAINBOW TROUT ON NATIVE MINNOWS

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Rainbow trout (*Oncorhynchus mykiss*) are widely stocked, worldwide, to supplement naturalized populations and support put-and-take fisheries, despite the evidence that salmonid introductions may negatively impact native fishes. We conducted experiments in a model stream to assess the effects of hatchery rainbow trout on the space use of warpaint shiners (*Luxilus coccogenis*), a common cyprinid in Southern Appalachian streams. We used the LoCoH algorithm, commonly used to describe the home ranges of radio-tagged mammals, to generate polygons describing the areas used by warpaint shiners before and after the introduction of a rainbow trout. Rainbow trout did not affect the edge/area ratio of the shiners' use polygons, but significantly increased the mean size of a shiner's use polygon by 57%. Both rainbow trout and two control treatments reduced the average overlap between individual shiners' home ranges. When rainbow trout were present, warpaint shiners were displaced from their baseline habitat use into microhabitats with significantly higher current velocities. These effects were consistent across two realistic densities of warpaint shiners, under two seasonal temperature and light regimes, and were not observed during controls.

Keywords: Rainbow trout, Warpaint shiner, LoCoH, spatial ecology, laboratory experiment

EVALUATION OF HABITAT UTILIZATION, RECRUITMENT BOTTLENECKS AND MOVEMENT OF A COASTAL STRIPED BASS POPULATION

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The ultimate goal of our current striped bass research is to build a restoration model for coastal striped bass; here we report our ongoing evaluation of habitat utilization, recruitment bottlenecks and population dynamics in the Ashley River, SC. Our project utilizes cultured animals and molecular genetic tools to minimize risk associated with re-establishing a coastal population of striped bass and to address these challenging ecological questions, building upon preliminary research in this system that once sustained a natural striped bass population. Unlike our preliminary results, we have not detected any recruitment bottlenecks during our first year of implementing a full factorial stocking design and an expanded sampling area. We have documented through GIS-based evaluation substantial utilization of upstream reaches of coastal streams, specifically with older fish using the uppermost reaches of the system while the young of year fish were recaptured more often in the mid reaches. Even with the increased sample sizes this spring, we had no multiple recaptures of fish to evaluate within-system movement; however, our standardized random sampling throughout coastal SC allowed us to document low levels of striped bass movement between systems. Samples from 2010 included the identification of eight non-stocked fish from the 2009YC within the Ashley River, suggesting evidence of natural reproduction within the system or recruitment into the system for the first time in several decades. Genetic-based restoration designs require a full understanding of the natural population genetic diversity, estimated survival of stocked animals and appropriate strategy for re-introducing animals back into the system. Therefore, through the continuation of our striped bass research within the Ashley River, we will be able to robustly determine the potential for establishment and sustainability of a population within this coastal system.

CONSERVATION STATUS OF THE KENTUCKY ARROW DARTER, *ETHEOSTOMA SAGITTA SPILOTUM*

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The Kentucky arrow darter, *Etheostoma sagitta spilotum*, is restricted to the upper Kentucky River basin in eastern Kentucky. Its range is separate from that of the Cumberland arrow darter, *Etheostoma s. sagitta*, which is restricted to the upper Cumberland River basin in Kentucky and Tennessee. From 2007 to 2009, we completed range-wide surveys for *E. sagitta spilotum* using backpack electrofishing methods. We visited 68 of 73 historic streams and 100 of 119 historic sites. Surveys revealed that *E. sagitta spilotum* had declined significantly across its range, with observations of arrow darters limited to only 33 of 68 historic streams (49 percent) and 45 of 100 historic sites (45 percent). Based on our observations and a review of the literature, we believe the observed decline of *E. sagitta spilotum* can be attributed to water quality and habitat degradation across its range. A variety of human activities - coal mining, logging, agriculture, gas/oil well exploration, and land development - have contributed to the decline, but coal mining activities represent the most imminent and significant source of these threats. Mined areas, especially those with valley fills, have the potential to alter the water quality of receiving streams through inputs of dissolved metals and other dissolved solids that elevate stream conductivity and increase sulfate levels. Our study demonstrated that *E. sagitta spilotum* is excluded from mined watersheds when conductivity levels exceed about 350 μ S. Historic Kentucky arrow darter sites that lacked darters had higher conductivity values (average = 680 μ S) than historic sites that continued to support arrow darters (average = 105 μ S). Based on the subspecies' decline and the magnitude and imminence of its threats, the U. S. Fish and Wildlife Service has determined that *E. sagitta spilotum* warrants listing under the Endangered Species Act.

Keywords: Kentucky arrow darter, *Etheostoma sagitta spilotum*, Kentucky, conservation status, conductivity

GENETIC STRUCTURE OF THE IMPERILED TRISPOT DARTER, *ETHEOSTOMA TRISELLA*, IN THE COOSA RIVER DRAINAGE OF THE MOBILE BASIN

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The Trispot Darter, *Etheostoma trisella*, is endemic to the Coosa River drainage (Mobile Basin). This species is a member of the subgenus *Ozarka*, a group of colorful darters which rely upon spring seeps in ephemeral streams for spawning. Their unique life history strategy makes them extremely susceptible to habitat alteration and destruction. *Etheostoma trisella* has been considered extirpated in Alabama since historic sites were inundated by reservoir construction in the mid 1900s, but was rediscovered in Alabama in 2008. Phylogenetic analysis of complete mitochondrial ND2 gene sequence data of *E. trisella* from Alabama, Georgia, and Tennessee populations revealed only slight haplotype variation (< 1% sequence divergence). This is unexpected given 1) the patterns of differentiation of other fishes with disjunct populations in the middle and upper Coosa River (e.g. *E. brevirostrum*) and 2) the highly divergent populations of another Alabama *Ozarka* species, the Slackwater Darter (*E. boschungii*), which has up to 8.5% mtDNA sequence divergence between populations in separate tributaries to the lower bend of the Tennessee River. However, the lack of shared haplotypes between middle (Alabama) and upper (Georgia and Tennessee) Coosa River populations of *E. trisella* suggests that geographic distance may influence genetic structure. Microsatellite data are being incorporated to further examine genetic

structure and demographic history of *E. trisella* populations. The combined dataset will provide valuable information to guide proper conservation planning for this imperiled darter.

Keywords: *Etheostoma trisella*, genetic structure, conservation genetics, gene flow

GENETIC DIVERGENCE AND SYMPATRIC OCCURRENCE OF THE SPRING INHABITING COLDWATER DARTER (*ETHEOSTOMA DITREMA*) AND AN UNDESCRIBED STREAM INHABITING FORM (*E. SP. CF. DITREMA*)

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The Coldwater Darter, *Etheostoma ditrema*, is a groundwater-dependent species endemic to the middle and upper portions of the Coosa River drainage in Alabama, northwest Georgia, and a small portion of southern Tennessee. The species is state-protected throughout its range, but widespread degradation of its delicate spring habitats, drought, and groundwater pumping may cause rapid population losses over the next few decades. Thus, knowledge about the genetic composition of this species throughout its range may be useful in immediate and future conservation planning for this unique fish. Previous morphological and allelic analyses revealed a unique stream inhabiting form in the middle Coosa River in Alabama and a possible third distinct form in Coldwater Spring, Calhoun County, Alabama. Using a combination of mitochondrial (mt) and nuclear DNA, molecular diversity and evolutionary history of the *E. ditrema* complex were examined with respect to the Gulf Darter (*E. swaini*), its widespread lowland sister species. Phylogenetic analyses recovered a sister relationship between *E. swaini* (Cahaba River) and the stream-occupying *E. sp. cf. ditrema*, which was sister to *E. ditrema*. Substantial mtDNA divergence (2.95%) was revealed among spring and stream forms of *E. ditrema*. Interestingly, our analyses revealed that the mtDNA haplotypes from both spring and stream forms co-occur in at least one locality at their zone of contact. Ongoing morphological and molecular analyses are being conducted to understand whether populations in the contact zone hybridize or maintain their morphological and molecular identity.

Keywords: genetic divergence, spring populations, phylogeny, conservation genetics, Coldwater Darter

SYMBIOTIC REPRODUCTION AND PATTERNS OF RARITY VERSUS COMMONNESS AMONG NEW RIVER, VIRGINIA, CYPRINIDS

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The predominant model for conservation of biodiversity is the protection of species or distinct populations. Protection is generally conferred if a species or population exhibits some aspects of rarity, maintains a population size below viability, shows consistent downward trend in population size, or faces current or eminent threats. Protection is usually of the nature of lessening direct anthropogenic threat to the species or its habitat. Conservation strategies could also utilize the fitness role of symbiotic interactions such as mutualisms, commensalisms, or parasitisms that may be favorable to imperiled species. Such a model may require maintaining larger than just viable sizes of populations of non-imperiled species. I studied 12 cyprinid species of the New River basin, Virginia, with focus on their tendency toward association with bluehead chub *Nocomis leptocephalus* nest for spawning and aspects of rarity (or commonness) exhibited by each species. Six out of seven species with the strongest tendency toward chub-nest association exhibited one or more aspects of rarity relating to small

geographic range, restricted habitat, or small local populations whereas all four species considered weak or facultative nest-associates exhibited commonness. In a related study, the nesting activity of bluehead chub has been shown to promote its persistence in urbanized streams, thus potentially providing the spawning environment needed for persistence of its nest-associates in these streams. If the observed patterns of rarity and commonness of cyprinids mediated by mode of reproduction is found pervasive in the family, successful conservation of the rare (and often imperiled) species may depend not only on protection of habitat but also of the symbiotic relationships with other species. I recommend further studies for a better understanding of the fitness consequences of the coevolved modes of reproduction among chubs and their nest-associates.

