South Atlantic Slope Rivers Session

Recent Finfish Studies in the Savannah Harbor

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The lower Savannah River has been severely perturbed for decades. Repeated dredging and channel deepening, and point/nonpoint source pollution have been identified as the primary disturbances. In order to determine the biological effects of planned deepening, information on the present community is required. A three-year study of adult shortnose sturgeon and the effectiveness of a previous sturgeon stock enhancement project is nearing conclusion. A study funded by the Georgia Ports Authority on the short-term movements and habitat utilization of juvenile shortnose sturgeon, in the lower Savannah River is currently in progress. Goals of this study are to establish baseline estimates of shortnose sturgeon abundance; abundance and age distribution of juveniles; the verification of recruitment; water quality conditions through monitoring changes in dissolved oxygen levels; and use of telemetry to determine behavior of adults and juveniles within potentially impacted areas. Concurrently, a faunal survey for the Environmental Protection Agency (EPA) was conducted during the summer of 1999 in the lower Savannah River. This biological monitoring study will help determine composition and relative abundance of species utilizing the area. Thirty-nine species of five fish were collected with trawls and gillnets, including four recreationally important species.

Savannah River Trout Stocking Evaluation

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Water temperature, dissolved oxygen, fish species assemblage, and creel data were collected from the 36 mile section of the Savannah River tailwater between Clarks Hill Dam and the New Savannah Bluff Lock and Dam for the purpose of evaluating stocking trout. A test stocking of 10,000 rainbow and 9,500 brown trout was made at the request of the Savannah River Trout Association. Five hundred of each species was tagged. Water temperature exceeded criteria previously used for classifying secondary trout streams in northwest Georgia at most sample locations. Dissolved oxygen concentrations in the uppermost portion of the study area were below minimum state water quality standards for trout water (5.0 mg/l) from July through September. Dissolved oxygen increased but water warmed rapidly as it flowed over the Augusta shoals, 16 miles downstream from Clarks Hill Dam. In the upper 15 miles of the study area, where temperatures remained marginally cool enough for trout survival, oxygen levels were severely depressed. Farther downstream, where oxygen levels were reasonably high, temperature became too high to expect significant trout survival. The study area supports a diverse assemblage of warmwater fish species, many of which could be expected to compete with or prey upon stocked trout. No trout tags were returned and only two trout were recorded in the creel survey. The studied reach of the Savannah River is unable to support trout due primarily to low dissolved oxygen and high temperature.

Back River Section 1135 Environmental Restoration Study, Savannah River GA/SC

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REFERENCE:
A Section 1135 Environmental Restoration Study has been authorized under the U.S. Army Corps of Engineers' Continuing Authorities Program (CAP) directing the U.S. Army Corps of Engineers to study and develop a restoration plan for Striped Bass in the Back River, Savannah River GA. Georgia Department of Natural Resources - Fisheries Division (GADNR) is the local sponsor for this study. Funds for the Feasibility Phase have been appropriated, a scope of work developed, and a feasibility level study is well underway. Working in partnership with Georgia DNR, University of Georgia - Fisheries Unit, US Fish & Wildlife Service, and Berry College the Feasibility Study will be completed by May 2001.

Estimation of Striped Bass Egg Drift Patterns in the Lower Savannah River using Gellan Gum Balls

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Since the 1970s, alterations of water flow patterns in the Lower Savannah River near Savannah, GA, have impacted the native striped bass population. Research has indicated a decrease in the number and a change in the distribution of striped bass eggs within the Little Back River (LBR), a historic spawning site. The goal of this project was to determine the movement pattern of simulated striped bass eggs in the LBR using Gellan Gum Balls, which have a mean density and diameter similar to striped bass eggs. Over the course of eight sampling days, approximately 2.5 million balls were released into the LBR and recoveries were made at four sites. In addition, a number of physical parameters were measured. Results show the drift rate was 67 % of the prevailing current and approximately 27 % of the balls left the LBR through Rifle Cut. Results also indicate that eggs settle to the river's bottom during slack tide and are then picked back up on a tidal flow. There also is evidence that striped bass eggs could be exposed to soft sediments and increased salinity if the adults are attempting to use historic spawning sites.

Overview of Harbor Deepening Impacts and Striped Bass Population Recovery in the Savannah River

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The impacts of Savannah Harbor deepening on the imperiled Savannah River population of striped bass is presently being studied by a multiple agency group titled the Stakeholders Evaluation Group. The Georgia Department of Natural Resources continues to stock 40,000 six to eight inch striped bass in the Savannah River each year. Additionally, annual population monitoring is conducted in the lower Savannah River estuary. The Savannah River does not yet contain a population of adult striped bass capable of sustaining the population at historic levels. Although, CPUE of striped bass greater than 9.0 kg in recent surveys has been higher on average (0.22 fish/hr) than it has been since 1986 (0.18 fish/hr), CPUE of fish greater than 9.0 kg remains lower than the period from 1978 to 1981 when it averaged 1.01 fish/hr. from January 21, 1998 to April 13, 1998.

Pollution History of the Savannah River Estuary

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As part of the NOAA National Status and Trends Program, 13 cores werecollected from the Savannah River Estuary for the production of historical pollutant profiles. These cores, representing intertidal salt marsh, subtidal channel and abandoned boat-slip environments, were dated using Pb-210 geochronologies and analyzed for the metals Al, Ag,As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Se, Sn, and Zn, as well as pesticides, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and butyltins. Four contaminant-time patterns were identified. For Ag, Cd, and Zn, profiles show an increase in concentration up to the present time, indicating an increasing loading from non-point-source pollution. Cr and DDT isomers exhibit distributions characterized by maxima that get progressively shallower (and younger) down-estuary, representing redistribution of contaminated material. In one core, Hg exhibits a sharp subsurface maxima, indicating a localized anthropogenic input that has since been controlled. Pb, PCBs and PAHs exhibit subsurface maxima representing peak inputs prior to the institution of environmental regulatory controls. In comparison to densely populated and industrialized regions, the concentrations of most anthropogenic chemicals found in cores from the Savannah Estuary are low. Decreases in these components over the past few decades suggest that pollution control regulations have been effective, even while industrial and population growth has occurred. However, levels of inorganic pollutants are approximately twice what they were in the previous century and what they are in contempory nearby settings.

A bioenergetics approach for determining the effect of increased striped bass population on its prey in the Chesapeake Bay

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The purpose of this study is to examine the predatory demand and prey species contributions to the production of striped bass in Chesapeake Bay. We collected adult striped bass to examine diet composition. Specimens were collected from April 1998 through December 1999. Angling was the primary sampling method however seining, gillnetting, and electroshocking were also used. Sand shrimp *(Crangon ssp)* made up over 74% of the numerical diet and 2% of the biomass. Bay anchovy (18%), blueback herring(1%) and menhaden (1%) were the next most numerous prey items found in the diet. Gizzard shad (28%) contributed the greatest proportion to the total diet biomass. Menhaden (20%) contributed the next highest percentage to the biomass followed by blueback herring (13%). Blue crab made up approximately 1% of the total diet biomass and frequency of occurrence. Consumption varied among cohorts and showed seasonal differences. Age 1 striped bass were closest to reaching their predatory demand throughout the sampling period. The consumption of blue crabs and blueback herring was low for all cohorts. The dominant prey species, relative to biomass, changed over the collection period. Blueback herring dominated in April, gizzard shad dominated the May-June and September-October collections, and Atlantic menhaden dominated the November-December collection. Bay anchovy occurred throughout the collection period and dominated the July-August collection. The diversity of striped bass diets may reflect the abundance and distribution of its prey items. It is speculated that current prey abundances may not be able to support the increased striped bass population. Changes in prey abundances may adversely affect the health of the striped bass.

Savannah River Striped Bass and 10 Years of Recovery Effort: Where Are We Now?

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The Savannah River striped bass population suffered a major population decline in the 1980's. Increased salinity in spawning and nursery grounds and accelerated transport of eggs and larvae to areas of toxic salinity have been identified as the causative agents. Mitigative efforts began in 1990 with the institution of a state-sponsored annual stocking program, removal of a tidal gate, and filling of a diversion canal (1991). The alterations seem to have been successful as salinity and flow patterns are similar to pre-disturbance levels, and traditional spawning may areas may now support spawning and recruitment. The stocking program also seems to have been successful; catch-per-unit-effort of adult striped bass has steadily increased over the past several years. However, patterns of distribution and abundance of striped bass eggs and larvae have not recovered to historic levels. Traditionally, spawning was centered in the Back River, within the confines of the Savannah National Wildlife Refuge; however, the majority of eggs now are found in the channelized, industry-heavy Front River. Egg abundances continue to be an order of magnitude lower than they were prior to habitat degradation, although results from 1999 indicate a promising trend.

Occurrence, Distribution, and Movement of Shortnose Sturgeon (<u>Acipenser</u> <u>brevirostrum</u>) in the Chesapeake Bay, Maryland

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During a reward program for Atlantic sturgeon (<u>Acipenser</u> <u>oxyrinchus</u>), 32 endangered shortnose sturgeon (<u>Acipenser</u> <u>brevirostrum</u>) were captured between January 1996 and September 1999 by commercial fishers from Maryland waters of the Chesapeake Bay. This is over twice the number of shortnose sturgeon reported from the Chesapeake Bay between 1876 and 1995; consequently, little information has been available on distributions and movement. We used fishery dependent data collected during the reward program to determine the distribution of shortnose sturgeon in the Chesapeake Bay. Additionally, sonically-tagged shortnose sturgeon in the Chesapeake Bay and Delaware River were tracked to examine patterns of movement and to determine if individuals swim through the Chesapeake and Delaware Canal. Shortnose sturgeon were primarily distributed within the upper Chesapeake Bay, and individuals displayed wandering, localized, and upstream

movements. The movements of one individual, tagged within the Chesapeake Bay and later relocated in the canal and Delaware River, indicated that individuals traverse the C&D canal. Consequently, shortnose sturgeon within the Chesapeake Bay may be transients from the Delaware River population.

A Fisheries Survey of the Tidal James River, Virginia

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The James River drains portions of four major physiographic provinces of Virginia. The tidal fresh- and brackish-water portions of the River and its tributaries support important fisheries for freshwater species such as largemouth bass (Micropterus salmoides) and catfish (Ictalurus spp.). In addition, numerous anadromous fish species inhabit the system, including striped bass (Morone saxatilis), American shad (Alosa sapidissima), hickory shad (Alosa mediocris), blueback herring (Alosa aestivalis), alewife (Alosa pseudoharengus) and Atlantic sturgeon (Acipenser oxyrhynchus). Despite the historical and/or present importance of these fisheries, no system-wide survey of fish assemblages had been conducted in these waters prior to 1998. During 1998 and 1999, 45 sites on 24 major tributaries and 27 sites in the tidal mainstem were sampled using electrofishing. At 53 of these sites, samples were taken during each of three seasons: spring, summer, and fall of 1998. The remaining 19 sites were sampled once during either 1998 or 1999. Catch rates for game species, in particular largemouth bass, typically were higher in tributaries than in the mainstem; probably due to differences in habitat quality and availability. Generally, growth rates of game fish were fast compared to those of other Atlantic slope tidal systems. Results related to species composition and relative abundance will be discussed and compared to other tidal systems of the Atlantic Slope.

A Fisheries Survey of the Tidal James River, Virginia

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Use of striped bass egg surrogates to assess gear detection thresholds and sampling efficiency in the Savannah River Estuary

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The abundance of striped bass eggs in the Savannah River Estuary (SRE) declined in the 1980's and has remained low. Historically, the majority of these eggs were collected in the Front (FR) and Back Rivers (BR), but data on gear detection thresholds and efficiency of egg collection methods are non-existent. Typically, evaluations of egg abundances in the SRE were limited to comparing relative changes in the spatial and temporal densities of eggs. Estimates of the actual number of eggs at large have been unobtainable. Gellan ® flavor beads are similar in shape, size, and specific gravity to striped bass eggs and behave similar to eggs floating in a river. In the spring of 1999, we used known amounts of these beads to determine the detection threshold and efficiency of our egg sampling gear. We recaptured 49 of the 5.1 million (~0.001%) beads released, which suggest that each egg in our sample represented about 100,000 eggs in the SRE. This net calibration technique will improve egg abundance assessment by allowing the number of eggs in the estuary to be estimated. Also, stronger inferences about the adequacy of striped bass egg production during a spawning season are now possible.

Use of ultrasonic imaging to assess the reproductive status of striped bass in the Savannah River Estuary

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The abundance of striped bass in the Savannah River Estuary (SRE) declined dramatically during the late 1980's. A state-sponsored stocking program has increased the number of adults in the SRE. Nonetheless, the abundance of eggs and larvae remain well below historic levels. Whether these low densities are related to the maturational status of the population or to a lack of suitable spawning conditions is unknown. The primary cause of the population decline has been remedied, and environmental conditions seem suitable for striped bass spawning; however, the current maturational status and fecundity of this population are unknown. During Spring 1999, we used ultrasonic imaging techniques to examine the ovaries of 31 striped bass from the SRE. We also took one 1-mm sample of ovarian tissue from each female and used the samples to enumerate eggs and estimate their maturational stage. We used these data to develop a model (V= -0.257 + 1.04 [log of mean ovary diameter] + 1.56 [log ovary total length]; R^2=0.96) that predicts ovary volume and will be used to predict total fecundity and maturational status of striped bass in the SRE. Assessing the maturational status of this population will improve environmental mitigation efforts and fisheries management decisions.

Effects of Catch and Release Stress on Striped Bass, *Morone saxatilis*, as a Function of Angling Time and Temperature

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The Atlantic striped bass (*Morone saxatilis*) has historically supported some of the most important recreational and commercial fisheries from Maine to North Carolina. Steady declines in the abundance of striped bass, particularly Chesapeake Bay stocks, began in the early 1970's, primarily due to excessive fishing mortality. This prompted legislative and administrative actions, which included restricted harvest regulations. Regulations increased the number of sub-legal fish but also increased catch and release fishing. Fish caught by commercial or recreational methods often struggle to the point of complete exhaustion. This can result in severe physiological disturbances and a significant percentage may die from the

ordeal. The objective of this study was to determine the effect of angling time on blood pH, HCO_3 -, pCO_2, TCO_2, pO_2, and O_2 saturation. A secondary objective was to monitor mortality of the fish angled at 0-0.5, 1, 2, 3, 4, and 5 min. The effect of temperature (26_C, 8_C) on the stress response and acute mortality was also examined. There was a significant effect ($P<0.05$) of angling time on acute mortality and the blood parameters, with the exception of oxygen values. As playing time increased, trends in blood parameters indicated both a respiratory and metabolic acidosis. Higher temperatures resulted in significantly lower blood pH, HCO_3 -, TCO_2, pO_2, and O_2 saturation values, indicating a more severe metabolic acidosis than fish caught in the winter. However, fish caught in the winter had a more severe respiratory acidosis.

Key words: respiratory acidosis, metabolic acidosis, striped bass, mortality, catch and release

Habitat Utilization by Striped Bass in J. Strom Thurmond Reservoir During the Summer

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A radio telemetry study is currently being conducted to record the summer and seasonal habitat use of adult striped bass *Morone saxatilis* in J. Strom Thurmond Reservoir, and to relate actual habitat use to available habitat. Thurmond Reservoir is a 28,329-ha impoundment on the Savannah River that undergoes thermal stratification. This will provide a baseline index of available and utilized striped bass habitat prior to modification of the thermal and dissolved oxygen levels greater than 2 mg/L is a potential limiting factor in populations of striped bass. During spring and early summer of 1999, a total of 34 adult striped bass (>3 kg) were surgically implanted with temperature-sensing radio transmitters. A systematic tracking survey of individual fish locations was conducted at least twice a month from May to October. At each location, GPS position, fish body, and a temperature and dissolved oxygen profile of the water column were. Striped bass made large scale (>10 km) movements in response to changes in temperature and oxygen. Preliminary results show adult striped bass distribution and movement in J. Strom Thurmond Reservoir is affected by changing temperature and dissolved oxygen levels during the summer.

History of the Robust Redhorse in the Savannah River

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The robust redhorse *(Moxostoma robustum*), a large riverine catostomid first described in 1869, remained largely unknown to science until the discovery of a population in the Oconee River, Georgia in 1991. Although historical records suggested that the species once inhabited medium to large rivers along the lower Atlantic slope, the existence of a population in the Savannah River was not clearly documented until 1997. Large scale sampling efforts have now yielded a total of 31 adult robust redhorse from the upper coastal plain and Augusta Shoals area of the Savannah River. Efforts to recover the robust redhorse were initiated in 1992 and the Robust Redhorse Conservation Committee was established in 1995 by a Memorandum of Understanding among a diverse group of stakeholders, including state and federal agencies, power companies, and conservation groups. These efforts were extended to the Savannah River Basin in 1995 when fingerlings were introduced into the upper Broad River Basin. Broodfish obtained from the Savannah River were first spawned in 1999. It is anticipated that the Savannah River will continue to be a focus of ongoing conservation efforts for the robust redhorse.

Effects of Watershed and Stream Habitat Conditions on Fish Communities in the Upper Roanoke River Watershed, Virginia

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Fish communities are impacted as urbanization continues to alter landscapes**.** Our study compared fish communities in watersheds of varying degrees of urbanization to determine ways to mitigate impacts and direct future development scenarios. We sampled 43 sites in the upper Roanoke River watershed, Virginia during late Spring and Summer of 1998 and 1999. Using one pass backpack electrofishing, we sampled 22 small, 13 medium, and 8 large stream sites with average stream widths from 2.8 to 11.0 m. Stream habitat variables included depth, substrate size, habitat type, and canopy closure while watershed land use conditions were categorized as forest, agriculture, and low or high intensity development. We compared fish community attributes using metrics for Index of Biotic Integrity (IBI) applications to stream habitat and watershed land use variables at three spatial scales. We collected 49 species from 9 families totaling 54,809 individuals.

Results indicate that fish community attributes depend on several factors; some, such as stream width and elevation, reflect natural differences in streams while others, such as watershed land use and sedimentation, are due to antropogenic effects. Our results identify factors influencing fish community attributes, suggest land development scenarios that may lessen stream impacts, and identify useful metrics for IBI applications.

Movement of Largemouth Bass in a Savannah River Tributary

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Movements of largemouth bass in Steel Creek, a Savannah River tributary, and between Steel Creek and the Savannah River were evaluated with radio telemetry. Thirty largemouth (>250 mm) bass were implanted with radio transmitters and released either at the headwater of Steel Creek, near the mouth of Steel Creek or in the Savannah River near Steel Creek in the spring of 1999. Fish locations were determined biweekly, and temperature, oxygen and discharge were monitored throughout the study. In addition to biweekly locations, a subset (10) of fish were located hourly for 24 hours once in summer and once in fall. Largemouth bass in Steel Creek have relatively small (<200 m) well defined home ranges. Individual home ranges tend to overlap within Steel Creek. Some large-scale (>1 km) movements were observed and were loosely correlated with discharge. Preliminary results suggest that movement of largemouth bass between Steel Creek and the Savannah River are limited during Summer and Fall.

Changes in the Fishery of the Altamaha River System after the Illegal Introduction of the Flathead Catfish

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The flathead catfish *pylodictis olivaris* has been introduced into several Atlantic coastal plain river systems. Many of these stockings have resulted in the creation of viable flathead catfish populations. The unauthorized introduction of this nonnative predator into the Altamaha River system in Georgia has negatively impacted native fish species. Flathead catfish were first introduced into the upper Ocmulgee River, one of the two main tributaries of the Altamaha River, during the 1970's. This unauthorized stocking established flathead catfish as one of the dominant fish species in the Altamaha River by the late 1980's. Prior to the introduction of the flathead catfish, redbreast sunfish *Lepomis auritus* were the dominant game fish species as measured by electrofishing catch rate and angler harvest. Decreases in redbreast sunfish and bullhead *Ameiurus* spp., population abundance were first noticed by anglers and later confirmed by the Georgia Department of Natural Resources Wildlife Resources Division. Reaction from anglers to this change in species abundance has been mixed. Some anglers enjoy catching flathead catfish while other anglers dislike flathead catfish and would like their number reduced. The Wildlife Resources Division is currently removing flathead catfish from a portion of the Altamaha River system to determine if the flathead catfish population can be reduced and to determine what impact this may have on the redbreast sunfish population.

