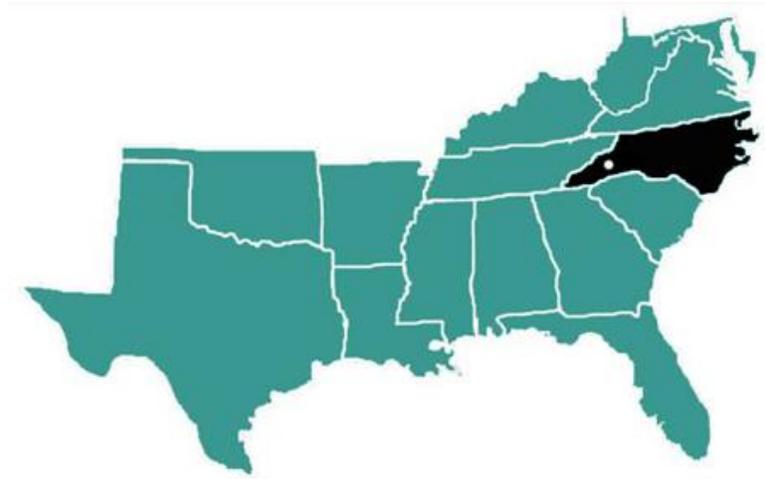


Fisheries Across the Eastern Continental Divide



Abstracts for oral presentations and posters,
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Potential for trophic competition between introduced spotted bass and native shoal bass in the Flint River

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Largemouth bass, shoal bass, and spotted bass were collected from six sites over four seasons on the Flint River, Georgia to assess food habits. Diets of all three species was very broad; 10 categories of invertebrates and 15 species of fish were identified from diets. Since few large spotted bass were collected, all comparisons among species were conducted only for juvenile fish (< 200 mm) and subadult fish (200-300 mm). Juvenile largemouth bass diets were dominated by fish in all seasons, mainly sunfish. Juvenile largemouth bass rarely ate insects except in spring, when all three species consumed large numbers of insects. In contrast, juvenile shoal bass diets were dominated by insects in all seasons but winter. Juvenile spotted bass diets were more varied- highly piscivorous in the fall and winter and highly insectivorous in spring and summer. Diets of subadult largemouth bass were similar to that of juvenile fish, and heavily dominated by fish, particularly sunfish. Similar to juveniles, diets of subadult shoal bass were much less piscivorous than largemouth bass. Crayfish were important components of subadult shoal bass diets in all seasons but summer. Insects were important components of shoal bass diets in fall and summer. Diets of subadult spotted bass were generally more piscivorous than shoal bass, but less than largemouth bass. As fish size increased, largemouth bass diets shifted from fish to crayfish, until crayfish became the dominant item in diets of fish > 400 mm. In contrast, although the chance of crayfish dominating the diets of shoal bass and SPB also increased with fish size, the chance of fish being in their diets increased with fish size as well. Thus while largemouth bass shifted their diets from fish to crayfish as they grew, fish were readily eaten by shoal bass and spotted bass along with crayfish. Diets of introduced spotted bass appeared to occupy an intermediate position between the two native black bass species, but was generally more similar to shoal bass. Despite the high diversity observed in diets of shoal bass and spotted bass, significant diet overlap was common between these species, occurring in 50% of the samples. In contrast, diet overlap was only observed in 30% of the samples between spotted bass and largemouth bass, and only 20% of the time between the two native bass species. Thus, concerns about the trophic effects of spotted bass on shoal bass appear to be well-founded, and could be a potential issue whenever food is limiting.

food habits, competition

Priority rivers for the conservation of North Carolina's imperiled fishes

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Thirty-four of North Carolina's 215 indigenous, described and undescribed, freshwater fish species are considered imperiled by the American Fisheries Society (2008) as either vulnerable (19), threatened (10), or endangered (5). Since 1979 the number of imperiled species has almost doubled with only the Kanawha Minnow, Bigeye Jumprock, and Kanawha Darter being de-listed during this period. Except for the Waccamaw Darter which has a restricted range, the modification and loss of a taxon's habitat was the listing justification for 33 species. The Greater Yadkin-Pee Dee River system has 17% of its indigenous fauna imperiled, the most of any system; only the Watauga and the New rivers systems had none of their fauna imperiled. The Yadkin-Pee Dee (16 species, including the Robust Redhorse), Neuse (9 species, including the Carolina Madtom), and Little Tennessee (7 species, including the Sicklefing Redhorse) rivers systems were selected as the priority rivers for conservation accounting for 25 imperiled species. Major threats to these systems include urbanization that results in poor water quality, hydrologic modifications and habitat fragmentation due to existing dams and the construction of new reservoirs; the establishment, expansion, and ramifications of nonindigenous species; and nonpoint source runoff of sediment and of waste from confined animal feeding operations. Conservation efforts in these systems include intensive surveying and life history-habitat utilization studies of listed species; captive propagation and re-introductions, studies of potential impacts of nonindigenous species; dam removal; participation in the FERC relicensing process; establishment of watershed, county, and regional conservation partnerships; and the acquisition of river corridor easements and new state parks.

Imperiled fish fauna, threats to fish fauna, conservation efforts

3 Contributed Paper

Oral Presentation

Riverine smallmouth bass management: Past, present, and future implications for western North Carolina rivers and streams

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Riverine smallmouth bass *Micropterus dolomieu* populations provide important fishery resources, but little is known about smallmouth bass population dynamics in North Carolina streams. In 2007, North Carolina Wildlife Resources Commission (NCWRC) began a three-year study to obtain riverine smallmouth bass data in western North Carolina. Study objectives were to identify smallmouth bass populations, collect life

history information, and evaluate management opportunities. When feasible, backpack or boat-mounted electrofishing gear was used to obtain samples. In waters where access or physical habitat prevented electrofishing, fish were collected by angling. During summer 2007 and 2008, NCWRC personnel collected 1,058 and 1,066 smallmouth bass, respectively. Thirty-one different populations were sampled, of which 16 were sampled both years. Smallmouth bass total lengths ranged from 30-495 mm TL (mean = 204; SE = 1.7). Smallmouth bass two-year mean PSD, PSD-P, and PSD-M values were 27 (SE = 2.6), 8 (SE = 1.1), and 1 (SE = 0.2), respectively. Mean relative weight values for all populations ranged from 79-105 (mean = 91; SE = 0.8); however, relative weight values generally declined as fish total length increased. Preliminary data suggest growth and mortality rates vary considerably among populations and may be influenced by annual water temperature patterns.

smallmouth bass, North Carolina Wildlife Resources Commission, management

4 Contributed Paper

Oral Presentation

Identifying the fundamental unit of management and historical demographic patterns in U.S. Atlantic Coast sturgeons: A genetic perspective

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The issue of defining appropriate units of management becomes acute when taxa under consideration are threatened or endangered and protection relies on proof of distinction of the units. Sturgeons present significant challenges for investigating the evolutionary processes shaping the nuclear genomes of extant species due to the presence of polyploidy ranging in a series from 4N-8N times the haploid number. We will present the results of range-wide surveys of nDNA (nuclear microsatellite DNA) variation for two at-risk acipenserids exhibiting different ploidy levels: Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*; 4N) and shortnose sturgeon (*A. brevirostrum*; 6N). A survey of 12 disomic nDNA markers in 465 young-of-the-year and spawning adult *A. oxyrinchus* sampled from eight river systems unambiguously delineated population structure, confirmed the presence of reproducing populations in the Delaware and James rivers, and allowed a coalescence-based determination of the demographic history of each unit of management. Survey of polysomic microsatellite markers (11 loci and 181 alleles) allowed delineation of population structure and a re-defining of the number of distinct evolutionary lineages (at least 6) among 561 *A. brevirostrum* sampled from 17 river/bay systems. Results also suggest the presence of at least three regional *A. brevirostrum* metapopulations; i) Northeast, ii) Delaware River and Chesapeake Bay proper, and iii) Southeast. The identification of metapopulation structure is encouraging as this may help stave off localized extinctions. These and other recent research results appear to bode well for the persistence of some *A. brevirostrum* populations. Comparisons and contrasts will be made of phylogeographic patterns observed between the species and between nuclear and mitochondrial genomes.

5 Contributed Paper

Oral Presentation

Influences of environmental gradients and land use on fish biodiversity in the Arkansas-White-Red River basin

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The biodiversity of fishes has been found to increase with longitudinal position, flow, and habitat area. In this study, we used Poisson regression to model native fish richness based on occurrence data reported by NatureServe for 8-digit USGS hydrologic units (HUC8). Richness was expressed as a linear function of discharge, elevation, area in forest, shrubland, and agriculture, number of dams, and SWAT-predicted annual loadings of nutrients and sediment. In addition to this full model, we compared alternative models with subsets of these predictor variables using information-theoretic criteria. We found that environmental gradients in flow and elevation were the best predictors of native fish species richness, followed by longitudinal position, land cover, water quality and number of dams. However, correlations between flow and other predictors were high so that models without flow predicted nearly as well based on longitudinal position and land cover. In most cases, we found the expected relationships. Fish richness increased along downstream longitudinal gradients and with increasing discharge and decreased with

increasing elevation, area agriculture and shrubland, nitrogen and sediment loadings. Unexpectedly, richness increased in response to phosphorus inputs. Our goal is to use these models to predict changes in fish richness in response to changing land cover associated with increased production of bioenergy crops.

native fish biodiversity, environmental gradients, land cover, water quality

7 Contributed Paper

Oral Presentation

Hatch dates and growth rates of three species of age-0 black bass in the Flint River, Georgia

Goclowski, M.R.* and Sammons, S.M. Auburn University

Age-0 largemouth bass (*Micropterus salmoides*), shoal bass (*M. cataractae*), and spotted bass (*M. punctulatus*) were collected from two regions of the upper Flint River, Georgia, in 2008 and 2009 to investigate the potential for competition among the three species at early life stages. Age-0 black bass were collected during early summer of both years; all fish were measured (TL, mm), weighed (g), and had sagittal otoliths removed for age determination. Hatch dates and growth rates were estimated for each aged fish. Hatching occurred from April to June each year; hatch durations varied from 21-61 d for largemouth bass, 21-56 d for shoal bass, and 23-38 d for spotted bass. Mean hatch dates varied among species and region, but there were no consistent trends in the relative timing of mean hatch. Mean hatch dates were later in 2009, when the Flint River experienced high discharge levels due to flood events. Mean growth rates varied from 0.82-0.95 mm/d for largemouth bass, 0.89-1.1 mm/d for shoal bass, and 0.94-1.0 mm/d for spotted bass among regions and years. Mean growth rates varied among species and regions but differences were not consistent across sample periods. Growth rate increased with hatch date for all species, indicating that early spawning did not provide any growth advantages. Our data suggest that hatching periodicity does not promote any competitive advantages among species of black bass in the Flint River.

8 Contributed Paper

Oral Presentation

Diel spawning activity of red porgy (*Pagrus pagrus*: Sparidae) in North Carolina

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Diel spawning activity of commercially important *Pagrus pagrus* has been minimally documented. Various fish species are known to focus spawning activity during particular times of day or night to maximize rates of fertilization and egg survival. In this study we collected specimens of *P. pagrus* aboard commercial hook fishing vessels in 160 feet of water off of Cape Fear North Carolina during the main spawning season throughout daylight hours when the fish were actively caught. For each specimen we macroscopically determined sex and maturity, calculated GSI and recorded time of day. Less than 1% of all fish collected were immature, and 100% of mature females were either in late stages of development or ripe with hydrated oocytes. No evidence of skipped spawning was detected. Median time of capture was 08:30 EST for ripe females 13:40 EST for developing females. Mean time of capture was significantly different

between developing and ripe females ($P < 0.001$). These data suggest that *P. pagrus* in North Carolina waters spawn primarily during morning daylight hours. Investigators attempting to describe seasonal maturity cycles in this species should account for the time of capture so that diel variation does not confound seasonal variation. The adaptive significance of morning spawning in this species is not clear, though daylight spawning is known to occur in species that have visual courtship displays.

red porgy, pagrus pagrus, diel spawning, reproductive biology

9 Contributed Paper

Oral Presentation

Post-stocking movement and survival of rainbow trout in Tennessee reservoirs

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Bettoli, P.W. (USGS, Tennessee Tech University)

Hatchery rainbow trout (*Oncorhynchus mykiss*) ($n = 44$; mean total length = 235 mm) were implanted with ultrasonic transmitter tags and stocked into Dale Hollow Lake, TN, on 7 January and 6 March 2009. Fish were tracked at least once per week for eight weeks to describe post-stocking dispersal rates, movements, and habitat use (cove versus main-channel habitat) and to estimate weekly mortality rates. Predators of rainbow trout were also identified and size-related trends in predation were assessed. Dispersal and movement followed a 3-stanza pattern characterized by rapid movement away from each stocking site during the first week, relatively little movement during the following three weeks, and a resumption of large movements during the final four weeks that fish were tracked. Rainbow trout exhibited a strong affinity for coves and embayments and were infrequently encountered in pelagic main-channel habitats. Trout stocked in March exhibited lower weekly mortality (2.7%) than those stocked in January (6.0%) during the first eight weeks post-stocking. Walleye (*Sander vitreus*), three species of black bass (*Micropterus* spp.) and holdover rainbow trout all preyed on recently stocked rainbow trout. Smallmouth bass and walleye differentially consumed smaller rainbow trout and the probability of consuming a trout was positively related to predator size. Walleye were more likely to feed during January than March. Weekly losses of stocked trout resulting only from walleye predation were 2.2 to 2.9 times greater for fish stocked in January than for fish stocked in March.

rainbow trout, movement, dispersal, predation, stocking

10 Contributed Paper

Oral Presentation

Implementation of the southeast aquatic habitat plan in the southeastern US.

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The Southeast Aquatic Resources Partnership (SARP) is a regional Fish Habitat Partnership operating under the National Fish Habitat Action Plan. The Southeast Aquatic Habitat Plan is guiding efforts to conserve and protect fish habitats throughout the region. This presentation will review SARP's activities in 2009 and discuss future plans for regional aquatic habitat assessment and conservation. SARP, through the National Fish Habitat Action Plan and other means, helps fund and facilitate on-the-

ground (or in-the-water) habitat conservation projects. Projects funded in the past two years include riparian area restoration and enhancement on important stream reaches in Arkansas and Tennessee, reservoir shoreline habitat enhancement and riverine gravel bar spawning habitat restoration in Georgia, stream bank restoration in Kentucky, oyster reef restoration in Florida, and salt marsh restoration in North Carolina. Opportunities for future funding of habitat restoration projects will also be discussed.

habitat, habitat assessment, restoration, SARP, National Fish Habitat Action Plan

12 Contributed Paper

Oral Presentation

The effectiveness of different fish attractors in North Carolina reservoirs

Baumann*, J. R., Oakley, N. C., McRae B. J. North Carolina Resources Commission (NCWRC).

Fish attractors are tools that have been widely used by fisheries managers to enhance fish habitat and to increase the concentration of fish in a known location. However, fish attractors are often designed and deployed without any validation for how well they meet management goals. The objective of this project is to evaluate the effectiveness of four different types of fish attractors to concentrate fish in North Carolina Piedmont reservoirs. ANOVA using a randomized, complete block design with repeated measurements is used to evaluate fish abundance from three types of artificial attractors, one natural attractor, and a control area devoid of structure. The materials and general designs of the attractors vary from a cube structure constructed from PVC pipes and plastic barrels, a cube structure built from PVC pipes and corrugated plastic pipes, a commercially available PVC product called the Porcupine, and a bundle of three evergreen trees. Each structure is designed to encompass a volume of approximately 3.375 m³ to minimize bias associated with attractor size. Fish abundance at unmarked attractors is evaluated once per season using instantaneous counts from images taken by a dual-frequency identification sonar (DIDSON) device. Preliminary results from the first year (of three years) showed that the only significant difference (P =0.05) in fish abundance among structures was between the structure with corrugated pipes and the control area. This study will increase fisheries managers understanding of the effectiveness of these fish attractors and help them make informed decisions when enhancing angling opportunities using artificial structures.

fish attractors, artificial structure, DIDSON, North Carolina

13 Contributed Paper

Oral Presentation

Population assessment of roanoke bass in two piedmont streams in North Carolina

Oakley*, N.C., Baumann, J.R., and McRae, B.J. North Carolina Wildlife Resources Commission (NCWRC).

Roanoke bass (*Ambloplites cavifrons*) populations in the Eno and Flat rivers in North Carolina have not been intensively studied since 1980. The primary goal of this project was to assess the population status of Roanoke bass in the upper Neuse River basin. Fish were collected at sampling sites approximately 300 m in length from both the Eno and Flat rivers. Roanoke bass were collected using a Smith-Root model 2.5 GPP

electrofishing unit mounted to a small barge. A capture-recapture event was conducted per site with recapture occurring 2 d post capture. Length structure of both populations indicated high abundance of fish less than 150 mm but larger fish were less abundant in the samples. Ages ranged from 0 to 7 while both river populations exhibited similar recruitment. Recruitment for both populations was likely affected by similar environmental factors. Population estimates, per 300-m sampling site, ranged from 0-484 individuals in Eno River and from 92-293 individuals in the Flat River. Density estimates ranged from 0-665 fish/ha in the Eno River and from 196-914 fish/ha in the Flat River. In both rivers, Roanoke bass exhibited moderate growth, variable recruitment, and an affinity for habitats with high gradients, large boulders, and little sedimentation. Stream fishing for a rare game fish provides a unique opportunity for Piedmont anglers and this fishery should be publicized. However, conservative harvest restrictions should be implemented to help sustain these fisheries.

Roanoke bass, Neuse River Basin, Population assessment, mark-recapture

14 Contributed Paper

Oral Presentation

Affect of grading frequency on production of alligator gar fingerlings in tanks

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Alligator gar fingerling production may be influenced by cannibalism. Grading is time consuming, and the benefits have not been quantified. Our objective was to quantify the relation between grading frequency and survival or growth. Eight day post hatch larvae were stocked into 75-L tanks at 2 larvae/L. Grading occurred at four frequencies. During each grading effort, larvae were redistributed among three or four 75-L tanks to minimize within tank size variability. Larvae were initially offered Artemia at 5 nauplii.mL⁻¹d⁻¹. Larvae were also fed combinations of moist starter and extruded floating pellets, at 10% of body weight/d. Tank bottoms were siphoned twice daily, and water quality was monitored daily. At 50 days post hatch, alligator gar from each grading frequency and tank were individually counted, weighed, and measured. Average (SD) weight of fingerlings was 2.7 (0.9) g. Survival ranged from 53% to 65%. Growth rates ranged from 1.5 to 1.8 mm/d. There was no relation between grading frequency and survival or growth. There was a significant difference in size frequency distributions among the grading frequencies ($X = 138.25$, $df = 24$, $P < 0.001$), with smaller larvae present when grading occurred every day, and larger larvae without grading.

alligator gar fingerling grading

15 Contributed Paper

Oral Presentation

Beyond protection: Emerging evidence of marine protected areas as a management tool

Nick Myers, East Carolina University.

This paper reviews the current literature and questions if there is sufficient evidence that marine protected areas (MPAs) result in increased numbers of targeted commercial species outside their borders and, if so, under what conditions. The use of MPAs as part

of an ecosystem-based management approach to marine fisheries and resources has grown exponentially over the past few decades. The majority of studies show strong evidence of positive change within reserves, increasing organism size and diversity by 20-30% relative to non-protected areas and tripling biomass.

However, the pressing question regarding the practicality of MPAs as a fisheries management tool remains; can they contribute significantly to fish stocks outside of reserve boundaries? In order to address the political and economic questions within the societies that create MPAs, it will be necessary to demonstrate corresponding material results. The goal of MPAs as a fishery management tool, then, is a net export of harvestable species into waters surrounding protected areas. Although there is still a lack of coordinated, quantitative studies of the impacts of MPAs on surrounding areas, ongoing studies are slowly improving our understanding of how MPAs function in this role and indicate that, for some species, they may be a valuable tool for ecosystem-based management of commercial and recreational fisheries.

marine protected areas, ecosystem based management, marine fisheries management

16 Contributed Paper

Oral Presentation

Influence of landscape- and lake-level characteristics on sportfish production in southeastern U.S. impoundments

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The ability to increase fish production, especially trophy fish biomass, is a long-standing and important question challenging fisheries managers. Furthermore, the ability to identify potentially productive water bodies for successful recreational fisheries management based on known lake variables would conserve agency resources. Using existing standardized sampling data, we evaluated the relative influence of landscape- (e.g. physiographic region, underlying geology), watershed- (e.g. watershed area, mean elevation of watershed, surrounding land use in watershed), local-level (e.g. lake surface area, shoreline development index, impoundment age), and local weather (e.g., mean annual precipitation, mean annual temperature) variables on game fish production and biomass in small- and medium-sized impoundments in Public Fishing Areas (PFAs). The impoundments occurred in four physiographic regions throughout Georgia. Their size ranged from 10 to 357 acres, and age ranged from one to 60 years. We developed candidate hypothesis, each of which was represented by a specific regression model, to explain how predictor variables influenced fish production as measured by sportfish catch-per-unit-effort. Potential models were evaluated by using Akaike's Information Criteria (AIC), followed by best-fitting model performance assessment based on cross validation procedures. We hypothesize that landscape- and watershed-level variables will relate more strongly to standing stock production and biomass of game fish species than local lake-level characteristics. These data should help sportfish managers better

target their management resources to better produce quality sportfish angling in small- and medium-sized regional impoundments.

17 Contributed Paper

Oral Presentation

A question of complexity: How an invasive aquatic plant may boost lake productivity

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Water hyacinth is among on the of the world's most widespread invasive aquatic plants known to cause ecological and economic changes. Prior studies suggest greater invertebrate density and diversity associated with water hyacinth than open water or other aquatic vegetation. We compared invertebrate assemblages associated with water hyacinth, open water, emergent vegetation, and submerged trees on Lake Chapala, Mexico, during winter and summer of 2007 and 2008 to further our understanding of water hyacinth's ecological effects. We collected invertebrate samples from the top 28 cm of the lake to test for differences in invertebrate density, taxonomic richness, and assemblage composition. We found that invertebrate density and taxonomic richness was generally higher in association with water hyacinth, but that the mean percent coverage of water hyacinth affected the magnitude of differences among habitat and vegetation types. Moreover, results from our invertebrate analysis and prior research on Lake Chapala fish diets suggest that water hyacinth may have had a neutral, if not positive effect on fish productivity in Lake Chapala during this study.

invasive aquatic plants, invertebrates, water hyacinth

18 Contributed Paper

Oral Presentation

Predation by sub-adult red drum (*Sciaenops ocellatus*) on juvenile blue crabs (*Callinectes sapidus*): estimation of daily ration and seasonal variation in the contribution of blue crab to the diet.

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Physical processes have been identified as affecting the number of blue crab larvae settling into appropriate estuarine nursery habitats, and implicated in the regulation of initial year class strength. However, biotic interactions such as predation may significantly modify the initial patterns of larval supply and shape population structure. The red drum has been identified as a consistent and important predator of blue crabs throughout its range, yet the contribution of blue crabs to their diet has not been quantified. Using a field based approach, we quantified seasonal variation in diet composition, diel variation in gut fullness, and daily consumption estimates of red drum in the New River estuary, North Carolina. Two years (May2007 - Feb 2009) of sampling have been completed, with over 500 age-0 red drum sampled for diet analysis. Prey items were retrieved from 74% of all fish sampled, with blue crab occurring in 17% of all guts containing food items. Other dominant prey items include, Penaeid shrimp (*Penaeus* spp.), and Atlantic menhaden (*Brevoortia tyrannus*). Diel sampling illustrated variable

diurnal feeding patterns and identified several periods of declining gut fullness. Estimates of gastric evacuation rates were calculated, and resulted in a conservative ration estimate of 4.3 % of body weight consumed daily. Using this ration estimate and mean sizes of blue crabs consumed monthly, we have estimated the average age-0 drum in our study system to consume approximately 200 individual blue crabs over a six month period (May - Oct). This size-based diet information will help to discern crab life stages that are most heavily impacted by red drum predation, and ultimately enable the fraction of blue crab natural mortality due to predation to be determined.