Keywords: Bluehead chub (*Nocomis leptcephalus*), nest association, coevolution, rarity, conservation of symbioses

DEVELOPMENT OF A NON-LETHAL APPROACH FOR ASSESSING STRESS IN FRESHWATER MUSSELS

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The Southeastern U.S. is home to a diverse assemblage of freshwater mussels, which are the most imperiled fauna in North America. Threats to this group overlap with those to freshwater fishes and include habitat degradation, pollution, and alterations to natural flow regimes. Evidence of decline or stress in mussel populations is not only of interest in the context of mussel conservation, but can also indicate stressors that will eventually affect fishes and other stream biota. For example, the Flint River Basin is highly impacted by agricultural water usage, and is home to a diverse assemblage of aquatic organisms including endemic fishes and five federally listed mussel species. Due to the imperiled status of these mussels, the development of effective nonlethal biomonitoring techniques is imperative. Changes in tissue glycogen and hemolymph chemistry profiles are potential biomarkers for non-lethally monitoring stress in freshwater mussels. To assess how these parameters may change in response to a stress event, lab studies were conducted in which little spectaclecase (*Villosa lienosa*), southern rainbow (*V. vibex*) and elephant ear mussels (*Elliptio crassidens*) were exposed to three temperature treatments: 25°C, 30°C, and 35°C. Tissue and hemolymph samples were collected from five different animals in each temperature treatment at Day 0, 3, and 7. Tissue samples were analyzed for glycogen levels and hemolymph was analyzed for a suite of parameters with a Hitachi Blood Chemistry Analyzer. Glycogen levels and hemolymph chemistry parameters that responded to stress (high temperatures) will be incorporated into a biomonitoring approach for wild populations of imperiled freshwater mussels in the Flint River Basin. Field validation of this approach is in progress. These data will help inform managers of at-risk populations prior to large-scale mortality events.

Keywords: freshwater mussels, biomarkers, stress, hemolymph

STATUS OF ATLANTIC AND SHORTRNOSE STURGEON IN THE SATILLA AND ST MARYS RIVERS, GA

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Atlantic and shortnose sturgeons are components of the biodiversity of fishes in the rivers of the North American Atlantic coast, but overfishing and habitat destruction have extirpated many populations. Historical records indicate that both species once inhabited the Satilla and St Marys Rivers, Georgia, but neither species has been documented in recent years. The objective of this project was to assess the

population status of Atlantic and shortnose sturgeon in the Satilla and St Marys Rivers, and to evaluate the current habitat availability for these species in each river system. A rigorous sampling program for both species was initiated in October 2008 and continued to July 2010. We expended >2800 hours of sampling effort on both river systems. On the Satilla River we captured 220 Atlantic sturgeon, but only eleven shortnose sturgeon. Only 9 Atlantic sturgeon and one shortnose were captured on the St Marys. Weekly measures of basic water quality suggested that low dissolved oxygen (<3 mg/L) and high water temperatures (>27°C) during the summer months may affect survival and growth of young sturgeon that require freshwater riverine habitats. While our findings suggest that a remnant population of Atlantic sturgeon may still remain in the Satilla River, habitat degradation from current agricultural, silvicultural, and municipal developments will likely jeopardize the continued existence of both species in these rivers.

DOES TURBIDITY DISRUPT VISUAL SIGNALING AND SEXUAL SELECTION IN CYPRINID FISHES?

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The spread of introduced red shiner (*Cyprinella lutrensis*) and hybridization with native blacktail shiner (*C. venusta*) in the Coosa River basin presents opportunities to demonstrate how novel management strategies could prevent the loss of native species. Repeated surveys indicate that a hybrid swarm formed around 1998, following at least 6 years of intermittent hybridization (Walters et al., 2008). Since 2001, the hybrid swarm has been rapidly expanding up river, but colonization remains largely limited to mainstem reaches (Walters et. al 2008). Hubbs et al. (1953) and Jurgens (1951) observed that episodes of hybridization between naturally sympatric red shiner and blacktail shiner in the Guadalupe River (Texas) and San Marcos River (Texas) coincided with increased turbidity resulting from excessive sedimentation. It has been shown that turbidity can influence sexual selection between aquatic organisms (Seehausen et al., 1997), however the extent to which turbidity can drive the evolution of reproductive behavior is unknown. To test the extent to which turbidity impairs visual communication, and weakens prezygotic sexual selection, I conducted a series of female mate-choice trials in clear and turbid conditions. Both blacktail shiner (*Cyprinella venusta*) and red shiner (*Cyprinella lutrensis*) were collected from the Lower Conasauga River in northwest Georgia, where blacktail shiner and non-native, red shiner (*Cyprinella lutrensis*) naturally co-occur and hybridize. Females were placed in experimental aquaria and given the opportunity to visually interact with both conspecific and heterospecific males. Twenty females of each species were tested in both clear and turbid (100mg/L) conditions. Preliminary data demonstrate that red and blacktail shiner females show preference for conspecific males under both clear and turbid conditions. These results suggest that visual impairment is an unlikely driver behind the formation of shiner hybrid swarms.

Keywords: mate-choice, environmental change, sexual selection, turbidity

POPULATION REGULATION IN SOME SOUTHERN APPALACHIAN STREAM FISHES

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We assessed the relative importance of density and environmental factors on a variety of demographic characteristics of longnose dace (*Rhinichthys cataractae*), rosyside dace (*Clinostomus funduloides*) and rainbow trout (*Oncorhynchus mykiss*) in a southern Appalachian stream drainage. We sampled fishes in

spring and fall in both 30m (3 sites) and 100m (3 sites) long sites between 1984 and 1995 and 1991 and 2004 respectively. The study period included years of high flows and two droughts (1985-1988 and 1999-2002). PCA demonstrated that habitat availability and flow varied in the sites among years (high flow years with erosional substrata vs. low flow years and increasing amounts of depositional substrata). Similar results were noted in all 6 sites. Using regression analysis and AIC, we found evidence of density-dependence on the per capita rate of increase for all species. Rainbow trout displayed the strongest effects of density-dependence and rosyside dace the least. Density – independent forces were most important for rosyside dace. Variation in standard length of both adults and YOY for all three species was primarily explained by both density – dependent and density – independent forces (i.e. flow variation). These data should yield insights into the process of population regulation in stream fishes and aid in their conservation.

Keywords: minnow, dace, Rainbow trout, density dependence, drought, floods

TEMPORAL CHARACTERISTICS OF MORPHOLOGICAL CHANGE IN *CYPRINELLA VENUSTA* ASSOCIATED WITH IMPOUNDMENT

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Dam construction is a potent ecological and evolutionary force in the aquatic landscape and can influence body shape in stream fishes. Comparisons of contemporary adjacent reservoir and stream fish populations have established that morphological shifts are associated with impoundment, but the temporal characteristics of those shifts are unknown. Museum collections provide the opportunity to examine such temporal trends after the fact. Here we present a study of the temporal characteristics of morphological change associated with impoundment, examining collections of *Cyprinella venusta* from the Tulane University Museum of Natural History, originally collected from the present-day site of Claiborne Lake between 1967 and 1986. Construction of the Claiborne Lock and Dam on the Alabama River fifteen miles northwest of Monroeville, AL, was begun by the Army Corps of Engineers in 1965. Navigation locks opened in 1969 and the dam was completed in 1976. Using geometric morphometrics, we quantitatively characterize year-to-year shifts in body morphology associated with the construction of Claiborne Lock and Dam on the Alabama River.

Keywords: impoundment, *Cyprinella*, geometric morphometrics, body shape

FISH ASSEMBLAGE SURVEY OF SELECTED SITES IN THE ALABAMA RIVER

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The Alabama River system is rich in species diversity, containing over 180 native fishes and at least 33 endemics. Many studies have surveyed critically imperiled fishes, such as the Alabama Sturgeon (*Scaphirhynchus suttkusi*), but few document the entire fish assemblage structure. Maintaining records of fish assemblage structure is necessary in monitoring species and assemblage composition over time. Current assemblage data can be compared to historic collections to detect shifts in assemblages and monitor the effects of habitat alteration. Our objective was to survey fish assemblages of selected Alabama River habitats. The sample sites in this study include historic collection localities, relatively undisturbed, and recently altered habitats. We plan to compare our data to the rich historic collections of R. D. Suttkus and G.E. Gunning, and the Geological Survey of Alabama. The study area is

concentrated to the most natural stretch of the Alabama River below Claiborne Lock and Dam. Our sample sites are focused on sand and gravel bar habitats where fish diversity is high and the habitat is suitable for seining. We collected fish by pulling 50' and 100' seines in the appropriate habitat. Since July 2010 we have collected 28 samples from 19 sand and gravel bars including day and night comparisons. These sites are located over 50 river miles from Claiborne Dam to Dixie Cutoff near Monroe Point. We have observed notable species in our collections including Gulf Menhaden (*Brevoortia patronus*) as far north as Alabama River mile 72 and Inland Silversides (*Menidia beryllina*) at river mile 60 and 68.8. We collected *Brevoortia patronus* at 15 of the 19 sample sites ranging from 1 to estimated 25,000 individuals. Future work will include seasonal samples allowing us to compare temporal variation, as well as studying the effects of sand bar size and spatial variation on the fish assemblage structure.