Contributed Paper Session

Natural recruitment failure of walleye in Tennessee reservoirs

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Early Mortality Syndrome (EMS) has been linked to poor reproductive success of salmonids in the Great Lakes and New York Finger Lakes. Low thiamine concentrations in eggs are indicative of the syndrome, causing high fry mortality. In those northern lakes, salmonids feed on alewives Alosa pseudoharengus, which contain thiaminase, a thiamine-degrading enzyme, and thiamine concentrations in brood fish and eggs are lowest where alewives are the predominant prey item. Alewives are common in several Tennessee reservoirs, particularly those where walleyes Stizostedion vitreum suffer chronic recruitment problems. In spring of 1999, we initiated a study to determine if a relationship existed between poor reproductive success of walleyes and the presence of alewives. Preliminary analysis revealed that thiamine concentrations in walleye eggs were higher, not lower, in systems where alewives were most abundant. However, large differences in age and size structure among alewife populations may have accounted for these initial findings. Currently, the minimum concentration of thiamine needed for normal embryonic development of walleye eggs is unknown. To further investigate the relationship between thiamine concentrations in walleye eggs and hatching success, walleye eggs will be hatched and assayed for thiamine from three different reservoirs with varying densities of alewife in spring 2000.

Keywords: Walleye, early mortality syndrome, alewives, reproductive failure

Assessment of Brook Trout Restoration Efforts in Two Great Smoky MountainsNational Park Streams

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Brook trout (*Salvelinus fontinalis*) distribution in the Great Smoky Mountains National Park (GSMNP) has undergone a major decline during the past century. Once common from the low gradient streams near the Park boundary to the highest tributaries, brook trout are now primarily limited to small, high elevation streams, which provide marginal habitat. Loss of brook trout range has been attributed to habitat degradation and introductions of exotic rainbow trout (*Onchorhynchus mykiss*). Efforts are currently underway to restore brook trout populations in two streams within the GSMNP. Pilkey Creek is a small stream (mean width = 2.27 m) on the North Carolina side of the GSMNP, which has been devoid of trout since logging activity made the creek uninhabitable in the early 1900's. LeConte Creek (mean width = 3.10 m) flows from the Park into Gatlinburg and had an allopatric population of rainbow trout, which was removed in a series of four removal procedures during 1998 and 1999.

This study will examine the survival and reproduction of translocated brook trout. Brook trout (N=177) were translocated to a 1.5 km reach of Pilkey Creek during the fall of 1998. Surveys conducted during summer 1999 resulted in the recapture of 33% of the translocated fish. Capture of 88 young-of-the-year fish indicated a successful spawn during fall 1998. Three hundred fish were translocated to a 2.4 km reach of LeConte Creek during fall 1999. Surveys will be conducted during summer 2000 to assess survival and reproduction in LeConte Creek.

An Evaluation of the Trout Fishery on the Hiwassee River below Apalachia Dam

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The Tennessee Wildlife Resource Agency annually stocks the Hiwassee River below Apalachia Dam with about 100,000 catchable (> 200 mm, TL) rainbow trout Oncorhynchus mykiss and 18,000 catchable brown trout Salmo trutta. However, because of difficulty in sampling this tailwater, the performance and fate of these salmonids was unknown. The objectives of this study were to evaluate the growth, survival and condition of stocked trout. All of the brown trout and four cohorts of

rainbow trout were marked using uncoded wire microtags. Monthly samples were taken from February through December 1999 using a whitewater electrofishing raft and a jet powered electrofishing boat. With the exception of the January cohort, growth and survival were poor for all rainbow trout. Brown trout exhibited better growth and survival than rainbow trout; however, long term growth of brown trout on the Hiwassee River was slow, when compared to other Tennessee tailwaters. A survey to estimate the population size and standing crop of trout was conducted in February 1999 and will be repeated in January 2000. The 1999 survey revealed low numbers of holdover trout (59/ha) and biomass (20kg/ha) when compared to other tailwater systems.

A Comparison of Trap Nets and Otter Trawls for Sampling Black Crappie in Two Florida Lakes

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We compared a recreational shrimp Penaeus spp. trawl to trap nets for assessing black crappie Pomoxis nigromaculatus populations. Lakes Griffin and Monroe were sampled with both gears simultaneously during October-December 1997. Coefficients of variation (CV=SD/_*100) on mean catch-per-effort (CPE) values ranged from 105 to 161 for trap nets and from 62-96 for trawls. Both trawls and trap nets collected fish < 150 mm total length (TL), but trawls sampled significantly more adult fish (> 250 mm TL). Variable catches in trap nets would require more sampling effort (up to four times as much) to obtain precise estimates of mean CPE than trawl sampling. Trawl sampling was preferable to trap nets based on size of fish captured, precision of abundance estimates, cost of the gear, and required sampling effort to estimate mean CPE. However, trawl sampling may be impractical in water bodies with excessive submerged structures, debris, and submersed macrophytes. We are encouraged by the effectiveness of the trawl for assessing black crappie populations in lakes where it is possible to use a bottom-sampling trawl.

Largemouth Bass Annual Exploitation in Felsenthal National Wildlife Refuge, Arkansas as Determined by a Tag-Reward Study

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Currently, there is a concern with an apparent lack of largemouth bass (*Micropterus salmoides*) exceeding 51 cm or 2.27 kg in Felsenthal National Wildlife Refuge (FNWR) reservoir, a 15,000-acre impoundment in south central Arkansas. Refuge anglers have reported annual fish die-offs during the summer months. Analysis of electrofishing data revealed that RSD-P was at the low end of the acceptable range and tournament data indicated a recent decrease in the number of tournaments in which the largest bass was greater than 2.27 kg. During November 1997, a 1-year tag-reward study was initiated in FNWR reservoir to quantify exploitation. A total of 519 bass were captured, tagged with a small, PDB-type Hallprint dart tag, and released. The annual exploitation rate was adjusted for tagging mortality, tag loss, and non-reporting of tagged fish. Anglers harvested a high percentage (76%) of tagged largemouth bass. This was reflected in an annual exploitation rate (u) of 46%. Total annual mortality (A) is being calculated based on cove rotenone and electrofishing data in FNWR. Using this data, we will compare the criteria for implementing a regulation change based on the Arkansas Largemouth Bass Management Plan and MOCPOP.

Evaluation of a 254-mm Size Limit and Supplemental Stocking as Management Strategies for Tennessee Reservoir Crappie Fisheries

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Effects of a 254-mm size limit on crappie harvest in ten Tennessee reservoirs was simulated using a Beverton-Holt equilibrium yield model. Simulations indicated that size limit impacts varied across reservoirs and that potential yield benefits were not always realized with the restriction. At low levels of conditional natural mortality (CM = 30%) size limits positively impacted yield in all reservoir simulations; however, a 229-mm limit provided higher predicted yields than the current 254-mm limit in some scenarios. The effectiveness of size restrictions at CM = 40% was variable and generally increased with increases in exploitation. Size limits did not positively impact yield when CM was 50%. On average, crappies recruited to the 254-mm limit at age 3 and crappie growth was variable among systems. Relationships between crappie growth and species composition, annual mortality, and reservoir characteristics were analyzed. In fall 1997 and 1998 age-0 crappies were marked with oxytetracycline and stocked into four reservoirs. Marking efficacy ranged from 98 to 100%. Stocked crappies represented 90% of the age-1 crappies collected in rotenone samples from Normandy Reservoir in August 1998. Age-1 stocking contributions in 1999 will be presented for Woods, South Holston, and Normandy Reservoirs.

Key words: crappies, size-limit, stocking, oxytetracycline, growth

Evaluation of a 254-mm Size Limit and Supplemental Stocking as Management Strategies for Tennessee Reservoir Crappie Fisheries

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The Oklahoma statewide minimum harvest size for saugeye (*Stizostedion canadense x S. vitreum*) was established at $\geq$ 457 mm in 1993 (no prior size restriction). We investigated the regulation's effect on saugeye populations in eight Oklahoma reservoirs. Saugeye catch rates and length frequencies from gillnetting before and after the regulation indicated that two fisheries had benefited, but the number of $\geq$ 457 mm saugeye had not increased or had possibly decreased in six lakes. Four reservoirs were chosen as representative saugeye fisheries and further investigated to determine why abundance of large (> 457 mm) saugeye was not increasing. These reservoirs were electrofished (spring and fall) and lengths, weights, ages and stomach content of saugeye recorded. Fall gillnetting was also conducted and catch rates, relative weights, length - at - age and shad abundance calculated and compared. Relative weights and catch rates were unsatisfactory at lengths $\geq$ 432 mm in three of the four fisheries. Possible explanations were low forage abundance, competition and possibly emigration during heavy outflows. These factors combined with angler dissatisfaction and unneeded or ineffective crappie control by saugeye have led to a reduced length limit at three fisheries to increase angler harvest and satisfaction, reduce competition and possibly increase growth and relative weights of older fish.

Detecting Largemouth Bass Population Responses to a Minimum Length Limit: Effects of Variable Recruitment and Duration of Evaluation

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We used a simulation model to evaluate how population density, population biomass, total catch (fish harvested and released), yield, and proportional stock density (PSD) of largemouth bass Micropterus salmoides would differ in response to a single three-year or five-year length limit evaluation at various recruitment variabilities. Recruitment variation modeled (coefficient of variation, CV= SD/_ * 100% in recruits to age-1) ranged from 20-100%. Minimum length limits modeled were 305, 356, and 457-mm. Simulations revealed that largemouth bass populations would not exhibit detectable differences in any population parameter (all P > 0.1) unless recruitment variability was ≤40% for a 305-mm and ≤65% for a 356-mm length limit, respectively. Values of CV in recruits to age-1 for largemouth bass populations averaged 66% (range 11-189, N=13). A 457-mm length limit provided detectable differences in total biomass and PSD up to CV in recruits of 100%. Five-year evaluation periods yielded more detectable differences than three-year evaluations. Proportional Stock Density (PSD) was the variable most likely to change in response to the size limit. However, at recruitment variabilities > 90%, detectable differences did not occur unless the size limit was 457-mm. Fishery managers should consider effects of variable recruitment and duration of evaluation period when evaluating the success of a length limit.

Hatching periodicity, hatching distributions, and daily growth rates of age-0 white crappies in response to hydrology and zooplankton densities in Normandy Reservoir, Tennessee

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Age-0 white crappies Pomoxis annularis were collected from 1994 to 1998 in cove samples from Normandy Reservoir, a 1,307-ha flood control impoundment on the upper Duck River in south-central Tennessee. Crappies were collected in every year buts 1995. Age-0 crappies were measured and weighed; otoliths were removed and hatch dates and daily growth rates were determined for the aged fish. Crappies hatched as early as 10 April and as late as 3 June. Hatch date distributions and length frequencies were unimodal in all years. First hatch date and mean hatch date of white crappies were positively correlated to the first day the reservoir achieved full pool. Growth ranged from 0.32 to 0.83 mm/d. Growth did not appear to be affected by density of crappie larvae, but was weakly correlated with cladoceran and copepod densities. White crappies hatched earlier and grew slower than largemouth bass Micropterus salmoides and spotted bass M. punctulatus collected concurrently. Unlike largemouth bass, white crappies never experienced bimodal hatching distributions; earlier-hatched fish grew at slower rates than later-hatched fish in three of four years, likely due to warmer water temperatures experienced by later-hatched fish. Growth of age-0 white crappies appeared to be little affected by spring or summer water-level events, but may have been influenced by hatch date and zooplankton density.

Top Down Influences of Larval Shad on Zooplankton Abundance at Hugo Reservoir, Oklahoma

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The data presented are part of an evaluation of an experimental water level manipulation plan intended to increase recruitment of largemouth bass *Micropterus salmoides* **,** white crappie, *Pomoxis annularis*, and shad *Dorosoma* spp. The objective of this study was to determine if increased shad abundance had a negative effect on zooplankton abundance which, in turn, may influence survival of age-0 sport fish. Weekly trawl and zooplankton samples were collected from April through September, 1995-98. Crustacean zooplankton and copepod abundance was negatively correlated with shad abundance in 1995, 1997, and 1998. Copepod nauplii and cladocerans were negatively correlated with shad abundance in 1995 and 1997. Cyclopoid copepod, *Daphnia*, and rotifer abundances were not related to shad densities. A winter-kill of threadfin shad *D. Petenense* in 1995-96 decreased shad catches in the 1996 trawl samples by >10 fold. Zooplankton abundance in 1996 was

double the levels of the other years studied, exceeding 100/L throughout the sampling period. However, increased zooplankton abundance in 1996 did not improve survival of age-0 crappie and largemouth bass as measured in fall trap-net and electrofishing samples.

Isolating the Parentals of the late Summer Spawn of Threadfin Shad in Hugo Reservoir, Oklahoma

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The presence of larval threadfin shad (*Dorosoma petenense*) in summer trawl collections from Hugo Reservoir, Oklahoma in 1997 and 1998 established evidence of multiple spawning bouts. The first spawn occurred in the spring with an ensuring spawn following during late July and into August. Weekly gill net samples were collected from March through August 1999. It is hypothesized that age-1 and older shad spawn in the spring and that parentals of the summer spawn are the fish from the summer spawn of the previous year. Threadfin shad were grouped into 20-mm length classes, and ovaries and otoliths of 10 fish from each length class were removed and examined. A gonadal somatic index (GSI) was created for each length class to follow ovarian development over the course of the entire spawning period. GSI patterns showed a peak in ovary weights from late April through May in all length classes. A secondary increase in ovarian weight occurred during the second week of July in all length classes. Ova diameters are being measured to determine maturation rates by size and age over time.

Differential growth rates and mortality rates between gizzard shad and threadfin shad at Hugo Reservoir Oklahoma, 1997-1998

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Young -of-year shad (*Dorosoma* spp.) collections for Hugo Reservoir, Oklahoma in 1995 and 1996 suggested differential morality rates between gizzard shad (*D. cepedianum)* and threadfin shad (*D. petenense)* larvae and juveniles. The objectives of this study were to determine the instantaneous mortality rates and growth rates between weekly cohorts of gizzard shad and threadfin shad and to investigate relationships between mortality and growth to zooplankton abundance. Trawl samples from 1997 and 1998 were collected from Hugo Reservoir with paired 1-m^2 -towed nets starting in April and ending in September. Otoliths were removed from 15 shad of each species per 5-mm length group per sample. Daily growth rings were counted, hatch dates calculated and fish assigned to respective weekly cohorts. Catch rates (no./m^3) for each cohort were calculated from each sample. Twenty consecutive weekly cohorts of shad spp. were identified for 1997. The aging process of the 1998 data is ongoing and will be reported at the meeting. For both years, two separate spawns of threadfin shad were found; a spring spawn (April through June) and a late July through early August spawn. Mortality rate comparisons of the two threadfin shad spawns will be made. In 1997, age-0 gizzard shad dominated the samples through May and threadfin shad dominated the samples from June through September. Mortality and growth rates will be reported at the meeting.

Assessing Potential Instream Flow Impacts on the Fishes of Baron Fork Creek, Oklahoma

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We used the Instream Flow Incremental Methodology (IFIM) and Physical Habitat Simulation System (PHABSIM) to model habitat-discharge relationships with habitat-use guilds for the fish assemblages in Baron Fork Creek, Oklahoma. The objectives of this study were to model these relationships with both the smallmouth bass population and the entire fish assemblage. Mesohabitat typing indicated that mid-channel pools comprised the largest area of habitat types in our study site

(37.1%), followed by runs (23.1%), lateral pools (21.4%) riffles (16.3%), and backwater (7.0%). Microhabitat analysis of depth, velocity, substrate, and cover variables in all 5 habitat types was conducted and compared with habitat suitability criteria obtained at the site. We then identified microhabitat associations of all fish species collected at the site to identify habitat-use guilds. Our hypothesis is that riffle, nearshore run, and nearshore pool habitats will be most affected by reductions in flow. These reductions will likely negatively impact fishes in these habitats. PHABSIM modeling will be used to verify this hypothesis.

Keywords: IFIM; PHABSIM; fish habitat-use guilds; smallmouth bass

Survival, habitat use, and movement patterns of adult striped bass in Lake Blackshear, Georgia

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In 1995 and 1996, fingerling striped bass were stocked in Lake Blackshear, GA to develop a self-sustaining sport fishery. To assess the long-term fate of the stocked fish, 27 adult Gulf-strain striped bass (>5 kg) were fitted with radio transmitters and released in Lake Blackshear. These fish were monitored to determine their survival, habitat use, and movement patterns. Tagged fish were monitored from time of release until water temperatures cooled to 15EC in Fall 1999. Thirteen tagged fish died, and six of these transmitters were found or returned by anglers within two weeks of release. Ten of the remaining 14 fish were located in the lake for up to six months after being released, but were not found after June 24, 1999. In early June, the remaining four fish moved near two cool-water refuges in Lake Blackshear after water temperatures were >26EC. Three of these four fish remained alive until the beginning of August. Some mortality may be related to handling stress, but drought conditions and intermittent spring flows in several refuges also may have affected striped bass survival. These results suggest that cool-water habitat in Lake Blackshear is insufficient to sustain a population of adult (>5 kg) striped bass.

Response of anglers to a differential harvest regulation on three black bass species in an Oklahoma reservoir

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We used a two-stage probability roving creel survey in Skiatook Lake, Oklahoma to estimate angler catch, harvest, effort and knowledge about a differential black bass harvest regulation. The regulation, implemented in 1997 because of a large increase in the abundance of the spotted bass allows for the harvest of largemouth and smallmouth bass over 14 inches with a daily creel limit of 6 fish while the daily creel limit for spotted bass is 15 fish of any size. Fishing effort decreased slightly in 1998 compared to 1997 while catch and harvest rates remained similar between years. Fifty-five percent of the anglers were aware of the regulation change in 1997 and 1998. Significantly higher percentage of anglers could identify spotted bass by feeling for a tooth patch on their tongue and smallmouth bass by their external body coloration in 1998 compared to 1997. A significantly smaller percentage of anglers reported that they would increase their effort and harvest directed at spotted bass in 1998 compared to 1997 while anglers opinions of the regulation change and angler satisfaction levels remained between years. Data from the 1999 creel season are currently being analyzed. This regulation change has been ineffective to date.

Key words: creel survey, harvest, largemouth, smallmouth, spotted bass

Comparison of Prepositioned Area Electrofishers and Electric Seines for Sampling Stream Fish Communities

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Prepositioned area electrofishers (PAE's) and electric seines have been useful for sampling stream fishes; however, questions remain on the effectiveness of these gears in sampling stream fish communities. Our study compares these two gears in northeastern Oklahoma streams and estimates the benefits and costs of using each gear. We also estimate the minimum number of samples needed to adequately describe stream fish communities in our study streams for both gear types. Preliminary results indicate that electric seining may be more effective at sampling fish communities within specific habitats but PAE's may be better at estimating fish distributions within microhabitats.

Occurrence of Daily Growth Rings in Otoliths of Young-of-the-Year Flathead Catfish.

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The sagittal otoliths of young-of-the-year flathead catfish Pylodictis olivaris were examined for the presence of daily growth rings. Fifty-nine individuals measuring from 38 mm to 150 mm total length were collected during daylight hours using boat electrofishing. An otolith from each specimen was glued to a microscope slide and lightly sanded and polished until the rings became visible at 400X magnification. Plotting the radii of the otoliths against the fishes' total lengths revealed a linear relationship. We are currently engaged in two experiments to validate whether the rings are deposited daily. We are marking otoliths with oxytetracycline hydrochloride and aging known-age fish. If otoliths from young-of-the-year flathead catfish can be aged, they may provide important information for flathead catfish biology and management, such as age, growth hatching dates, and mortality.

Assessing the effects of feeding strategies on growth of hybrid bluegill

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The compensatory growth response has recently been shown to increase growth in hybrid bluegill (F1 male *Lepomis macrochirus* X female *L. cyanellus*). However commercial feeds were not used in these experiments. The current study evaluates growth rates of hybrid bluegill fed commercial diets (45% protein) on cycling no feed periods (2 or 4 days, D2 and D4 respectively), followed by ad libitum refeed periods. Refeeding continued as long as daily weight specific consumption of treatment fish was significantly higher than controls fed ad libitum daily. Absolute growth rates of controls and D2 treatments were significantly higher than that of D4 treatments. Gross growth efficiency of controls and D2 treatments was also higher than that of D4 treatments. These results contradict earlier studies and suggest that no feed / refeed cycles need further assessment as an aquaculture strategy.