20 Contributed Paper

Oral Presentation

Freshwater residency of southern flounder, *Paralichthys lethostigma* in a North Carolina coastal river.

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In 2008 the commercial harvest of southern flounder (*Paralichthys lethostigma*) had a landed value of 5.6 million dollars, making southern flounder the most profitable commercial finfish fishery in North Carolina. However, there has been limited research devoted to determining and identifying the importance of freshwater (0 - 0.5 ppt) habitat for the southern flounder fishery in North Carolina. Southern flounder are known to utilize coastal rivers, but the duration of their residency is unknown. Residency and use of freshwater habitats by southern flounder was examined using fatty acid profiles and total mercury levels of muscle tissue, and otolith microchemistry. Southern flounder were collected using fishery independent techniques in 2007 and 2008 from three locations in coastal North Carolina: the Tar and Pamlico Rivers, and Pamlico Sound. Results indicated that 74% of southern flounder collected in the Tar River were resident, pre-spawning fish. Fatty acid profiles of resident southern flounder had low *n-3:n-6* ratios (\bar{X} = 2.01, SD = 0.40), elevated total mercury levels (\bar{X} = 0.105, SD = 0.034), and low otolith strontium concentrations confirming residency in a freshwater environment. Age-0 and older sub-adult southern flounder were commonly found utilizing flat, shallow muddy-sand or sandy banks in the curves of the river. Total mercury levels were elevated in southern flounder residing in freshwater, but were substantially below the human consumption advisory guideline of 0.4 mg/kg. Reduced growth and low abundance are several indicators that coastal rivers are not optimal habitat for southern flounder, but should be considered as important, secondary habitat. *Southern flounder, fatty acids, otolith microchemistry, mercury*

21 Contributed Paper

Oral Presentation

An evaluation of the influence of stream flows on freshwater mussel growth

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The southeastern US is home to the most diverse freshwater mussel assemblages. However, freshwater mussels throughout the Southeast have experienced substantial population declines in recent decades that have been attributed to a variety of factors ranging from naturally occurring disturbances (e.g., periodic drought) to disturbances resulting from water resource development activities and land use conversions. Of these, changes to the flow regime, in particular increases in the frequency of low flows, have been identified as a significant factor contributing to the decline of mussels in the Lower Flint River Basin, located in southwestern Georgia. Low flows can potentially influence mussel populations through acute (e.g., desiccation) and chronic (e.g., reduced growth and reproductive fitness) mechanisms. Previous studies have documented the effect of low flows on mussel survival. Here we evaluated the potential influence of changes to the flow regime on mussel growth. Live mussels and fresh dead shells were collected within tributaries of the Lower Flint River Basin for age determination and growth measurement. Shells then were thin-sectioned on a low speed isomet saw and mounted to microscope slides. Annuli were identified by a consensus of observers and growth increments were measured using image analysis software. We then evaluated the relation between annual growth and stream flows measured at adjacent USGS gages using repeated measures linear regression. The resulting models will be used to develop tools for assessing the effects of water use on mussel populations.

22 Contributed Paper

Oral Presentation

Age and growth of lake trout (*Salvelinus namaycush*) in two Tennessee reservoirs

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Lake trout (*Salvelinus namaycush*) are widely distributed throughout the higher latitudes of North America, primarily Canada and the northeastern United States. Lake trout predominate in deep, cold lakes and are restricted to such cold-water systems. Although far south of their natural range, some Tennessee reservoirs offer good habitat for lake trout. Over one million hatchery-reared lake trout have been stocked since the 1990s into Watauga Lake and South Holston Lake, two tributary reservoirs in the upper Tennessee River basin, and little information exists about their growth or habitat use. We used experimental sinking horizontal gillnets to sample lake trout in both reservoirs from May 2009 to October 2009. Estimates of age and growth were made by analyzing cross sections of sagittal otoliths from 176 lake trout. The largest fish captured was an 842-mm total length (TL), 7.2 kg, age-13 female. The largest male was age-12, 823 mm long, and weighed 4.7 kg. The oldest fish was age 20. The total annual mortality rate (A) between ages 3 and 20 for Watauga Lake lake trout was 17%. Additional sampling in the winter and spring of 2010 is planned to help identify the time of annulus formation in these southern latitude populations.

23 Contributed Paper

Oral Presentation

The heat is on: Can a reintroduced population of lake sturgeon survive the heat of southern rivers?

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In the Coosa River of northwest Georgia summer temperatures in excess of 30° C may limit survival of stocked juvenile lake sturgeon. Although previous studies have estimated the critical thermal maxima (CTM) of lake sturgeon at 26° C, recent studies in the Coosa River have documented summer survival of age-1 and older juveniles at water temps of 32-34° C. The primary objectives of this study were (1) to experimentally determine the critical thermal tolerances of age-0 and age-1 lake sturgeon juveniles and (2) to determine how varying acclimation temperatures may affect these critical parameters. In a series of replicated, controlled, laboratory experiments, we evaluated the effects of acclimation temperature on both CTM and lethal thermal max (LTM) of age-0 and age-1 lake sturgeon. Our experimental results showed that CTM and LTM of individuals acclimated to 25 °C was 35.7 and 36.8 for age-0 juveniles; and 35.1 and 36.6 for age-1 juveniles. Although age did not significantly affect these parameters, fish acclimated at 25° C had significantly higher CTM and LTM than those acclimated at 18.6° C. Our findings suggest that the current thermal regime of the Coosa River will not likely preclude successful spawning by lake sturgeon; however, further studies are needed to better understand how prolonged thermal stress during the summer months may affect recruitment in this reintroduced population.

24 Contributed Paper

Oral Presentation

Demographic population model for American shad: will access to additional spawning habitat above dams increase population sizes?

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American shad are in decline in their native range and modeling possible management scenarios could help guide restoration. We developed a density-dependent, deterministic, stage-based matrix model to predict possible population-level effects of transporting American shad to spawning habitat above dams on the Roanoke River, North Carolina and Virginia. We used data on sonic-tagged adult American shad and oxytetracycline-marked American shad fry released above and below dams in the Roanoke River to estimate a starting population size and vital rates. We used the model to predict the adult population size over 30 years under different scenarios of transport, effective fecundity, and outmigration survival. We also evaluated possible effects of increased survival rates for either young or adults. The model predicts that the population will increase slowly over the next 30 years. Transport was predicted to benefit the population only if high rates of egg production and young survival could be achieved. Predicted population increases were highest when survival of young-of-year was improved. Presently, the estimated adult population size (5,224 females) is much smaller than either of two assumed values of carrying capacity for the lower Roanoke River; therefore, the

predicted population-level effects of access to additional habitat were less than they would be for an American shad population nearing carrying capacity. Better information about natural mortality rates and carrying capacity for American shad in regulated rivers would improve the model and its evaluation of the benefits of access to additional spawning habitat above dams.

Alosa sapidissima

25 Contributed Paper

Oral Presentation

Are we there yet? Documenting largemouth bass recovery in Chowan River, North Carolina following a major fish kill

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In September 2003, flooding from Hurricane Isabel caused extensive fish kills in the Chowan River basin of northeastern North Carolina. A recent study documented the natural recovery process of the Chowan River largemouth bass population by showing relative abundance had returned to pre-Isabel levels by spring 2006. Largemouth bass size structure, however, remained dissimilar to length distributions observed prior to the storm. Hence, the objectives of this study were to evaluate the current status and further describe the natural recovery of the largemouth bass population in the Chowan River basin. We used standard boat electrofishing techniques to collect largemouth bass during March-May in 2007 and 2009. Catch rates of largemouth bass >200 mm were above average levels for North Carolina coastal rivers (25 fish/h) in both sample years and increased from 2007 to 2009. Length frequency analysis showed a slight upward shift in size structure from 2007 to 2009, and age and growth analysis identified the 2004 and following year classes as comprising the majority of the population in 2007 (81%) and 2009 (95%). Additionally, most individuals from the 2004 year class (age-5) that were collected in 2009 were larger (mean TL = 413 mm) than the current minimum length limit (356 mm). The continued expansion in population size and age structure noted during this study indicates that at least five years must pass following a major fish kill in the Chowan River before an individual cohort (i.e. the 2004 year class) is fully recruited to harvestable size.

largemouth bass, fish kill

26 Contributed Paper

Oral Presentation

Crappie recruitment relative to flooding in Northern Mississippi flood-control reservoirs

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Crappies *Pomoxis* spp. evolved in river systems as floodplain specialists, thriving in backwaters and temporally inundated habitats, adeptly roaming in and out of these environments to exploit changing conditions. In reservoirs with fluctuating water levels,

the amount of floodplain habitat available depends on timing and magnitude of water level rises. We assessed crappie recruitment in four flood-control reservoirs relative to floodplain inundation. Recruitment of young-of-the-year crappies in the reservoirs was indexed with samples taken with trap nets in late summer. Crappie recruitment in reservoirs with more flooded habitat at the onset of the spawning period (approximately March 1) was higher than in reservoirs with no or minimal flooding. Grenada Lake (3,330 ha over conservation pool) and Arkabutla Lake (922 ha over conservation pool) averaged 40 and 21 crappie per trap net, respectively. Conversely, Enid Lake (255 ha over conservation pool) and Sardis Lake (324 ha under conservation pool) averaged 7 and 6 crappie per trap net, respectively. The alteration of rule curves to include biologically significant flooding should be actively pursued as a management strategy for promoting crappie recruitment in reservoirs where substantial sections of the floodplain can be inundated.

27 Contributed Paper

Oral Presentation

Status and population trends of shortnose sturgeon (*Acipenser brevirostrum*) in the Altamaha River, Georgia

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The shortnose sturgeon (*Acipenser brevirostrum*) is a small, amphidromous sturgeon species that inhabits large rivers along the Atlantic coast of North America. Although federally listed as endangered in 1967, most populations remain depressed with few river systems supporting populations >1000 individuals. Within the southern half of the range, the Altamaha River is thought to support the largest discrete population segment based on a 2004 population estimate of 8,233 individuals. Although this previous estimate provided the first comprehensive assessment of the Altamaha population, continued recovery is uncertain because long-term studies of shortnose sturgeon are completely lacking for southern rivers. The objectives of this study were to quantify recent trends in abundance, age structure, and population dynamics of shortnose sturgeon in the Altamaha River. From 2005-2009, we used entanglement gear to conduct annual mark-recapture estimates of the population using the Huggins closed-capture model in Program MARK. We also collected samples of pectoral fin rays to evaluate age and growth and annual survival. Over the 5 years of the study we captured a total of 1552 shortnose sturgeon (including 57 recaptures) in 840 net-hours. Results show that while adult abundance has remained relatively constant, juvenile abundances have fluctuated from a high of 58% of the population in 2004 to a low of only 5% in 2009. Further studies are needed to identify key environmental factors affecting annual recruitment of shortnose sturgeon in southern rivers.

shortnose sturgeon, population dynamics, recruitment, endangered species, Acipenseridae

28 Contributed Paper

Oral Presentation

Cumulative watershed scale impacts from mining on stream fishes in a fragmented Appalachian riverscape

Martin, Roy W.* Petty, J. Todd. West Virginia University.

It is increasingly recognized that stream fish community and population dynamics are influenced by processes operating at both local and regional scales. As a result, localized disturbances can have watershed scale consequences for fish assemblages. The overriding objective this study was to quantify the relative influence of local (i.e., stream segment scale) and regional (i.e., drainage network scale) environmental factors on fish populations and assemblage structure within the upper Monongahela River watershed in northern WV. Specifically, we (1) developed models for predicting the occurrence and abundance of individual fishes and the composition and integrity of fish assemblages using indicators of local and regional condition, and (2) quantified the relative cost of local and regional impairment to individual taxa and local assemblage composition and integrity. Our results confirm that there are measurable, non-additive, biological consequences to cumulative mining impacts within the regional stream network. We also observed substantial variability in species-specific responses to local and regional conditions. Finally, we were able to generate explicit estimates of relative biological costs associated with local and regional conditions on species abundance and likelihood of occurrence as well as assemblage composition and integrity (IBI). Our findings suggest that effective management of stream fishes must consider the watershed context and should seek to affect local and regional conditions through the restoration and protection of interconnected drainage networks.

Regional versus local impairment, Acid Mine Drainage (AMD), fish community, Index of Biological Integrity

29 Contributed Paper

Oral Presentation

Impacts of distance distortion on a common movement-index for radio-tagged animals

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Impacts of coordinate system on interpretation of movement data from radio-tagged animals are poorly documented. Average Daily Movement (ADM) is the minimum distance traveled by radio-tagged animals between consecutive trips divided by the number of days elapsed. Movements of radio-tagged grass carp were used to compare linear distance and ADM calculated from geographic (WGS84) and projected coordinate-systems (NAD83). Differences between coordinate systems were calculated by subtracting the distance estimated by WGS84 from that estimated by NAD83.

Magnitude of difference was the absolute value of the difference. Direction of differences described whether distances from WGS84 were larger (+) or smaller (-) than those from NAD83. Magnitude and direction of difference between distance estimates from WGS84 and NAD83 depended on the actual distance measured. Analysis of variance (ANOVA) was used to test the effects of season and stocking location on linear distance and ADM calculated from each coordinate system. Projecting coordinates from

WGS84 to NAD83 increased the significance and power of ANOVA tests using linear distances, and decreased these parameters using ADM. These results have broad implications for interpretation of movement data from radio-tagged animals. By using projected coordinate systems for distance measurements, researchers can reduce uncertainty in estimates from telemetry data.

Telemetry, distance distortion

30 Contributed Paper

Oral Presentation

Effects of stocked trout on native nongame riverine fishes

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Stocking waters with hatchery-reared trout species (Salmonidae) to support local recreational fisheries is common practice among state and federal agencies in the United States; however, the effects on native nongame fish communities are poorly understood. To address this, we conducted research during 2008-2009 on the North Toe River, a high gradient Appalachian Mountain river. We employed a BACI (before-after-control-impact) experimental design with snorkeling surveys to intensively quantify density and microhabitat use of the fish community at a treatment site and two downstream reference sites before and after trout stocking. We also extensively backpack electrofished several other delayed harvest trout waters from four river basins across western North Carolina paired with reference sites that received no trout stocking to supplement our findings. In our intensive study, we found no significant changes in fish density, microhabitat use, or community composition as a result of trout stocking, but we observed differences between years in density and microhabitat use. This suggests that the fish community responded to environmental conditions, but not differentially in the stocked site. We also detected no differences in density, community composition, or average fish weight in the paired delayed harvest electrofished sites. Our results suggest minimal ecological effects of trout stocking on the nongame fish assemblage, relative to the inherently high variability in environmental conditions and fish community dynamics in this river. These findings may assist natural resource agencies in planning for the coexistence of recreational fisheries and nongame fish conservation efforts in coldwater river ecosystems.

trout, nongame, rivers, streams, stocking, snorkeling

31 Contributed Paper

Oral Presentation

A 10 year monitoring plan for spotfin chub in the Little Tennessee River, North Carolina: overview and results from the first three years.

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A 10 year effort to assess the federal and state-threatened spotfin chub, *Erimonax monachus*, population in the upper Little Tennessee River began in August 2007. Goals are: 1) assess spatial and temporal distribution and abundance over a 10 year period; 2) provide information to guide management decisions, recovery efforts, and further research; and 3) provide any additional life history and habitat use information as observed. Ten sites were selected within the 37 km occupied reach. Snorkel surveys along fixed transects and timed, random searches were conducted at each site. Baseline data were gathered in 2007 at all 10 sites and the average number of spotfin chubs observed per 50 m transect and per hour of random search was 2.7 and 5.8. In 2008 and 2009 an alternating subset of five sites were sampled. The average number of spotfin chubs observed per 50 m transect and per hour of random search increased in 2008 (13.8 and 44.1) and decreased slightly in 2009 (8.8 and 27.5). In all three years, more adult and sub-adult spotfin chubs were observed in the lower half of the study reach. Extreme hydrologic events, both floods and drought, appear to affect the spotfin chub population. Fixed transects and timed, random searches sometimes produced differing results, confirming the importance of utilizing each sampling method.

spotfin chub, Little Tennessee River, snorkel surveys, population assessment

32 Contributed Paper

Oral Presentation

Quantitative survey of the freshwater mussel fauna in the Powell River, Virginia and Tennessee

Johnson, M. S.*, Neves, R. J., Henley, W. F., Jones, J. W. Virginia Tech.

The Powell River is home to 9 federally endangered species of mussels; including the dromedary pearl mussel (*Dromus dromas*), Cumberlandian combshell (*Epioblasma brevidens*), Oyster mussel (*Epioblasma capsaeformis*), shiny pigtoe (*Fusconaia cor*), fine-rayed pigtoe (*F. cuneolus*), birdwing pearl mussel (*Lemiox rimosus*), rough rabbitsfoot (*Quadrula cylindrica strigillata*), Cumberland monkeyface (*Quadrula intermedia*), and Appalachian monkeyface (*Q. sparsa*). Long-term quantitative sampling at multiple sites in the Powell River has documented a decline in mussel densities over the past 30 y. In 2008 and 2009, we completed a survey of 22 sites (1000+ person-hours) to document the current presence, relative abundance, density, and size-class structures of the mussel fauna in the river. Qualitative (catch-per-unit-effort, CPUE) and quantitative (0.25m² quadrat) sampling were both used during the survey. The qualitative portion of the survey documented 29 species representing >15,000 live mussels. Four species documented in previous surveys (*Cumberlandia monodonta*, *Epioblasma capsaeformis*, *Fusconaia cuneolus*, and *Hemistena lata*) were not observed during this survey. Seven of the 9 federally endangered species found in the Powell River were collected live and were represented by 265 individuals. The CPUE (mussels/person-hour) and mussel density (mussels/m²) values ranged from 0.33 mussels/hr to 21.98 mussels/hr and 0.00mussels/m² to 2.24mussels/m², respectively, and generally increased at sites further downstream from known human impacts in SW Virginia. Data will be compared to

those of previous surveys at overlapping sites to determine temporal changes in mussel density, and a long-term monitoring program at key sites will be developed.

Freshwater Mussels, Powell River

33 Contributed Paper

Oral Presentation

Bottom up effects on bluegill relative weight (Wr): Influence of sediment nutrients and benthic macro-invertebrates in recreational fishing ponds.

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An experiment is currently being conducted in five earthen recreational fishing ponds in northern Mississippi. The aim of the project is to identify the bottom up effects that sediment nutrient concentrations have on benthic macro-invertebrate community compositions and density as well as bluegill (*Lepomis macrochirus*) condition in fertilized and unfertilized ponds in the southeastern United States. The five ponds will be sampled with the objectives of identifying spatial and temporal distributions of sediment nutrients (carbon and nitrogen) and benthic macro-invertebrates, determining seasonal bluegill condition and identifying potential relationships between sediment nutrients and benthic macro-invertebrate characteristics, and lastly comparing sediment nutrient concentrations, benthic macro-invertebrate characteristics and bluegill condition between fertilized and unfertilized ponds. Sediment nutrients and benthic macro-invertebrates will be sampled by using a yabby pump. Fish will be sampled using electrofishing and condition will be quantified as a relative weight (Wr) index for all intermediate bluegill between 76 and 150 mm as described by Swingle (1950). For these objectives we predict that sediment nutrient concentrations and benthic macro-invertebrate distributions will be positively correlated with bluegill condition. We also foresee that seasonal changes in the relationships between sediment nutrients, benthic macro-invertebrates and bluegill conditions will be evident. Lastly, we expect to see elevated concentrations of sediment nutrients, benthic macro-invertebrate densities and mean relative weights in the fertilized ponds when compared to the unfertilized.

34 Contributed Paper

Oral Presentation

Establishing aquatic macrophytes as self renewing fish habitat in Little Bear Creek reservoir, Alabama

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Reestablishment of native aquatic macrophytes has been used to restore habitat for fish and other organisms. Native plants have positive effects on water quality and provide

areas for refuge and foraging for many YOY fish. Species selection for re-vegetation may be of great importance due to lake-specific ecological factors that affect survival such as water depth, light and temperature. Since 2007 we have used a variety of aquatic plant species and strategies for re-vegetation efforts in Little Bear Creek Reservoir, Alabama. Several factors may have led low survival of most species, such as low water levels, high water temperatures, and herbivory. In 2008 we tested whether planting depth contributed to the overall survival of plants inside protective exclosures. We performed an experiment in which we planted three species along a depth gradient (0.30, 0.60, and 1.0 m): sago pondweed (*Stuckenia pectinata* (L.) Böerner), water celery (*Vallisneria americana* Michx.), and American pondweed (*Potamogeton nodosus* Poir). Our results indicated that the depth in which species were initially planted had no effect on pooled survival ($P < 0.05$); but species did have an effect ($P < 0.05$), with American pondweed having the highest survival (93%). The results of these trials will provide us with information that will aid in future native aquatic plant reestablishment in areas where plant restoration can benefit aquatic systems. Additionally, we plan to incorporate our data into spatial models in a GIS and fish bioenergetics models to assess the potential effect of our restoration efforts on bluegill (*Lepomis macrochirus*).

Aquatic plants, habitat, restoration

35 Contributed Paper

Oral Presentation

Estimating survival and abundance of *Etheostoma inscriptum* during extremely low flows in a sixth-order river bedrock shoal

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Streamflow alterations, such as drought and water withdrawals, are imminent threats to many native freshwater fishes. To understand how fish populations respond to such environmental change, it is essential to estimate changes in fundamental demographic rates (i.e., survival, recruitment, and emigration). An effective approach for estimating such parameters is to use mark-recapture methods. By using a robust design capture-recapture model, we evaluated demographic rates of the Turquoise darter, *Etheostoma inscriptum*, during extremely low flows in the Middle Oconee River (GA). During the late summer and fall of 2008 and 2009, a total of 3227 individuals were marked and released within a 1500m² bedrock shoal. The average probability of capture was 0.11 and density estimates were relatively high in both years (1.2 to 2.0 m⁻²). As expected, apparent survival was higher for adult fish compared to the young-of-year (y.o.y. < 42mm SL) age class during the fall of 2008 (0.92 and 0.82 per month, respectively). In contrast, apparent survival over the winter (e.g., Nov-Aug) was extremely low for both age classes (adult 0.40 and y.o.y 0.04), despite individuals exhibiting site fidelity during the fall of 2008. Recruitment of age-0 individuals was similar between years, with an increase of 61% (2008) and 56% (2009) of y.o.y individuals between July and September. Applying the robust-design model over multiple years will allow us to evaluate the importance of emigration and recruitment as well as the effects of drought

and streamflow alterations on population dynamics of a larger-order river shoal dependent fish species.

Mark-recapture, darter, abundance, survival, streamflow, Middle Oconee River

36 Contributed Paper

Oral Presentation

Misidentification of freshwater mussels: Contributing factors, management implications, and potential solutions

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It is generally well accepted that not all animals are captured and all species detected during field sampling, and a variety of sample design and modeling procedures can account for incomplete capture. However, the prevalence and influence of false-positive errors (e.g., detecting species when they are actually absent) is much less well known and understood. Such misidentification errors can arise because of factors associated with species traits (e.g., cryptic coloration) and observers (e.g., identification ability). Because surveys are often conducted for multiple species by different people at different points in time and space, ecological patterns may be confounded with those induced by misidentification errors. Such errors may be particularly prevalent for poorly understood species such as freshwater mussels. We conducted a laboratory-based identification exercise to evaluate the influence of species and observer characteristics on misidentification error rates for 27 mussel species native to the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Alabama, Florida, and Georgia. Misidentification error rates varied among species, averaging 26% and ranging from 4% to 56%. Species with highly distinctive traits such as shell texturing were misidentified least often, whereas species lacking distinctive traits (e.g., smooth-shelled species) were misidentified most often. Although misidentification error rates declined with observer experience, there was substantial variability among observers after controlling for experience. Our results suggest that misidentification errors may be common in the ACF and other river basins, potentially biasing estimates of population status and distribution. However, misidentification error rates could potentially be reduced through the use of regional workshops and testing.