Keywords: fish, assemblage, Alabama River, Menhaden

MULTI-LOCUS PHYLOGENETIC ANALYSES REVEAL MITOCHONDRIAL INTROGRESSION AND PATTERNS OF NUPTIAL TRAIT EVOLUTION IN SPOTTAIL DARTERS (PERCIDAE: *ETHEOSTOMA*)

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The *Etheostoma squamiceps* species group (spottail darters) contains ten described species distributed in the Green, Cumberland, and Tennessee Rivers, as well as some small direct tributaries of the Mississippi River. During breeding season, males of several species of spottail darters develop prominent fin ornamentation (egg knobs) on the second dorsal fin that may serve to attract females to nests. The relationships among species in the group have been uncertain due to discordance among previously published phylogenetic analyses based on morphological and molecular data. Moreover, analyses based on a mitochondrial gene tree suggested multiple origins or losses of nuptial egg knobs. Here, I present a Bayesian multi-locus phylogenetic analysis based on sequence data from one mitochondrial gene and 13 nuclear loci. Results from this analysis support a single origin of nuptial egg knobs in spottail darters, and possibly two examples of mitochondrial introgression between egg knob bearing and non-egg knob bearing species.

PHYLOGEOGRAPHY OF *PERCINA NIGROFASCIATA*

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The Blackbanded Darter, *Percina nigrofasciata* possesses one of the largest geographic ranges within *Percina*, occurring throughout the Gulf Coastal Plain. Two subspecies were previously described by Crawford in 1956, *Percina nigrofasciata nigrofasciata* and *P.n.raneyi*. A note in the same study also recognized drainage-based "races." The wide geographic range and previous morphological investigation provides an excellent opportunity to investigate phylogeographic relationships of *Percina nigrofasciata*. Over 100 specimens were sampled throughout the Gulf Coastal Plain. Bayesian and maximum parsimony of cytochrome b reveal two non-monophyletic clades of *Percina nigrofasciata*, with a geographic breaking point at the Choctawhatchee River, but nuclear genes (RAG1 exon 3 and S7-intron1) do not recover the same results. Taxonomic implications of these findings will be discussed.

Keywords: phylogeography, *Percina*

ECOLOGICAL RESEARCH TO GUIDE ROBUST REDHORSE MANAGEMENT IN THE PEE DEE RIVER, NORTH AND SOUTH CAROLINA

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The robust redhorse (*Moxostoma robustum*) is a rare species that occurs from the Pee Dee River drainage of North and South Carolina to the Altamaha drainage of Georgia. Water quality problems and the construction of hydropower dams have altered habitat and restricted its range. The objectives of this collaborative research in the Pee Dee River were to determine robust redhorse population size, migratory patterns, and use and availability of spawning and non-spawning microhabitats. We used a Cormack-Jolly-Seber model with annual capture-recapture data from 2006 to 2009 to calculate annual population size. Population estimates of adult robust redhorse were very low and ranged from 38 (95% CI 23-80) individuals in 2006 to 55 (95% CI 34-118) individuals in 2008. Telemetry relocations and capture data indicate that there are resident and migratory subpopulations. The migratory subpopulation moves downstream after spawning (up to 100 rkm) into the South Carolina Coastal Plain region, while residents remain in deep pools near shoals in the Piedmont region. Three spawning shoals have been identified, but only two are consistently used. Spawning habitat consists of shallow, fast-moving water with gravel and cobble substrate and boulders as cover. Non-spawning habitat consists of deep, slow-moving pools with bedrock and sand substrates with boulders or coarse woody debris cover. Microhabitat suitability analysis and flow modeling suggest that augmented flows will increase suitable habitat during spawning and non-spawning periods. These results are playing an essential role in defining our robust redhorse management strategy in the Pee Dee River.

Keywords: Robust redhorse, microhabitat use, population size, telemetry

BURROWING BEHAVIOR AND SUBSTRATE PREFERENCES OF THE PIEDMONT BLUE BURROWER (*CAMBARUS HARTI*)

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The Piedmont Blue Burrower (*Cambarus (Depressicambarus) harti*) is a state-Endangered crayfish endemic to Georgia, found in only 3 confirmed extant populations in Meriwether County. *C. harti* constructs elaborate burrows in the highly organic soils associated with hillside seeps adjacent to streams in the Pine Mountain ridge, however very little is known about its basic biology, behavior, and ecology. As some of these populations are on unprotected property, knowledge of crayfish habitat preferences are vital when considering suitable alternative sites if translocation becomes warranted. In this study, we examined burrowing behavior and substrate preferences of *C. harti* using acrylic-sided artificial burrowing chambers (ABCs). We filled each of five ABC's on one side with type-locality soil and on the other a clay/sand mixture that has been shown to be an optimal substrate for the closely related *C. striatus*. A single *C. harti* was placed in each ABC and allowed to burrow over a period of 5 days. Using tracing paper and imaging software, we determined total and underwater burrow area for each substrate treatment over 5 days. Crayfish showed an overall preference for their type-locality soil in terms of total ($p < 0.001$) and underwater burrow area ($p < 0.001$). However, this preference was strongest on the first day of the experiment and decreased as crayfish expanded their burrows, with

most subsequent excavation occurring above the groundwater. These results suggest that *C. harti* has an immediate and below ground-water preference for its type locality soil, however will explore and build extensive burrows in other substrates.

IMPERILED FISHES OF LOWER SHADES CREEK, CAHABA RIVER DRAINAGE OF THE MOBILE BASIN

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Shades Creek is a major tributary of the Cahaba River with headwaters in Birmingham, AL. This stream has been severely impacted by the harmful effects of urbanization. In spite of its history of poor water quality and sedimentation, Shades Creek still provides suitable habitat for sensitive species along its lower reaches near its confluence with the Cahaba. Recent improvements in the Cahaba River drainage including the removal of a low head dam known as the Marvel Slab prompted a survey of lower Shades Creek to determine whether or not imperiled species found in the Cahaba may occur in portions of Shades Creek. The first survey was conducted in October 2006 and further study has continued through May 2010. These surveys have been targeted toward three protected species that are known to occur in the Cahaba near the mouth of Shades Creek, the federally endangered Cahaba Shiner (*Notropis cahabae*), federally threatened Goldline Darter (*Percina aurolineata*), and the state protected Coal Darter (*Percina brevicauda*). Our study has shown that populations of these three species do persist in Shades Creek. A total of 10 Cahaba Shiners have been collected in the lowermost riffles of Shades Creek with the most upstream collection being about 1.5 miles from the mouth of the Cahaba. A total of 90 Goldline Darters have been collected with the most upstream collection being about 4 miles from the mouth of the Cahaba. A total of 73 Coal Darters have been collected with the most upstream collection being about 3.5 miles from the mouth of the Cahaba. Efforts are currently under way to remove the remnants of a makeshift stream crossing constructed of modified rail cars. These submerged rail cars may be obstructing the migration of imperiled fishes in Shades Creek.

Keywords: Cahaba, endangered, restoration

SWIMMING TOWARD A BRIGHTER FUTURE: PROMISING DEVELOPMENTS FOR THE ENDANGERED CAPE FEAR SHINER

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Dams built for hydropower, water supply, navigation, and flood control have a profound impact on riverine habitats. In North Carolina, they have fragmented habitats occupied by the federally endangered Cape Fear shiner (*Notropis mekistocholas*), a minnow endemic to the Cape Fear basin. However, a 2005 dam removal in the Deep River demonstrated that given the opportunity, these fish will readily recolonize newly available habitats. In 2004 (pre-removal), no Cape Fear shiners were found within the impounded reach; five years later, with the return of riverine habitat, 58 individuals were collected at the same site. In 2007, a range-wide survey suggested that current populations are locally robust and individuals were distributed in areas where they were not observed in decades. A 2009 riparian habitat survey of the Deep River identified sites where bank stabilization could improve habitat quality via reduction of sediment and livestock exclusion. With restoration of these areas and passage

through or removal of dams, there is a high potential for Cape Fear shiner population expansion within this drainage. This goal could be further aided by reintroduction of the fish into currently unoccupied habitat in the Rocky River above a hydropower dam. These and other studies are currently being synthesized into a Strategic Habitat Conservation Plan through the U.S. Fish and Wildlife Service that will provide a centralized management strategy to enhance Cape Fear shiner conservation.