Evaluation of Rainbow Trout Introduction in Northeastern Oklahoma Streams: A Conceptual Framework

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Recently, angling groups in Oklahoma have indicated interest in stocking rainbow trout *(Oncorhynchus mykiss)* into coolwater, spring fed streams of northeast Oklahoma. Possible negative impacts of trout stocking on native fish populations have prompted the Oklahoma Department of Wildlife Conservation (ODWC) to adopt a "risk free" position, denying all stocking permits pending evaluation of trout introduction in these stream ecosystems. Of particular interest are possible

impacts of trout introduction on smallmouth bass (*Micropterus dolomieu*) populations, which support an active recreational fishery in northeast Oklahoma. Trout may compete with smallmouth bass for food and habitat, and may prey on juvenile smallmouth bass. Effects of trout stocking on native non-game fishes, invertebrates, and trophic interactions are also unknown. Project design involves characterization of fish communities, mesohabitat, and fish (particularly smallmouth bass) microhabitat use and diet in two streams for one year prior to trout introduction. Beginning fall 2000, rainbow trout will be stocked into one of the streams to evaluate changes in resource use and community structure of native fishes in the presence of trout. This presentation explores the ecological concepts and fisheries issues raised by this project, and also outlines the steps that will be taken to address specific research objectives.

Effects of Highly Fluctuating Flows on Nest Success of Redbreast Sunfish in the Tallapoosa River, Alabama

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To quantify spawning success, 140 redbreast sunfish (*Lepomis auritus*) nests were observed from late May through June 1999, in the Tallapoosa River, Alabama, 22 km below R.L. Harris Dam, a peaking hydropower facility. Underwater observations using snorkeling techniques were made at least three times a week on redbreast sunfish nests to examine survival of early life history stages in relation to flow regime. Nests were subject to pulse flows from 6,000 cfs to greater than 10,000 cfs daily. Our data suggest that nest persistence is dependent upon developmental stage of eggs and larvae and position of the nest. Eggs and yolk sac larvae were more likely to survive high flow events than swim-up fry. In addition, nests located close to cover were less likely to be destroyed than nests positioned away from structure. Only eight nests of the 140 yielded swim-up fry during observation. Provision of stable flow periods would likely increase recruitment of centrarchids in this system.

Evaluation of the Effectiveness of Hoop Nets for Sampling Channel Catfish

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Current standardized sampling procedures in Oklahoma call for the use of gill nets to collect relative abundance and length frequency data on channel catfish *Ictalurus punctatus*. While gill nets are fairly effective for sampling channel catfish, the resulting data is highly variable. Furthermore, gill nets represent a lethal means for sampling channel catfish which can adversely effect channel catfish abundances. Hoop nets have been found to be an effective alternative method for sampling channel catfish, but little is known concerning seasonal effects on catch efficiency of hoop nets, especially in reservoirs. We sampled two Oklahoma reservoirs monthly from March through October 1999 using baited hoop nets. The resulting data were analyzed for monthly differences in catch rates, length-frequency distributions, and estimates of variability. Length-frequency distributions were similar for all months. During June, catch rates were highest for both reservoirs while variability estimates were lowest. Based on these results, June seems to be a favorable time for sampling channel catfish with hoop nets. The results of this study will be used to further evaluate the effectiveness of hoop nets by comparing them with gill nets.

Bus Route Creel Survey of the Duck River, Tennessee

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No information existed on the recreational fishery on the Duck River in south-central Tennessee, which has the largest stretch of unregulated river in the state. A bus route creel survey was conducted on a 240-km reach of the Duck River during April-October 1998. In order to define angler species preferences and measure effort, catch, harvest, and economic impact. Anglers caught 28 species and harvested 26 species. Black bass (Micropterus dolomieu, M. punctulatus, and M. salmoides) were the preferred species for 17% of the respondents and represented 19% of the total catch. However, black bass only represented 7% of the total harvest. Catfish (Ameiurus natalis, Ictalurus punctatus, and Pylodictis olivaris) were the target species for 17% of the respondents and represented 19% of the total catch and 29% of the total harvest. During preliminary surveys, a locally intense redhorse (Moxostoma anisurum, M. carinatum, and M. macrolepidotum) fishery during the pre-spawn and spawn period was observed. The reach of the Duck River surveyed was not a very popular fishing destination; pressure over the seven months was only 25,105 h. Monthly effort peaked in May with 7819 h of effort. Expenditures included variable and travel costs and totaled only $83,230.

Utilization of two river basins by common snook, *Centropomus undecimalis* in Tampa Bay, Florida

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The common snook, *Centropomus undecimalis*, is one of the most sought-after gamefish in the inshore waters of southern Florida. Snook are euryhaline and may be found in a wide variety of habitats, including rivers, estuaries, coastal beaches, and nearshore reefs. The objective of this study was to describe abundance, spatial and temporal distribution, and habitat preference of snook along shoreline habitats in two river basins in Tampa Bay, Florida. Stratified random (SRS) and fixed station sampling was conducted with a 21.3-m (3.1-mm mesh) center-bag seine in the Alafia and Little Manatee rivers between January 1989 and December 1998. Additional fixed station sampling was conducted with a 183-m (38-mm stretch mesh) haul seine in the Alafia River between December 1992 and August 1996 to collect larger sub-adult and adult snook (<200 mm SL). A total of 4,266 snook, ranging from 8 to 875 mm standard length, were collected in 2,956 seine collections. Snook catch per unit effort (CPUE) with the 21.3-m seine was higher in the Little Manatee River (Fixed: 2.99 fish/haul; SRS: 0.73 fish/haul) than in the Alafia River (Fixed: 0.70 fish/haul; SRS: 0.28 fish/haul). Snook length-frequencies differed between rivers. Although initial recruits (< 30 mm) were found in both rivers, fewer recruits and more sub-adult and adult snook (> 200 mm) were collected in the Alafia River than in the Little Manatee River. Snook were present in both rivers year-round, with peak abundance from August through December, coinciding with recruitment of YOY snook. Young-of-the-year snook (< 50 mm) were present during all months of the year in the Little Manatee River and during all months but May and June in the Alafia River, suggesting a protracted spawning period for snook in Tampa Bay. Most of the snook were collected from shorelines containing some type of overhanging vegetation (e.g., mangroves), which can provide both shade and protection.

Using Geographic Information Systems Technology to Model Relationships between Black Bass Abundance and Physicochemical Characteristics in an Oklahoma Reservoir

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We used geographic information systems (GIS) technology to examine relationships between largemouth bass, smallmouth bass, and spotted bass abundance and the physicochemical characteristics of Skiatook Lake, Oklahoma. A GIS was used to generate maps of the physicochemical environment through interpolation of sample data into GIS coverages for subsequent analysis. We then used stepwise multiple regression to examine which of the physicochemical factors affected the relative abundance of each species. Largemouth bass relative abundance was weakly related to decreasing shoreline slope model (R^2 = 0.06). Smallmouth bass relative abundance was positively related to secchi depth (R^2 = 0.35). Spotted bass relative

abundance was related to increasing shoreline slope and increasing water temperature ($R^2 = 0.27$). Although GIS technology enabled us to interpolate sample data to explore spatial relationships between black bass abundance and environmental characteristics in the reservoir, the low explanatory power of the regression models suggests considerable error in interpolated GIS coverages. We recommend that such error be quantified and reported when interpolating reservoir characteristics using GIS.

A Reciprocal Transplant Study for the Comparison of Two Genetic Strains of Largemouth Bass in South Carolina

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A statewide reciprocal transplant study was initiated to compare the performance of two strains of largemouth bass. South Carolina is located in the broad hybrid zone that exists between the ranges of the northern and Florida subspecies of largemouth bass. Allozyme surveys have shown South Carolina coastal largemouth bass populations possess 98% Florida alleles, while Piedmont populations possess as few as 36% Florida alleles. Thirty seven new or renovated farm ponds were stocked in 1994 and 1995 with fingerlings produced from either the coastal or Piedmont strain of largemouth bass. We characterized performance differences between the two strains by evaluating growth of original stocks at one and three years. We are also monitoring the change in allele frequencies over subsequent year classes. Selected water quality parameters were monitored to define productivity differences among ponds. Region (Coastal Plain or Piedmont), strain, and the interaction of region and strain were tested as predictors of growth rate for first year and third year growth. Differences between regions were significant (P=0.05) for growth at age-1 and at age-3, with fish stocked in the Coastal Plain growing faster. Differences due to strain and the region/strain interaction were not significant. Collection and genetic analysis of subsequent year classes are on going. A shift in allele frequencies over successive generations will provide direct evidence as to what genetic strains, if any, are selected for in each region.

Effects of Ingesting Red Imported Fire Ants on Fishes

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The red imported fire ant Solenopsis invicta has become established throughout the southeastern United States since being introduced to this country in the mid 1930's. It is considered a nuisance and has been implicated in numerous fish kills. We conducted a number of experiments to determine if ingesting fire ants has a negative impact on fishes. Small (36 $\pm$ 5.9 mm; 0.4 $\pm$ 0.27 g) and large (59 $\pm$ 7.5 mm; 1.7 $\pm$ 0.53 g) yellow fin shiners Notropis lutipinnis and rainbow trout Onchorhynchus mykiss (106 $\pm$ 12.3 mm; 11.9 $\pm$ 3.72 g) were twice fed fire ants ad libitum with a 3-d period between feedings. Large yellowfin shiners ingested fewer fire ants the second feeding than the first feeding. We recorded 4% mortality for both small and large test yellowfin shiners and 0% mortality for control fish. Rainbow trout also avoided ingesting fire ants after one exposure. No mortalities were recorded for test or control rainbow trout. To expose fish in a more natural manner, a large floating ball of fire ants was offered twice with a 5-d interval to tilapia Oreochromis niloticus maintained in flow-through raceways. Fish were allowed to eat fire ants for one hour, then twenty fish from each replicate (N=3) were removed, euthanized, and frozen. Presence of fire ants in the gasto-intestinal tract did not differ between feddings. No mortalities were recorded for test or control fish. Our laboratory is currently conducting similar eexperiments with blugill Lepomis macrochirus and green sunfish L. cyanellus.

Response of a Brown Bullhead Population to Flathead Catfish Introduction in a Small Virginia Impoundment

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Flathead catfish Pylodictis olivaris were stocked in 1990 and 1994 in a 31 ha Virginia impoundment to control stunted and undesirable fish populations including brown bullhead Ameiurus nebulosus. Changes to the fishery were monitored with creel surveys and gill nets. Brown bullhead harvest decreased from 2285 in 1992 to 25 in 1998. Average weight of

harvested brown bullheads increased (r^2=0.94; P<0.0001) as population numbers declined. Brown bullheads harvested in 1998 averaged 761g; whereas, those harvested before flathead catfish introduction rarely exceeded 150 g. Brown bullhead catch in gill nets followed a similar trend from 1993 through 1998, and average weight increased (r^2=0.86; P=0.02); whereas, catch declined significantly (r^2=0.73; P=0.03). Flathead catfish appeared to have effectively controlled brown bullheads in our study lake.

An assessment of water quality, crayfish and *Corbicula* of the Reedy River, South Carolina following a diesel oil spill

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On June 26, 1996 a subsurface pipeline ruptured and discharged approximately 957,600 gallons of #2 fuel oil (diesel) into the Reedy River, near Greenville, South Carolina. The spill affected 23 river miles. Approximately 94% (897,120 gallons) of the diesel fuel was recovered during cleanup operations. Subsequent to the spill, the responsible party and the State of South Carolina cooperatively developed a program to assess the impacts to and recovery of the biological community within the Reedy River. The assessment program included sampling of the water column, *Corbicula* and crayfish (additional sampling of fish and macroinvertebrate communities will be presented separately). Five sample sites, one upstream and four downstream of the oil spill, were sampled through October 1997. Water-column sampling included analysis of total petroleum hydrocarbons and diesel-range organic concentrations. Biological sampling included population assessments of *Corbicula* and crayfish, and concentrations of polycyclic aromatic hydrocarbons in tissues of these organisms. A detailed summary of the population and tissue sample results will be presented. These data suggest the biological community of the Reedy River is recovering from spill-related impacts.

Recovery of the Reedy Creek Fish Community following a Major Diesel Oil Spill

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In June of 1996, a pipeline broke and approximately one million gallons of diesel oil spilled into the Reedy River. A major fish kill occurred. The objective of this effort was to monitor the recovery of the fish community. Five sites, including one upstream from the spill, were sampled in July and October, 1996, October, 1997, and October 1998. Each site was sampled for three passes with a combination of backpack and barge-mounted electrofishers. In 1996, a severe impact was noted. By 1998, species richness had largely recovered to pre-spill conditions. Recovery was most rapid at sites located close to major tributaries or reservoirs.

A macroinvertebrate biological assessment of the Reedy River in South Carolina following a diesel oil spill from a subsurface pipeline

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On June 26, 1996 a subsurface pipeline ruptured and discharged approximately 22,800 barrels (957,600 gallons) of Fuel Oil #2 (diesel) into the Reedy River, near Greenville, South Carolina. Macroinvertebrate sampling was conducted by the South Carolina Department of Health and Environmental Control (SCDHEC) in July, 1996 and by a private consulting firm in October, 1996 and July 1997. Macroinvertebrates were sampled from five locations in the river. One sampling site was located upstream from the spill and served as a control, while four sampling sites were located below the spill site. In addition, historic data collected at one of the downstream sites in 1989 and 1992, were used as controls. The July, 1996 results indicated that the sites downstream of the spill were severely impacted relative to the upstream and historic controls.

No recovery was evident as far downstream as 20 km. By October, 1996 all stations below the break site had begun to recover and by July, 1997 all were comparable to the upstream and historic controls.

Conservation of the Freshwater Nongame Aquatic Fauna in the Southeast - Challenges for the New Millennium

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The Southeastern Fishes Council (SFC) recognizes an urgent need to provide up-to-date taxonomic, distributional, and conservation information on southern U.S. fishes. Research on taxonomy, distribution, and status of fishes is not usually readily available nor consulted and understood by the public, natural resource managers, or policy makers. The sheer number of native fishes, the rapidity of taxonomic discovery, the backlog of taxa awaiting formal description, and the growing numbers of jeopardized fishes exacerbate this communication lapse. To bridge the information gap, the Technical Advisory Committee of SFC reviewed the distribution and status of southern fishes over 16 states and 51 major drainage units. We documented 673 total units of fish diversity in southern fresh waters, including 545 freshwater species, 46 subspecies, and 56 undescribed taxa; 9 diadromous species; and 19 marine species. We assigned conservation ranks to all fishes and found about 26% of fish species and subspecies in southern waters are in need of conservation management. For freshwater and diadromous taxa, we considered 83 taxa (13%) as endangered or threatened and 86 other taxa (13%) as vulnerable. The results strongly indicate that conservation of southern fishes cannot be achieved one species at a time but will require management for biological integrity of our land and water resources.

Keywords: Diversity, Distribution, and Conservation Status of Freshwater Fishes of the Southern United States

Natural Biological Entities and their Surrogates: Prerequisites to Effective on Conservation Strategies for Biodiversity

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Biodiversity is the product of descent with modification. Descent is intrinsic to all organisms and all types of attributes are modified through a unique history. Patterns of descent reflect processes responsible for the origins and current existence of organisms-species-lineages. Phylogenetic systematics is the only method designed to recover these patterns, as well as reconstruct past evolutionary events of species, intraspecific entities, and their attributes. Species are fundamental in evolution; they are viewed as the nuclear elements of evolution. Thus, understanding species and their evolution is essential to understanding biological systems and their conservation. Only the Evolutionary Species Concept (ESC) is consistent with both the theoretical and empirical domains of evolutionary biology. The use of other concepts is inherently detrimental to our abilities to understand and conserve biodiversity. Furthermore, the rarity of many imperiled species or intraspecific entities often precludes any proactive conservation and recovery efforts. Knowledge of their phylogenetic relationships and assurance of their naturalness allows researchers to work with surrogate taxa (close relatives) to develop effective conservation and recovery strategies to be applied to imperiled taxa. Thus, only with input from systematics and the ESC can naturally occurring biodiversity have the opportunity to be recognized and conserved in perpetuity.

From Molecules to Management: Demystifying Genetics for Nongame Species

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The applications of molecular techniques to studies of nongame species are numerous in kind and scope. Advances in molecular biology have increased the ease at which these techniques are applied to the assessment of small or threatened populations. Information regarding the divergence or similarity of molecular markers in conjunction with available morphological, ecological, and behavioral information yields a more complete picture of organisms at either the population or species level. When other forms of information are not available, genetic data can identify management units or evolutionary significant units. Many molecular techniques are available to resolve the status of populations or assess higher-level taxonomy. Knowledge of the applicability and limits of these techniques is essential to a better understanding of the profuse amount of genetic information generated today. Coding genes, Variable Nucleotide Tandom Repeats (VNTRs), and introns are several types of units of analysis currently used to examine populations. The potential utility of these data to the implementation of management plans for endangered or threatened species will be illustrated using examples from the southeastern region.

Patterns of Imperilment of Southern Appalachian Fishes

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North America north of Mexico has the richest temperate fish fauna in the world. Most of the diversity-about 350 species or 44% of the North American ichthyofauna-occurs in the southeastern United States in the unglaciated highlands of southern Appalachia. Comprised of four physiographic provinces, southern Appalachia is a geologically and environmentally complex area that has and continues to be a major center of evolution in the North American fish Fauna.

The broad impact of southern economic and population growth on aquatic biodiversity is the basis for the Southeast being recognized as a global freshwater conservation hot spot. Imperilment of southeastern freshwater fishes is increasing and has been recently estimated to be as high as 25%. Imperilment in southern Appalachian fishes was examined by comparing the imperiled fraction of the fauna to the nonimperiled across the following attributes: Physiographic province, range size, macrohabitat, vertical orientation in water column, trophic guild, spawning guild, body size, longevity, and fecundity. The resultant matrix of ~350 species by 48 categorical variables was analyzed by running 10,000-iteration randomized sampling of the matrix to construct a statistical model unique to the data set. The data closely approximated a chi-square distribution.

Significant differences were detected between the imperiled and nonimperiled southern Appalachian fishes. In general, small, short lived, benthic-adapted fishes with low-to-moderate fecundity and small-to-moderate ranges were disproportionally imperiled. This pattern of imperilment suggests that degradation of benthic habitats in creeks and rivers is correlated with decline of benthic fishes.

Habitat and the conservation of riffle inhabiting fishes: population and assemblage responses to temporal and spatial habitat change.

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Habitat forms the template upon which the biological processes of organisms, populations, and communities occur, and spatial and temporal fragmentation affects the suitability of this template. We examined effects of habitat fragmentation on bayou darters and other riffle inhabiting fishes in Bayou Pierre, MS. We then evaluated simple predictions of metapopulation

and source-sink models, relative to bayou darter populations. Bayou Pierre is undergoing extensive erosion which has been moving upstream 124-750 m/year. This erosion has decreased sinuosity, increased channel width, eliminated certain downstream riffle habitats, and created new riffle habitats upstream. From 1986-1994, the riffle fish assemblage (15 most abundant species), was stable. Total fish densities and densities of bayou darters did not vary among years or between Bayou Pierre and Foster Creek (a major tributary), and there was not a significant interaction among years and water bodies. Density of riffle fishes did not vary among the different degrees of recent erosion, but showed a significant interaction effect with individual streams. Bayou darters may comprise a metapopulation with local populations inhabiting riffles separated by intervening pools. Larval drift of bayou darters allows for replenishment of downstream riffles from those upstream; however, characteristics of downstream adult populations were not consistent with predictions of source-sink models.

Native Fishes Below Dams: Working With What We Have

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A century of improvements for efficient barge travel and electricity production has transformed the physical and biological character of southeastern rivers. Remnants of native riverine communities now persist in headwaters and tributaries of impounded river systems and, importantly, in unimpounded river fragments flowing between an upstream dam and the next downstream reservoir. Our research in the eastern Mobile River basin has shown large differences in relative diversity and abundance of native fishes among regulated river fragments. For example, regulated segments of the Tallapoosa River support substantial populations of as much as 70% of the native non-anadromous fauna. In contrast, regulated segments of the Etowah River and lower Coosa River support a smaller fraction of their native fish faunas, at low abundances. Differences in integrity among regulated segments partly correspond to differences in dam operations, hydrologic regimes and instream habitat, especially with respect to short-term flow stability and availability of shallow-water riffle habitats. Applying adaptive management to these regulated segments, by integrating management with research designed to test hypothesized mechanisms of species survival, could enhance conservation of native fauna and improve our understanding of relations between river fishes and hydrologic regimes.