37 Contributed Paper

Oral Presentation

A multi-scaled approach to evaluating the fish community structure in southern Appalachian stream fishes

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Stream fish community structure is known to be influenced by local stream features, watershed characteristics, and biotic interactions occurring at multiple scales. However,

there is much uncertainty regarding the relative roles of local stream and landscape characteristics and interspecific interactions in structuring stream fish assemblages. Thus, we evaluated the relative importance of environmental characteristics and species interactions, at local and landscape scales, on stream fish communities within tributaries of the upper Little Tennessee River basin, North Carolina and Georgia. Using a quadrat sample design, fishes were collected and habitat characteristics were measured at 46 reaches in 29 wadeable streams during July through September 2009. The sample streams were chosen to represent the range of stream sizes, geology, and dominant land uses in the basin. We used hierarchical, multi-species occupancy models to evaluate the relative support of models that related fish community structure to local and landscape level features. Modeling results indicated that the probability of detection varied considerably among species and was related to local stream habitat features, such as sample unit depth. Stream fish community structure, however, was most strongly related to large scale environmental characteristics, such as watershed elevation and land use. In addition, species associations varied with scale and suggested that different mechanisms influenced assemblage structure at different scales.

stream fishes, community structure, Appalachian

38 Contributed Paper

Oral Presentation

Visual survey and habitat association of three rare darters (*Etheostoma cinereum*, *Percina burtoni*, and *Percina williamsi*) in the Little River, Blount County, Tennessee

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The Little River in Blount County is home to one of the richest darter faunas in East Tennessee. Increases in agriculture and development on several tributaries and the main stem of the Little River are suspected as causes for reduced abundances and diversities in fish populations. Earlier research on the Little River identified three species (*Etheostoma cinereum*, *Percina burtoni*, and *Percina williamsi*) as having low densities. From May - October 2009 snorkel observations were made at 11 predetermined sites along the mainstem of the river to determine abundance and habitat association of these target species. All fish observed while snorkeling were identified and the locations of target fish were marked with lead weights to facilitate microhabitat measurements. Observations included 39 fish species, including 49 *Percina burtoni* and 6 *Percina williamsi*. *Etheostoma cinereum* were not encountered during this study period. Our observations indicate that darter populations during 2009 were much lower than historic populations. This may be attributable to multiple factors including: habitat degradation due to development and agriculture, two consecutive years of drought 2007-2008, and potential sampling bias due to high flows in 2009. Additional sampling of possible winter pool habitat with coated wire minnow traps has yet to be completed.

39 Contributed Paper

Oral Presentation

Habitat effects on instantaneous rates of growth (G) and mortality rates (M) of larval river herring (*Alosa aestivalis* and *A. pseudoharengus*) cohorts in the Tar-Pamlico River, Pamlico Sound, North Carolina.

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We estimated the variation in instantaneous rates of growth (G) and mortality (M) between cohorts of larval blueback herring *Alosa aestivalis* and alewife *A. pseudoharengus* in Tar-Pamlico River, Pamlico Sound North Carolina. The ages of larvae captured by push net in main-channel and backwater areas were estimated by counting daily rings on the sagittal otoliths. Weight-at-age and abundance-at-age data were used to generate instantaneous daily rates of growth and mortality for 6-d cohorts. Both species showed bimodal patterns in hatch dates but alewife hatch dates lagged behind blueback hatch dates. The instantaneous daily growth rate was relatively constant between cohorts, ranging from 0.103 to 0.277 for alewife and from 0.105 to 0.200 for blueback herring. The instantaneous daily mortality rate was more variable between cohorts, ranging from 0.064 to 0.270 for alewife and from 0.100 to 0.251 for blueback herring. The physiological mortality rate, or M/G, was calculated for all cohorts. All but one blueback herring cohort, had an M/G value >1.0, indicating that these cohorts were barely maintaining or losing biomass during the early larval stage. For alewife, the M/G values were more variable where 50% of the cohorts had values <0.37 and the remaining cohorts had values >1.0. The effect of habitat was consistent between species where M/G values were consistently higher and closer to 1.0 in the backwater areas. The overall M/G values were 1.6 for blueback herring and 0.57 for alewife indicating that the environmental conditions in the Tar-Pamlico river are more favorable for alewives than blueback herring.

river herring, habitat growth, mortality

40 Contributed Paper

Oral Presentation

A rapid response effort to remove introduced tilapia (*Oreochromis* spp.) in Port Sulphur, LA

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An introduced population of tilapia (*Oreochromis* spp.) was discovered in Port Sulphur, LA in April 2009. An Incident Action Plan (IAP) was established by the Louisiana Department of Wildlife and Fisheries (LDWF) to evaluate and remove the tilapia population from impacted waters. Over 100 locations were sampled throughout Plaquemines Parish to determine the geographic extent of the population. Specimens were sent to the Louisiana State University Agricultural Center where they were electrophoretically identified as a Nile tilapia (*Oreochromis niloticus*) and blue tilapia (*Oreochromis aureus*) hybrid. The Secretary of LDWF invoked a fishing closure in May 2009 that included all public and private water bodies within a 915 hectare zone in Port Sulphur, LA. After further evaluation of the impact zone, a decision was made to remove the tilapia by means of rotenone application. Results from several impromptu

experiments indicated that rotenone concentrations of 5 ppm were needed to successfully remove adult tilapia and tilapia eggs. Approximately 74 hectare-meters of water (33 surface hectares) were treated with a total of 10,270 liters of rotenone over a 7 week period. Several predatory fish species were collected from the Bonnet Carre Spillway and the Atchafalaya Basin and stocked into the impacted water bodies post treatment to serve as a biological control against the potential repopulation of tilapia. No tilapia were observed during post-treatment monitoring in August 2009. Further monitoring will continue on a quarterly basis over the next 2 years to determine the effectiveness of the removal effort.

tilapia, rotenone, invasive species removal, Incident Action Plan, rapid response

42 Contributed Paper

Oral Presentation

Production of estuarine-use functional guilds of fishes in managed impoundments in coastal South Carolina

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Estuarine intertidal wetlands have been characterized as net exporters of secondary production. In coastal South Carolina, many 18th-century rice field impoundments are now managed to provide habitat for migratory waterfowl. Water levels in these impoundments are manipulated such that intertidal habitat is closed to fish migration for most of the year; and when open, only limited migration occurs. The effects of impoundments on fish production and energy transfer are largely unknown. In this study, summer production of the estuarine-use functional guilds of fishes in three impoundments (BRF, Nieuport, and ACE) was calculated using the size-frequency method. Production levels were predicted to vary depending on the characteristics of the impoundment. For example, the impoundments vary in salinity; BRF is the most saline (17 – 22 psu), Nieuport is intermediate (4 – 13 psu), and ACE is the freshest (4 – 9 psu). Marine migrants (MM) move upstream from coastal waters in the winter then migrate downstream to higher salinity water through the summer. We hypothesized that MM production levels would be highest in BRF, where the salinity is similar to natural summer habitat. Production of MM in 2008 was 223.60 ± 228.94 kg/ha/summer in BRF; 23.72 ± 60.75 kg/ha/summer in Nieuport; and -22.42 ± 83.05 kg/ha/summer in ACE. These preliminary results are similar to the results we predicted and suggest that impoundment salinity may partially dictate MM production. We are unaware of estimates of estuarine production of MM from coastal impoundments elsewhere. Accordingly, we are reporting our results as baseline estimates for managed coastal impoundments in the SE United States.

production, marine migrants, impoundments

43 Contributed Paper

Oral Presentation

Mining and residential development interact to produce highly impaired stream conditions in an intensively mined Appalachian watershed

Merriam, E.M.*; Merovich, G.M.; Petty, J.T. West Virginia University Division of Forestry and Natural Resources.

Large scale surface mining in the central Appalachians causes significant alteration of headwater stream networks. It is unclear, however, the extent to which mining interacts with other stressors to determine physical, chemical, and biological conditions in aquatic systems downstream. Through a watershed scale assessment of Pigeon Creek (a tributary of the Tug Fork in Mingo County, WV), the specific objectives of this study were to: 1) develop landscape-based indicators of mining and residential development; 2) quantify the interactive effects of mining and residential development on in-stream conditions; and 3) identify landscape-based thresholds above which biological impairment occurs in intensively mined watersheds. Correlation analysis and partial Mantel tests indicate that mining (total % mining) resulted in more acute changes in water chemistry (r ranging from 0.74 to 0.91), whereas residential development (parcel density) had a stronger impact on both physical habitat (r ranging from 0.65 to 0.81) and macroinvertebrate community structure (r ranging from 0.64 to 0.93). The combined effects of mining and development on in-stream conditions appeared to be additive. At equivalent levels of both total % mining and parcel density, sites impacted by both stressors exhibited lower EPT richness than mined or developed sites. Furthermore, the degree of impairment observed at a given level of mining was directly proportional to the intensity of residential development and vice versa. Impairment thresholds were observed at ~25% total mining (equivalent to a specific conductance of $\sim 100\mu\text{S}/\text{cm}$) and at a parcel density of $\sim 14\text{parcels}/\text{km}^2$. Our results suggest that effective management of impacts from new mine development and watershed restoration efforts in mined watersheds must address the prevalence of non-mining related impacts.

Mountaintop mining, residential development, interactive stressors, landscape thresholds

44 Contributed Paper

Oral Presentation

Age and growth characteristics of channel catfish (*Ictalurus punctulatus*) in coastal rivers of Mississippi following Hurricane Katrina with emphasis on the Pascagoula River

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In the Pascagoula River, hypoxia-induced fish kills occurred for two weeks following Hurricane Katrina and were estimated at 60.8 million fish. Fish kills were also reported in other southern Mississippi streams and backwaters. Catfish tend to be the principle target for recreational anglers in the Pascagoula River. In 2007, 2008, and 2009, channel catfish were captured in six coastal rivers (Pascagoula, Wolf, Pearl, Tchoutacabouffa, Jourdan, and Biloxi) by electrofishing, trotline, and hook-and-line sampling techniques. Pectoral spines were taken for age analysis, and lengths at age were back calculated to estimate growth. Pre-hurricane channel catfish growth (June-August 2001-2002) was

also compared to post hurricane growth (June-August 2007-2009). Estimates of individual growth rates for channel catfish in 2007 suggested that Pascagoula River stocks (N = 415) grew faster (von Bertalanffy $k = 0.60$) than stocks from the other five coastal rivers and also faster than the average channel catfish from rivers throughout the species' North American range. Furthermore, the 2007 mean back-calculated lengths at age are nearly two times the estimates reported for pre-hurricane channel catfish sampled in 2001 and 2002. However, from 2007 to 2008, the mean back-calculated length at age of channel catfish in the Pascagoula River decreased as did the individual growth rate ($k = 0.37$). Our results suggest that following Hurricane Katrina, natural competition for resources was reduced, resulting in increased growth and potentially reproductive success for channel catfish that had survived.

catfish hurricane rivers

45 Contributed Paper

Oral Presentation

A new approach to field identification of river sturgeon (*Scaphirhynchus*) in the Mississippi River

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Pallid sturgeon and shovelnose sturgeon are sympatric in the Missouri River and several tributaries, and in the Mississippi River from the confluence of the Missouri to the Gulf of Mexico, including its distributary the Atchafalaya River. A suite of characters was identified in the mid 20th century to distinguish the two species, and several character indices (CI) have since been developed for identification. Specimens having characters intermediate between pallid and shovelnose sturgeon have been considered as 'hybrids' or, more recently, as intermediates. The suite of distinguishing characters upon which CIs are based, however, are from a relatively small number of individuals which do not capture morphological variation throughout the range of either species. This has led to potential misidentification of a disproportionate number of young adult and subadult pallid sturgeon captures as either hybrids or intermediates, particularly in the Mississippi River. Allometric growth in the characters employed in the CIs is a primary factor in their inadequacy to distinguish young adults, subadults, young-of-year or metalarvae of the species. Although genetic techniques have been developed to distinguish the species, genetic assignment using STRUCTURE analysis shows some specimens are intermediate between the species which has also been interpreted as hybridization. Additionally, comparison of genetic and CI assignments are often discordant. Following a decade of observations of river sturgeon in the Atchafalaya and Lower Mississippi rivers, we have identified a suite of three characters for rapidly differentiating adult and maturing pallid and shovelnose sturgeon in the field. Two of these, barbel morphology and belly scalation, have been recognized as primary distinguishing qualitative characters since the description of pallid sturgeon. The third character, mouth to head width, was recognized in the original description of pallid sturgeon, but has been used sparingly since. Barbel

morphology and mouth width also appear to distinguish most pallid and shovelnose metalarvae through 200 mm fork length.

pallid sturgeon, shovelnose sturgeon

46 Contributed Paper

Oral Presentation

Is multi-pass electrofishing a viable alternative to cove rotenone?

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Use of rotenone as a fisheries management tool poses issues of poor public relations, logistical challenges, manpower, and safety concerns to the applicator and public. Because of these issues, we wondered if multi-pass depletion electrofishing could be used as an alternative to rotenone to estimate fish populations in reservoir coves; we also wanted to determine our recovery efficiency when using rotenone in coves. Our study was conducted in Richard B. Russell and J. Strom Thurmond Reservoirs located on the borders of Georgia and South Carolina. We used depletion models to estimate population size and compared those results to results from rotenone samples taken at the same locations. We analyzed multi-pass depletion electrofishing data by using the DeLury method and two maximum likelihood removal models: a variable probability removal estimator, and a variable probability removal estimator $M(bh)$ that accounts for behavior and heterogeneity. In all cases, our results indicated that removal estimators underestimated fish population size. Numbers of fishes collected per cove by rotenone ranged from 2,554 to 14,339 and averaged 17 times greater than depletion model estimates derived from multi-pass electrofishing. Also, recovery efficiency in the sampled coves was variable and ranged 77% to 87% depending on the generalized species classes. We conclude that multi-pass electrofishing was not a viable alternative to rotenone for sampling small coves in JST and RBR reservoirs. Further, the variable capture efficiency among species and coves leads us to recommend using mark and recapture to adjust rotenone estimates at sites selected for rotenone sampling.

Depletion models, Electrofishing, Rotenone

47 Contributed Paper

Oral Presentation

Variables affecting trawl catch rates of sturgeon in the lower Mississippi River.

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Few studies have assessed the affect abiotic variables have on catch rates of juvenile *Scaphirhynchus* spp. This study estimated which environmental variables may have affected catch rates in the lower Mississippi River. An otter trawl was used to capture juvenile *Scaphirhynchus* spp. from July to November 2009. Sampling occurred between river kilometers 898-933 on sand bars along inside river bends. Samples were taken on each sand bar at three longitudinal positions and three depth ranges (1-2, 3-4 and 5-6 m). Variables considered in data analysis include: water velocity, water temperature, depth, bend, river stage and 24 hour change in river stage. Regression tree analysis was used to estimate which variables had the greatest effect on catch rates. Preliminary results show that river stage was the most important factor affecting catch rates, followed by surface velocity and depth. The best model explained 39.6% of the variation in catch rates. Although preliminary analysis revealed that catch rates are primarily influenced by river stage, more sampling is needed to increase sample size and better assess the factors affecting catch rates of juvenile *Scaphirhynchus* spp. in the lower Mississippi River.

Trawl, Sturgeon, Regression tree

49 Contributed Paper

Oral Presentation

Seasonal movements of adult robust redhorse stocked in the Oconee River, GA.

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We used radio telemetry to assess seasonal habitat use and movement of adult robust redhorse stocked in the Oconee River in middle GA. Hatchery-reared individuals from Oconee River broodstock were anesthetized, implanted with radio transmitters, and released. Within two weeks, 27 of 33 robust redhorse traveled upstream of the release site. From late April to June 2008, about 72% of the fish moved 24 km above the release point and 28% moved about 24 km downstream. Movement was limited to about 6 km during December 08 and January 09 and about 2 km during summers 2008 and 2009. Movement was greatest (~37 km) during fall 2008. In mid-April 2009, four fish were tracked over a 24-hour period and relocated at 2-hr intervals. Two fish moved during that period; both moved about 10 km upstream and most of that movement occurred during daylight. During March-April 2009, 100% (n=14) of the fish migrated upstream toward the known Avant mine spawning area and remained there until the May 2009 spawning period. None of the radio-tagged fish were located on the gravel bar where spawning occurred historically; however, six individuals were relocated (some multiple times) in a new area that contained gravel substrates. This new site is about 1.3 kilometers upstream of the Avant Mine site and may be a new spawning location for robust redhorse in the Oconee River. Generally, robust redhorse were found in the main channel and were associated with variable current, deep water, sandy substrates, and woody debris.

robust redhorse, radio telemetry, seasonal movements

50 Contributed Paper

Oral Presentation

Influence of turbidity on the foraging of largemouth bass in aquaria

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Water turbidity has the capacity to influence fish foraging success and behavior. Largemouth bass (LMB) *Micropterus salmoides* is a popular sport-fish in the southeast and is primarily a visual predator. It is likely that high turbidity which can be attributed to sediment loading from agricultural lands will reduce light availability in the water column and have direct impacts on LMB foraging success. We investigated the effect of turbidity levels (0, 10, 25, 50, 100, 250 nephelometric turbidity units [NTU]) on largemouth bass foraging in aquaria. The comparison between the prey captured percentages from aggregated data in multiple trials at the treatment levels 0 and 250 NTU differed significantly ($P < 0.05$). One-hundred percent of the bass in the 0 NTU treatments captured the prey. Conversely, only 15% of the bass in the 250 NTU treatments captured prey throughout all trials. Average time taken for bass to capture prey was also significantly different ($P < 0.05$) in the two treatments. The results from this study suggest that higher turbidity levels can reduce the chances of LMB capturing prey and therefore the potential fitness of the species, thus impacting the approaches that should be taken when managing the watershed and LMB fishery.

51 Contributed Paper

Oral Presentation

Fish barriers in tributaries to the Little Tennessee River

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Between 2007 and 2009, a team of federal, state, and local partners studied the significance of road crossings in impeding fish movement on tributaries to a 23-mile section of the upper Little Tennessee River that hosts a highly diverse community of native aquatic species. The study team used modified US Forest Service protocols to assess culverts and other potential barriers, measuring structure physical dimensions and applying models of swimming ability developed for fish of the Appalachian region. Those crossings determined impassable or possibly impassable were tested by monitoring fish communities up and downstream of each crossing during fall migrations of spotfin chub, whitetail shiner, and telescope shiner from the Little Tennessee River. Across all sites with free access to the Little Tennessee River, fall migrants comprised 36% of all fish sampled, and other river-dependent fishes comprised another 43%. Fish monitoring confirmed the impassability of three of six crossings deemed impassable through physical surveys and one of seven crossings deemed possibly impassable through physical surveys. Those crossings upstream of other barriers could not be fully tested with fish monitoring. Our results illustrate that problematic road crossings are not necessarily permanent barriers but instead differentially permeable filters depending on flow levels.

Little Tennessee River, barriers, fish passage

The effects of fishing effort on catchability of largemouth bass

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The effect of fishing on the catchability of a population receiving intense angler effort has long been debated but not measured. This study evaluated the effect of fishing effort on catchability of adult largemouth bass *Micropterus salmoides* in high-density ponds and determined whether catchability was affected by a period of no fishing. Eight, 0.5-2.0 ha impoundments were fished once a week at a rate of 0.4 angler hours per hectare per week during two successive May-October fishing seasons to evaluate whether catch rates differed between populations fished continuously and populations with the fishing season interrupted by a 2-month period of no fishing. Linear regression revealed a negative correlation between catchability and fishing effort in five of the eight ponds ($R^2 = 0.33-0.67$; $P < 0.05$). For four of the ponds, discontinuous linear regression results indicated that catch rates were different ($P < 0.10$) after a period of no fishing. Although our results indicated that catch rate decreases with increased fishing effort and increases after periods of no-fishing, the low explanatory power of the analysis due to high variability in catch makes evaluating the effectiveness of a fishing layoff difficult.

Gear evaluation for the capture of sturgeon in the Lower Mississippi River

Patrick Mirick*, Harold Schramm, Jr. Mississippi State University.

Paul Hartfield U.S.F.W.S.

Conservation of shovelnose sturgeon *Scaphirhynchus platyrhynchus* and endangered pallid sturgeon *Scaphirhynchus albus* in the free-flowing lower Mississippi River will require information about adult population size, habitat use, migrations and mortality; all of which are unknown and will require capture of many individuals. Therefore, we conducted an evaluation to determine the most effective sampling gear for catching sturgeon in the LMR. Trotlines were more effective than otter trawls for catching adult pallid (>600 mm FL), and the probability of catching one or more adult pallid sturgeon with a trotline peaked in 9-19 °C water, 0.7-0.9 m/s surface current velocity, and in deep water. Trotlines were also more effective for catching adult shovelnose sturgeon (>600 mm FL), with peak catch rates in similar temperatures, although in shallower water. Otter trawls were effective for catching juvenile sturgeon (100-600 mm FL) and catch rate was highest during low river stages. Catch rates of shovelnose sturgeon were higher than pallid sturgeon for each gear. Habitat, river stage change, season, and location had little effect on the catch of sturgeon for either gear. The results of this study can be used as a guide to select the appropriate sampling gear based on size and species desired, and to determine the optimal sampling conditions to maximize sampling efficiency.

sturgeon trotline trawl

Habitat use of female Meek's Crayfish during reproductive seclusion

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Stream habitat use of female crayfish during brooding of eggs and hatchlings represents a poorly studied aspect of crayfish life history and ecology. Therefore, the goal of this study was to use passive integrated transponder (PIT) technology to identify the habitat use of female Meek's Crayfish *Orconectes meeki meeki* during reproductive seclusion. PIT tags (12.5 mm long, 2.07 mm diameter) were externally attached to Meek's Crayfish (16.0-33.7 mm carapace length) in Rock Creek, Barry County, Missouri during November 2008 and tracked with a portable detector from early February through May 2009. Spearman rank-order correlation analyses indicated significant correlations ($P < 0.05$) between the presence of brooding females and water depth (+), bottom (-) and column (-) water velocity, percent embeddedness (+), substrate roughness (+), dominant (+) and subdominant (+) substrate, conductivity (-), silt (+), and macrohabitat type (+). In addition, Meek's Crayfish utilized habitat that differed from available habitat for the same ten variables. During reproductive seclusion burrow depths ranged from 6 to 18 cm (mean \pm SD = 11 ± 4 cm), and cover rock surface area averaged 1032 ± 926 cm² (range: 60-3177 cm²). In general, females utilized low turbulence pool habitat that contained cobble and boulder substrate.

Meek's Crayfish, habitat use, reproductive seclusion

Temporal and spatial distribution of native and invasive bivalves in Bayou Lafourche, Louisiana

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The zebra mussel *Dreissena polymorpha* and the Asian clam *Corbicula fluminea* are invasive, bio-fouling species that were introduced into North America during the last century. Invasive bivalve introductions may result in a loss of biodiversity, particularly among vulnerable native freshwater mussel populations. From 2007 to 2010 we sampled native and invasive freshwater bivalve populations in Bayou Lafourche, a former tributary of the Mississippi River. Bayou Lafourche is connected to the Mississippi River via a pumping station at the headwaters in Donaldsonville, Louisiana. Seasonally, we examined the spatial distribution of mussel populations using a ponar sampler, settlement cages and bridge scrapings. Additionally, we assessed the thermal tolerance of zebra mussels collected during August 2009 from warm water (31 C), with a high sediment load. The highest zebra mussel (375 mussels/m²) and *C. fluminea* densities (5875 clams/m²) were found near the pumping station. Existing literature suggests that high summer water temperatures (> 30 C) prevent the establishment of permanent zebra mussel populations, however, live mussels were collected on 23 June 2009 at 32 C and 14 August 2009 at 31 C. The acclimated (0.2 C/day) upper lethal limit of south

Louisiana floodplain zebra mussels is $32\text{ C} \pm 1\text{ C}$, which is comparable with previous laboratory studies. We identified five species of native freshwater bivalves in Bayou Lafourche. Native freshwater mussels in southeastern Louisiana are poorly studied and the impacts and distribution of invasive species in the Lower Mississippi River Basin must be determined if native species are to be managed and conserved.

56 Contributed Paper

Oral Presentation

The influence of freshwater on nekton community structure in hydrologically distinct basins in northeastern Florida Bay, FL, USA

Flaherty*, K.E., Matheson, Jr., R.E., and McMichael, Jr., R.H. Florida Fish and Wildlife Conservation Commission.