Keywords: Cape Fear shiner, endangered, dam

PHYLOGEOGRAPHY OF *NOTHONOTUS CAMURUS*, BLUEBREAST DARTER

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Nothonotus camurus has the widest distribution of any species of *Nothonotus*, but populations are highly disjunct and individuals are rarely abundant. Large geographic distances between small populations can result in highly structured populations, or even speciation, through isolation and genetic drift or selection. Previous morphological studies found some variation among populations and pigmentation differences have been noted, but the phylogeography and population history of *Nothonotus camurus* is still mostly unknown. We analyzed genetic data for over 90 individuals to create phylogenetic trees and estimates of demographic histories, and morphological data for over 500 individuals to identify population differentiation. We identified a strong divergence between the Cumberland River populations and all other populations. Interestingly, there was very little genetic divergence between populations at the periphery of the range, including; Vermillion R. (IL), French Cr. (PA), Elk R. (WV), and upper Tennessee R. tributaries. Historical demographic estimates indicate recent expansion for the non-Cumberland group of populations, supporting a hypothesis that the northern populations originated from the Tennessee River populations.

ADAPTIVE MANAGEMENT ON THE SAVANNAH RIVER: SUCCESSES AND CHALLENGES SEVEN YEARS OUT

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The Savannah River Basin is a highly regulated basin that supplies water for several major and expanding urban communities in South Carolina and Georgia. Communities that live near or adjacent to the three major Savannah River reservoirs depend upon the lakes as a source of recreation, water supply and hydropower for peak energy demands. Changes in Thurmond Dam operation affect the only remaining shoal habitat in the river, inundation of one of the most expansive floodplain forests in the southeast, and critical freshwater inflow into an estuary that supports trust resources such as the federally endangered shortnose sturgeon (*Acipenser brevirostrum*), striped bass (*Morone saxatilis*), robust redhorse (*Moxostoma robustum*) and multiple other diadromous species. Because of the ecological significance of the Savannah River, The Nature Conservancy initiated a collaboration with the Army Corps of Engineers, state and federal natural resource agencies, other NGOs and academic institutions in 2003 to define relationships between biota and flow regime, and begin adaptive management of Savannah reservoirs for both human and ecosystem benefits. Since that time, multiple high flow pulses have been released to benefit floodplain and estuarine ecosystems. River regulation in combination with

water diversions and severe droughts, however, have exacerbated low river-flow conditions with likely impacts to inhabiting fauna. Although adaptive management of the Savannah River during hydrologically defined “wet and average” water years has been successful, challenges remain during low-flow conditions due to competing water interests. This talk will focus on how ecosystem flow restoration has been implemented and how ecological monitoring of some species and habitats, including shortnose sturgeon, have led to the redefinition of earlier ecosystem flow prescription and some changes in water management.

Keywords: Savannah River, adaptive management, drought, endangered species, water supply

STATISTICAL ANALYSIS OF CONSERVATION STATUS OF LOUISIANA’S RARE FRESHWATER FISH SPECIES

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The Louisiana Natural Heritage Program lists 28 species of fish as rare in Louisiana. We use historical catch data from the Royal D. Suttkus Fish Collection to reassess the conservation status of 23 of the 28 species listed, chosen for their freshwater nature as well as the consistency of available data. We used parametric and nonparametric forms of the Solow equation, probabilities of which may be used to infer relative levels of threat and extinction risks. To further aid in the reassessment, sighting rate models and Mann-Kendall trend analysis were used to make statistical inferences about extinction risks for these species. Seventeen of the 23 species tested (74%) showed significant probabilities of threat or extinction in at least one of the probabilistic methods, and 10 (43%) showed significant probabilities for all of the methods used. Eight of the 23 species (35%) showed significant declines in Mann-Kendall trend analyses. This study provides improved analysis methods for setting conservation priorities in the state of Louisiana and elsewhere, and demonstrates the utility of large data mined from natural history collections.

Keywords: Louisiana, fish, conservation

ENVIRONMENTAL DIFFERENCES PREDICT MALE COLOR DIFFERENCES IN DARTERS (PERCIDAE: *ETHEOSTOMA*)

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Male darters in the subgenera *Etheostoma* and *Ulocentra* exhibit striking nuptial coloration during their three month breeding season. These characters are likely under the influence of sexual selection, but may also be influenced by the environment in which they have evolved. Differences in habitat have been linked to divergence in male coloration in African cichlids (Seehausen *et al.*, 2008). Here, we test for correlations between the environment and secondary sexual characters by measuring environmental differences and male color differences in 6 species pairs of darters in the subgenera *Etheostoma* and *Ulocentra*. Correlations between our measurements and genetic distance are also analyzed to address the potentially confounding effects of time, as differences in both traits may correlate due to time. Using linear regression, we find that genetic distance does not predict environmental differences or male color differences. However, a significant correlation is observed between environmental differences and male color differences suggesting a role for the local environment in promoting divergence in darter mating signals.

Keywords: *Etheostoma*, *Ulocentra*, sexual selection, male color

FISH COMMUNITY RESTORATION IN A REGULATED RIVER: WHEN REALITY HURTS

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Extensive flow regulation has resulted in the loss of fluvial habitats and, in turn, the decline of species diversity. The restoration of flow magnitude and variability has shown some success at increasing species diversity in regulated rivers; however, the successful recolonization of species also depends on relationships between flow, fluvial geomorphology, and physical habitat conditions as well as linkages between the restored habitat and source populations. The purpose of this study is to provide an example of the influence of flow restoration on fish diversity in a regulated river with respect to habitat conditions and source populations. The objectives of this study were to 1) provide community data for a regulated river and source populations in order to provide a baseline for future monitoring, 2) evaluate changes in the fish community following flow restoration, and 3) provide insights into how habitat conditions and fragmentation may limit community restoration. Following a FERC relicensing agreement in 2005, flow restoration along with morphological restoration (aquatic gravel additions) was initiated in the Cheoah River, in western NC. After five years following flow restoration, only 1 out of the 10 potential recolonist species established residency. Single individuals of other potential recolonist species have been observed following restoration, but populations have yet to be established. We provide some evidence that temperature and habitat conditions are limiting the restoration of fish populations in the Cheoah River and may be the cause of decline of 1 darter species. Because habitat fragmentation limits recolonization in the Cheoah River, reintroductions are being conducted and populations are being monitored. Our results suggest that morphological and water quality (i.e. temperature) restoration should accompany flow restoration in order to be effective in systems where project operations have occurred for long periods.

Keywords: flow, fragmentation, dams, darter, redhorse

A POST RESTORATION SURVEY OF THE FISHES AND MACROINVERTEBRATES OF MILL BRANCH, KNOX COUNTY, KENTUCKY, WITH EMPHASIS ON THE FEDERALLY THREATENED BLACKSIDE DACE (*CHROSOMUS CUMBERLANDENSIS*)

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Mill Branch is a small headwater stream located in Knox County, Kentucky, in the Upper Cumberland River basin. Historically, agricultural and residential impacts, along with poor logging practices and coal mining had altered the once natural physical and chemical composition of the stream by increasing sedimentation and conductivity. In fall 2005, several federal and state agencies, with the cooperation of several private landowners, implemented the first stream habitat restoration project for the blackside dace (*Chrosomus cumberlandensis*) by restoring the lower 700 meters of Mill Branch. The process also included the replacement of the old perched culvert, located 500 meters above the mouth, with a new concrete stream simulation culvert. In August 2009, the newly restored channel was connected to the mainstem and the old channel was eliminated. A post-restoration survey was conducted on the fishes (with emphasis on the federally threatened blackside dace, *Chrosomus cumberlandensis*) and benthic macroinvertebrate communities to determine whether the restoration effort resulted in biological improvement. It appears that Mill Branch is gradually becoming more stable in terms of habitat, water quality, and overall biotic community. The blackside dace population has increased significantly since

2006 prior to construction. Blackside dace have begun to utilize areas below the new culvert. However, due to current problems associated with beaver dams (i.e. large pools) the lower section below the new culvert is in jeopardy of becoming over-populated with sunfishes. This could greatly impact the overall dynamics of the lower section of Mill Branch by eliminating suitable habitat for blackside dace. Finally, long-term monitoring can provide opportunities to develop our current understanding of blackside dace, and the overall stream ecosystem structure and function of Mill Branch, therefore, aiding in our abilities to successfully repair degraded streams elsewhere.

Keywords: Blackside dace, stream restoration, post-survey, long-term monitoring

SCRATCHING THE SURFACE: RE-INVENTING OUR IMAGERY TO COMMUNICATE THE BEAUTY OF SOUTHEASTERN AQUATIC BIODIVERSITY

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Southeastern rivers host an extraordinary diversity of life, but like most freshwater ecosystems their beauty and diversity is generally obscured and underestimated. This obscurity undoubtedly precludes public sympathy for Southeastern aquatic species, and may ultimately limit public support for river conservation. Freshwaters Illustrated has begun a long-term effort to capture, collect, and share imagery of Southeastern aquatic species, habitats, research, and conservation efforts through educational media and film projects. I will present preliminary imagery from these efforts and share future plans for expanding this project and engaging broader support and collaboration.