Academia, Management, and Policy: The Challenge of Pulling Our Oars in the Same Direction

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There are fundamental disconnects between the ecological information academia produces, the data needed by natural resource managers, and the information used to make environmental policy. This three-legged stool has always been crooked, weak, and generally non-functional. The reasons are many: academia is too narrow, fragmented, and overspecialized, and generally irrelevant to management; managers often do not have the time or expertise to pursue and understand the relevant scientific information produced; there are fundamental cultural differences among these groups with very different goals, motivations, and reward systems; and environmental policy is based on much more than scientific information (and often in complete disregard for that information even when it exists). Good scientific information often does not reach the managers or policy makers. Solutions include: changing the academic reward system to recognize influences on participatory problem solving; breaking down disciplinary walls in academia for more interdisciplinary thinking; more effective communication among managers, policy makers, and academics *before* studies are pursued; and changes in institutional cultures so that effective and timely problem solving--rather than satisfying bureaucratic objectives--is the goal. This will require personal commitments by courageous individuals to counter the accepted trends and thinking in the respective organizations, individuals who will serve as leaders and role models for institutional change.

Recovering Rare Fishes: An Update on Success in the Southeastern United States

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Efforts to recover rare southeastern fishes by translocation and reintroduction are increasingly successful. Translocated snail darter population are becoming more robust and the species is apparently invading additional streams. Abrams Creek, in the Great Smokey Mountains National Park now contains reintroduced populations of four federally listed fishes on the verge of becoming established, and self-sustaining. Techniques to propagate mussels have also been refined in the past few years. These successes have led to a serval recent proposals to attempt re-establishment of extirpated fish and mussel populations in the Tennessee River system in Alabama and Tennessee. Several species of several federally listed fishes are being captively produced for use in refining water quality standards. Theses tests document the sensitivity of some species, and might provide evidence to explain extirpation of historical populations. These data might also be useful in prioritization of candidate stream reaches for reintroductions. Watershed-level projects, which were relatively new in 1996, are now prevalent throughout the Southeast. Activities to reduce non-point source pollution are priorities to most of these associations. More coordination between agencies and groups attempting these projects is needed. Although environmental education is part of public education, the plight of southeastern aquatic animals is still largely unknown. It is especially important to target politicians, land managers, and developers.

Status of Ozark cavefish, cave crayfish, and other stygobionts in Arkansas

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We are currently studying the status of endangered stygobionts in Arkansas, principally Ozark cavefish, Amblyopsis rosae, and cave crayfish, Cambarus aculabrum, and the quality of their habitats. Additional objectives are to survey populations of other cavefish (Typhlichthyes subterraneus) and cave crayfish (e.g. C. zophonastes), and to find other, perhaps new, stygobionts in Arkansas. About 75-80% of the observable Ozark cavefish (ca. 166/220) occur in Cave Springs, Arkansas. This population has increased steadily since 1980 but the water quality has declined during this time. Similar habitat degradation is occurring at other locations. Less than 20 individuals of each of the cave crayfish species is known to exist, one from two caves and the other from a single cave. Stable isotope analyses indicate that Ozark cavefish and cave crayfish may depend on endangered gray bats (Myotis griscescens) for trophic support. Our studies portend undesirable outcomes for these interesting species.

Nongame Freshwater Fish Conservation in the Southeast

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The Southeast harbors one of the world's most diverse temperate aquatic faunas. Arkansas shares in this high biodiversity, but conservation efforts are limited. Arkansas is home to approximately 69 mussels, 215 fishes, and over 50 crayfishes. When Amendment 35 to the Arkansas Constitution created the Arkansas Game and Fish Commission in 1944, there was no distinction between game and nongame species. The difficulty in the past has been that the source of funding for agency activities was the sale of hunting and fishing licenses. Our responsibility was much broader than this, but additional funds were needed. Amendment 75 created a 1/8th cent Conservation Sales Tax, to be divided among natural resource agencies. My charge is to implement a nongame program in the Commission's Fisheries Division. The program must integrate with current programs and organizational structure, coordinate partner organizations and agencies, increase awareness and appreciation of aquatic resources among citizens, and provide adequate protection for aquatic species. The nongame responsibilities are in the Management Divisions, rather than in a separate division. This emphasizes an ecosystem approach, where biologists are responsible for all aquatic resources in their district. The danger lies in the tradition of consumptive use focus. The goals for the program are an aquatic biodiversity database, increased knowledge of imperiled species, manage

land for persistence of native aquatic fauna, increased appreciation of aquatic species, cooperation with other organizations, recovery of endangered species, identify imperiled species, sustainable commercial harvest, and an aquatic nuisance species response plan.

Conservation of Aquatic Biodiversity in Georgia

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The southeastern United States is widely recognized as the global center of temperate freshwater biodiversity. The number of fish, mussel, crayfish, and snail species in Georgia represents approximately 25 percent of the national total. As is common throughout the Southeast and the United States, many of these species are declining. Several factors contributing to these declines have been identified, including siltation, chemical pollution, and physical alteration of streams and rivers. One difficulty that many state agencies face when trying to combat these problems is lack of a consistent funding source. In 1997, the Georgia Department of Natural Resources began receiving monies from sales of a special wildlife license plate. These funds support projects aimed at conservation, education, and land acquisition. The top priority identified for use of this money was the Aquatic Fauna Conservation Initiative. As a result, the Georgia Department of Natural Resources, Wildlife Resources Division hired an aquatic biologist whose duties include conservation and management of imperiled aquatic species. These monies have also contributed to studies and conservation of the robust redhorse (*Moxostoma robustum*) and the recent acquisition of a State Natural Area along the Conasauga River. Other important projects needed to facilitate protection of nongame aquatic species in Georgia are distribution surveys, detailed life history studies, and instream flow studies.

Aquatic Resource Conservation Planning in Florida

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The Florida Fish and Wildlife Conservation Commission (FWC) began a project, four years ago, to comprehensively access the status of aquatic biodiversity throughout the state. The first phase, completed in 1998, was an assessment of watersheds containing rare and imperiled fish species. Fish collection records were obtained to determine the Florida distribution of the selected species. River reaches and their surrounding watersheds that contained rare or imperiled fish species were identified. Watersheds were ranked based upon the number and relative rarity of the species present. Water quality and upland land use were analyzed to determine potential threats to the identified watersheds and river reaches. Watersheds identified as threatened were targeted for potential restoration, water quality improvements, or additional surveys.

The current phase of the project involves assessing riverine and lake systems for all fish and mussel species. The Nature Conservancy's Aquatic Habitat Classification System is being tested in Florida systems. One step in the classification system involves the identification of ecological and ecoregional drainage units. Species habitat affinities are being developed for modeling purposes. Once the habitat characterization is complete, species potential will be predicted, compared with known occurrences, and aquatic conservation priorities can be established.

Evolution of Nongame Aquatic Conservation in North Carolina Since 1986

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Since 1986, North Carolina's nongame aquatic conservation staff has grown from 1 biologist to 6+ full-time biologists and technicians and additional seasonal help. We have moved from not knowing much about the distributions and health of most nongame taxa to a more refined understanding. Our knowledge of the fauna and associated habitats has helped the state focus millions of dollars toward conservation of key aquatic habitats throughout North Carolina during recent years.

A Facility for Captive Propagation and Restoration of Rare Southeastern Fishes

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Captive propagation is a component of many recovery plans intended to supplement existing or to restore extirpated populations of rare fishes. It can provide critical life history information for poorly studied fishes, as well as clues as to why particular species are vulnerable to extinction or extirpation. In addition, culturing rare fishes can provide laboratory test subjects to refine water quality standards in a watershed containing those fishes. Conservation Fisheries, Inc. Currently maintains captive populations of more than a dozen rare fishes including four darters, (*Etheostoma wapiti, E. Percnurum, E. Chienense*, and *Percina Aurolineata*); two madtoms (*Noturus baileyi* and *N. Flavipinnis*); four minnows (*Cyprinella monacha, C. Caerulea, Notropis cahabae*, and *N. Mekistocholas*); two pygmy sunfish, (*Elassoma alabamae* and *E. Boehlkei*); and theBarrens topminnow, (*Fundulus julisia*). Surrogate species have also been propagated to develop culture protocols for species that are currently not available because of their extreme rarity. These include: *Erimystax dissimilis* and *E. insignis* (for *E. cahni*); and *Percina copelandi* (for *P. aurora*). Captively produced individuals have been successfully reintroduced within their historic range, and others are planned. Also, CFI is partnering with other institutions to act as refugium for some species with only one or two known natural populations.

Assessing Nongame Fish Distributions On The Cherokee National Forest

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The USDA Forest Service manages habitats that maintain viable populations of all native plants, fish and wildlife species. Accomplishing this goal and presenting convincing evidence to the public, has been a challenging task in the aquatic environment. A complication to any population analysis is the devastating habitat alterations that occurred as the result of the denuding of the landscape prior to Forest Service management.

Consistent habitat definitions are needed to objectively evaluate fish distributions. Three habitat factors, gradient, order and elevation, have demonstrated significant reliability in defining fish distributions. These characteristics were developed for 768 stream reaches on the Forest. Fish species found within a given reach were assumed to occur throughout that reach. Each reach was linked to the fish collection database through ArcView®. By defining different themes, I was able to display the distribution for all 154 species of fish documented on the Forest; and generate a list of fish and habitat characteristics for each reach.

A clear picture of the fish distribution on this Forest is now available. Viability concerns are being evaluated for those species with limited numbers of populations and appropriate re-introduction sites are being proposed. Finally, realistic assessments of the impacts of Forest activities on the fish habitats and populations are being accomplished

Development of a predictive stream assessment model using the tolerances of Maryland freshwater fishes to physical habitat, chemistry and land use

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A model was developed that predicts the fish species expected to occur in a stream if there were no impacts to the stream. The model uses tolerance limits of fishes to nine parameters related to naturally occurring stream conditions, including width, depth, gradient, discharge, current velocity, watershed area, Dissolved Organic Carbon, drainage basin, and physiography, to make predictions. The model was applied to 905 stream sites throughout Maryland. Results indicate that most streams have many fewer fish species than they could have if it were not for human impacts. Only 118 of the 905 sites (13%) had all or most of the fish species that we would expect to find based on naturally occurring stream conditions. A low percent of expected species (<25%) was observed at 149 of 905 sites (16%). A low percent of expected species present was used to

indicate that a stream was impacted. Once a stream was identified as impacted, species tolerance ranges to 26 physical habitat, chemical, and land-use parameters were used to diagnose potential sources of impact. If a value for a parameter was not in the tolerance range for a species and the species was absent, but expected to occur, then the parameter was identified as a potential source of impact. The most prevalent sources of impacts responsible for the absence of fish species in Maryland streams where they were expected to occur based on this model were related to urbanization and large amounts of impervious land cover.

Distribution and abundance of fishes in tidal freshwater wetlands of the Cooper River, SC

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We are testing if the distribution and abundance of fishes differs among 3 different forms of aquatic macrophytes in abandoned ricefields. Water flow in the Cooper River was reduced in 1985 and concomitantly the cover of wetland emergent vegetation, both intertidal and subtidal, has increased whereas subtidal submergent cover has decreased. Based on preliminary data of fish abundance, we are using a stratified sampling design for the collection of small fishes among the 3 macrophyte forms in 2 wetlands. We collect fish using an aluminum drop trap (100 x 100 x 100 cm). During spring sampling, the average number of fish collected per square meter was 35.0 for subtidal emergents, 20.5 for intertidal emergents, and 16.3 for subtidal submergents. Summer samples exhibit a similar pattern. Numerically dominant members of the fish assemblage include species of the Poeciliidae, Heterandria formosa and Gambusia holbrooki, and the Fundulidae, Lucania parva and L. goodei. This is similar to other studies of southeastern wetlands. Two species collected from these wetlands for the first time are Poecilia latipinna and Fundulus confluentus If we find an association between vegetative cover patterns and fish distribution and abundance, such information can be incorporated into basin level management plans.

Strontium/Calcium Ratios in Robust Redhorse Otoliths

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The robust redhorse (*Moxostoma robustum*) is a rare catostomid fish that is currently found only in Georgia. Biologists surmise its historic range was the Atlantic slope from Georgia to North Carolina. Numerous, though not exhaustive, surveys in this range have collected several catostomid species though robust redhorse have yet to be collected above the Fall Line. The authors present some information on saline water use by catostomids that may indicate why current robust redhorse populations have not been found above the first impassable barrier.

Otolith microchemistry is an analytical technique that may answer the question of saltwater exposure by robust redhorse with material already 'on-hand'. The ratio of strontium to calcium (Sr/Ca) in fish otoliths has demonstrated exposure to saline waters for various fish species and was employed in this study. Preliminary analyses of Sr/Ca ratios in robust redhorse otoliths are presented with implications for future research.

Temporal and Spatial Characteristics of the Fish Assemblage in a Large Regulated River

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We sampled the French Broad River below Douglas Dam, Tennessee every other month at 14 sites distributed along the length of the 52 km tailwater. Eight sites were located in pool habitat, while the remainder were in run habitat. Fish were

collected by boat electrofishing in both habitats. Trammel nets were also drifted in the pools to collect fish inhabiting the midstream. Significant differences in species richness occurred temporally and spatially in runs ($P < 0.05$). Sites near the dam had low diversity and were dominated by large cyprinids and catastomids. Downstream sites were more diverse and supported a higher seasonal abundance of percids and ictalurids. Fish assemblages in pools also showed significant temporal variation ($P < 0.05$), but species richness was spatially similar. However, distributions of some species (e.g., Micropterus spp.) seemed limited to certain areas of the river. Throughout the study period, catch-per-unit-effort (CPUE) for largemouth bass *M. salmoides* was greatest at sites near the dam, while CPUE for spotted bass *M. punctulatus* and for smallmouth bass *M. dolomieui* was higher in downstream reaches.

Population Biology Of Madtoms; A Review And Generalized Model

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Madtoms (genus *Noturus*) are a cryptic group of dwarf catfishes, consequently they are overlooked by fisheries managers. Madtoms are often locally important bait fish and most species are threatened or endangered in parts of their distribution. We constructed a Leslie matrix model of a generalized madtom population from the literature and compared madtom life history information against the assumptions of age-structured models. Even for well studied species, critical management information was lacking for such models. Madtom populations meet model assumptions of closed populations. Species have initial sex ratios of 1:1 but females do not live as long as males (by 1 or 2 yrs). Most species mature at Age 2 and number of eggs per nest is unrelated to size of guardian males. Currently, no information exists on genetic structure of populations and there is little knowledge of temporal and spatial variation of parameters for species. Results from the model indicate that potential female reproductive capacity exceeds available environmental resources based on literature reports of age class survival and population densities. Our results are useful to managers interested in conservation or restoration of madtoms by suggesting controlling factors of madtom populations.

The Status of *Etheostoma osburni* (candy darter) in West Virginia

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Etheostoma osburni is endemic to the upper Kanawha River system of West Virginia and Virginia. It inhabits cool to warm waters of small streams to medium sized rivers in the Ridge and Valley Province of Virginia and West Virginia, and the Appalachian Plateau of West Virginia. Due to extirpations and/or low numbers at certain sites and a lack of recent data, conservation documents have listed this fish as a species of concern in both states and consequently, at the federal level. In 1991, a survey to determine the abundance of candy darters at historic locations in the Monongahela National Forest suggested that West Virginia's population was declining. In response to this limited survey and the federal designation, the West Virginia Division of Natural Resources initiated a survey in 1993 to evaluate the status of the candy darter throughout its entire range in the state. To date, approximately 40 of 50 historic candy darter sites (i.e., localities established prior to 1980) have been visited. This new information reveals that, although this species is probably declining or has been extirpated from certain waters within its West Virginia range, several excellent sites still exist. Reasons for population declines are presented, new threats are identified, and management strategies to enhance the population are discussed

Genetic and meristic variations between and within populations of *Etheostoma moorei* (Yellowcheek darter)

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The yellowcheek darter, *Etheostoma moorei*, is an endemic species found only in four headwater streams of the Little Red River, Arkansas. The purpose of the study was to determine the current population structure of Turkey, South and Middle forks. The individual streams have been isolated and largely inundated since 1962, when Greers Ferry Reservoir was created. Allozyme electrophoresis was used to determine genetic variation for 17 loci (n=86) and meristic variation was determined for six characters (n=80). The greatest divergence occurred between the Turkey Fork versus the Middle and South fork populations (Nei's unbiased genetic distance = 0.213 and 0.205, respectively). Dramatic population declines, due in part to severe drought, over the past two decades has not resulted as yet in loss of genetic diversity for populations compared to previous genetic studies (H= 0.063; P= 0.277). Meristic analysis showed less divergence than genetic analysis. ANOVA showed significant differences for three of the six meristic traits studied, whereas MANOVA showed no significant difference when the six traits were combined. The genetic distinctiveness of the Turkey Fork yellowcheek darter population warrants classification as an evolutionary significant unit and special management precautions are needed to enhance population recovery.

Status of Snail Darters (*Percina tanasi*) in the Lower French Broad River, Tennessee

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TVA has monitored federally threatened snail darters in the French Broad River below Douglas Dam since 1997, concurrent with modernization of the hydro turbines at the dam. This population resulted from snail darter transplants into the lower Holston River, 1978-79. In 1999, following replacement of two turbines and their subsequent operation, the snail darter population is healthy and may in fact be expanding. Adult snail darters were found at all three sites under study, spanning over 20 river miles. While the health of snail darters and improvements in the fish community in general are attributed to TVA's Reservoir Releases Improvement program, which provided minimum flows and reaerated discharges at Douglas Dam since 1993, the operation of the two new turbines has apparently had no negative effects. Challenges facing snail darters in the lower French Broad river include residential development, nonpoint source pollution, contamination from the Little Pigeon River, excessive aquatic macrophytes, sand dredging, and potentially, exotic fish species. A critical research need in conserving this population is determination of its early life history.

Biology and Management of Reef Fishes

Manmade Reefs As A Model In Marine Reserve Research

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Marine manmade reefs have been used over the past several decades in most coastal states to provide additional hard bottom habitat to enhance recreational and commercial fishing activities. While hard bottom habitats created through the intentional placement of manmade materials onto relatively flat, featureless soft marine bottom are not identical in every respect to hard bottom habitats typically found where geological features such as limestone ledges and outcroppings permit their establishment, there are many obvious similarities between the living reef communities that develop on each of these sites over time. "No-take" marine reserves are currently being considered as possible fishery management tools for use in the

southeastern United States, being potentially valuable in the management of many stocks within the snapper-grouper management complex. Essential areas of marine habitat that would be incorporated into such reserves would include sufficient quantities of naturally-occurring marine hard bottom. Although marine reserves have been in use in other parts of the world for a number of years with positive results, their acceptance and eventual use in the U.S. will be predicated by the ability to convince fisheries managers and reluctant key user groups of their utility and potential benefits in our own coastal waters. This paper describes efforts by the state of South Carolina to gain insight into the potential benefits offered by the existence of "no-take" hard bottom marine habitats through the use of specially designed manmade reefs as an experimental model. Preliminary results from data collection begun in 1999 will be presented.

Life history of the red grouper (*Epinephelus morio*) off the North and South Carolina Coast

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Red groupers were sampled from commercial catches off North Carolina between December, 1997 and December 1998. A total of 1851 specimens was obtained, ranging from 384 to 851 mm TL (mean=561 mm). Additional samples were obtained through fishery-independent sampling. Ages of 460 red groupers, estimated from sectioned sagittae, ranged from 2 to 18 years. Marginal increment analysis indicated that annulus formation occurred during the late summer and early fall. Observed length at age is described by the following von-Bertalanffy growth equation: TL (mm) = 863(1-exp (-0.1755(age (yrs)-2.252))).

Sex and maturity of 439 red groupers were assessed by histological analysis. Female red grouper (N=387) ranged from 371 to 793 mm TL. Males (N=16) ranged from 610 to 840 mm TL. Spawning females, recognized by the presence of vitellogenic oocytes and post-ovulatory follicles, were found between April and August. Red groupers are protogynous hermaphrodites, and transition (N=36) was observed in individuals between three and eighth years old.