Natural patterns of freshwater delivery to the Florida Bay estuary that were important to its nekton community have been disrupted by flood-control and water-supply projects. Restoration efforts are likely to alter salinity regimes in basins located in northeastern Florida Bay and therefore alter the patterns of nekton distribution and abundance. The objectives of this study were to conduct fisheries-independent surveys to determine nekton habitat use and to evaluate seasonal patterns of distribution and abundance of nekton in Florida Bay. We used 21.3-m seines, 6.1-m otter trawls, and 183-m haul seines to sample nekton communities in shallow- and deep-water habitats. The nekton community sampled by using small seines and trawls was numerically dominated by small resident fish that may be useful indicators of ecosystem health because they spend their entire lives within the bay and because their populations are not directly influenced by human harvest. Larger, more transient fish, including several economically important species, dominated the catch in the large seine. Differences in small-bodied nekton communities among basins were more pronounced during the dry season than during the wet season, but season only marginally affected large-bodied nekton communities. Differences in community structure of small- and large-bodied nekton revealed that a gradient of community similarity was correlated with the gradient of freshwater influence among basins. These observed changes in community structure are associated with salinity regimes within and between basins and highlight the importance of monitoring nekton communities before and after alterations in freshwater inflow.

57 Contributed Paper

Oral Presentation

Influence of selenium on bluegill (*Lepomis macrochirus*) in Mud Reservoir, Lincoln Co, West Virginia

Anderson, Alison M.* and Mazik, Patricia M. West Virginia University.

As an essential nutrient, Selenium (Se) helps maintain proper growth and function of cells, and is required at certain concentrations for fish (0.1-0.5 ug/L dry weight) (Gatlin and Wilson, 1984; Hudson and Hilton, 1993). When excess selenium is mobilized, by mining, into the environment, cells cannot discriminate between sulfur and selenium, resulting in erroneous substitutions when forming amino acids (Diplock, 1976). These deformed selenium containing proteins are then accumulated in metabolically active

tissues like the gonads, liver, and kidney (Gillespie and Baumann, 1986). Selenium can then be deposited in the yolk sacs of fish eggs, which results in the accumulation of misshaped proteins in the developing larvae/fry. Since this is a critical time in development, larvae demonstrate teratogenic deformities. These individuals typically do not make it to swim-up stage.

Mud Reservoir, located in Lincoln County West Virginia, has an average selenium level (0.0068 mg/L) which is above the US EPA regulation of 0.005 mg/L (USEPA, 1987). Other selenium based studies have shown that deformities occur at these higher levels; this has not been recorded for Mud Reservoir fish, specifically bluegill (*Lepomis macrochirus*). In order to evaluate the effect of selenium in Mud River, pairs of fish will be spawned in the laboratory using Mud Reservoir water, and standard early life stage tests for chronic toxicity will be performed and compared to the results from Plum Orchard Lake (spawned using Plum Orchard Lake water), which contains very low average levels of selenium (.0002 mg/L).

selenium, bluegill

58 Contributed Paper

Oral Presentation

Aquatic habitat mapping using georeferenced underwater video in the Citico Creek, Cherokee National Forest

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Herrig, J., US Forest Service, Cherokee National Forest.

Rakes, P., Conservation Fisheries Institute.

An Underwater Video Mapping System (UVMS) was used to map substrate, river characteristic and depth in the Citico Creek (located in the Cherokee National Forest). The UVMS consists of kayak-mounted underwater and above water cameras, GPS, depth sensor and underwater lasers. GIS-based maps of the river systems provide large-scale comprehensive description of aquatic habitat that can be used for river system management. The procedure for determining optimum habitat for the Endangered Smoky Madtom and Citico Darter (formerly duskytail darter), and the Threatened Yellowfin Madtom in Citico Creek will be described. The presentation will include a description of the underwater videomapping system and aquatic habitat map development.

aquatic habitat, map, endangered species

59 Contributed Paper

Oral Presentation

A direct comparison of two hybrid striped bass crosses stocked into a high flow-through Oklahoma reservoir.

Kuklinski, Kurt E. Oklahoma Department of Wildlife Conservation.

The Oklahoma Department of Wildlife Conservation (ODWC) currently restricts the stocking of hybrid striped bass (*Morone Saxatilis* x *Morone Chrysops*) to reservoirs with low flow-through (water exchange) rates to reduce the likelihood of stocked hybrids leaving the lake during periods of high flow. Equal numbers of fingerling common cross

hybrid striped bass (striped bass *M. Saxatilis* female x white bass *M. Chrysops* male) and fingerling reciprocal cross hybrid striped bass (striped bass *M. Saxatilis* male x white bass *M. Chrysops* female) were stocked in Kaw Lake, Oklahoma for five consecutive years. All common cross hybrids were marked with oxytetracycline prior to stocking in order to differentiate between hybrid crosses. Project objectives were to measure abundance and growth of each hybrid cross, and to determine emigration from the lake through tailwater sampling. A total of 340 hybrids (173 common cross and 167 reciprocal cross) of all age classes were collected in the lake during the five-year study. Gillnet samples showed equal abundance of each hybrid cross in Kaw Lake. Tailwater samples also showed equal abundance of each hybrid cross, with 80 individuals (41 common cross and 39 reciprocal cross) collected over the course of the study. Common cross hybrids were faster growing at all ages in fall length at age analysis. It is recommended that ODWC continue to stock Kaw Lake with hybrid striped bass, but future stockings should be done with only common cross hybrids.

Hybrid striped bass, Reservoir, Oklahoma

60 Contributed Paper

Oral Presentation

A discovery of the federally endangered roanoke logperch in North Carolina

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The Roanoke logperch, *Percina rex*, is a Federally Endangered fish once considered endemic to portions of the Roanoke and Chowan River basins of Virginia. However, recent surveys have verified an extant population in North Carolina. In 2007, the first NC specimen was collected from the Dan River (Roanoke River basin) in Rockingham County near the Dan-Smith Rivers confluence. Biologists assumed this specimen was a washout from a known population located in the upper Smith River of Virginia. Since this discovery, 18 specimens of the Roanoke logperch have been collected in NC from four Dan River drainage waterways: the Dan River, Smith River, Mayo River and Big Beaver Island Creek. Additionally, a recent VA fish kill in a small tributary of the Dan River near the VA-NC line resulted in another occurrence locality. These occurrences, plus genetic investigations conducted by biologist in VA, suggest that the fish collected in the Dan River drainage represent a unique population that has remained undiscovered until now. North Carolina Wildlife Resources Commission biologists are conducting surveys to further delineate the range of the Roanoke logperch in NC and to obtain data on population structure (e.g., density, age structure, etc.). Suitable habitat has been identified in the upper reaches of the Dan and Mayo Rivers of NC but the Roanoke logperch appears absent. Several dams located on these rivers in Rockingham Co. may be preventing upstream expansion of this endangered fish. Thus, translocation efforts and/or dam removal may be viable management options towards recovery.

Roanoke logperch, Percina rex, darter, Federally Endangered, Dan River, Roanoke River, Smith River, Mayo River, dam removal, translocation

61 Contributed Paper

Oral Presentation

Habitat credit trading as a mitigation tool for transportation projects: Use of a recovery crediting system in relation to a pilot project in Arkansas for an endangered mussel

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Recognizing that piecemeal approaches to endangered species conservation are not optimal, the Federal Highway Administration (FHWA) is considering a market-based system, Habitat Credit Trading, to address Section 7 of the Endangered Species Act (ESA) requirements for transportation projects on a national scale. Two programs within the U.S. Fish and Wildlife Service's Habitat Credit Trading Program currently exist to allow 'banking' of habitat credits: traditional Conservation Banking and the newly introduced Recovery Crediting System (RCS). Similar to a conservation bank, an RCS allows federal agencies to bank credits in advance of anticipated impacts to threatened and endangered species, their habitat, and its functions. Unlike a conservation bank, recovery crediting encourages federal agencies to partner with private and non-federal landowners to accrue credits through mutually beneficial conservation agreements, which may be in perpetuity (easement or fee title purchase) for permanent impacts, or that may address temporary construction impacts through non-perpetual easements. The FHWA is proposing to use a credit trading approach to species mitigation and recovery and hopes to gain further insight into habitat credit trading through pilot projects involving suitable species and habitats. In this presentation we analyze the applications of the RCS and evaluate the efficiency of this conservation tool in relation to a potential pilot project in Arkansas focusing on the endangered fat pocketbook mussel (*Potamilus capax*).

Preliminary calculations indicate the use of such programs to be effective in achieving conservation objectives for target species while providing an extremely cost effective alternative for addressing ESA regulatory requirements.

Recovery crediting system, conservation banking, endangered mussel, Potamilus capax, Federal Highway Administration

62 Contributed Paper

Oral Presentation

Summer microhabitat use of the endangered tuxedo darter *Etheostoma leminiscatum*

Davis, J.G. and Cook, S.B. Department of Biology, Tennessee Technological University.

The tuxedo darter *Etheostoma leminiscatum* is a recently-described, endangered fish, located in the Big South Fork of the Cumberland River in Tennessee and Kentucky. As

part of a monitoring project, summer microhabitat use of tuxedo darters was quantified to identify specific habitat requirements and habitat that should be protected. Data was collected during the summer of 2008 and 2009 at 12, 50-m long sites. Measured variables included depth, velocity of flow, substrate, habitat type, cover rock size, and canopy cover. Macrohabitat conditions were quantified at each site as well to determine factors contributing to tuxedo darter presence. Relative frequency histograms and correlation analysis were used to understand relationships of variables to presence and to other variables. Univariate and multivariate logistic regression models were constructed using the best subsets method. Variables that were significant ($F = 0.1$; $p < 0.001$) were depth, substrate, velocity at 60% of stream depth, and surface area of cover rock. Probability of tuxedo darter presence at a site increased with available cobble substrate and shallow pool habitat. Preferred microhabitat included depths between 30 - 70 cm, velocities less than 0.1 m/s, and cover rocks with a surface area of 400 - 1200 cm².
tuxedo darter, microhabitat, Etheostoma leminiscatum

63 Contributed Paper

Oral Presentation

Fish species richness relative to connectivity in oxbow lakes of the White and Yazoo River Basins

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Oxbow lakes within the White and Yazoo river basins of Arkansas and Mississippi vary in their degree of connectivity to their respective parent rivers. Lakes within the Yazoo River Basin were historically connected to their parent rivers during seasonal inundation; however, many lakes are presently separated from their parent rivers by the levee system and may connect to the river only through water control structures or intermittent drainage channels. Alteration to the connectivity regime has ultimately resulted in the disruption of natural processes that structure fish assemblages and maintain aquatic biodiversity in the region. In order to design plans to preserve and restore the fish species richness and biodiversity in these oxbow lakes, this study examined the relationship between the level of connectivity and fish species richness in oxbow lakes within the Yazoo and White river basins. Fish community data were collected from 41 lakes in the Yazoo River Basin and 8 lakes in the White River Basin. Connectivity was measured in terms of the distance of the path of least resistance for the flow of water from each oxbow lake to its parent river. Preliminary results indicate that fish species richness tends to decrease as lakes experience higher degrees of disconnection. There was a reduction in the number of species by nearly 50% from the most connected lake to the least connected lake, asserting that lakes farther from their parent rivers may experience a lack of colonization or immigration events and an amplification of extinction events.

64 Contributed Paper

Oral Presentation

Reservoir fish habitat partnership - A collaborative effort to enhance and restore reservoir fish habitats in the southeast

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The National Fish Habitat Action Plan, established in 2006, is a galvanized effort among federal and state agencies, tribes, NGO's, private industry, and local conservation groups to reverse the declines in fish habitats. Fish Habitat Partnerships are the primary work units of the Plan. These partnerships are formed around important aquatic habitats and distinct geographic areas (e.g., Southeast Aquatic Resources Partnership,) 'keystone' fish species (e.g., eastern brook trout and western native trout) or system types (e.g., large lakes, impoundments, estuaries.). The Reservoir Fish Habitat Partnership (RFHP) was recognized in 2009, making it one of 14 partnerships currently recognized by the National Fish Habitat Board. RFHP is the only currently recognized partnership that is national in scope. A strategic plan has been drafted laying out an ambitious course of action which focuses on reservoirs as part of a landscape or watershed scale. RFHP is currently organized into Governance, Outreach, and Science and Data Committees. The Science and Data Committee is currently working on rating reservoirs on an impairment scale, a reservoir classification system based on physical properties, and a nationwide database on reservoir metrics. Habitat Impairments clustered into tailwater water quality issues, sediments, pollution, tailwater flows, macrophytes, and structure. Several of these impairments can best be addressed on the watershed scale. RFHP plans to work through SARP and SDAFS Reservoir Committee to develop reservoir habitat protection/restoration projects in the Southeast.

reservoirs, habitat

65 Contributed Paper

Oral Presentation

Fifteen years of Oklahoma bass tournament data

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The Oklahoma Department of Wildlife Conservation (ODWC) has gathered statewide bass tournament results since 1994 using a mail-in post card and an on-line data entry system. Tournaments are a source of information that biologists rely on in managing bass fisheries because they do not conduct electrofishing surveys annually nor do they have creel survey data. The numbers and sizes of bass caught, especially trophy bass, figures into the Department's Florida bass stocking criteria. Trends over the 15-year period show declining tournament participation since 1998 but the average size of events has increased. The number of bass caught per angler per day has risen since 2005 as has the percent of anglers weighing at least one fish, as impacts from the Largemouth Bass Virus in 2000 and 2001 subside. Average weight per bass and the number of bass over 5 pounds declined following the disease outbreak in many popular tournament waters. The average 'Big Bass' of each tournament also fell at that time but has returned to pre-2000 levels. Lakes were ranked according to five catch statistics to produce a Top-20 list each year. Lake Hudson ranked as the overall top tournament lake in the state based on 15 years of results. It edged out its higher profile upstream neighbor, Grand Lake, by just a few points. In addition to providing biologists with valuable information, the program has been very popular with anglers who use the information to plan future fishing trips and tournament schedules.

An evaluation of largemouth bass stocking into a Tennessee Valley tributary reservoir

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A five-year supplemental fingerling-stocking program was initiated in 2003 to counter decreases in largemouth bass, *Micropterus salmoides*, abundance and angler catch rates in Lake Nottely. Normal (25 mm TL) and advanced production (50 mm TL) fingerlings were stocked annually (April to June); all fingerlings were mass marked in oxytetracycline hydrochloride (OTC) to differentiate between stocked and wild largemouth bass. Age-1 stocked fingerling contribution ranged from 17 – 100% and age-3 contribution ranged from 8 – 54%. Mean total length was similar between normal production and advanced production fingerlings at age 1 and age 3 ($P > 0.3137$). Normal production largemouth bass fingerlings contributed to each age cohort and were more cost effective than advanced production fingerlings.

stocking, largemouth bass, contribution

Contaminants in stream ecosystems of Puerto Rico: Implications for recreational and subsistence fisheries

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Cope, W. G., Department of Environmental and Molecular Toxicology, North Carolina State University, Raleigh, North Carolina 27695-7633.

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Shea, D., Department of Biology and Department of Environmental and Molecular Toxicology, North Carolina State University, Raleigh, North Carolina 27695-7617

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Thousands of chemicals are released annually into the environment with a variety of adverse effects. Water pollution is of particular concern for densely populated areas like Puerto Rico, but few contaminant studies have been conducted on the island and none have examined stream ecosystems. Our objectives were to quantify occurrences of PAHs, pesticides, PCBs, and heavy metals in the habitat and biota of Puerto Rico streams. We sampled water, sediment, and native fish and shrimp species that may be pursued in fisheries and evaluated their contaminant burdens in relation to ecological and human health at 13 sites spanning a broad land use pattern (e.g., urban, agricultural, forested). Overall, water contaminant concentrations were below available established

protective criteria, however, Rio Piedras, a highly urbanized watershed, had the greatest concentrations of waterborne contaminants. All organic and most metal (cadmium, lead, mercury, zinc, selenium) contaminants in stream sediment were below criteria values. However, sediment at 8 of 13 sites exceeded nickel criteria, and sediment at all sites exceeded copper criteria. Organic contaminant concentrations were generally greater in mountain mullet (*Agonostomus monticola*), river goby (*Awaous banana*), and American eel (*Anguilla rostrata*). Metal concentrations varied among species. Copper concentrations were greatest in bigclaw river shrimp (*Macrobrachium carcinus*) and zinc and nickel were greatest in sirajo goby (*Sicydium* spp.) and river goby. Mercury concentrations were all below human consumption criteria. These results and our ongoing intensive sampling will provide natural resource managers with the scientific information needed to guide fisheries management and human health risk assessments.

Puerto Rico, contaminants, water pollution, streams, rivers

68 Contributed Paper

Oral Presentation

Evaluation and development of tools to estimate large-river ecological integrity

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Irwin, E.R. USGS, ALCFWRU, Auburn, AL.

Rapid methods for assessment of ecological integrity are highly-valued tools for natural resource managers charged with making management decisions across broad spatial scales. The index of biotic integrity (IBI) is perhaps the most common and widely-used rapid assessment tool in fisheries management. Using data from a large-scale monitoring program within the Tallapoosa River basin, Alabama, we examined the utility of the IBI for rapid assessment in a diverse, large-river system. Index values for each of 25 sites within the basin were compiled for each sampling year (2005-2008). Species-specific detection probabilities were calculated and evaluated according to spatial (habitat) and temporal (season, year) covariates. Subsequent models of habitat-specific detection probabilities were incorporated into an “informed species richness” belief network that used conditional probabilities to predict the number of captured species in each sample. Index values varied widely among sites, within and among river reaches, between seasons, and among years. Detection probabilities were generally low among species, but typically varied by type of habitat sampled (depth, velocity, amount of vegetation), by season (summer or fall), and/or by year. These data suggest the importance of incorporating detection probabilities into rapid assessment of highly diverse, large-river systems; the “informed species richness” belief network is an example of a potential tool that could allow managers to make more accurate and consistent assessments of large-river ecological integrity.

belief network, detection probability, habitat use, IBI, large rivers, rapid assessment

69 Contributed Paper

Oral Presentation

Mapping habitat in navigable streams using low-cost side scan sonar

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A need exists within the natural resource community for an inexpensive and rapid technique for mapping and quantifying the habitat of navigable river systems at the landscape scale. Unlike more expensive side scan sonar devices, the Humminbird® Side Imaging system (\$2,000) can be interfaced with global positioning systems (GPS) to capture spatially-referenced imagery in rivers and streams that include shallow, rocky areas. Since first presenting a concept for sonar mapping in 2007, we have refined our techniques for capturing sonar imagery and developed the tools required to produce sonar image maps (SIMs) exclusively within a geographic information system (GIS) environment employing ESRI's ArcGIS 9.x software. The resulting SIMs are high resolution (~10 cm) GIS layers representing continuous, bank-to-bank imagery that can be interpreted and analyzed to map features such as substrate types, large woody debris, and relative depth. To demonstrate the utility of sonar-based maps and to explore the effective boundaries of the technique we conducted a series of mapping studies on small (width 30-50 meters) to medium sized (90-130 m) river systems in Northwest and Southwest Georgia. Overall, the technique produced accurate (classification accuracies 77-84%), spatially explicit habitat maps of underwater landscapes. The applications for such detailed maps are widespread and numerous; techniques for map production are now accessible to researchers and managers alike.

habitat mapping, side scan sonar, GIS

70 Contributed Paper

Oral Presentation

Implementation of the Southeast Aquatic Habitat Plan in Texas: Conserving fish and aquatic habitats through watershed conservation

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More than 40% of fish and mussel taxa in Texas are listed as imperiled, a trend that is consistent across the southeastern US. Habitat degradation is the principle contributing factor in species declines, and the principle motivation for the development of the Southeast Aquatic Habitat Plan (SAHP). The SAHP was developed in 2008 by the Southeast Aquatic Resources Partnership to facilitate the cooperative conservation of fish and aquatic habitats in the region, and fulfill the national goals outlined in the National Fish Habitat Action Plan. To coordinate implementation of the SAHP in Texas, the Texas Parks and Wildlife Department has developed a new watershed conservation initiative. The initiative focuses on working through local partnerships to protect and restore aquatic, riparian and upland habitats essential to the health and sustainability of fish and aquatic habitats. Specifically, the initiative: (1) establishes and nurtures local partnerships to identify conservation priorities and leverage available resources; (2) provides technical guidance and planning assistance; and (3) organizes community involvement in local fish habitat protection and restoration projects. This presentation will highlight recent and ongoing fish habitat protection and restoration projects in Texas and discuss progress towards reaching conservation targets identified in the SAHP.

Facility level development of biosecurity best practices

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The recent discovery of Viral Hemorrhagic Septicemia in freshwater fisheries has provided additional impetus for development of facility level Best Management Practices to protect valuable stocks as well as the value of fish production facilities and related commerce. This presentation provides an overview of a report, guide and workshop developed by the authors for the Southern Illinois University, Fisheries and Illinois Aquaculture Center, to encourage practical biosecurity best practices in the Great Lakes and other watershed basins in the U.S. Dissemination of information to educators and state and federal regulators is important. However, this does not mean that practical tools are available to implement biosecurity protocols where they are needed. This need includes farmers that raise and trade aquatic animals that may be potential hosts for pathogens or may be vectors of invasive species that can be shipped unknowingly to or from another destination.

The Biosecurity Best Practices presented herein are based on:

- The “Guiding Principles of Responsible Aquaculture” promulgated by the Global Aquaculture Alliance
- Federal and state biosecurity regulations
- Review of diseases and invasive species pertinent to a facility or locale
- A Facility Biosecurity Plan integrated with Best Management Practices.

Since no two aquaculture facilities are the same, development of facility specific best practices will benefit from employing a template that includes:

- Documentation of general facility information that will guide the facility and its local aquatic health expert in developing a plan
- An outline of general facility goals such as “improve health and quantity of cultured aquatic animals”, or specific goals such as “limiting the potential introduction of VHS virus”
- Evaluation of general facility infrastructure, operational practices and regulatory knowledge to assess potential facility risks
- Identification of biosecurity measures that limit facility risk to pathogens and nuisance species.

biosecurity, fish health, best management practices, viral hemorrhagic septicemia

Population ecology and habitat use of the invasive northern snakehead (*Channa argus*) near Brinkley, Arkansas

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The Northern Snakehead (*Channa argus*), a predatory species native to Asia, was discovered in the Big Piney Creek drainage near Brinkley, Arkansas in 2008. In March, 2009, Arkansas Game and Fish Commission and US Fish and Wildlife Service launched a large effort to eradicate the Northern Snakehead from an area of over 200 square kilometers using rotenone distributed by ground and air crews. University of Central Arkansas students collected fish community samples at 45 sites, 7 of which had Northern Snakeheads present. Snakeheads were also collected at 22 additional locations for a total abundance of 787 individuals. Snakehead density ranged from 0.002 to 0.02 individuals per square meter of stream and was not significantly different from the density of the ecologically similar native Bowfin (mean 0.0086 bowfin/m², mean 0.01 snakehead/m²; P=0.629), suggesting niche overlap between the two species. A length frequency histogram revealed a stable, growing population with a large number of young-of-year and several adult age classes. Preliminary results suggest Snakeheads are reproductively mature by age one and all females in the population are able to reproduce in a given year. Specimens were collected in all habitat types searched, except for areas of high flow in Big Piney Creek. Presence of Northern Snakeheads displays no correlations to biotic or abiotic conditions, suggesting the species was successfully dispersing throughout the Big Piney Creek drainage by March, 2009.

73 Contributed Paper

Oral Presentation

Marking otoliths and fin spines of juvenile shortnose sturgeon *Acipenser brevirostrum* with OTC and the advantages of stabilizing water temperatures during treatment.