Keywords: video, photo, biodiversity, education, conservation

PAST AND PRESENT PROCESSES INFLUENCING A NATURAL POPULATION OF ATLANTIC STURGEON, *ACIPENSER OXYRINCHUS OXYRINCHUS*

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Deterministic threats such as habitat loss, invasive species, or over-exploitation cause species extinctions; however, stochastic processes can accelerate extinction rates as census sizes decline. Using molecular and ecological data, we explored the influence of these processes on the demography of a candidate species under the U.S. Endangered Species Act – the Atlantic sturgeon. We used molecular microsatellites markers to estimate the effective population size (N_e) and effective number of breeders (N_b) and mark-recapture data to estimate the number of spawners (N_a) for Atlantic sturgeon of the Altamaha River, GA. We found that estimates of N_b were 7-45% less than that of N_a over four consecutive cohorts and showed that skewed sex ratios could explain the relative decrease of N_b to N_a . Our contemporary estimate of effective population size (N_e) was 74-335 and was at least an order of magnitude less than the historical estimate (based on coalescent theory) suggesting that this population experienced a significant reduction in N_e presumably owing to severe over-exploitation and/or habitat degradation. Together, molecular and demographic data provided for an understanding of past and present processes influencing a natural population of Atlantic sturgeon.

Key words: demography, effective population size, genetics, life history, linkage disequilibrium

NUCLEAR GENES AND THE PHYLOGENETICS OF DARTERS

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Over the past three years, our research group has been developing the use of 20 nuclear genes to investigate the phylogenetic relationships of darters. Most published molecular phylogenetic analyses of darters have relied exclusively on mitochondrial DNA gene sequences, but we have shown that at least 12.5% of all darter species possess a mtDNA genome of heterospecific origin. In this presentation I explore resolution of darter phylogeny at deep and shallow evolutionary divergences using nuclear gene DNA sequence data. Much to our delight, nuclear genes lead to inferences of well-resolved phylogenies of darters that exhibit consistency across loci. In addition, these nuclear genes allow an exploration of the timing of origin of darters and major darter subclades. The time-calibrated darter molecular phylogenies will serve as a basis for several ongoing investigations describing macroevolutionary patterns of diversification in darters.

Keywords: darter, *Percina*, *Etheostoma*, phylogeny, molecular clock

MUD, SWEAT, AND JEERS: THE SCIENCE AND POLICY OF INSTREAM FLOWS

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The development of effective policies to protect environmental flows includes the “Science of *Muddling Through*,” the Sweat equity of riverine scientists, and the Jeers that are inevitable when we attempt to put limits on human uses. In this talk I will review the history of development of policies to protect instream flows in the U.S. and illustrate how “muddling through” was a non-adaptive approach leading to inadequate preparation for water shortages. I will highlight important policy developments that empower us to conserve and protect fishes and environmental flows. The *Sweat* of untold numbers of investigators has been critically important to dispel Instream Flow Myths. We are witnessing the emergence of scientific findings that provide guidance for establishing standards and criteria for environmental flows. Today’s graduate students are emerging with a better set of scientific tools and interdisciplinary focus for understanding stream ecohydrology, ecohydraulics, and biotic responses to hydrologic variability. Further applied research to link flow changes to services provided by stream ecosystems is needed if we are to manage future water demands as we approach peak ecological water and impose limits to excessive alteration. The southeastern U.S is at the epicenter of the clash between opposing values of water. With more miles of rivers and a more diverse aquatic fauna than any other region in the nation, we have more to lose if water use is not managed to protect environmental flows and ecosystem services. At this crossroads of increasing demands, uncertainty of climate change, and better science, I expect that *Jeers* will continue, especially from vested interests groups that wish to protect the status quo in water allocations. I will urge fish specialists to become involved in examining water laws and policies and support adoption of progressive legislation. We will need to adopt more adaptive strategies in addition to the natural flow paradigm in order to rehabilitate the many miles of highly altered rivers in the region. The scientific findings that are emerging will not be implemented without more instream flow management specialists, more supportive laws, regulations, and policies, and a more knowledgeable public.

PHYLOGEOGRAPHY AND CONSERVATION GENETICS OF *ETHEOSTOMA CINEREUM* (PERCIDAE) WITH EMPHASIS ON A NEWLY REDISCOVERED POPULATION IN THE ELK RIVER, TENNESSEE

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Complete and partial sequence for the mitochondrially encoded cytochrome b gene was obtained from *Etheostoma cinereum* (n=40) from all but one (Buck Creek, Kentucky) of the known extant populations including a recently rediscovered population in the Elk River, Tennessee. Sequence data from nearly all other darter subgenera and *Sander canadense* were included in a phylogenetic analysis to test for the possibility of introgression of mtDNA of other lineages into *E. cinereum*. Despite the inclusion of these data, the analysis recovered all *E. cinereum* sequences as a clade with 100% bootstrap support. This refutes a hypothesis of differences among *E. cinereum* being due to introgression. The analysis was consistent with previous work indicating three distinct clades corresponding to populations in the Duck, Cumberland and Upper Tennessee rivers with moderate to high bootstrap support and mean between group divergence ranging from 1.0 to 2.7%. The Elk River specimens did not form their own clade, but were contained entirely within the Upper Tennessee clade as was a single specimen from the Emory River. This suggests that the previous description of the Upper Tennessee Management Unit (MU) should be revised to include the populations in the Elk and Emory rivers. Rediscovery of these populations and recent expansion in the Clinch River suggest surveys in historical localities with seemingly appropriate habitat where *E. cinereum* appears to be extirpated may reveal extant populations that have remained undetected for decades much like the Elk River population. Their rediscovery also suggests that this MU may not be as critically endangered as previously thought. However, the species still persists at only a few localities, is found mostly in very low numbers, and appears to be a habitat specialist making it highly vulnerable to extinction.

Key words: cryptic biodiversity, mtDNA, Tennessee River, Cumberland River, Duck River

DEFINITIONS OF RARITY FOR NORTH AMERICAN FRESHWATER FISH AND THE BIOLOGICAL TRAITS ASSOCIATED WITH RARITY

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Rare species are a vital component of biodiversity and many rare species are listed as endangered, threatened, or vulnerable. Conserving rare species and protecting biodiversity and ecosystem functioning depends on sound information on the nature of rarity. Rarity is multidimensional and has been defined a number of ways by many different researchers, presenting the need for a quantitative classification scheme by which to label species as rare or common. We constructed a classification for North American freshwater fishes in order to better describe rarity in fishes and provide researchers and managers with a tool to streamline conservation efforts. We used (1) the range extents, (2) habitat specificities, and (3) local abundances of North American freshwater fishes and employed a variety of quantitative methods and statistical decision criteria to determine appropriate cutoffs to label a species as rare or common along each of these dimensions. The resulting classification of species into eight groups conforms to a well-established framework for rarity. We then compared biological and reproductive traits among species classified into the rarity framework and found that large, highly fecund, late maturing fishes were generally more common by range extent and local abundance than small, early maturing fishes. Also, species that do not guard nests or bear live young were more frequently rare by local abundance than nest guarding species. These results indicate that rare fishes

differ in their biology and reproduction from common fishes. Understanding the biology that drives patterns of rarity is an important step for conserving rare fishes.

Keywords: rare species, range extent, habitat specificity, local abundance, biological traits

USING VARIABILITY IN REFERENCE CONDITIONS AS A FILTER FOR THE SELECTION OF FISH IBI INDICATORS FOR A STREAM ASSESSMENT PROGRAM IN THE SOUTHEASTERN PLAIN ECOREGION

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The reference condition for biological integrity (RC(BI)) as approximated at minimally disturbed conditions (MDC) is frequently used to develop indicators to measure stream integrity as defined by the Clean Water Act. Using this reference-site approach, MDC stream sites in the Southeastern Plains ecoregion were selected based on GIS based land cover characterization of watersheds in limited access federal installations in the southeast (NC, SC, GA). Fish community assessment was conducted in 2009 and 2010 using a two-pass backpack electrofishing technique. Fish community structure and abundance data from MDC sites naturally possess inherent variability. Indicators used for stream assessment based on these data should be selected in such a way as to minimize this variability. Less variable indicators more consistently define the MDC condition in a certain ecoregion and therefore better measure deviations from this condition. The variability of approximately 30 fish IBI indices used by the states of NC, SC, and GA were estimated and the best potential indicators were selected for further consideration. Indices defining species richness and trophic structure such as number of native species, number of darter species, total species, percentage of omnivores and herbivores, percentage of insectivores, and percentage of piscivores were predicted to be less variable in the streams sampled. Indices defining abundance data such as number of fish were predicted to be more variable.