Population genetic partitions and phylogeography of Atlantic reef zones: *Rypticus saponaceous* and *Epinephelus adscensionis* (Perciformes: Serranidae)

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The soapfish *Rypticus saponaceous* and rock hind *Epinephelus adscensionis* are serranid species associated with reef habitat throughout the tropical Atlantic Ocean. Populations of these nonmigratory fishes are separated by discontinuities (ocean expanses and soft bottom habitat) between the major Atlantic biogeographic provinces of Brazil, the Caribbean, and West Africa. We sequenced a segment of the mitochondrial cytochrome *b* gene from individuals collected in the northeast Caribbean, Brazil, Ascension Island (mid-Atlantic ridge) and Sao Tome (Gulf of Guinea). Fixed differences (reciprocal monophyly) distinguished soapfish in the East versus West Atlantic, and rock hind in the Caribbean versus elsewhere in the Atlantic. Other locations were distinguished by significant haplotype frequency shifts. Overall, a substantial portion of genetic diversity in these species is distributed across biogeographic zones, indicating that at least some management issues must be considered on this geographic scale.

Genetic studies of white grunt, *Haemulon plumieri*, indicate restricted gene flow and deep phylogeographic divergence between Caribbean, Trinidadian and Atlantic Coast populations

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White grunt, *Haemulon plumieri* were taken from North Carolina, South Carolina, Florida, the Yucatan peninsula, Belize, Puerto Rico, and Trinidad. Genetic variation was assessed in the ND-1 region of the mtDNA molecule and at microsatellite loci. Analysis of mtDNA variation found three highly distinctive lineages. A northern type was found from the Carolina's and Gulf of Mexico south to the Florida Key's. A southern form was found in the Florida Keys, Yucatan, Belize and Puerto Rico. A third haplotype was found exclusively in Trinidad. Analysis of DNA sequences indicate that the Caribbean and Carolinian forms are more closely related (2% divergence) to each other than either is to the Trinidad (7% divergence). These data are subject to at least two interpretations. First, the may indicate zoogeographic structuring in white grunt. If true, this indicates that genetic exchange is far more restricted than one might expect in a pelagically dispersed organism. Second, the magnitude of genetic differences were compatible with that found between closely related species and may that white grunt, as currently, recognized is actually three distinct species. Analysis of nuclear gene variation strongly supported the first hypothesis.

Analysis Of Mitochondrial Dna Sequence Variation And Ecological Distribution Of Six Color Morphologies Of The Serranid Fish *Hypoplectrus*

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Members of the genus *Hypoplectrus* are small, brightly colored coral reef fish commonly referred to as hamlets. The twelve color morphologies of this genus are structurally invariant rendering them indistinguishable save for color. These various color morphs have historically been regarded as either many different or one polychromatic species evidenced by morphology, protein polymorphism and/or behavioral characteristics. However, strong genetic evidence has previously been lacking. In this study, the genetic structure of six color morphs of *Hypoplectrus* in the British Virgin islands and Cayman islands has been investigated using nucleotide sequences of regions of the mitochondrial DNA molecule via the polymerase chain reaction. No variation was found among sequences of the 16s rRNA region from individuals of 'yellowbelly', 'yellowtail', 'shy', 'barred', or 'black' hamlets. Sequences from the 'butter' hamlet differed by only one base with sequences from the previous five color morphs. Data were also gathered on the ecological distribution of each color morph. Habitat separation may be a prezygotic reproductive isolating mechanism within the genus. The phylogenetic and systematic implications of these and other data will be discussed.

Red snapper reproduction revisited: spawning and fecundity in the northern Gulf of Mexico, 1998-1999

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Due to increased management concern by NMFS, we analyzed gonads and otoliths from red snapper (Lutjanidae*: Lutjanus campechanus*) landed in Texas, Louisiana, Mississippi, Alabama and west Florida during 1998-1999. Our main objective was to provide age-specific estimates of annual fecundity (from batch fecundity and frequency of spawning) for large red snapper landed west of Panama City, Florida, to south Texas. We previously provided estimates of fecundity from northwest Florida red snapper, and ongoing work by the NMFS Beaufort Laboratory Headboat sampling program is providing an increased size range and broader geographic representation. Red snapper were often selected non-randomly to provide the best possible sample numbers of large fish (500 to ~900 mm total length, TL). Sex ratio of 939 headboat-caught fish was 1:1. Spawning began in April-May and ended in September-October from Texas to Florida. The smallest ripe female was 279 mm TL. Batch fecundity (estimated from 60 ripe fish ranging from 359 to 901 mm TL) was 3.4 million for a 851 mm TL, 11 year-old

Louisiana fish. Spawning frequency estimates by age were about 50% greater for age 6-35 females than for age 3-5 females. Estimates of spawning frequency and annual fecundity are in progress.

Changes in life history patterns of vermilion snapper and red porgy in the Gulf of Mexico

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Recent studies of reef fish populations have shown that life history traits such as growth and reproduction have changed over time. These changes (e.g. lower mean lengths at age, changes in sex ratio, and decreased lengths and ages at maturity) have been associated with increasing fishing pressure. Vermilion snapper and red porgy are important components to the Gulf of Mexico (GOM) reef fish fishery. Fishing pressure for both species has increased from the late 1970s, and a recent stock assessment of GOM vermilion snapper has indicated that this stock is currently overfished. From October 1995 to September 1996, we had the opportunity to sample both species from the hook-and-line GOM commercial and recreational fisheries for life history analyses. We used sectioned otoliths to age the fish and used histologically prepared gonads to assess reproductive state. We found that mean length at age and estimated length and age of maturity were lower than estimates from studies conducted in the GOM in the early 1980s. The magnitude of differences observed in the GOM was similar to those reported for these species in the South Atlantic over the same time period. While these changes in life history patterns of GOM stocks may be a response to increased fishing pressure, other factors such as the use of different aging structures and differences in sampling locality between GOM studies could also account for the observed changes. Because fishing gear and fishing depth were similar between studies, these factors were considered less likely to explain differences in length at age and length and age of maturity.

Reproductive biology and ecology of red porgy, *Pagrus pagrus*, in the northeastern Gulf of Mexico

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The objective of this study is to determine why red porgy *Pagrus pagrus* may be highly sensitive to exploitation. In September 1999 the red porgy fishery in the U.S. South Atlantic Bight (SAB) was closed because of substantial declines in landings, a 99% decline in recruitment between 1973 and 1997, and a 97% drop in total spawning biomass. South Carolina biologists recently documented decreases in size at maturity and size at transition since the early 1970's. I am focusing on the reproductive traits and ecology of the lightly-fished northeastern Gulf of Mexico population, and will compare them with those of the severely overfished SAB population. The size distributions of 321 hook and line-caught males and 676 females were typical for a protogynous species; median sizes were 236 mm Fl for females and 267 mm for males, and only 17% of females were ≥275 mm, versus 40% of the males. Transitional fish (n=17) were collected during March-August, ranged from 200 to 287 mm, and made up 1-5 % of the fish sampled. The overall proportion of males was 0.32, but this value varied with size and depth - 0.03 below 201 mm FL, 0.21 at 201-250 mm, 0.45 at 251-300 mm, 0.59 at 301-350 mm, and 0.82 above 350 mm. The proportion was lowest in the shallowest sites - 0.18 in the 20 m zone - and ranged from 0.22 to 0.38 between 30 and 90 m. GSI data indicated peak spawning in January but some activity occurring from December through March.

Distribution, abundance and habitat utilization of adult and juvenile jewfish, *Epinephelus itajara*, in southwest Florida, USA

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Jewfish, *Epinephelus itajara*, are large, long-lived groupers that were severely overfished on their spawning aggregations and have, subsequently, been protected from all harvest in U.S. waters since 1990. The species is now a candidate for the US threatened/endangered species list. To assess the recovery of this species, we have been monitoring the density of adult spawning aggregations and the distribution and habitat requirements of juveniles. Our censuses on four aggregation sites show a precipitous decline in abundance in 1980's, followed by a gradual increase in abundance through 1998. The size structure of the aggregations suggest, however, that these adult fish are not new recruits to the population. In June 1997 we began tagging juveniles and quantifying significant features of their habitat in the Ten Thousand Islands area of southwest Florida. We have processed scales and dorsal fin rays for age determination in juveniles. Using acoustic tags, we have been able to monitor the movements of juvenile fish in the mangrove habitat and have found that they live among island undercuts and deep holes in tidal passes throughout the year. We are continuing to tag the juveniles, in order to estimate absolute abundance, survival, degree of site fidelity, and growth rates.

Good and bad years in the Gulf: tracking age-structure for gag grouper and red snapper

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As management interest and otolith sample availability for reef fish has increased during the decade, we looked back through archived otolith samples to construct and compare annual age frequencies for gag and red snapper since 1991. Samples were largely obtained from recreational "for hire" and commercial hook and line fishing sectors. These samples of over 7000 aged red snapper ranged from age-1 to 39 and 2500 gag grouper ranged from age-1 to 23. Although some annual sample sizes were relatively small (a few hundred fish), consistent trends were observed revealing patterns of gear selectivity and year-class strength. Gag in particular showed a series of strong year classes. The 1983, 1989, 1993 and 1994 cohorts reached ≥30% of an annual sample age structure and could be "tracked" across several years. Although red snapper are longer-lived, dominant year-classes were not as readily evident from the aged samples. An increased sampling effort in 1998 allowed a comparison of red snapper age structure by fishing gear. It was apparent that all hook and line fisheries for red snapper, whether commercial or recreational, were harvesting similar ages; predominantly age-3 and age-4. The age proportions of hook and line caught fish also appeared to be very low beyond age 8-9, dropping to less than 1% of the ages within each fishing sector. An inference from the archived data is that this pattern has persisted through the 1990s. However, long-line gear, representing a small component of the commercial fishery, was harvesting older individuals with fish reaching age 18 before the proportion of age was less than 1%.

Age and Growth of Yellowtail Snapper, *Ocyurus chrysurus*, collected from the South Eastern United States

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Current life history information is unavailable for yellowtail snapper, *Ocyurus chrysurus*, in southeastern US and Gulf of Mexico waters for development of a fishery management plan. This study was conducted to provide basic life history information on age, growth, sex ratio, and total mortality rates. From 1996-1999, over 2,000 otoliths were collected from

commercial and recreational fisheries by federal and state port agents for analysis. Marginal incremental analysis was used to validate annular rings. Preliminary results suggest that the major portion of fish harvested ranged in age from 1-3 years; to date, the oldest specimens were 7 years of age. Fish ranged in size from 217 to 742 mm TL, and 0.12 to 4.52 kg in weight.

Fish Assemblages on High Latitude Coral Reefs: A Work in Progress

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In an effort to promote reef fisheries management and conservation, NSUOC and NCRI has initiated a comprehensive baseline survey of the reef fish assemblages of Broward County, Florida. Using SCUBA, divers conducted quantitative surveys of the fishes associated with these high latitude reefs. Stationary visual surveys were conducted over 180 sites along 20 east-west transects spaced every quarter mile along the coast. These transects crossed each of the three reef lines that run parallel to the coast. The three reef lines are generally referred to, with increasing depth and distance from shore, as the first (4-8m depth), second (7-18m), and third reefs (+12m). On each transect, three sites on each reef line were surveyed. These sites included the east and west reef edges and a site in the center of the reef. Species richness, abundance and fish size (TL) ranges were analyzed and compared within each reef line and between transects. It appears there are differences in fish abundance as well as species richness between the three reef lines. The first reef generally has lower fish abundance and richness than the second or third reefs. However, these conclusions are preliminary and will be strengthened as more of the Broward reefs are surveyed.

A preliminary study of reef fish of Navassa Island

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A preliminary study of reef fish was conducted at Navassa Island during a 24-hr period beginning 9 September 1998. Navassa Island is a small island (5.2 square kilometers) located in the Caribbean Sea Windward Passage between Jamaica and Haiti. Conducting a reef fish study at Navassa Island (an uninhabited U.S. protectorate) was of particular importance since Navassa Island is believed to be one of the least exploited islands in the Greater Antilles. Navassa Island was designated a United States National Wildlife Refuge during April 1999. This designation mandates protection for terrestrial and marine fauna within 12-mile territorial waters. Reef fish (and associated habitats) were assessed with stationary underwater video cameras at 3 survey sites. Forty-nine reef fish identifications to lowest possible taxon representing 18 families were made from video footage.

The Distribution of *Enneanectes* (Blennioidei: Tripterygiidae) on Multiple Spatial Scales

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Patterns of community structure for coral reef fishes have provided insight into ecological relationships within and among taxa, but these patterns have not been widely tested on multiple spatial scales. To address this, I examined the tripterygiid genus *Enneanectes* at three distinct scales: 1) a regional scale incorporating 379 stations from Belize and Honduras, 2) Glover's Reef atoll serving as a local scale, and 3) a site-specific scale restricted to the patch reef habitat within the lagoon of Glover's Reef atoll. Patterns of species distribution were determined by examining taxon fidelity to habitats at each scale. Overall, species of *Enneanectes* exhibited a clumped distribution within discrete habitats at each spatial scale, suggesting that tripterygiid assemblage patterns are stable irrespective of scale. At the second spatial scale, shape differences among

populations of taxa within and among defined habitats were quantified using a Truss analysis. The quantification of shape proved useful and provided new characters by which species could be discerned taxonomically. Lastly, substrate preference and nearest neighbor interactions were recorded and quantified in the third spatial scale analysis. It is recommended that analyses of multiple spatial scales be incorporated in future studies to obtain a more reliable estimate of community dynamics.

Fishery-independent and fishery-dependent data: which should be used to manage the resource?

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As more pressure is placed on fished populations around the world, fishery managers are often requested to place increasingly severe restrictions on the exploitation of a given stock. In the United States, managers are required by the Magnuson-Stevens act to base their decisions on the "best available data." The most commonly available data in the southeastern United States are landings data from commercial fisheries, with some length-frequency information available, and sometimes with enough fish sampled to provide age-length keys. Recreational data are available for some species. Fishery-independent data, however, is available for many species from this region. Samples from commercial and recreational fisheries are often biased due to the selectivity of the commercial or recreational gear - whether from fishermen desiring to maximize their harvest in the face of a bag limit, size limits, etc. Fishery-independent data are usually collected without regard to size and may be more representative of a population. Various population parameters were compared between data sources for five species of reef-associated fish: red porgy, *Pagrus pagrus*; grey triggerfish, *Balistes capriscus*; vermilion snapper, *Rhomboplites aurorubens*; white grunt, *Haemulon plumieri*; and scamp, *Mycteroperca phenax*. Our data shows that estimates of yield per recruit, $F_{0.1}$, and F_{max} can vary tremendously depending on the data source used, with estimates based solely on fishery-dependent data often being higher than those derived from fishery-independent data.

Age, growth, and reproduction of scamp, *Mycteroperca phenax*,in the southwestern North Atlantic, 1979-1996

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Scamp (*Mycteroperca phenax*) is a protogynous grouper that may form spawning aggregations and is a popular commercial and recreational species in the southeastern Atlantic states. Landings of scamp have increased at a rate similar to gag, therefore we investigated scamp collected from the southeastern US between 1979 and 1997 to determine if any changes in life history parameters were apparent and to describe the reproductive biology of scamp using histological techniques. Scamp sampled from the commercial fishery were significantly older (median age 5 years, n=1,379) than scamp sampled by MARMAP (median age 4 years, n=657) and headboats (median age 4 years, n = 441). Although the median age of scamp from within each data source showed significant declines between the two time periods, no temporal trends were evident for length at age data, either within a data source or for all data combined. There was a sharp increase in the number of individuals undergoing sexual transition after the spawning season (mid May). The decline in the mean age and length of scamp due to the removal of larger, old individuals from the population may affect the population in ways that are not accounted for in the SPR.

Changes in life history patterns of vermilion snapper and red porgy in the Gulf of Mexico

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Recent studies of reef fish populations have shown that life history traits such as growth and reproduction have changed over time. These changes (e.g. lower mean lengths at age, changes in sex ratio, and decreased lengths and ages at maturity) have been associated with increasing fishing pressure. Vermilion snapper and red porgy are important components to the Gulf of Mexico (GOM) reef fish fishery. Fishing pressure for both species has increased from the late 1970s, and a recent stock

assessment of GOM vermilion snapper has indicated that this stock is currently overfished. From October 1995 to September 1996, we had the opportunity to sample both species from the hook-and-line GOM commercial and recreational fisheries for life history analyses. We used sectioned otoliths to age the fish and used histologically prepared gonads to assess reproductive state. We found that mean length at age and estimated length and age of maturity were lower than estimates from studies conducted in the GOM in the early 1980s. The magnitude of differences observed in the GOM was similar to those reported for these species in the South Atlantic over the same time period. While these changes in life history patterns of GOM stocks may be a response to increased fishing pressure, other factors such as the use of different aging structures and differences in sampling locality between GOM studies could also account for the observed changes. Because fishing gear and fishing depth were similar between studies, these factors were considered less likely to explain differences in length at age and length and age of maturity.

A Socio-Demographic Assessment Of Commercial Reef Fishermen In The South Atlantic

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Resource management and regulatory agencies have historically focused on the biological dimensions of fisheries management, often neglecting the directive of the Magnuson-Stevens Act to address important social dimensions as well. As fishermen and their families incur the impacts of regulations, responsible management practices require an understanding of the social and economic climate of the commercial fishing industry and should acknowledge the perceptions of the industry's professionals. Because there was a lack of up-to-date relevant social and cultural data, this project sought to provide selected socio-demographic data on commercial reef fishermen needed in supporting and evaluating management actions. The research was comprised of two components, qualitative and quantitative. Primary data were collected via focus groups, ethnographic interview, and a self-administered survey mailed to inactive and active commercial reef fishermen in the South Atlantic. This study identifies and documents socio-demographic characteristics, attitudes, and opinions of reef fishermen, and evaluates the social impacts of both current and proposed management options.

The effects of shelf-edge fishing on the demographics of the gag, *Mycteroperca microlepis*, population of the southeastern United States

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Demographic changes in the gag, *Mycteroperca microlepis*, population (size structure, size at maturity, and sex ratios) of the southeastern U.S. have occurred in concert with increased fishing pressure. Comparison of relative sex ratios over the last two decades derived from hook and line catches during aggregation (Dec–Mar), post aggregation (Apr-Jul) and pre aggregation (Aug-Nov) periods in comparable areas of the Gulf and Atlantic indicate significant declines in the proportion of males. An age- or strictly size-mediated sex change process in gag is not supported by the data, whereas a social component to sex change is. Because sex change in gag occurs in temporal proximity to the aggregation period, and because large gag

(> 900 mm TL) have also experienced a decline in the proportion of males, sex change probably depends on social information available only during aggregation. A mechanism is proposed for the observed decline in the relative proportion of males which involves disruption of the sex change process by aggregation fishing and subsequent loss of newly transformed males through fishing on shelf-edge reefs in post and pre aggregation periods. The relative benefits of marine reserves are discussed in light of the observed demographic changes.

Fish populations and habitat recovery in the *Oculina* Research Reserve (1995 to 1999) off Ft. Pierce, FL

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Our research in the 92 nm^2 Experimental *Oculina* Research Reserve (EORR) off Ft. Pierce, FL, USA since the 1994 closure to all bottom fishing has focussed on (1) side-scan sonar mapping and GIS database development, (2) sediment geology, (3) habitat mapping, (4) experimental *Oculina* habitat restoration, (5) effects of artificial reef structure, and (6) video and acoustic monitoring of fish populations. Maps of pinnacle structures and sediment geology have been produced in a GIS format, but mapping of intact *Oculina* habitat has not yet begun. Initial submersible surveys in 1995 and subsequent ROV surveys indicate extensive, apparently trawl-induced damage of *Oculina* habitat. *Oculina* transplant-settlement-growth experiments, begun in 1996 to evaluate the potential for habitat restoration indicate high transplant survival rates, but low natural recruitment rates. Habitat recovery will take on the order of 30 years. Comparison of reef fish populations observed on intact *Oculina* habitat in 1995 with observations made on the same habitat in 1980 indicate the apparent fishing-induced loss or diminution of grouper spawning aggregations and large fish in general. Although recovery of grouper and snapper populations has been hampered by observed poaching in the EORR in 1997, indirect observations suggest that poaching has diminished or stopped.