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Oxytetracycline hydrochloride (OTC) has been used to mark saggital otoliths of juvenile shortnose sturgeon (*Acipenser brevirostrum*). However, mark quality is inconsistent, possibly due to declining temperatures in the OTC baths while marking. Mark detection in captured fish must be reliable and non-lethal. Our objectives were to determine if OTC marks can be applied to first ray pectoral fin spines and if the declining water temperatures impact mark quality on otoliths and fin spines. Juvenile shortnose sturgeon were marked in static OTC baths where temperatures were either controlled using heaters (stable treatment) or uncontrolled (decreasing treatment). Fish were euthanized 21 days following treatment. Otoliths and fin spines of specimens were independently analyzed by two readers, and a mark quality score was given based upon mark detectability. Results indicate that stabilizing temperatures during the OTC baths produces a superior mark on otoliths and fin spines when compared to the decreasing temperature treatments. Mark quality on fin spines and otoliths across treatments were not found to be significantly different. Our research demonstrates the ability to mark otoliths and fin spines of juvenile shortnose sturgeon with similar

results, and that fin spines could prove useful for fishery managers who need non-lethal detection techniques.

74 Contributed Paper

Video Presentation

A narrative of the spruce pine dam from construction to demolition.

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The Spruce Pine (or North Toe River) dam was built in 1918 to furnish electric power to the Sparks Kaolin plant, and during the early 1920's furnished electricity to the town of Spruce Pine, North Carolina. The Company sold the dam and its system to the Carolina Power and Light Company in 1926 and it continued to provide at least part of the electricity for the community until the middle 1940's. The dam was abandoned by the early 1950's. The small reservoir behind the dam silted in by the late 1950's, and the structure was dynamited in 1960 to clear the river of silt. In 2007, the Blue Ridge Resource Conservation and Development Council (Blue Ridge RC&D) contacted the U.S. Fish and Wildlife Service's (Service) Asheville Field Office to determine if funding was available to take the remaining dam fragments out of the North Toe River. Upon further investigation by the Service, they noted during field observations and using NC Natural Heritage Program (NHP) records that the dam had been and continued to serve as a barrier to the upstream movement of fish and other aquatic organisms. Historical NHP database records demonstrated the presence of two fish that are Federal Species of Concern, the sharphead (*Etheostoma acuticeps*) and olive (*Percina squamata*) darters, above the dam. Neither fish has been observed in the river upstream of the dam since the mid-20th century. In addition, the Appalachian elktoe (*Alasmidonta raveneliana*), a federally endangered freshwater mussel, occurs in reaches downstream of the dam, but has not been observed in the North Toe River above the dam, although suitable habitat for this species is present in upstream reaches. The dam was also a serious safety threat in its previous, partially demolished condition. A breached center section supported a powerful and dangerous hydraulic overfall that claimed one recreational boater's life in 1983. While there have been no fatalities since that time, the dam continued to be a threat to swimmers, boaters, and fishermen that frequent the area. With the support of two local conservation organizations (the Blue Ridge RC&D and the Toe River Valley Watch), funding from the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife and Fish Passage Programs and NC DENR-Department of Water Resources, and the support of local contractors and landowners, the main portions of the dam were demolished and passage was opened up for recreational boaters and aquatic species during August of 2009.

75 Contributed Paper

Oral Presentation

Texas reservoir habitat impairments and implications for management priorities

John B. Taylor, Leandro E. Miranda, J. Warren Schlechte, Tim Birdsong, and David R. Terre

In collaboration with the Reservoir Fish Habitat Partnership's national assessment of reservoir habitat, we conducted an assessment of habitat impairments on Texas reservoirs (n = 170). Management biologists were asked to subjectively rate the current degree of habitat impairment in 12 categories using a 5-point scale, rating their perceptions of the severity of each impairment category. The categories included turbidity, sedimentation, shoreline erosion, excessive nutrients, point-source pollution, non-point source pollution, contaminants, oxygen or temperature stratification, water level fluctuations, insufficient water storage, excessive aquatic macrophytes, and lack of aquatic macrophytes. We subjected these ratings to factor analyses to identify relationships among the variability of impairment scores. Six underlying factors driving the variation were identified. The first factor accounted for 44% of the variation among scores and was indicative of siltation processes; strong loadings for turbidity, sedimentation, shoreline erosion, and excessive nutrients were observed for this factor. The second factor accounted for an additional 23% of the variation in scores and was indicative of differences in water regimes; strong loadings water level fluctuation and insufficient water storage were observed. We then used cluster analysis to group reservoir with similar factor scores. 51% of Texas reservoirs fell into two clusters with low scores for both the siltation and water regime factors. A cluster containing 12% of the reservoirs had high scores for both factors, and a cluster containing 4% of the reservoirs had high scores for siltation and moderate scores for water regime. The remaining cluster had moderate scores for both factors.

76 Contributed Paper

Oral Presentation

Life history traits of yellow bass, *Morone mississippiensis*, in Barren River Lake, Kentucky.

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During the late 1990s, yellow bass (*Morone mississippiensis*) invaded Barren River Lake, a flood-control reservoir located in the south central Kentucky. Since the 1980s, the white bass (*M. chrysops*) population in the lake has declined dramatically. The purpose of this study is to elucidate life history traits of yellow bass to determine if they may be playing a role in the decline of white bass. Three sampling regions were chosen: the main basin and two arms of the reservoir. Samples were taken monthly in all three regions between March 2008 and February 2009. Individuals were captured using an electrofishing boat and returned to the lab for analyses. A total of 307 yellow bass were collected. Maximum age was 8 years with large declines in abundance in fish over age 5. During spring and summer, yellow bass diet shifted from larval insects to young-of-year gizzard shad (*Dorosoma cepedianum*). In fall and winter, piscivory declined and many adult yellow bass had empty guts. No white bass were collected in the course of this study. Yellow bass life history traits will be discussed in relation to recent declines in the white bass population and possible competition between these congeneric species.

Initial mollusk culture efforts of the Alabama Aquatic Biodiversity Center

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Recovery efforts at the Alabama Aquatic Biodiversity Center (AABC) have primarily been dedicated to the construction and refit of husbandry and culture facilities. Trial culture efforts were initiated in 2009 to develop specific culture protocols preparing for full-time recovery operations in 2010. Mussel production efforts in 2009 focused on culture techniques for newly transformed juveniles with non-listed species. Transformation efforts produced 102,000 individuals of 7 species from the Alabama and Tennessee River basins. Culture trials tested up-welling, down-welling, and flow-through sediment trays. Up-welling systems without sediments were the most successful, and juvenile mussels added 28-55 μm shell length/day increase for 5 species tested. However flow-through sediment trays also demonstrated good growth with some species. Supplemental feeding with commercially available shellfish diets improved juvenile survivorship to 61% at 15 weeks post-transformation. Mussel culture systems will next focus on variations of pond deployed systems for continued grow-out. Performance of these systems will be examined with both air and pump driven culture chambers. Gastropod culture efforts in 2009 produced > 40,000 juveniles of 9 species in 3 different families. Production focused heavily on 3 federally listed and candidate species, culturing juveniles to 3-8 mm shell width at 6 months post-hatch. Although gastropod culture systems performed well, release and reintroduction efforts have been delayed by heavy rains and high water levels. In addition to culture activities, substantial mollusk recovery and strategic habitat planning efforts were completed in 2009.

non-game species, restoration, mollusk, propagation, recovery

Population modeling of two endangered mussel species in the Clinch River, U.S.A.: quantitative criteria to evaluate harvest and reintroduction of *Epioblasma brevidens* and *Epioblasma capsaeformis*

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Population modeling of two endangered mussel species, *Epioblasma brevidens* and *E. capsaeformis*, in the Clinch River, U.S.A., was conducted to determine suitable harvest levels for translocation of sub-adults and adults, and quantitative criteria to evaluate performance and recovery of extant and reintroduced populations. For both species, the recommended annual harvest was <1% of local population size to minimize risk of decline. Reintroduction modeling indicated that size of the initial population created during a 5 y build-up phase greatly affected final population size at 25 y, being similar to

size at the end of the build-up phase, especially when expected growth rate was low (e.g., 1-2%). Excluding age-0 individuals, age-1 juveniles or recruits on average comprised approximately 11% and 15% of a stable population of each species, respectively. Age-class distribution of a stable or growing population was characterized by multiple cohorts, including juvenile recruits, sub-adults, and adults. Molecular genetic and demographic data indicated that the ratio of N_e/N_c was ~5% for both species. Based on this ratio and predicted declines of genetic variation at different population sizes, target total sizes for reintroduced or recovered populations of each species should be ~5,000 individuals ($N_e=250$) and ~10,000 individuals ($N_e=500$), respectively, and ideally should be comprised of multiple smaller demes spread throughout a river. Demes of both species in the river are currently large enough to sustain harvest for translocation and reintroduction purposes, offering an effective biological recovery strategy.

freshwater mussels, endangered, Epioblasma brevidens, E. capsaeformis, population modeling, harvest, reintroduction, quantitative recovery criteria.

Decades of water and habitat quality improvement resulting from the Tennessee Valley Authority's integrated operation of the Tennessee River system

Shute, Peggy W., Tennessee Valley Authority, Knoxville, TN.

The TVA Act was initially established to provide for navigation, flood control, economic development, and generate electrical power. As a federal agency, the Endangered Species Act requires TVA to consult with the U.S. Fish and Wildlife Service on actions that could affect federally-listed species, including routine operation and maintenance activities at TVA's dams. However, in spite of the potential to affect a total of 29 federally-protected aquatic species (six fish and 23 mollusks) at 49 dams in seven southeastern states, consultation on TVA's dam operations resulted in the need to change operations to improve conditions for endangered species in three areas: Tims Ford Dam on the Elk River, dams in the Bear Creek system, and Wilson Dam on the mainstem Tennessee River. This is partly because TVA established minimum flows and commitment to meet minimum dissolved oxygen (DO) levels in releases from 16 dams. Since the early 1990's, TVA has spent about \$60 million to add equipment and change operations to increase DO and provide minimum flows, resulting in dramatic improvements in DO over more than 300 miles of river and wetted habitat maintained over 180 miles of river previously impacted by intermittent drying. These improvements resulted in designation of Nonessential Experimental Population status for several federally-listed fish and mollusks in a mainstem river reach (Tennessee River downstream of Wilson Dam) and a tributary reach (French Broad River downstream of Douglas Dam). TVA's biological sampling has documented improvements, especially in warm tailwaters, but cold tailwaters have also improved.

Restoration, endangered species, regulated river, reservoir release improvement, recovery

Habitat selection in southern stream fishes

Grossman, Gary D., Warnell School of Forestry & Natural Resources, University of Georgia, Athens, GA.

I review traditional and mechanistic approaches to meso- and microhabitat selection in NC and GA stream fishes and link these approaches to population regulation. I describe two models, the first, for benthic fishes characterizes the relationship between prey availability and patch selection, and the second for water-column feeders quantifies the relationship between energy gain and focal-point velocity use. Mottled sculpin have small home ranges, and large mottled sculpin select patches with significantly higher prey abundances than small sculpin or random patches. Large sculpin have significantly higher growth rates and lower mortality rates than small sculpin and occupy patches with higher prey renewal rates. When large sculpin are removed from a site, small sculpin shift into their patches. This indicates that sculpin likely select patches on the basis of prey abundance. Long-term population studies confirm that sculpin show strong density-dependence probably linked to intraspecific competition for patches. Prey abundance also affects patch use by longnose dace, and to a lesser extent black-banded and tessellated darters. A simple model relating prey capture success (i.e. energy gain) to focal-point velocity in four drift-feeding minnows and rainbow trout was an excellent predictor of focal-point velocities selected by these species in Coweeta Creek, NC. Finally, position in the landscape, proved to be the best predictor of stream fish biodiversity in second and third order Hungarian streams. These data suggest that a variety of factors affect habitat selection in stream fishes and that fitness-linked approaches are effective in helping understand this process.

habitat, fitness, food availability, competition

104 Restoration of Non-Game Species

Oral Presentation

Lake sturgeon restoration in the upper Tennessee River system

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Since 1999, this program seeks to restore a self-sustaining lake sturgeon population in the upper Tennessee River system in east Tennessee. Each spring, USFWS personnel from the Warm Springs (GA) NFH travel to the Wolf River, Wisconsin in coordination with WIDNR to obtain fertilized sturgeon eggs. Subsequent fry are reared at six hatcheries for 6-8 months prior to release in the French Broad and Holston rivers downstream of major dams near Knoxville. To date, approximately 85,000 sturgeon have been released. Stockings will continue for a total of 20 years to ensure a diversity of age classes. Monitoring with trot lines at standardized sites will determine success, while incidental fishermen catches are tracked. Many fish remain in the general release vicinity, but some have moved downstream as far as Guntersville Reservoir, AL, approximately 275 river miles away. Sturgeon reproduction in the upper Tennessee River system is anticipated to begin in the next five years.

lake sturgeon, Tennessee, restoration, French Broad, Holston

Genetic risks and recommendations for managing or conserving small, isolated populations

Moyer, Gregory R., U.S. Fish and Wildlife Service, Warm Springs, GA.

Populations have become increasingly fragmented due to human induced habitat modification. When populations become small in number and isolated, there exists a risk that the fitness of the population will be reduced due to inbreeding depression. Reductions in fitness can affect population persistence; therefore, managers are often faced with the dilemma of how to save a population from inbreeding depression. One possible solution to this problem is to infuse the depressed population with individuals from a genetically and demographically healthy population; however, enthusiasm for this strategy is often tempered by the possibility that population mixing may induce outbreeding depression and do more harm than good. This talk will explore the relative risks associated with outbreeding and inbreeding depressions and provide recommendations to minimize these risks for reintroduction and restocking programs. As a general rule, however, managers should proceed with extreme caution when faced with the dilemma of intentional hybridization of populations. That is, it should only be entertained when there is quantitative evidence that a population is suffering from inbreeding depression

inbreeding, outbreeding, translocation

A summary and preliminary evaluation of stocking as a recovery strategy for the imperiled robust redhorse (*Moxostoma robustum*)

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Sessions, Forrest, South Carolina Department of Natural Resources, Bonneau, SC.

The robust redhorse (*Moxostoma robustum*) is a rare catostomid that is only found in Georgia, South Carolina, and North Carolina. In Georgia, the Oconee River population has declined since its discovery in 1991 and recruitment rates appear to be low. An artificial propagation program was initiated in 1993 that eventually led to the establishment of a total of five stocked populations in Georgia and South Carolina. The Robust Redhorse Conservation Committee was established in 1995 to coordinate recovery activities throughout the range of this species. Primary goals of the stocking program are to secure species viability by 1) establishing refugial populations in rivers and ponds, 2) increasing the number of self-sustaining riverine populations to a long-term minimum recovery goal of six, 3) augmenting low natural recruitment in the Oconee River, and 4) providing early life stages for research into habitat preferences and physiological tolerances. To date, active spawning has been documented in stocked populations in the Ocmulgee, Ogeechee, and Broad rivers in Georgia and status surveys are being conducted in all stocked rivers to evaluate reproductive success and long-term sustainability. Present evidence from the robust redhorse recovery project emphasizes

the potential utility of stocking in recovery programs for some imperiled fishes. Life history characteristics combined with improvements in habitat quality in rivers within the historical range may enhance the efficacy of stocking as a recovery strategy for this species.

robust redhorse, imperiled species, stocking

107 Restoration of Non-Game Species

Oral Presentation

In-situ feasibility study of freshwater mussel reintroduction: survival and growth of the wavy-rayed lamp mussel (*Lampsilis fasciola*) in the Pigeon River, NC

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The Pigeon River, NC has a long history of habitat degradation due to high levels of toxic effluents from and water diversion to a paper mill. Over the last 20 years the paper mill has modernized its processes and reduced water use and waste production greatly. Historically the wavy rayed lamp mussel, *Lampsilis fasciola*, was present throughout the river, it currently only persists upstream of Canton, NC. In this study, we compare the survival and growth of *L. fasciola* placed in the downstream portion of the Pigeon River with those placed upstream of Canton, NC. The mussels are individually marked and caged in portable concrete silos designed by Chris Barnhart from Missouri State University. The mussels were placed in the river at 2 upstream sites and 3 downstream sites in December 2008. We will present monthly survival and growth data collected from December 2008 to November 2009.

108 Restoration of Non-Game Species

Oral Presentation

Translocation of Cumberlandian mussels to achieve species conservation

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Surveys conducted since 2003 indicate that several rare mussel species in the Clinch and Duck rivers in Tennessee are in a strong faunal recovery period and that these rivers can serve as both nursery stock sites as well as receiving streams for the translocation of rare and federally endangered freshwater mussels. Our objective is to preserve the biological diversity of Tennessee's native freshwater mussel fauna by collecting adult mussels from the Clinch and Duck rivers. Individuals collected are translocated into the Duck, Nolichucky and Big South Fork rivers for restoration of extirpated species within their historical habitat and augmentation of populations that are at low levels. Adult mussels are also collected for natural history research and propagation purposes. The effort supports a long-term commitment involving The Nature Conservancy and state and federal agencies to achieve the objectives of the "Plan for the controlled propagation,

augmentation and reintroduction of freshwater mollusks of the Cumberlandian Region” produced by the Cumberlandian Region Mollusk Restoration Committee. The desired long-term result is to restore populations of endangered freshwater mussel species within historical habitats of the Duck, Nolichucky and Big South Fork rivers with viable populations such that de-listing or down-listing of some species can occur. Without increased emphasis on species propagation, translocation to suitable habitats, and augmentation of current populations, many of these species face an increased risk of decline or extirpation.

freshwater mussels, translocation

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Oral Presentation

Plans for population restoration of freshwater mollusks of the Cumberlandian Region and Mobile Basin

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The Southeastern US has the highest diversity of freshwater mollusks in the world. The Cumberlandian Region Basin (CRB) (comprising the Cumberland and Tennessee river drainages) and Mobile River Basin (MRB) (comprising the Alabama and Tombigbee river drainages) harbor the majority of the fauna. The molluscan faunas of these basins have also suffered an inordinate level of species imperilment primarily due to habitat alteration from impoundments, historic point source releases, and adverse land use changes. Combined, at least 44 species of snails and 21 mussels have become extinct over the past 100 years in these watersheds. The areas contain numerous federally listed mussels (31 CRB and 17 MRB) and snails (4 CRB and 7 MRB) and candidates (6 CRB and 2 MRB). Although existing populations of imperiled mollusks now occur in a highly fragmented landscape, several reaches contain habitat suitable for population restoration (augmentation or reintroduction) of imperiled species. These plans prioritize 57 mussels and 25 snails and 26 mussels and 30 snails that inhabit the CRB and MRB, respectively, while providing guidelines for population restoration activities through artificial propagation technology and adult translocation in priority streams.

Mussels, snails, imperiled, augmentation, reintroduction, population restoration

110 Restoration of Non-Game Species

Oral Presentation

Using a collaborative stakeholder hydro licensing process to address nongame species conservation needs in the Yadkin-Pee Dee River, North Carolina

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Progress Energy conducted Federal Energy Regulatory Commission (FERC) relicensing of the 108 MW Yadkin-Pee Dee River Hydroelectric Project located on the Yadkin-Pee

Dee River, North Carolina, from 2003 to 2008. To facilitate FERC relicensing, Progress Energy used a three-stage traditional relicensing process with enhanced stakeholder collaboration. This process presented a unique opportunity for resource agency and power company biologists to address conservation needs of native fish and mussel communities including rare, threatened, and endangered nongame species - robust redhorse (*Moxostoma robustum*), Carolina redhorse (*Moxostoma* sp.), shortnose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrinchus*) and several listed mussels. Independent of the relicensing process, resource agency and power company stakeholders voluntarily formed a robust redhorse technical work group who specifically prioritized research needs and conducted surveys to locate key spawning areas of this species. Survey results were used in relicensing to develop an instream flow study that addressed habitat needs and flow recommendations for this species and other native fishes. A seasonal instream flow regime was recommended for the Project which included spring flow stabilization periods to enhance fish spawning habitat. An interactive wetted perimeter model was also developed by the stakeholders to evaluate mussel habitat under different Project flow regimes to ensure protection of mussels. This collaborative relicensing effort provided recommended minimum flow and other water quality enhancements that will address long-term conservation needs of nongame species in the Yadkin-Pee Dee River.

Hydro Licensing, Nongame Species, Conservation

Habitat suitability of the endangered Cape Fear shiner: implications for species recovery

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The Cape Fear shiner, *Notropis mekistocholas*, is an endangered minnow endemic to the Cape Fear River basin of North Carolina, and only five populations remain. Until recently, little was known of the fish's ecology, which hampered recovery planning. Advances in knowledge during the past decade include population parameter estimates, distribution surveys, predator-prey interactions, development of instream physical habitat suitability functions, intensive water quality testing and field bioassays to determine water quality suitability, and the efficacy of dam removal to restore habitat. Our research findings indicate that the Cape Fear shiner is extremely restricted in spatial distribution, but locally abundant where it occurs; it most frequently occupies riffles and velocity breaks over gravel substrates, with moderate depths that are shallower during spawning. The Cape Fear shiner shares a distribution with invasive predaceous flathead catfish, but their microhabitat overlap is minimal. The interactions between contaminants and fish populations are unclear, but contaminant presence at certain sites may reduce survival and growth. Suitable combinations of microhabitat characteristics are rare throughout its range, but dam removal has resulted in restoration of suitable habitat for the species.

These new findings can form the basis for recovery planning and implementation of management actions to ensure persistence of the species. Protection of remaining suitable habitat should consider water quality, instream habitat, and biotic interactions, as well as human uses and alterations of the river, riparian zone, and watershed.

112 Restoration of Non-Game Species

Oral Presentation

Assessing the improvement of water quality in the Pigeon River from 1995 to 2005 using benthic macroinvertebrate sampling in Haywood County, North Carolina, and Cocke County, Tennessee

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The water quality appears to be improving in the Pigeon River. The successful re-introduction of freshwater snails into the river in 2000 was the first major bio-indicator of improved water quality. I predict that the overall number of aquatic insect indicator species, more specifically the Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, has increased throughout the river from the summer of 1995 to the summer of 2005. Benthic macroinvertebrates have been attractive targets of biological monitoring because they are a diverse group of long-lived, sedentary species that react strongly and, often, predictably to human influences on aquatic ecosystems (Cairns et al, 1993). Benthic macroinvertebrate studies have a rich history in the literature and are currently used by state and federal agencies in the US to determine water quality levels. These invertebrates are bio-indicators for many environmental factors such as amount of dissolved oxygen, organic matter, or heavy metals present in a localized area. Many benthics are habitat-specific and will be present only when a certain type of habitat is present. These species are good indicators for a healthy, diverse river system. Healthy rivers are important to local communities. The aesthetic values, recreation uses and local economic uses of rivers cannot be overlooked. The Pigeon River is a river that provides all these things to communities along its banks. One of the river's major economic values is the paper mill at Canton, North Carolina. Blue Ridge Paper Products has been integral in providing local jobs and sewage treatment. In the past 10 years, there has been a visible improvement in the color and overall esthetic beauty of the Pigeon due to the upgrading of paper mill equipment and removal of harmful effluent from the paper production discharge. Blue Ridge Paper continues to upgrade their facility and refine its paper processing to reduce effluent. These efforts by Blue Ridge lead me to hypothesize that the water quality of the Pigeon River has improved in the last 5 years. The Environmental Protection Agency (EPA) requires benthic macroinvertebrate testing every 5 years to renew the operating permit for Blue Ridge Paper. The most recent benthic macroinvertebrate sampling took place in July-September 2005. I am predicting that the mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) diversity has increased over the last 5 years (2000-2005).