Keywords: reference condition, indicators, stream assessment, fish community, variability

REASSESSMENT OF THE FISHES OF THE LITTLE RIVER BASIN, WESTERN KENTUCKY

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The Little River represents one of the most impaired watersheds in western Kentucky due to continued impacts from nonpoint source pollution associated with agriculture and urbanization. To evaluate historical changes in habitat, water, and fish community quality in the Little River, we sampled fishes and conducted habitat assessments during periods of high and low base flow in 2010 and compared findings to those of previous studies conducted from 2000 to 2003. In the current study, eleven families and 35 species of fishes were collected from the 16 previously sampled localities. Twenty percent, compared to thirty three percent previously, of species collected were found to be intolerant of high levels of nutrient overload and sedimentation. However the highest re-occurrence of fishes sampled from our sites were Bluntnose Minnow (14 of 16 sites), Scarlet Shiner (13 of 16 sites), and Striped Shiner (12 of 16 sites), which are all tolerant to such disturbances. Previous studies found the highest reoccurrence of fishes were the Bluntnose Minnow (13 of 16 sites), Scarlet Shiner (15 of 16 sites), and the Striped Shiner (14 of 16 sites). Comparisons of current Kentucky Index of Biotic Integrity scores to scores from previous studies indicate the water quality and diversity of fish species in the Little River have decreased over the past ten years, with the majority of sites receiving a 'Fair' or 'Poor' rating. The Kentucky Fish and Wildlife Department designated 'rare' species, *Etheostoma microlepidum*, was found

at the same localities as in previous studies. Although the range of this species in the watershed appears stable, habitat and water quality scores for each site have declined and its status in the Little River should be closely monitored. The Little River continues to be an imperiled watershed that is in need of management and remediation. Future work will include examination of historical land-use changes in the system to highlight areas most in need of management.

EXTENSIVE DISPERSAL OF ROANOKE LOGPERCH INFERRED FROM GENETIC MARKER DATA

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The spatial ecology of reproductive effort and juvenile dispersal is poorly understood for most nongame stream fishes. We used genetic marker data to investigate these ecological attributes in the 2005 cohort of Roanoke logperch (*Percina rex*) in the upper Roanoke River. Ninety-four individuals from this particularly large year-class, as well 37 potential parents, were captured along a 55-km reach of the Roanoke River and its two forks (15 spatial sites). Microsatellite genotype data were used to estimate relatedness between individuals and reconstruct full-sib families. We found that juvenile logperch were no more closely related within than among sampling sites, and no relationship between spatial distance and relatedness was detected. Family reconstruction indicated the presence of many small families: 60 full-sib families were inferred, each containing from one to three individuals. Most families were captured across multiple sampling sites, indicating dispersal of juveniles, dispersal of spawners between clutches, or both. Family members were widely dispersed, separated by an average of 13 km and up to 45 km. The number of breeders that produced the sample was estimated to be in the hundreds, and the total *N_e* of the 2005 cohort was estimated to be in the thousands. Extensive dispersion of spawning effort and/or juveniles appears to promote genetic panmixia over large distances in this population, and may enhance fitness and dampen population fluctuations in variable riverine environments.

Keywords: dispersal, sibship, parentage, effective population size

UPPER TOMBIGBEE RIVER FISHES BEFORE AND AFTER THE TENNESSEE-TOMBIGBEE WATERWAY

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The physical template of the biologically diverse Upper Tombigbee River was altered in the late 1970's through its incorporation into the Tennessee-Tombigbee Waterway (TTW). Museum vouchers archived pre-TTW provided a contrast for collections describing contemporary fish assemblages (2002-2010). We have documented differences in pre- and post-TTW assemblages. Twelve species that occurred pre-TTW were absent from our post-TTW collections. Two functional groups can be recognized: fluvial specialists (e.g., *Ichthyomyzon castaneus*, *Hybognathus nuchalis*) or migratory fishes (e.g., *Alosa alabamae*, *Anguilla rostrata*). The statuses of two fishes are questionable as they were not appropriately targeted by our sampling methodology (i.e., *Scaphirhynchus suttkusi* and *Cycleptus meridionalis*). Nineteen fishes were absent from the main channel, but present elsewhere in the system (e.g., *Noturus munitus*, *Etheostoma histrio*). Although tributaries maintain a number of species now absent from the main channel, we documented significant declines for fluvial specialists in the East Fork Tombigbee River.

These shifts were smaller in the Noxubee River, another tributary. The silverside *Menidia audens* is a potential post-TTW immigrant from the Tennessee River system and its diet overlaps with that of the native silverside *Labidesthes sicculus*, leading to speculation concerning competitive exclusion. Some fishes occurring throughout the system during both time periods exhibited dietary shifts. Most notable is that of the crystal darter, *Crystallaria asprella*. It fed primarily on macroinvertebrates pre-TTW and consumed more zooplankton post-TTW. Preliminary data suggest altered interactions between fishes and mussels. The percentage of longear sunfish, *Lepomis megalotis*, bearing a glochidial load has increased post-TTW. The number of glochidia in lamellae of individual sunfish has not changed in contrast. Future work will determine the taxonomic structure of glochidia infestations in these sunfish to provide insight into how mussel assemblages have changed. Also, stable isotopes may be used to characterize the history of trophic structure in the system.

Keywords: Tombigbee River, Tennessee-Tombigbee Waterway, flow regime, channelization, habitat fragmentation

NOVEL MARKERS PROVIDE NOVEL INSIGHT UNTO THE PHYLOGENETIC POSITION OF ELASSOMATIDAE

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North American sunfishes (Centrarchidae) and pygmy sunfishes (Elassomatidae) are the only freshwater percoid families endemic to the Western Hemisphere. Their phylogenetic affinities have implications upon our understanding of the colonization history and vicariance processes responsible for continental patterns of freshwater biodiversity. A potential sister group relationship between the two families has been argued for over a century, drawn primarily from their sympatric distribution and similar external morphology. In addition, recent molecular phylogenies have suggested ties between one or both families to temperate freshwater perciform groups from East Asia (Sinipercidae) and/or the Southern Hemisphere (Percichthyidae). Morphologists previously suggested such transcontinental relationships, but synapomorphies and parent taxa have not been described. Using novel and published nuclear markers, we identify two well supported monophyletic clades that are independently recovered through concatenated and parallel analyses of a multi-gene matrix, which represent the most likely resolution to the "Elassoma problem". A secondary objective of this study is to explore the limit of phylogenetic resolution for mitochondrial DNA data. Using the cytochrome b gene, we examine the effects of taxonomic sampling bias on MP and ML topologies, a factor likely to account for discordant interfamilial relationships among published mtDNA trees. We identify strong substitution rate heterogeneity among functional domains within seven mitochondrial genes, which is implicated in the generally unreliable performance of mtDNA at deep nodes. As an alternative to mtDNA, four novel DNA repair genes are developed and analyzed alongside 11 nuclear exons previously described in literature. In contrast with mtDNA, the concatenated dataset and majority rule consensus of 15 nuclear genes recover the same topology (Elassomatidae+Centrarchidae) Sinipercidae) with strong bootstrap support. Deeper relationships within Acanthomorpha are also presented. Results are discussed in the context of transcontinental biogeography as well as a novel interpretation of *Elassoma* morphology.

DIVERSITY-STABILITY IN MISSISSIPPI STREAM FISH COMMUNITIES

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The relationship between ecosystem diversity and stability has long intrigued ecologists. Recent empirical data from field and mesocosm experiments offer support for the correlation between diversity and enhanced levels of ecosystem stability. To date however, most studies have focused on terrestrial systems, and we are unaware of any documented examples among stream fishes. Stream community ecology over the last thirty years has centered on the influence of stochastic vs. deterministic processes in regulating community properties. There are well-documented relationships between fish community and habitat structure and changes in habitat structure leading to changes in community structure. In the present study, we explored the relationships between species richness, environmental variability and community stability through time. Using stream fish community and corresponding environmental datasets across 36 Mississippi streams, we show that more diverse communities were more stable and while community structure was related to environmental variables, the change in environmental variables was not related to levels of community stability.

VARIATION IN BODY SHAPE ALONG THE RIVER CONTINUUM

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Hydrologic conditions and predator regimes are two factors known to exert strong selective pressure and induce plasticity in fish body shapes. Hydrologic conditions and predator regimes also vary in predictable ways along small stream-large river gradients. If these factors are paramount, some predictions can be made about variability in body shape along small stream-large river gradients. Species in the *Fundulus notatus* species complex (*F. notatus*, *F. olivaceus* and *F. euryzonus*) are typically abundant throughout the small stream-large river gradient. *F. olivaceus* usually dominates headwaters with *F. notatus* occurring downstream. However, in some drainages *F. olivaceus* is found throughout and in others *F. notatus* is found exclusively in headwaters. We used geometric morphometrics (17 landmarks on 500 fish from 60 sites in 8 drainages) to examine variability in body shape among populations along the small stream-large river gradient. We ask: 1) Is variability in body shape consistently related to position in the small stream-large river gradient? 2) Is this pattern repeated among drainages and species? Finally, we examined body shape of select *Fundulus* sp. populations reared in mesocosms to assess the role of plasticity in determining body shape.