Larval Biology and Transport Scenarios for Lutjanids and Haemulids of Southwest Cuba and Southeast Florida

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Based on otolith increment transitions associated with settlement and increment counts of settlers collected in southern Florida and western Cuba, mean planktonic larval duration (PLD) estimates ranged from 31-42 d post-fertilization in six species of *Lutjanus* and *Ocyurus*, and from 13-20 d in six species of *Haemulon* and *Anisotremus*. Larval behaviors that foster

retention may influence transport more than PLDs. Snapper larvae occur offshore while grunt larvae are rare despite often being gregarious "settlers" on nearby benthic habitats. Available evidence suggests grunt larvae may associate with the middle or lower water column in a saltatory manner, characterized by near-bottom associations as early as the flexion-stage. Off southwest Cuba, an area of extensive reefs, many cyclonic and anticyclonic features have been identified during spawning seasons by satellite-tracked drifters. Gyres at several scales are also associated with the Dry Tortugas, the southwest FL shelf, and the Pourtales Platform. These have residence times exceeding known PLDs, suggesting that within-subsystem retention may be substantial. Based on PLDs and behavioral information, grunt populations may be less subject to advection than snappers. These and alternative hypotheses of taxa-specific variations in larval transport will be examined. The assumption of at least partial self-replenishment is becoming increasingly valid in several areas often assumed to primarily export spawning products.

Age, Growth and Reproductive Biology of the Black Sea Bass, *Centropristis striata*, from the southeastern United States

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Black sea bass, *Centropristis striata*, is a protogynous serranid that occurs along the Atlantic coast from Cape Cod, Massachusetts to Cape Canaveral, Florida. In the Gulf of Mexico, black sea bass are reported to be a separate subspecies. During 1978-1997, 85,075 black sea bass were sampled by the Marine Resources Monitoring Assessment and Prediction Program (MARMAP) at the South Carolina Department of Natural Resources (SCDNR). Black sea bass were caught from 27^{o} to 34^{o} and at depths ranging from 9 to 55 m. A total of 13,889 individuals were aged, and sex and maturity was determined for 24,143 individuals. Ten age groups were identified, however, 93% of the fish aged were between one to five years old. At 16-35 m, there was a significant difference in the size at age by latitude with a significantly smaller size at age occurring at higher latitudes. Males constituted 33.6%, females 56.8% and transitionals 9.6% of the black sea bass that were collected during 1978-1997. Females dominated size intervals < 200 mm SL and ages < 4. Female black sea bass became sexually mature at significantly smaller sizes and younger ages during 1985-1991 and 1992-1997 than during 1978-1982. Peak spawning of females was during March through May.

MARMAP Studies of Reef Fishes off the Southeastern United States 1983-2000

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The Marine Resources Monitoring Assessment and Prediction Program (MARMAP) has conducted a cooperative effort with the National Marine Fisheries Service at the South Carolina Department of Natural Resources since 1972. Initially, MARMAP surveyed ichthyoplankton and groundfish but since the early 1980's MARMAP has concentrated on monitoring the abundance of reef fishes with trapping gear and conducting life history studies on species of commercial and recreational importance. In 1996, MARMAP also began monitoring fishes associated with deep water reefs and in the tilefish grounds with longline. Routine sampling with standard trapping gear has documented significant declines in the catch per unit effort (CPUE) of species such as black sea bass, red porgy, and vermilion snapper suggesting that these species are overfished. However, CPUE of other species (i.e. gray triggerfish and white grunt) has increased. Similar trends have been observed for headboat catches. Life history studies conducted by MARMAP during the last few years also indicate that many reef species are probably overfished. For example, red porgy and vermilion snapper have shown significant declines in the size at age and size at maturity. There has been a decline in the percentage of males in several grouper species (gag, scamp, snowy grouper). Significant increases in the size at age of gag and snowy grouper have occurred. Recently completed life history studies on white grunt, bank sea bass, golden tilefish, black sea bass and scamp indicate that some of these species are also overfished. In the next two years, MARMAP will finish life history studies of red snapper, gray triggerfish, and blueline tilefish.

The Role of Public Aquaria in the Conservation of Fish Species: Examples from the South Carolina Aquarium

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Public aquaria and zoos are regarded as one of the most trusted sources of marine environmental information in the nation, second only to National Geographic and Jacques Coustea, according to a study funded by the Pew Memorial Trust last year. Conservation of fish species is often considered harder to achieve than conservation of other animal species. Captive breeding of rare populations of fish is often difficult and public awareness of the need for fish conservation is low. Reef fish species are not easily recognized and are often seen only on menus and in markets. Public aquaria have a role to play in solving some of these problems by pursuing captive breeding programs and educating large numbers of visitors each year. The South Carolina Aquarium, which will open in the spring of 2000, and similar facilities can present animals in their habitats along with high quality education programs designed to stress conservation topics. The South Carolina Aquarium has had some success raising awareness of Swordfish conservation on a local level and is designing specific efforts to educate our visitors about problems facing reef fish.

A Summary of MARMAP's Reef Fish Tagging Activities off the Southeastern United States

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Several reef fish species have demonstrated extensive migrations, distribution gaps, or unusual size gradients that require research to clarify stock identification and assess the impact of potential regulations. To address these questions, as well as to provide data for sound management of the resource, mark/recapture experiments are being used by the Marine Resources Monitoring, Assessment and Prediction Program (MARMAP) of the South Carolina Department of Natural Resources. During 1995-1998, a total of 16,642 reef fish including vermilion snapper, red porgy, white grunt, gray triggerfish, greater amberjack and gag grouper were captured in the South Atlantic Bight through deployment of chevron trap or hook and line gear over known live bottom locations. These fish were then tagged in the abdomen, shoulder, or both, and released alive. Tag recapture rates were 12% for greater amberjack, 9% for gag, 6% for black sea bass, 3% for gray triggerfish, 2% for vermilion snapper, 2% for white grunt, and 1% for red porgy. A total of 3,354 gag and 1,897 amberjack were tagged off NC, SC, GA, and FL. Recapture data indicate that gag and greater amberjack are capable of moving great distances. All gag that moved >100 NM (22%) were tagged off SC and recaptured off GA, northern FL, central FL, the FL Keys, western FL, and the FL middle grounds in the Gulf of Mexico. Most greater amberjack that moved >100 NM (29%) were tagged off SC and recaptured off GA, northern FL, central FL, southern FL, western FL, AL, northern Cuba, southern Cuba, and Cancun, Mexico.

Life History of the Gray Triggerfish from the Southeastern United States

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A life history study of gray triggerfish from the southeastern United States was conducted from 1992-1997 as part of the Marine Resources Monitoring Assessment and Prediction Program (MARMAP) of the South Carolina Department of Natural Resources. A total of 1,210 gray triggerfish were collected for use in age determination and reproductive analysis. Monthly samples were obtained from fishery-independent and commercial sources to allow for comparison between gear types. The first dorsal spine was sectioned (1 mm) for ageing. Marginal increment analysis verified the annual nature of increment formation, and determined that annuli were deposited in summer. Fish collected from the commercial fishery were significantly larger than fish from MARMAP samples for ages 1-4, regardless of sex. Males were significantly larger than females for both gear types. Reproductive biology was examined using histological techniques. Spawning condition in females was determined by the presence of post-ovulatory follicles (POF's), and spawning season was found to occur in

summer, with a peak in July. Gonadosomatic Index was calculated, and a peak in June and July corresponded with the presence of POF's. Males appear to be in spawning condition year round.

Spawning Season, Sexual Maturity, And Gonad Development Of White Grunt From The Gulf Coast Of Florida

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White grunt (*Haemulon plumieri*) is landed in recreational, head-boat, and commercial fisheries in Florida, primarily from the west coast. Spawning season, size and age at sexual maturity, and gonadosomatic indices were determined for white grunt along the Gulf Coast of Florida, from St. Petersburg Beach to Steinhatchee. Fish were aged using thin-sections of sagittal otoliths. In the southern portion of the study range (Crystal River to St. Petersburg Beach), white grunts (n=2,736) were sampled from the landed catch of the head-boat fishery. In the northern portion of the study (Crystal River to Steinhatchee), research and commercial landings (n=1,334) were used to obtain length, weight and reproductive condition of white grunts. Both female and male white grunt became sexually mature between 180 and 210 mm total length, and all were mature when >250 mm or 2-3 years of age. Grunts showed a peak in spawning activity in April-June, as evidenced by the presence of hydrated oocytes or milt, and maximum gonadosomatic indices.

Stock structure of red snapper in the northern Gulf of Mexico: Is their management as a single unit stock justified based on spatial and temporal patterns of genetic variation, otolith microchemistry, and growth rates?

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We are examining stock structure of red snapper, *Lutjanus campechanus*, in United States' waters of the Gulf of Mexico (Gulf) along three interdependent, but not mutually exclusive, lines of investigation. Lines of investigation include examining nuclear-encoded microsatellite DNA loci to determine if discrete subpopulations of red snapper occur in the northern Gulf; examining movement patterns and mixing rates of adult red snapper using otolith microchemical fingerprints of age-0 nursery habitats; and, examining growth and reproduction to determine if differences in population dynamics parameters exist east and west of the Mississippi River delta. In this our first year of sampling, we have collected otoliths, gonads, and tissues for genetic analysis from 2,000+ fish that were caught in the recreational fishery and landed in Alabama, Louisiana, and Texas. Additionally, age-0 red snapper from nursery areas around the northern Gulf will be collected aboard the National Marine Fisheries Service's Fall Groundfish Survey. Methods employed and preliminary results from each line of investigation will be discussed.

Do Stock Assessments Reflect Reality?

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Hurricanes Dennis and Floyd plus general procrastination have precluded a meaningful abstract. Presentation will center on the South Atlantic Fishery Management Council's decision to take emergency action and close the red porgy (Pagrus pagrus)

fishery. The stock assessment used to reach this management action and the Council's rationale to close the fishery will be discussed.

Attraction of age-0 red snapper, *Lutjanus campechanus*, to areas of reduced bycatch mortality

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In 1998, we built 30 4m^2 reefs of shell and 30 4m^2 reefs of shell/concrete blocks/bricks, at depths of 17 to 21 m, in the Gulf of Mexico, 14 to 25 km south of Dauphin Island, Alabama. There were 3 sites, 20 reefs each, placed at 20 m intervals and alternated from shell to block type. Total mean counts for all red snapper, *Lutjanus campechanus*, were significantly different between reef types, with 14 fish/block reef and 19 fish/shell reef ($P < 0.05$). Separated into age-0 and age-1 year classes, few age-0 red snapper were observed in July, while age-1 were common. In August, age-0 red snapper reached counts up to 113 fish/reef. There was a significant interaction effect with age-0 more abundant on shell reefs at site 1 (mean = 47 fish/reef), and age-1 significantly more abundant on block reefs at site 3 (mean = 13 fish/reef; $p < 0.05$). Due to a hurricane in September 1998, all 1998 reefs were destroyed. In 1999, we rebuilt all 60 reefs. Counts up to 216 age-0 red snapper were observed on individual reefs. It appears that these low profile (10 cm) oyster shell reefs can attract very high numbers of age-0 red snapper, suggesting that shell planting could attract age-0 red snapper away from areas of intensive trawl fishing, thus enhancing survival.

Ingress Of Postlarval Snappers (Principally *Lutjanus Griseus*) Into The Newport River Estuary, North Carolina

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An understanding of the process of estuarine ingress of larval fishes is important for understanding the variations in abundance of adults. Along the southeastern U.S. coast, summer-spawning, estuarine dependent species have not been as well studied as winter-spawning species. Ingressing postlarval snappers were sampled with a fixed neuston net from a bridge over a channel in the Newport River Estuary in 1993 and 1998. *Lutjanus griseus* was the most abundant species found, at densities as high as 11 per cubic meter. Other species collected include *L. analis, L. synagris,* and *L. apodus*. In both years, ingress of snappers occurred from July to October. A lunar pattern was found; snappers ingress primarily during new moon and secondarily during full moon. Interestingly, snappers which ingress into the estuary are rare as adults in offshore waters of North Carolina. Larvae may be transported to North Carolina estuaries from the south by Gulf Stream processes. Whether these fish survive to join adult populations is unclear. Age and growth studies are currently underway for *Lutjanus griseus*. A pilot study is also in progress to assess the ability of the juvenile snappers to survive egress in North Carolina.

Trophic Subsidies in the Twilight Zone: Food Web Structure of Outer Continental Shelf Reef Fishes

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Food web structure of reef fishes was examined along the Mississippi-Alabama outer continental shelf. Fish communities on high-profile topographic features are numerically dominated by roughtongue bass, *Pronotogramus martinicensis*, and red barbier *Hemanthias vivanus*. Stomach content analysis reveals those calanoid copepods, mollusk larvae and pelagic tunicates dominate the diet of both species, and these fishes in turn serve as prey for large reef predators. Seasonal shifts in the diet of planktivores were also evident. Fish eggs and fish larvae constitute a greater portion of stomach contents in Feb/March samples, and indicate trophic links to pelagic, soft-bottom, and possibly inshore primary production (via spawning aggregations of large, migrating species). Dietary shifts in large predatory species reveals that pelagic plankton and planktivorous reef fishes form the primary trophic pathways through the year for common fishes in the deep reef community.

Developments in Reservoir Habitat Enhancement

Abiotic Habitat Enhancements in U.S. Lakes and Reservoirs: A Survey of the Southern Division Reservoir Committee

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The Reservoir Committee of the Southern Division of the American Fisheries Society conducted a survey of state agencies to identify: (1) agency goals of habitat enhancements, (2) preferences for different habitat enhancement methods, and (3) efforts to assess fish-population responses to habitat enhancements. We received a total of 67 responses from 48 state agencies and Puerto Rico, of which 83% conducted abiotic habitat enhancements. We divided habitat structures into four general categories: cover, spawning, shoreline stabilization, and substrate structures. The majority of habitat structures were used to attract fish to improve angler catch and harvest (71%), but other objectives included improved recruitment of juvenile fish (39%), increased fish production via creation of spawning habitat (34%), and creation of adult habitat or sanctuary (30%). The most widely used habitat enhancement structures were brush piles due to low cost and availability of materials. Although most states utilized habitat enhancement structures, only 40% of respondents evaluated for fish-population responses. Evaluations usually comprised catch-per-effort of fish in structures but did not assess fish recruitment or survival responses to habitat enhancements. Information from this survey will be compiled into a Habitat Enhancement Manual for fishery managers and others interested in lake habitat enhancement.

Establishment of native aquatic plants for habitat enhancement: Why and How?

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There is much interest in establishment of native aquatic plants to improve fish habitat in unvegetated systems. Large reservoirs, in particular often lack aquatic plants, and these systems especially could benefit from littoral vegetation. Reservoirs are constructed to meet specific project objectives (flood protection, water supply, etc.) and their water levels are controlled accordingly. Unfortunately, reservoir operations are not often conducive to establishment and growth of aquatic

plants. The lack of aquatic plants in many man-made reservoirs, coupled with a predominance of exotic weedy species in many others, suggests to many that only weedy exotic species are capable of growing in these systems. Although the environmental conditions prevailing in many reservoirs may preclude natural establishment of native aquatic plants, it is often possible to artificially establish desirable vegetation. Methods to facilitate plant establishment are currently being developed and refined. Although these efforts are still at a rather crude level of experimentation, we are beginning to learn how to overcome many of the obstacles to plant establishment. The presentation will provide an overview of the important factors affecting plant establishment, considerations in attempting to establish vegetation, and methods that might be used to establish plants in reservoir systems.

Aquatic Plant Introduction Survey

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The Reservoir Committee of the Southern Division of the American Fisheries Society conducted a national survey of state and Federal agencies, power companies, universities, and others to determine the use of aquatic plant introductions in habitat management programs. Information concerning planting methods, species used, success, etc. will be compiled into an aquatic plant introduction handbook made available through the Southern Division of the American Fisheries Society on the Reservoir Committee web page. The survey and preliminary results to date will be presented.

Restoring Fish Habitat with Native Aquatic Plants in Arcadia Reservoir, Oklahoma

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Aquatic vegetation was introduced into Arcadia Reservoir, Oklahoma in 1997 and 1998 to restore fish habitat. Twenty-two species of plants and several herbivore exclosures were evaluated. Obstacles included common carp, red-ear turtles and terrestrial herbivores which prevented plant expansion and beavers, muskrats and floating debris which damaged exclosures. Indoor production of plant propagules was unsuccessful due to inadequacies in light, temperature, and substrate. Fluctuating reservoir water levels caused problems in 1997 and a drought in 1998 exposed 90% of the vegetated plots. Recovery by several species provides hope that these techniques will, in time, prove successful in establishing mixed native plant communities and enhance recruitment of sport fish.

Establishment of Native Vegetation in El Dorado Lake, Kansas

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El Dorado Lake, located in south central Kansas, is a moderately fluctuating Corps of Engineers' flood control reservoir. The Tulsa District and Kansas Department of Wildlife and Parks initiated a Section 1135 ecosystem restoration project designed to restore spawning and nursery habitat for fish by establishment of aquatic vegetation in the lake. Twenty species of submersed, floating-leaved and emergent plants were tested in the lake over a three-year period, with many of these established in founder colonies. Within protective exclosures, most plant species grew well and spread quickly. Unprotected plants did poorly. Spread from protected areas appeared to be limited by grazers, primarily common carp.

Evaluation of Methods for Establishing Native Aquatic Vegetation in Seven Texas Reservoirs

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Because many Texas reservoirs are either sparsely vegetated or contain an overabundance of non-native species such as hydrilla (*Hydrilla verticillata*), the Texas Parks and Wildlife Department, Inland Fisheries Division began a new initiative to develop procedures for establishing diverse native aquatic plant communities. The objective of the first phase of the initiative was to determine survival of introduced native aquatic vegetation planted in different exclosure types (to protect against herbivory) in 7 reservoirs representing a variety of ecological conditions. One-year survival for plants protected by two levels of exclosures (small-scale exclosures within cove or shoreline fences) was 15% for submersed species, 48% for floating-leaved species and 56% for emergent species. Survival was considerably lower without protection from herbivory: 1% for submersed species, 14% for floating-leaved species, and 36% for emergent species.

Key words: aquatic plants, aquatic vegetation, native vegetation, habitat, herbivory.

An Integrated Approach to Managing Aquatic Plants at Lake Jacksonville, Texas

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We developed an integrated management plan to control 48 ha of hydrilla *(Hydrilla verticillata)* on Lake Jacksonville, Texas (a 547 ha municipal water-supply reservoir). Our objective was to control a problematic, invasive, exotic plant while increasing coverage and community diversity of native plants for fish habitat. Our plan was to reduce hydrilla biomass with aquatic herbicide, stock a minimal number of grass carp *(Ctenopharyngodon idella)* to control re-sprouting, and introduce a diverse native plant community. Hydrilla was treated with Aquathol K ™ in spring 1997 and 1998 followed by stocking 100 grass carp each year. Following each treatment, native plants representing floating-leafed, emergent, and submersed growth forms were planted in protective cages (to limit herbivory). In fall 1998 hydrilla was found only in cages where native plant survival was low. Herbivores appeared to be selectively removing hydrilla from the plant community outside of the cages where it had been observed in summer. Despite drought and low water conditions in 1998, many of the native plant species survived through fall 1999 and are expanding beyond the protective cages. These preliminary results indicate that an integrated approach has the potential to control hydrilla while promoting diversity of the native plant community.

Key words: hydrilla control, plant introduction, fish habitat, grass carp, macrophytes.

Materials and Techniques for Live Staking Plants onto Reservoir Shorelines

Julie Mitchell and Larry Dyck, Clemson University, Clemson, S.C.

Much of the shorelines of our South Caroline Piedmont reservoirs are exposed to high levels of wave energy, resulting in heavily eroded banks. How can we vegetate these wide expanses of shoreline inexpensively? Three questions must be considered. Initially, how can plants be propagated inexpensively? Various methods of inexpensive plant propagation techniques will be discussed, with an emphasis on propagation by stem cuttings. Secondly, how can these inexpensive propagation techniques be applied to Shoreline Bioengineering? The stem cutting propagation technique will be applied to Shoreline Bioengineering techniques. The techniques will be briefly discussed. Thirdly, how can we select plants that are appropriate for Shoreline Bioengineering of our S.C. Piedmont reservoirs? I will present a list of appropriate plants (readily

available and/or good rooting ability), developed with the assistance of Chapter 16 of the NRCS Engineering Field Handbook, various herbaria located throughout S.C., and Radford's manual. Fascine and live stake installations of the plants of the developed list occurred in consolidated clay at the Cooperative Shoreline Plant Nursery. The species that were successful are *Cephalanthus occidentalis*, *Cornus amomum*, *Itea virginica*, *Salix nigra*, and *Sambuccus canadensis*. Thus, these species are good live staking candidates for S.C. Piedmont Reservoirs.