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Oral Presentation

Assessing dam removal for compensatory stream mitigation in North Carolina

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Dam removal is one of the most beneficial techniques for restoring rivers and streams. In North Carolina, interest in utilizing dam removal as compensatory stream mitigation inspired regulatory agencies to develop guidance to promote consistent project review, feasibility, and forecast the anticipated success of dam removal projects. State and federal resource agencies collaborated to identify characteristics of a successful project, the benefits of dam removal, how successful restoration of the appropriate stream functions would be determined, as well as how to quantify those functions for compensatory mitigation. The vision is to encourage dam removal in North Carolina by increasing opportunity and garnering the fiscal resources that are often lacking.

dam removal, stream mitigation, restoration

114 Restoration of Non-Game Species

Oral Presentation

Captive propagation of rare fishes at Conservation Fisheries, Inc.: a twenty year overview

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For more than 20 years, Conservation Fisheries, Inc. (CFI) has been propagating small, generally imperiled, stream fishes in a Knoxville, TN hatchery. These fishes have been used for reintroduction/restoration projects, toxicity testing, host fish for mussel propagation, maintenance of “Ark” populations, and, in some cases, simply to work out propagation protocols in the event captive propagation should be warranted to help conserve the species. Over the years, CFI has worked with more than 60 species and currently houses nearly 40 species or separate populations. Despite CFI’s history of propagation, every season produces unanticipated findings. More often than not, efforts with new species present unique challenges, from inducing spawning to optimizing juvenile growth. Refinement of propagation techniques is a constant process, even on species that have been produced for years! A sampling of the various techniques used in the CFI hatchery will be discussed. The merits and potential pitfalls of these various techniques will be evaluated. In addition, several of the projects will be examined and results discussed. *Captive propagation; fish; imperiled; endangered; hatchery; CFI; Conservation Fisheries, Inc; restoration; reintroduction*

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Oral Presentation

Survival and reproduction of re-introduced species of selected darters and shiners in Coal Creek, TN

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Coal Creek and its tributaries have historically suffered the effects of run-off from coal strip mining, most of which has ceased. Implementation of the Surface Mining Control and Reclamation Act of 1977 brought a concern and a desire by the community to improve the health of Coal Creek. Signs of recovery were documented in 2004 with an

increase in ecological indices calculated by TVA, however, several common native fish species were missing. Re-colonization by these warm-water species was blocked by the cold tailwaters of the Clinch River which prohibits natural recruitment. The target species for initial re-introduction were small, non-game species consisting of the rainbow darter (*Etheostoma caeruleum*), Tennessee shiner (*Notropis leuciodes*), telescope shiner (*N. telescopus*) and Warpaint shiner (*Luxilus coccogenis*). All fish were collected from area streams within the Clinch River drainage from February 2007 through May 2008. Darters were batch tagged with one of two colors of visible implant fluorescent elastomer (VIE) before release at one of six re-introduction sites. Darters were tagged to assess their survival and reproduction. Monitoring surveys, conducted in late summer through late fall of 2008, used seining and/or electroshocking, found representatives of 3 of the 4 species. Rainbow darters, tagged and untagged, as well as juveniles were documented. Warpaint shiners and young of the year telescope shiners were collected. The second year of a 2-year drought made monitoring difficult in very low flows. Monitoring in 2009 has been handicapped by flows well above normal.

Coal Creek, Re-introduction, Native species, Rainbow darter, Shiners

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Oral Presentation

Pigeon River restoration: the first eight years

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In 2001, a cooperative effort was begun to restore native fish populations to the Pigeon River, once so polluted that all mollusks and many fish species were extirpated. Volunteers from federal and state agencies, industry, and private organizations created the Pigeon River Recovery Project to begin re-introduction of fish and other aquatic species. Early successes in TN led to the expansion of the project into western NC. Twenty species of fish collected from the French Broad basin and the upper reaches of the Pigeon River have been re-introduced into the Pigeon River at selected sites in TN and NC. Reproduction was first documented in gilt darters in 2003. Monitoring surveys over the past five years have documented gilt, bluebreast, and stripetail darters, mountain madtoms, and mountain brook lampreys in the Pigeon River near Newport, TN. In 2005, a survey of the lower five miles of the Pigeon River documented gilt darters in nearly every riffle; this species appears to be re-colonizing the lower Pigeon River. As of 2008, the stripetail darter and the mountain brook lamprey have also established populations. Of nine transplanted species in NC, four shiners (mirror, telescope, Tennessee, silver) and the gilt darter have been collected during monitoring efforts. Silver and telescope shiners have re-established populations in a 10-mile reach of the Pigeon River in NC. Management of this project must be flexible. Continued relocation of selected species in TN and NC reaches will be undertaken based on available habitat and reproductive success of targeted species.

Techniques for restoring imperiled aquatic species: assessing the effects of dam removal on a freshwater mussel assemblage

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We conducted a 4-year study to assess the effects of removing a small hydropower dam (Carbonton Dam) on freshwater mussels in the Deep River (Cape Fear River drainage) of North Carolina. Our objectives were to determine the short-term effects of dam removal on mussels by annual pre- and post-removal monitoring of their density, richness, and survivorship within the tailrace and impoundment (impact sites) and at two reference sites. A combination of timed visual surveys along with quadrat excavation was used to sample mussels. Over the project duration, a total of 10 mussel species were identified among the sites, including four state listed species and one significantly rare species. Eastern elliptio (*Elliptio complanata*) was numerically dominant. BACI analyses of variance detected no significant change in mussel density (total or according to taxon) or river substrate composition in the tailrace or drained impoundment sampling reaches following removal of the dam. Observations indicated that minimal mussel mortality occurred in the former impoundment immediately after dam removal. Using mark and recapture techniques, we estimated apparent survivorship of eastern elliptio between our sampling periods; estimates for the tailrace site remained similar among all periods (0.69 from 2005-2006, 0.72 from 2006-2007, and 0.65 from 2007-2008). The results of this study indicate that adverse short-term impacts of dam removal on downstream mussel assemblages can be minimized with proper timing and techniques and that additional monitoring will be required to determine potential long-term recovery of mussels within the former impoundment.

dam removal, freshwater mussels, imperiled species restoration

Guidelines for propagation, translocation, reintroduction, and augmentation for freshwater fish conservation

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Rakes, P.L. and Shute, J.R. Conservation Fisheries, Inc., Knoxville, TN.

Reestablishment of locally extinct populations and augmentation of declining populations are management activities used with increasing frequency in the conservation of imperiled fishes in the United States. Unfortunately, these options were not always carefully or appropriately used in past cases, partly owing to a lack of guidelines that address scientifically-based protocols for propagation, translocation, reintroduction, and augmentation (PTRA). PTRA programs are an important management tool for the recovery of imperiled fishes when undertaken with careful planning, including everything from determining that PTRA is necessary to incorporating knowledge of life history and genetics into the PTRA plan. In addition, PTRA programs must also assemble advisory groups, obtain funding and permitting, construct and maintain propagation facilities, and raise community awareness of the program. Because such diverse skills are needed, successful PTRA programs should prepare for long-term partnerships to achieve the goal of recovery.

captive propagation, conservation aquaculture, restoration

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Oral Presentation

Fish community responses to the addition of wood in Smith Creek, VA

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Large woody debris (LWD) is an important component of healthy stream ecosystems. LWD shapes stream physical habitat features, captures and stores organic matter, and serves as shelter, feeding sites, and reproductive substrate for fish and other aquatic organisms. Loss of in-stream LWD and sources of LWD as a result of human activities has negatively impacted many streams. Recently, restoration of in-stream LWD and riparian sources of LWD have become important facets of stream restoration, though many projects involving LWD restoration lack monitoring and evaluation. We examined the effects of adding LWD on the fish community in Smith Creek, a small warmwater stream located in Northwest Virginia with a history of habitat degradation due to intense agricultural activity throughout the watershed. We added wooden pallets to previously established fish population monitoring stream sections and employed a repeated measures design to examine changes in fish community metrics one year after wood addition. Analyses revealed no differences in total fish density, but proportions of two dominant benthic species decreased in sections that received wood additions. These results suggest possible interactions between increases in habitat complexity and species diversity in degraded streams. This research can provide valuable information about expected fish community responses to the restoration or addition of LWD in streams and could have implications for future management decisions involving riparian forest management and stream habitat restoration.

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Oral Presentation

Effects of regulated flows on habitat use of the robust redhorse

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The Robust Redhorse, *Moxostoma robustum*, is a rare and imperiled fish found only in the Pee Dee (North Carolina, South Carolina), Savannah (South Carolina, Georgia), and Altamaha (Georgia) drainages. In all three drainages, hydroelectric dams have altered habitat and restricted its range. Blewett Falls Dam on the Pee Dee River in North Carolina is hydro-regulated, and a new minimum flow regime that will affect available habitat for robust redhorse is being implemented. The river reach downstream of Blewett Falls Dam is the only known spawning area for robust redhorse in the river. Our objectives were to describe and quantify spawning and non-spawning microhabitat and quantify how these will be affected after the implementation of augmented minimum flows. Microhabitat use data were obtained from relocated radio-tagged robust redhorse from Spring 2008 through Summer 2009, including, depth, mean velocity, substrate, cover, and distance from bank. Seasonal longitudinal migration was documented with resident and migratory subgroups in the Pee Dee River. Non-spawning habitat consisted of deep, slow-moving pools with bedrock and sand substrates with boulders or coarse woody debris cover. Spawning habitat consisted of shallower, faster-moving water with gravel and cobble substrate and boulders as cover associated with shoals. Spawning microhabitat use identified by telemetry and habitat availability analysis suggests the augmented flows will increase available spawning habitat. Our results will assist managers in refining the regulated flows in the Pee Dee River to enhance habitat for the robust redhorse and other fish populations.

Robust redhorse, habitat use, minimum flows, telemetry

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Oral Presentation

**Investigating fish responses to flow restoration in the Cheoah River, NC:
implications of detection probability on conclusions**

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Restoring aspects of a natural flow regime may influence fish populations in regulated rivers. However, differences in detection probabilities among methodologies, environmental conditions, and location may lead to erroneous conclusions. We sampled the Cheoah River, a regulated system in western NC, in the summer of 2008 and 2009 as a part of FERC license requirement to determine the influence of restoring minimum and flood flows on the fishes. Our goals were to 1) continue long-term sampling efforts on fish occupancy, 2) determine the influence of methodology on species detection probabilities, and 3) provide recommendations for future long-term sampling in the Cheoah River. In 2008 and 2009, we snorkeled and electrofished a series of mesohabitats in order to estimate survey-specific detection probabilities for six species in the program PRESENCE. In both years, we found that snorkeling detection probabilities were

comparable to or higher than electrofishing for *Percina aurantiaca*, *Hypentelium nigricans*, and *Moxostoma duquesnei*. However, in the case of rare species, such as the Tuckasegee darter (*Etheostoma. gutselli*), electrofishing detection probabilities were higher than snorkeling both years. We found that trends in *H. nigricans*, *M. duquesnei*, and *P. aurantiaca* occupancy may have been confounded due to differences in methodology or site location. However, trends in *E. gutselli* and *C. anomalum* occupancy may be accurate. In a clear, intermediate-sized river such as the Cheoah, snorkeling is a viable sampling method; however, in the case of rare species with low detection probability, electrofishing should also be conducted in riffle habitats.
Flow, restoration, detection probability, occupancy, endemic Fish

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Oral Presentation

Recolonization of blacknose dace after restoration of an acidified stream

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Restoration of acidified streams from acid deposition has focused on recovery of trout species with little attention to native non-salmonid species. Recovery of the entire fish assemblage is an important metric for success. I documented survival, dispersal and reproductive success of multiple attempts (1993-2009) to reintroduce blacknose dace (*Rhinichthys atratulus*) in an acidified headwater stream that had been restored through addition of limestone sand. Although brook trout (*Salvelinus fontinalis*) recolonize quickly after liming, blacknose dace have taken over fifteen years to produce an age-class. The re-establishment of blacknose dace in restored acidified streams may be very difficult and require frequent large stockings over multiple years to reestablish a reproducing population. My results provide insight into the difficulty and long-term recovery efforts that may be needed to restore the entire native fish assemblage to acidified streams.

125 Brook Trout Symposium

Oral Presentation

Long-term population dynamics of a southern brook trout population.

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We used information theoretic statistics (AIC) and regression analysis to assess the processes capable of explaining long-term demographic variation in a lightly exploited brook trout population in Ball Creek, NC. We sampled a 100m long 3rd order site during both spring and autumn 1991- 2004, using three pass electrofishing. PCA indicated that the site had lower average velocities, greater amounts of depositional substrata and lower amount of erosional substrata during the 1999-2002 drought. Drought years had lower

flows and lower variation in flows than non-drought years. Both young-of- the year (YOY) and adult density varied by an order of magnitude. We examined the effects of density dependence, recruitment limitation, habitat and flow variation [density independence] on per capita rate of change data for both YOY and adults using AIC. Simple density-dependence was the only interpretable model for both YOY ($w_i = 0.39$) and population ($w_i = 0.76$) data sets. We detected a significant stock-recruitment relationship between autumn density of adults in year t and autumn YOY density in year $t+1$. Several correlations were indicative of density dependence and autumn YOY mean standard length (SL) was negatively correlated with both autumn adult and YOY densities. Nonetheless, density independent factors affected YOY densities, because both spring and autumn YOY densities were inversely correlated with high flows. This population appears to be regulated by a combination of density-dependent and density-independent processes.

Islands in the stream: Fine-scale analysis of brook trout genetic population structure reveals the need for research and management paradigm shifts

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Wofford J, Shenandoah National Park, Luray, VA

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The U.S. Geological Survey and U.S. National Park Service have collaborated to develop a suite ($N=13$) of microsatellite DNA markers for brook trout (*Salvelinus fontinalis*) and to conduct an extensive survey of allelic variation in over 10,000 fish from 270 collections comprising the species' native range. This survey identified previously undetected demographic histories (e.g., supplemental or restorative stocking; bottlenecks) and evolutionary relationships among populations, yielded a wide range of allelic diversity, demonstrated differentiation at all hierarchical levels studied (individual to watershed), and documented similar levels of differentiation among collections within drainages and among collections between drainage basins. Findings indicate that the individual stream (or collections within) should be considered the fundamental unit of management (contrary to the current paradigm). These research findings create somewhat of a management conundrum - Does genetic divergence observed among brook trout reflect adaptive significance (natural selection) or is this indicative of drift-induced differentiation? Given that natural selection ultimately acts on the genetic variation underlying character variation, identifying the genes associated with parallel evolutionary changes among recently diverged lineages is essential to uncovering candidate genes implicated in adaptive phenotypic variance. Determining whether fisheries managers should focus their resources on identifying/characterizing genetic relatedness (e.g., everything from morphological comparisons to gene expression profiling) or determining the number of brook trout needed to establish population

viability should now become a high priority research need (i.e., a new research paradigm). We will discuss how contemporary research results directly and indirectly affect the degree to which research and management paradigm shifts (while doing no harm) may be warranted.

127 Brook Trout Symposium

Oral Presentation

Resiliency of brook trout habitat to climate change

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Climate change is predicted to extirpate many of the existing brook trout throughout their native range, eliminating brook trout in Virginia. Previous large-scale assessments of the effects of climate change on cold-water fishes have models that assumed a steady relationship between air and water temperature. While these models were appropriate for large-scale assessments they may be inaccurate at smaller scales where brook trout management occurs. Our pilot study showed that the relationship between air and water temperature is 1) highly variable at the catchment scale (average size = 237 ha), 2) potentially influenced by local conditions (i.e. elevation, aspect, riparian cover, latitude, and ground water sources) and 3) is often best fitted to a sigmoid curve. These relationships can be quantified and modeled to rank existing brook trout populations for their resiliency to climate change. We identified and dissolved contiguous brook trout occupied catchments into patches of brook trout habitat (n = 272; average size 2856 ha). We placed air and water thermographs at the centroid, and downstream border of selected brook trout patches. Data will be collected at 30 minute intervals for 17 months to include two critical summer periods (July 1-September 15). Sample patches were selected from cluster analysis groupings using land-use and topographic metrics. Results from sampled patches will be used to model and rank the remainder of the un-sampled patches for resiliency to climate change. The resiliency rankings of patches of brook trout habitat will be useful for priority setting of monitoring and restoration work.

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Oral Presentation

A revisit of Maryland brook trout genetics

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Since the early 80s, there was considerable interest in the genetics of Maryland brook trout *Salvelinus fontinalis* populations, as evidenced by the number of papers and reports produced on this native species. Historically, Maryland contained significant precolonial native brook trout *Salvelinus fontinalis* populations, but now contains only remnant,

highly-fragmented and disjoint populations throughout the state. Using microsatellite data, collected from 26 brook trout populations in Maryland drainages, we describe the genetic and population relationships of the species in Maryland, with a discussion on zoogeographical mechanisms. These relic brook trout populations are highly vulnerable to anthropogenic stresses, and many extant populations may be extinct in the near future. Native brook trout populations, in many Maryland watersheds, are increasingly becoming more restricted to headwaters, with resulting detrimental effects on population connectivity and potentially genetic structure.

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Oral Presentation

Brook trout population trends in western Maryland 1988 - 2007

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Western Maryland is one of the last strongholds for brook trout populations in the mid-Atlantic region. Concerns of declining brook trout populations prompted a re-inventory of previously sampled sites. Sixteen brook trout populations in western Maryland were sampled during 1988-1989 and sampled again in 2007 in order to assess the status of each population. Sites were divided into low, medium, or high abundance categories based on the initial surveys from 1988-1989. Adult brook trout abundances declined (10 out of 16) at most of the re-survey sites, but responses were quite variable. All high abundance sites declined in 2007, whereas most of the low abundance sites increased to a degree. Three streams maintained very low abundances of brook trout from the early surveys to the most recent ones. Despite appearances to be on the verge of disappearing, they have persisted at low abundances for 15 years. Only three streams had populations that appreciably increased from the first survey period to the most recent one 15 years later, with one receiving considerable help from mitigation of acid mine drainage to raise pH and overall buffering capacity. In contrast, two streams traditionally considered to be the gems of the Savage River watershed, Monroe Run and the Middle Fork of the Savage River, both experienced severe declines with abundances an order of magnitude lower in 2007 than when previously sampled roughly 15 years ago. Other traditionally strong populations have also experienced noticeable declines. Five of these six streams are within the Savage River watershed, which recently received strict regulations prohibiting the possession of brook trout by anglers.

130 Brook Trout Symposium

Oral Presentation

Assessing brook trout at various scales: Lessons learned from the eastern brook trout joint venture

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Beard, D.T. United States Geological Survey, Reston, VA

Unbiased large scale assessments are critical for the conservation of fishes. The Eastern Brook Trout Joint Venture (EBTJV) examined and summarized existing knowledge regarding the distribution and status of self-sustaining populations of brook trout *Salvelinus fontinalis* across their native range in the eastern United States. Differences in data quality, quantity, and spatial scale created difficulties in assessing status and mapping the distribution of brook trout at the finer scales. The EBTJV assessment was done at the subwatershed scale because lack of small scale data in many areas and the difficulties in summarizing existing data from over 17 states and government agencies. I summarized current occupancy of brook trout at four different scales: sub-basins (mean area, = 254,172 ha); watersheds (mean area, = 41,201 ha); subwatersheds (mean area = 8,879 ha) and catchments (mean area, = 237 ha). Differences in the reporting scale influenced the results; brook trout occupied 88% of sub-basins; 72% of watersheds; 47% of subwatersheds and 10% of catchments. The scale at which results are reported can bias impressions of the true status and distribution of the species. In general the smaller the scale the smaller the bias, however, fine scale assessments require large amounts of fine scale data that rarely are available in a compatible way for large extents of species distributions.

Dispersal and within-stream spatial population structure of brook trout revealed by sibship and parentage analysis

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Coombs, J.A. University of Massachusetts, Amherst, MA

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Letcher, B.H. U.S. Geological Survey, Biological Resources Division, S. O. Conte Anadromous Fish Research Center, Turners Falls, MA

Spatial patterns of spawning and early dispersal have important implications for the population dynamics of stream-dwelling salmonids, but limitations of marking technology have made it difficult to measure these processes in wild populations. We used microsatellite DNA markers and sibship and parentage analyses to follow the dispersal, spatial distribution, and distribution of reproductive success in a small isolated allopatric brook trout population 4, 16 and 28 months after fry emergence. For the 2004 year class (high recruitment cohort) we identified 180 full sibling families representing individual spawning events. Offspring were unevenly distributed across families, with 20% of the families accounting for 51% of the offspring and 53% of families represented by < 3 individuals. However, a large proportion of adults had some successful reproduction, resulting in a high effective population to census size ratio (~ 0.4). Spatial and family size distributions for young of the year were similar between the 2004 and 2006 (low recruitment) year classes in spite of a 3-fold difference in abundance. The spatial locations of full sibs were closely associated, indicating limited dispersal in the first four months post emergence. Spatial locations of assigned parents were correlated to locations of their offspring. For the 2004 cohort, sibling dispersal substantially increased

after the four-month sample, but neither fish length, family size (number of individuals), nor fish density was related to dispersal distance at any time interval. In this study, we demonstrate the ability of sibship and parentage analyses to reveal important aspects of brook trout population structure and movement. Our results suggest that limited dispersal by young of the year brook trout and their parents results in a high level of within-stream spatial population structure, even in the absence of barriers to movement, which must be accounted for in genetic surveys and management studies.

Restoration creates Tennessee's best brook trout stream

Habera*, J. Tennessee Wildlife Resources Agency, Morristown, TN

Left Prong of Hampton Creek, located near Roan Mountain State Park, is now Tennessee's premier brook trout stream, but had none of these fish just over a decade ago. Although Left Prong would have historically supported brook trout, they were likely lost during the early twentieth century through habitat degradation associated with contemporary logging and agricultural practices. Rainbow trout later became naturalized in Left Prong through stocking or colonization from downstream populations. Interest in restoring a brook trout population in Left Prong developed following its designation in 1986 as a State Natural Area. It culminated in a 1997 agreement among several natural resource management agencies and conservation organizations to re-establish brook trout in the upper 2 km of the stream. An existing culvert was modified to serve as a barrier, and the upstream rainbow trout population (over 2,300 fish) was removed by electrofishing in 1998 and 1999. Unlike previous projects, the initial removal effort (three passes) was made in the fall (October), when young-of-the-year rainbow trout were larger and less abundant, and was followed up before spring to eliminate as many adults as possible and thereby prevent any further spawning. Further removal efforts during the summer of 1999 indicated that spawning had been suppressed in 76% of the restoration zone. In September, 273 native, southern Appalachian brook trout from three nearby streams were translocated to Left Prong and these fish successfully spawned in the fall of 1999. Brook trout biomass in the upper part of the restoration zone exceeded that of the previous rainbow trout population by 2003 and now averages over 100 kg/ha—4-5 times higher than in other Tennessee brook trout streams. Rainbow trout were virtually eliminated by summer 2000, as an electrofishing survey in July produced only two rainbow trout from the 1999 cohort. However, the presence of adult rainbow trout in the lower part of the restoration zone after 2002 indicated that the culvert barrier was ineffective and would need to be replaced to maintain the high-quality brook trout population. Grants were secured by two local Trout Unlimited chapters and a new structure, incorporating a low-water ford and waterfall approximately 2.75 m in height was designed by the Natural Resource Conservation Service. Construction was completed in August 2007 at a cost of \$45,680, half of which represented the value of labor provided by project partners. Electrofishing efforts during the fall of 2007 and 2008 were successful in removing the rainbow trout remaining upstream of the barrier; none were captured in 2009 surveys. Annual population monitoring and periodic barrier

maintenance will ensure that Left Prong continues to support its exceptional native, southern Appalachian brook trout fishery both as a link to the area's natural heritage and for the enjoyment of anglers.

133 Brook Trout Symposium

Oral Presentation

Using antimycin to remove non-native fish species from lakes, ponds and streams: Lessons learned, pitfalls and challenges

Kulp, M. A.* and Moore, S.E., National Park Service, Great Smoky Mountains National Park, Gatlinburg, TN

Antimycin has been used to effectively remove non-native fish species from lakes, ponds, and streams for over 50 years. During this time, managers have learned a great deal about antimycin application techniques, application rates, equipment, safety, impacts to non-target species, detoxification and other confounding factors. Lessons learned over time and confounding factors, such as the effects of droughts, floods, high background organic loads, episodic events and predators, can cause restoration projects to fail if not recognized and properly mitigated. Prudent and thorough planning, setup, design and mitigation of challenges associated with conducting an antimycin treatment will lead to a successful project. Properly applied, antimycin can remove 100% of the target fish species from a water body with minimal short-term (<3 months) and no long-term (>12 months) impacts to non-target macroinvertebrate species. Native species can be transplanted back into the restored habitat rather quickly in comparison to restoration projects using other fish toxicants. Timely restoration of native fish populations, leading to re-establishment of public use, can greatly improve public relations. Comparatively, antimycin project costs (\$3,930/km) are typically 60-70% lower per stream kilometer than multiple electrofishing removal projects costs (\$12,416/km), mainly due to greatly reducing project completion time. The use of antimycin to restore native fish populations should remain a viable restoration option hindered only by future product availability.