Keywords: geometric morphometrics, shape, hydrology, *Fundulus*

ESTIMATING THE INFLUENCE OF STREAM FLOW CONDITIONS ON POPULATION DEMOGRAPHIC RATES FOR THREE FEDERALLY ENDANGERED MUSSEL SPECIES IN SAWHATCHEE CREEK, GEORGIA, USA

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The southeastern United States has experienced severe, recurrent drought and rapid human population growth during recent decades, resulting in greater demand for the Region's water resources. Freshwater mussels (unionids) in the Region have experienced substantial population declines during this time period. Consequently, there is growing interest in determining how mussel population declines are related to activities associated with water resource development. Determining the causes of mussel

population declines requires, in part, an understanding of the factors driving mussel population dynamics. However, little is known of basic mussel ecology, life history, and population-level parameters for many species. We developed Pradel reverse-time capture-recapture models to estimate survival, recruitment, and population growth rates for three federally endangered mussel species in the Apalachicola-Chattahoochee-Flint River Basin, Georgia. The models were parameterized using mussel mark-recapture data collected over six consecutive years from Sawhatchee Creek, a small Chattahoochee River tributary located in southwestern Georgia. Mussel survival and recruitment were modeled as a function of stream discharge, and estimates of survival and recruitment were used to calculate mussel population growth rates. Model results suggest that mussel survival was negatively related to stream discharge, whereas recruitment was strongly and positively related to stream discharge. Our models also suggest that population growth rates for the three endangered mussel species may be reduced with decreasing discharge associated with drought and consumptive water use. These models will be used in conjunction with ongoing research to inform management decisions aimed at identifying and conserving at-risk populations of rare and endangered mussel species.

Keywords: unionids, populations, demographic rates, Georgia, ACF Basin

POPULATION DISTRIBUTION AND HABITAT UTILIZATION OF THE RUSH DARTER, *ETHEOSTOMA PHYTOPHILUM* IN BEAVER CREEK, TRIBUTARY TO TURKEY CREEK, BLACK WARRIOR RIVER SYSTEM, ALABAMA

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The rush darter (*Etheostoma phytophilum*), a candidate species for federal listing, is known from only three areas in Alabama's upper Black Warrior River system. One of these is the upper portion of Beaver Creek, a tributary of Turkey Creek. Between October 2008 and May 2009, a survey of this creek was conducted to determine the population distribution and habitat utilized by *E. phytophilum*. Fish were located by seining. All fish captured were recorded and released. Localities where the fish was found were geo-referenced using a Garmin 76 CSx GPS. Stream width, depth, current, substrate and aquatic vegetation were also recorded. Three populations of *E. phytophilum* were found in the middle and upper portions of Beaver Creek in areas of spring flow. The first location is an approximately 1.4 hectare spring fed pond and marsh, the origin of the creek. During the spawning season (February - April) large numbers of post-larva, juveniles and adults were found in the creek channel downstream of this site. In most years, by late spring or early summer the creek at this point dries up leaving only the pond-marsh as a refuge for the fish. This pond-marsh and upper stream channel undoubtedly houses the major source population of *E. phytophilum* in Beaver Creek. Approximately 1.5 km downstream is a second population center. Here the fish inhabits the channel and two springs flowing in from the east. This population may be dependent for its long-term survival upon periodic emigration from the source population. The third population is very small and associated with a small spring outflow. We found little evidence of spawning at this locality and believe this population is maintained by migrants from the upstream sites.

Keywords: Rush darter, *Etheostoma*, *phytophilum*, habitat

GENETIC INTEGRITY OF THE SOUTHERN WALLEYE AS INFERRED FROM MITOCHONDRIAL AND MICROSATELLITE DATA

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The Southern Walleye is an imperiled fish endemic to the Mobile Basin of Alabama and Mississippi. Although its taxonomic status is uncertain, it is generally agreed that the fish is ecologically and genetically distinct from the Northern Walleye. Immediate threats to the Southern Walleye include dwindling population sizes and hybridization with the Northern Walleye, two factors that may erode the genetic integrity of this imperiled fish. Unfortunately, our knowledge of genetic variation within the Southern Walleye is limited to older and non-comparable data sets. Introgression of northern alleles into fish collected from the Black Warrior River was reported in an allozyme survey undertaken in the mid 1990s, while evidence of inbreeding was suggested by microsatellite data collected from brood stock held in Mississippi. The purpose of our study was to assess the genetic integrity of the southern walleye through both microsatellite and mitochondrial variation in contemporary (2005-2009) and samples archived from the 1990s. Archived and contemporary samples from the Black Warrior River system included specimens that represented hybrids with the Northern Walleye and Sauger. We also found evidence for hybridization and backcrossing in the upper Coosa River system in our contemporary samples. No hybrids were found in either the captive population or the fish collected from Hatchet Creek. Thus, while the broodstock and Hatchet Creek populations remain “pure,” potential brood stock for the Southern Walleye should be genetically screened as the Northern Walleye and its hybrids appear to be established in the Mobile Basin.

Keywords: *Sander*, microsatellite, mtDNA, Walleye, genetic integrity

THE SHIFTING SHAPES OF SANDY BOTTOMS: DOES EROSION CONTROL INFLUENCE STREAM DIMENSION?

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Erosion has long been recognized as a major factor in the formation, maintenance, and alteration of aquatic systems. Stream channel formation and sediment supply into these systems are a product of hydrology, geology, and vegetative stabilization within the riparian zone. Disturbance in any of these may result in a shift in the stream capacity to function properly. Typically, anthropogenic impacts are in the form of disturbance to the hydrology or vegetative stabilization within a watershed. On Eglin Air Force Base, where the geology is primarily Lakeland sands, historic construction of roads, borrow pits, and clearing for test ranges or mission activities has destabilized stream banks and valley slopes. The result has been an estimated 70,000 tons of eroded sediment entering streams within Okaloosa darter watersheds per year. In 1995, Eglin initiated a program to eliminate erosion in Okaloosa darter streams and as of 2010 erosion rates had been reduced to around 1,500 tons per year. Ongoing Okaloosa darter monitoring efforts have included flow measurements with depth profiling at established transects beginning in 1995. By plotting depth profiles for each stream cross-section, we can visualize the changes in stream dimension through time and compare these shifts to erosion rates and subsequent rate reductions within each watershed. Understanding the relationship between the elimination of excessive sediment supply and stream channel dimensions will assist managers in recovery efforts for aquatic systems degraded by anthropogenic influences.

Keywords: stream geomorphology, sediment transport, endangered species

DISPERSAL OF NON-NATIVE SMALLMOUTH BASS IN THE CHATTAHOOCHEE RIVER

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Recently, the smallmouth bass (*Micropterus dolomieu*; SMB) was illegally introduced into the Chattahoochee River below Morgan Falls Dam (MFD). This non-native centrarchid poses potential threats to similar endemic species like the shoal bass (*M. cataractae*). Considered a “coolwater” fish, the southern extent of SMB native distribution lies in northern Alabama. However, thermal alteration of the Chattahoochee River has created artificially cooler water temperatures near MFD. The objective of this study was to predict seasonal dispersal of non-native SMB below MFD based on known thermal thresholds. The study area extended from MFD downstream approximately 100 river kilometers. We used ten years (1/1/2000 – 1/1/2010) of daily water temperature data to calculate mean monthly water temperature at three separate USGS stream gauge locations. We then used kriging in ArcGIS to interpolate mean monthly water temperatures for every 500 meters of stream within the study area. Literature estimates of SMB thermal tolerances were used along with water temperature data to create spatially explicit maps depicting all habitats below MFD with temperature regimes suitable for SMB. Our results showed that water temperatures throughout the study area were, in fact, suitable for SMB early life stages, although summer temperatures probably confine SMB to the cooler waters immediately downstream of MFD for several months. From September through February, however, no thermal limitation on SMB dispersal was evident. These findings suggest that SMB could become established downstream of MFD wherever thermal refuge exists for over-summering. Future studies should focus on monitoring SMB distribution and potential interactions with native Chattahoochee River species.

Keywords: Chattahoochee River, kriging, Morgan Falls Dam, Smallmouth bass, thermal tolerance

REDISCOVERY OF EASTERN SAND DARTER, *AMMOCRYPTA PELLUCIDA* (PUTNAM), IN THE MAUMEE RIVER BASIN IN NORTHWESTERN OHIO WITH IMPLICATIONS FOR CONSERVATION

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The eastern sand darter (*Ammocrypta pellucida* Putnam) is a small (up to 7 cm) bottom dwelling fish that inhabits small to medium rivers with clean sand substrates. This species burrows itself, headfirst, into sand substrate likely to conserve energy and maintain position in a shifting sand habitat. Few stream fishes are as strongly associated with a particular habitat variable (clean sand substrate) as is the eastern sand darter and its congeners found throughout the southeastern United States. Siltation and degradation of habitat in rivers inhabited by the eastern sand darter caused this fish to become rare throughout its entire range, originally extending from the St. Lawrence River and the Lake Champlain drainage to southwestern Ontario, southeastern Michigan, and throughout much of the Ohio River basin to eastern Illinois and south into Kentucky. *A. pellucida* was documented as being abundant in the Maumee River basin (western Lake Erie drainage) in the late 1800s. Increased erosion and siltation in the Maumee River basin are suspected to have caused a sharp decrease in its abundance and they have been not reported from the Ohio portion of the Maumee River basin since 1944. In November 2009, using a 1.2m x 3.7m seine (3 x 4mm mesh size) placed 3m downstream of a 6 volt battery powered electroshocker (ETS ABP-2 Backpack Electroshocker), we captured and released a total of 18 *A. pellucida* from five 10m² sites near the town of Antwerp, OH. This was the first record of this species in the Ohio portion of the Maumee River basin in 65 years. Sampling efforts in September 2010, using the same technique, revealed a total of 24 eastern sand darter in six out of twelve sites in 4.8km of river. Four 10cm long sediment cores were taken at each site and analyzed for particle size distribution (using

sieves and laser diffraction) and organic matter content (loss-on-ignition). Rediscovery of the eastern sand darter in northwest Ohio suggests cleaner sand substrates now exist in the upper reaches of the Maumee River drainage. Conservation tillage practices and other erosion control methods likely contributed to these improved substrates. Our results may help guide future conservation efforts for the eastern sand darter and its congeners throughout their range.