Grasses for Reservoir Shorelines

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The purpose of this talk is to discuss the erosion that occurs on the reservoirs of South Carolina's piedmont. It will cover the different types of reservoir management and how the conditions are different depending on the management of the reservoir. This talk will describe how grasses have ideal characteristics for holding soils and slowing wave energy without reducing the views across the reservoir. It will cover the process involved in testing the grasses in order to decide which species are best for reservoir erosion control. I will discuss the tests that were performed in the Cooperative Shoreline Plant Nursery as well as the tests performed on the shorelines of Lake Hartwell and Lake Keowee. Finally, I will recommend some of the grass species that have been found to be successful, and I will discuss some of the species that are still being tested.

The Aquatic Plant Restoration Program in Illinois

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Aquatic and wetland plant restoration is primarily needed for larger impoundments and renovation of wetland. Illinois' larger impoundments are generally void of aquatic vegetation. High wave action caused by wind and recreational boating, and water level fluctuations are believed to be the main reasons for the lack of aquatic vegetation establishment. Other factors might include turbidity, lack of an adequate seed bed and uprooting of plants caused by carp and other fish species. Biologists have tried transplanting aquatic vegetation from other lakes or purchasing plants and root stock from private nurseries. Transplanting from other lakes is discouraged due to introduction of unwanted species that might be attached or come in with the plants (i.e. zebra mussels, the spiny water flea, Eurasian milfoil, curlyleaf pondweed). The Department is also concerned about genetic strains of plants and would prefer not to buy plants, tubers or seed from private nurseries unless they can guarantee the use of local seed for their nursery stock. The Mason Tree Nursery in our Division of Forestry has undertaken a program to try and furnish the needs of the biologist from the Divisions of Natural Heritage and Fisheries. Nursery personnel have been experimenting with the culturing of different aquatic and wetland plants to meet the needs of the biologist. It is up to the requesting biologist to furnish the seed, proper identification and location from where the seed were obtained. The nursery will then raise the plants in trays containing 45 tubes which can then be easily transported to the biologist for planting at the appropriate time. Much of the work has been conducted at Clinton Lake, a 5000 acre impoundment located in central Illinois. Early (1990) attempts to plant sago pondweed (*Potamogeton pectinatus)* and wild celery (*Vallisneria sp)* failed even though they were protected with plastic snow fencing. The reason for failure was thought to be due to high turbidity and possibly the late planting date, July 2. Limited success was obtained with American pondweed (*Potamogeton nodosus).* The American pondweed grew well the first year though failed to come back the following year. Water willow (*Justica americana*) was planted from 1991 through 1998, except in 1994. In each year five to nine beds were established. Evaluations conducted in July and August 1998 indicated that an average of 70% (33 to 89%) of the beds planted between 1991 and 1998 were successful. Plantings from 1991 through 1995 were primarily along the main shoreline in order to provide shoreline protection as well as fish habitat. Average bed survival for these years was 56% (range 33-86%). Plantings from 1996 through 1998 occurred in protected coves, or in the upper arms of the lake where wave action was less severe. Average bed establishment was 88% (range 86-89%). Substrate type and protection from wave action probably increased survival in these areas. Planting clumps of water willow plants vs individual plants increased survival greatly. From 1996 through 1998 15 beds of wild celery were planted. Evaluations in August 1998 indicated that 53% of these beds were still actively growing. Beds protected with geo-jute and snow fencing planted in ambient water temperatures, in clear water and where depth was at least 12 in deep in August performed the best. The recent establishment of lizards tail (*Saururus cermuus*) and water willow along stream banks is showing some promise. Recent attempts to grow the wetland plants hardstem bulrush (*Scirpus acutus*), three-square bulrush (*Scirpus americanus*), river bulrush (*Scirpus fluviatilus),* deep-water duck potato (*Sagittaria rigida*) and spadder dock (*Nuphar Iuteum*) have met with mixed success.

Wetland renovation is becoming a bigger part of watershed management and will require more attention to determine which plants will provide the best habitat in the various types of wetlands.

Socioeconomics and Fisheries Management

Shrimp Baiting: Potential Impacts on the Profitability of South Carolina Commercial Shrimpers

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A concern has been raised that the South Carolina recreational shrimp baiting fishery might be reducing catch rates and therefore revenues of the commercial shrimp trawler industry. Moreover, some commercial shrimp trawler owners and related businesses (e.g., coastal wholesalers, etc.) share the view that harvest and/or illegal sales by non-commercial actors in state shrimp markets may have an impact on the long-term viability of the commercial trawler sector in SC. At present it is not clear whether the shrimp baiting fishery has actually reduced the fall season catch rates of the SC shrimp trawler fleet and research by others is planned to address this concern. With this caveat in mind, two economic issues warrant careful study when considering the existing commercial trawling industry. First, if the shrimp baiting fishery has or could eventually reduce the catch rates of the SC trawler fleet during the fall season, will this catch rate effect have a significant influence on the cash flow and the related overall profitability of commercial trawlers and related businesses? Second, if the shrimp baiting fishery has a significant impact, what are the likely aggregate economic impacts on coastal counties and the state of South Carolina? This study of the SC trawler industry addresses these shrimp industry issues.

Marginalization of African-Americans in Commercial Fishing in Georgia

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At the turn of the century, the shrimp fishery in Georgia was composed almost exclusively of African-Americans. One generation later, approximately 1925-30, African-Americans were a distinct minority in the fishery, working mostly as strikers. By the end of the century, they had virtually disappeared from the fishery altogether. The blue crab fishery is following a similar pattern, only 50 years later. In 1975, most of the crabbers were African-Americans, but only a few remain at the close of the century. In each case, half a century apart, the major proximate factor that led to the change appeared to be advances in technology, but the ability to finance the technology may also have played a key role. African-Americans were less able to make the economic investments necessary. Cultural factors may also have contributed to the decline, especially a deep-seated reluctance on the part of African-Americans to take the risks associated with increased reliance on technology and a move from subsistence-level to _commercialization.

Marine Reserves in the South Atlantic Region: Socioeconomic Issues to be Addressed

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The South Atlantic Fishery Management Council is considering the use of marine reserves as a management tool in the case of overfished fish stocks; specifically to aid in the recovery of the snapper grouper complex. In addition, there has been some interest in building artificial reefs on barren areas that would be set aside as harvest refugia. Advisory groups to the council have come up with a list of criteria, which will be used to evaluate proposed marine protected areas. Socioeconomic impacts is one of the criteria to be considered in developing potential marine reserves. This presentation focuses on the economic analyses required to provide necessary information for the decision making process, and to fulfill federal mandates that require socioeconomic information. Identification of relevant use and non-use values of all stakeholders is the first major step

in this endeavor. The appropriate use of benefit-cost analysis, and input-output analysis will be a fundamental part of this discussion.

A New Approach to Determining the Legal Monetary Value of Marine Finfish Species

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The South Carolina Department of Natural Resources (SCDNR) does not currently have specific regulations for evaluating the legal monetary value of most marine finfish species. These species oriented values could be used in litigation and fines involving environmental accidents and illegal activities which result in the injury or loss of these species. In 1999, a project was funded through the SCDNR's Marine Resources Division to organize and conduct evaluation panels to determine the legal value of selected marine finfish species. The panel approach is a departure from complex, large sample survey techniques and has the potential of providing a flexible technique for determining the legal value of numerous species. This technique is based upon assigning monetary values to various criteria ranking scales of selected marine finfish species groups by a lay and expert evaluation panels. The initial ranking scales were developed from a small sample survey of SCDNR marine biologists familiar with the life history and population characteristics of marine finfish species found in or near South Carolina. The panel methodology was pretested during 1999 using the ranking scales. The panels are scheduled for March, 2000. Based upon the analysis of the evaluation panel responses, recommendations for possible monetary value regulations will be prepared.

A Decision Support System for Recreational Fisheries Management

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An interactive decision support system was developed to allow managers to evaluate the potential effects of alternative regulatory actions for king mackerel, red snapper and gag grouper fisheries in the Gulf of Mexico and South Atlantic waters of Florida. The Windows-based computer program is driven by the results of a strategic choice model developed from a study of saltwater anglers in Florida. The strategic choice model used a fractional factorial design to generate hypothetical profiles of fishing experiences described by bag, size and season limits, distance traveled on water, and expectations of catch size and number on the allocation of fishing days. Recreational and anglers were asked to allocate ten days among fishing trip alternatives for king mackerel, red snapper and gag grouper, an alternative to fish for different species, and an alternative to engage in a non-fishing activity. Analysis was conducted with a multinomial logit model in which the aggregated allocation of fishing days to each alternative served as the independent variable. Part-worth utilities were estimated for each attribute level of each variable and selected interactions. The decision support system allows managers to estimate changes in recreational fishing trips based on changes in individual attributes (e.g. changing a three-fish limit to a five-fish limit or raising a minimum size limit from 20 inches to 24 inches). Linkages to estimating the economic effects of regulatory changes are also presented.

Expenditure Patterns of South Carolina's Saltwater Private Boat Recreational Anglers

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A telephone survey of South Carolina saltwater recreational fishing license holders was conducted in 1997 by the Marine Resources Division, SC Department of Natural Resources to collect data on the expenditure patterns of respondents who were involved in saltwater fishing in South Carolina during the sampling period. Information was obtained on a variety of variables including the number of days spent fishing, number of fishing trips, expenditures in South Carolina fishing supplies, food, lodging, etc., overall purpose of the fishing trip, and species of fish targeted. In addition, selected demographic information was obtained (i.e. age, race, sex, occupation, household income, and education). Based upon the mailing addresses of license holders, the following three geographic strata were sampled: the SC coastal region, the SC non-coastal region, and out-of-state areas, mainly Georgia and North Carolina. The results and implications of this survey will be discussed.

Analysis of Access Site Use by Georgia Saltwater Anglers

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Similar to other coastal states in the Southeast, Georgia has experienced an increase in recreational saltwater fishing over the past two decades. Accompanying this increase in fishing activity there has been a concurrent increase in the demand for boating and non-boating access. In an effort to meet this demand the Georgia Department of Natural Resources is conducting a survey of resident saltwater anglers to determine access site use patterns and preferences. The results of this survey will allow managers to better direct limited funding and prioritize access enhancement projects. This survey is part of an effort to make management more responsive to the angling public.

Oral Histories, Environmental Knowledge, and the Folk Sequence of Commercial Crab Fishers in Coastal Georgia

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The blue crab fishery in Georgia has experienced a decline in catch per unit effort. Fishery scientists and managers across the nation would all agree that there is not enough data to definitively explain the cause of this decline. Some scientists and managers in Georgia have indicated that they believe that the crabbers have a rich understanding of the fishery and the coastal ecosystem and could really contribute to the study of this decline. What is needed, they believe, is someone to elicit this knowledge from the fishermen and present it in a cohesive, organized, accessible format, to help bring new perspectives to the study of the trends in the crab fishery. This project will document the environmental knowledge of "old timer" blue crabbers and their opinions on "the way things were" (ecologically and otherwise) and the way they "should be" through oral histories. Second, it will clarify how Georgia crabbers believe humans have affected the integrity, diversity, resilience, and resource productivity of the coastal ecosystem. Finally, it will describe the cultural and economic significance of crabbing, enhancing resource managers' ability to create policies satisfactory to all stakeholders.

Demographics and license buying trends of Oklahoma Anglers

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Between 1995 and 1997, Oklahoma annual fishing license sales remained flat at slightly over 300,000 per year. Eighty five percent of the annual fishing license sales occurred prior to July 1 of each year. Females accounted for about 30% of the sales over this period. This was significantly higher than female hunting participants. The median age for licensed anglers was 37 years old. While census information indicated that 42% of Oklahoma's population was found in the metro Oklahoma City and Tulsa areas, Only 33% of the fishing license sales came from these locations. Between 1995 and 1996 only 53% of Oklahoma anglers renewed their fishing license with 55% renewing between 1995 and 1997. This suggests that more emphasis should be placed on marketing strategies directed toward license retention as well as looking for new participants. Several areas for potential license revenue increase are discussed.

Stream Restoration Symposium

Experiment in Passive Habitat Rehabilitation, Lower Missouri River

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The "Great Flood" of July 1993 broke through levees on the Missouri River at Lisbon Bottom near Glasgow, Missouri. Subsequent large floods in 1995 and 1996 eroded more of the Bottom and connected levee- break scours to form a 3-kilometer since-channel chute. The chute has attracted considerable interest because of the hazard it poses to barge navigation and because of its potential value as fish and wildlife habitat. The chute also has many similarities to highly engineered side-channel rehabilitation projects on the lower Missouri River. However, unlike engineered rehabilitation projects, the Lisbon Bottom chute has been allowed to erode and deposit freely and create natural side-channel habitats. As such, the Lisbon Bottom chute provides a field experiment in passive, minimum-cost flood-plain rehabilitation. Repeated mapping of the chute, its bathymetry, substrate, and velocity distributions indicate that it is evolving from a narrow, fast channel toward a wide, shallow channel similar to chutes that existed before extensive channelization of the Missouri River. Concurrently, sinuosity has increased, although not enough to decrease the channel slope to that of the main channel. Bathymetric, bed-classification, and acoustic Doppler velocity data indicate that the naturally evolving chute provides habitats that are not well represented in the main channel.

Effects of Road Crossings on Fish Movement and Community Composition in Ouachita Mountain Streams

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Low-water bridges are common in forested upland ecosystems. This study was initiated to measure the influence of road crossings on fish movement and assess the impact of the crossings on fish communities. We established three, sample sites in each of six upland tributaries of the Ouachita River, Arkansas. Three of the tributaries had crossings modified in an attempt to improve fish passage. The three sample sites included a 50-m reach upstream of a low-water bridge, another 50-m reach downstream of the bridge, and a 50-m reference reach. The low-water bridge was within a non-sampled 50-m reach between the upstream and downstream sampled reaches. Similarly, a 50-m reach without a low-water bridge, was not sampled between the downstream and reference reaches. We captured fish by electrofishing and marked them differentially by reach with a sub-cutaneous injection of a biologically compatible fluorescent dye three times in the spring and three times during

the summer. Fish were less than half as likely to move 50 m across reaches with low-water bridges compared to 50-m reaches without low-water bridges. Fish moved upstream and downstream equally between reaches not separated by low-water bridges, but were twice as likely to move downstream, rather than upstream, between reaches separated by low-water bridges. Average species richness was higher for fish communities downstream of the low-water bridges compared to upstream (12.5 versus 6.3) indicating that the reduced movement could affect community structure. Two low-water bridges back-filled with rip-rap to eliminate the plunge pools below the aprons were the only ones allowing upstream fish passage. These preliminary findings suggest that engineering design could lessen the impact of road-crossings on the structure of fish communities in streams.

Stream Restoration Using a Natural Channel Design Approach

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In recent years there has been a growing interest in restoring the physical integrity of streams that have been damaged by impacts from land use changes. An approach that has been found to have merit is one using a design approach based upon natural, stable stream channels. This paper will summarize the necessary steps required to accomplish restoration using the natural channel design approach from identifying the potential versus the current state, estimating the design discharge, finding appropriate stream types to fit the valley morphology, and finally matching the dimensionless ratios of stable streams of the same type from equivalent hydrophysiographic regions. Examples of restoration projects including information on the response of aquatic life to the beneficial changes effected by restoration are given. Finally, some observations on the strengths, limitations and pitfalls inherent in this approach are given.

Geomorphic Considerations In Stream Restoration Efforts

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One of the greatest and most widespread problems in river and stream alluvial channels is accelerated geomorphic change. Geomorphic change implies significant and adverse erosional modification, and includes several inter-related processes such as channel degradation, streambank erosion, and excessive sedimentation. Accelerated implies that these changes are occurring rapidly, over a few years or decades. For the most part, they are triggered by human activities. These events are biologically significant in that they may result in the local extirpation of riparian and aquatic species. They are economically significant in that they result in substantial loss of public and private property, as well as diminished recreational values associated with lotic and riparian habitats. Among the most extreme examples of accelerated geomorphic change are headcuts. Headcuts are most often associated with activities that cause changes in channel slope, depth, width, sediment/water balances, etc.. Common practices that may precipitate headcuts or more localized manifestations of accelerated geomorphic channel changes, include channelization, dredging or other navigation maintenance practices, and sand and gravel mining within or adjacent to channels. At different stages of the process, headcuts are evidenced by falling tributaries (indicating lower base level), extensive bank erosion, shallowing and widening of the channel, and point bar development. Biotic responses to headcuts include loss of characteristic riparian flora, loss of aquatic fauna, and shifts in aquatic community dominance. Understanding the causes, processes, and progression of accelerated geomorphic changes is an essential step in stream and river restoration projects. Plans to address erosion or sedimentation problems may include identifying and stopping adverse activities, reducing or controlling adverse activities to decrease effects on the system, or, in extreme cases, the construction of protective structures.

A GIS-Based Watershed Quality Model for Identifying Land-Based Pollution Problems

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The recent focus on watershed-based approaches to land and water resource issues has prompted the need to develop assessment tools. In many watersheds, water resources serve municipal, industrial, recreational, and ecological purposes; therefore community decisions makers must consider all user interests and not to upset the holistic balance of water resource uses. To address the need for resource assessment tools, a watershed quality integrity model (WQI) was developed using universally accepted model components and readily available data. The WQI model is a GIS-based model that links three watershed-process models, the Agricultural NonPoint Source model (AGNPS), the Modular Three-Dimensional Finite-Difference Groundwater Flow model (MODFLOW), and the RCHRES module of the Hydrological Simulation Program-Fortran model (HSPF). Input geographic data included soils, hydrography, land use, land cover, topography, and locations of discharge and recharge points. Watersheds are divided into hydrologically connected subwatersheds and each subwatershed is further subdivided into cells of 0.9 ha. The integration of these models and the GIS coverages provides comprehensive analysis of watershed quality as depicted by the watershed quality index. The watershed quality index is a unitless score derived by simulated output of 12 chemical and physical parameters. Simulations can be made by single-storm events with rainfall of between 13 mm to 125 mm or a time-series event of a one month period. The resulting watershed quality index provides the user an understanding of the resulting quality of a receiving stream following land use and/or watershed management practices. Additional, a costing module allows the user an understanding of the estimated costs of a proposed action.

The WQI model was applied to a Richland Creek watershed of the large Elk River basin in south-central Tennessee, USA. The Elk River basin drains 17,929 km^2 of primarily farm and forest lands. Water resource development includes a large hydro-electric impoundment, a cooling water impoundment, and several small water supply impoundments. The Richland Creek watershed drains 1254 km^2 primarily of karst geology, and gently rolling or steep-sided hills. Farmland account for 60% of land cover, with the remaining 37 % in forest and 3 % urban. Richland Creek is the main water source for a human population of 25,000. One non-point source remediation approach modeled was the reforestation of several subwatersheds. This practice increased the watershed quality index in the treated subwatershed as well as connected subwatersheds by as much as 35 %. The cost of this approach would be $ 22,280,000 (USA). A second alternative approach simulated was the conversion of buffer zones adjacent to the streams. This approach resulted in improvements approaching 30 % with a projected costs of only $ 460,700 (USA). Point-source techniques were also applied by upgrading the sewage treatment plant (STP) discharging directly into Richland Creek. Improvements to the STP by upgrading to tertiary treatment only improved by WQI by less 10 % at a cost of $ 15,000,000 (USA).

Using Soft Technology to Rehabilitate Impacted Streams

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Sediment is the number one pollutant in Arkansas and in most of the United States. Aquatic habitat and related vertebrate and invertebrate biota can be negatively impacted by sedimentation in these systems. The source of much of this sediment is streambank erosion. In the last 10 years there has been an accelerated evolution in environmental rehabilitation, especially in the field of erosion control. Traditional thinking relative to remediation of eroded streambanks, degradation of stream habitat, or any number of environmental impacts usually stressed "hard" engineering solutions emphasizing riprap as a major means of stabilizing sloughing or eroding streambanks. Based on slope stabilization using trees, rocks and other type armoring and bank renovation using vegetative options, new technology has been melded with ancient engineering for "softer", more flexible yet effective solutions. Several case histories are presented to give examples of solutions to common challenges experienced by aquatic biologists relative to aquatic habitat renovation. These include the use of log cribbing, cedar tree revetments, organic/synthetic erosion control matting, biologs, rooted and unrooted cuttings, fascines, and other nontraditional methods.