134 Brook Trout Symposium

Oral Presentation

Brook trout restoration, Great Smoky Mountains National Park: History and future

Moore*, S.E., and Kulp, M. A. National Park Service, Great Smoky Mountains National Park, Gatlinburg, TN

The primary mission of the National Park Service is to protect and preserve native species where feasible. Historic land management practices and stocking of non-native rainbow trout resulted in native brook trout losing approximately 75% of their historic range. In an effort to reverse this trend, in 1976, Great Smoky Mountains National Park (GRSM) initiated a program to evaluate the effectiveness of electrofishing for the eradication of non-native rainbow trout upstream of waterfalls or cascades in six small streams. An evaluation of this effort in 1981 revealed that two streams had been

successfully restored, because of their small size and the presence of a barrier. Several studies completed during this period indicated that streams with complex habitat coupled with large deep pools rendered the complete removal of non-native fish using backpack electrofishing gear unattainable. These studies also revealed that the use of multiple electrofishing units and multiple removals in a year would increase the chances of success in appropriate sized streams. The combination of these methods has resulted in segments of six streams have been successfully restored. During this same time frame, the impacts of acidic deposition to the Parks aquatic ecosystems became evident. This information increased the urgency of restoring lower elevation stream segments for brook trout and the park completed an environmental assessment for the use of a piscicide for brook trout restoration in 2001. The environmental assessment provided evidence that the fish toxicant Fintrol® (antimycin) could be used with minimal impact to non-target organisms. The environmental assessment identified eight stream segments for the use of Fintrol® and was approved with the condition that data from the first stream clearly demonstrated no impacts to non-target organisms. The first stream treated with the piscicide was Sams Creek and data from this study demonstrated that aquatic macroinvertebrates, salamanders of crayfish were at or above pre-treatment levels within one year of treatment. Comparisons of cost and time requirements for each method clearly demonstrate that projects involving the use of Fintrol® are much cheap

Brook trout management in North Carolina: A review of past, present and future efforts

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Brook trout *Salvelinus fontinalis* is the only salmonid native to North Carolina. Intensive stockings of northern-strain fishes served as the primary form of brook trout management until the 1960s, when interest in preserving wild populations increased and more restrictive regulations were applied to those fisheries. In 1978, the first rigorous effort by the North Carolina Wildlife Resources Commission (NCWRC) to inventory North Carolina's trout streams began. Since that initial 4-year study, the NCWRC has identified approximately 508 wild brook trout populations, and of these 401 have been genetically typed via allozyme analysis. Results from testing indicate that 36% of the populations are Southern Appalachian origin, 10% are northern origin and 54% are of mixed genetic origin. Future management efforts of brook trout will be dependent upon technological advancements and utilization of human dimensions data obtained by the NCWRC. Microsatellite DNA analysis will be employed to help answer questions regarding historic distribution of Southern Appalachian brook trout and to shape restoration efforts within the Gulf of Mexico and Atlantic drainages. Angler opinion data reveal that the state's trout anglers feel it is important to specifically devote resources to brook trout management. Assessment of the economic impact of trout fishing in North Carolina found that NCWRC-managed waters generate significant revenue for western counties (approximately \$174 million per year in total economic output). NCWRC

wishes to capitalize upon the economic importance of these fisheries to heighten community interest in the adequate protection and enhancement of North Carolina's brook trout.

136 Brook Trout Symposium

Oral Presentation

Georgia's brook trout restoration efforts

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Joyce, M.P. United States Forest Service

McGrath, K.F. Trout Unlimited

Georgia's brook trout restoration initiative is a multi-year effort by the state and federal fisheries management agencies with assistance from Trout Unlimited. The primary objective of this project is to blanket brook trout streams across the Chattahoochee National Forest with adequate refuge habitat to sustain populations during drought years and enhance carrying capacity in other years. From 2007-2009, Eastern Brook Trout Joint Venture grant funds were primarily used to construct a combination of wedge dams, channel deflectors, and channel constrictors in 15 streams located in seven major river systems across the national forest. Over this period, 204 individual structures were installed during the summer months using work crews of six to eight people. Preliminary results indicated that stream habitat enhancements increased stream depth by 51%, percent pools by 151%, large woody debris by 270%, and brook trout biomass by 48% when compared to adjacent reference sites. Secondary objectives of brook trout restoration efforts in Georgia included pre- and post-construction habitat and population monitoring, installation of migration barriers, removal of non-native trout species from historic brook trout waters, and temperature and water quality monitoring (i.e. pH and ANC). Future brook trout management efforts in Georgia will attempt to reconnect isolated populations within historic watersheds.

137 Brook Trout Symposium

Oral Presentation

Sixty years of stream channel "restoration" on North River, Augusta County, Virginia

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Dawn Kirk, U.S. Forest Service, P.O. Box 10, Natural Bridge Station, Virginia 24579

The North River is a third order native brook trout stream located on U. S, Forest Service land in northwest Augusta County, Virginia. Various stream channel projects have been carried out since a large flood in 1948 to control both flooding and sediment movement. Historic efforts included channel modification, debris removal, gabion construction and dam building. Most past efforts have resulted in destabilization of the river channel and excessive movement of cobble. Streambed cobbles have built to a point where summer low flows are now generally sub-surface, resulting in loss of most brook trout habitat.

The current restoration project attempts to re-establish summer surface lows by creating low flow channels, removing gabions and installing habitat structures. This project is designed to be a continuing long term project. Physical results of the first five years of the project will be presented.

150 Blackbanded Sunfish Symposium

Oral Presentation

Status of blackbanded sunfish in the Southeastern United States

Stranko*, S.A, and Kilian, J.V. Maryland Department of Natural Resources, Annapolis, MD

The blackbanded sunfish inhabits slow, shallow, heavily vegetated, acidic waters of streams, margins of rivers, ponds, and lakes in the Eastern U.S., from New Jersey to Florida. The American Fisheries Society Endangered Species Committee did not list blackbanded sunfish on the 1989 list of imperiled freshwater and diadromous fishes of North America. It is, however, listed as vulnerable on the 2008 list, indicating that the species has experienced a decline over the last 20 years. It is currently considered imperiled, vulnerable, endangered, or presumed extirpated in seven of the nine states within its range. Current published research and conversations with biologists from these nine states suggest that the species is continuing to decline. The most often reported threats to this species include drying of ponds and swamps, pesticide contamination, collection for aquariums, and competition and predation by non-native centrarchids. Conservation efforts are being implemented to reduce threats and bolster populations in certain states, but a region wide strategy may be needed to ensure perpetuation of this species in the Southeast.

151 Blackbanded Sunfish Symposium

Oral Presentation

New Jersey... a surprising stronghold for blackbanded sunfish (*Enneacanthus chaetodon*) in a shrinking refugium.

Crouse*, S. New Jersey Division of Fish and Wildlife, Lebanon, NJ.

Although the most densely populated state in the Union, New Jersey is one of the last strongholds for blackbanded sunfish (*Enneacanthus chaetodon*). Once found more widespread throughout New Jersey's coastal plain, this sensitive native species has been limited primarily to a 1.1 million acre refuge known as the Pinelands National Preserve. Although not currently listed as a State Threatened, Endangered, or Species of Concern, this unique creature is considered one of New Jersey's *Species of Regional Priority*, defined as *potentially at risk for state and/or regional listing* and is considered an indicator species. Water quality and habitat degradation resulting from various landuse changes pose many threats. Among other factors, increased pH allows the invasion of non-native centrarchid species previously excluded from naturally highly acidic water with low conductivity. Subsequent predation, coupled with habitat changes including but not limited to the loss of various aquatic macrophytes such as bladderwort species, seem to exceed the tolerance of this distinguished, yet secretive freshwater fish species. Work

is currently underway to better assess the status and distribution of the blackbanded sunfish in New Jersey waters.

152 Blackbanded Sunfish Symposium

Oral Presentation

Status and distribution of blackbanded sunfish (*Enneacanthus chaetodon*) in Delaware

Kalasz*, K.S. and Martin, C.C. Delaware Division of Fish and Wildlife, Smyrna, DE

The blackbanded sunfish (*Enneacanthus chaetodon*) historically ranged throughout much of Kent and Sussex Counties on the coastal plain of Delaware and was documented at over 20 locations. The species' status remained S2 under Natural Heritage ranking guidelines when it was last formally reviewed in 2003. New findings based on recent surveys indicate many of those populations have either significantly declined or have been extirpated making the species particularly vulnerable to retaining continued existence in the State. Most troubling is the near complete loss of populations in the Nanticoke River watershed, once considered its stronghold. It has now been given a Natural Heritage rank of S1 and is proposed for state endangered species listing. There is uncertainty as to the causes of the decline but known threats include collection pressure, declines in water and habitat quality, and predation.

blackbanded sunfish

153 Blackbanded Sunfish Symposium

Oral Presentation

An interstate conservation action strategy for blackbanded sunfish in the Chesapeake Bay watershed

Kilian*, J.V., and Stranko, S.A. Maryland Department of Natural Resources, Annapolis, MD

Raesly, R.L. Frostburg State University, Frostburg, MD

Kalasz, K.S. Delaware Division of Fish and Wildlife, Smyrna, DE

The distribution of Blackbanded Sunfish in the Chesapeake Bay watershed is restricted to Maryland and Delaware. Historically, it was known from 19 locations, but currently only six extant populations remain in the watershed. In response to the watershed-wide decline of this species, the Maryland Department of Natural Resources (MDNR) and Delaware Department of Natural Resources and Environmental Control (DNREC) initiated a conservation action strategy for Blackbanded Sunfish in 2008. The goal of this conservation action strategy is to ensure the persistence of Blackbanded Sunfish in the Chesapeake Bay watershed by developing and implementing a collaborative, interstate conservation effort to protect all populations. This presentation will summarize the current status of Blackbanded Sunfish in the region and describe short- and long-term conservation actions aimed at maintaining and developing Blackbanded Sunfish populations in the Chesapeake Bay watershed.

154 Blackbanded Sunfish Symposium

Oral Presentation

Historical records of *Enneacanthus chaetodon* and its current population status in wadeable streams in South Carolina

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Poly, W.J. SCDNR, Eastover, SC

We reviewed records of blackbanded sunfish (BBS) dating to 1853 to assess the spatial and temporal distribution of historical collections in South Carolina. Most of the records included abundance information. We also compiled the most recent collections associated with the South Carolina Stream Assessment (SCSA), an ongoing sampling program targeting wadeable streams statewide. One aspect of the SCSA is probabilistic site selection, allowing us to estimate abundance of BBS across its coastal plain range. Historically, collections occurred in all river basins of the state and in 23 of 28 counties below the Fall Line. A single individual was usually reported and the vast majority of individual collections consisted of ≤ 5 individuals, although 61 fish were reported at one locale in the Pee Dee River basin in the 1970s. Over time, occurrence was predictably associated with collection effort rather than indicating actual fluctuations in sunfish distribution. Since 2000 there have been more than a dozen collection sites. Although the SCSA does not target all BBS habitats and is not yet completed, it does allow an estimate of abundance to be calculated, standardized by stream length sampled relative to total stream length across their range. BBS occurred at 2.8% of coastal plain SCSA sites sampled (4 of 145), exclusively in Savannah and Wateree/Santee basin streams. BBS abundance (uncorrected for detectability) in wadeable streams of the SC coastal plain is estimated at 0.58 fish/km (95% CI = 0 - 1.24). The Savannah River basin had the highest abundance estimate at 3.69 fish/km (0 - 8.35).

blackbanded sunfish, Centrarchidae, stream sampling, abundance estimate, coastal plain, conservation

155 Blackbanded Sunfish Symposium

Oral Presentation

Conservation status of the blackbanded sunfish in Florida and Georgia.

Tate*, B. US Fish and Wildlife Service, Niceville, FL

Walsh, S. US Geological Survey, Gainesville, FL

Darden, T. South Carolina Department of Natural Resources, Charleston, SC

Albanese, B. Georgia Department of Natural Resources, Social Circle, GA

Though more common along the northern Atlantic Slope, the blackbanded sunfish is considered a threatened species in the state of Florida and endangered in Georgia. Recent attempts to collect the species in Florida and Georgia have been largely unsuccessful. The only consistent records for the species come from within Okefenokee Swamp National Wildlife Refuge where it has been collected regularly. In recent years, the blackbanded sunfish has been collected at two sites in Florida and one site in Georgia outside the Okefenokee Swamp NWR. Habitat complexity may have confounded collection efforts, however fragmentation or loss of wetland habitat resulting from urbanization or natural impacts has likely contributed to population declines in both states. Biological information on the blackbanded sunfish is extremely limited,

especially for Florida populations, and there is a critical need for additional data on distribution and ecology in order to implement effective conservation measures to protect this species. Conservation of populations of blackbanded sunfish depends upon maintaining habitat quality in the Okefenokee Swamp and in other appropriate habitats.

156 Blackbanded Sunfish Symposium

Oral Presentation

Patterns in the distribution of banded sunfish on the Maryland Coastal Plain

Ciccotto*, P. and Stranko, S.A. Maryland Department of Natural Resources, Annapolis, MD

Blackwater streams, characterized by dark-stained acidic waters, comprise critical habitats for banded sunfish (*Enneacanthus obesus*) throughout the species range on the Atlantic slope of the United States. In Maryland these habitats are restricted mainly to the Delmarva Peninsula on the Coastal Plain where the state imperiled banded sunfish is found. Non-metric multidimensional scaling was used to identify patterns in the distribution of this species on the Delmarva Peninsula in Maryland with chemical, physical habitat, and land use data. Banded sunfish occurrence was found to be associated with dissolved organic carbon concentrations greater than 8.0 mg/L, characteristic of blackwater streams in Maryland. High forested land use, low agricultural land use, and low nitrate concentrations were also found to be associated with banded sunfish occurrence. Other centrarchid species, including the congeneric bluespotted sunfish (*E. gloriosus*), did not exhibit a specialist pattern towards blackwater habitats and appear more tolerant to agricultural disturbance. These results indicate the replacement of forest by agricultural land use in this part of the state alters water chemistry and is detrimental to the occurrence of banded sunfish in Maryland.

Banded sunfish, landscape alterations, water chemistry

157 Blackbanded Sunfish Symposium

Oral Presentation

Assessment of the impact of predation by non-native piscivores on *Enneacanthus*

Cessna*, J.F., Klein, S.M., and Raesly, R.L. Frostburg State University, Frostburg, MD

Enneacanthus chaetodon (blackbanded sunfish) is presently restricted to aquatic habitats with low pH and low abundances on non-native piscivores in Maryland. Historical localities from which blackbanded sunfish have been extirpated are typically occupied by large populations of largemouth bass (*Micropterus salmoides*) and crappie (*Pomoxis nigromaculatus* and *P. annularis*). During the summer of 2009 we collected non-native centrarchids from eight ponds containing *E. chaetodon* and/or *E. gloriosus* and determined diets of these species by stomach flushing. All ponds were located in Caroline County, Maryland. We captured 117 largemouth bass and 14 crappie; 43 of these individuals had empty stomachs. Preliminary analysis revealed evidence of piscivory by 53 (45%) of the largemouth bass. No fish remains were detected in the diets of *Pomoxis* spp. During summer most of the prey items were insects, with adult dragonflies being common. We dissected the anterior portion of the digestive tract (esophagus and stomach) from a subset of captured fishes to determine if stomach

flushing removed all prey items from the gut. Stomach flushing did not completely evacuate 25 (21%) largemouth bass stomachs. Of these, 17 (68%) contained intact, large prey items (fish and crayfish). These data indicate that stomach flushing may not be a reliable technique for diet analysis in some circumstances, as larger prey species may be overlooked and results of diet analyses may be skewed towards smaller prey items.

Dietary analyses will continue seasonally through 2010.

blackbanded sunfish, predation, non-native piscivores

158 Blackbanded Sunfish Symposium

Oral Presentation

Population size and size structure of *Enneacanthus chaetodon* and *Enneacanthus gloriosus* in five Maryland Coastal Plain ponds.

Raesly*, R.L., Klein, S.M., and Cessna, J.F. Frostburg State University, Frostburg, MD
Kilian, J.V. Maryland Department of Natural Resources, Annapolis, MD

We estimated population sizes of two *Enneacanthus* species in five small ponds in Caroline County, Maryland in August 2009. Population estimates were conducted by randomly sampling non-overlapping shoreline transects 20m in length with a seine. Standard lengths of individual blackbanded and bluespotted sunfish were recorded at the time of capture. We used linear regression analysis to estimate populations with cumulative shoreline length as the independent variable and cumulative catch as the dependent variable. We constructed length-frequency histograms for populations of each species in each pond. Bluespotted sunfish were captured in all five ponds and population estimates varied from 152 ± 49 to 1681 ± 207 . Blackbanded sunfish were only captured in three of the five ponds even though we documented their presence in the other two ponds less than two weeks prior to conducting our population estimates. Population sizes of blackbanded sunfish varied from 26 ± 10 to 232 ± 29 . Our estimates are very conservative because they are based only on shoreline habitat. Three or four size classes of *E. gloriosus* are present in most of the ponds. The smaller sample sizes for *E. chaetodon* preclude the identification of more than two size classes. Size structures were similar among most ponds but there were notable differences among some ponds.

blackbanded sunfish, population estimation, size structure

159 Blackbanded Sunfish Symposium

Oral Presentation

Stratified site selection for blackbanded sunfish sampling

Bourquin*, R. M., Kilian, J. V., and Stranko, S.A. Maryland Department of Natural Resources, Annapolis, MD

As a part of the Interstate Management and Conservation of Blackbanded Sunfish Project, we attempted to find new populations of the Blackbanded Sunfish (*Enneacanthus chaetodon*) in Maryland and identify habitats suitable to their reintroduction. The Blackbanded Sunfish is a small centrarchid associated with heavily vegetated, acidic ponds, swamps, and slow-moving streams (Lee et al. 1980; Jenkins and Burkhead 1994). After 50 years of decline, this species is currently known from only one of 19 historical sites within the entire Chesapeake Bay watershed. Given the disjunctive and localized

distributions of the Blackbanded Sunfish (Smith et. al. 2001; Darden 2008), we assumed that all lentic habitats within basins that contained historical collection localities could potentially harbor Blackbanded sunfish. We therefore randomly selected 76 out of 238 potential sites, identified by aerial photography and GIS, in the Marshyhope Creek watershed in the Nanticoke River basin, as this watershed currently contains the last known extant population of Blackbanded sunfish in Maryland. To maximize the likelihood of finding this hard to detect species, we prioritized site selection based on known habitat preferences, such as low pH values and aquatic vegetation, and utilized multiple gear types during sampling. Despite intensive sampling at the most suitable locations, no Blackbanded Sunfish were detected during 2009 sampling. However, we did succeed in finding several ponds that provide ideal habitat to support the re-introduction of this species into the Nanticoke watershed.

Blackbanded Sunfish

160 Blackbanded Sunfish Symposium

Oral Presentation

Courtship behavior of blackbanded sunfish (*Enneacanthus chaetodon*) in Maryland

Klein*, S.M., Cessna, J.F., and Raesly, R.L. Frostburg State University, Frostburg, MD

Spawning behaviors of blackbanded sunfish (*Enneacanthus chaetodon*) were observed while snorkeling during July and August 2009 and recorded using a high-definition underwater video camera. All observations were from a single pond in Caroline County, Maryland. Six pairs of *E. chaetodon* were observed associated with nests that were constructed in a diversity of locations that differed by depth, slope and substrate type. One nest was located on a sand/gravel bottom, one male constructed the nest on submerged woody debris, and four males used areas of detritus in patches of filamentous algae and aquatic vegetation. Males fanned out a circular depression approximately 10cm in diameter and 4-9cm deep. After digging the male would leave the nest and patrol a perimeter around the area, then return after 1-2 minutes. Upon return he would then clean the nest and patrol again. This cycle was repeated approximately 6-10 times per hour. When a male accompanied a female over the nest, courtship behavior primarily consisted of rubbing the sides of their bodies together in an erratic, undulating motion. The pair would then descend into the nest and continue. Females were frequently observed leaving the male then returning. Actual release of gametes by a pair was not possible to determine since clear observations were obstructed by the rim of the nest.

blackbanded sunfish, courtship, nest construction, spawning

161 Blackbanded Sunfish Symposium

Oral Presentation

Captive propagation of blackbanded sunfish for population recovery

Pottern*, G., Robert J. Goldstein & Associates, Raleigh, NC.

The Blackbanded Sunfish *Enneacanthus chaetodon* spawns readily in captivity, and captive propagation may be helpful for enhancing depleted or extirpated populations in waters where suitable habitat has been restored. Newly caught Blackbanded Sunfish are prone to *Flexibacter*, *Saprolegnia*, protozoan parasites and other stress-induced diseases,

especially when collected in low-conductivity acidic water. Precautions should be taken to control water quality and minimize ion loss while collecting, transporting and acclimating wild brood-stock. Newly caught fish should be fed small live crustaceans, worms or insects soon after capture to replenish lost minerals and glycogen. Some will later adapt to frozen foods and chopped earthworms, shrimp or crab meat within a few weeks, but others may refuse non-living foods. Sexes look similar except when breeding, when contrast between the black bars and tan background increases on females and decreases on males, and the male's fins darken. They can live several years at room temperature year-round, but successful spawning is increased by winter cooling. One male and two to four females can spawn in 20 gal or larger aquaria. Larger groups can spawn in 15 inch or deeper plastic pools, with trays of sand and clumps of plants placed around the perimeter to separate nesting sites. Provide bio-filtration without strong flow, as eggs are easily flushed out of the nest and eaten by non-spawning fish. Live plants will help maintain good water quality without excessive water circulation. The male guards the nest site but does not protect the fry which scatter soon after hatching. Post-larvae require rotifers, copepod nauplii, other very small zooplankton, or small grades of fresh-hatched *Artemia*. Fry survival is usually low if only non-living foods are offered. Low pH and low conductivity water are not necessary for maintaining and breeding Blackbanded Sunfish; however, these conditions may be beneficial for selection and adaptation of young raised for release into such waters.

200 Poster Presentation

Influence of population density and environmental variables on electrofishing catchability in freshwater streams

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Estimating stream fish populations is important for management of both game and nongame species. Mark-recapture or removal estimators are commonly employed to estimate populations using electrofishing as a sampling technique. Electrofishing catchability may be used to estimate populations with single-pass electrofishing catch. However, fish catchability may vary with environmental conditions and population density. We examined relationships between fish density and stream environmental characteristics and electrofishing catchability. Backpack electrofishing was conducted October-November 2009 in blocked 50-m stream reaches located in the Neuse River Basin of the Piedmont physiographic region in North Carolina. We found no significant relationships explaining catchability with temperature, turbidity, and stream width. Significant catchability trends were evident for certain fish size classes with population density, conductivity, and mean stream velocity. Catchability was negatively related to population density for large size classes. Catchability was found to be positively related to conductivity for large size classes and negatively related for small size classes. Catchability was negatively related to mean stream velocity for large size classes. Additional data may further describe and elucidate these relationships. These findings add insight to explain trends in electrofishing catchability and bias that may improve fish

population estimates in freshwater streams, and may ultimately enhance population management.

201 Poster Presentation

Evaluating the potential of match:mismatch between zooplankton and larval fish production within a coastal river system

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Temporal and spatial overlap between larval fish and their prey is thought to have important effects on growth, survival, and recruitment success. The goal of this project was to investigate the ecological processes that influence recruitment of American shad (*Alosa sapidissima*) and river herring (alewife *A. pseudoharengus* and blueback herring *A. aestivalis*) to nursery habitats within Roanoke River and Albemarle Sound, North Carolina. Larval fish and zooplankton were collected weekly at 19-stations from March through June (2008 and 2009). Ichthyoplankton were collected at night using paired pushnets mounted on the bow of a 5.8-m boat. Zooplankton were collected by vertical haul from a depth of 3.8 ± 0.1 m (mean \pm S.E.). A total of 1,186 ichthyoplankton samples were collected during the two-year study. The volume of water sampled and sampling speeds were 123.7 ± 0.571 m³ and 1.00 ± 0.004 m/s, respectively. Alosines were collected at all stations; although distribution and density varied spatiotemporally. Collections peaked in April with abundances of 13.0 ± 3.0 larvae per 100 m³ for 2008 and 62.6 ± 12.8 larvae per 100 m³ for 2009. For both years, larval abundances were highest within the main stem of the lower Roanoke River (17.6 ± 2.4 larvae per 100 m³) as compared to the river delta (5.3 ± 0.7 larvae per 100 m³) and Albemarle Sound (2.9 ± 0.3 larvae per 100 m³). Zooplankton abundances were highly variable, ranging from 997 to 33,384 individuals per m³ with the highest abundances in Albemarle Sound and lowest abundances in Roanoke River. The results of this study will be used to determine whether match:mismatch regulation could exist in a riverine environment with low or patchy distributions of food.