EDWARD D. COPE'S CONTRIBUTIONS TO OUR KNOWLEDGE OF THE NORTH CAROLINA FISH FAUNA AND RE-VISITING NORTH CAROLINA'S TYPE LOCALITIES

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The first 5 of 204 described and indigenous freshwater fish species known from North Carolina were scientifically named in 1758 by Carolus Linnaeus, though generally from locales in the northern US. A flurry of activity in the late 1810s by Constantine Rafinesque ascribed names for 25 more nominal species, again from locales outside North Carolina. Between 1860 and 1870, 48 species were described, 43 of them by Edward D. Cope. As a young man of 29 years with a wife and an age-three daughter in tow, Cope spent from late August until early December 1869 in North Carolina. Equipped with only a small seine of fine mesh, a great fervor, and a penchant for interacting with the local commercial fishermen and their weir traps, his travels took him from Warm Springs in Madison County to Wilmington in New Hanover County including stops at Pleasant Garden, the Koontz Plantation, and Raleigh. He collected more than 95 described and undescribed species during his travels. By June 7, 1870, less than six months since leaving Raleigh, Cope had described approximately 20 percent of the species presently recognized in North Carolina. Under existing species concepts, there are 36 type localities in North Carolina including 15 of Cope's. In 2008 a study was begun to revisit each of these sites, including Cope's, to determine if each species is still present and what are the existing site conditions, or to determine why the species is absent. Field work for this study is nearing completion and results will be presented in 2011.

Keywords: E. D. Cope, North Carolina, type localities

EFFECTS OF HURRICANE KATRINA ON FRESHWATER FISH ASSEMBLAGES IN A SMALL COASTAL TRIBUTARY OF LAKE PONTCHARTRAIN, LOUISIANA

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Hurricane Katrina struck southeastern Louisiana on 29 August 2005 and presented an opportunity to examine the effects of a catastrophic storm on fish assemblages in a coastal stream. Bayou Lacombe is a small (46.1 km), primarily freshwater stream that drains into the northeastern portion of Lake Pontchartrain, a large oligohaline estuary located north of New Orleans. Prior to the hurricane in summer 2005, three upstream and three downstream reaches of Bayou Lacombe were surveyed by electrofishing. These same six reaches were re-surveyed after the hurricane in the summer of 2006 to assess the effects of the disturbance on fish assemblages. There were significant changes in fish assemblages at the downstream reaches and the upstream reaches. At the downstream reaches, centrarchid species such as bluegill (*Lepomis macrochirus*), warmouth (*L. gulosus*), and red-spotted sunfish (*L. miniatus punctatus*) increased in abundance after the hurricane as did inland silversides (*Menidia beryllina*) and striped mullet (*Mugil cephalus*), both estuarine dependent species. At the upstream reaches, longear sunfish (*L. megalotis*) decreased after the hurricane and weed shiners

(*Notropis texanus*), goldstriped darters (*Etheostoma parvipinne*), and *L. gulosus* were absent from post-hurricane samples. Principal Components Analysis and BEST analyses showed differences in dissolved oxygen between years were related to fish assemblage changes in the upstream reaches. Salinity and temperature were associated with fish assemblage changes in the downstream reaches. Similar significant changes could occur in other coastal streams prone to increased hurricane activity.

Keywords: Hurricane Katrina, community ecology

POTENTIAL GENETIC TOOL FOR AGE ESTIMATION OF LONG-LIVED FISHES

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Accurate monitoring and management of fish populations is critical to sustainability as human perturbation of habitats and fishing pressure increase. Oversight is generally provided by periodic model-based assessments that provide estimates of the current state of fish populations. One underlying population parameter of these assessments is age structure, which is often estimated from growth curves that delimit age classes based on length – a method which becomes problematic in long-lived species in which length becomes asymptotic with respect to age. More reliably, age is determined by evaluating annual calcium deposition on structures such as otoliths and other bony structures. Although conventional methods provide excellent information, their invasive and/or lethal nature is unappealing to conservation biologists. Recently, a non-destructive method of aging individuals has been developed which exploits the relative length of degenerative DNA regions known as telomeres. As cell divisions occur, the number of telomere repeat units typically decreases so that the average telomere length observed within a given tissue decreases as an individual ages. Therefore, average telomere length observed in individuals of known age could be used to develop a standard age curve for that particular species. As telomere-based research has originated in the medical field, most work to date has been conducted on short-lived organisms and individuals kept in controlled laboratory conditions. We are currently evaluating the ability to exploit telomere lengths to determine ages in four species of long-lived fishes: red drum, cobia, shortnose sturgeon, and Atlantic sturgeon. Therefore, our evaluation of a telomere-based aging tool will represent one of the first applications of telomere knowledge to long-lived, natural wild populations and if successful will increase the accessibility of critical population parameters for fish conservation and management.

Keywords: telomere, sturgeon

IMPORTANCE TO FISHES OF WOODY MICROHABITATS IN SAND-BED UPPER COASTAL PLAIN STREAMS

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We investigated fish use of standardized, constructed woody microhabitats (cane bundles) in four north Mississippi sand-bed streams with different degrees of channel degradation and natural instream woody cover. The streams described a disturbance gradient: Lee Creek (deeply incised, least depth and wood), Cypress Creek (channelized, low depth and wood), Puskus Creek (natural channel, moderate depth and wood) and Chewalla Creek (natural channel, deepest, highest wood). We deployed replicate cane bundles over one year (six samples). We focused on three measures of microhabitat use: fish occupancy, abundance, and assemblage structure. Across all streams, we captured 30 fish species representing eight families. Fishes used bundles least in the most disturbed stream (7% occupancy) but showed

similar occupancy in the others (20-27%). Mean fish abundance in bundles differed greatly between the two most disturbed streams but was intermediate and similar in the least disturbed streams. Fish assemblages in bundles were distinct among streams. Pairwise effect sizes in assemblage similarity described a gradient from the most to least disturbed stream. Small wood in these sand-bed streams is obviously an important but dynamic component of fish habitat, but responses of fishes to that habitat are mediated largely by the disturbance history of the stream.

Keywords: small wood, microhabitat, disturbance, channel degradation, small-bodied fishes

FEMALE PREFERENCE FOR MALE COLORATION MAY EXPLAIN BEHAVIORAL ISOLATION IN SYMPATRIC DARTERS

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Animal color patterns are among the most striking examples of biological diversity. Elaborate coloration is thought to play a role in mate choice within populations and to pose a barrier to interbreeding between species, with individuals preferring the color patterns of conspecifics. Ideally, the importance of coloration as a barrier to interbreeding would be tested in a manner where all traits are held constant and the variable of interest (e.g., color or pattern) is manipulated to test its effect. The best examples of such experiments come from butterflies, in which researchers use models to control for confounding variables (e.g., size, shape, odor) and demonstrate male preference for conspecific female color patterns. However, to our knowledge, no such experiments have shown that females prefer conspecific male coloration in species with elaborate males and cryptic females, the phenotypes originally motivating the theory of sexual selection, as proposed by Darwin. Here we use motorized models to test whether females in a pair of sexually dimorphic and sympatric fish species, *Etheostoma barrenense* and *E. zonale*, prefer conspecific male color and pattern elements over those of the heterospecific. Previously, we showed that these darter species are behaviorally isolated, and females appear to prefer conspecific males based on visual cues alone. By isolating and reproducing components of male phenotypes such as hue (red vs. green) and pattern (horizontal stripe vs. vertical bars) in controlled models, we show here that females of both species strongly prefer conspecific male color and pattern. We also show that the simplified stimuli are sufficient, in most cases, to elicit a female response equivalent to that toward live stimuli, measured previously. These results provide some of the strongest evidence to date that female preference for conspecific male nuptial coloration may play a critical role in behavioral isolation.

Keywords: association preference, behavioral isolation, color, *Etheostoma*, pattern

MOLECULAR SYSTEMATICS AND POPULATION SUBDIVISION WITHIN *CRYSTALLARIA ASPRELLA*: RECENTLY REDISCOVERED POPULATIONS FROM MISSOURI

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The genus *Crystallaria* contains two species of darters that are collectively distributed broadly but disjunctly across eastern North America. The recent rediscovery of multiple populations of *Crystallaria asprella* in several river systems in Missouri and in the Mississippi River proper has warranted a range wide reappraisal of genetic diversity and subdivision within these species as these populations were unavailable at the time of the last published study. Evaluation of mitochondrial and nuclear data sets for

these species suggest novel patterns of genetic divergence within *Crystallaria asprella*. These data will be presented and compared to patterns of genetic subdivision within co-distributed species of darters in an effort to gain a more complete perspective on extrinsic factors promoting population subdivision.

Keywords: *Crystallaria*, systematics, phylogeography