Incorporating Instream Fisheries Habitat Considerations When Designing Streambank Stabilization Projects

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Streambank stabilization and the design of natural stream channels have become a major emphasis of natural resource agencies in their efforts to improve watersheds. In our attempts to achieve a natural look while keeping costs as low as possible, considerable effort has been expended in eliminating traditional hard engineering solutions. Although some very economical solutions can be employed to stabilize streambanks, incorporating some hard structure can greatly enhance the finished product both in terms of stability and physical instream habitat while maintaining a very natural look. Several projects will be reviewed that combine the use of riprap, rock placement, logs and rootwads with numerous bio-engineering techniques to achieve stable, functioning stream channels with significantly improved fisheries habitat.

The effects of suspended sediment on the reproductive success of the tricolor shiner: implications for conservation in *Cyprinella* (Cyprinidae)

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Excessive sedimentation is an underappreciated, pervasive stressor to aquatic life and habitats. Suspended sediment causes multiple negative effects in fishes and degradation of benthic habitats, particularly in streams. The effects of suspended sediment on the reproductive success in the tricolor shiner (*Cyprinella trichroistia)* were experimentally examined. The experiment was based on an ANOVA model where the response variables were numbers of propagules spawned and relative proportions of developmental stages. Each of the three trials had four replicates of four treatments: 0(control), 100, 300, and 600 mg/1 suspended clay fines (≤63µ). Suspended sediment significantly reduced the incidence of spawning, numbers of propagules spawned, and delayed the intiation of spawning behavior. The effects were inferred to be a generalized reduction of behavioral interactions due to obfuscation of visual stimuli. Spawning behavior in *Cyprinella* is remarkably uniform with males exhibiting sexual dimorphism and dichromatism, and engaging in ritualistic displays that are components of visual communication. With chronic exposure during spawning seasons, it is probable that excessive sedimentation prevents adequate reproduction and contributes to range fragmentation and imperilment in sensitive *Cyprinella*.

Damaged Riparian Zones and their Eco-Geomorphic Consequences

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The riparian zone is a unique environmental setting where terrestrial and aquatic ecosystems overlap. This transitional area allows for the development highly diverse biotic communities within the zone of overlap and provides critical refugia, food sources, and nursery areas for the adjacent ecosystems, additionally, riparian areas (floodplains in particular) may trap and store large amounts of suspended sediment and associated environmental contaminants; intact riparian zones play a major role in natural water-quality processes. Large areas of riparian habitat (including Bottomland Hardwood forested wetlands) have been lost or damaged through dam and levee construction, channelization, and filling particularly in the southeastern United States. Human activities that lead to channel incision (channelization, dams) may locally increase bank erosion and suspended-sediment load and lower the water table on the flood plain leading to tree mortality and wholesale community shifts. The loss of contact between streamflow and the riparian area may have far-reaching downstream effects including reduced sediment and contaminant trapping and increased water velocities (increased bed and bank erosion) leading to an overall decrease in water quality. Concomitant shifts in aquatic habitat and stream regime may also occur. Research and restoration of critical reparian areas will be an important component in the long-term sustainability of aquatic systems and water quality.

Estimating long distance movements by stream fishes using mark-recapture techniques.

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The importance of long distance movement to the persistence of stream fish populations is widely recognized, but most studies have been ineffectual at documenting such movements. This problem is particularly acute for small fishes where radio tracking is impractical. Inferences from mark-recapture studies are often limited because of low recapture rates, limited spatial extent of study areas, and lack of uniform detectability for distances that fish moved. Attempting to compensate for these limitations, I examined the movement of several small fishes in a network of streams in the upper James drainage, Virginia. The spatial configuration of mark and recapture sites and the extent of the study area strongly influenced the movement patterns observed. Use of bi-directional fish traps increased the overall recapture rate and allowed detection of exceptional movement distances and pulses of movement. Future fish movement studies should consider the spatial arrangement of mark and recapture sites in both study design and data analysis, sample the largest amount of stream possible and utilize trapping techniques. Incorporation of these recommendations will strengthen the inferences that can be drawn from mark recapture studies and allow more accurate characterization of movement patterns for stream fishes.

Poster Session

Effect of threadfin shad and fathead minnows on blue green algae in channel catfish ponds

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Channel catfish stocked at 7,500 per acre in 1/4 acre earthen ponds alone, with 200 threadfin shad per acre, or with 1,500 fathead minnows per acre. Each treatment was evaluated in three ponds of a total of nine ponds. Production of channel catfish ranged from 683 to 993 pounds per pond. The weight of channel catfish harvested from ponds with fathead minnows was greater than that from ponds with shad but not significantly different from the control. Catfish in ponds with minnows fed more vigorously as observed in their higher feed intake. Survival of channel catfish was not significantly different among treatments. Algal populations in all ponds started the growing season with dominance by Chlorphyta. Ponds with threadfin shad generally developed dominant populations of *Oscillatoria sp.* by mid-Summer and *Microcystis aeruginosa* by late Fall. Ponds with fathead minnows were dominated by *M. aeruginosa* by mid-Summer and by *Oscillatoria sp.*, *M. aeruginosa*, or *Scenedesmus sp.* by late Fall. Control ponds were dominated by *M. aeruginosa* until late Fall when *Dactylococcopsis* or *Aphanocapsa* became dominant in two out of three ponds. Species diversity dropped by during the Summer in all control ponds and some ponds containing threadfin shad or fathead minnows. However, algal species diversity was relatively stable in two of six ponds containing threadfin shad or fathead minnows. By November, shad populations had spawned in only two of three ponds. Fathead minnows had spawned in three ponds. Variable effects of planktivorous fish on phytoplankton populations reflected the variability in spawning success of shad or fathead minnows. Early stocking and provision of spawning substrate could enhance the effects of planktivorous fish, particularly threadfin shad in channel catfish ponds.

Evaluation of the Genetic Status of the Ozark Hellbender Population in the Spring River, Arkansas

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Hellbenders (Cryptobranchus alleganiensis) are large aquatic salamanders found in flowing waters with large structural elements. A localized group of populations referred to as the Ozark hellbender has been recognized variously as a subspecies, C. a. bishopi, or a distinct species, C. bishopi. Only the Ozark hellbender occurs in Arkansas. The species is thought to have declined over the long term in the state. The most abundant population in the state, that of the Spring River, appears to have declined precipitously in the last decade. The possibility of supplementing the population through captive propagation has been suggested, raising concerns over genetics of the population. Tissue samples were collected from 12 hellbenders from the Spring River, AR, 8 from the Eleven Point River, AR, and 25 from the North Fork White River, MO. Spring River hellbenders were larger (500mm TL, 676 grams), than those from the Eleven Point (438 mm TL, 455 grams) or North Fork White (436mm TL, 580 grams) Rivers. Tissue sample were analyzed using random amplified polymorphic DNA (RAPD) techniques. Analysis using primer OpB12 produced a marker, designated SR450, that distinguished between hellbenders from the Spring River and the Eleven Point River. This marker did not distinguish North Fork White River hellbenders from the Spring River hellbenders. The Spring River population appears to have impaired recruitment and condition. The North Fork White River may provide the most appropriate source for captive rearing broodstock outside the Spring River itself. Further research on this population is needed to assess the abundance and distribution, protect and restore habitat, identify parameters limiting the population's survival and reproductive success, continued exploration of population genetics, and exploring the feasibility of captive propagation.

Aquaculture of Black Sea Bass (*Centropristis striata*)

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A new market is emerging for live black sea bass (*Centropristis striata*), in the sushi markets of the northeast United States. Due to increased fishing pressure, recent regulations have been imposed on *C. striata*. In an effort to satisfy demand while protecting native stocks, the Shellfish Aquaculture Lab is trying to develop aquacultural methods for hatchery reared fingerlings of *C. striata*. Fish (0.8 ± 0.05 g wet weight) were reared in replicate (n=3) 70 L tanks in a flow through system. Fish were fed four commercial diets at a 5% ration (grams dry weight of food/grams wet weight of fish) and showed significant differences ($p < 0.0001$) in weight after 12 weeks. By week 18, fish fed Zeigler's Salmon Starter (14.5 ± 0.92 g) > Rangen's Trout and Salmon Starter (11.4 ± 0.93 g) > Nelson's Silver Cup Salmon Crumbles (7.3 ± 0.85 g) = Nelson's Silver Cup Trout Crumbles (4.5 ± 0.29 g). Fish (0.6 ± 0.03 g wet weight) were also cultured in replicate (n=3) 70 L tanks housed in temperature regulated rooms. Fish raised at 30° C doubled in size after two weeks (0.6 ± 0.03 g to 1.2 ± 0.06 g) but most succumbed to mycobacterial (*M. marinum*) infections. After 10 weeks, all fish raised at 30° C had succumbed to disease. By week 10, significant differences in weight ($p < 0.0001$) of fish raised at 25° C, 20° C and 15° C were found with fish reared at 25° C (2.8 ± 0.14 g) = 20° C (2.3 ± 0.11 g) > 15° C (1.1 ± 0.04 g). Excellent potential exists for developing a black sea bass aquacultural fishery.

Diel variation in habitat use by stream fish

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We investigated variation in microhabitat selection by stream fish between day and night hours. We sampled a small warm-water stream using a point observation technique. Observations were made using mask and snorkel. The stream was divided into habitat units and five points were selected within each unit. Transects were laid at five random points in each habitat unit, and one sampling point was chosen at random along the length of each transect. Depth, mean water velocity, and substrate composition were measured at each of the observation points. A single observer counted all fish present within one

meter of the point selected. Samples were taken in daylight and at night with diurnal and nocturnal runs within 24 hours of each other. Night samples were taken using a submersible flashlight. Samples were taken in spring and fall, 1999. Preliminary results from spring indicate selection of shallow water at night and deeper water during the day in most species. This pattern seems to become weaker during the fall. Some fish show no selection during fall while others reverse selection as compared to spring. Variation in light intensity appears to cause shifts in microhabitat requirements among stream fishes. Assessment of species-specific microhabitat requirements may be directly dependant on when assessments are made.

Freshwater Mussels of the Choctawhatchee River Drainage in Alabama and Florida

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A freshwater mussel survey was conducted at 135 sites in the Choctawhatchee River Drainage in Alabama and Florida between 1998 and 1999. Unionids were found at 100 (74%) sites. The non-indigenous bivalve, *Corbicula fluminea*, was found at 91 (67%) sites, and was the only bivalve at 12 (9%) sites. Results from this inventory identified 23 species, of which 48% are considered rare. The rare species are: *Anodontiodes radiatus, Elliptio arctata, Elliptio mcmichaeli, Fusconaia succissa, Lampsilis australis, Pleurobema strodeanum, Ptychobranchus jonesi, Quincuncina burkei, Strophitus subvexus, Villosa choctawensis,* and *Villosa villosa*. *Villosa lienosa* was located at 70 (52%) sites, and was the most commonly encountered unionid species in this survey. *Anodontoides radiatus, Glebula rotundata, P. jonesi* and *V. villosa* were each located at only one site within the drainage basin. Future research will focus on collecting historical museum data and surveying historical sites.

Examination of Juvenile and Adult Freshwater Mussel (Bivalvia: Unionidae) Stream Parameter Preferences

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The objective of this study was to determine if juvenile and adult freshwater mussels of *Elliptio icterina, Quincuncina kleiniana, Pleurobema pyriforme*, from the New River, Suwannee River Drainage, Florida, exhibit stream parameter preferences. The following stream parameters were recorded from 2000 quadrat samples of $0.25m^2$ each: habitat type, sediment type, relative amount of detritus, and density of an exotic bivalve, *Corbicula fluminea*. Juvenile *E. icterina* exhibited a preference for detritus amount and *C. fluminea* density, while adults exhibited a preference for habitat type, sediment type, and *C. fluminea* density. Juvenile *Q. kleiniana* exhibited no preferences, while adults exhibited a preference for habitat type, sediment type, and *C. fluminea* density. No juvenile *P. pyriforme* were collected during this study. Adult *P. pyriforme* exhibited no stream parameter preferences. *Pleurobema pyriforme* may have stream parameter preferences that remain undetected due to low densities. Stream parameter preferences for different habitat types, sediment types, and detritus amounts may be related to host fish preferences, food availability, water flow and depth, or a combination of these factors. A preference for quadrats with high densities of *C. fluminea* may indicate a competition for resources.

Preliminary Assessment of Sheepshead (*Archosargus probatocephalus*) Age, Growth and Movement in Georgia's Waters

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The sheepshead (Archosargus probatocephalus) is a widely distributed Sparid common along the coast of the Southeastern United States and the Gulf of Mexico. In the South Atlantic, the sheepshead's importance as a commercial and recreational food fish has grown markedly in recent years. In addition, sheepshead appear to form spawning aggregations on nearshore reefs in the winter and spring, making them vulnerable to concentrated fishing effort. Sheepshead were collected from Georgia's waters through fisheries-independent sampling programs and the GA DNR Carcass Recovery Program. A total of 509 sheepshead were sampled for age-growth analysis. Sizes ranged from 171 mm to 579 mm fork length. Ages were

determined by counting annuli in thin sections of sagittal otoliths and age determination techniques were validated by marginal increment analysis. The maximum age determined through otolith analysis was 17 years. A total of 388 sheepshead have been marked with external tags. Of these, 67 were returned by anglers and 13 were recaptured during fisheries-independent sampling. The maximum time at large for sheepshead was 413 days and the maximum distance traveled was 70 miles.

Preliminary Assessment of the Striped Mullet (Mugil cephalus) in the Altamaha River of Georgia

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The striped mullet is an important estuarine finfish which supports a relatively large recreational fishery in the Altamaha River with average recreational landings of 18,600 pounds since 1997. In September of 1997, the Department of Natural Resources initiated an MARFIN study of striped mullet life history and movement patterns along the Georgia coast. Electrofishing gear was utilized in the low salinity waters of the lower Altamaha River to capture large numbers of striped mullet. A total of 671 striped mullet were sacrificed for age-growth analysis. Sizes of sacrificed fish ranged from 191 to 557 mm total length. Preliminary age data is being compiled and will be presented. A total of 2,269 striped mullet were marked with 70 mm external dart tags and released. Since 1998, 66 marked striped mullet were returned by anglers and 44 have been recaptured during fisheries-independent sampling. The maximum distance traveled was 281 miles and the maximum time at large was 304 days.

Modeling Annual White Shrimp (Litopenaeus setiferus) Harvest from Fishery Independent Assessment Parameters

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Georgia's white shrimp (Litopenaeus setiferus) fishery is the state's largest economic producer and ranks second in terms of total pounds landed. In order to better manage the fishery, the need for a predictive model indicating a relationship between annual landings and monthly coastwide assessment parameters (e.g. pounds per hour, water temp. and salinity)was addressed**.** Two potential models were developed. One model utilized data collected over the course of a calendar year (January 1 through December 31 of the landings year) while the other utilized data collected over the course of a shrimp production year (July 1 of the previous year through June 30 of the landings year). The shrimp production year model was developed as a means to make better management recommendations earlier in the landings year. Although the calender year model does not function well as a management tool (requires data collected in the last few months of the landings year) it does give insight into critical parameters that affect landings. Multivariate regression, utilizing a backward elimination procedure, was applied in both cases to determine which parameters significantly contributed to the prediction of annual landings.

Development and Application of the Oklahoma Stream Fisheries Management Information System

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The Oklahoma Stream Fisheries Management Information System is a compilation of available stream fisheries data into a GIS database to be used as a decision making tool by stream fisheries biologists. Focusing on eastern Oklahoma, it will contain data on stream fish sampling, stream flow, instream habitat data, and land use data. This database can be broken down into two parts: a spatial database and an attribute database. The spatial database includes coverages of streams, fish sampling sites and watershed characteristics, such as surficial geology and land use; while the attribute database contains non-spatial data such as fish keys and species indexes and attributes to spatial datasets including fish collection data and stream flow data. Upon completion, the Oklahoma Stream Fisheries Management Information System will provide information to address management issues about fisheries in eastern Oklahoma.

Riparian habitat Restoration: An Important Tool in the Recovery of Federally Listed Riverine Species in the Southeastern United States

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The Asheville, North Carolina, Field Office of the U.S. Fish and Wildlife Service has the task of listing and then recovering species in several southeastern states. An important tool in carrying out riverine species recovery plans is riparian habitat restoration. Asheville has helped initiate nine restoration projects in Tennessee, Kentucky, northern Alabama, northern Georgia, and western North Carolina by working closely with numerous partners, such as the Nature Conservancy, Resource Conservation and Development Councils, and grassroots watershed groups. Typical on-the-ground activities include streambank stabilization, revegetation, riparian fencing, and providing livestock with alternate watering sources. The restoration of riparian lands benefits aquatic species and their habitats by maintaining a stable streamside buffer that acts as a filter for sediments and other pollutants from upland runoff. We have projects in the following river systems: lower Ohio (Green River), Cumberland (Buck and Horse Lick creeks), Tennessee (Clinch, Duck, Little Tennessee, and Paint Rock rivers, and Owens Springs/Town Branch), and upper Coosa (Consauga and Etowah rivers). Collectively, project streams harbor exceptional biodiversity, with records for a large number of federally listed aquatic species (i.e. 38 mussels, 10 fishes, and a gastropod). Many more aquatic species of concern are benefitted by our efforts.

An historical bioenergetics evaluation of striped bass in Chesapeake Bay

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Numerous studies have been undertaken to evaluate the stability of the current striped bass population in Chesapeake Bay and the predatory demand it places on prey species. However little information exists on the predatory demand of this species prior to its decline in the 1970's. In this study, a bioenergetics modeling approach will be used to investigate the density dependent effects historical populations of striped bass had in Chesapeake Bay during the 1950's and late 1960's. Estimates of predatory demand and prey species contributions to the production of striped bass will also be evaluated. Data on diet composition, growth and age has been obtained for striped bass ages 1 through 17. These fish were collected by Maryland DNR during most months of the year and within the Maryland portion of the Chesapeake Bay. Of the 906 striped bass collected from 1955 through 1959, May 1968 and April 1969, 514 had food in their stomachs. The most numerous prey items were bay anchovy (40%) and Atlantic menhaden (40%). Analysis of historical data using current techniques can provide a valuable tool of comparison that may be used to better understand the current striped bass predator prey relationship in the Chesapeake Bay.

Attributes of shortnose and juvenile Atlantic sturgeon populations in the lower Ogeechee River, Georgia during spring-summer 1999."

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We surveyed shortnose sturgeon, Acipenser brevirostrum, and juvenile Atlantic sturgeon, Acipener oxyrinchus oxyrinchus, in the lower (river kilometers 36 to 57) Ogeechee River, Georgia using 30 m experimental monofilament gill nets from May

through September 1999. Twenty-three shortnose sturgeon were captured, mean CPUE was 0.0035 fish per net-meter-hour, and peak success was 0.0326 fish per net-meter-hour measured in mid June. There were no shortnose sturgeon recaptures from the current year's sampling and a population estimate was impossible. However, two shortnose sturgeon were recaptures from a 1998 capture and tagging project. About 90% of the fish we captured were adults (> 55 cm FL) suggesting that recruitment was limited or that our sampling was inadequate to describe the population. We speculate that recruitment is limited and that hatchery stockings may contribute significantly to the population since at least 3 of 23 fish we collected were cultured and released into the Savannah River at age 1. Forty-five Atlantic sturgeon were captured and none were adults (>2.2 m FL). Mean CPUE was 0.0077 fish per net-meter-hour; peak sampling success peaked at 0.0271 fish per net-meter-hour in mid August suggesting that Atlantic and shortnose sturgeon may be separated temporally. An initial population estimate of juvenile Atlantic sturgeon was approximately 82 fish (217<82<52; the mean and a 95% confidence interval). Surveying sturgeon populations is both costly and manpower intensive; a total of 6990.5 net-meter-hours of netting and 1,056 person hours were expended for these initial population estimates. High conductivity in the Ogeechee River during 1999 made radio telemetry much less successful than in earlier studies. Future efforts will focus on developing age and growth information from pectoral spines, estimating mortality of shortnose sturgeon, improving population estimates, improving tracking capabilities, and locating critical and spawning habitats.