202 Poster Presentation

Evaluation of a new preparation technique for flathead catfish pectoral spines

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Koch, J.D. Kansas Department of Wildlife and Parks

Schultz, R.D. Iowa Department of Natural Resources, Chariton Iowa

We evaluated the precision and processing times of two methods used to prepare flathead catfish *Pylodictus olivaris* pectoral spines. The first method utilized a bench-mounted sander to remove the portion of the articulating process traditionally cut using jeweler's or low-speed saws. Structures prepared with this method were compared to conventional

sections of the basal recess of the pectoral spine. The two methods produced structures with equally precise age estimates; however, exact agreement between structures prepared using the two methods was only 41%. When age estimates of the two methods did not agree, basal recess sections were generally assigned older ages than articulating processes. Preparation time was similar, although readers noted that more effort was needed to age and manipulate articulating process samples under the microscope. In addition, both readers agreed that basal sections were generally more readable than articulating processes. If sanding of articulating processes is used as a spine preparation method, caution should be used to avoid sanding too far into the central portion of the process which contains annuli from early years of life.

203 Poster Presentation

Evaluating the ecological function of mitigation structures in the Little Coal River
Miller*, E.M. and Petty, J.T. West Virginia University

Surface mining and mountaintop removal/valley fill (MTR/VF) coal mining in the Appalachians, in particular, raise numerous questions about hydrologic impacts. The effects of mining are a major problem locally, but also miles downstream. The coal industry uses off site mitigation as an attempt to compensate for what has been destroyed. The Little coal River in Kanawha and Lincoln County is being used as an off-site mitigation area. The river is affected mainly by sedimentation from miles upstream. The WVDEP has placed habitat enhancing structures along a portion of the Little Coal River and plan to place more in the fall/winter of this year. I will present my preliminary data quantifying the local physical and biological benefits of the habitat enhancing structures. Data such as, sediment type, depth, decomposition, cross sectional surveys, and longitudinal profile were conducted on existing structures and the locations of proposed structures. Also, I will be looking at the macroinvertebrates within different substrate types. Next year the same surveys will be conducted for final analysis. The goals of this research is to get a better understanding of the downstream affects of MTR/VF, evaluate the success of the structures, and to develop a long term management plan for the Little Coal River.

204 Poster Presentation

Effects of acid precipitation and acid mine drainage on leaf litter decomposition rates in central Appalachian streams

Stewart, M, F.*; Merovich, G.M.; Petty, J.T. West Virginia University

Acid precipitation and acid mine drainage have dramatically altered chemical conditions and biological assemblages in streams throughout the central Appalachians. Effects of acidification on functional stream processes such as nutrient uptake and organic matter decomposition, however, remain poorly understood. The objectives of this study were to: 1- quantify differences in organic matter decomposition among reference streams, streams impacted by acid precipitation, and streams impacted by acid mine drainage; and

2- determine if lowered decomposition rates are the result of reduced microbial activity or reduced shredder abundance or both. We quantified water chemistry, organic matter decomposition, microbial activity, and macroinvertebrate community structure in 15 headwater streams in the Allegheny Plateau ecoregion (5 circum-neutral reference, 5 AMD, and 5 acid precipitation). Water chemistry and invertebrate communities were sampled in spring and fall. OM decomposition was quantified from leaf packs deployed for a period of 120 days. Microbial activity was measured as microbial respiration, ergosterol content, and capillary DNA sequencing. As expected, acidification resulted in dramatically altered macroinvertebrate assemblages and reduced overall OM decomposition. Decomposition rates were lowest in AMD impacted streams, probably as a result of a complete loss of invertebrate production and coatings of metal precipitate on leaf packs. Estimates of fungal activity are incomplete. Our results provide additional information on the ecological losses associated with stream acidification in the central Appalachians and the potential benefits of large scale acid remediation programs in this region.

205 Poster Presentation

Telemetry-based survival estimates of juvenile spot in two North Carolina estuarine creeks

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Spot (*Leiostomus xanthurus*) is both economically and ecologically important in North Carolina estuaries. Despite its importance, relatively little is known about natural mortality, a key variable in stock assessments. We directly estimated natural mortality rates (M) of juvenile spot using a sonic telemetry approach. Prior to our field study, we conducted laboratory experiments to determine if a relatively large sonic telemetry tag [VEMCO V9-6L (2.9g in air)] had any adverse effects on age-1 spot. We compared growth, survival, and tag retention in age-1 spot between control and surgery groups. Over an 80-day experimental period, there were no mortalities and growth rates were not significantly different between control and surgery groups; thus, the relatively large tag had no obvious negative effects on growth or survival. In spring of 2009, we surgically implanted 48 age-1 spot with sonic transmitters in two North Carolina creeks. Spot were tracked for 80 days using a stationary VR2 receiver array supplemented by manual tracking. Using a Kaplan-Meier approach we estimated combined creek annual survival at 0.61, equivalent to an M of 0.50. Our observed natural mortality rate is considerably lower than predicted (M=1.0) for this size fish. This result will have implications for stock assessments and potentially management of this species.

206 Poster Presentation

A baseline survey of crayfish species in the Pigeon River, Tennessee

Dunn, C. B.*, L. Wilson, University of Tennessee.

The Pigeon River watershed has been the focus of a major recovery project to reintroduce fish and other aquatic species into the river where they were historically present. A paper mill at Pigeon River Mile 63.2 began operations in 1908 and discharged effluents which had a detrimental impact on the aquatic wildlife. Recent modifications to the mill have significantly improved effluent quality such that most aquatic organisms are recolonizing the river. The present study is a baseline survey of crayfish species in the Pigeon River and its tributaries; it also includes a comparison of crayfish abundance and diversity upstream and downstream of the paper mill. Crayfish are important to the aquatic ecosystem and food web because they serve as cutters that help to break down leaf litter and carrion, and are also a food source for predators. Crayfish were collected using modified minnow traps, snorkeling along turning rocks, and electroshocking; the method used was determined based on characteristics of the stream reach sampled, including water depth, flow, transparency, and type of substrate. A total of 342 crayfish specimens representing 7 species were collected during the 7-month study. Crayfish were found in 9 Pigeon River tributaries and also in the mainstem river upstream of the paper mill and below the hydroelectric facility at PRM 13.2. No crayfish were collected or found downstream of the paper mill to Waterville Lake at the hydroelectric facility.

207 Poster Presentation

Sturgeon bycatch in the Altamaha River shad fishery, Georgia

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Although the shortnose sturgeon (*Acipenser brevirostrum*) has been federally protected as an endangered species since 1967, incidental capture of shortnose sturgeon in commercial shad fisheries has been documented as a source of mortality that may limit recovery of some populations. As such, shortnose sturgeon bycatch assessments were recently identified as a priority by the National Marine Fisheries Service, as part of the iterative process of identifying and reducing threats to East Coast sturgeon. The objective of this study was to estimate total bycatch and mortality of shortnose sturgeon in the anchored gill net portion of the Altamaha River commercial shad fishery from 2007-09. Using a roving creel survey design, we conducted on-the-water counts of commercial shad nets to estimate fishing effort. Catch-per-unit effort was estimated from log books and direct observations of net retrievals by randomly selected commercial fishermen. During the 3 years of the study, total estimated bycatch of shortnose sturgeon was 65, 53, and 498 fish, respectively. Catch rates were highest during January and February of 2009 in upriver commercial nets near previously confirmed spawning locations in the river. Mortality of captured shortnose sturgeon was low in all three years (< 10%), although we did not

assess post-release survival. Future studies are needed to better assess population level effects and sub-lethal effects of incidental capture on shortnose sturgeon.

208 Poster Presentation

Population fluctuations in two southern Appalachian rainbow trout populations: magnitude and potential causes

Ewing*, T.D. and Borawa, J.C. North Carolina Wildlife Resources Commission

Salmonid populations exhibit inter-annual fluctuations in density. We quantified the population fluctuations and attempted to elucidate the factors that drive these population fluctuations using ten years of data from two unexploited rainbow trout (*Oncorhynchus mykiss*) populations in western North Carolina. Both rainbow trout populations exhibited high degrees of variability. Rainbow trout recruitment in both streams was highly and negatively correlated with the maximum instantaneous flow occurring during the incubation and emergence periods. These results indicate that fluctuations in rainbow trout density in these two streams are determined by density-independent factors. These results have implications for impact assessment and operation of hydroelectric facilities.

209 Poster Presentation

Creating river habitat maps for the Obed and Big South Fork River systems

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Bakaletz, S., National Park Service.

A GPS-based underwater videomapping system (UVMS) was used to map 45 river miles of the OBRI river system and 81 miles of the BISO river system. The UVMS is kayak-mounted with georeferenced under and above water cameras, depth sounder and underwater lasers. GIS maps of substrate, depth and river characteristic were developed. A technique to define optimum habitat locations for endangered fish and mussel species was implemented. GIS-based video tours of the above and below water river features at OBRI and BISO will be demonstrated.

210 Poster Presentation

Annual reproductive chronology of Puerto Rico native freshwater fish

Smith, W.E. and Kwak*, T.J. North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University

An understanding of the reproductive chronology of native freshwater fishes is important for the management of water, fisheries, and ecosystems. The spawning season is unknown for native freshwater fish in Puerto Rico, limiting resource management

planning. We determined the timing of spawning for the four most common native amphidromous fish species in Puerto Rico rivers, mountain mullet (*Agonostomus monticola*), bigmouth sleeper (*Gobiomorus dormitor*), river goby (*Awaous banana*), and sirajo goby (*Sicudium plumieri*). We investigated regional variation in spawning time by analyzing gonadosomatic indices for fish in three broadly distributed river basins. Little regional variation in the timing of spawning was evident among the basins that were sampled. Our results indicate an extended spawning season from late spring through fall for most species, but bigmouth sleeper appear to spawn during a briefer period that ends by September. Our results can be directly applied to guide dam operation and flow regulation to ensure adequate flows and connectivity to marine waters during reproductive seasons, which is critical for completion of the life cycle and persistence of these amphidromous fishes.

211 Poster Presentation

A new freshwater nongame aquaculture facility in North Carolina

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Briggs, K., Deaton, D., and Russ, T.R. Wildlife Resources Commission, Marion, NC

The North Carolina Wildlife Resources Commission (WRC) and North Carolina State University (NCSU) are working together to propagate native freshwater fish and mussel species in need of conservation throughout the state. Two WRC state hatchery facilities and a third at the NCSU College of Veterinary Medicine are currently supporting spawning, host fish infestation, and growout of a total of 13 species, including state and federally listed imperiled species such as the Carolina Heelsplitter (*Lasmigona decorata*) and the Tar River Spiny mussel (*Elliptio steinstansana*). Groundbreaking discoveries such as host species identification and successful propagation techniques for the latter two federally endangered species have been accomplished through this cooperative work. The new facility in Marion, NC is a 15 x 7.5 meter converted storage building with a flow-through system that pumps water from an onsite pond through multiple growout and holding tanks. Seven mussel species are held there presently, including juvenile Carolina Heelsplitters. Goals for animals produced from this increased culture capacity include endangered species recovery, toxicological studies, life history research, and river ecosystem restoration.

212 Poster Presentation

Microhabitat use, dispersal and predation risk of three reintroduced fishes in Abrams Creek, Great Smoky Mountains National Park

Billings, M.S., Miller*, J. E., and Cook, S.B. Tennessee Technological University

Smoky madtom (*Noturus baileyi*), yellowfin madtom (*Noturus flavipinnis*), and Citico darter (*Etheostoma sitikuense*), three federally-protected fishes, have been successfully reintroduced into Abrams Creek. However, little is known of their habitat use or dispersal. Objectives of this study are to (1) identify microhabitat use for each species, (2) determine predation risks, and (3) observe dispersal patterns of reintroduced fishes. During summer 2009, fifteen 200-m sites were surveyed in lower Abrams Creek within known distributions for the three species. Microhabitat characteristics were measured at locations where fish were observed and at randomly selected points without fish present. Logistic regression analysis will be conducted to identify variables correlated to species presence.

In fall 2009, 200 Citico darters, 100 smoky madtoms, and 100 yellowfin madtoms were marked with visual implant elastomer, and reintroduced at two locations. Release sites were surveyed to observe short-term dispersal and evidence of predation. Potential predator fish were collected after release, and stomach contents were analyzed to determine extent of predation. Additional surveys will be conducted to determine dispersal and predation upon naturalized fish. Results from this study will aid in future reintroduction efforts and assist in recovery for each species.

213 Poster Presentation

Updating size- and age-at-maturity schedules for southern flounder in North Carolina

Midway*, S.R., and Scharf, F.S. University of North Carolina-Wilmington

Southern flounder (*Paralichthys lethostigma*) are consistently among the most valuable finfish resources in North Carolina. However, elevated harvest rates during the past two decades have contributed to a “depleted” status for the stock. Although recently completed studies have improved our understanding of southern flounder biology and harvest patterns within the state, they have also generated evidence questioning the validity of the current estimates of size- and age-at-maturity being used to assess the stock. Accurate maturity schedules are essential to rebuild stock biomass and promote population recovery. We have collected southern flounder throughout the 2009 spawning season from multiple North Carolina locations to update the size- and age-at-maturity estimates. We are currently investigating macroscopic stages of gonadal tissue and identifying correlates with a suite of other morphological characteristics, such as length, weight, and the gonadosomatic index (GSI). We are also working to validate the present macroscopic staging methods currently used by state resource biologists by examining histological samples in an effort to improve the accuracy and precision of macroscopic techniques. Otolith microchemistry will also be analyzed to help describe patterns of habitat use as they relate to reproductive events.

214 Poster Presentation

Development of a protocol to monitor the concentration of *Edwardsiella ictaluri* bacteriophages in commercial catfish ponds

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One of the most important diseases of farm-raised channel catfish is enteric septicemia of catfish (ESC), which is caused by the gram-negative bacterium *Edwardsiella ictaluri*. Infected catfish tend to have red and white ulcers on their skin, a white spot on the fish head and the abdomen is swollen. Internal signs in the body cavity can include: swollen kidney, ascites or fluid in the abdomen, hemorrhage in the gut tissues, nodules in the liver and congested spleen. ESC is typically diagnosed by culture and isolation of the causative bacterium from the internal organs or brain tissue on tryptic soy agar (TSA) with 5 % sheep's blood or brain heart infusion (BHI) agar. An early diagnosis is possible if pond managers make daily observations on feeding response, behavior and mortality. Currently, only Romet 30®, Romet B® (Hoffmann-LaRoche, Inc.), Terramycin® (Pfizer, Inc.) and Aquaflor (Schering-Plough Veterinary Corporation) are approved by the U. S. Food and Drug Administration to treat food fish. Bacteriophages are viruses that infect bacteria. The purpose of this project is to develop a procedure to monitor the levels of bacteriophages that infect *E. ictaluri* in catfish ponds. This project is the first step toward using bacteriophages to treat ESC. Plaque assay, utilizing the agar overlay method, is the most useful method for enumerating phages. We have developed the protocols to collect samples and process catfish pond water samples to quantify *Edwardseilla ictaluri* bacteriophages. This is an ongoing project that will continue on throughout the winter and through next summer.

215 Poster Presentation

Capture Efficiency of Underwater Observation Methods for Three Imperiled Fishes Davis, J.G.*, Miller, J., Billings, S., Gibbs, K., and Cook, S.B. Department of Biology, Tennessee Technological University

Endangered species monitoring that employs snorkeling methods typically report qualitative data. Monitoring programs should also collect quantitative data by estimating population size using a standardized monitoring protocol. For accuracy, counts require correction by measuring capture efficiencies of sampling protocols. Underwater observational capture efficiencies were calculated for three small, benthic imperiled fishes, the Citico darter (*Etheostoma sitikuense*), the yellowfin madtom (*Noturus flavipinnis*), and the smoky madtom (*Noturus baileyi*). Capture efficiencies were estimated from multiple mark-recapture studies. Hatchery-raised fishes were tagged with visual implant elastomer tags, released at two sites within Abrams Creek in the Great Smoky Mountains National Park and recaptured by snorkeling release sites. Efficiencies were calculated by comparing number of released individuals to number of recaptures. Tag retention was 100 percent, and no post-tagging mortality was observed. Mean capture efficiency (<0.10) was low for all species. Low capture efficiencies could have resulted from predation upon released fish before recapture sampling, emigration of fish

from study sites, or difficulty in sampling some habitat within sites. Our results highlight challenges to estimating capture efficiencies for imperiled stream fishes, especially when using underwater observational methods. When applied to monitoring, population sizes may be larger than observed due to low capture efficiencies.

216 Poster Presentation

Aquatic species conservation in the Mobile River basin - The North River strategic habitat unit

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In 2004 the U.S. Fish and Wildlife Service designated 26 stream segments in the Mobile River Basin as critical habitats for 11 listed mussel species. Strategic Habitat Units (SHUs) were established for each critical habitat unit, encompassing the entire watershed of each. The North River SHU, located in the Black Warrior River system of west Alabama, is home to 5 federally listed species: *Hamiota perovalis*, *Medionidus acutissimus*, *Pleurobema furvum*, *Pleurobema perovatum*, and *Ptychobranthus greenii*. Mussel surveys performed by the Geological Survey of Alabama (GSA) and others in 1991 and 2008 documented a decline in species richness and abundance in the North River SHU. *Hamiota perovalis* and *P. furvum* were the only listed species encountered in either survey and significant declines in distribution and abundance were documented for each. Causes of these declines (likely changes in water and habitat quality) are under investigation by GSA. Stream habitat evaluation revealed sediment bedload to be a significant nonpoint source pollutant, particularly in the Clear Creek watershed, and analysis of land cover changes from 1974-2007 documented a 32% increase in impermeable surface areas, such as cultivated fields, urban development, and mining. Recent water quality investigations revealed high levels of *E. coli* and Specific Conductance values in the watershed. Nutrients flush through the watershed, eventually reaching Lake Tuscaloosa, once considered an oligotrophic lake, but now becoming eutrophic. Recovery of imperiled aquatic species and removal of North River from the 303(d) list will require cooperation among landowners and government and non-government agencies.

217 Poster Presentation

CADDIS: Water quality analysis of Coal Creek based upon macroinvertebrates

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The benthic macroinvertebrate survey is an effective method of determining water quality. However, a process of objectively analyzing the biological data in relation to the aquatic system is needed. The EPA Causal Analysis/Diagnosis Decision Information System (CADDIS) fills this need. The purpose of CADDIS is to identify stressors which

cause specific biological effects determined through data on benthic macroinvertebrates, fish, and algal populations in streams.

We have applied CADDIS stressor identification to analysis of Coal Creek, part of the Lower Clinch Watershed in Tennessee. Coal Creek is included in the 303(d) List of impaired streams in Tennessee, but the cause of biological impairment is listed as “unknown”. We have identified specific biological effects leading to impairment to be diminished EPT richness (Ephemeroptera, Plecoptera, Trichoptera), and increased incidence of nutrient tolerant macroinvertebrates. Candidate causes of these specific biological effects we have evaluated include low dissolved oxygen, ammonia toxicity, elevated dissolved solids, and elevated suspended solids. In CADDIS analysis, candidate causes are systematically tested. In this case, we are able to evaluate candidate causes through evidence of spatial/temporal co-occurrence, evidence of exposure, through stressor-response relationships, existence of causal pathway, evidence of temporal sequence, and results of ecological modeling (using AQUATOX). The purpose of this study is to use preexisting macroinvertebrate and chemical and physical data to determine the cause of impairment in Coal Creek using CADDIS stressor identification.

218 Poster Presentation

A community-based approach to setting conservation goals and objectives for multiple fish species on the Cumberland Plateau in Tennessee

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The Cumberland Mountains and Plateau Region in northern Tennessee are home to rich natural resources and biodiversity. Resource extraction and development continues to expose terrestrial and aquatic species to a variety of threats. We are currently developing two Habitat Conservation Plans to address the potential effects of forest management activities and commercial/residential development on more than 40 threatened species in the Cumberlands, including 11 fish species (eight percids, three cyprinids). We will provide an example of how agency biologists and university scientists recently formed a team to work with species experts, foresters, and land managers to generate biological goals, objectives, and conservation measures for the target species. In the forestry HCP, for example, we are using several fish species as “umbrella species” to protect key biotic communities in Cumberland Plateau aquatic habitats. We will describe the process and criteria we used to choose umbrella species and how the fish-species attributes are being used to generate conservation measures.

Cumberland Plateau, Habitat Conservation Plan

219 Poster Presentation Restoration of Non-Game Species

Qualitative evaluation of non-game fisheries restoration success following Carbonton Dam removal

Dickinson, T. E. and T.W. Savidge The Catena Group

The Carbonton dam removal project performed by Restoration Systems LLC is projected to result in the restoration of more than 10 river miles of the mainstem Deep River of the Cape Fear River Basin, as well as portions of tributaries. One of the goals of the restoration effort was to restore habitat for the federally Endangered Cape Fear shiner (*Notropis mekistocholas*), allowing populations that were isolated by the presence of the dam to be reconnected. In addition, restoration of these habitats is expected to benefit several species of rare mussels, and other riverine fish and mollusk species.

Restoration success criteria require documenting the diversity of aquatic fauna and characterizing habitat within the reservoir pool created by the dam, and then monitoring changes in faunal composition and habitat following the dam's removal. The Catena Group Inc. was retained to conduct the pre-dam removal and post-removal monitoring of aquatic species. Qualitative surveys were conducted at 18 sites to provide baseline species composition data at both impounded and reference sites for freshwater mussels and clams, aquatic snails, and freshwater fish in 2005.

Currently in the fourth year of monitoring, surveys have documented the development of at least 12 substantial riffle habitats in the former reservoir pool. The Cape Fear shiner was located at eight of the formerly impounded sites. Additionally, at least 10 of the 13 sampled sites appear to have fish faunal components approaching those of their respective reference sites and freshwater mussel and aquatic snail faunas have begun to transition from lentic-adapted to lotic-adapted species in the former impoundment.

220 Poster Presentation Restoration of Non-Game Species

Impacts of stream restoration on fish and macroinvertebrate communities in western North Carolina streams

Tobler*, P.D. and Gillette, D.P.

Stream restoration is becoming a popular means of offsetting anthropogenic effects on ecosystems. There have been many stream restoration projects done in Western North Carolina; however, there is little to no emphasis put on biological monitoring. Instead, the criteria for success of a project are based on stream morphology and riparian planting. Our research seeks to create an applicable way to assess stream health in mountain streams in North Carolina by collecting data on benthic macroinvertebrates and fish. We sampled five restoration sites, three of which were completed in 1998, and the other two in 2002. We sampled restored reaches as well as upstream degraded reaches. We also sampled two reaches in Pisgah National Forest that represent pristine sites. We will compare the benthic macroinvertebrates and fishes among the three site types in order to assess success of the restored reaches.

A survey prior to removal of a dam on the North Toe River, Mitchell County, NC

Daniel*, K.M. and Gillette, D.P.

Removing dams has become popular because many people believe that their removal will improve water quality, increase benthic invertebrate populations, and improve passage for fishes. However, the scientific data shows varied results as to how this affects fish and macroinvertebrates. To test this, a 3 meter dam in the Toe River was studied before it was removed by the U.S. Fish and Wildlife Service. Four sites were established on the river: one upstream reference, one upstream treatment, one downstream treatment and one downstream reference. The treatment sites were close to the dam while the reference sites were far from the dam. All of these sites were sampled twice before the dam's removal. The variables that were studied include: fish and invertebrate populations, dissolved oxygen, turbidity and temperature. The fish were collected using a backpack electrofisher while a surber samples was used on the invertebrates. The comparison between the four sites will be presented and discussed.
